From: Rob DiPerna <rob@wildcalifornia.org>
Sent: Thursday, May 01, 2014 1:14 PM
To: Wildlife Management
Subject: Attn Neil Clipperton--EPIC status review comments--supporting documentation
Attachments: Forsman et al 2011.pdf; BOnd et al 2002.pdf; USFWS 2009 Regulatory and Scientific Basis for FWS Guidance for Evaluation of Take for NSO 121409.pdf; Clark_2013 _NSO_Fire.pdf; ExecSummaryFinalEIS.pdf; NSO5-YrReview-R8SignedCopy10-26-2011.pdf; pnw_gtr850.pdf; franklin 2000 ecol mono.pdf; ta_spi_modifiedsurvey_nso_2013.docx

Dear Mr. Clipperton and Department Officials:

This message constitutes the first of several correspondences that will contain supporting materials for our comments to the Department for consideration as part of its CESA status review for the Northern Spotted Owl.

Please note that our comments will be delivered later today. Also please note that we will not be delivering referenced-items that we believe the Department already has access to from other sources.

Thank you for your attention. Please do not hesitate to contact me at either of the numbers provided below as necessary.

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Short-term effects of wildfires on spotted owl survival, site fidelity, mate fidelity, and reproductive success

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Abstract The effects of wildfire on wildlife are important considerations for resource managers because of recent interest in the role of fire in shaping forested landscapes in the western United States. This is particularly true of wildfire effects on spotted owls (*Strix occidentalis*) because of the uncertainty of impacts of controlled burning within spotted owl habitat. Therefore, we documented minimum survival, site fidelity, mate fidelity, and reproductive success for 21 spotted owls after large (>540 ha) wildfires occurred within 11 owl territories in California, Arizona, and New Mexico. In each territory, fire burned through the nest and primary roost sites. Eighteen owls (86%) were known to be alive at least 1 year after the fires, which was similar to reported annual adult survival probabilities for the species. Of 7 pairs of which both members were later resighted, all were located together on the same territories during the breeding season following fires, and 4 pairs produced a total of 7 fledglings. No pair separations were observed after fire. On 8 territories where fire severities were mapped, 50% experienced predominantly low- to moderate-severity fires while 50% experienced high-severity fires that burned large (>30%) areas of the territories. We hypothesize that wildfires may have little short-term impact on survival, site fidelity, mate fidelity, and reproductive success of spotted owls. Further, prescribed burning could be an effective tool in restoring habitat to natural conditions with minimal short-term impact on resident spotted owls. While we do not advocate wholesale prescribed burning in spotted owl territories at this time, we believe our observations justify large-scale experiments on effects of prescribed burning on spotted owls to corroborate our observations and to establish cause-and-effect relationships.

Key words prescribed burning, spotted owl, *Strix occidentalis*, wildfire

Wildfire is a natural process that has shaped the character of western forests (Agee 1990). In many areas, pre-settlement fire regimes consisted of frequent low-severity fires at 5–30-year intervals (Kilgore 1973, Horton and Mannan 1988, Weatherspoon et al. 1992, MacCracken et al. 1996). In central and southern California, the Southwest, and eastern slopes of the Cascades, low-severity fires created a mosaic of uneven- and even-aged forest stands (Kilgore 1973, Horton and Mannan 1988,

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MacCracken et al. 1996). In northwestern California, the xeric end of the Pacific Northwest rainforest, fire frequency occurred at about 20-year intervals and the fire regime was more similar to southwestern than other northwestern regions (Agee 1990, 1993). However, western forests were not immune to higher-severity wildfires, which occurred infrequently and were patchy in nature (Stephenson et al. 1991, MacCracken et al. 1996). Therefore, both low- and high-severity fires have had significant impacts on forest structure, composition, and distribution. Risk of high-severity wildfires associated with drought, insect and disease epidemics, and global warming has increased significantly in the western United States following decades of fire suppression (Agee 1993).

Many studies have been conducted on indirect impacts of wildfire on bird populations (e.g., Marshall 1963, Biswell 1989). Indirect impacts include changes in vegetation type, canopy closure, and relative food abundance, which influence local densities of birds (Kilgore 1973, Horton and Mannan 1988). In addition to indirect effects, direct mortality of birds due to fire has been assumed or suspected (Robbins and Myers 1992, Smith 2000). Further, avian lungs may be more susceptible to damage from smoke exposure than mammalian lungs because of an apparent inability of the avian respiratory tract to repair itself (Rombout et al. 1991). While nest destruction caused by fires has been reported for some ground-nesting birds in North Dakota (Robbins and Myers 1992), few studies have examined avian mortality and behavior directly following fire (McMahon and deCalesta 1990).

Some biologists assume that large wildfires negatively impact long-term survival of the spotted owl (*Strix occidentalis*; e.g., Weatherspoon et al. 1992, MacCracken et al. 1996), and believe catastrophic or "stand-replacement" fires, which kill all vegetation within the fire boundary, pose the greatest natural risk to spotted owl habitat (United States Fish and Wildlife Service [USFWS] 1992, 1995; Verner et al. 1992). Management plans generally recommend reducing risk of catastrophic fire in forests occupied by spotted owls (e.g., Verner et al. 1992). One method of reducing risk of wildfire is the use of prescribed fire to remove fuels that can facilitate surface fires becoming crown fires (Biswell 1989). Because northern (*S. o. caurina*) and Mexican spotted owls (*S. o. lucida*) are federally listed as threatened subspecies, prescribed fires within owl areas require consultation with the USFWS. USFWS smoke and wildlife guidelines for prescribed burning currently exist for site-preparation of clearcut units located near northern spotted owl Habitat Conservation Areas (HCAs), but some agency biologists have proposed prescribed burns within northern spotted owl HCAs (J. Perkins, United States Forest Service [USFS], Klamath National Forest, unpublished report). Because of uncertainty over fire effects on owls, controlled burning as a habitat management tool is not conducted routinely within areas reserved for spotted owls. For example, researchers have examined occupancy of spotted owl territories in years following a wildfire (Elliot 1985, MacCracken et al. 1996, Gaines et al. 1997, Scott 1998, Jenness 2000), but short-term impacts on individuals could not be assessed because owls were not color-marked.

We describe minimum survival, site fidelity, mate fidelity, and reproductive success of color-marked spotted owls after wildfires burned nest and roost areas in northwestern California, southern California, Arizona, and New Mexico. After a fire occurred within an owl territory, we posed 4 questions:

1. Did the owl(s) survive the fire (minimum survival)?
2. If an owl survived, was it found in the same territory after the fire (site fidelity)?
3. If both members of a pair survived a fire, did they retain the same mates (mate fidelity)?
4. If both members of a pair survived a fire, did they nest successfully the year after the fire (reproductive success)?

Direct observations of fire effects on spotted owls are difficult to obtain because of the patchy and infrequent (due to fire suppression) nature of fire, and logistical or political limitations associated with conducting fire experiments on a meaningful scale. Nevertheless, we provide insight on short-term effects of fire on spotted owls by presenting observations gathered during 15 years of study throughout a large portion of the species' range.

Study areas

We recorded spotted owl responses to fires >540 ha that occurred on 4 long-term demographic study areas, representing all 3 subspecies of the owl. Study areas were located in northwestern California (292 km^2, 1985–2000, northern spotted owl);

San Bernardino Mountains, southern California (1,890 km^2, 1987–2000, California spotted owl [*S. o. occidentalis*]); Tularosa Mountains, New Mexico (323 km^2, 1991–2000, Mexican spotted owl); and Coconino Plateau, Arizona (585 km^2, 1991–2000, Mexican spotted owl).

Forests in northwestern California were primarily mixed evergreen (Sawyer et al. 1988), dominated by Douglas-fir (*Pseudotsuga menziesii*) with a hardwood subcanopy of madrone (*Arbutus menziesii*), tanoak (*Lithocarpus densiflora*), and canyon live oak (*Quercus chrysolepis*) below 1,200 m elevation. Above 1,200 m, forests were mainly subalpine forests (Sawyer and Thornburgh 1988) dominated by white fir (*Abies concolor*) and pines (*Pinus* spp.). Forests in the San Bernardino Mountains consisted of mixed evergreens (Sawyer et al. 1988) below 1,500 m, and ponderosa pine (*P. ponderosa*) and white fir-sugar pine (*P. lambertiana*) forests (Thorne 1988) above 1,500 m. Forests consisted of various combinations of white fir, ponderosa pine, sugar pine, incense-cedar (*Calocedrus decurrens*), and black oak (*Q. kelloggii*) at higher elevations, and canyon live oak and bigcone Douglas-fir (*Pseudotsuga macrocarpa*) at lower elevations. Forests in the Tularosa Mountains were primarily mixed-conifer and pine-oak. Douglas-fir and white fir were the dominant species in mixed-conifer forests. Pine-oak forest was dominated by ponderosa pine and Gambel oak (*Q. gambelii*). Piñon-juniper woodland, dominated by piñon pine (*P. edulis*) and alligator juniper (*Juniperus deppeana*), was an extensive community within the mountain range. Forests on the Coconino Plateau were pine-oak dominated by ponderosa pine and Gambel oak (Peet 2000). Other communities on the plateau included mixed-conifer forest having Douglas-fir, ponderosa pine, and white fir in the overstory and quaking aspen (*Populus tremuloides*) and Gambel oak in the understory; and piñon-juniper woodland dominated by piñon pine and junipers (*Juniperus* spp.; Peet 2000).

Methods

Owl surveys

We surveyed each study area annually for spotted owls during the breeding season from 1985–2001 following methods described by Forsman (1983) and Franklin et al. (1996). We captured adult and juvenile owls using snare poles, noose poles, and mist nets. All captured birds were marked with a locking aluminum USFWS band on 1 leg and a plastic band and tab with a unique color combination on the other leg (Forsman et al. 1996). We determined the sex of owls by calls and behavior (Franklin et al. 1996). Rate of band loss for spotted owls was negligible (Franklin et al. 1996). This project was approved by the University of Minnesota's Animal Care and Use Committee (Animal Subjects Code Number: 0003A42461).

Impacts of fire

We used USFS records of severity, extent, and duration of all fires >540 ha occurring within territories of individually color-marked spotted owls. We limited our study to fires at least this large because home-range sizes of spotted owls range from 422–591 ha in northwestern California (northern spotted owl; Zabel et al. 1995), 415–810 ha in the San Bernardino Mountains (California spotted owl; Zimmerman et al. 2001), and 648 ha in Arizona (Mexican spotted owl; Ganey and Balda 1989). In each case, nest and roost areas were located within the fire perimeter, and all were burned. Detailed information about conditions (e.g., weather condition, fuel moisture, humidity, and fuel load) at owl nests and roosts was unavailable. We used available USFS data to describe the extent of each fire at the landscape and territory scales. At the landscape scale, we obtained the name, season, and year of the fire, as well as total size and duration of each fire. We addressed fire at the territory scale by estimating percent of each individual owl territory that burned, and percent of the fire-affected area in the territory that burned at high, moderate, or low severity. We defined an owl territory as a circle, with a radius of one-half the average nearest neighbor distance for each study area (see Bingham and Noon 1998) around the nest or roost site during the breeding season, at the time of or prior to the fire (northern spotted owl = 710 m [Franklin et al. 2000]; California spotted owl = 748.5 m [Smith et al. 2002]; Mexican spotted owl, AZ = 1,178 m [May 2000]; and NM = 1,060 m [Peery et al. 1999]). To estimate percent of each territory that burned and nest or roost area location within the fire, we overlaid owl territories onto digitized fire maps obtained from the USFS using ArcView GIS 3.2 (Environmental Systems Research Institute 1996).

Fire-severity classifications for each coverage were conducted by each USFS district within which the fire occurred. Coverages were classified as follows: 1987 autumn King Titus fire (24,282 ha) in northwestern California (3 owl territories) into low (<30% canopy kill), moderate (31–70% canopy kill), and high severity (>70% canopy kill); 1995 summer HB fire (5,261 ha) in New Mexico (3 owl territories) into low (≤35% canopy kill) and high (>35% canopy kill) severity; 1987 autumn Cold fire (4,876 ha) in northwestern California (1 owl territory) into high (small and subcanopy trees killed, and many to most overstory trees killed) and moderate (most small trees killed, some subcanopy trees killed or heavily damaged, and occasional mortality of overstory trees) severity; and 1996 spring Pot fire (2,833 ha) in Arizona (1 owl territory) into crown ("standing black sticks" with no live trees), high (>70% crown scorch of standing overstory trees), medium (30–70% crown scorch of standing overstory trees), and low/underburn (<30% scorch of standing overstory trees or generally on flanks or heel of fire area). Severity on the King Titus and HB fires was estimated using aerial photography; satellite imagery was also used on the HB fire. The Cold fire severity was estimated from ground surveys. The Pot fire map was developed using satellite imagery followed by ground verification. Unfortunately, USFS GIS data for the remaining 3 summer fires in southern California (Verbena, 1995 [9,308 ha], Mill, 1997 [541 ha], Willow, 1999 [25,091 ha]) portrayed only boundaries. We recognized that a boundary may be over-simplified, but severity maps for these fires were unavailable. We did not include more detailed pre- and post-fire habitat information in our analysis because our study focused on short-term effects of fire on survival and movements of owls rather than long-term habitat changes. No salvage logging or other major anthropogenic changes to vegetation within owl territories occurred between the time of the fire and the time we surveyed owls the following year.

We qualitatively described impacts of fire on survival, site fidelity, mate fidelity, and reproductive success of individuals and pairs because these were opportunistic observations taken over a long period of time. We pooled data across subspecies because sample sizes for each subspecies were small (≤4 territories) and we were describing observational responses rather than conducting comparative statistical analyses. We defined minimum survival rate as percent of individuals resighted alive at least 1 year after the fire ($n=21$ owls). We defined site fidelity as percent of individuals resighted alive within the same territory before the fire occurred and 1 year after the fire occurred ($n=$ 18 owls). We defined mate fidelity as percent of pairs that survived the fire ($n=7$ owl pairs) and both original pair members remained together (i.e., resighted in same territory as a social pair) 1 year after the fire occurred. Our evaluation of mate fidelity does not imply cause and effect if a pair-bond was broken. Rather, we interpreted it to mean only that a fire did not mediate a pair dissolution if they remained together. Reproductive success was defined as average number of fledglings per pair of owls that survived ($n=7$ owl pairs) 1 year after the fire occurred.

We compared overall estimates of annual adult spotted owl survival and reproductive success for each study area from our previous research (W. S. LaHaye, unpublished data; Seamans et al. 1999, Franklin et al. 2000) with qualitative findings from this study. Our previous survival estimates were based on mark-recapture estimators, whereas fire survival estimates were empirical estimates from a small sample size. Therefore, confidence limits for empirical estimates did not reflect uncertainty due to recapture probability. We compared short-term (1-year) reproductive success of owls surviving fires with general rates of owl reproduction. However, caution must be used when drawing conclusions about reproduction because spotted owl reproduction was more variable than survival and differences from overall averages could have been due to annual variation rather than effects of fire.

We also estimated overall annual site fidelity for each study area based on long-term data. We calculated annual site fidelity by dividing number of owls remaining on territories from year t to year t+1 by total number of owls surviving from year t to year t+1. Only banded, adult owls were used in site-fidelity calculations.

Results

Data were gathered from 4 study areas representing 38 observation years, >2,000 banded owls, >300 owl territories, and 7 wildfires. Wildfires occurred in 11 spotted owl territories (10 pairs and 1 single owl) during the period of investigation (1985–2001). Fires occurred in 4 northern, 3 California, and 4 Mexican spotted owl territories. All territories were >80% burned (83–100%). In all cases, nest and roost areas were burned. Four of 8 territories where fire severities were mapped burned primarily at low to moderate severity. However, the remaining 4 territories experienced fires that burned 36–88% of the territory at high-severity levels.

Eighteen of 21 (86%) individual owls affected by fires were resighted at least 1 year after the fires, and 16 of the 18 (89%) resighted owls were located in the same territories in the breeding season after the fire. Among 7 owl pairs in which both members were resighted after a fire, all were site- and mate-faithful. Among 3 individuals whose mates were never resighted, 2 females were resighted after the fire on different territories with different males, and 1 male exhibited site fidelity after the fire but was found paired with a different female. Four of 7 surviving owl pairs (57%) produced 7 fledglings the year following fire.

Minimum survival of spotted owls experiencing fires was similar to overall annual survival rates reported for the 3 subspecies (Table 1). Site fidelity among fire-impacted birds was also similar to overall estimates from the 4 demographic studies (Table 1). Reproductive success of spotted owls 1 year after fire occurred was higher than overall annual rates of reproduction (Table 1).

Discussion

Results from previous studies on impacts of wildfires on spotted owls have been equivocal. In some cases, large stand-replacing wildfires appeared to have a negative impact on owl occupancy (Elliot 1985, MacCracken et al. 1996, Gaines et al. 1997). Other reports have suggested that low- to moderate-severity wildfires did not adversely impact spotted owls (Yasuda 1997, Scott 1998, Jenness 2000). Although high-severity fires may displace some owls from territories (Elliot 1985, Gaines et al. 1997), it was unknown whether birds moved or died because owls in these studies were not marked. Since we monitored fates of color-marked owls, we could derive modest inference on effects of fire on individual survival, site fidelity, mate fidelity, and reproductive success. In our study, fates of only 3 of 21 owls exposed to fire were unknown. Relatively large wildfires that burned nest and roost areas appeared to have little short-term effect on survival, site fidelity, mate fidelity, and reproductive success of spotted owls, as rates were similar to estimates independent of fire. While post-fire reproductive rates were higher than background rates for these populations, they were well within the range of variation seen in these populations. Most (6 of 8) territories burned ≥50% at low to moderate severity. Therefore, we hypothesize that spotted owls may have the ability to withstand the immediate, short-term (1-year) effects of fire occurring at primarily low to moderate severities within their territory.

Horton and Mannan (1988) noted that animals that occupied forests having frequent fire intervals

Table 1. Estimates (95% confidence intervals) of minimum post-fire survival, site fidelity, and average number of fledglings per pair for 21 spotted owls (*Strix occidentalis*) that experienced fire in their territories in northwestern California, southern California, Arizona, and New Mexico, compared with overall average annual survival, site fidelity, and average number of fledglings per pair for the 4 populations at the above locations, 1987–2001.

		Estimates			
	Post-fire	*S.o. caurina*	*S.o. occidentalis*	*S.o. lucida*	
Parameter	estimates	NWC[a]	SC[b]	NM[c]	AZ[d]
Survival					
	0.86 (0.71–1.00) n=21	0.876 (0.84–0.91)	0.79 (0.76–0.81)	0.832 (0.78–0.89)	0.814 (0.72–0.91)
Site Fidelity					
	0.89 (0.74–1.00) n=18	0.88 (0.85–0.92)	0.91 (0.88–0.94)	0.90 (0.85–0.95)	0.92 (0.85–0.99)
Average no. fledglings/pair					
	1.0 (0.62–1.38) n=7 pairs	0.62 (0.56–0.68)	0.643 (0.59–0.69)	0.77 (0.70–0.84)	0.93 (0.86–1.0)

[a] Northwestern California: survival estimate from 1985–1998 (source: Franklin et al. 2000). Site fidelity estimate from 1985–2000; n = 42–68 owls per year for 15 years. Reproduction estimate from 1985–2001; n = 1019 pair observations.

[b] Southern California: survival estimate from 1987–1998 (source: W. S. LaHaye, unpublished data). Site fidelity estimate from 1987–1998; n = 35–93 owls per year for 11 years. Reproduction estimate from 1987–1998; n = 840 pair observations.

[c] New Mexico: survival estimate from 1991–1997 (source: Seamans et al. 1999). Site fidelity estimate from 1991–2000; n = 21–41 owls per year for 10 years. Reproduction estimate from 1991–2001; n = 203 pair observations.

[d] Arizona: survival estimate from 1991–1997 (source: Seamans et al. 1999). Site fidelity estimate from 1991–2000; n = 19–36 owls per year for 10 years. Reproduction estimate from 1991–2001; n = 241 pair observations.

should be adapted to repeated fires. While pre-settlement fire regimes of western forests consisted of frequent low-intensity burns, infrequent high-severity fires also occurred and were important determinants of forest structure, composition, and distribution (Agee 1990, Stephenson et al. 1991). Given historical fire regimes within its range, the spotted owl may be adapted to survive wildfires of various sizes and severities. Therefore, prescribed burning could be an effective tool in reducing current fire risk and restoring forests to natural conditions with minimal short-term impact to owls. However, we believe that programmatic prescribed burning in spotted owl territories cannot be justified solely on the observations we report here. Experiments testing effects of fire on spotted owls are still needed to corroborate the effects we observed, establish cause-and-effect relationships, and determine long-term impacts on spotted owls.

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Research Article

Relationship Between Wildfire, Salvage Logging, and Occupancy of Nesting Territories by Northern Spotted Owls

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ABSTRACT The northern spotted owl (*Strix occidentalis caurina*) is one of the most intensively studied raptors in the world; however, little is known about the impacts of wildfire on the subspecies and how they use recently burned areas. Three large-scale wildfires in southwest Oregon provided an opportunity to investigate the short-term impacts of wildfire and salvage logging on site occupancy of spotted owls. We used Program MARK to develop single-species, multiple-season models of site occupancy using data collected during demographic surveys of spotted owl territories. In our first analysis, we compared occupancy dynamics of spotted owl nesting territories before (1992–2002) and after the Timbered Rock burn (2003–2006) to a reference area in the south Cascade Mountains that was not affected recently by wildfire. We found that the South Cascades had greater colonization probabilities than Timbered Rock before and after wildfire ($\hat{\beta} = 1.31$, 95% CI = 0.60–2.03), and colonization probabilities declined over time at both areas ($\hat{\beta} = -0.06$, 95% CI = -0.12 to 0.00). Extinction probabilities were greater at South Cascades than at Timbered Rock prior to the burn ($\hat{\beta} = 0.69$, 95% CI = 0.23–2.62); however, Timbered Rock had greater extinction probabilities following wildfire ($\hat{\beta} = 1.46$, 95% CI = 0.29–2.62). The Timbered Rock and South Cascades study areas had similar patterns in site occupancy prior to the Timbered Rock burn (1992–2001). Furthermore, Timbered Rock had a 64% reduction in site occupancy following wildfire (2003–2006) in contrast to a 25% reduction in site occupancy at South Cascades during the same time period. This suggested that the combined effects of habitat disturbances due to wildfire and subsequent salvage logging on private lands negatively affected site occupancy by spotted owls. In our second analysis, we investigated the relationship between wildfire, salvage logging, and occupancy of spotted owl territories at the Biscuit, Quartz, and Timbered Rock burns from 2003 to 2006. Extinction probabilities increased as the combined area of early seral forests, high severity burn, and salvage logging increased within the core nesting areas ($\hat{\beta} = 1.88$, 95% CI = 0.10–3.66). We were unable to identify any relationships between initial occupancy or colonization probabilities and the habitat covariates that we considered in our analysis where the β coefficient did not overlap zero. We concluded that site occupancy of spotted owl nesting territories declined in the short-term following wildfire, and habitat modification and loss due to past timber harvest, high severity fire, and salvage logging jointly contributed to declines in site occupancy.

KEY WORDS colonization, extinction, northern spotted owl, occupancy, salvage logging, site occupancy, southwest Oregon, *Strix occidentalis caurina*, wildfire.

Northern spotted owls (*Strix occidentalis caurina*, hereafter spotted owl) are a medium sized, forest-dwelling owl with high levels of mate and site fidelity (Forsman et al. 1984, 2002; Thomas et al. 1990; Zimmerman et al. 2007). Nesting territories of spotted owls have greater proportions of mature and older forest than surrounding landscapes (Ripple et al. 1991, 1997; Meyer et al. 1998; Swindle et al. 1999). Forest stands used by spotted owls have large proportions of downed woody debris and snags, high canopy cover and high structural diversity (Hershey et al. 1998, North et al. 1999, Irwin et al. 2000). The features that provide structural complexity within spotted owl habitat also serve as ladder fuels that increase the likelihood of stand-replacing wildfire (Agee 1993, Wright and Agee 2004). As a result, forest stands that provide favorable habitat conditions for spotted owls within dry forest ecosystems are at risk of stand-replacing wildfire (Agee 1993, Agee et al. 2000). Presently, wildfire is the leading cause of spotted owl habitat modification on

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federally administered lands, and the rate of habitat modification due to wildfire within dry forest ecosystems has exceeded predictions (Davis and Lint 2005). Consequently, the viability of owl populations in dry forests has been questioned (Spies et al. 2006), and wildfire has been identified as a threat to the persistence of spotted owls occupying dry forest ecosystems (U.S. Fish and Wildlife Service [USFWS] 2011).

Despite the perceived threat of wildfire, little is known about the effects of wildfire on spotted owls, and the hypothesized effects come from research conducted in unburned landscapes. Numerous studies have documented that spotted owl survival, reproduction (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005), and territory occupancy (Blakesley et al. 2005, Dugger et al. 2011) were positively associated with increased amounts of late-successional forest within their core use areas or home range. Furthermore, owl territories with large reductions in the amount of older forest will have low reproduction or be abandoned (Bart and Forsman 1992, Bart 1995). These studies suggest that loss of older forests negatively affects spotted owls; however, the response of spotted owls to high severity fire and subsequent harvest of dead standing trees is unknown. Conversely, survival rates of spotted owls were greater at territories that were not entirely composed of late-successional forests (Franklin et al. 2000, Olson et al. 2004), which suggests that spotted owls may be adapted to natural disturbances such as wildfire that create a mosaic of forest conditions. Territory occupancy and nest success of spotted owls decreased as the amount of the territory composed of clear-cuts increased (Thraillkill et al. 1998), which suggests widespread post-fire salvage logging may negatively affect spotted owls.

The few studies that have been conducted on spotted owls in burned landscapes have provided equivocal results regarding the effects of wildfire on the species. Lack of consensus between studies may be owing to the confounding effects of salvage logging, the short-term nature of studies, small sample sizes from which to draw inference, treating the effect of fire as a binomial variable (i.e., burned or unburned), or potentially different responses of the 3 subspecies of spotted owls to wildfire. Radio-marked northern and California spotted owls (*Strix occidentalis occidentalis*) used forest stands that burned with low to high severities (Clark 2007, Bond et al. 2009); however, survival rates of radio-marked northern spotted owls occupying a burned area that was subsequently salvage logged were less than others reported throughout the subspecies' range (Clark et al. 2011). Conversely, short-term (<1 yr) survival rates of northern, Mexican (*Strix occidentalis lucida*), and California spotted owls in burned landscapes that were not subjected to post-fire salvage logging were similar to annual survival rates (Bond et al. 2002). The number of reproductive spotted owl pairs and the number of occupied spotted owl territories declined 1 year post-fire on the eastern slope of the Washington Cascade Range (Gaines et al. 1997); however, only 6 territories were surveyed in this study, 1 of which had a large amount of stand-replacing fire. Other studies indicate low and moderate severity burns may have minimal impacts on spotted owls. Territory occupancy of Mexican spotted owls in burned areas was similar to unburned areas (Jenness et al. 2004). Probability of territory occupancy for California spotted owls in the Sierra Nevada Mountains of California were similar between randomly selected burned and unburned sites (Roberts et al. 2011).

Because spotted owls are territorial and have high site fidelity (Forsman et al. 2002, Zimmerman et al. 2007), occupancy of nesting territories is essential for successful survival and reproduction. Occupancy models (MacKenzie et al. 2003, 2006) are well suited for investigating territory occupancy by spotted owls because the structure of existing spotted owl surveys (Franklin et al. 1996) fits the model framework well. Furthermore, occupancy models allow the inclusion of site-specific covariates, which allows the investigation of fire severity and habitat influences on site occupancy dynamics (i.e., extinction and colonization rates). The Biscuit, Quartz, and Timbered Rock burns in southwest Oregon provided an opportunity to investigate the impacts of wildfire and subsequent salvage logging on site occupancy by spotted owls. Our first objective was to determine if occupancy rates changed substantially following wildfire and subsequent salvage logging when compared to pre-burn occupancy rates and to occupancy rates in a landscape that had not been recently affected by wildfire. We met this objective by comparing occupancy rates of spotted owls before (1992–2002) and after (2003–2006) the Timbered Rock burn to an adjacent unburned landscape in the southern Oregon Cascades. We predicted that occupancy rates of spotted owls would be similar between study areas prior to the Timbered Rock burn but occupancy rates would decline substantially following the Timbered Rock burn in response to modification and loss of owl habitat from wildfire and subsequent salvage logging. Our second objective was to model the impacts of fire severity, salvage logging, and habitat characteristics on site occupancy of spotted owls at the Biscuit, Quartz, and Timbered Rock burns from 2003 to 2006. We predicted that extinction probabilities would increase as the amounts of past timber harvest, high severity burn, and salvage logging within a territory increased. We also predicted that initial occupancy and colonization probabilities within the 3 burned areas would be greater at territories with decreased levels of disturbance. In particular, we predicted that initial occupancy and colonization probabilities within the 3 burned areas would be greater at territories that had more intermediate-aged and older forest that burned with low or moderate severities.

STUDY AREA

We studied site occupancy by spotted owls at the Biscuit, Quartz, and Timbered Rock burns in southwest Oregon. Each burn was located within a distinct geographic region: the mid-Coastal Siskiyou Mountains (Biscuit burn), the Siskiyou Mountains (Quartz burn), and the southern Oregon Cascades (Timbered Rock burn). We also analyzed site occupancy of spotted owls at the South Cascades Demographic Study Area, which was adjacent to the

Timbered Rock burn and was not affected by a large scale wildfire within the last 100 years. Consequently, site occupancy by spotted owls in this area served as a reference for comparison to the Timbered Rock study area.

Common tree species within our study areas included ponderosa pine (*Pinus ponderosa*), sugar pine (*P. lambertiana*), Douglas-fir (*Pseudotsuga menziesii*), incense cedar (*Calocedrus decurrens*), white fir (*Abies concolor*), California red fir (*A. magnifica)*, mountain hemlock (*Tsuga mertensiana*), Oregon white oak (*Quercus garryana*), California black oak (*Q. kelloggii*), tanoak (*Lithocarpus densiflorus*), and Pacific madrone (*Arbutus menziesii*). Prior to the implementation of active fire suppression policies by state and federal agencies, most of southwest Oregon was characterized by frequent low-intensity fires and occasional stand-replacing fires at higher elevations (Agee 1993, Taylor and Skinner 1997, Heyerdahl et al. 2001). After active fire suppression policies were implemented, fire frequencies declined and high-intensity wildfires became more common (Agee 1993, Agee and Skinner 2005). The climate regime in southwest Oregon is characteristically temperate with hot, dry summers and cool, moist winters. During our study, the warmest and coldest average daily temperatures occurred in July (21° C) and December (4° C), respectively. Average annual rainfall was lowest at the Quartz burn (66 cm) and highest at the Biscuit burn (113 cm; Oregon Climate Service, Oregon State University, unpublished data).

The Biscuit burn originated from several lightning strikes in July 2002. The small fires eventually merged into a complex fire that covered 201,436 ha. Land ownership within the burn was predominantly public (U.S. Forest Service [USFS], Bureau of Land Management [BLM], Oregon Department of Forestry [ODF], and Josephine County). Fifty documented spotted owl territories were within the burn. We non-randomly selected a sample of 9 territories on the eastern side of the burn to include in our study that were similar to forest types at the Timbered Rock and Quartz burns and provided reasonable access. The 9 territories included in this study were located within the Briggs Creek, Silver Creek, Deer Creek, and Illinois River watersheds, ranging in elevation from 300 to 1,400 m. The remaining 41 territories were not included in our study because of logistical concerns or because they were located in mesic forest types on the western side of the burn. The 9 study territories were surveyed annually from 2003 to 2006. The area within 2.2 km of the 9 study territories burned with a mixed severity and received the least amount of salvage logging of the 3 burns (Table 1).

The Quartz burn was ignited by lightning in August 2001 and burned 2,484 ha of public (USFS, BLM, and ODF) and private (primarily industrial forest) lands. The fire burned portions of the Glade Creek, Little Applegate, and Yale Creek watersheds at elevations ranging from 600 to 1,850 m. The fire completely or partially burned (i.e., burned the majority of a 2.2-km buffer around the territory center) 9 spotted owl territories. All 9 territories were surveyed annually from 2003 to 2006. The study area burned with a mosaic of fire severities and was subjected to substantial amounts of salvage logging, primarily on private lands (Table 1).

The Timbered Rock burn was ignited by lightning in July 2002 and burned 11,028 ha of land within the Elk Creek watershed at elevations ranging from 450 to 1,350 m. Land ownership was dominated by a checkerboard pattern of public (BLM) and private industrial forest lands in the southern two-thirds of the burn and contiguous USFS managed lands in the northern third. Twenty-two spotted owl territories were within the burn perimeter and were surveyed annually from 2003 to 2006. These 22 territories were also surveyed prior to the burn from 1992 to 2002. The study area burned with a mixed severity and much of the private land was salvage logged (Table 1).

The South Cascades Demographic Study Area (South Cascades) is 1 of 8 study areas included in the range-wide monitoring program for spotted owls (Lint et al. 1999, Anthony et al. 2006), and it served as a reference area for our analyses. From 1992 to 2006, surveys to locate spotted owls were consistently conducted on an annual basis at 103 spotted owl territories by the Oregon Cooperative Fish and Wildlife Research Unit (OCFWRU). The South Cascades area encompasses approximately 223,000 ha of lands managed by the USFS at the southern terminus of the Oregon Cascades and at elevations ranging from 900 to 2,000 m. No large-scale wildfires occurred within the study area from 1992 to 2006. Forest conditions have been influenced historically by mixed-severity wildfire and more recently by forest management, livestock grazing, and fire suppression. Forest management has included individual tree selection, stand thinning, and even-aged management (U.S. Department of Agriculture [USDA] 1997, 1998). Current management activities are guided by the objectives set forth by the Land-use Allocations of the Northwest Forest Plan.

Table 1. The percentage (±SE) early seral, intermediate-aged or older forest that burned with a low, moderate, or high severity or was salvage logged within 2,230 m of 40 northern spotted owl territories at the Biscuit, Quartz, and Timbered Rock burns in southwest, Oregon, USA from 2003 to 2006.

		Intermediate-aged or older forests			
Study area	**Non-forest or early seral**	**Low severity**[a]	**Moderate severity**[b]	**High severity**[c]	**Salvage logged**[d]
Biscuit	27.2 ± 6.1	40.5 ± 6.7	13.6 ± 1.8	17.1 ± 3.6	1.6 ± 0.7
Timbered Rock	27.8 ± 1.6	35.9 ± 4.1	10.1 ± 0.7	9.3 ± 1.4	16.9 ± 3.2
Quartz	21.7 ± 1.5	48.5 ± 4.4	6.6 ± 1.5	10.0 ± 2.3	13.2 ± 2.7

[a] ≤20% of the forest canopy removed by wildfire.
[b] 21–70% of the forest canopy removed by wildfire.
[c] >70% of the forest canopy removed by wildfire.
[d] Areas that were intermediate-aged or older forest prior to the burn that were salvage logged.

The main purpose of matrix lands is timber production, whereas the late-succesional reserves are for conservation of older forests and silvicultural treatments are intended to promote forest stand structures similar to historical conditions or old forest characteristics (USDA and U.S. Department of the Interior [USDI] 1994).

METHODS

Data Acquisition and Preparation

To assess the effects of wildfire on occupancy of spotted owl territories, we created post-fire habitat maps in ArcGIS 9.1 (ESRI, Redlands, CA) by merging 3 data layers: 1) a pre-fire habitat map (Davis and Lint 2005), 2) a fire severity map, and 3) the boundaries of salvage logged areas (see Clark 2007 for additional details). The final map output had 8 distinct habitat classes (Table 2) and a minimum mapping unit of 2 ha. We used ground plot data to calculate map accuracies, which we estimated to be 68% for the Timbered Rock burn, 69% for the Biscuit burn, and 75% for the Quartz burn. Seventeen of 20 (85%) classification errors at the Biscuit burn, 10 of 15 (67%) at the Quartz burn, and 11 of 22 (50%) at the Timbered Rock burn were within 1 habitat or fire severity class of the correct classification. Based on these estimates, overall map accuracy within 1 habitat or fire severity class was 95% at the Biscuit burn, 92% at the Quartz burn, and 84% at the Timbered Rock burn (Clark 2007).

We conducted annual surveys between 1 March and 31 August to determine the occupancy of spotted owls on nesting territories according to established survey protocols (Franklin et al. 1996) and Oregon State University, Institutional Animal Care and Use Committee guidelines (IACUC Number 3040). Post-fire surveys were conducted as a collaborative effort between the OCFWRU, the BLM, the USFS, and private timber companies. From 1992 to 2006, we surveyed 22 and 103 territories at the Timbered Rock and South Cascades study areas, respectively. We also surveyed 9 territories at both the Biscuit and Quartz burns from 2003 to 2006. The average number of visits conducted varied by study area and year (range: 1.9 [Timbered Rock 2002]–5.8 [Timbered Rock 1994]). The maximum number of surveys at individual spotted owl territories ranged from 7 to 9 depending on the year. The variability in survey effort was a function of occupancy and nesting status (i.e., territories that were occupied by a pair of non-nesting owls were visited less). Occasionally, some territories were not surveyed every year, which was most often because of limited access during years of high snowfall. Fortunately, differences in survey effort and missing observations can easily be accounted for in open population models if you assume that occupancy dynamics are the same at territories that are and are not surveyed (MacKenzie et al. 2006), which is a reasonable assumption as long as survey effort is unbiased.

We used results from demographic surveys to create site-specific detection histories for owl pairs. Owl pairs represent the appropriate ecological unit of interest when modeling site occupancy. Protocols for adapting survey data from spotted owls using methods outlined in Franklin et al. (1996) to fit an occupancy modeling framework were established by Olson et al. (2005). These protocols were used in subsequent occupancy analyses for spotted owls (Kroll et al. 2010, Dugger et al. 2011) and this analysis. If a pair of owls was detected, we coded the visit as a 1 and if 1 or no owls were detected, we coded the visit as a 0. However, if 1 owl was detected and the owl exhibited nesting behavior (e.g., the owl was observed on a nest) or if young were observed with an adult owl, we coded the visit as a 1. If a survey was not conducted, we coded the visit as a missing observation (·). A hypothetical detection history of 10.1 would indicate that a pair of owls was detected on the first and fourth surveys, no owls or a single owl was detected on the second survey, and the territory was not visited during the third survey.

Data Analyses

Basic modeling procedures.—We estimated site occupancy in Program MARK (White and Burnham 1999) using single-species, multiple-season models (MacKenzie et al. 2003, 2006). This analysis generated estimates of 4 parameters: Ψ, the probability that a site is occupied in the first year of the study (initial occupancy); ε, the probability an occupied site became unoccupied the subsequent year (extinction); γ, the probability an unoccupied site was occupied the subsequent year (colonization); and P, the probability of detection (detection). In our analyses, primary sampling occasions were years and secondary sampling occasions were visits to

Table 2. Definitions of habitats used in the assessment of the impacts of wildfire and salvage logging on northern spotted owl site occupancy at the Biscuit, Quartz, and Timbered Rock burns in southwest Oregon, USA, from 2003 to 2006.

Habitat class	Description
Early seral	Non-forested areas, early seral, and pole sized conifer stands
Intermediate forest[a]—low severity burn	Intermediate-aged conifer stands with ≤20% of the canopy removed by fire
Intermediate forest—moderate severity burn	Intermediate-aged conifer stands with 21–70% of the canopy removed by fire
Older forest[b]—low severity burn	Older conifer forest with ≤20% of the canopy removed by fire
Older forest—moderate severity burn	Older conifer forest with 21–70% of the canopy removed by fire
High severity	Intermediate-aged and older conifer forests with >70% of the canopy removed by fire
Salvage	Intermediate-aged and older conifer forests that were salvage logged
Edge	The interface between the combined area of intermediate-aged and older forest that burned with a low or moderate severity and all other habitat types

[a] Forest stands that provide suitable roosting and foraging habitat for spotted owls.
[b] Forest stands that provide nesting habitat for spotted owls.

territories within years. This modeling framework was flexible and allowed for time-specific parameter estimates, inclusion of site-specific covariates, the ability to include missing observations, the direct estimation of colonization and extinction, and it assumed detection probabilities were <1 (MacKenzie et al. 2003, 2006).

We modeled the 4 occupancy parameters using a step-wise approach (Olson et al. 2005, MacKenzie et al. 2006, Dugger et al. 2011). We first determined the most parsimonious model for within year detection probabilities followed by among year detection probabilities, retained that model, and then proceeded to model initial occupancy. We then retained the most parsimonious model for initial occupancy and proceeded to model colonization and extinction parameters. We followed the conventions of Lebreton et al. (1992) and White and Burnham (1999) when developing and naming models. We considered several possible temporal effects on detection probabilities both within and among years that included constant detection (·), linear (*T*), log-linear (ln *T*), and quadratic (*TT*) trends. We did not evaluate time-specific models (*t*) within years because they required estimation of too many parameters to obtain reasonable estimates (Olson et al. 2005); however, we considered models that included time-specific effects among years (year). We also considered models that included differences in detection probabilities between study areas, because experience and effort of survey personnel may have differed. We considered 2 initial occupancy models that contrasted differences between study areas (area) and constant initial occupancy (·). When modeling extinction and colonization parameters, we considered models that compared differences between study areas (area) and no differences between areas (·), and we considered several biologically plausible temporal effects including constant rates among years (·), variable rates among years (*t*), and linear (*T*), log-linear (ln *T*), and quadratic (*TT*) trends over time. Models that included $\geq$2 study areas included additive and interactive effects between study area and temporal effects, where appropriate.

We used Akaike's Information Criterion corrected for small sample sizes (AIC_c) and the difference between the AIC_c value of the best model and the *i*th model (ΔAIC_c) to rank and compare candidate models at each step of the analysis. We used Akaike weights to evaluate the strength of evidence for 1 model versus another model (Burnham and Anderson 2002). We considered models that were $\leq$2.0 AIC_c of the best model as competitive. We used estimates of regression coefficients ($\hat{\beta}$) and their 95% confidence intervals to evaluate the relative effect and measure of precision of various covariates in our models. Following the approach outlined by Anthony et al. (2006), we used 95% confidence intervals for the coefficients as a relative measure of support for observed relationships rather than a strict test of the hypothesis that $\beta = 0$. Covariates whose 95% confidence intervals did not overlap 0 had strong evidence for an effect, those that narrowly overlapped 0 had some evidence for an effect, and those that broadly overlapped 0 had little or no evidence for an effect on the parameter of interest. We used this approach because significance testing is not valid under an information theoretical approach (Burnham and Anderson 2002), and it is best to present estimates of effect size and precision under this analysis paradigm (Anderson et al. 2000).

Comparison of South Cascades and Timbered Rock.—We compared occupancy at Timbered Rock and South Cascades from 1992 to 2006. Our objective was to determine if extinction and colonization probabilities following the Timbered Rock burn were different from unburned landscapes in the South Cascades (i.e., the control) during the same time period. In this analysis, we considered all study area and temporal effects on site occupancy parameters that are outlined above in the basic modeling procedures. In addition, we considered 10 models for colonization and extinction that were modifications of common study area and time effect models (Fig. 1). We considered these models because they may identify distinct changes in extinction and colonization rates following a disturbance such as wildfire and subsequent salvage logging. We predicted that under model [Pre-burn(·)Post-burn(area)] the South Cascades and Timbered Rock would have similar, constant extinction probabilities prior to the Timbered Rock burn, but extinction probabilities would be greater at Timbered Rock following the burn. In contrast, we predicted the opposite for colonization probabilities (e.g., under model [Pre-burn(·)Post-burn(area)], colonization rates would be equal at Timbered Rock and South Cascades prior to the Timbered Rock burn, but colonization rates would be less at the Timbered Rock study area following the burn). We retained the best ranked initial occupancy, extinction, colonization, and detection probability models and combined them to determine our best overall model. We used the best overall model to calculate estimates of year-specific probabilities of site occupancy in Program MARK using the equation from MacKenzie et al. (2003):

$$\hat{\Psi}_t = \hat{\Psi}_{t-1}(1 - \hat{\varepsilon}_{t-1}) + (1 - \hat{\Psi}_{t-1})\hat{\gamma}_{t-1}$$

Relationship between wildfire, salvage logging, and spotted owl site occupancy.—We modeled occupancy of nesting territories after fires from 2003 to 2006 at the Biscuit, Quartz, and Timbered Rock burns. Our objective was to model the potential influence of fire severity, salvage logging, and habitat covariates on site occupancy of spotted owls. In this analysis, we used a multiple step approach outlined in previous occupancy analyses for the species (Olson et al. 2005, Dugger et al. 2011). This approach included 3 steps: 1) determine the occupancy model that best described temporal and study area effects, 2) retain the best model from step 1 and model individual covariates to determine the best spatial scale and relationship of the covariate, and 3) retain the best model from step 1 and the best spatial scale and relationship of covariates from step 2 to test specific hypotheses regarding the effects of covariates on site occupancy.

Our first step was to determine the best model that only included study area and temporal effects by following the methods outlined in the basic modeling procedures. Our objective in this step was to develop a base model upon

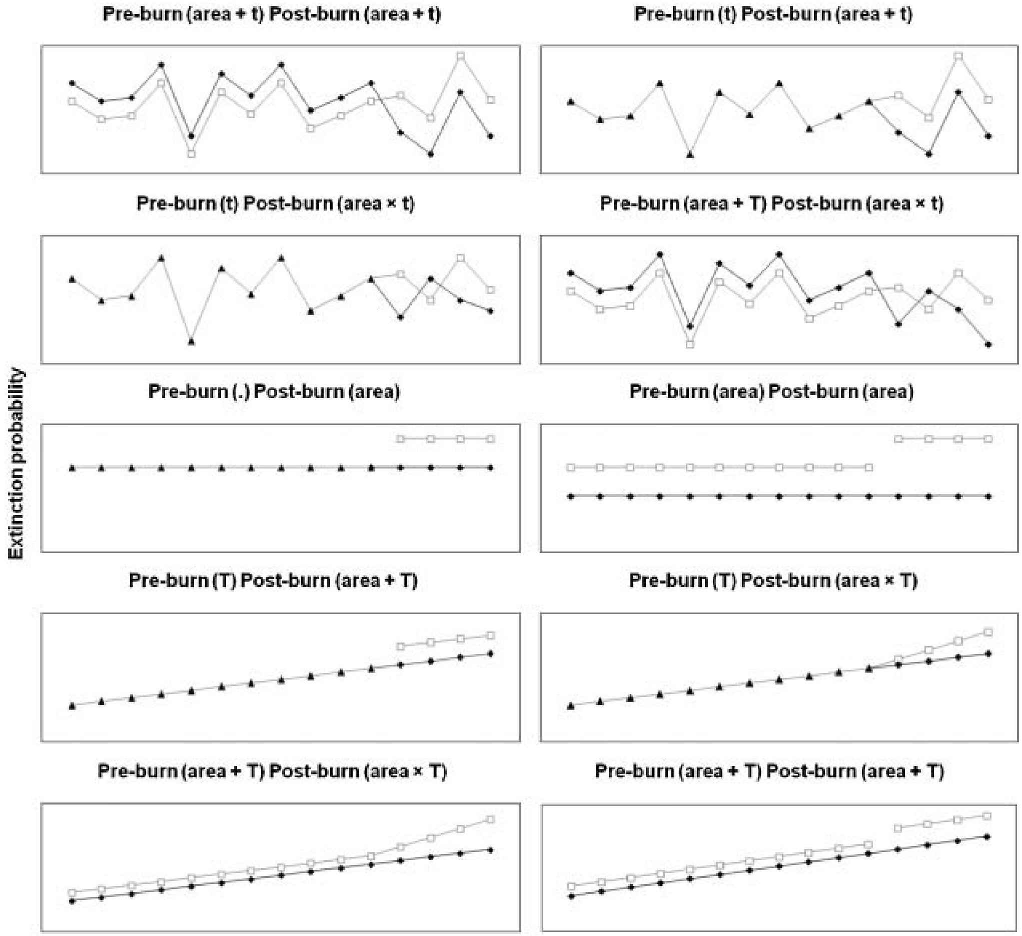

Figure 1. Visual representation of 10 hypothetical models comparing extinction rates of northern spotted owl territories at the Timbered Rock burn and South Cascades Demographic Study Area. We considered models that compared differences between study areas (area) and no differences between areas (·), and we considered several biologically plausible temporal effects including constant rates among years (·), variable rates among years (*t*), and linear (*T*) trends over time. The last 4 intervals represent the predicted changes in extinction probabilities following the Timbered Rock burn. The opposite relationship was predicted for colonization rates. Grey lines with open boxes represent the Timbered Rock study area, black lines with black diamonds represent the South Cascades Demographic Study Area, and gray lines with black triangles represent no differences between study areas.

which we modeled the effects of covariates. We considered all models outlined in the basic modeling procedures and 3 additional study area covariates for initial occupancy, extinction, and colonization models that incorporated various study area combinations including, 1) the Quartz and Timbered Rock burns would have similar occupancy dynamics because they include large amounts of private land (BIS $\neq$ TR $=$ Q), 2) the Timbered Rock and Biscuit burns would have similar occupancy dynamics because they occurred 1 year after the Quartz burn (BIS $=$ TR $\neq$ Q), and 3) the Quartz and Biscuit burns would have similar occupancy dynamics because they are both located in the Siskiyou Mountains (BIS $=$ Q $\neq$ TR). Our primary objective during this portion of the analysis was to develop a parsimonious model on which to model covariates; consequently, we did not consider competing models in this step of the analysis. After determining the best study area and temporal effects model, we retained this model and proceeded to the second step of the analysis.

In the second step of this analysis, our objective was to determine the spatial scale and relationship that best explained the effect of various covariates on initial occupancy, extinction, and colonization probabilities. We calculated site-specific covariates at 2 spatial scales (territory and core area) and with 2 relationships (linear and log-linear), which represented 4 possible models for each covariate. We calculated covariate values in ArcGIS 9.1 from post-fire habitat maps as the percent of each cover type within a 2,230-m radius (1,560 ha; territory scale) and a 730-m radius (167 ha; core area scale) of the territory center. We selected these spatial scales because they were used to model spotted owl survival and reproduction in the same geographic region (Dugger et al. 2005).

For initial occupancy and colonization probabilities, we modeled 9 covariates (Table 3) to determine the best spatial scale and relationship of the covariate. All of the covariates we modeled on initial occupancy and colonization parameters were thought to represent the quality of habitat remaining at the territory and were based on biologically meaningful relationships. Forested areas that burned with a low or moderate severity likely had minimal changes in the amount of canopy cover, snags, and downed woody debris, which are

Table 3. Candidate model sets for initial occupancy, extinction, and colonization parameters in the analysis of covariate effects on site occupancy of northern spotted owls at the Biscuit, Quartz, and Timbered Rock burns in southwest Oregon, USA, from 2003 to 2006.

Initial occupancy (Ψ) and colonization (γ)[a]	Extinction (ε)[b]
INTL + INTM + OLDL + OLDM	EARLY + HIGH + SALVAGE
INTL + OLDL	HIGH + SALVAGE
INT + OLD	HARVEST + HIGH
OLDL + OLDM	EARLY + HISALV
OLDL	HISALV
OLD	HARVEST
LOW + MOD	SALVAGE
LOW	HIGH
EDGE	EARHISALV
	EDGE

[a] INTL, intermediate-aged forest that burned with a low severity; INTM, intermediate-aged forest that burned with a moderate severity; OLDL, older forest that burned with a low severity; OLDM, older forest that burned with a moderate severity; INT, intermediate-aged forest that burned with a low or moderate severity (combined area of INTL and INTM); OLD, older forest that burned with a low or moderate severity (combined area of OLDL and OLDM); LOW, intermediate-aged and older forest that burned with a low severity (combined area of INTL and OLDL); MOD, intermediate-aged and older forest that burned with a moderate severity (combined area of INTM and OLDM); EDGE, the interface between forested areas that burned with low or moderate severity and areas that were early seral stands, burned with high severity, or were salvage logged; EDGE was modeled as an additive effect with the best ranked covariate model to determine if it improved model fit.

[b] EARLY, non-forested areas early seral stands that burned with any severity; HIGH, the combined area of intermediate-aged and older forest that burned with a high severity; SALVAGE, any intermediate-aged or older forest that was salvage logged; HARVEST, any forested area, that was harvested before or after the burn (combined area of EARLY and SALVAGE); HISALV, any forested area, excluding early stands, that burned with a high severity or was salvage logged (combined area of HIGH and SALVAGE); EARHISALV, any early seral stand or forested area that burned with high severity or that was salvage logged (combined area of EARLY, HIGH, and SALVAGE).

all critical components of spotted owl habitat (Hershey et al. 1998, North et al. 1999, Irwin et al. 2000). Intermediate-aged forests contribute to landscape heterogeneity, which influenced spotted owl survival in other studies (Franklin et al. 2000, Olson et al. 2004), so we hypothesized that it would also influence site occupancy by the subspecies. Spotted owl territories usually have high proportions of mature and older forests (Ripple et al. 1991, 1997; Meyer et al. 1998; Swindle et al. 1999), so we expected that initial occupancy and colonization probabilities would be influenced by the amount of older forest within the territory.

We elected to use a different set of covariates on extinction probabilities because of the highly correlated nature of extinction and colonization probabilities (MacKenzie et al. 2006). Modeling the same set of covariates on extinction and colonization parameters can result in counter-intuitive results. This is because sites that went extinct are the sites available for colonization. As a result, factors that contribute to increased extinction probabilities could also contribute to increased colonization probabilities. For extinction models, we modeled 7 covariates (Table 3) to determine the best spatial scale and relationship of the covariate. All of the covariates considered for extinction were thought to be related to the impacts of habitat loss and modification attributable to past timber harvest, high severity fire, and salvage logging. We hypothesized that all 3 of these factors would negatively affect site occupancy. Spotted owl territories that had increased amounts of clear-cut timber harvest had decreased occupancy (Thrailkill et al. 1998). Timber harvest and post-fire salvage commonly results in large-scale clear-cuts; as a result, site occupancy by owls should be negatively affected by these factors. High severity fire removes downed woody debris and reduces canopy cover and structural diversity. All of these factors influence spotted owl habitat selection (Hershey et al. 1998, North et al. 1999, Irwin et al. 2000), so we hypothesized that increased amounts of high severity fire may increase extinction probabilities.

We considered the effects of the amount of edge habitat on initial occupancy, extinction, and colonization probabilities because we suspected edge could have positive or negative impacts on site occupancy. Greater amounts of edge habitat may increase site occupancy by increasing prey availability, particularly woodrats (*Neotoma* spp.), which are common in edge habitats (Zabel et al. 1995, Ward et al. 1998) and are a primary prey item in this portion of the spotted owl's range (Forsman et al. 2004). In contrast, increased amounts of edge habitat may decrease the amount of interior forest available to owls, which has been associated with decreased spotted owl survival (Franklin et al. 2000). To avoid the potential correlation between extinction and colonization parameters (MacKenzie et al. 2006), we only used edge in 1 of the parameters, not both, in the same model. We used edge as an additive effect with the best ranked covariate model for initial occupancy and extinction or colonization to determine if it improved model fit (i.e., decreased the AIC_c value).

We modeled each of the 4 possible models of each covariate individually, as an additive effect, with the best model from the first step of our analysis. We took this approach to reduce redundancy in the potential list of covariates due to spatial scales and relationships of covariates being correlated and to reduce the number of candidate models that would be considered in the final step of the analysis. We ranked each model using AIC_c values to determine the best spatial scale and relationship of each covariate.

The third step of our analysis combined the best individual covariates from the second step of our analysis into more complex models to test a specific set of biologically plausible hypotheses (Table 3). We did not use covariates on detection probabilities because they are nuisance parameters for which we had minimal interest. Our most complex initial occupancy and colonization models included 4 covariates (combinations of intermediate-aged and older forests and low and moderate burn severity; Table 3). Other models were variations of the most complex model that included a subset of these covariates or combined 2 covariates into a single covariate. Our most complex extinction model included 3 covariates (early seral stands, forests with high burn severity, and salvage logged forests; Table 3). The remaining candidate models were variations of the most complex model that had fewer covariates or combined 2 or more covariates into a single covariate. Prior to fitting our candidate model set (Table 3), we looked for correlations between variables that may be included in the same model. We did not include candidate models with highly correlated variables ($r^2 > 0.70$). After determining the best covariate model for initial occupancy, extinction, and colonization probabilities, we retained these models and combined them to determine our best overall model.

RESULTS

Comparison of the South Cascades to Timbered Rock

The best model for detection probabilities was *P* (year + area + ln *T*), and the second ranked model [*P* (year + ln *T*)] was not competitive ($\Delta AIC_c = 13.18$; Table 4). The best model indicated that detection probabilities varied among years, differed between areas, and followed a log-linear time trend within years. Detection probabilities were greater at South Cascades than at Timbered Rock in 10 out of 15 years. In most years (8 out of 15), detection probabilities declined over the survey season, but in the remaining 7 years, detection probabilities increased over the survey season. Detection probabilities during 1 survey over the 15 years of the study varied considerably and ranged from 0.24 to 0.82 at the South Cascades and 0.11–0.79 at Timbered Rock. The range of detection probabilities within years was less variable. The best model for initial occupancy was Ψ (area), and the second ranked model [Ψ(·)] was not competitive ($\Delta AIC_c = 7.21$). The best model indicated that the South Cascades had greater initial occupancy ($\hat{\beta} = 2.21$, 95% CI = 0.65–3.76) than Timbered Rock. We estimated initial occupancy probabilities in 1992 to be 0.94 (95% CI = 0.88–1.00) at South Cascades compared to 0.65 at Timbered Rock (95% CI = 0.44–0.86).

The best model for extinction probabilities was ε[Pre-burn (area + *t*)Post-burn(area + *t*)], and 2 models were highly competitive (i.e., $\Delta AIC_c < 2.0$) with the best extinction model (Table 4). However, model ε[Pre-burn(area + *t*)Post-burn(area + *t*)] had a weight of 0.42, indicating strong support for the best model. Interpretation of the best model was that extinction rates varied by year and study area, but the study areas followed the same pattern over time (Fig. 2). We found some evidence that the South Cascades had greater extinction probabilities than Timbered Rock prior to the burn because the 95% confidence interval barely overlapped 0 ($\hat{\beta} = 0.69$, 95% CI = −0.06 to 1.43). Following wildfire and subsequent salvage logging at the Timbered Rock study area, extinction probabilities were greater than at the South Cascades ($\hat{\beta} = 1.46$, 95% CI = 0.29–2.62; Fig. 2). Model ε[Pre-burn(*t*)Post-burn(area + *t*)] was the second ranked extinction probability model ($\Delta AIC_c = 1.53$; Table 4). This model suggested that extinction probabilities varied by year and the Timbered Rock and the South Cascades study areas had similar extinction probabilities prior to the Timbered Rock burn, but extinction probabilities were greater at Timbered Rock following wildfire and subsequent salvage logging. Model ε (*t*) was the third ranked extinction model ($\Delta AIC_c = 1.84$; Table 4). This model suggested that extinction probabilities varied by year, and the Timbered Rock and South Cascades study areas had similar extinction probabilities before and after the Timbered Rock burn. We did not consider this model further, because the 2 best ranked models had similar interpretations with a combined model weight of

Table 4. Model selection results for extinction (ε), colonization (γ), and detection (*P*) probability models in the analysis of site occupancy of northern spotted owls at the South Cascades Demographic Study Area and the Timbered Rock study Area in southwest Oregon, USA, from 1992 to 2006. We presented only models with an Akaike weight ≥0.01. We considered models that compared differences between study areas (area) and no differences between areas (·), and we considered several biologically plausible temporal effects including constant rates among years (·), variable rates among years (*t*), and linear (*T*), log-linear (ln *T*), and quadratic (*TT*) trends over time. For all extinction, colonization, and detection probability models, the best initial occupancy (Ψ) model was Ψ (area).

Model	AIC_c[a]	ΔAIC_c[b]	w_i[c]	K[d]	Deviance
Extinction—ε					
ε(Pre-burn(area + *t*)Post-burn(area + *t*))γ(area + *T*)*P*(year, area + ln *T*)	8689.47	0.00	0.42	66	8552.27
ε(Pre-burn(*t*)Post-burn(area + *t*))γ(area + *T*)*P*(year, area + ln *T*)	8691.00	1.53	0.19	65	8555.96
ε(*t*)γ(area + *T*)*P*(year, area + ln *T*)	8691.31	1.84	0.17	64	8558.42
ε(area + *t*)γ(area + *T*)*P*(year, area + ln *T*)	8692.58	3.12	0.09	65	8557.54
ε(Pre-burn(area + *t*)Post-burn(area × *t*))γ(area + *T*)*P*(year, area + ln *T*)	8692.77	3.30	0.08	69	8549.08
ε(Pre-burn(*t*)Post-burn(area × *t*))γ(area + *T*)*P*(year, area + ln *T*)	8694.30	4.83	0.04	68	8552.78
Colonization—γ					
ε(area × *t*)γ(area + *T*)*P*(year, area + ln *T*)	8700.13	0.00	0.43	78	8536.83
ε(area × *t*)γ(area + *TT*)*P*(year, area + ln *T*)	8702.15	2.03	0.16	79	8536.66
ε(area × *t*)γ(Pre-burn (area + *T*)Post-burn area + *T*))*P*(year, area + ln *T*)	8702.29	2.16	0.15	79	8536.80
ε(area × *t*)γ(Pre-burn(area + *T*)Post-burn(area × *T*))*P*(year, area + ln *T*)	8702.32	2.19	0.15	79	8536.83
ε(area × *t*)γ(Pre-burn(area)Post-burn(area))*P*(year, area + ln *T*)	8703.02	2.89	0.10	78	8539.72
ε(area × *t*)γ(Pre-burn(*T*)Post-burn(area × *T*))*P*(year, area + ln *T*)	8708.47	8.35	0.01	79	8542.98
Detection probability—*P*[e]					
ε(area × *t*)γ(area × *t*)*P*(year, area + ln *T*)	8729.48	0.00	1.00	103	8510.61
ε(area × *t*)γ(area × *t*)*P*(year, ln *T*)	8742.66	13.18	0.00	88	8557.33

[a] Akaike's Information Criterion corrected for small sample sizes.
[b] The difference between the model listed and the best AIC_c model.
[c] Akaike weight.
[d] No. parameters in model.
[e] Detection probability modeling notation is *P* (among year detection, within year detection).

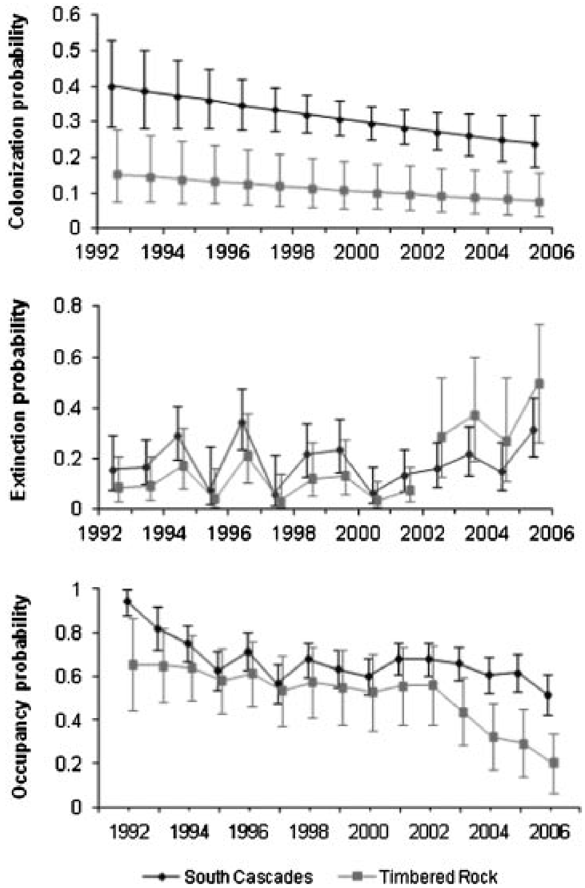

Figure 2. Estimated extinction, colonization, and site occupancy probabilities (95% CI) of northern spotted owls at the Timbered Rock and South Cascades study areas in southwest Oregon, USA from 1992 to 2006.

0.62 and indicated that post-burn, extinction probabilities were greater at Timbered Rock.

The best model for colonization was γ (area + T), and no models were within 2.0 AIC_c units of the best model (Table 4). Model γ (area + T) had a weight of 0.43 indicating strong support for this model. Interpretation of the best model was that colonization probabilities differed between study areas and declined linearly over time. Colonization probabilities were greater at the South Cascades ($\hat{\beta} = 1.31$, 95% CI = 0.60–2.03) than at Timbered Rock and declined over time ($\hat{\beta} = -0.06$, 95% CI = -0.12 to 0.00) at both areas (Fig. 2). Wildfire and salvage logging did not appear to influence post-burn colonization probabilities at Timbered Rock because models that included changes in colonization probabilities following wildfire were not competitive (i.e., $\Delta AIC_c > 2.0$) with the best model (Table 4).

We combined the best ranked models for initial occupancy, extinction, colonization, and detection probabilities to obtain our best overall model (Table 4), which we used to contrast trends in occupancy probabilities over time at the Timbered Rock and South Cascades study areas. We used the best overall model [Ψ(area)ε[Pre-burn(area + t)Post-burn(area + t)]γ(area + T)P(year + area + ln T)] to calculate year-specific occupancy estimates for each study area.

Site occupancy by spotted owls at the South Cascades declined from 1992 to 1994, remained relatively stable from 1995 to 2005, and declined again in 2006 (Fig. 2). In contrast, site occupancy by spotted owls at Timbered Rock declined slightly from 1992 to 2002 and declined in an almost linear fashion from 2003 to 2006, which corresponded to the years following the Timbered Rock burn (Fig. 2). Between 2002 and 2006, the estimated proportion of spotted owl territories occupied by a pair at South Cascades declined from 0.68 to 0.51, a 25% reduction in site occupancy. In contrast, the estimated proportion of spotted owl territories occupied by a pair at Timbered Rock declined from 0.56 to 0.20, a 64% reduction in site occupancy during the same time period. This indicated that occupancy of territories by spotted owls in a recently burned landscape that was subjected to salvage logging declined at a greater rate than in a recently unburned landscape.

Relationship Between Wildfire, Salvage Logging, and Spotted Owl Site Occupancy

Our objective in this portion of the analysis was to determine the best model prior to modeling habitat covariates; consequently, we did not consider any competing models. The best model that described study area and temporal effects on spotted owl site occupancy at the Biscuit, Quartz, and Timbered Rock burns from 2003 to 2006 was $\Psi(\cdot)\varepsilon(\text{BIS} \neq \text{TR} = \text{Q} + T)\gamma(\cdot)P(\cdot)$ (Table 5). Detection probabilities were constant within and among years, and equal between study areas. The probability of detecting a spotted owl pair on any 1 visit was 0.46 (95% CI = 0.39–0.53). The probability of initial occupancy was similar between study areas and was 0.46 (95% CI = 0.30–0.62) in 2003 at all 3 study areas. Colonization probabilities were also similar among study areas and constant over time. The probability that an unoccupied territory would be colonized the subsequent year was 0.15 (95% CI = 0.07–0.26). Extinction probabilities were greater at the Biscuit burn ($\hat{\beta} = 5.58$, 95% CI = 1.25–9.91) than the Quartz and Timbered Rock burns and increased from 2004 to 2006 ($\hat{\beta} = 2.96$, 95% CI = 0.97–4.94) at all 3 study areas. Extinction probabilities at the Quartz and Timbered Rock burns increased from 2004 to 2006 (0.11, 95% CI = 0.03–0.36; 0.72, 95% CI = 0.41–0.90, respectively). In contrast, extinction probabilities increased from 0.37 (95% CI = 0.11–0.73) in 2004 to 0.92 (95% CI = 0.58–0.99) in 2006 at the Biscuit burn. Based on the point estimates, extinction probabilities have increased dramatically for all areas (11–92%).

We modeled individual covariates as an additive effect with the best study area and temporal effects model (Table 5) to determine the spatial scale (core or territory) and relationship (linear or log-linear) that best described the effect of the covariate on initial occupancy, extinction, and colonization parameters (Table 6). In most cases, the models for alternative spatial scales and relationships were competitive (i.e., $\Delta AIC_c < 2.0$) with the best model for each covariate; however, our objective was to reduce redundancy between models and reduce the number of models in the final step of our

Table 5. Model selection results for initial occupancy (Ψ), extinction (ε), colonization (γ), and detection (*P*) probability models in the analysis of site occupancy of northern spotted owls without site-specific covariates at the Biscuit (BIS), Quartz (Q), and Timbered Rock (TR) burns in southwest Oregon, USA, from 2003 to 2006. We presented only models with an Akaike weight ≥0.05. We considered models that compared differences between study areas (area) and no differences between areas (·), and we considered several biologically plausible temporal effects including constant rates among years (·), variable rates among years (*t*), and linear (*T*), log-linear (ln *T*), and quadratic (*TT*) trends over time.

Model	AIC_c[a]	ΔAIC_c[b]	w_i[c]	*K*[d]	Deviance
Extinction—ε					
Ψ(·)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)	476.93	0.00	0.28	6	464.38
Ψ(·)ε(*T*)γ(·)*P*(·, ·)	477.79	0.86	0.18	5	467.39
Ψ(·)ε(BIS ≠ TR = Q + ln *T*)γ(·)*P*(·, ·)	477.94	1.01	0.17	6	465.39
Ψ(·)ε(ln *T*)γ(·)*P*(·, ·)	478.65	1.72	0.12	5	468.26
Ψ(·)ε(*t*)γ(·)*P*(·, ·)	479.35	2.42	0.08	6	466.80
Ψ(·)ε(*TT*)γ(·)*P*(·, ·)	479.35	2.42	0.08	6	466.80
Ψ(·)ε(area + *t*)γ(·)*P*(·, ·)	480.17	3.24	0.05	8	463.21
Colonization—γ					
Ψ(·)ε(area × *t*)γ(·)*P*(·, ·)	482.39	0.00	0.70	10	460.91
Ψ(·)ε(area × *t*)γ(BIS ≠ TR = Q)*P*(·, ·)	487.41	5.02	0.06	13	458.90
Initial occupancy—Ψ					
Ψ(·)ε(area × *t*)γ(area × *t*)*P*(·, ·)	499.61	0.00	0.44	20	453.52
Ψ(BIS ≠ TR = Q)ε(area × *t*)γ(area × *t*)*P*(·, ·)	501.12	1.51	0.21	21	452.37
Ψ(BIS = Q ≠ TR)ε(area × *t*)γ(area × *t*)*P*(·, ·)	501.50	1.89	0.17	21	452.75
Ψ(BIS = TR ≠ Q)ε(area × *t*)γ(area × *t*)*P*(·, ·)	502.27	2.66	0.12	21	453.52
Ψ(area)ε(area × *t*)γ(area × *t*)*P*(·, ·)	503.70	4.09	0.06	22	452.26
Detection probability—*P*[e]					
Ψ(area)ε(area × *t*)γ(area × *t*)*P*(·, ·)	503.70	0.00	0.52	22	452.26
Ψ(area)ε(area × *t*)γ(area × *t*)*P*(ln *T*, ·)	506.28	2.58	0.14	23	452.11
Ψ(area)ε(area × *t*)γ(area × *t*)*P*(*T*, ·)	506.44	2.74	0.13	23	452.26
Ψ(area)ε(area × *t*)γ(area × *t*)*P*(*TT*, ·)	506.51	2.81	0.13	23	452.33
Ψ(area)ε(area × *t*)γ(area × *t*)*P*(year, ·)	507.56	3.86	0.08	25	447.79

[a] Akaike's Information Criterion corrected for small sample sizes.
[b] The difference between the model listed and the best AIC_c model.
[c] Akaike weight.
[d] No. parameters in model.
[e] Detection probability modeling notation is *P* (among year detection, within year detection).

analysis. As a result, we did not consider competing models and assumed the highest ranked model best described the relationship of the covariate on each occupancy parameter. After determining the best spatial scale and relationship of each covariate, we looked for correlations between variables that were included in the same model. None of the variables that were included in the same model were highly correlated ($r^2 < 0.31$ in all contrasts). Consequently, we did not exclude any variables from our candidate model set because of colinearity (Table 3).

Fire severity and habitat effects.—The best model that described the relationship between site occupancy and fire severity, salvage logging, and habitat covariates at the Biscuit, Quartz, and Timbered Rock burns from 2003 to 2006 indicated that initial occupancy was best predicted by intermediate-aged and older forest that burned with a moderate severity at the core scale and amount of edge at the core scale. Extinction was best predicted by early seral stands that burned with high severity or were salvage logged at the core scale and amount of edge at the territory scale with extinction rates differing across time and at Biscuit sites. Colonization was best predicted by intermediate-aged older forests with low and moderate burn severity at the core scale and detection was constant across variables (Table 6). One model was within 2.0 AIC_c units of the best model for extinction probability (Table 6). However, this model was a slight variation of the best model and did not include the covariate representing edge at the territory scale, so it was not considered further because the amount of edge at the territory scale improved model fit. No models competed with the best initial occupancy and colonization probability models (Table 6). The best overall covariate model ranked substantially higher ($\Delta AIC_c = 27.12$) than the model that only included study area and temporal effects (Table 6). This indicated that the covariates used in this model explained some of the variability observed in post-fire site occupancy by spotted owls at the Biscuit, Quartz, and Timbered Rock burns.

Our best initial occupancy model included variables for the amount of low severity burn and edge (km) within the core use area (Table 6). The confidence intervals of the beta coefficients for the amount of low severity burn within the core area ($\hat{\beta} = 0.52$, 95% CI = −0.22 to 1.26) and the amount of edge (km) in the core area ($\hat{\beta} = -0.42$, 95% CI = −0.92 to 0.10) broadly overlapped zero, which indicated that neither of these variables influenced initial occupancy probabilities. Extinction probabilities increased as the combined area that was previously harvested, burned with a high severity, or salvage logged increased ($\hat{\beta} = 1.88$, 95% CI = 0.10–3.66; Fig. 3a). We found some evidence that the amount of edge (km) within a territory had a positive effect on extinction probabilities as the 95% confidence intervals overlapped 0 slightly ($\hat{\beta} = 0.18$, 95% CI = −0.01 to 0.37; Fig. 3b). We found weak support that colonization proba-

Table 6. Initial occupancy (Ψ), extinction (ε), and colonization (γ) models in the analysis of covariate effects on site occupancy of northern spotted owls at the Biscuit (BIS), Quartz (Q), and Timbered Rock (TR) burns in southwest Oregon, USA, from 2003 to 2006. We presented only models with an Akaike weight ≥0.05. For all initial occupancy, extinction, and colonization models the best detection probability model was constant detection among and within years (*P*(·, ·)).

Model[a]	AIC_c[b]	ΔAIC_c[c]	w_i[d]	*K*[e]	Deviance
Best overall model					
Ψ(ln LOWc + EDGEc)ε(BIS ≠ TR = Q + *T* + ln EARHISALVc + EDGEt)γ(INTLc + INTMc + OLDLc + OLDMt)*P*(·, ·)	449.81	0.00	1.00	14	418.89
Ψ(·)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)—Base model	476.93	27.12	0.00	6	464.38
Initial occupancy—Ψ					
Ψ(ln LOWc + EDGEc)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)	473.78	0.00	0.36	8	456.82
Ψ(ln LOWc)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)	476.01	2.22	0.12	7	461.27
Ψ(INTLc + OLDLc)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)	476.09	2.30	0.12	8	459.13
Ψ(RFc + ln NRFc)ε(BIS ≠ TR = Q + *T*) γ(·)*P*(·, ·)	476.43	2.65	0.10	8	459.47
Ψ(·)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)—Base model	476.93	3.15	0.08	6	464.38
Ψ(INTLc + INTMt + OLDLc + OLDMt)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)	477.43	3.65	0.06	10	455.94
Ψ(OLDLc)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)	477.64	3.85	0.05	7	462.89
Ψ(ln NRFc)ε(BIS ≠ TR = Q + *T*)γ(·)*P*(·, ·)	477.88	4.09	0.05	7	463.14
Extinction—ε					
Ψ(·)ε(BIS ≠ TR = Q + *T* + ln EARHISALVc + EDGEt)γ(·)*P*(·, ·)	464.61	0.00	0.60	8	447.65
Ψ(·)ε(BIS ≠ TR = Q + *T* + ln EARHISALVc)γ(·)*P*(·, ·)	466.50	1.89	0.23	7	451.76
Ψ(·)ε(BIS ≠ TR = Q + *T* + ln HARVESTc + HIGHc)γ(·)*P*(·, ·)	469.49	4.88	0.05	8	452.53
Ψ(·)ε(BIS ≠ TR = Q + *T* + ln EARLYc + HISALVc)γ(·)*P*(·, ·)	469.73	5.12	0.05	8	452.77
Colonization—γ					
Ψ(·)ε(BIS ≠ TR = Q + *T*)γ(INTLc + INTMc + OLDLc + OLDMt)*P*(·, ·)	462.72	0.00	0.65	10	441.24
Ψ(·)ε(BIS ≠ TR = Q + *T*)γ(INTLc + INTMc + OLDLc + OLDMt + ln EDGEc)*P*(·, ·)	464.93	2.21	0.22	11	441.14
Ψ(·)ε(BIS ≠ TR = Q + *T*)γ(OLDLc + OLDMt)*P*(·, ·)	467.27	4.54	0.07	8	450.31

[a] Variables preceded by ln were modeled using a log-linear relationship, variables followed by a c were modeled at the core area scale, and variables followed by *t* were modeled at the territory scale. INTL, intermediate-aged forest that burned with a low severity; INTM, intermediate-aged forest that burned with a moderate severity; OLDL, older forest that burned with a low severity; OLDM, older forest that burned with a moderate severity; LOW, intermediate-aged and older forest that burned with a low severity (combined area of INTL and OLDL); MOD, intermediate-aged and older forest that burned with a moderate severity (combined area of INTM and OLDM); EDGE, the interface between forested areas that burned with low or moderate severity and areas that were early seral stands, burned with high severity, or were salvage logged; EDGE was modeled as an additive effect with the best-ranked covariate model to determine if it improved model fit; EARLY, non-forested areas early seral stands that burned with any severity; HIGH, the combined area of intermediate-aged and older forest that burned with a high severity; SALVAGE, any intermediate-aged or older forest that was salvage logged; HARVEST, any forested area that was harvested before or after the burn (combined area of EARLY and SALVAGE); HISALV, any forested area, excluding early stands, that burned with a high severity or was salvage logged (combined area of HIGH and SALVAGE); EARHISALV, any early seral stand or forested area that burned with high severity or that was salvage logged (combined area of EARLY, HIGH, and SALVAGE); RF, intermediate-aged forest that burned with a low or moderate severity (combined area of INTL and INTM); NRF, older forest that burned with a low or moderate severity (combined area of OLDL and OLDM); *T*, linear time.
[b] Akaike's Information Criterion corrected for small sample sizes.
[c] The difference between the model listed and the best AIC_c model.
[d] Akaike weight.
[e] No. parameters in model.

bilities increased as the amount of intermediate-aged forest that burned with a low severity within the core area increased ($\hat{\beta} = 0.10$, 95% CI = −0.01 to 0.38; Fig. 4a) as the amount of older forest that burned with a low severity within the core area increased ($\hat{\beta} = 0.10$, 95% CI = −0.01 to 0.22; Fig. 4b), and as the amount of older forest that burned with a moderate severity within the territory increased ($\hat{\beta} = 0.82$, 95% CI = −0.05–1.69; Fig. 4c). We found no evidence that colonization probabilities were associated with the amount of intermediate-aged forest that burned with a moderate severity within the core area ($\hat{\beta} = -1.20$, 95% CI = −3.21 to 0.80).

DISCUSSION

Comparison of the South Cascades to Timbered Rock

As predicted, the Timbered Rock and South Cascades study areas had relatively similar trends in site occupancy prior to the Timbered Rock burn. However, extinction probabilities increased at Timbered Rock following wildfire and subsequent salvage logging, which combined with the lesser colonization rates at Timbered Rock contributed to greater declines in site occupancy than were observed in recently unburned landscapes at the South Cascades (Fig. 2). The Timbered Rock study area had an approximately 64% reduction in site occupancy following wildfire, whereas the South Cascades study area had a roughly 25% reduction in site occupancy during the same time period. This supported our prediction that occupancy rates in burned and salvage logged landscapes would decline at a greater rate than unburned landscapes. Our results contrast with those of previous studies that compared occupancy rates of spotted owls in burned and unburned landscapes. Jenness et al. (2004) found that territory occupancy of Mexican spotted owls in burned areas was similar to unburned areas. Roberts et al. (2011) found that site occupancy of California spotted owls in randomly selected burned and unburned areas were similar. Neither of these studies was affected by the high degree of salvage logging we observed following the Timbered Rock

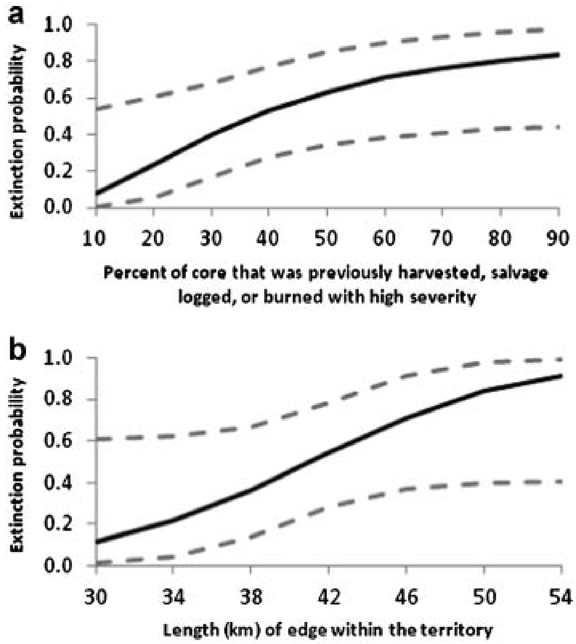

Figure 3. The estimated effects of the percent of (a) forested area that burned with a high severity or was previously harvested or salvage logged and (b) forest edge on extinction probabilities of northern spotted owls at the Biscuit, Quartz, and Timbered Rock burns in southwest Oregon, USA from 2003 to 2006. The 95% confidence intervals for the estimated effects are represented by gray, dashed lines. The median values of the additional covariates in the model were held constant while varying the covariate of interest over the observed range of values.

burn, which may explain the difference between our results and those of previous studies.

The approximately 25% reduction in site occupancy at the South Cascades from 2002 to 2006 was somewhat surprising given that the study area did not have any large scale disturbances during this time. However, several spotted owl populations have been declining throughout the subspecies' range (Anthony et al. 2006, Forsman et al. 2011), and declines in site occupancy at the South Cascades could be related to ongoing population declines that are unrelated to natural disturbances. Dugger et al. (2011) found that barred owls (*Strix varia*) had negative impacts on site occupancy by spotted owls by decreasing colonization rates and increasing extinction rates. This likely explains much of the nearly 25% decline in site occupancy we observed from 2002 to 2006 at the South Cascades. The 64% reduction in site occupancy at Timbered Rock from 2002 to 2006 was substantially greater than the roughly 25% decline observed at South Cascades, which suggests that wildfire, subsequent salvage logging, and past timber harvest contributed to the greater declines in site occupancy at Timbered Rock. We estimated that following the Timbered Rock burn only 46% of the area within 2,230 m of spotted owl territories were intermediate-aged or older forests that burned with a low or moderate severity (Table 1). This amount of habitat is marginal for successful reproduction (Bart and Forsman 1992) and may cause decreases in survival rates of the subspecies (Franklin et al. 2000, Dugger et al. 2005).

The large declines in site occupancy following the Timbered Rock burn are most likely explained by dispersal

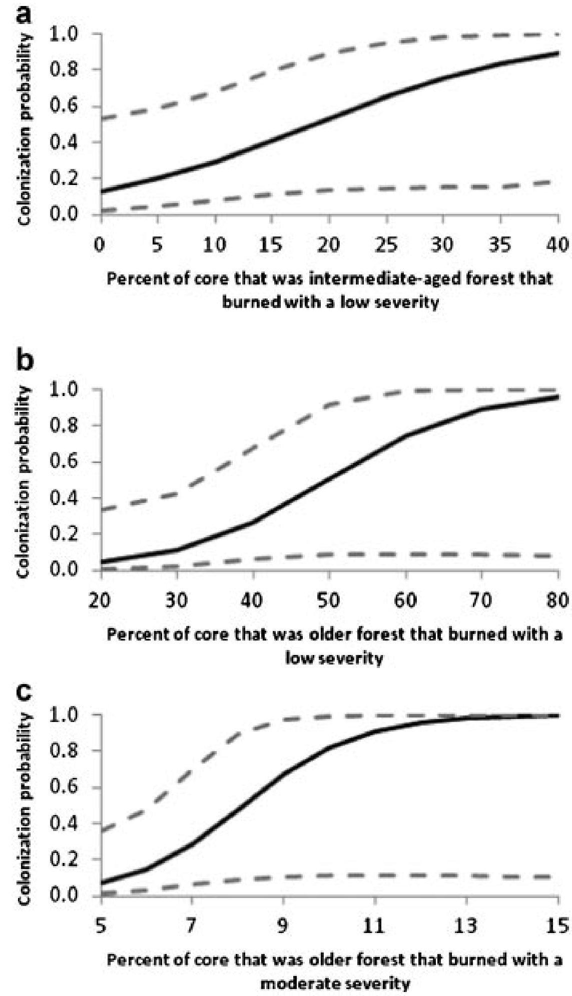

Figure 4. The estimated effects of the percent of (a) intermediate-aged forest that burned with a low severity, (b) older forest that burned with a low severity, and (c) older forests that burned with a moderate severity on colonization probabilities of northern spotted owls at the Biscuit, Quartz, and Timbered Rock burns in southwest Oregon, USA from 2003 to 2006. The 95% confidence intervals for the estimated effects are represented by gray, dashed lines. The median values of the additional covariates in the model were held constant while varying the covariate of interest over the observed range of values.

out of the burn (i.e., emigration) and decreased survival of spotted owls. Several color-banded, adult spotted owls at the Timbered Rock burn (2 pairs and 1 individual, 25% of the known pre-fire population) dispersed to an unburned territory adjacent to the burn, 1–2 years post-fire (OCFWRU, unpublished data). Adult dispersal is a relatively rare occurrence in spotted owls throughout their range (Forsman et al. 2002: 5%, Zimmerman et al. 2007: 2%); however, owl territories may be abandoned when large amounts of mature and older forest are lost (Bart and Forsman 1992, Bart 1995). We believe that the relatively high rate of adult dispersal following the Timbered Rock burn suggests that insufficient habitat remained at abandoned territories to support a spotted owl pair. In addition, radio-marked spotted owls that maintained a territory within the Timbered Rock burn had lower survival rates ($\hat{S} = 0.69 \pm 0.12$; Clark et al. 2011) than reported throughout the subspecies' range ($\hat{\Phi} = 0.75$ to

0.91 ± 0.01 to 0.05; Anthony et al. 2006). Annual survival of spotted owls was positively associated with greater amounts of older forest within their home ranges or core use areas in other studies (Franklin et al. 2000, Olson et al. 2004, Blakesley et al. 2005, Dugger et al. 2005). High severity wildfire and salvage logging removed and modified 26% of the intermediate-aged and older forests within 2,230 m of spotted owl territories at the Timbered Rock burn, and 28% of the remaining area was previously harvested (i.e., early seral forest; Table 1). Consequently, the large degree of habitat loss and modification from past timber harvest, high severity fire, and salvage logging following the Timbered Rock burn likely contributed to the high levels of dispersal out of the burn, decreased survival rates and subsequent declines in site occupancy that we observed. These declines in site occupancy appear to have continued past the conclusion of our study because no spotted owls were detected during surveys conducted during the 2011 breeding season at the Timbered Rock study site (OCFWRU, unpublished data).

Increased extinction rates following the Timbered Rock burn may have been exacerbated by the checkerboard land ownership pattern of private and BLM lands (Richardson 1980). Private lands within the area of the Timbered Rock burn are managed as industrial forests and are frequently subjected to large-scale timber harvest, which creates large tracts of early seral forest. Following the Timbered Rock burn, much of the private land was salvage logged (17% of the study area), which created large clear-cuts throughout the landscape. Territory occupancy by spotted owls was negatively associated with increased areas of clear-cuts within the territory in another study (Thraillkill et al. 1998). Consequently, the large areas of clear-cuts created by salvage logging and past timber harvest (approx. 45% of the area within 2,230 m of spotted owl territories; Table 1) potentially exacerbated declines in site occupancy following the Timbered Rock burn or confounded the effects of wildfire. Declines in site occupancy may not be as large in burned areas that were not subjected to previous timber harvest or substantial amounts of post-fire salvage logging.

Relationship Between Wildfire, Salvage Logging, and Spotted Owl Site Occupancy

Extinction.—We predicted that occupancy of nesting territories by spotted owls after fires would decline because of increased extinction probabilities attributable to habitat loss and modification from past timber harvest, high severity fire and salvage logging. Our results supported this prediction because extinction probabilities increased as the combined area of high severity burns, salvage logging, and early seral forest increased (Fig. 3a; $\hat{\beta} = 1.88$, 95% CI = 0.10–3.66). This was the strongest relationship we observed in this analysis because it was the only habitat covariate where the 95% confidence interval for the regression coefficient did not overlap 0. Unfortunately, we were unable to separate the impacts of these 3 variables on extinction probabilities. When these 3 variables were included separately, the models were not competitive with the model that combined these variables into a single covariate (Table 6). This may indicate that we lacked the precision to separate the impacts of these 3 variables or they were confounded. However, our results suggest that these 3 variables work in concert and generate synergistic effects. Any 1 disturbance event may not generate negative effects on occupancy of territories, but the combined loss and modification of habitat from these 3 factors negatively affected spotted owls in our study. The combined influence of these 3 factors may reduce spotted owl habitat to such an extent that a threshold is passed and spotted owls are no longer able to occupy the territory.

Spotted owls are associated with late-successional forests (Forsman et al. 1984, Thomas et al. 1990), and their territories have greater amounts of older forests than surrounding landscapes (Ripple et al. 1991, 1997; Meyer et al. 1998; Swindle et al. 1999). Forest stands used by spotted owls have large proportions of downed woody debris and snags, high canopy cover, and high structural diversity (Hershey et al. 1998, North et al. 1999, Irwin et al. 2000). Timber harvest, salvage logging, and high severity fire remove or alter many of these structural characteristics associated with spotted owl habitat. As a result, we were not surprised that these factors were associated with increased extinction probabilities and declines in site occupancy. Spotted owls have high site fidelity (Forsman et al. 1984, 2002; Zimmerman et al. 2007), and survival rates are positively correlated with increased amounts of older forest in their territories (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005); consequently, owls that occupied territories with a large degree of past timber harvest, salvage logging, and high severity fire were likely forced to emigrate out of the burned area or risk decreased survival.

Radio-marked spotted owls at the Timbered Rock burn were located closer to edge habitats than at random (Clark 2007), which suggests edge habitat may provide a benefit to the subspecies. Spotted owls may prefer to forage in habitat edges because of greater densities of some prey in early seral forests (Carey and Peeler 1995, Franklin and Gutiérrez 2002), particularly woodrats in southwest Oregon and northwest California (Zabel et al. 1995, Ward et al. 1998). Our results provided some evidence that extinction probabilities increased as the amount (km) of edge increased within nesting territories increased (Fig. 3b; $\hat{\beta} = 0.18$, 95% CI = −0.01–0.37), suggesting a negative impact of edge habitat on spotted owl territory occupancy. In our analysis, edge represented a metric of habitat fragmentation. Dugger et al. (2011) observed greater colonization probabilities at spotted owl territories when older forest was less fragmented, and our results were similar. Franklin et al. (2000) indicated that spotted owls are likely to have decreased survival at territories with reduced amounts of interior forest, suggesting that habitat fragmentation negatively affects spotted owls. The patchy nature of high severity fire and salvage logging created large amounts of edge habitat, which likely reduced the amount of interior forest available to owls and contributed to declines in site occupancy in our study. Furthermore, increases in edge may be correlated with increased amounts of nonhabitat (i.e., nonforested and early seral stands) and increases in nonhabitat have contributed to declines in territory occupancy of California spotted owls (Blakesley et al. 2005) and increases in extinction probabilities in this study. Despite indications that spotted owls are negatively affected by habitat fragmentation, the mechanism of these effects is not well understood (Franklin and Gutiérrez 2002). We calculated the amount of edge as the interface between intermediate-aged and older forests that burned with a low or moderate severity and all other habitat types (Table 2). This classification of edge habitat delineated distinct boundaries between stands of larger living trees and high severity burns or early seral stands. Additional types of edge habitats exist at the interface between intermediate-aged and older forests or the interface between low and moderate severity burns, and these types of edges may provide foraging habitat for spotted owls. Additional research between the association of various edge habitats on spotted owl demography and site occupancy is needed to clarify this relationship.

Colonization.—Overall, our estimated effects of habitat covariates on colonization probabilities were relatively imprecise. We attributed this lack of precision to the fact that we observed only 6 colonization events at our 3 study areas from 2003 to 2006. Despite the fact that we observed relatively few colonization events, we were still able to document several biologically meaningful associations between post-fire habitat and colonization probabilities. We suspect that if additional colonization events had occurred during the course of our research, our estimated effects of habitat on colonization probabilities would be more precise.

We found some evidence that colonization probabilities in our study were positively associated with increased amounts of older forest that burned with a low severity within the core area (Fig. 4b; $\hat{\beta} = 0.10$, 95% CI $= -0.01$ to 0.22). Although this estimated effect had weak support, this finding was expected and follows the well documented association between spotted owls and older forest (Forsman et al. 1984, Thomas et al. 1990). Furthermore, previous research indicated that territory occupancy of California spotted owls was positively associated with older forest (Blakesley et al. 2005), extinction probabilities at northern spotted owl territories were greater at territories with lesser amounts older forest (Dugger et al. 2011) and site occupancy by California spotted owls in areas that primarily burned with a low and moderate severity was similar to unburned areas (Roberts et al. 2011). Older forests that burned with a low severity are likely the highest quality spotted owl habitat in post-fire landscapes. These areas likely retained much of the canopy cover, downed woody debris, snags, and structural diversity that is selected by spotted owls (Hershey et al. 1998, North et al. 1999, Irwin et al. 2000). As a result, unoccupied territories that have high quality habitat (i.e., older forest that burned with a low severity) will have the greatest probability of being colonized by spotted owls. Within the Timbered Rock burn, radio-marked spotted owls strongly selected for older forest that burned with a low severity (Clark 2007), further demonstrating the influence of this habitat on spotted owls in post-fire landscapes.

Moderate severity burns likely remove and modify more of the forest stand features selected by spotted owls than low severity burns, yet many critical habitat features are likely retained and allow moderately burned areas to provide habitat for spotted owls following wildfire. Our analysis provided weak support that colonization probabilities were positively associated with increased amounts of older forest that burned with a moderate severity (Fig. 4c; $\hat{\beta} = 0.82$, 95% CI $= -0.05$ to 1.69). In addition to potentially providing many of the critical habitat features of forest stands that burned with a low severity, moderately burned stands likely have decreased risk of stand-replacement in the future because of removal of ladder fuels (Agee 1993), which likely increases the resilience of the forest stand to future disturbance. Spotted owls have been shown to disproportionately forage in habitats that have high levels of prey abundance (Carey et al. 1992, Carey and Peeler 1995, Zabel et al. 1995). Moderate severity burns may increase habitat heterogeneity and prey abundance, similar to the effects of heterogeneous thinning of young forest stands (Carey 2001). However, we did not test this hypothesis, and the potential benefits of moderate severity burns in older forests for spotted owls are unclear.

Previous studies have suggested a quadratic relationship between survival and reproduction of spotted owls and the amount of older forest surrounding nesting territories (Franklin et al. 2000, Olson et al. 2004). These studies suggest that territories that are not entirely comprised of older forests are beneficial to spotted owls and that spotted owls may be adapted to natural disturbances such as wildfire that create a mosaic of forest conditions. Our results provided weak support for this hypothesis because owl territories in our study that had increased amounts of intermediate-aged forest that burned with a low severity have a greater probability of being colonized by a pair of owls (Fig. 4a; $\hat{\beta} = 0.10$, 95% CI $= -0.01$ to 0.38). However, we expect a threshold exists in this relationship because spotted owls are associated with older forest (Forsman et al. 1984, Thomas et al. 1990) and spotted owls that occupy territories with insufficient amounts of older forest will have decreased survival and reproductive rates (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005). The amount of intermediate-aged forest that burned with a low severity at any 1 owl territory in our study ranged from 0 to 38%. Territories that have insufficient amounts of older forest will likely not be occupied by spotted owls, but our results provided some evidence of a benefit of habitat heterogeneity for spotted owls.

Initial occupancy.—We were unable to identify any relationships between initial occupancy probabilities and the habitat covariates that we considered in our analysis. Our best model for initial occupancy probabilities (Table 6) included variables for the amount of the core area that burned with a low severity ($\hat{\beta} = 0.52$, 95% CI $= -0.22$ to 1.26) and the amount of edge habitat ($\hat{\beta} = -0.42$, 95% CI $= -0.92$ to 0.10); however, both of these estimates were imprecise and the 95% confidence intervals broadly overlapped zero, which suggested these relationships were not meaningful. Since these relationships were not supported by the data, additional research is needed to investigate the influence of low severity fire and edge habitat on spotted owl site occupancy.

Our analysis of site occupancy at the Biscuit, Quartz, and Timbered Rock burns indentified several meaningful relationships between site occupancy and amount of post-fire habitat. All of these relationships were based on biologically plausible hypotheses and have implications for spotted owl management. However, the relationships we observed were based on small sample sizes, non-random samples at the Biscuit burn, and our estimated relationships were often imprecise. Furthermore, our study was opportunistic and observational, which prevents us from assigning cause and effect relationships. Consequently, we suggest a cautionary approach when applying our findings to future land management decisions. In particular, the relationships we observed in our analysis may not be applicable to spotted owls in post-fire landscapes that are not affected by post-fire salvage logging.

Both wildfire and barred owls have been identified as threats to the persistence of spotted owls (USFWS 2011). Barred owls have expanded throughout the entire range of the northern spotted owl (Dark et al. 1998, Pearson and Livezey 2003) and are negatively affecting spotted owls (Kelly et al. 2003, Olson et al. 2005, Dugger et al. 2011). Furthermore, barred owls have a more generalized diet (Hamer et al. 2001, Wiens 2012) and use a wider range of habitats (Hamer et al. 2007) than spotted owls, which suggests that barred owls may be better adapted to persist in burned landscapes. We only detected 2 barred owls at the Biscuit, Quartz, and Timbered Rock burns during demographic surveys conducted between 2003 and 2006, so we believe that barred owls had little to no effect on our results.

Jointly, our analyses suggest that site occupancy by spotted owls in burned landscapes is likely to decline, at least in the short-term. These declines in site occupancy are driven by large increases in extinction probabilities in post-fire landscapes and are attributable to past timber harvest, high severity fire, and salvage logging. Although territories that had increased amounts of older forest that burned with a low severity had the greatest colonization probabilities, we only observed 6 colonization events at our 3 study areas from 2003 to 2006, and this level of colonization was insufficient to offset the high extinction probabilities we observed. This suggests that insufficient habitat remained at many of the spotted owls territories included in our analyses to support a pair of spotted owls following wildfire. Site occupancy by Mexican and California spotted owls in landscapes that burned primarily with low or moderate severities was similar to unburned landscapes (Jenness et al. 2004, Roberts et al. 2011), which suggests that spotted owls may be able to persist in burned landscapes. These findings contrast our results, which suggested that spotted owl site occupancy will decline in burned landscapes; however, our results were confounded by the effects of past timber harvest and salvage logging. Additional research in post-fire landscapes that have not been impacted by past timber harvest and salvage logging are needed to help clarify these relationships.

MANAGEMENT IMPLICATIONS

We identified several factors that influenced occupancy of nesting territories by spotted owls in post-fire landscapes; however, the strongest association we observed was that site occupancy declined because of increased extinction probabilities. Increased amounts of past timber harvest, salvage logging, and high severity burns jointly contributed to increased extinction probabilities and subsequent declines in spotted owl site occupancy. Past timber harvest negatively influenced site occupancy in our analysis, so we recommend increased protection of older forest in dry forest ecosystems to prevent future habitat loss to timber harvest and mitigate potential losses of older forest to stand-replacing fire and subsequent salvage logging. High severity fire was 1 of 3 factors that combined to increase local-extinction probabilities of spotted owls in our study; however, we were unable to separate the impacts of wildfire from land management activities. As a result, we recommend future research to clarify the relationship between high severity fire and spotted owl site occupancy in the absence of past timber harvest and salvage logging. We believe that widespread, stand-replacing wildfires will negatively affect site occupancy by spotted owls, so we suggest efforts should be made to reduce the risk of widespread, stand-replacing wildfire in spotted owl habitat. However, a precautionary approach should be taken when implementing fuel reduction techniques that will reduce that risk of stand-replacing wildfire. Research is needed to ensure that fuel reduction techniques, particularly commercial or non-commercial thinning, are not detrimental to spotted owls, their habitat, or prey before fuel reduction techniques are implemented on a large scale. Our results also indicated a negative impact of salvage logging on site occupancy by spotted owls. We recommend restricting salvage logging after fires on public lands within 2.2 km of spotted owl territories (the median home range size in this portion of the spotted owl's range) to limit the negative impacts of salvage logging. Our results indicated a negative response of spotted owls to wildfire in the short-term, but the response is likely to vary over time; however, little is known about the long-term response of spotted owls to wildfire. As a result, long-term monitoring studies should be implemented in post-fire landscapes to determine the response of spotted owls to wildfire over time.

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Experimental Removal of Barred Owls to Benefit Threatened Northern Spotted Owls

Final
Environmental Impact Statement

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Executive Summary

This Final Environmental Impact Statement (Final EIS) describes and evaluates nine alternatives for an experimental removal of northern barred owls (*Strix varia varia*) (barred owl) on a scale sufficient to determine if the removal would increase northern spotted owl (*Strix occidentalis caurina*) (spotted owl) site occupancy and improve population trends. Results from these experiments would be used by the U.S. Fish and Wildlife Service (Service) to inform future decisions on potential long-term management strategies for barred owls.

S.1 Background

The purpose of the proposed action is to conduct research on the effects on spotted owls of the removal of barred owls. This research would require we obtain a permit under the Migratory Bird Treaty Act for scientific collection of barred owls, a Federal action. As a component of the issuance of that permit we are conducting a National Environmental Policy Act (NEPA) review. Because of the scope and controversy over the potential removal of a number of barred owls from the wild, we developed this Final EIS. We are also conducting a consultation under section 7 of the Endangered Species Act (ESA). Depending on the study area and land management agency involved, the experiment may require additional Federal and State permits. Any experiment on National Parks or Recreation Areas would require a research permit. Study areas on National Forests may require a special use permit. This Final EIS may serve as the NEPA documentation for issuance of these permits.

In the most recent review of the condition of northern spotted owls, the Revised Recovery Plan for the Northern Spotted Owl (Revised Recovery Plan) (USFWS 2011, entire) identified past habitat loss, current habitat loss, and competition from the recently arrived barred owls as the most pressing threats to the northern spotted owl (USFWS 2011, p. I-6.).

The Revised Recovery Plan states, "Barred owls reportedly have reduced spotted owl site occupancy, reproduction, and survival. Limited experimental evidence, correlational studies, and copious anecdotal information all strongly suggest barred owls compete with spotted owls for nesting sites, roosting sites, and food, and possibly predate spotted owls…. Because the abundance of barred owls continues to increase, the effectiveness in addressing this threat depends on action as soon as possible" (USFWS 2011, p. III-62).

Barred owls are native to eastern North America, but only recently arrived in the West. They were first documented in the range of the northern spotted owl in Canada in 1959 and in western Washington in 1973. The range of the barred owl in the western United States now completely overlaps with the range of the northern spotted owl. We observe that as the number of barred owls detected in historical spotted owl territories increase, the number of spotted owls decrease. In the Pacific Northwest, barred owl populations developed first in Washington and spotted owl populations have declined at the greatest rate in these areas.

Although northern spotted owl populations have been declining for many years, the presence of barred owls exacerbates the decline. Recent studies (Olson *et al*. 2005, p. 918; Forsman *et al*. 2011a, pp. 69-70, 75-76) have established negative relationships between barred owl presence and declines in spotted owl population performance across the range of the subspecies. This could result in the extirpation (local extinction) or near extirpation of the northern spotted owl from a substantial portion of their historical range, even if other known threats, such as habitat loss, continue to be addressed. Given the continuing range expansion and population growth of barred owl populations in the western United States and concurrent decline in northern spotted owl populations, information on the effectiveness of a removal program is urgently needed.

Recovery Action 29 in the Revised Recovery Plan focuses on acquiring the information necessary to help identify effective management approaches and guide the implementation of appropriate management strategies for barred owls. It proposes experimental removal of barred owls to determine if the removal would increase spotted owl site occupancy and improve population trends (USFWS 2011, pp. III-62, III-65).

> *"Recovery Action 29: Design and implement large-scale control [removal] experiments to assess the effects of barred owl removal on spotted owl site occupancy, reproduction, and survival.*

While the evidence of threat is strong and very persuasive, it is not yet sufficient for the Service to consider undertaking a wider removal effort. We need data on the effectiveness of barred owl removal in improving spotted owl population trends, as well as the efficiency of removal as a management tool. Conducting this experiment would allow us to develop a better understanding of the impacts barred owls are having on spotted owl populations. It would also allow us to determine our ability to reduce barred owl populations at a landscape level to permit spotted owl population growth. Finally, it would allow us to estimate the cost of barred owl removal.

This Final EIS is specific to implementation of Recovery Action 29—implementation of large-scale removal experiments to assess the effects of barred owl removal on spotted owl populations. This Final EIS is limited to addressing this portion of the barred owl threat, the removal experiment. The Service anticipates using the information from this experiment to assist with future barred owl management decisions. We have no specific direction for future management at this time, nor would the results of this experiment trigger any automatic actions. Future decisions could range from no active management of barred owls to a mix of strategies, including barred owl removal, other methods to reduce barred owl populations, or methods to change the competitive advantage of barred owls. Even if removal of barred owls is chosen as a component of barred owl management, this could range from small removal efforts in specific areas and over short time frames to landscape-level removal efforts for long periods, periodic removal programs, or other actions as yet not described. If a decision is made to manage barred owl populations in the future, implementation would be preceded by completion of any necessary legal requirements and NEPA compliance.

S.2 Purpose of and Need for the Action

The purpose of the proposed action is to contribute to fulfilling the intent of the Act by rapidly implementing experimental research necessary for conservation of the spotted owl in accordance with Recovery Action 29 of the Recovery Plan (USFWS 2011, p. III-65). More specifically, the purpose of the proposed action is to: (1) obtain information regarding the effects of barred owls on spotted owl vital rates of occupancy, survival, reproduction, and population trend through experimental removal; (2) determine the feasibility of removing barred owls from an area and the amount of effort required to maintain reduced barred owl population levels for the duration of the experiment; (3) estimate the cost of barred owl removal in different forested landscapes; and (4) develop the information necessary to make a future decision about the management of barred owls as expeditiously as possible.

The need for the action is that we lack desired information to: (1) determine the response of spotted owl site occupancy, survival, reproduction, and population trend to barred owl removal; (2) evaluate whether barred owls can be effectively removed from an area and level of ongoing removal required to maintain low population levels of barred owls; (3) determine the cost of removal in different types of forested landscapes to inform future management decisions; and (4) inform timely decisions on whether to move forward with future barred owl management.

S.3 Description of the Proposed Action

The proposed action is to conduct an experiment to provide scientifically rigorous results regarding the effects of barred owls on the spotted owl vital rates of occupancy, survival, reproduction, and population trend through experimental removal, and determine the feasibility of experimental removal of barred owls.

All action alternatives include the same experimental approach. Each study area is divided into two comparable portions; barred owls are removed from the treatment area and left in the control area. All areas are surveyed for spotted and barred owls. Spotted owl population data is compared between the control and treatment areas to determine if removal of barred owls in the treatment area resulted in a significant change in spotted owl population dynamics.

Potential study areas were selected from across the range of the northern spotted owl in Washington, Oregon, and California, and may include ongoing spotted owl demographic study areas, inactive spotted owl demographic study areas, or additional areas with varying levels of past spotted owl surveys. Most study areas are focused on Federal lands, including areas within National Forests, Bureau of Land Management managed lands, and National Parks and Recreation Areas (North Cascades National Park, Ross Lake National Recreation Area, Lake Chelan National Recreation Area, Olympic National Park, and Mount Rainier National Park). Some wilderness areas may be included. We are also considering a study area on the Hoopa Valley Indian Reservation. In some cases, interspersed private and State lands may occur within the boundaries of the study area. Where possible, we would seek cooperation from nonfederal landowners. Nonfederal lands would be included in the active experiment only if the landowners are willing.

The experiment will run until sufficient information is gathered to determine the effects of the removal of barred owls on spotted owl population trends. The experiment will begin as soon as possible, and results will be reviewed annually to determine when data are sufficient to answer the research questions. Removal activities will end when data are sufficient to meet the purpose and need. We set a maximum duration of 10 years of barred owl removal for the experiment. If the experiment has not provided enough information to reach a conclusion within 10 years, it is likely that removal of barred owls is not achieving the desired goal, thus other avenues should be considered and the experiment ended.

S.4 Considerations Used in Developing the Alternatives

S.4.1 Number of Study Areas

The alternatives range from 1 to 11 study areas. An experiment involving a single study area is logistically simpler to conduct, but would not fully represent the diversity of physical features, habitat types, barred owl density, and invasion history across the range of the northern spotted owl. Given that each study area represents a single experiment, a single study area does not provide for any replication, and results from a single study area may not be representative of effects of barred owl removal in other parts of the northern spotted owls' range. Multiple study areas have greater total costs and require more complicated logistics, but can better represent the range of conditions experienced by spotted owl populations, allowing better inferences across their range. Multiple areas also allow for replication of results. By providing alternatives with an array from 1 to 11 study areas, we can evaluate the costs and benefits of these different approaches.

S.4.2 Distribution of Study Areas

In alternatives with more than one study area, we selected from different portions of the northern spotted owl's range to best represent the variation in conditions across the range. We considered the following information:

- *History of barred owl presence.* Study areas in the north were invaded by barred owls earlier and have a longer history of barred owl site occupancy than areas in southern Oregon and northern California.
- *Current density of territorial barred owls.* Study areas in the north have generally higher densities of barred owls than study areas in southern Oregon and northern California, though this varies by study area.
- *Current density of territorial spotted owls.* Spotted owl population levels and site occupancy on study areas have declined substantially and are declining in northern Oregon. In southern Oregon and northern California, spotted owl populations and site occupancy are higher, but are declining on most study areas.

- *Different habitat types.* Spotted owl habitat varies across its range. There are large differences in habitat type between wet and dry forests (west to east) and between areas north and south of the Klamath Physiographic Province in Oregon.
- *Differences in spotted owl food habits.* North of the Klamath Physiographic Province in Oregon northern flying squirrels represent a primary food source for spotted owls. South of the Klamath Province the dusky-footed woodrat is a primary food source.

Based on these considerations, we divided the range of potential study areas into three basic regions: Washington, northern Oregon, and southern Oregon/northern California.

S.4.3 Type of Study

All experiments described in the alternatives are based on a treatment (removal) and control (non-removal) study design. Under this approach, study areas are divided into two comparable segments. Barred owls are removed from the treatment area but not from the control area. Spotted owl population parameters (e.g., site occupancy, demographic performance, population trend) are estimated using the same methodology in both areas and the population measurements are compared between the treatment and control areas.

Johnson *et al.* (2008, entire) described four basic study designs for barred owl removal experiments to evaluate potential effects on spotted owls: demographic studies, occupancy studies, site-specific studies, and invasion studies. We considered all of these approaches in developing the alternatives, and are proposing to utilize both a demographic and occupancy study approach.

DEMOGRAPHIC STUDY APPROACH. In demographic studies, individual spotted owls are banded with a uniquely numbered leg band and a uniquely colored leg band. Territories are surveyed every year in an effort to determine if the individual is still alive and present. Using this information, scientists can calculate survival and recruitment rates (the rate at which new individuals are added to the population). From this they can estimate the annual population growth rate of spotted owls on the study area (Forsman *et al.* 2011a, p. 8). Additionally, in most demographic studies data on the number of young fledged per year are recorded, allowing for examination of effects on spotted owl reproduction. A primary goal of this approach is to compare changes in population growth rates between treatment (removal) and control (non-removal) areas, with the untreated control areas used to distinguish population changes that might be occurring for other reasons.

A demographic experimental approach has several advantages. It allows us to estimate annual population growth rate for treatment and control areas and assess the effects of barred owl removal on spotted owl population trends. Because individual spotted owls are tracked, we can measure the underlying vital rates (e.g., annual survival and recruitment of new individuals into the population) of the population and determine which of these are influenced by barred owl competition (Johnson *et al.* 2008, p. 19).

However, the demographic experimental approach has some limitations. It requires the capture, banding, and following of individual spotted owls, a relatively intensive method of data collection.

OCCUPANCY EXPERIMENTAL APPROACH. In occupancy studies, spotted owl sites are monitored rather than individual owls (individuals are not banded). Scientists use the presence or absence of spotted owl detections, based on auditory surveys, to determine whether sites are occupied or not. In its simplest form, we record only presence or absence of spotted owl detections, though we can choose to gather information on the number of young produced on each site. Presence/absence data can be used to estimate the rate of population change if the study area is surveyed consistently. This approach provides less information on how the barred owl removal changes the spotted owl population dynamics than the demographic approach; because we cannot determine which vital rate (annual survival or recruitment) has changed in response to barred owl removal. Because individual spotted owls are not banded or followed, we cannot tell if any observed change occurs because individuals are on average surviving longer, or because they are constantly replaced.

An occupancy experimental approach has several advantages. It is a relatively simple process, only requiring comparable surveys on the treatment (removal) and control (non-removal) portions of the experiment. There is no need to capture, band, or relocate individual owls. The occupancy experimental approach has some limitations. Data collected in an occupancy experiment can be used to provide estimates of site occupancy and potentially the rate of population change, but do not provide estimates of annual survival or recruitment. Therefore, we cannot identify which vital rates (survival or recruitment) are most affected by barred owl competition, and obtain less information about the biological mechanisms of interspecies competition than with demographic studies (Johnson *et al.* 2008, p. 19). The lack of banded or individually identified spotted owls delays our ability to detect sink population dynamics, situations where site occupancy is high because a series of individuals continue to occupy the site while the overall population declines. Site occupancy may remain high and the actual loss of birds go undetected until the source of non-territorial spotted owls to fill behind territorial spotted owls is exhausted. Because we intend to terminate the experiment once we have statistically significant data, we could miss the actual population decline altogether. Additionally, occupancy studies provide data and conclusions with a lower ability to detect differences (strength of inference) than the demographic approach, given that few study areas have pretreatment data.

All experimental approaches and action alternatives include the following three basic components:

- Survey spotted owls—survey the entire study area using spotted owl recorded calls and current demographic survey protocols. The data collected varies by type of experiment.
- Survey barred owls—survey the entire study area using barred owl recorded calls to define barred owl density and locate barred owl sites.
- Remove barred owls—using the process described below; remove all barred owls from the treatment area.

S.4.4 Removal Method

All experiments described in the alternatives would substantially reduce barred owl populations in portions of the proposed study areas through the removal of barred owls. All removal methods would avoid removing breeding barred owls with dependent young. There are two basic methods to remove barred owls: lethal and nonlethal.

LETHAL REMOVAL METHOD. We selected a procedure for lethal removal that is as humane and efficient as possible. It is designed to minimize the risk of accidental removal of other species, particularly northern spotted owls and other listed species. The procedure is designed to maximize the potential for specimens to be collected and used for other scientific purposes, within the constraints of a quick and humane death. The general approach involves attracting territorial barred owls with recorded calls and shooting birds that respond when they approach closely

NONLETHAL REMOVAL METHOD. As with lethal removal, we designed a nonlethal removal method that is as humane as reasonably possible and reduces stress on the birds. To accomplish the experiment, any barred owls captured must be removed completely from the study area. To avoid undue stress and problems with inadequate housing, we require that we have a destination ready to take the birds before any capture is attempted. The procedure minimizes the risk to other species, though this is less of an issue with capture as non-target species can be removed from the capture apparatus and released in most cases. The approach involves attracting territorial barred owls with a recorded call, and catching the responding birds in nets or other trapping devices. Birds would be transported to temporary holding facilities, checked for injuries or other health concerns, stabilized, and transported to permanent facilities or release locations.

COMBINED REMOVAL METHOD. A combination of lethal and nonlethal removal may be applied on a single study area. In this instance, we would capture enough birds to meet placement opportunities and remove the remaining birds lethally.

S.5. The Alternatives

In addition to the No Action Alternative, we developed a Preferred Alternative and seven additional action alternatives, two with sub-alternatives, based on an array of considerations. These alternatives span the feasible and reasonable approaches to meeting the purpose and need described in Chapter 1 of this Final EIS. The alternatives vary in number of study areas, distribution of those study areas, type of study, method of removal, and presence or absence of pretreatment data.

S.5.1 No Action Alternative

Under the No Action Alternative, no experimental removal would be conducted by the Service. This would not prevent others from proposing such studies and seeking the necessary permits, but there is no guarantee that any such efforts would occur.

S.5.2 Action Alternatives

The action alternatives vary by location and number of study areas (1 to 11), type of experiment (demographic or occupancy), and removal method (lethal or combined). We did not include the nonlethal removal method because, based on early efforts, we do not anticipate being able to find placement for more than 100 barred owls. All the action alternatives require the removal of more than 100 barred owls. Since we would not capture barred owls without a location ready to accept them, none of the alternatives could be implemented if limited to nonlethal removal. Because of the limitations placed on using nonlethal removal methods for the experiment, the limited options for placement of captured birds, the stress on the birds, and the likely outcome if released elsewhere, use of nonlethal removal as the sole removal method in the experiment is not included in the action alternatives.

S.5.2.1 Preferred Alternative

This alternative involves a demographic study approach using a combination of lethal and nonlethal removal methods. This experiment would be conducted on four study areas with pre-treatment demography data spread across the range of the northern spotted owl, including the Cle Elum in Washington, one-half the combined Oregon Coast Ranges and Veneta in northern Oregon, the Union/Myrtle in southern Oregon, and the Hoopa (Willow Creek) in California. Given the size and number of spotted owl sites in the combined study areas, this alternative would require an estimated duration of 4 years of barred owl removal to detect significant results.

S.5.2.2 Alternative 1

This alternative involves a demographic study approach using lethal removal methods. This experiment would be conducted on a single study area, out of the nine ongoing spotted owl demographic study areas. We are considering the use of any one of these nine areas and are analyzing the effects for each area. The estimated duration of barred owl removal for this alternative varies from 4 to 7 years by study area, due primarily to the size of the study area and the number of spotted owl sites. Smaller study areas or areas with fewer spotted owl sites would take longer to detect statistically significant results.

S.5.2.3 Alternative 2

This alternative involves a demographic study approach using a combination of lethal and nonlethal removal methods. This experiment would be conducted on three study areas spread across the range of the northern spotted owl. To ensure that this represents the various conditions across the range of the northern spotted owl, the three study areas would be distributed such that one in Washington, one in northern Oregon, and one in southern Oregon or northern California. Given the size and number of spotted owl sites in the combined study areas, this alternative would require an estimated duration of 4 years of barred owl removal to detect significant results.

S.5.2.4 Alternative 3

This alternative involves a demographic study approach using a combination of lethal and nonlethal removal methods. This experiment would be conducted on two study areas in Oregon that are not spotted owl demographic study areas, but that have data to allow an estimate of pretreatment spotted owl population trends: Veneta and Union/Myrtle. The Union/Myrtle area has long-term monitoring data and the Veneta area has research and monitoring data that would allow us to estimate pretreatment spotted owl population trends and survival rates. Both have current or recent data on most spotted owl sites and banded spotted owls. Because they are relatively small, we paired these treatment (removal) areas with control (non-removal) areas on adjacent ongoing spotted owl demographic study areas. The Union/Myrtle area would be paired with the Klamath Spotted Owl Demographic Study Area; the Veneta area would be paired with a comparable portion of the Oregon Coast Ranges and Tyee Spotted Owl Demographic Study Areas. Given the size and number of spotted owl sites in the two study areas, this alternative would require an estimated duration of 4 years of barred owl removal to detect statistically significant results.

S.5.2.5 Alternative 4

This alternative involves a demographic study approach using a combination of lethal and nonlethal removal methods. This experiment would be conducted on two study areas that lack current demographic data—Columbia Gorge in Washington and McKenzie in Oregon. These two study areas have some past and current spotted owl survey data.

Alternative 4 includes two sub-alternatives. Under sub-Alternative 4a, we would take time to gather pretreatment demographic data before beginning the removal portion of the experiment. Under sub-Alternative 4b, we would start removal on the treatment portion of the study area after year 2, immediately after establishing a population of banded spotted owls, and rely on differences between the control and treatment areas to determine the effects of removal. Lack of pretreatment data reduces the strength of the experimental approach.

Sub-Alternative 4a would require 5 years of pre-removal data collection to establish demographic values (population trend, survival, recruitment), and 5 years of barred owl removal to establish changes in these demographic measures between the control and treatment areas, for a total of 10 years. Sub-Alternative 4b would require approximately 8 years: 2 years to develop a population of banded spotted owls for analysis, and 6 years of barred owl removal to develop the demographic measurements and detect differences between the control and treatment areas.

S.5.2.6 Alternative 5

This alternative involves an occupancy study approach using lethal removal methods. Occupancy studies can be done as simple occupancy (presence or absence of spotted owls on each site) or, with added effort, we can add information on reproductive success. This experiment would be conducted on three study areas with existing and recent occupancy data distributed across the range of the northern spotted owl. We selected the Cowlitz Valley, Veneta (Oregon Coast Ranges/Tyee), and Union/Myrtle (Klamath) Study Areas for this alternative. As described in Alternative 3, the Veneta and Union/Myrtle areas would be treatment (removal) areas paired with control (non-removal) areas on adjacent ongoing spotted owl demographic study areas.

Given the size and number of spotted owl sites on the three study areas, a simple presence/absence occupancy experiment would require 3 years of barred owl removal to detect differences between the control and treatment areas (Option 1). If we add reproductive success to the experiment, it would require an additional 2 years, bringing the duration to 5 years of barred owl removal (Option 2).

S.5.2.7 Alternative 6

This alternative involves an occupancy study approach using a combination of lethal and nonlethal removal methods. This experiment would be conducted on three study areas that do not have current occupancy data. The McKenzie and Horse/Beaver Study Areas would contain both treatment and control areas. Removal would occur on the Olympic Revised portion of the Olympic Revised (Olympic Peninsula) Study Area with a control (non-removal) area on the Olympic Peninsula Spotted Owl Demographic Study Area. These cover the three regions of the spotted owl range described in Alternative 2.

Alternative 6 includes two sub-alternatives. Under sub-Alternative 6a, we would take time to gather pretreatment occupancy data before beginning the removal portion of the experiment. Under sub-Alternative 6b, we would start removal on the treatment portion of the study area immediately and rely on differences between the control and treatment areas to determine the effects of the removal. Lack of pretreatment data reduces the strength of the experimental approach.

Sub-Alternative 6a would require 3 years of pre-removal data collection to establish occupancy values and 3 years of barred owl removal data to establish changes in occupancy between the control and treatment areas, for a total of 6 years for simple occupancy data, and 2 additional years of barred owl removal if we add reproductive success measurements. Sub-Alternative 6b would require approximately 4 years of barred owl removal for simple occupancy, and 2 additional years of barred owl removal if we add reproductive success measurements.

S.5.2.8 Alternative 7

This alternative involves both demography and occupancy study approaches, depending on the study area, using a combination of lethal and nonlethal removal methods. For this experiment, we selected a total of 11 study areas. We attempted to select one from each physiographic province to provide stronger information from across the range of the northern spotted owl. In some cases, where study areas have few potential spotted owl sites, more than one was selected within a province to provide sufficient sample size. In very large provinces, additional study areas were included to provide better distribution of results.

For most study areas we estimated the duration of barred owl removal based on the time required to detect achieve significant results relative to the effects of removal on spotted owls. These vary from 3 to 10 years. For four study areas spread across the range of the spotted owl, we chose to continue the barred owl removal for 10 years to determine if there were any different long-term effects of removal. For example, whether observed changes in spotted owl populations continue past the initial phase, taper off, or even reverse after the initial years of the experiment.

S.6. Action Area

For this Final EIS, the action areas are the study areas, and the action area for each alternative is made up of a combination of study areas. One study area may occur in more than one alternative, and alternatives may have more than one study area in the action area. In most cases, each study area is independent—actions on one study area do not affect those on other study areas. This is due to the distance between study areas and the lack of significant effects of the experiment beyond the study area boundary.

The study areas include Ross Lake, Wenatchee, Cle Elum, Olympic Peninsula, Olympic Revised (Olympic Peninsula), Rainier, Cowlitz Valley, and Columbia Gorge in Washington; Oregon Coast Ranges, Veneta (Oregon Coast Ranges/Tyee), Tyee, McKenzie, HJ Andrews, Union/Myrtle (Klamath), Klamath, South Cascades, and Rogue Cascade (South Cascades) in Oregon, and Horse/Beaver, Goosenest, Hoopa (Willow Creek), and Corral in California.

S.7. Environmental Consequences

For this Final EIS, we conducted an analysis of the potential effects to the human environment (environmental consequences and cumulative effects). We identified potential effects for the following resource areas: barred owls, northern spotted owls, other species, social and ethical, economic, cultural resources; and recreation and visitor use, and are summarized below. We determined no potential for effects to the remaining resource areas such as air, water, and wetlands.

S.7.1 Effects on Barred Owls

Under the No Action Alternative no barred owls would be removed from this experiment. The lowest number of barred owls we estimate would be removed, 321, occurs if we chose the Hoopa (Willow Creek) Study Area in Alternative 1. The highest estimated number, 8,892, would be removed under Alternative 7 (Table S-1). Under the Preferred Alternative, we estimate the removal of 3,603 barred owls over the course of a 4 year experiment.

There are no estimates of the total population of barred owls in the range of the northern spotted owl or throughout their range in North America with to compare these values. Therefore, to provide the regional and rangewide context, we considered the percent of habitat from which barred owls would be removed. Because no habitat estimates exist for barred owls, we used spotted owl habitat as a conservative estimate within the range of the northern spotted owl.

The smallest treatment area from which barred owls would be removed occurs if we chose the Tyee Study Area in Alterative 1. Removal would occur on approximately 0.31 percent of the habitat in the range of the northern spotted owl and 0.01 percent of the range of the barred owl. The largest treatment area occurs in Alternative 7, approximately 6.55 percent of the habitat in the range of the northern spotted owl and 0.20 percent off the range of the barred owl. Under the Preferred Alternative, removal would occur on 1.72 percent of the habitat in the range of the northern spotted owls and 0.05 percent of the range of the barred owl.

Table S-1. Summary of the estimated number of barred owls removed, percent of habitat in the range of the northern spotted owl, and percent of habitat in the range of the barred owl.

Alternative/ Sub-Alternative	Estimated Barred Owls Removed During Experiment	Percent of Total Habitat within Range of Spotted Owl [1]	Percent of North American Range of Barred Owl [2]
Preferred Alternative	3,603	1.72	0.05
Alternative 1	321 to 2,242	0.31 to 1.59	Less than 0.01 to 0.05
Alternative 2	1,450 to 5,784	1.33 to 3.90	0.04 to 0.12
Alternative 3	2,003	1.13	0.04
Sub-Alternative 4a	2,183	1.42	0.05
Sub-Alternative 4b	2,509	1.42	0.05
Alternative 5	2,494 to 3,463	2.05	0.07
Sub-Alternative 6a	2,007 to 2,787	2.08	0.10
Sub-Alternative 6b	2,397 to 3,175	2.08	0.10
Alternative 7	8,892	6.55	0.20

[1] Approximately 12,104,100 acres of spotted owl habitat occurs within the range of the northern spotted owl. We use spotted owl habitat as a surrogate for barred owl habitat which has not been mapped or defined.
[2] Range of barred owl within range of northern spotted owl is approximately 3 percent of total range of barred owl in North America.

S.7.2 Effects on Northern Spotted Owls

Depending on the study area(s) chosen, the percentage of spotted owl habitat from which barred owls would be removed ranges from 0.31 percent to 6.55 percent, and between 38 and 630 potential spotted owl sites within the treatment (removal) area may be reoccupied during the experiment. The Preferred Alternative would remove barred owls from 1.72 percent of the habitat in the range of the northern spotted owls, and effect up to 363 potential spotted owl sites in the treatment areas. The magnitude of positive effect would vary based on current barred owl population levels, likely being greatest where barred owl densities are low enough to have allowed some spotted owls to persist on the treatment area. The proportion of spotted owl sites with barred owl detections ranges from 18 percent to 71 percent within each of the study areas, and the overall magnitude of positive effect would vary based on current spotted owl site occupancy. Higher current occupancy allows spotted owls to reoccupy sites from which barred owls are removed more quickly. Current spotted owl site occupancy varies from 22 percent of the sites occupied, to 67 percent occupancy, and an average of 48 percent occupancy on the study areas of the Preferred Alternative

The primary effect we anticipate is a positive change in spotted owl demographic performance on the treatment portions of the study areas. Some minor and short-term negative effects may result from the survey and removal activities.

S.7.3 Effects on Ongoing Spotted Owl Demographic Study Areas

Alternative 4 does not include any ongoing spotted owl demographic study areas. Alternatives 3, 5, and 6 do not include any removal on ongoing spotted owl demographic study areas. We anticipate no significant effect from these surveys.

Alternatives 1, 2, and 7 include removal from up to one-half of one to three ongoing spotted owl demographic study areas. The Preferred Alternative includes removal on three ongoing spotted owl demography study areas, including two that are part of the Northwest Forest Plan Effectiveness Monitoring Program. This would reduce the sample size of spotted owls for the ongoing demographic study on the included study areas by up to 50 percent, increasing the variance of estimates of demographic rates for both treatment and control areas. Because three areas would be used for removal in the Preferred Alternative and Alternatives 2 and 7, the overall impact of these effects would be larger than for Alternative 1. Once the removal experiment is concluded and barred owl populations recover to levels comparable to the control areas, the treatment area(s) can be recombined with control area(s).

S.7.4 Effects on Other Species

Depending on the study area chosen, the treatment area would potentially provide temporary relief from predation and competition from 4 to 25 State- or Federal-listed species. Thirteen of the 21 potential study areas include at least some area within the likely inland range of the marbled murrelet: Ross Lake, Olympic Peninsula, Olympic Revised (Olympic Peninsula), Wenatchee, Cle Elum, Rainier, Cowlitz Valley, Oregon Coast Ranges, Veneta (Oregon Coast Ranges/Tyee) Tyee, Union/Myrtle (Klamath), Klamath, and Hoopa (Willow Creek). The Hoopa portion of the Hoopa (Willow Creek) Study Area lies within the potential inland range of the marbled murrelet; however, extensive surveys of the Hoopa portion of the Hoopa (Willow Creek) Study Area have not verified any marbled murrelet use. If any of these are chosen, some late-nesting marbled murrelets may be disturbed during barred owl removal. The overall primary effect on other wildlife species is reduced predation and competition from barred owls.

S.7.5 Effects on the Social Environment

Ethical considerations in the removal of barred owls are very important to individuals and will affect the way in which each person views the various alternatives in this Final EIS. The Service has taken these perspectives, as expressed by commenters and the Barred Owl Stakeholders Group into consideration in developing the approach and alternatives identified in this Final EIS, including setting a clearly defined end point for removals (until information is sufficient to answer the questions, and no more than 10 years) and a detailed removal protocol to ensure as humane a removal process as possible. However, these are individual-level issues. We do not anticipate that the proposed experimental removal of barred owls would change or impact individual values in a manner that would affect the larger regional social environment.

We have identified three ways in which the alternatives may impact the social environment: (1) public health and safety, (2) environmental justice, and (3) economic effects. The risk to public health and safety is insignificant due to the use of shotguns by trained, authorized professionals only, and a tight removal protocol. There are no foreseeable effects from any of the alternatives that create any pollution or other deleterious environmental justice effects. Therefore, the removal experiments do not raise concerns about environmental injustice. Potential effects to the economy are described in Chapter 3.8 of this Final EIS.

S.7.6 Effects on Recreation and Visitor Use

Selecting one of the three potential study area including National Parks, Ross Lake, Rainier or Olympic Peninsula Study Areas could result in impacts to the visitor experience through changes in the soundscape from the discharge of shotguns during removal. Selecting any of the other study areas would have no significant effect on recreation or visitor use as these Federal lands, nonfederal lands, and wilderness areas are all open to hunting. The sound of firearms would not significantly change the soundscape of the area. The Primary effect is a result of the use of lethal removal methods on National Parks where visitors are not anticipating the sound of firearms. National Parks may experience barred owl removal under Alternatives 1, 2, and 7. No removal on National Parks would occur under the Preferred Alternative.

S.7.7 Effects on the Economy

The primary mechanism for effect is the potential restriction on timber harvest around newly reoccupied spotted owl sites in the treatment areas. Due to State law and habitat conservation plans, there is no effect on timber harvest in study areas in Washington and California. For Oregon study areas, the potential economic effect is between zero and the value of the timber on 2,893 acres of land, for the 3- to 13-year duration of barred owl removal and recovery of barred owl populations, depending on the study area, habitat condition, flexibility of the landowner, and interest in a Safe Harbor Agreement. Any effect would be temporary, and the acres would likely be available for harvest within 3 years after cessation of the barred owl removal. The potential though temporary economic effect of the Preferred Alternative is up to the value of the timber on 2,400 acres of forest for the 4 years of the barred owl removal experiment and 3 years for recovery of the barred owl populations, again depending on habitat condition, flexibility of the landowner, and interest in a Safe Harbor Agreement.

S.7.8 Effects on Costs of the Experiment

The cost of the experiments described in the alternatives range from a total of $398,000 on the Hoopa (Willow Creek) Study Area in Alternative 1, to $11,831,000 to implement Alternative 7. The estimated cost of the Preferred Alternative is $2,910,000.

S.7.9 Effect on the Cultural Environment

We identified no effects to the cultural environment. If Hoopa (Willow Creek) is the selected study area, this would be responsive to the Hoopa Valley Tribe's concerns for maintaining the culturally significant spotted owl on their lands.

See complete series list on page 105.

POPULATION DEMOGRAPHY *of* NORTHERN SPOTTED OWLS

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Cover photo: Adult female Spotted Owl in the Oregon Coast Range. Photo by Patrick Kolar.

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Population Demography of Northern Spotted Owls

Abstract. We used data from 11 long-term studies to assess temporal and spatial patterns in fecundity, apparent survival, recruitment, and annual finite rate of population change of Northern Spotted Owls (*Strix occidentalis caurina*) from 1985 to 2008. Our objectives were to evaluate the status and trends of the subspecies throughout its range and to investigate associations between population parameters and covariates that might be influencing any observed trends. We examined associations between population parameters and temporal, spatial, and ecological covariates by developing a set of *a priori* hypotheses and models for each analysis. We used information-theoretic methods and $QAIC_c$ model selection to choose the best model(s) and rank the rest. Variables included in models were gender, age, and effects of time. Covariates included in some analyses were reproductive success, presence of Barred Owls (*Strix varia*), percent cover of suitable owl habitat, several weather and climate variables including seasonal and annual variation in precipitation and temperature, and three long-term climate indices. Estimates of fecundity, apparent survival, recruitment, and annual rate of population change were computed from the best models or with model averaging for each study area. The average number of years of reproductive data from each study area was 19 (range = 17 to 24), and the average number of captures/resightings per study area was 2,219 (range = 583 to 3,777), excluding multiple resightings of the same individuals in the same year. The total sample of 5,224 marked owls included 796 1-yr-old subadults, 903 2-yr-old subadults, and 3,545 adults (≥3 yrs old). The total number of annual captures/recaptures/resightings was 24,408, and the total number of cases in which we determined the number of young produced was 11,450.

Age had an important effect on fecundity, with adult females generally having higher fecundity than 1- or 2-yr-old females. Nine of the 11 study areas had an even–odd year effect on fecundity in the best model or a competitive model, with higher fecundity in even years. Based on the best model that included a time trend in fecundity, we concluded that fecundity was declining on five areas, stable on three areas, and increasing on three areas. Evidence for an effect of Barred Owl presence on fecundity on individual study areas was somewhat mixed. The Barred Owl covariate was included in the best model or a competitive model for five study areas, but the relationship was negative for four areas and positive for one area. At the other six study areas, the association between fecundity and the proportion of Spotted Owl territories in which Barred Owls were detected was weak or absent. The percent cover of suitable owl habitat

was in the top fecundity model for all study areas in Oregon, and in competitive models for two of the three study areas in Washington. In Oregon, all 95% confidence intervals on beta coefficients for the habitat covariate excluded zero, and on four of the five areas the relationship between the percent cover of suitable owl habitat and fecundity was positive, as predicted. However, contrary to our predictions, fecundity on one of the Oregon study areas (KLA) declined with increases in suitable habitat. On all three study areas in Washington, the beta estimates for the effects of habitat on fecundity had 95% confidence intervals that broadly overlapped zero, suggesting there was less evidence of a habitat effect on fecundity on those study areas. Habitat effects were not included in models for study areas in California, because we did not have a comparable habitat map for those areas. Weather covariates explained some of the variability in fecundity for five study areas, but the best weather covariate and the direction of the effect varied among areas. For example, there was evidence that fecundity was negatively associated with low temperatures and high amounts of precipitation during the early nesting season on three study areas but not on the other eight study areas.

The meta-analysis of fecundity for all study areas (no habitat covariates included) suggested that fecundity varied by time and was parallel across ecoregions or latitudinal gradients, with some weak evidence for a negative Barred Owl (BO) effect. However, the 95% confidence interval for the beta coefficient for the BO effect overlapped zero ($\hat{\beta}$ = -0.12, SE = 0.11, 95% CI = -0.31 to 0.07). The best models from the meta-analysis of fecundity for Washington and Oregon (habitat covariates included) included the effects of ecoregion and annual time plus weak effects of habitat and Barred Owls. However, the 95% confidence intervals for beta coefficients for the effects of Barred Owls and habitat overlapped zero ($\hat{\beta}_{BO}$ = -0.104, 95% CI = -0.369 to 0.151; $\hat{\beta}_{HAB1}$ = -0.469, 95% CI = -1.363 to 0.426). In both meta-analyses of fecundity, linear trends (T) in fecundity were not supported, nor were effects of land ownership, weather, or climate covariates. Average fecundity over all years was similar among ecoregions except for the Washington–Mixed-Conifer ecoregion, where mean fecundity was 1.7 to 2.0 times higher than in the other ecoregions.

In the analysis of apparent survival on individual study areas, recapture probabilities typically ranged from 0.70 to 0.90. Survival differed among age groups, with subadults, especially 1-yr-olds, having lower apparent survival than adults. There was strong support for declining adult survival on 10 of 11 study areas, and declines were most evident in Washington and northwest Oregon. There was also evidence that apparent survival was negatively associated with the presence of Barred Owls on six of the study areas. In the analyses of individual study areas, we found little evidence for differences in apparent survival between males and females, or for negative effects of reproduction on survival in the following year.

In the meta-analysis of apparent survival, the best model was a random effects model in which survival varied among study areas (g) and years (t), and recapture rates varied among study areas, sexes (s), and years. This model also included the random effects of study area and reproduction (R). The effect of reproduction was negative ($\hat{\beta}$ = -0.024), with a 95% confidence interval that barely overlapped zero (-0.049 to 0.001). Several random effects models were competitive, including a second-best model that included the Barred Owl (BO) covariate. The estimated regression coefficient for the BO covariate was negative ($\hat{\beta}$ = -0.086), with a 95% confidence interval that did not overlap zero (-0.158 to -0.014). One competitive random effects model included a negative linear time trend on survival ($\hat{\beta}$ = -0.0016) with a 95% confidence interval (-0.0035 to 0.0003) that barely overlapped zero. Other random effects models that were competitive with the best model included climate effects (Pacific Decadal Oscillation, Southern Oscillation Index) or weather effects (early nesting season precipitation, early nesting season temperature). Ownership category, percent cover of suitable owl habitat, and latitude had little to no effect on apparent survival.

Apparent survival differed among ecoregions, but the ecoregion covariate explained little of the variation among study areas and years.

Estimates of the annual finite rate of population change (λ) were below 1.0 for all study areas, and there was strong evidence that populations on 7 of the 11 study areas declined during the study. For four study areas, the 95% confidence intervals for λ overlapped 1.0, so we could not conclude that those populations were declining. The weighted mean estimate of λ for all study areas was 0.971 (SE = 0.007, 95% CI = 0.960 to 0.983), indicating that the average rate of population decline in all study areas combined was 2.9% per year. Annual rates of decline were most precipitous on study areas in Washington and northern Oregon. Based on estimates of realized population change, populations on four study areas declined 40 to 60% during the study, and populations on three study areas declined 20 to 30%. Declines on the other four areas were less dramatic (5 to 15%), with 95% confidence intervals that broadly overlapped 1.0.

Based on the top-ranked *a priori* model in the meta-analysis of λ, there was evidence that ecoregions and the proportion of Spotted Owl territories with Barred Owl detections were important sources of variation for apparent survival (φ_t) and recruitment (f_t). There was some evidence that recruitment was higher on study areas dominated by federal lands compared to study areas that were on private lands or lands that included approximately equal amounts of federal and private lands. There also was evidence that recruitment was positively related to the proportion of the study area that was covered by suitable owl habitat.

We concluded that fecundity, apparent survival, and/or populations were declining on most study areas, and that increasing numbers of Barred Owls and loss of habitat were partly responsible for these declines. However, fecundity and survival showed considerable annual variation at all study areas, little of which was explained by the covariates that we used. Although our study areas were not randomly selected, we believe our results reflect conditions on federal lands and areas of mixed federal and private lands within the range of the Northern Spotted Owl because the study areas were (1) large, covering ≈ 9% of the range of the subspecies; (2) distributed across a broad geographic region and within most of the geographic provinces occupied by the owl; and (3) the percent cover of owl habitat was similar between our study areas and the surrounding landscapes.

Key Words: Barred Owl, fecundity, Northern Spotted Owl, Northwest Forest Plan, population change, recruitment, *Strix occidentalis caurina*, *Strix varia*, survival

During the last 40 years, the management philosophy on federal forest lands in the United States has undergone profound changes as government agencies have become increasingly aware of the importance of federal lands in species conservation. Nowhere has this change been more controversial than in the Pacific Northwest (Washington, Oregon, and northern California), where attempts to maintain viable populations of Northern Spotted Owls (*Strix occidentalis caurina*), Marbled Murrelets (*Brachyramphus marmoratus*), red tree voles (*Arborimus longicaudus*), and other plants and animals that thrive in old forests have resulted in large reductions in harvest of old forests on federal lands (Ervin 1989, Durbin 1996). Because of the controversial nature of these changes and the need to know whether management policies were achieving desired objectives, the U.S. Forest Service and U.S. Bureau of Land Management initiated eight long-term mark–recapture studies of Northern Spotted Owls during 1985 to 1991 (Lint et al. 1999). The primary objective of these field studies was to provide federal agencies and the public with data on the status and trends of Spotted Owl populations and to determine if the management plans adopted by the agencies were resulting in recovery of the owl, which was listed as a threatened subspecies in 1990 (USDI Fish and Wildlife Service 1990). In addition, the recent invasion of Barred Owls (*Strix varia*) into the range of the Spotted Owl represents a competitive threat that many research groups are trying to assess. The information generated in these studies has been featured in many publications (Franklin 1992, Burnham et al. 1994, 1996, Forsman et al. 1996a, Franklin et al. 2000, Kelly et al. 2003, Hamer et al. 2007, Olson et al. 2004, 2005, Anthony et al. 2006, Bailey et al. 2009, Singleton 2010) and has played a key role in several court cases and in the development of the Northwest Forest Plan (NWFP). The NWFP is an interagency plan that was designed to protect all native plants and animals on federal lands within the range of the Northern Spotted Owl, while at the same time providing jobs and wood products (USDA Forest Service and USDI Bureau of Land Management 1994). The data from the long-term demography studies were also considered by the team that prepared the 2008 recovery plan for the Northern Spotted Owl (USDI Fish and Wildlife Service 2008) and by a committee of The Wildlife Society (2008) who commented on the plan. Research on the long-term demography of the Spotted Owl has focused attention on forest management and conservation of forest wildlife in the western United States. This research, and the controversy it has created, have changed forest management in the region and helped to bring about a general reassessment of the role of forest management in species conservation, forest ecosystem management, and human health (Thomas et al. 1993, USDA Forest Service and USDI Bureau of Land Management 1994, Dietrich 2003).

With any large-scale, long-term monitoring program, important criteria are consistency in methods and funding, and a consistent protocol for analyzing the data and reporting the results. Standard protocols are especially important in cases like the Spotted Owl, where (1) the economic stakes are high, (2) there is occasional disagreement regarding the potential for bias in the estimates of demographic parameters (Loehle et al. 2005, Franklin et al. 2006), and (3) where many different agencies and stakeholders are responsible for collecting the data. For the Northern Spotted Owl, the methods for collecting, analyzing, and reporting demographic data have been described by Franklin et al. (1996), Lint et al. (1999), Anderson et al. (1999), and Anthony et al. (2006). Because of considerable scientific and public interest in these studies, one of the key features in the monitoring program has been regularly scheduled workshops in which all of the researchers who are conducting demographic studies of Northern Spotted Owls, meet and conduct a meta-analysis of all of the demographic data (Lint et al. 1999). Since 1993, there have been four cooperative workshops, the results of which have been described in three published articles (Burnham et al. 1994, 1996, Anthony et al. 2006) and one unpublished report (Franklin et al. 1999). The most recent of these workshops was conducted in January 2009, where we completed an updated meta-analysis in which we analyzed all of the demographic data currently available on the Northern Spotted Owl, including an additional five years of data from 2004 to 2008, and modeled the demographic parameters as a function of a new set of environmental covariates. Our demographic analyses, which represent the most complete and up-to-date summary of the population status of the subspecies, are the focus of this volume of Studies in Avian Biology.

Estimates of vital rates and population trends are more interesting when there is some understanding of the environmental factors that may influence those estimates. Anthony et al. (2006) included covariates for the cost of reproduction and presence of Barred Owls in their analyses of survival and population trends of Spotted Owls, but they were not able to include habitat or weather covariates in their analysis. In our analysis, we included the same covariates examined by Anthony et al. (2006) but add several new range-wide weather covariates and habitat

covariates in Washington and Oregon. Thus, our analysis is the most comprehensive to date in terms of the number of covariates examined. Our analysis also differed from earlier analyses of Spotted Owl populations (Burnham et al. 1994, 1996) in that we use the *f*-parameterization of Pradel's (1996) temporal symmetry model to estimate the annual rate of population change (λ), and examine trends in the components of population change, including survival and recruitment rates. Our analyses have led to some valuable insights regarding our ability to discern the possible influence of environmental covariates (e.g., habitat, Barred Owls, weather) on a species that has high temporal variation in survival and reproduction. Our general approach will be of interest to other research groups investigating population dynamics of other long-lived vertebrates with similar life histories.

Our purpose in this report is threefold. First, we wanted to determine if the declines in apparent survival and populations that were reported previously (Anthony et al. 2006) have continued or stabilized. Second, we used multiple covariates in the analysis of demographic rates in an attempt to better understand which environmental factors best explained annual and spatial variability in these rates. We reasoned that one or more of these covariates might explain the recent declines in demographic rates of the subspecies. Last, we report on the use of the *f*-parameterization of the Pradel (1996) temporal symmetry model to estimate components of the annual finite rate of population change (λ), including apparent survival and recruitment rates, one of the first applications of this new technique in demographic analyses of Northern Spotted Owl populations.

STUDY AREAS

We obtained data from 11 study areas, including three in Washington, five in Oregon, and three in California (Fig. 1). Study area names and acronyms used throughout the report are described in Table 1. Size of study areas ranged from 356 to 3,922 km^2 (Table 1). The total area covered by all 11 study areas (19,813 km^2) was equal to approximately 9% of the total range of the Northern Spotted Owl, which has been estimated at 230,690 km^2 (USDA Forest Service and USDI Bureau of Land Management 1994). Our study areas included one (GDR) that was entirely on private land, one (HUP) on an Indian Reservation, four (OLY, HJA, CAS, NWC) that were primarily on federal lands, and five (CLE, RAI, COA, TYE, KLA) that included a mixture of federal, private and state lands (Table 1). Of the 11 study areas, eight (OLY, CLE, COA, HJA, TYE, KLA, CAS, NWC) were established by the U.S. Forest Service and U.S. Bureau of Land Management to document the status of Northern Spotted Owls on federal lands within the region encompassed by the Northwest Forest Plan (Lint et al. 1999). In some analyses, we present results separately for these eight areas, which we refer to as "NWFP study areas" (Table 1, Appendix A). We made a distinction between types of study areas because the Northwest Forest Plan is the overarching interagency land management plan that applies to federal lands within the range of the Northern Spotted Owl, which is of special interest to federal land managers (USDA Forest Service and USDI Bureau of Land Management 1994).

Our study areas differed from those included in Anthony et al. (2006) in that data collection on three of the 14 study areas examined therein, was either discontinued or reduced, so data from those three areas (Wenatchee, Warm Springs, and Marin study areas) were no longer available for a meta-analysis. In addition, the OLY study area was reduced in size because of lack of funding, and the size of the GDR study area was expanded in 1998. In two cases (TYE, NWC), sizes of study areas in Table 1 are different than in Anthony et al. (2006), not because of any change in area, but because we mapped the boundaries based on boundaries used in analyses of population change. In contrast, the study area boundaries for the TYE and NWC study areas displayed in Anthony et al. (2006) included survey polygons in areas adjacent to the main study areas. Because of the changes in number and size of study areas and the addition of five years of data, results of

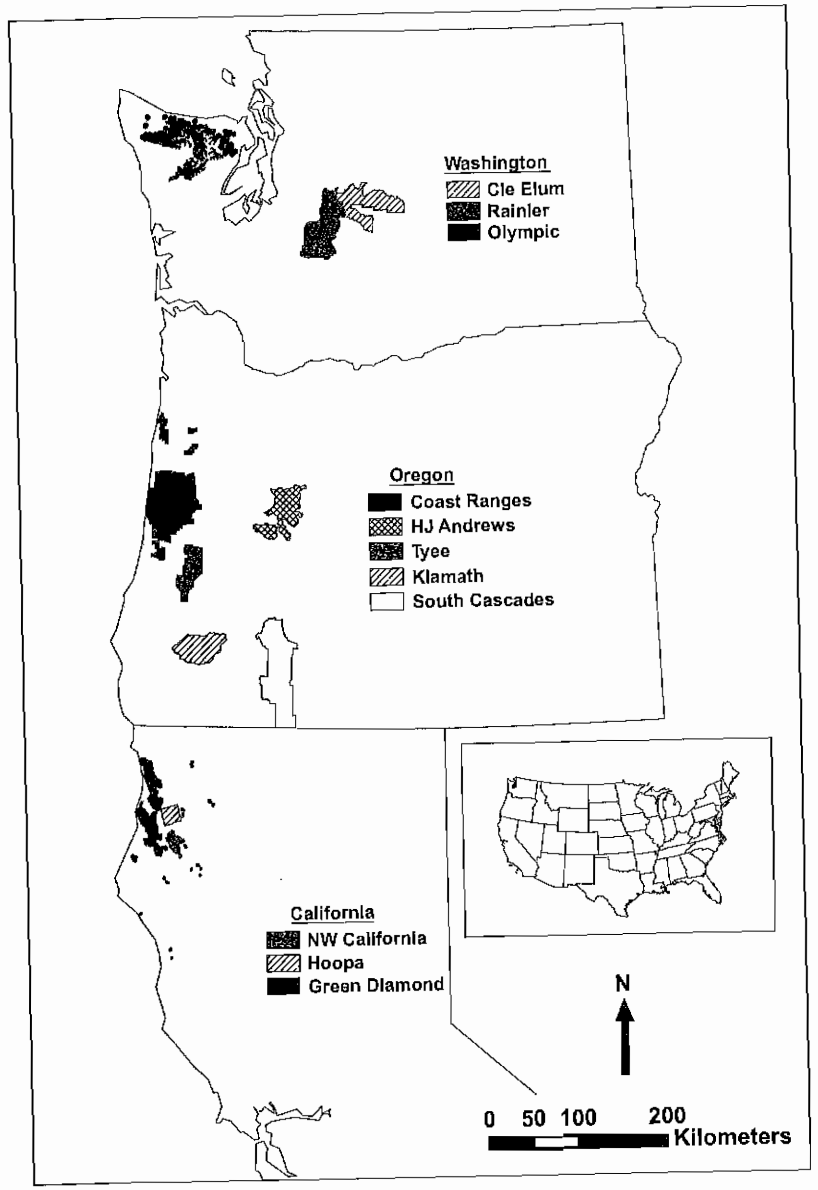


Figure 1. Locations of 11 study areas used in the analysis of vital rates and population trends of Northern Spotted Owls.

this analysis are not directly comparable to previous analyses conducted by Burnham et al. (1996) and Anthony et al. (2006).

The study areas were distributed across a broad geographic region, from central Washington south to northern California, and varied widely in climate, vegetation, and amount of topographic relief. Study areas in the coastal mountains of Oregon and California (COA, TYE, KLA, NWC, GDR, HUP) typically occurred at low to moderate elevations, where the highest elevations were $<$1,250 m, whereas study areas in the Cascades and Olympic Mountains (CLE, RAI, OLY, HJA, CAS) occurred in areas with high mountains, where forests extended from the lowland valleys up to timberline, at or above 1,500 m elevation. Climate varied from relatively warm and dry on study areas in southern Oregon and northwestern California to extremely wet in the temperate rain forests on the west side of the Olympic Peninsula, where annual precipitation ranged from 280 to 460 cm/year (Table 1). Study areas on the west slope of the Cascades Range (RAI, HJA, CAS) were typically warm and dry during summer and cool and wet during winter, with much of the winter precipitation falling as snow at higher elevations. The only study area that was entirely on the east slope of the Cascades (CLE) was characterized by warm, dry summers and cool winters, with most precipitation occurring as snow during winter.

Forests on all study areas were dominated by conifers, or mixtures of conifers and hardwoods, but there were regional differences in species composition. Forests on study areas in Washington and northern Oregon were comprised of mixtures of Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*), or, in coastal areas, by mixed stands of western hemlock and Sitka spruce (*Picea sitchensis*). Ponderosa pine (*Pinus ponderosa*) was also a dominant species on the east slope of the Cascades in Washington. Study areas in southwestern Oregon and northwestern California had diverse mixtures of mixed-conifer forest or mixed-evergreen forest (Franklin and Dyrness 1973, Küchler 1977). Common canopy trees in mixed-conifer

TABLE 1

Descriptions of 11 study areas used to estimate vital rates of Northern Spotted Owls in Washington, Oregon, and California (see also Appendix A).

Asterisks indicate the eight study areas that are part of the federal monitoring program for the northern spotted owl (Lint et al. 1999).

Study area	Acronym	Years	Area (km^2)	No. owls banded by age class[a]: S1	S2	Adults	Total owls	Total encounters[b]	Mean annual precip. (cm)
Washington									
Cle Elum*	CLE	1989–2008	1,784	31	32	148	211	1,170	142
Rainier	RAI	1992–2008	2,167	8	12	133	153	583	216
Olympic*	OLY	1990–2008	2,230	19	32	337	388	1,510	290
Oregon									
Coast Ranges*	COA	1990–2008	3,922	66	97	486	649	3,306	219
H. J. Andrews*	HJA	1988–2008	1,604	28	91	457	576	3,082	201
Tyee*	TYE	1990–2008	1,026	137	110	243	490	2,315	125
Klamath*	KLA	1990–2008	1,422	169	134	347	650	2,800	121
South Cascades*	CAS	1991–2008	3,377	43	80	479	602	2,364	123
California									
NW California*	NWC	1985–2008	460	114	80	280	474	2,550	155
Hoopa Tribe	HUP	1992–2008	356	38	47	130	215	951	195
Green Diamond	GDR	1990–2008	1,465	143	188	505	836	3,777	188
Totals			19,813	796	903	3,545	5,244	24,408	

[a] Age class codes indicate owls that were 1 year old (S1), 2 years old (S2), or ≥ 3 years old (Adults). Counts include owls first banded as S1's, S2's, or Adults, as well as owls first banded as juveniles that were subsequently recaptured when they were 1, 2, or ≥ 3 years old.
[b] All captures, recaptures, and re-sightings, excluding multiple encounters of individuals in the same year.

or mixed-evergreen forests included: Douglas-fir, grand fir (*Abies grandis*), western white pine (*P. monticola*), sugar pine (*P. lambertiana*), ponderosa pine, incense cedar (*Calocedrus decurrens*), tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), California laurel (*Umbellularia californica*), and canyon live-oak (*Quercus chrysolepis*). The GDR study area in coastal northwestern California also included considerable amounts of coast redwood (*Sequoia sempervirens*) forest at lower elevations.

Forest age and structure varied widely among areas, ranging from one study area (GDR) that was mostly dominated by forests that were <60 years old to some study areas on federal lands (OLY, HJA, NWC, CAS) in which >60% of the landscape was covered by mature (80 to 199 years old) and old-growth forests (≥200 years old) with multilayered canopies of large trees that were typically 50 to 200 cm diameter at breast height (dbh). All study areas were characterized by diverse mixtures of forest age classes that were the product of a long history of logging, fire, windstorms, disease, and insect damage. Forests on the OLY and RAI study areas were also naturally fragmented by high-elevation ridges that were covered by snowfields and bare rock.

As stated by Franklin et al. (1996) and Anthony et al. (2006), the 11 study areas in our analysis were selected based on many considerations, including forest type, logistics, funding, land ownership boundaries, and local support from management agencies. As a result, the study areas were not randomly selected or systematically spaced. However, the study areas covered ~9% of the range of the subspecies, and an analysis by Anthony et al. (2006) indicated that the amount of suitable owl habitat in the study areas was similar to the surrounding areas. We believe, therefore, that the habitat conditions within our study areas were broadly representative of conditions on federal lands within the range of the owl, and that our results are indicative of population attributes of Northern Spotted Owls on federal lands in general. We are less confident that our estimates reflect typical trends on non-federal lands because our sample only included two study areas situated exclusively on non-federal lands (HUP and GDR). Both of those areas were in California, near the southern end of the range of the Northern Spotted Owl (Fig. 1) and were unique in that both landowners were actively managing to provide nesting and foraging habitat for Spotted Owls.

FIELD METHODS

We surveyed our study areas each year to locate owls, confirm bands, band unmarked owls, and document the number of young produced by each territorial female. Owls were trapped with a variety of methods, most commonly with a noose pole or snare pole (Forsman 1983). Each owl was marked with a U.S. Geological Survey numbered band on one leg and a unique color band on the other leg that could be observed without recapturing the owl (Forsman et al. 1996b, Reid et al. 1999). Surveys were conducted using vocal imitations or playback of owl calls to incite the owls to defend their territories, thereby revealing their presence (Franklin et al. 1996). However, once we became familiar with traditional nest and roost areas used by owls, it was often possible to locate owls by walking into traditional nest areas during the day and calling quietly while visually searching for owls near the nest. The number of visits to each survey polygon or owl territory within each study area was usually ≥3, although fewer visits were allowed in rare cases in which females either had no brood patch during the nesting season, or were observed for ≥30 min during the period when they should have been in the late incubation or early brooding stage, and showed no sign of nesting.

In most study areas, there were some Spotted Owl territories that were known from historical surveys before the studies began, but there were also many areas that had never been surveyed and where occupancy by Spotted Owls had never been reported. Because it took several years for surveyors to become familiar with their study areas and to locate and band the territorial owls within their study areas, we truncated the data to exclude the first 1 to 5 years of data on individual study areas. Truncation reduced the number of years in the sampling period, but eliminated some problems with small sample size and incomplete surveys in the early years on each study area. Once surveys began and a sample of owls was banded, new owls entered the study population when they were first detected and banded within the study area.

If owls were located on any of the visits to a given survey area, we followed a standard protocol to document the number of young fledged (NYF) by each female (Lint et al. 1999). The Lint et al. protocol took advantage of the fact that Spotted Owls are relatively unafraid of humans and will readily take live mice from human observers and carry the mice to their nest or fledged young (Lint et al. 1999, Reid et al. 1999). Except in the rare cases mentioned above, our protocol required that owls be located and offered ≥3 mice on two or more occasions each year to document their nesting status and the number of young that left the nest or "fledged" (NYF). If owls ate or cached all the mice offered, and no juvenile owls were detected, then pairs were considered to be non-nesting or failed nesters and were assigned a score of "0" for NYF. For owls that produced ≥1 young, the NYF was coded as the maximum number of young observed on at least two visits after the juveniles left the nest tree. The protocol included some exceptions that we adopted to reduce bias in fecundity estimates. For example, females were given a "0" for NYF if they (1) appeared to be non-nesting based on one or more visits during the spring and then could not be relocated on multiple return visits or (2) were determined to be nesting but could not be relocated on repeated visits to the area. We included these exceptions in our fecundity estimates because females that did not nest and females that nested but failed to produce young sometimes disappeared before the full protocol could be met, and excluding these birds would have caused a positive bias in fecundity estimates. Reproductive data from owls that did not meet the above protocols were recorded as "unknown" and excluded from our analyses.

ANALYTICAL METHODS

Development of Covariates

Barred Owl Covariate

We hypothesized that the presence of Barred Owls near areas occupied by Spotted Owls could have a negative effect on detectability, fecundity, survival, recruitment, or rate of population change of Spotted Owls within our study areas (Kelly et al. 2003, Olson et al. 2005). We did not specifically target Barred Owls in our surveys, but frequently heard or saw Barred Owls while conducting surveys for Spotted Owls, and we recorded the dates and locations of all such detections. The Barred Owl covariate that we used to evaluate our hypotheses was the annual proportion of Spotted Owl territories in each study area that had Barred Owls detected within a 1-km radius of the annual activity centers that were currently or historically occupied by the Spotted Owls on each territory. Consequently, the Barred Owl covariate was a random effect, time (year)-specific variable in analyses of individual study areas that was applied at the scale of the study area or owl population, not individual territories. In meta-analyses of survival and population change (λ), the Barred Owl covariate was a random effects variable that was applied at the meta-population level, but with data that were specific to each study area.

To develop the Barred Owl covariate, we identified an annual "activity center" for each Spotted Owl territory based on the most biologically significant records of the year, ranked in order of declining importance as follows: (1) active nest, (2) fledged young, (3) primary roost, (4) diurnal location, (5) nocturnal response to playbacks, or (6) most recent activity center if no Spotted Owls were located. The territory-specific frame of reference for this analysis was the cumulative area encompassed by 1-km-radius circles around all of the annual activity centers at each Spotted Owl territory. If there was only a single activity center within a territory in all years of the study, then the frame of reference was a single 1-km circle. If there were multiple activity centers used in different years in the same territory, then the frame of reference was the cumulative area encompassed by 1-km-radius circles around all of the annual activity centers within the territory. If Barred Owls were detected anywhere within the cumulative frame of reference in a given year, then that territory was considered to be occupied by Barred Owls in that year, and the annual study area covariate was the proportion of Spotted Owl territories occupied by Barred Owls (Appendix B). We felt that this approach was the best indicator of whether there was likely to be a Barred Owl effect on the Spotted Owls that occupied each territory. Preliminary results indicated that the relative abundance of Barred Owls varied considerably among years and study areas, and that the appearance of Barred Owls in any appreciable numbers on the study areas occurred in Washington in the mid-1980s, Oregon in the early 1990s, and California in the mid-1990s. Consequently, we predicted that any associations between demographic rates of Spotted Owl and Barred Owl detections would be variable among study areas.

Habitat Covariates

Another objective of our analysis was to determine if fecundity, survival, or recruitment were related to the annual percent cover of suitable owl habitat within or adjacent to individual study areas. The frame of reference for habitat covariates in the analysis of fecundity, apparent survival, and recruitment was the percent cover of suitable habitat within each study area. For this estimate, we used a 2.4-km radius around all historical owl activity centers to define each study area (Fig. 2, Appendix C). The acronym used for this environmental covariate was "HAB1." Choice of the 2.4-km radius as the criteria for defining study area boundaries was based on an approximation of the annual area used by resident pairs of Northern Spotted Owls (Forsman et al. 1984, 2005; Carey et al. 1992; Hamer et al. 2007). Although annual home ranges of Spotted Owls vary widely among geographic regions, we opted to simplify the analysis by using a constant radius to define all study areas.

Our definition of suitable habitat was based on Davis and Lint (2005), who created a base map of suitable Spotted Owl habitat for Washington and Oregon based on multiple covariates, including tree diameter, stand structure, canopy cover, and elevation. Accuracy assessments of these maps were conducted at both the physiographic province and territory scale. At the province scale, maps correlated well with locations of known owl territories, with Spearman rank coefficients ranging from $r_s = 0.83$ to 0.99 ($P < 0.001$; Appendix E in Lint 2005). At the territory scale, 19 sets of independent data from radio-marked Spotted Owls in Oregon indicated that average Spearman rank correlations between suitable habitat and locations of owls were 0.99 in the Coast Ranges, 0.93 in the western Cascades, and 0.94 in the southern Oregon Cascades (Appendix F in Lint 2005). Although there were exceptions, the majority of forests that fit the Davis and Lint (2005) definition of suitable habitat were characterized by large overstory conifers (dbh > 50 cm) and high (>70%) canopy cover (e.g., see Table 3-3 in Davis and Lint 2005:41). The Davis and Lint definition of "suitable owl habitat" does not perfectly define suitable habitat for Northern Spotted Owls throughout their geographic range, but was the best and most current habitat map that was available for our study areas in Oregon and Washington.

Because the base map created by Davis and Lint was based on a single snapshot in time (1996), we used time period-specific stand replacement/disturbance data (Cohen et al. 1998, Healey et al. 2008) to add or subtract habitat in the base map to create a time series of habitat maps for each study area in Oregon and Washington, with four-year time steps in 1984, 1988, 1992, 1996, 2000, and 2002. To create this time series, we assumed that "change" represented loss of habitat, and that the time scale was too short for regrowth of habitat. Therefore, the historical time step maps could be created by "adding back" habitat to the baseline map in years prior to 1996 and subtracting

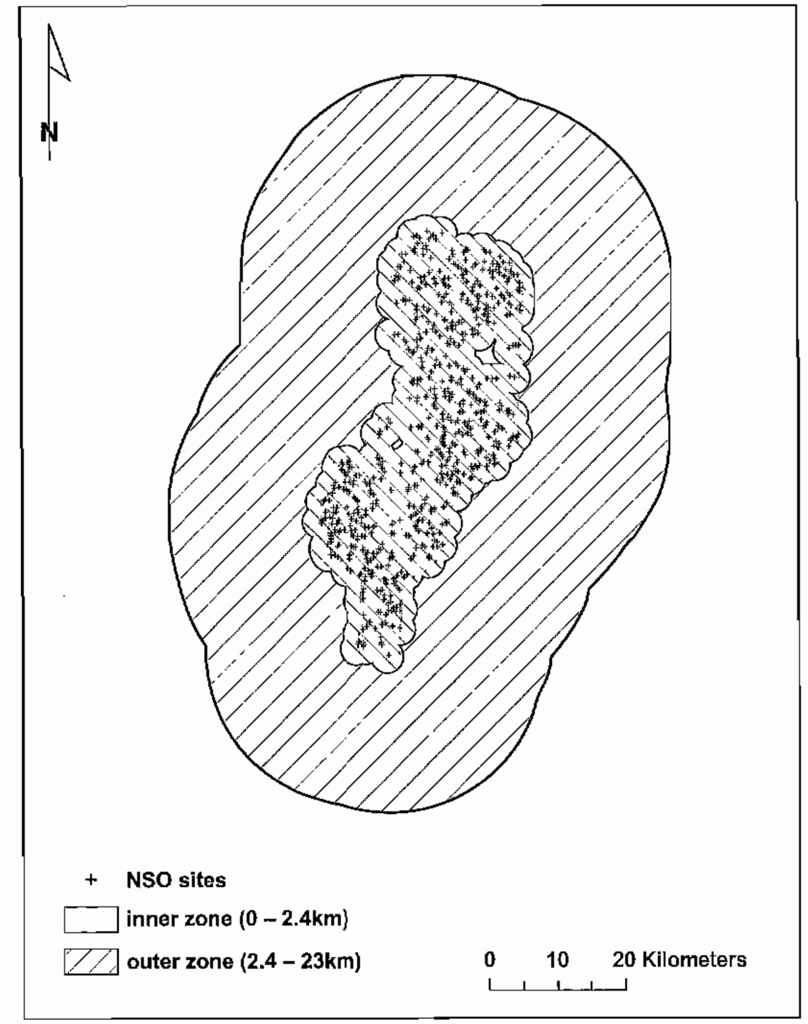


Figure 2. Example illustrating frames of reference used to evaluate the proportion of the landscape covered by suitable owl habitat on one of the Northern Spotted Owl demographic study areas (in gray). The small polygon indicates the area within 2.4-km-radius circles around all owl site centers, and the larger polygon indicates the area within 23-km-radius circles around all owl site centers, exclusive of the area of the inner polygon.

habitat from the base map in the years after 1996. To produce annual estimates of suitable habitat, we plotted the estimated percent cover of suitable owl habitat in each time step and then estimated the percent cover of habitat in the years between time steps by assuming a linear trend between the 4-year intervals (Appendix C). Consequently, the habitat covariate was a random effects variable that was time (year)-specific and was applied at the scale of each study area or owl population, comparable to the Barred Owl covariate. For the meta-analyses of survival and λ, the habitat covariate was a random effects variable that was applied at the meta-population level, with population data that were specific to each study area.

For the habitat covariate in the analysis of λ, we used the same definition of suitable habitat as in the analysis of survival, but developed two covariates based on different spatial scales. One covariate (HAB2) was the same as the HAB1 covariate in the analysis of survival (2.4-km-radius scale), with minor differences due to the fact that we truncated the time-series data to use fewer years in the meta-analysis than the analyses of survival and fecundity on some individual study areas. The second covariate (HAB3) was based on the percent cover of suitable habitat within a 23-km radius of all historical owl activity centers minus the area in HAB2 (Fig. 2, Appendix C). We used the 23-km radius to account for the possible influence of habitat on recruitment from the region immediately surrounding the study area out to a distance that approximated the median natal dispersal distances of Northern Spotted Owls, which were about 19 km for males and 27 km for females (Forsman et al. 2002:15).

After reviewing the habitat map for California, we decided not to develop habitat covariates for study areas from the state map of California because of inconsistencies with the map for Washington and Oregon (Davis and Lint 2005). Two primary problems with the California habitat data were that (1) the California map was based on different remote-sensed data than the combined map for Oregon and Washington (Davis and Lint 2005), and (2) complete evaluation of habitat change in California was not possible because the change detection information for California dated back to only 1994. Therefore, rather than confound our results with maps that were not comparable, we opted to limit our examination of the effects of habitat covariates to Oregon and Washington.

Weather and Climate Covariates

To determine if fecundity, apparent annual survival, or rate of population change were associated with variation in weather and climate, we used climate covariates that were associated with demographic performance of Spotted Owls in previous studies, including mean precipitation and temperature, Palmer Drought Severity Index (PDSI), Southern Oscillation Index (SOI), and Pacific Decadal Oscillation (PDO; Franklin et al. 2000, Seamans et al. 2002, LaHaye et al. 2004, Olson et al. 2004, Dugger et al. 2005, Glenn 2009). These climate variables included measures of seasonal and annual weather as well as longer-term measures of climatic conditions.

We obtained mean temperature and precipitation data for each study area from Parameter Elevated Regression on Independent Slope Models (PRISM) maps (Oregon Climate Service 2008). PRISM maps were developed using weather station data and a digital elevation model to generate raster-based digital maps with 4-km^2 resolution of mean monthly temperature (minimum and maximum) and precipitation on each study area (Daly 2006). We combined the monthly maps into seasonal and annual maps that corresponded with important life history stages of the owl, including winter (1 Nov to 28 Feb), early nesting season (1 Mar to 30 Apr), late nesting season (1 May to 30 Jun), and annual periods (1 Jul to 30 Jun). Temperature and precipitation values for each study area and time period were obtained by computing the average values of raster cells for each seasonal or annual map that fell within the study area boundaries.

We used the Palmer Drought Severity Index (PDSI) as an index of primary productivity that has the potential to influence abundance of Spotted Owl prey (NOAA 2008a). The PDSI is the deviation of moisture conditions from normal (30-yr mean = 1970 to 2000), standardized so comparisons can be made across regions and over time (Alley 1984). Values ranged from -6 (extreme drought) to +6 (extremely wet), with zero representing near-normal conditions. The index was calculated separately for climate regions within each state. Most study areas fell within one climate region. For study areas that included multiple climate regions, we used a weighted average of PDSI values based on the proportion of the study area that fell within each climate region.

We used monthly values of the Southern Oscillation/el Niño Index (SOI; NOAA 2008b) and the Pacific Decadal Oscillation (PDO; University of Washington 2008) to assess region-wide climate patterns. We averaged monthly values to obtain annual (Jul 1 to Jun 30) measures of SOI and PDO. Consequently, all of the weather and climate covariates were random effects variables that were time-specific and

were applied at the scale of owl populations in the analyses of individual study areas. For the meta-analyses of fecundity, survival, and λ, the weather covariates were random effects variables that were applied at the meta-population level, but with data that were specific to each study area.

Land Ownership, Ecoregion, and Latitude Covariates

To evaluate whether vital rates or rates of population change differed depending on land ownership, ecoregion, or latitude, we developed covariates for land ownership (OWN), ecoregion (ECO), and latitude (LAT). The ownership covariate was a categorical variable that divided study areas into three categories depending on whether they were privately owned, federally owned, or included an approximately equal mix of private and federal ownership (Appendix A). The ecoregion covariate categorized each study area into one of five ecoregions that incorporated geographic location (state) and the major forest type in each study area (Appendix A). Latitude was a continuous variable measured at the center of each study area. In the meta-analyses of fecundity, survival, and λ, all of these covariates were fixed effects variables that were applied at the scale of meta-populations.

Reproduction Covariate

To determine if there was evidence for a cost of reproduction on adult survival in the following year, we used the mean number of young fledged per female as a year- and study area–specific covariate in analyses of apparent survival. We also used the mean NYF covariate in recapture models to investigate the effect of reproduction on detection probabilities in the current year. The mean NYF covariate was time (year)-specific and used as a random effects variable at the scale of populations, comparable to the way we used the Barred Owl and habitat covariates. In the meta-analysis of survival, the NYF covariate was applied at the scale of meta-populations.

Fecundity

Individual Study Areas

We conducted all analyses of reproduction based on the annual number of young produced per territorial female (NYF), but to be consistent with previous reports (Forsman et al. 1996a, Franklin et al. 2004, Anthony et al. 2006), we present the data as "fecundity," where fecundity is the average annual number of female young produced per female owl. We estimated fecundity as NYF/2, based on genetic evidence from blood samples of juveniles that the sex ratio of Spotted Owls is 1:1 at hatching (Fleming et al. 1996). We assumed that the owls in our samples were representative of the population of territorial birds and that sampling was not biased toward birds that reproduced. We think these assumptions were reasonable because Spotted Owls typically occupy the same areas year after year and are reasonably easy to find even in years when they do not breed (Franklin et al. 1996, Reid et al. 1999).

For the analysis of individual study areas, we used PROC MIXED in SAS (SAS Institute, Inc. 2008) to fit a suite of *a priori* models for each study area that included: (1) the effects of age (A), (2) general time variation (t), (3) linear (T) or quadratic (TT) time trends, (4) the proportion of Spotted Owl territories where Barred Owls were detected each year on each study area (BO; see Appendix B), and (5) an even–odd year effect (EO). In addition, we included a simple autoregressive time effect model and the climate and habitat covariates described above (see also Appendix C). The autoregressive time effect model [AR(1)] fits a time trend but allows residuals to be non-independent where $Y_t = \beta_0 + \beta_1 t + \varepsilon_t$ and the correlation of ε_t and $\varepsilon_{t+k} = \rho^k$. Model ranking and selection of best models were based on minimum AIC_c (Burnham and Anderson 2002).

Plots of the annual variance-to-mean ratio for all study areas confirmed that the variance of NYF was nearly proportional to the mean of NYF, with some evidence of smaller variances at higher levels of reproduction. This pattern was consistent with a truncated Poisson distribution

(Evans et al. 1993) because Spotted Owls seldom raise more than two young. However, despite the integer nature of the underlying data (0, 1, 2, and rarely 3 young), the average annual number of young fledged per age class in each study area in each year was not distributed as Poisson (Franklin et al. 1999, 2000; Anthony et al. 2006). For this reason, we did not use a Poisson regression because it is not robust to departures from a Poisson distribution (White and Bennetts 1996). Instead, we used regression models based on the normal distribution, which are less biased when distributions depart from normal. Sample sizes were also sufficiently large to justify the assumption of a normal distribution for each average as long as an allowance was made for the dependence of the variation on the mean (see below; Anthony et al. 2006). The process of averaging NYF also clarified the definition of the sampling unit for this analysis, as the appropriate sample unit was not the individual owl, but the study area–age class combination, which responds to yearly effects that influence the entire study area. Autocorrelation issues in NYF over time for a particular territory were also avoided by treating study areas as the sampling unit. For all these reasons, we used the normal regression model on the annual averages for the analysis of NYF in each age class.

We also reduced the effect of the variance-to-mean relation by fitting models to the annual mean NYF by age class. Annual means for each study area were modeled as

PROC MIXED; MODEL MEAN_NYF = fixed effects.

Thus, residual variation was a combination of year-to-year variation in the actual mean and variation estimated around the actual mean and is approximately equal to

$$\text{var(residual)} = \text{var(yr effects)} + \text{var(NYF)}/n,$$

where n = number of territorial females checked in a particular year. Our approach was justified for several reasons. First, we performed a variance components analysis in which we looked at the individual fecundity records of adult females and estimated the resulting variance components after adjusting for the obvious even–odd year effects. Because Spotted Owls are highly territorial and long-lived, it is difficult to distinguish between spatial and individual effects, and such effects are termed "spatial" components in this report. Our variance components analysis showed that when comparing components of variance, spatial variance among territories tended to be small relative to temporal variance among years and other residual effects (see Results). Therefore, we concluded that ignoring spatial variance within study areas would not bias the results, which negated the need to include owl territory as a random effect. Second, we were able to support the key assumption that the var(residual) was relatively constant because (1) var(NYF)/n was small relative to var(yr effects); (2) the total number of females sampled was roughly constant over time for each study area so that var(NYF)/n was roughly constant; and (3) relatively few (<10%) territorial subadults were encountered, such that var(NYF)/n was also about constant even though var(NYF) may decline with increasing age class. The assumptions were verified by Levene's test for homogeneity of variances (Ramsey and Schafer 2002). Third, we assumed that residual effects were approximately normally distributed because, based on the central limit theorem, the average of the measurements will have an approximate normal distribution with large sample sizes even if the individual measurements are discrete. Finally, covariates included in the analysis of each study area (such as BO) were more easily modeled at the study area (population) level with the above approach.

The best model was not consistent among study areas, so we used a nonparametric approach to estimate mean NYF. First, we computed mean NYF for each year and age class. Then we averaged the means across years within each age class. The estimated standard error was computed as the standard error of the average of the averages among years. This method for estimating NYF gave equal weight to all years, regardless of the number of birds actually sampled in a year, and did not force a model for changes over time. It treated years as random effects with year effects being large relative to within-year-sampling variation. Estimates weighted by sample sizes in each year were not substantially different.

Meta-analysis of Fecundity

In the meta-analysis of fecundity, we restricted the analysis to adult females only because samples of 1- and 2-yr-old owls were small (<10%) in most data sets. In this analysis, we developed a set of *a priori* models similar to those developed for individual study areas, but in addition to the effects included in the models for individual study areas, we also investigated the effects of latitude (LAT), ecoregion (ECO), and land ownership (OWN; Appendix A) as fixed random variables. We did not have habitat covariates for study areas in California, so we conducted two separate meta-analyses of fecundity. The first analysis included all study areas without any habitat covariates, and the second included study areas from Washington and Oregon only, with habitat covariates included in the *a priori* models.

We used mixed models to perform meta-analyses on mean NYF per year for the same reasons specified above for the study area analysis. An ecoregion by year (ECO*yr) treatment combination was defined for each study area with owls within study areas as units of measure. Thus, sampling units were study areas within ECO*yr, which we treated as a random effect in the mixed models. Because ownership, latitude, and ecoregion apply at the study-area level rather than at the individual level, we conducted model selection based on average NYF by study area and year. Model rankings and selection of best models were based on minimum AIC_c or $QAIC_c$ (Burnham and Anderson 2002).

Apparent Survival

Individual Study Areas

We used capture–recapture (re-sighting) data to estimate recapture probabilities (p) and annual apparent survival probabilities (φ) of territorial owls. Recapture probabilities were defined as the probability that an owl alive in year $t+1$ is recaptured, given that it is alive and on the study area at the beginning of year t. Apparent survival was defined as the probability that an owl survives and stays on the study area from time t to $t+1$, given that it is alive at the beginning of year t. Our general approach for estimating apparent survival was to first develop a set of *a priori* models for analysis based on biological hypotheses that were discussed and agreed upon by all participants at the workshop. The *a priori* models were then represented by statistical models in program MARK (White and Burnham 1999). Then we evaluated goodness-of-fit and estimated an overdispersion parameter ($\hat{c}$) for each data set, and estimated recapture probabilities and apparent survival for each capture–recapture data set with the *a priori* models in program MARK. If needed, we adjusted the covariance matrices and AIC_c values with $\hat{c}$ to inflate variances of parameter estimates and obtain $QAIC_c$ values for model selection. Then, we selected the most parsimonious model for inference based on the $QAIC_c$ model selection procedure (Burnham and Anderson 2002). Additional details on methods of estimation of survival from capture–recapture data from Northern Spotted Owls are provided by Burnham et al. (1994, 1996) and Anthony et al. (2006).

We used Cormack–Jolly–Seber open population models (Cormack 1964, Jolly 1965, Seber 1965, Burnham et al. 1987, Pollock et al. 1990, Franklin et al. 1996) in program MARK (White and Burnham 1999) to estimate apparent survival of owls for each year. The yearly estimate of apparent survival was roughly from 15 June in year t to 14 June in year $t+1$, which corresponded with the approximate mid-point of the annual field season in the demographic studies (March or April to August). Owls first banded as subadults or adults were assigned to one of three non-juvenile age classes based on plumage attributes (Forsman 1981, Moen et al. 1991, Franklin et al. 1996). The three age classes were: 1-yr-old subadults (S1), 2-yr-old subadults (S2), and ≥3-yr-old adults (A). We did not estimate juvenile survival rates because estimates of juvenile survival were confounded by permanent emigration caused by natal dispersal (Burnham et al. 1996, Forsman et al. 2002). Although permanent emigration can also cause underestimates of survival for non-juvenile owls, we did not consider this a serious bias because site fidelity of adult Spotted Owls is high and because breeding dispersal is most commonly restricted to short movements between adjacent territories (Forsman et al. 2002).

The goal of the data analysis and model selection process was to find a model from an *a priori* list of models that was best in the sense of Kullback–Leibler information (Burnham and Anderson 2002). Prior to model fitting we used the global model φ(a*s*t), *p*(a*s*t) to evaluate each data set for goodness-of-fit to the assumptions of the Cormack–Jolly–Seber model using the combined χ^2 values and degrees of freedom for Test 2 and Test 3 from program RELEASE (Lebreton et al. 1992). The global model included estimates of age (a), sex (s) and time (t) effects, plus the interactions among age, sex, and time for both φ and *p*.

We computed estimates of overdispersion ($\hat{c}$) using the median-$\hat{c}$ procedure in program MARK to determine if there was evidence of overdispersion in the data. In cases where there was evidence of overdispersion, we used estimates of $\hat{c}$ to inflate standard errors and adjust the log-likelihood function for the effects of lack of independence in the data.

For the analysis of survival on the individual study areas, we fit models that included the effects of age, sex, time, time trends (linear, quadratic, autoregressive, change-point, cubic spline), and the annual covariates for reproduction (Appendix D) and Barred Owls (Appendix B). We used cubic spline models to fit flexible trends without specifying their form (Hastie and Tibshirani 1990, Green and Silverman 1994, Venables and Ripley 1999). Spline models provide this flexibility by estimating cubic polynomial trends between a series of four knots (two boundary, two interior) in such a way that the polynomials meet smoothly (i.e., are differentiable) at each knot. Boundary knots were placed at the starting and ending year for each study, while one interior knot was placed midway between the first year of each study and 2002, and the other interior knot was placed at 2002. Cubic spline models with two interior knots estimated six additional parameters each.

We conducted model selection in three stages. First, we identified the best *p* structure for the data in each study area by using AIC_c model selection (see below) to choose the best model from among a set of *a priori* recapture models developed during the protocol session. The *a priori* models included 11 models that were the same for all study areas (Appendix E) plus up to three optional "biologist's choice" models that could be included if group leaders wanted to evaluate the effects of unique conditions on their study areas. In this stage, we used the same global structure on φ for all models [φ(g*s*t)], where "g" indicates study area. Then, in stage two, we applied the best *p* structure from stage one to 64 *a priori* survival models developed during the protocol session (Appendix F) and used AIC_c model selection to identify the best survival model for each study area. Then, we used the φ structure from the best 2 to 3 models in stage two in combination with the *p* structure from the best 2 to 3 models in stage one to develop 4 to 9 additional models.

We used maximum likelihood estimation to fit models (Brownie et al. 1978, Burnham et al. 1987) and optimized parameter estimation using program MARK (White and Burnham 1999). We used $QAIC_c$ for model selection (Lebreton et al. 1992, Burnham and Anderson 2002), which is a version of Akaike's Information Criterion (Akaike 1973, 1985; Sakamoto et al. 1986) corrected for small sample bias (Hurvich and Tsai 1989) and overdispersion (Lebreton et al. 1992, Anderson et al. 1994). We computed $QAIC_c$ for each candidate model and selected the model with the lowest $QAIC_c$ value as the best model for inference. We used $\Delta QAIC_c$ values to compare models, where $\Delta QAIC_{ci} = QAIC_{ci} - \min QAIC_c$. We used Akaike weights (w_i) (i.e., model probabilities) to address model selection uncertainty and the degree to which ranked models were considered competitive. We also used Akaike weights to compute estimates of time-specific, model-averaged survival rates and their standard errors for each study area (Burnham and Anderson 2002:162). We used model averaging because there were usually several competitive ($\Delta QAIC_c < 2.0$) models for a given data set (Burnham and Anderson 2002).

For each study area, we used the variance components module of program MARK to estimate temporal process variation ($\sigma^2_{temporal}$; White et al. 2001, Burnham and White 2002). Use of variance components allowed us to separate sampling variation (variation attributable to estimating a parameter from a sample) in apparent survival estimates from total process variation. Process variation was decomposed into temporal (parameter variation over time) and spatial (individuals on territories) components.

Meta-analysis of Apparent Survival

The meta-analysis of apparent survival rates was based on capture histories of adult males and females from 11 study areas. Subadults were not included because samples of subadults were small in many study areas, and our objective was to reduce the complexity of the analysis to focus on the main variables of interest, including trends in adult survival and the effects of the Barred Owl, reproduction, weather, and habitat covariates. Apparent survival and recapture probabilities were estimated with the Cormack–Jolly–Seber model using program MARK (White and Burnham 1999). The global model for these analyses was φ(g*s*t) *p*(g*s*t), where g was study area, s was sex, and t was time (yr). Goodness-of-fit was assessed with the global model in program RELEASE (Burnham et al. 1987), and the estimate of overdispersion (c) was computed as the average of the $\hat{c}$ estimates from the median-$\hat{c}$ routine for each of the 11 study areas, weighted by the number of owls in each study area analysis. Estimates of overdispersion were used to adjust model selection to $QAIC_c$ and to inflate variance estimates. We initially evaluated eight models of recapture probability [*p*(g+t), *p*(R), *p*(g+s+t), *p*(R+s), *p*([g+t]*s), *p*(R*s), *p*(BO), *p*(BO+g)] with a general structure on apparent survival [φ(g*t+s)], where R indicates the effect of reproduction in the current year and BO indicates the potential effect of Barred Owls. Using the best model structure for *p* from the initial eight models, we evaluated 15 additional models for apparent survival to determine which combinations of area, sex, time, Barred Owl effects (BO), and reproductive effects (R) minimized the amount of Kullback–Leibler information loss (Appendix G). Sex was then removed from the best model to check for strength of this effect. Then we ran four more models in which the group effect of study area (g) was replaced with the group surrogates OWN, ECO, OWN*ECO, and Latitude (LAT). Next, we added six climate covariates for all study areas and a habitat covariate (HAB1) for study areas in Washington and Oregon. The habitat covariate was added to the base model of φ(g) as either an additive (+) or an interactive (*) effect. Comparable habitat data were not available for study areas in California, so the habitat covariate was applied only to study areas in Washington and Oregon. Time variation for California study areas was modeled with an additive time effect (t) instead of habitat. Climate data for the Southern Oscillation Index (SOI), Pacific Decadal Oscillation (PDO), mean amount of precipitation during the early nesting season (ENP), and mean temperature during the early nesting season (ENT) were added to the base model of φ(g) as either additive (+) or interactive (*) effects.

After reviewing the results of the above analyses, we concluded that the annual variability in apparent survival was too great for any of the covariates for Barred Owls, reproduction, habitat, or climate to have a measurable effect on the modeling or estimates. Consequently, we used the Method of Moments random effects module (White et al. 2001) in program MARK to do some additional *a posteriori* modeling of apparent survival with the above covariates in order to determine the amount of temporal variability explained by each covariate. We used the general model φ(g*t) *p*(g+s+t) in the random effects analysis. To estimate the temporal variation explained by each covariate, a random effects design matrix was used that included the study area effect (g) plus the temporal covariate.

Annual Rate of Population Change (λ)

Individual Study Areas

In the analysis of annual finite rate of population change (λ), we used estimates from the reparameterization of the Jolly–Seber capture–recapture model (λ_{RJS}), which was implemented in program MARK based on the *f*-parameterization of the temporal symmetry models of Pradel (1996; see also Franklin 2001). The rationale for using this parameterization instead of Leslie matrix models was discussed in detail in Franklin et al. (2004) and Anthony et al. (2006). Most importantly, estimates of survival rates for juvenile owls from capture–recapture data are biased low because of extensive emigration from the study areas; losses to natal dispersal lead to negatively biased estimates of λ from Leslie matrix models (Anthony et al. 2006). Since the Pradel (1996) method analyzes capture histories in both a forward and backward manner, it treats mortality, reproduction (recruitment), and movements into and out of the study areas equally, and therefore produces less-biased estimates of λ (see Anthony et al. 2006:11 to 13). The two primary assumptions of the Pradel (1996) method are that study area size is constant and that survey effort is relatively constant in each sampling interval. In other words, owls are not gained or lost because of changes in effort or survey area.

In addition to obtaining annual estimates of λ (λ_t) and trends over time in these estimates, the Pradel model allowed for the decomposition of λ_t into two components, apparent survival (φ) and recruitment (f), where:

$$\lambda_t = \varphi_t + f_t$$

Here, φ_t is local apparent survival and reflects both survival of territory holders within study areas and site fidelity of territory holders to study areas. Recruitment (f_t) is the number of new animals in the population at time $t + 1$ per animal in the population at time t and reflects both *in situ* recruitment (individuals born on the study area that become established territory holders) and immigration of recruits from outside the study area. Unfortunately, we were unable to further decompose φ_t and f_t. The complement of adult survival includes losses to death and permanent emigration, whereas recruitment includes immigration of new adults, as well as reproductive rate, survival of young, and ability of young birds to obtain territories. Consequently, the estimates of λ_t accounted for all of the losses and gains in the study area populations during each year. All estimates of λ were truncated at 2006, because parameter estimates for the last two years of study were not estimable. In addition, we removed 1 to 5 of the first years of surveys to eliminate any potential bias in estimates of λ that may have been associated with any artificial population growth associated with initial location and banding of owls that occurred during the first few years of each study (Anthony et al. 2006). Our procedure resulted in truncated data sets for each study area, which satisfied the second assumption of equal sampling effort for the Pradel (1996) method.

Estimates of Realized Population Change

We used the methods of Franklin et al. (2004) to convert estimates of λ_t to estimates of realized population change ($\hat{\Delta}_t$), which is the proportional change in estimated population size relative to population size in the initial year of analysis. We computed annual estimates of realized population change on each study area as

$$\hat{\Delta}_t = \prod_{i=x}^{t-1} \hat{\lambda}_i$$

where x was the year of the first estimated λ_t. To compute 95% confidence intervals for Δ_t, we used a parametric bootstrap algorithm (see Franklin et al. 2004:19) with 1,000 simulations. Under this approach, we used the estimates of annual survival, $\hat{\varphi}_t$, recruitment, $\hat{f}_t$, and recapture probabilities, $\hat{p}_t$, together with an estimate of initial abundance, $\hat{N}_x$, to stochastically generate individual capture histories. Each of the 1,000 generated data sets (sets of capture histories) was then analyzed as data and used to obtain estimates of λ_t and Δ_t, from which empirical confidence intervals were constructed. Specifically, we followed the basic approach of Anthony et al. (2006), where the 95% confidence intervals were based on the *i*th and *j*th values of Δ_t arranged in ascending order, where $i = (0.025)(1{,}000)$ and $j = (0.975)(1{,}000)$.

Meta-analysis of Annual Rate of Population Change

We used encounter histories from banded territorial owls (subadults and adults) in the meta-analysis of λ from the 11 study areas. In this analysis, we used the most general model [$\varphi(g^*t)$ $p(g^*t)$ $f(g^*t)$] as the basis of the random effects modeling. Our approach permitted inferences about the influence of the various covariates on λ_t, φ_t, and f_t and allowed us to investigate whether φ_t or f_t appeared to covary more closely with λ_t. Modeling results included models in two categories: 45 models in the original *a priori* model set and six additional models developed *a posteriori* after looking at the results of the initial model set (Appendix H). Basically, there was evidence from the ranking of the *a priori* models that two covariates (ecoregions, Barred Owls) were important sources of variation for φ_t and f_t, so we developed six models that included both covariates (see last six models in Appendix H). Thus, our inferences were based on the original members of the model set, but we believe that the two-covariate models that we explored should be considered for future modeling in the next cooperative meta-analysis. As in the analyses of individual study areas, estimates of λ from the meta-analysis were truncated at 2006, because parameters for the last two years of study were not estimable.

Statistical Conventions

We used estimates of regression coefficients (β) and their 95% confidence intervals as evidence of an effect on fecundity, apparent survival, or annual rates of population change by the different factors or covariates in models. The sign of the coefficient represented a positive (+) or negative (-) effect of a factor or covariate, and the 95% confidence intervals were used to evaluate the evidence for $\beta < 0.0$ (negative effect) or $\beta > 0.0$ (positive effect). We did not use 95% confidence intervals as strict tests of $\beta = 0.0$, but as measures of precision and general evidence of an effect. For example, if the 95% confidence intervals for a regression coefficient did not overlap 0 and the covariate was included in the best or a competitive model, we concluded that there was "strong evidence" for an effect of that factor or covariate. If the 95% confidence interval overlapped 0 broadly, regardless of the model it occurred in, we concluded that there was "no evidence" for an effect of that factor or covariate. Lastly, if a 95% confidence interval overlapped 0 only slightly, with <10% of the interval above or below 0, we concluded that there was "some evidence" of an effect of that factor or covariate. We attempted to use this approach consistently throughout all of the modeling of fecundity, apparent survival, and annual rate of population change (Anthony et al. 2006).

WORKSHOP PROTOCOLS

Data from the demographic studies of Northern Spotted Owls have been examined in four previous workshops, the results of which have been described in four published reports (Anderson and Burnham 1992, Burnham et al. 1994, Forsman et al. 1996a, Anthony et al. 2006) and one unpublished report (Franklin et al. 1999). Participants in these workshops knew that their data and methods would be subjected to considerable scrutiny, and they developed a transparent and consistent protocol for conducting the analyses (Anderson et al. 1999). We followed the same protocol in our workshop, which was held during 9 to 19 January, 2009. Our first step was to subject the data to a formal error-checking process prior to the workshop to make sure that all data were correctly prepared for analysis and that all participants followed the same field protocols for assessing fecundity and survival of owls. The error-checking process was accomplished by first having the lead biologist on each study area prepare their fecundity files and capture history files in a standardized format for analysis in programs SAS (SAS Institute, Inc. 2008) or MARK (White and Burnham 1999). Then we had each group leader submit the field data forms for a randomly selected sample of 10 records each from their fecundity files and capture history files. If the data were correctly formatted and the field data forms supported the data in the random sample, then the data were approved for analysis. If not, the study area leader was apprised of any problems and asked to review and correct their files before resubmitting another 10 randomly selected records for review. The resampling process was repeated until no errors were found in the random samples from each area. Upon arrival at the workshop, each study area leader signed a form stating that their data had passed the error-checking process and were ready for analysis.

Once at the workshop, the entire group of biologists and analysts met and discussed the plausible hypotheses and developed the protocols and *a priori* models that were used in the analysis (Anderson et al. 1999). The planning part of the workshop involved 2.5 days of discussion, including presentations and discussions regarding the covariates that were available for analysis. Once the protocol session was complete and everyone was in agreement regarding which hypotheses would be used and how they would be modeled, the analysis began, and all participants agreed that, regardless of the outcome, they would not withdraw their data once the analysis started.

RESULTS

Fecundity

Individual Study Areas

Estimates of fecundity (mean number of female young fledged per female per year) were based on 11,450 observations of the number of young produced by territorial females. Female age was an important factor affecting fecundity on all areas (Table 2), with mean fecundity generally lowest for 1-yr-olds (0.070 ± 0.015), intermediate for 2-yr-olds (0.202 ± 0.042), and highest for adults (0.330 ± 0.025; Table 3). Estimates of mean fecundity also varied among study areas (Table 3). The overall composition of the territorial female population across all areas and years was 3.8% 1-yr-olds, 6.1% 2-yr-olds, and 90.1% adults. Mean fecundity of adults and 2-yr-olds was markedly higher on the CLE study area than on all other study areas (Table 3).

In 9 of the 11 study areas, the best model or a competitive model included a biennial pattern of high reproduction in even years and low reproduction in odd years (EO effect; Table 2). However, this even–odd year effect was stronger in some areas than others and appeared to be less prominent in the later years of the study (Fig. 3). In addition, alternative models with other types of time effects on fecundity [T, TT, AR(1)] were competitive with the EO models (Table 2). Thus, no single model adequately explained the annual variation in fecundity across all areas.

Of the 11 study areas, seven (CLE, COA, HJA, TYE, KLA, NWC, GDR) had top models or competitive models that included linear (T) or quadratic (TT) time trends on fecundity (Table 2). The best model that included a linear or quadratic time trend on fecundity is listed for each study area in Table 4, along with the slope coefficients and 95% confidence intervals for each model. Based on 95% confidence intervals for β's that either did not overlap zero or barely overlapped zero (Table 4), we concluded that fecundity was declining in five areas (CLE, KLA, CAS, NWC, GDR), stable in three areas (OLY, TYE, HUP), and increasing in three areas (RAI, COA, HJA). Although the best trend model for CAS was not competitive (ΔAIC_c = 6.07), the 95% confidence interval for the slope coefficient from that model did not include zero, suggesting this was an important, if not the best, effect that we investigated for fecundity on CAS (Table 4). Annual variation in fecundity was high on the Washington study areas compared to study areas in Oregon

TABLE 2

Best model and competing models with $\Delta AIC_c < 2.0$, from the analysis of mean age-specific fecundity for female Northern Spotted Owls on 11 study areas in Washington, Oregon, and California.

Study area	Models[a]	K	$-2\log L$	AIC_c	ΔAIC_c	w_i
Washington						
CLE	A + AR(1)	5	85.1	96.5	0.00	0.24
	A + AR(1) + HAB1	6	84.1	98.1	1.51	0.11
	A + T + AR(1)	6	84.1	98.2	1.69	0.11
RAI	A + EO + ENT	6	33.0	48.5	0.00	0.28
OLY	EO	3	52.1	58.9	0.00	0.22
	A + EO	5	47.7	60.0	1.10	0.13
	EO + HAB1	4	51.3	60.7	1.80	0.09
Oregon						
COA	A + T + AR(1) + HAB1	7	-3.7	13.5	0.00	0.06
	A + EO	5	2.2	13.8	0.30	0.05
	A + EO + HAB1	6	-0.5	13.8	0.30	0.05
	A + EO + ENT	6	-0.5	13.8	0.40	0.05
	A + EO + BO	6	-0.5	13.9	0.40	0.05
	A + AR(1) + HAB1	6	-0.2	14.1	0.60	0.04
	A + EO + T	6	-0.1	14.2	0.70	0.04
	A + T + HAB1	6	-0.1	14.3	0.80	0.04
	A + AR(1)	5	2.9	14.3	1.00	0.04
	A + T + AR(1)	6	0.3	14.6	1.10	0.03
	A + EO + T + HAB1	7	-2.6	14.6	1.10	0.03
	A + EO + SOI + HAB1	7	-2.5	14.7	1.20	0.03
	A + EO + ENP	6	0.7	15.1	1.60	0.03
	A + EO + BO + TT	7	-1.8	15.4	1.90	0.02
	A + TT + EO + AR(1)	8	-4.8	15.4	1.90	0.02
HJA	A + EO + HAB1	6	25.2	39.3	0.00	0.17
	A + EO + BO + HAB1	7	22.6	39.4	0.10	0.16
	A + EO + T + HAB1	7	23.7	40.5	1.20	0.09
	A + EO + LNP + HAB1	7	23.9	40.7	1.40	0.08
TYE	A + AR(1) + HAB1	6	28.2	42.0	0.00	0.19
	A + TT + AR(1) + HAB1	8	22.9	42.0	0.00	0.19
	A + T + AR(1) + HAB1	7	26.1	42.5	0.50	0.15
	A + T + AR(1)	6	28.8	42.6	0.60	0.14
	A + AR(1)	5	32.5	43.7	1.70	0.08
KLA	A + EO + T + HAB1	7	13.0	29.4	0.00	0.07
	A + BO	5	18.8	30.1	0.60	0.05

TABLE 2 *(continued)*

TABLE 2 (CONTINUED)

Study area	Models[a]	K	$-2\log L$	AIC_c	ΔAIC_c	w_i
	A + EO + BO + HAB1	7	13.7	30.1	0.60	0.05
	A + EO + HAB1	6	16.3	30.1	0.60	0.05
	A + EO + BO	6	16.6	30.4	0.90	0.04
	A + TT	6	16.9	30.7	1.30	0.04
	A + BO + HAB1	6	17.0	30.8	1.40	0.04
	A + EO + TT	6	14.4	30.8	1.40	0.04
	A*EO + T + HAB1	9	9.0	31.1	1.70	0.03
	A + EO + BO + T	7	14.9	31.3	1.90	0.03
	A	4	22.5	31.4	1.90	0.02
CAS	A + EO + ENT + HAB1	7	36.2	52.9	0.00	0.51
California						
NWC	A + T	5	45.4	56.4	0.00	0.18
	A + T + AR(1)	6	43.9	57.3	0.90	0.12
	A*EO + T	8	38.8	57.3	0.93	0.12
	A + TT	6	44.9	58.3	1.94	0.07
	A + EO + T	6	44.9	58.3	1.94	0.07
	A + BO + T	6	44.9	58.3	1.95	0.07
HUP	A + EO + ENT	6	-1.3	13.1	0.00	0.16
	A + PDO	5	2.1	13.8	0.64	0.12
	A + ENT	5	2.3	14.0	0.85	0.10
	A + EO + PDO	6	-0.4	14.0	0.88	0.10
	A + ENP	5	3.2	14.8	1.70	0.07
GDR	A + EO + T	6	-13.1	0.6	0.00	0.28
	A + EO + BO	6	-12.2	1.5	0.91	0.18

[a] Model notation indicates structure for effects of owl age (A), even–odd years (EO), linear time (T), quadratic time (TT), autoregressive time [AR(1)], proportion of territories with Barred Owl detections (BO), percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1), early nesting season precipitation (ENP), late nesting season precipitation (LNP), early nesting season temperature (ENT), and Pacific Decadal Oscillation (PDO). Habitat information was not available for California, so we did not fit models with habitat covariates for study areas in California.

and California, which may have made it more difficult to detect trends in Washington (Fig. 3). For example, there were a few years with zero reproduction on the RAI and OLY study areas in Washington, whereas years with no reproduction were rare on study areas in Oregon and were never observed in any of the California study areas (Fig. 3).

Models that included the Barred Owl covariate were part of the top model or competitive models for five study areas (COA, HJA, KLA, NWC, GDR; Table 2). Confidence intervals for the slope coefficients of the Barred Owl effect from the best linear or quadratic time-trend model that included the BO covariate indicated a negative relationship between Barred Owls and fecundity on four study areas (COA, KLA, CAS, GDR) and a positive relationship between Barred Owls and fecundity on one study area (HJA; Table 5). On the other six areas (CLE,

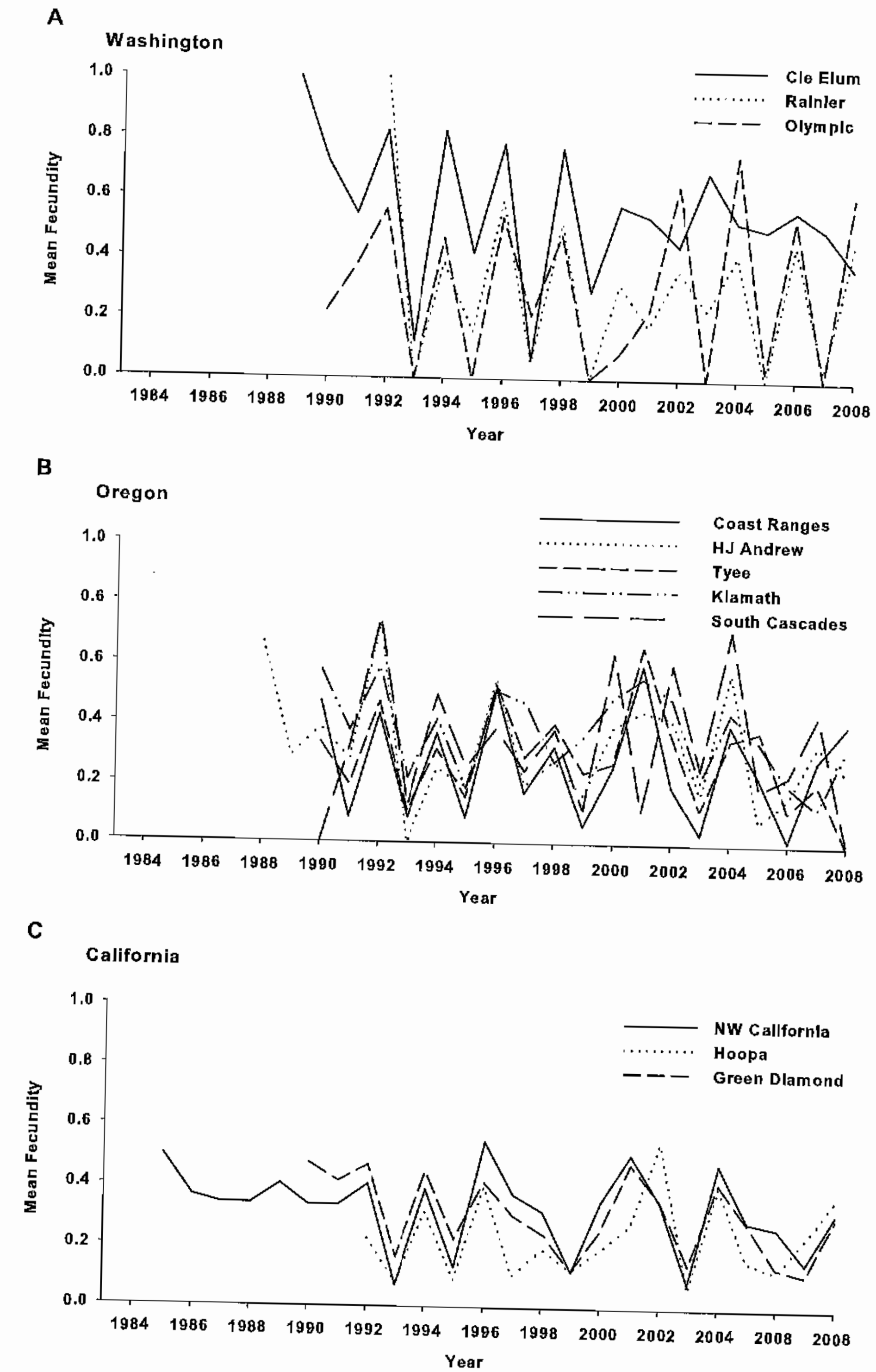


Figure 3. Annual fluctuations in mean fecundity (number of female young fledged per female) of adult Northern Spotted Owls in three study areas in Washington (A), five study areas in Oregon (B), and three study areas in California (C).

TABLE 3

Estimates of mean fecundity (number of female young produced per female) of Northern Spotted Owls on 11 study areas in Washington, Oregon, and California, subdivided by age class.

Study area	Years	S1			S2			Adults		
		n^a	$\bar{x}$	SE	n^a	$\bar{x}$	SE	n^a	$\bar{x}$	SE
Washington										
CLE	1989–2008	27	0.115	0.083	36	0.517	0.109	499	0.553	0.052
RAI	1992–2008	6	0.100	0.100	11	0.111	0.111	269	0.302	0.065
OLY	1990–2008	8	0.150	0.100	12	0.361	0.162	711	0.300	0.060
Oregon										
COA	1990–2008	25	0.000	0.000	53	0.094	0.039	1,460	0.263	0.040
HJA	1988–2008	15	0.083	0.083	48	0.110	0.043	1,184	0.323	0.041
TYE	1990–2008	67	0.018	0.013	87	0.218	0.065	946	0.305	0.034
KLA	1990–2008	90	0.056	0.024	133	0.289	0.045	1,137	0.377	0.033
CAS	1991–2008	37	0.060	0.038	68	0.210	0.064	1,176	0.347	0.052
California										
NWC	1985–2008	71	0.088	0.054	94	0.152	0.038	1,108	0.324	0.027
HUP	1992–2008	17	0.000	0.000	25	0.077	0.052	377	0.230	0.033
GDR	1990–2008	69	0.095	0.034	126	0.080	0.024	1,458	0.305	0.030
Averages		11	0.070	0.015	11	0.202	0.042	11	0.330	0.025

[a] Sample size indicates the number of cases in which we sampled owls in each age class. This is not a sample that was used to calculate means and standard errors. Those estimates were based on the number of years in the survey period. Estimates were determined using a nonparametric approach. Total number of samples by age class was: S1 = 432, S2 = 693, Adult = 10,325.

RAI, OLY, TYE, NWC, HUP), the 95% confidence intervals on the slope coefficients of the Barred Owl effect broadly overlapped zero, indicating little evidence of an effect of Barred Owls on fecundity (Table 5). In all study areas, the proportion of Spotted Owl territories with Barred Owl detections was increasing with time, but variable among study areas (Appendix B). As a result, temporal trends in fecundity and the Barred Owl covariate were negatively correlated and not easily separated. On some study areas, the temporal effect on fecundity may have been stronger, and this may explain, in part, the lack of effects of Barred Owls on fecundity in some areas. As a result, there was general uncertainty in selection of models with time trends versus Barred Owl effects for most study areas (Table 2).

The habitat covariate (HAB1) was in the top model for all study areas in Oregon, and in competitive models for two of the three study areas in Washington (Table 2). In Oregon, all 95% confidence intervals for regression coefficients for the habitat covariate excluded zero, and on four of the five areas (COA, HJA, TYE, CAS) the habitat effect was positive as predicted, with increased reproductive success associated with increased amounts of suitable habitat. The exception was the KLA study area, where there was evidence that reproductive success declined with increases in suitable habitat (Table 6). On all three study areas in Washington, 95% confidence intervals for the habitat covariate broadly overlapped zero, indicating that there was little evidence for a habitat effect on fecundity on those areas (Table 6).

TABLE 4

Regression coefficients ($\hat{\beta}$) for time trends on the mean annual number of young fledged by adult female Northern Spotted Owls in 11 study areas in Washington, Oregon, and California.

Estimates based on the best model containing linear (T), quadratic (TT), or autoregressive [AR(1)] time trends.

Study area	Best model[a]	ΔAIC_c	$\hat{\beta}$	$\widehat{SE}$	95% CI Lower	95% CI Upper
Washington						
CLE	A + T + AR(1)	1.69	-0.005	0.006	-0.017	0.006
RAI	A + EO + BO + T	4.49	0.030	0.017	-0.005	0.065
OLY	A + EO + T	3.89	0.004	0.008	-0.014	0.021
Oregon						
COA	A + AR(1) + T + HAB1	0.00	0.070	0.035	-0.001	0.142
HJA	A + EO + T + HAB1	1.22	0.010	0.008	-0.006	0.027
TYE	A + TT + AR(1) + HAB1[b]	0.00	0.106	0.046	0.014	0.197
			0.002	0.001	-0.000	0.004
KLA	A + EO + T + HAB1	0.00	-0.024	0.008	-0.039	-0.008
CAS	A + EO + T	2.34	-0.015	0.005	-0.026	-0.004
California						
NWC	A + T	0.00	-0.009	0.003	-0.015	-0.003
HUP	A + T	4.40	0.005	0.004	-0.004	0.013
GDR	A + EO + T	0.00	-0.007	0.003	-0.012	0.002

[a] Model notation indicates structure for effects of owl age (A), even–odd years (EO), linear time (T), quadratic time (TT), autoregressive time [AR(1)], proportion of territories with Barred Owl detections (BO), percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1), early nesting season precipitation (ENP), early nesting season temperature (ENT), and Pacific Decadal Oscillation (PDO). Habitat information was not available for California, so we did not fit models with habitat covariates for study areas in California.

[b] The first estimate is the linear term, and the second is the quadratic term.

Weather or climate covariates occurred in competitive models for RAI, COA, HJA, CAS, and HUP (Table 2), but the best covariate and the direction of the effect varied among areas (Table 7). In particular, the effect of temperature during the early nesting season (ENT) occurred in the top model or a competitive model for four study areas (RAI, COA, CAS, HUP; Table 2). In three of those areas (RAI, COA, CAS), fecundity was positively associated with ENT, as predicted, but the confidence intervals on the slope coefficient for COA included zero (Table 7). In contrast, fecundity was negatively associated with ENT on the HUP study area, which was contrary to what we predicted (Table 7). ENT was also the best climate covariate for GDR, but the model containing ENT was not competitive, and 95% confidence limits on the slope coefficients for the ENT effect included zero (Table 7).

Precipitation during the early nesting season (ENP) occurred in a competitive model for one study area (COA) and was the best weather/climate covariate for CLE and NWC as well (Table 7). The 95% confidence intervals on the slope coefficients for ENP excluded, or just barely included, zero for all three of these study areas, and the association was negative, as predicted (Table 7). There was weak evidence for a negative effect of precipitation on fecundity during the late nesting season (LNP) on the HJA study area, but the 95% confidence interval for

TABLE 5

Regression coefficients (β̂) for the effect of Barred Owls on the mean annual number of young fledged by adult female Northern Spotted Owls in 11 study areas in Washington, Oregon, and California.

Estimates are from the best model that included the Barred Owl (BO) covariate.

Study area	Best model[a]	ΔAIC_c	$\hat{\beta}$	$\widehat{SE}$	95% CI Lower	95% CI Upper
Washington						
CLE	A + TT + BO + AR(1)	5.25	0.584	0.983	-1.397	2.566
RAI	A + EO + BO	4.11	-0.505	0.462	-1.455	0.446
OLY	A + EO + BO	4.05	0.045	0.315	-0.601	0.691
Oregon						
COA	A + EO + BO	0.37	-0.137	0.083	-0.305	0.031
HJA	A + EO + BO + HAB1	0.12	0.289	0.176	-0.065	0.643
TYE	A + TT + BO + AR(1) + HAB1	2.34	-0.513	0.726	-1.972	0.946
KLA	A + BO	0.61	-0.459	0.234	-0.928	0.010
CAS	A + EO + BO	7.40	-0.972	0.387	-1.752	-0.193
California						
NWC	A + BO + T	1.95	0.554	0.806	-1.057	2.165
HUP	A + BO	4.88	0.197	0.230	-0.269	0.662
GDR	A + EO + BO	0.91	-0.494	0.203	-0.902	-0.087

[a] Model notation indicates structure for effects of owl age (A), even–odd years (EO), linear time (T), quadratic time (TT), autoregressive time [AR(1)], proportion of territories with Barred Owl detections (BO), percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1). Habitat information was not available for California, so we did not fit models with habitat covariates for study areas in California.

the beta coefficient overlapped zero (Table 7). The Southern Oscillation Index (SOI) was the best weather/climate covariate for OLY, but the model that included SOI was not competitive with the best model, and the 95% confidence interval on the slope coefficient overlapped zero (Table 7). The best weather/climate covariate for TYE indicated a negative effect of late nesting season temperature (LNT) on fecundity (Table 7). While this model was not competitive with the best model, the 95% confidence limits on the slope coefficient for the effect of LNT excluded zero, suggesting that temperature during the late nesting season was an important effect and possibly the best predictor of fecundity for TYE.

Estimation of spatial (site-to-site), temporal (year-to-year), and residual variance on the territory-specific data from the best models indicated that the proportion of variance in number of young fledged attributable to territories and/or individual owls (spatial) was generally <6% (Table 8). The proportion of variance attributable to fluctuations over time was usually in the range of 10 to 20%, while the proportion of unexplained (residual) variation was generally >80%. As a consequence, the explainable variation in fecundity by time and territory was overwhelmed by unexplained, residual variation.

Meta-analysis of Fecundity

The meta-analysis of fecundity for all study areas with no habitat covariates included produced three competitive models (ECO+t, LAT+t, ECO+t+BO), which accounted for 42%,

TABLE 6

Regression coefficients (β̂) from the best model containing the effect of habitat on the mean annual number of young fledged per adult female Northern Spotted Owl in eight study areas in Washington and Oregon.

Study area	Best model[a]	ΔAIC_c	$\hat{\beta}$	$\widehat{SE}$	95% CI Lower	95% CI Upper
Washington						
CLE	A + AR(1) + HAB1	1.5	1.236	1.129	-1.248	3.720
RAI	A + EO + ENT + HAB1	3.2	-1.465	3.832	-9.356	6.426
OLY	EO + HAB1	1.8	-9.253	10.305	-30.300	11.792
Oregon						
COA	A + T + AR(1) + HAB1	0.0	15.672	7.346	0.792	30.552
HJA	A + EO + HAB1	0.0	11.313	2.650	5.787	16.475
TYE	A + AR(1) + HAB1	0.0	0.909	0.432	0.031	1.788
KLA	A + EO + T + HAB1	0.0	8.737	3.415	-15.600	-1.871
CAS	A + EO + ENT + HAB1	0.0	6.066	2.313	1.405	10.727

[a] Model notation indicates structure for effects of owl age (A), even–odd years (EO), linear time (T), autoregressive time [AR(1)], percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1), early nesting season temperature (ENT), and forest habitat within 2.4 km radius of owl territory (HAB1). Habitat information was not available for California, so we did not fit models with habitat covariates for study areas in California.

34%, and 19% of the model weights, respectively (Table 9). These three models suggested that fecundity varied by time and was parallel across ecoregions or latitudinal gradients (Fig. 4), with some weak evidence for an additional Barred Owl effect. The estimate of the regression coefficient for the best model with the BO effect was negative, suggesting fecundity decreased as the proportion of territories where Barred Owls were detected increased. However, the 95% confidence interval for the beta coefficient for the BO effect overlapped zero ($\hat{\beta}$ = -0.12, SE = 0.10, 95% CI = -0.31 to 0.07). A linear time trend (T) in fecundity was not supported by the meta-analysis because of the high variation in fecundity over time and the breakdown of the even–odd year effect after about 1999 (Fig. 4). The ΔAIC_c estimates for the best models that included ownership (OWN+t) or climate (ECO+ENP) were 8.6 and 79.0, respectively, indicating that ownership and climate covariates explained little of the temporal variability in fecundity across the range of the Spotted Owl. Average fecundity over all years was similar among ecoregions except for the Washington Mixed-Conifer region, where mean fecundity was 1.7 to 2.0 times greater than in the other ecoregions (Table 10). Fecundity was lowest for the Oregon Coastal Douglas-fir ecoregion.

The meta-analysis of fecundity for Washington and Oregon, which included the habitat covariate, resulted in two competitive models (ECO+t, ECO+t+HAB1) and a third model that was only slightly less competitive (ECO+t+BO; Table 9). These three models accounted for 55%, 21%, and 17% of the model weights, respectively, and were similar to the most competitive models from the meta-analysis of all study areas, except for the competitive model that included the habitat covariate (Table 9). As in the meta-analysis of all areas, there was some evidence for a weak negative effect of Barred Owls on fecundity, although the 95% confidence

TABLE 7

Regression coefficients ($\hat{\beta}$) from the best model containing the effect of a climate or weather covariate on the mean annual number of young fledged by adult female Northern Spotted Owls in 11 study areas in Washington, Oregon, and California.

Study area	Best model[a]	ΔAIC_c	$\hat{\beta}$	$\widehat{SE}$	95% CI Lower	95% CI Upper
Washington						
CLE	A + ENP	2.57	-0.015	0.005	-0.025	-0.004
RAI	A + EO + ENT	0.00	0.091	0.038	0.013	0.169
OLY	A + EO + SOI	3.06	-0.061	0.060	-0.183	0.062
Oregon						
COA	A + EO + ENT	0.34	0.030	0.018	-0.007	0.067
HJA	A + EO + LNP + HAB1	1.39	-0.004	0.003	-0.011	0.003
TYE	A + LNT	7.45	-0.053	0.025	-0.103	-0.004
KLA	A + ENP	2.22	-0.002	0.001	-0.004	0.001
CAS	A + EO + ENT + HAB1	0.00	0.071	0.024	0.022	0.120
California						
NWC	A + ENP	5.12	-0.002	0.001	-0.004	0.000
HUP	A + EO + ENT	0.00	-0.060	0.024	-0.109	-0.011
GDR	A + EO + ENT	4.69	0.023	0.017	-0.011	0.056

[a] Model notation indicates structure for effects of owl age (A), even–odd years (EO), percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1), early nesting season precipitation (ENP), early nesting season temperature (ENT), late nesting season temperature (LNT), and Southern Oscillation Index (SOI). Habitat information was not available for California, so we did not fit models with habitat covariates for study areas in California.

interval for the beta coefficient for the effect of Barred Owls overlapped zero (β = -0.104, SE = 0.129, 95% CI = -0.369 to 0.151). There was no evidence for an effect of habitat on fecundity in the meta-analysis (β = -0.469, SE = 0.453, 95% CI = -1.363 to 0.426). Linear time trends (T) in fecundity had little support, and models that included ownership (OWN+t) or climate (ECO+ENP+HAB1) were not competitive with the top model (ΔAIC_c = 12.9 and 55.1, respectively).

Apparent Survival

Individual Study Areas

To estimate annual apparent survival we used a sample of 5,244 banded owls, including 796 (15.2%) 1-yr-old subadults, 903 (17.2%) 2-yr-old subadults, and 3,545 (67.6%) adults (Table 1). The total number of recaptures/resightings of banded owls (19,164) was approximately four times the number of initial captures. The overall χ^2 goodness-of-fit for the global model from program RELEASE summed across study areas was 1,543.2 with 972 degrees of freedom (χ^2 = 1.59, $P > 0.10$), indicating good fit of the data to the Cormack–Jolly–Seber open population mark-recapture model (Table 11). The range of χ^2 for the individual study areas was 0.86 to 2.79, with df ranging from 63 to 125 (Table 11), again indicating good fit to the model for most study areas. Examination of the data indicated that the small lack-of-fit to the Cormack–Jolly–Seber open population model was due primarily to temporary emigration, when owls moved off of the study area for one or more years and later returned or were temporarily displaced as a

TABLE 8

Variance components of the mean annual number of young fledged by adult female Northern Spotted Owls from a mixed-model analysis of year- and territory-specific estimates.

Study area	Spatial[a] Estimate	Spatial[a] % Total	Temporal[b] Estimate	Temporal[b] % Total	Residual Estimate	Residual % Total	Total Estimate
Washington							
CLE	0.054	6	0.144	16	0.691	77	0.898
RAI	0.000	0	0.009	2	0.453	97	0.467
OLY	0.005	1	0.109	21	0.399	77	0.518
Oregon							
COA	0.006	1	0.102	17	0.486	81	0.600
HJA	0.000	0	0.084	12	0.604	86	0.702
TYE	0.014	2	0.075	11	0.587	86	0.683
KLA	0.015	2	0.051	7	0.661	90	0.734
CAS	0.015	2	0.118	16	0.592	80	0.740
California							
NWC	0.007	1	0.043	6	0.647	91	0.711
HUP	0.021	4	0.016	3	0.481	92	0.523
GDR	0.013	2	0.040	6	0.605	91	0.665

[a] Spatial process variance is the random effects estimate of territory variability.

[b] Temporal process variance is the random effects estimate of annual variability.

TABLE 9

Model selection results from meta-analyses of the annual number of young fledged per adult female Northern Spotted Owl.

Only models with ΔAIC_c < 10 are shown.

Models[a]	K	$-2\log L$	AIC_c	ΔAIC_c	w_i
All study areas					
ECO + t	31	25.3	98.4	0.0	0.42
LAT + t	27	36.3	98.8	0.4	0.34
ECO + t + BO	32	24.1	99.9	1.6	0.19
t	26	44.5	104.1	5.7	0.04
OWN + t	29	42.4	104.6	8.6	0.01
Washington and Oregon study areas only					
ECO + t	26	34.6	97.9	0.0	0.55
ECO + t + HAB1	27	33.6	99.7	1.9	0.21
ECO + t + BO	27	34.0	100.2	2.3	0.17
ECO + t + BO + HAB1	28	33.2	102.3	4.5	0.06

[a] Model notation indicates structure for effects of ecoregion (ECO), general time (t), proportion of territories with Barred Owl detections (BO), ownership (OWN), and percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1).

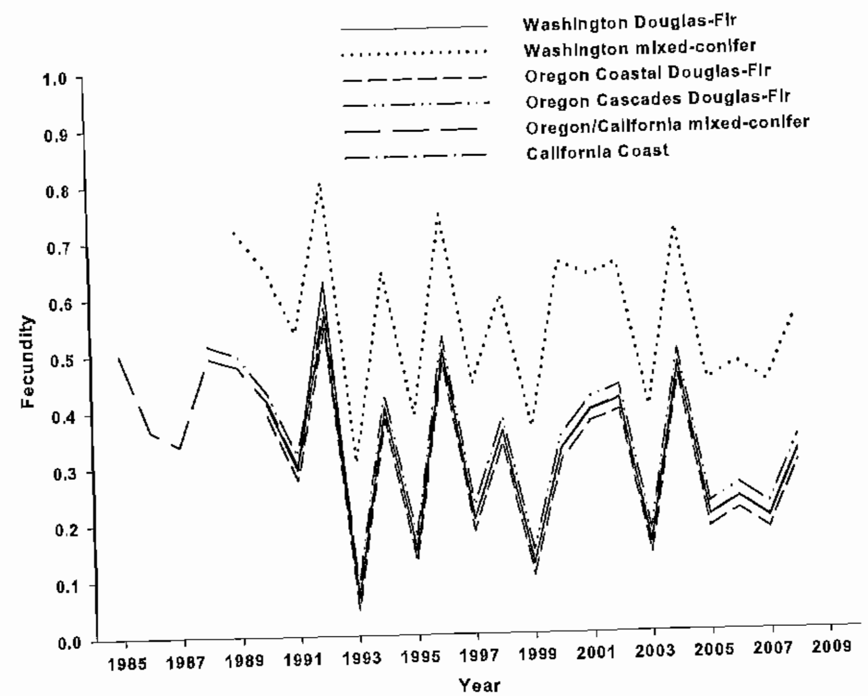


Figure 4. Mean annual fecundity (no. of female young fledged per female) of adult Northern Spotted Owls by ecoregion. Estimates are based on the best model (ECO+t) from a meta-analysis of 11 study areas, where t represents annual time effects and ECO represents the ecoregion effects.

TABLE 10

Estimates of mean annual fecundity (number of female young produced per female) for adult Northern Spotted Owls in six ecoregions.

Ecoregion	$\bar{x}$	SE	95% CI Lower	95% CI Upper
Washington Douglas-fir	0.301	0.043	0.217	0.385
Washington Mixed-conifer	0.553	0.052	0.451	0.655
Oregon Coastal Douglas-fir	0.284	0.026	0.233	0.335
Oregon Cascades Douglas-fir	0.334	0.032	0.271	0.397
Oregon/California Mixed-conifer	0.314	0.019	0.277	0.351
California Coast	0.305	0.030	0.246	0.364

TABLE 11

Estimates of goodness-of-fit and overdispersion ($\hat{c}$) in capture–recapture data for adult Northern Spotted Owls from 11 demographic study areas in Washington, Oregon, and California.

Study area	CJS[a] χ^2	CJS[a] df	CJS[a] χ^2/df	CJS[a] Median-$\hat{c}$	λ_{RJS}[a] χ^2	λ_{RJS}[a] df	λ_{RJS}[a] χ^2/df	λ_{RJS}[a] Median-$\hat{c}$
Washington								
CLE	72.05	68	1.06	0.99	35.21	51	0.69	1.03
RAI	77.39	72	1.07	1.11	33.73	47	0.72	1.00
OLY	151.50	95	1.59	1.08	156.42	104	1.50	1.04
Oregon								
COA	208.65	97	2.15	1.05	168.87	56	3.02	1.17
HJA	189.38	105	1.80	1.09	167.29	78	2.14	1.09
TYE	90.57	72	1.26	1.04	69.68	64	1.09	1.13
KLA	79.67	92	0.87	1.00	87.48	74	1.18	1.03
CAS	170.94	90	1.90	1.00	142.91	65	2.20	1.06
California								
NWC	76.16	89	0.86	1.00	124.93	81	1.54	1.06
HUP	78.64	63	1.25	0.97	46.06	52	0.89	1.09
GDR	348.25	125	2.79	1.00	139.81	50	2.80	1.00
Totals	1,543.20	972	1.59	1.03[b]	1,366.76	847	1.61	na

[a] CJS indicates data sets used for Cormack–Jolly–Seber estimates of apparent survival. λ_{RJS} indicates data sets used for reparameterized Jolly–Seber estimates of annual finite rate of population growth. Values for χ^2 and df are from TEST 2 and TEST 3 in program RELEASE. Estimates of $\hat{c}$ are from median-$\hat{c}$ routine in program MARK. Estimates of $\hat{c} < 1.0$ were set to 1.00 for analysis.

[b] Weighted average across all study areas.

territorial owl. The overall estimate of overdispersion from the median-$\hat{c}$ routine in program MARK was 1.03, with estimates for individual study areas ranging from 0.97 to 1.11 (Table 11). Overall, results of GOF testing indicated there was little to no overdispersion (i.e., lack of independence) of recaptured owls.

Although there were exceptions, estimates of annual recapture probabilities (p) typically were high, ranging from 0.70 to 0.95 on most study areas. High rates of recaptures/resightings make the Spotted Owl an ideal species for mark–recapture studies. In the analyses of recapture probabilities, factors affecting p in the best models varied among study areas (Table 12). For seven of the 11 areas, there was an effect of sex on p; in all seven cases, p was higher for males. Other effects on p in the top models for one or more areas were a variable time effect (OLY, HJA, CAS areas), negative Barred Owl effect (RAI, COA, KLA areas), and/or a positive reproductive effect (RAI, CLE, TYE areas; Table 12). There was no evidence of time trends on p on any study areas. On two study areas, the "biologist's choice" models were the best models for p. The best p model for one of these areas (NWC) included the additive effects of sex and recapture method; in this case, owls were physically recaptured in 1986 to 1987 and then resighted or recaptured in subsequent years. The other case in which the biologist's choice model was the best p model included an east–west division of the HUP study area based on differences in Spotted Owl density, forest type, and ease of access (Table 12).

TABLE 12

Estimates of model-averaged mean apparent survival ($\hat{\varphi}$) for three age classes of Northern Spotted Owls on 11 study areas in Washington, Oregon, and California.

Study area	Structure on best model[a]	Sex	S1[b] $\hat{\varphi}$	S1[b] $\widehat{SE}$	S2[b] $\hat{\varphi}$	S2[b] $\widehat{SE}$	Adult[b] $\hat{\varphi}$	Adult[b] $\widehat{SE}$
Washington								
CLE	φ(CP) p(R)	F	0.794	0.051	0.820	0.023	0.819	0.013
		M	0.795	0.051	0.820	0.023	0.819	0.013
RAI	φ[(S1 = S2, A) + BO] p(BO + R)	F	0.541	0.181	0.674	0.156	0.841	0.019
		M	0.546	0.181	0.678	0.157	0.844	0.018
OLY	φ[(S1, S2 = A) + s + T] p(s + t)	F	0.529	0.148	0.786	0.081	0.828	0.016
		M	0.571	0.145	0.814	0.075	0.852	0.014
Oregon								
COA	φ[(S1 + S2 + A) + TT] p(BO + s)	F	0.742	0.072	0.864	0.031	0.859	0.009
		M	0.748	0.071	0.868	0.030	0.863	0.008
HJA	φ[(S1, S2 = A) + t] p(s + t)	F	0.717	0.084	0.830	0.042	0.865	0.010
		M	0.717	0.084	0.830	0.042	0.864	0.010
TYE	φ[(S1, S2 = A) + TT] p(R + s)	F	0.761	0.043	0.864	0.020	0.856	0.008
		M	0.762	0.042	0.865	0.019	0.857	0.008
KLA	φ[(S1, S2 = A) + t] p(BO + s)	F	0.788	0.040	0.858	0.020	0.848	0.008
		M	0.786	0.040	0.857	0.020	0.847	0.008
CAS	φ[(S1, S2 = A) + TT] p(t)	F	0.692	0.069	0.733	0.053	0.851	0.010
		M	0.697	0.069	0.737	0.053	0.853	0.010
California								
NWC	φ[(S1 = S2, A) + T] p(Meth + s)	F	0.774	0.031	0.784	0.031	0.844	0.009
		M	0.776	0.031	0.787	0.031	0.846	0.009
HUP	φ(S1, S2 = A) p(EW + Effort)	F	0.758	0.087	0.838	0.038	0.854	0.014
		M	0.762	0.086	0.840	0.037	0.857	0.013
GDR	φ[(S1, S2 = A) + BO] p(s)	F	0.767	0.044	0.852	0.015	0.853	0.007
		M	0.764	0.045	0.850	0.015	0.851	0.007

[a] Model notation indicates structure for additive (+) or interactive (*) effects of sex (s), time (t), linear time trend (T), quadratic time trend (TT), 2004 change point (CP), reproduction (R), proportion of territories with Barred Owl detections (BO), age class (S1, S2, A), east–west binomial subdivision of study area (EW), survey method (Meth), or differential survey effort in particular years (Effort). An "=" sign means that age classes were combined, and a "," indicates they were modeled separately.

[b] Age classes (S1, S2, A) indicate owls that were 1, 2, or ≥3 years old. Average survival is the arithmetic mean of model-averaged annual survival estimates. Standard errors were calculated using the delta method.

The best model structure for apparent survival (φ) varied among study areas, but several patterns emerged (Table 12). Most notably, apparent survival tended to be higher for adults than for subadults and was similar between the sexes, except on the OLY study area where males had higher survival than females (Table 12). Presence of Barred Owls, variable time (t), or time trends (T or TT) were important effects on apparent survival in one or more study areas. In the best models for each study area (Table 12), the Barred Owl covariate was included in the φ

TABLE 13

Coefficient estimates (β) for the best models that included a time trend on apparent survival of non-juvenile Northern Spotted Owls on 11 study areas in Washington, Oregon, and California.

Study area	Model trend[a]	$\Delta QAIC_c$	$\hat{\beta}$	$\widehat{SE}$	95% CI Lower	95% CI Upper
Washington						
CLE	CP (T)[b]	0.00	-0.027	0.021	-0.069	0.015
			-0.182	0.073	-0.324	-0.039
RAI	CP (T)[b]	2.48	-0.143	0.057	-0.254	-0.031
			0.205	0.129	-0.048	0.458
OLY	T	0.00	-0.032	0.016	-0.064	0.000
Oregon						
COA	TT[c]	0.21	0.146	0.046	0.056	0.237
			-0.009	0.002	-0.014	-0.005
HJA	T	0.01	-0.013	0.010	-0.033	0.007
TYE	TT[c]	0.00	0.154	0.048	0.060	0.247
			-0.008	0.002	-0.013	-0.003
KLA	CP[d]	4.38	-0.030	0.025	-0.079	0.020
CAS	TT[c]	0.00	0.169	0.058	0.056	0.282
			-0.009	0.003	-0.015	-0.002
California						
NWC	T	0.00	-0.016	0.008	-0.033	0.000
HUP	CP[d]	1.61	-0.031	0.049	-0.127	0.063
GDR	T	0.54	-0.030	0.009	-0.048	-0.011

[a] T = linear time trend, TT = quadratic time trend, CP = change point starting in 2004.

[b] Models that have a change point beyond which the function changes. The first row estimate is the linear time trend (T) and the second is a change point starting in 2004 (CP).

[c] For quadratic models (TT), the first row indicates the linear term and the second row indicates the quadratic term.

[d] Constant survival from start year to 2004, with negative time trend beginning in 2004.

structure for two study areas (RAI, GDR) and the p structure for three study areas (RAI, COA, KLA). The Barred Owl covariate also occurred in competitive models for φ on the OLY and NWC areas (see Effects of Barred Owls on Recapture and Survival below).

Based on the best survival models that included time trends, we concluded that apparent survival was declining on 10 of the 11 study areas (CLE, RAI, OLY, COA, HJA, TYE, CAS, NWC, HUP, GDR), as indicated by 95% confidence intervals on β that either did not overlap zero or narrowly overlapped zero (Table 13). Declines in apparent survival were most evident in Washington, where all β estimates were negative with 95% confidence intervals that did not overlap zero (Fig. 5A). In addition, the declines in apparent survival on the CLE and RAI study areas were most precipitous during the last five years of the study, as represented by the change-point (CP) time structure in the best models and steeper declines after 2004 (Fig. 5A). Annual estimates of apparent survival for owls on the CLE, RAI, and OLY areas

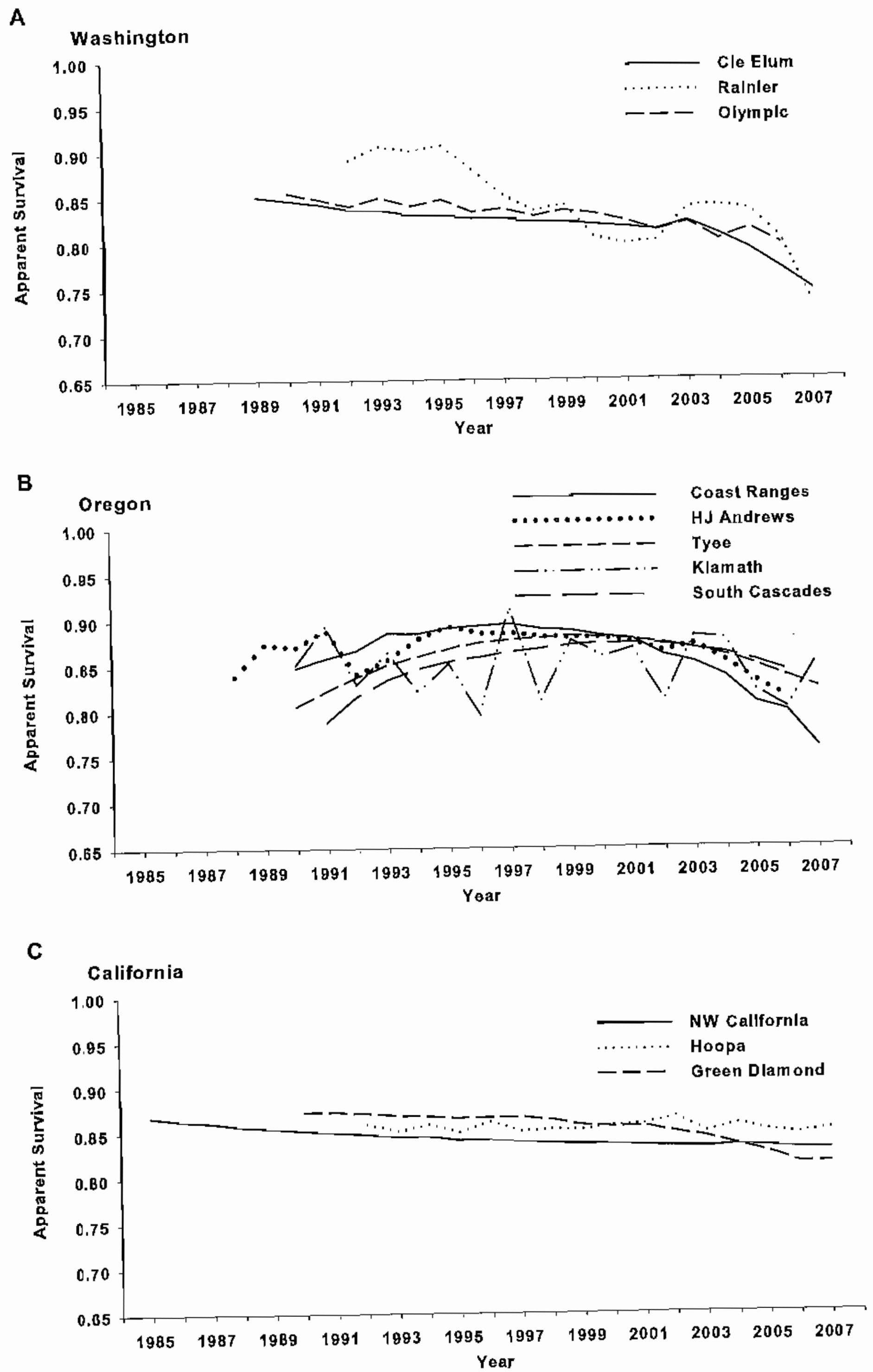


Figure 5. Model averaged estimates of apparent survival of adult female Northern Spotted Owls in three study areas in Washington (A), five study areas in Oregon (B), and three study areas in California (C).

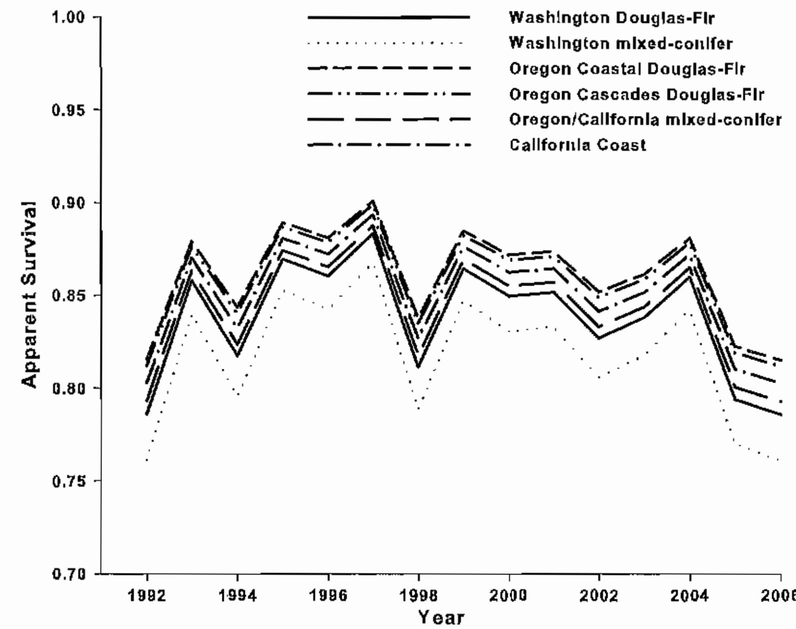


Figure 6. Estimates of apparent annual survival of adult female Northern Spotted Owls in six ecoregions, based on model φ(ECO+t) p(g+t+s) from the meta-analysis of 11 study areas, where ECO represents ecoregion, t represents annual time effects, g represents study area effects, and s represents sex effects.

were <0.80 during the latter years of the study, which were the lowest rates recorded. In Oregon, apparent survival declined on four (COA, HJA, TYE, CAS) of the five study areas, most noticeably during the last five years of study (Fig. 5B). Temporal changes in apparent survival for COA, TYE, and CAS were best described by a quadratic function, whereby survival increased during the early years of the study, then declined during later years. The owl population on the KLA study area was the only one in Oregon that did not have a declining survival rate, as the best model for KLA supported a variable time (t) effect (Table 12). In California, there was strong evidence for linear or change-point declines in apparent survival on all three study areas (NWD, HUP, GDR), as indicated by 95% confidence intervals for β's that either did not overlap zero or only narrowly overlapped zero (Table 13, Fig. 5C).

Meta-analysis of Apparent Survival on All Areas

We used encounter histories from 3,545 adults in the meta-analysis of apparent survival (Table 1). The estimate of goodness-of-fit from program RELEASE indicated good fit of the data to the Cormack–Jolly–Seber open population model (χ^2 = 1740.9, df = 1,012, P > 0.10). The weighted average estimate of median-$\hat{c}$ was 1.031, indicating little overdispersion (i.e., lack of independence) in capture histories. We used this estimate to adjust model selection from AIC_c to $QAIC_c$ and inflate variance estimates accordingly.

The best model from the meta-analysis of apparent survival was the random effects model φ(g*t) p(g+s+t): RE(g+R), which indicated that survival varied among study areas (g) and years (t) and that recapture rates varied among study areas, sexes, and years (Table 14). This model, which had a $QAIC_c$ weight of 0.18, also included the reproduction covariate (R). The effect of reproduction was negative with a 95% confidence interval that barely overlapped zero (Table 15). Several random effects models were competitive, including a second-best model that included the Barred Owl (BO) covariate. The regression coefficient for the BO covariate was negative, with a 95% confidence interval that did not overlap zero (Table 15). For more details on the effects of Barred Owls on apparent survival, see below. Other random effects models with ΔQAIC ≤ 2 from the best model were identical in structure

TABLE 14

Model selection criteria for a priori and post hoc models used in the meta-analysis of apparent survival of adult Northern Spotted Owls on 11 demographic study areas in Washington, Oregon, and California, 1985–2008.

Model[a]	K	Q-Deviance[b]	$QAIC_c^c$	$\Delta QAIC_c$	w_i
Random effects models					
φ(g*t) p(g + s + t): RE (g+R)	142.9	13,470.07	32,659.14	0.00	0.18
φ(g*t) p(g + s + t): RE (g + BO)	142.1	13,471.89	32,659.33	0.19	0.16
φ(g*t) p(g + s + t): RE (g + BO + PDO)	142.2	13,471.86	32,659.57	0.43	0.14
φ(g*t) p(g + s + t): RE (g + PDO)	143.2	13,470.27	32,659.89	0.75	0.12
φ(g*t) p(g + s + t): RE (g + T)	143.0	13,471.01	32,660.26	1.12	0.10
φ(g*t) p(g + s + t): RE (g + Mean)	143.3	13,470.49	32, 660.45	1.31	0.09
φ(g*t) p(g + s + t): RE (g + ENP)	143.7	13,470.15	32,660.82	1.68	0.08
φ(g*t) p(g + s + t): RE (g + ENT)	143.8	13,470.08	32,660.91	1.77	0.07
φ(g*t) p(g + s + t): RE (g + SOI)	143.9	13,470.04	32.661.06	1.93	0.07
φ(g*t) p(g + s + t): RE (g + HAB1)	205.2	13,460.60	32,776.34	117.02	0.00
Fixed effects models					
φ(ECO + t) p(g + s + t)	62	13,732.87	32,758.61	99.47	0.00
φ(ECO + OWN + t) p(g + s + t)	64	13,730.05	32,759.82	100.68	0.00
φ(g + t) p(g + s + t)	67	13,726.38	32,762.18	103.04	0.00
post hoc φ(g + t + BO) p(g + s + t)	68	13,725.04	32,762.86	103.72	0.00
φ(g + s + t) p(g + s + t)	68	13,725.90	32,763.71	104.57	0.00
post hoc φ(g + t + HAB1) p(g + s + t)	68	13,726.30	32,764.11	104.98	0.00
post hoc φ(g*California + HAB1 + t) p(g + s + t)	61	13,743.14	32,766.87	107.74	0.00
φ(LAT + t) p(g + s + t)	58	13,752.30	32,769.96	110.82	0.00
post hoc φ(t + BO) p(g + s + t)	58	13,752.60	32,770.31	111.17	0.00
φ(OWN + t) p(g + s + t)	59	13,752.80	32,772.54	113.40	0.00
φ(g + BO + s) p(g + s + t)	47	13,830.54	32,826.13	166.99	0.00
φ(ECO + T) p(g + s + t)	41	13,842.81	32,826.35	167.22	0.00
φ(g*R) p(g + s + t)	57	13,812.57	32,828.26	169.12	0.00
φ(ECO*T) p(g + s + t)	46	13,836.97	32,830.55	171.41	0.00
φ(R + s) p(g + s + t)	37	13,856.51	32,832.03	172.89	0.00
φ(g*s*t) p(g*s*t) global	782	12,764.58	33,287.46	628.32	0.00

[a] Codes indicate model structure for additive (+) or interactive (*) effects of ecoregion (ECO), study area (g), sex (s), annual time (t), linear time trend (T), land ownership (OWN), latitude (LAT), proportion of territories with Barred Owl detections (BO), percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1), reproduction (R), Pacific Decadal Oscillation (PDO), early nesting precipitation (ENP), early nesting temperature (ENT), or Southern Oscillation Index (SOI).

[b] Q-Deviance is the difference between -2log( )/$\hat{c}$ of the current model and -2log( )/$\hat{c}$ of the saturated model.

[c] $\hat{c}$ values for individual study areas can be found in Table 11.

TABLE 15

Coefficient estimates ($\hat{\beta}$) for covariates included in the meta-analysis of apparent survival of non-juvenile Northern Spotted Owls on 11 study areas in Washington, Oregon, and California.

Covariate	Model[a]	$\hat{\beta}$	$\widehat{SE}$	95% CI Lower	95% CI Upper
Random effects models					
R	φ(g*t) p(g + s + t): RE (g + R)	-0.024	0.013	-0.049	0.001
BO	φ(g*t) p(g + s + t): RE (g + BO)	-0.086	0.037	-0.158	-0.014
PDO	φ(g*t) p(g + s + t): RE (g + PDO)	0.009	0.006	-0.002	0.019
T	φ(g*t) p(g + s + t): RE (g + T)	-0.002	0.001	-0.004	0.000
ENP	φ(g*t) p(g + s + t): RE (g + ENP)	0.000	0.000	-0.001	0.000
ENT	φ(g*t) p(g + s + t): RE (g + ENT)	0.004	0.006	-0.007	0.015
SOI	φ(g*t) p(g + s + t): RE (g + SOI)	-0.002	0.006	-0.014	0.009
HAB1	φ(g*t) p(g + s + t): RE (g + HAB1)	0.339	0.354	-0.352	1.030
Fixed effects models					
Ecoregion[b]	φ(ECO + t) p(g + s + t)				
OR Cascades Douglas-fir		0.162	0.070	0.024	0.300
WA Mixed-conifer		-0.142	0.100	-0.338	0.055
OR-CA Mixed-conifer		0.042	0.070	-0.094	0.179
OR Coast Douglas-fir		0.184	0.071	0.046	0.323
CA Coast		0.103	0.075	-0.044	0.251
Ownership[c]	φ(ECO + OWN + t) p(g + s + t)				
Federal		-0.190	0.115	-0.416	0.036
Mixed		-0.136	0.113	-0.357	0.086
BO	*post hoc* φ(g + t + BO) p(g + s + t)	-0.339	0.293	-0.914	0.237
Habitat	*post hoc* φ(g + t + HAB1) p(g + s + t)	-0.466	1.852	-4.097	3.165
Latitude	φ(LAT + t) p(g + s + t)	-0.009	0.009	-0.026	0.009
Reproduction	φ(R + s) p(g + s + t)	-0.200	0.065	-0.328	-0.072

[a] Codes indicate effects of study area (g), time (t), sex (s), proportion of territories with Barred Owl detections (BO), reproduction (R), Pacific Decadal Oscillation (PDO), linear time trend (T), percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1), land ownership (OWN), latitude (LAT), early nesting precipitation (ENP), early nesting temperature (ENT), or Southern Oscillation Index (SOI).

[b] WA Douglas-fir was the reference type.

[c] Non-federal ownership was the reference type.

to the best model, except that the reproduction covariate was replaced by other environmental covariates, including Pacific Decadal Oscillation (PDO), linear time effects (T), mean effects, early nesting season precipitation (ENP), early nesting season temperature (ENT), or Southern Oscillation Index (SOI; Table 14). The random effects models were based on the assumption that the years of our study were a sample of all possible years, whereas the fixed effects models pertained directly to the years sampled. Although none of the fixed effects models were competitive with the best random effects model (Table 14), it is important to describe the results for each analysis because they represent different interpretations of the data (see Methods).

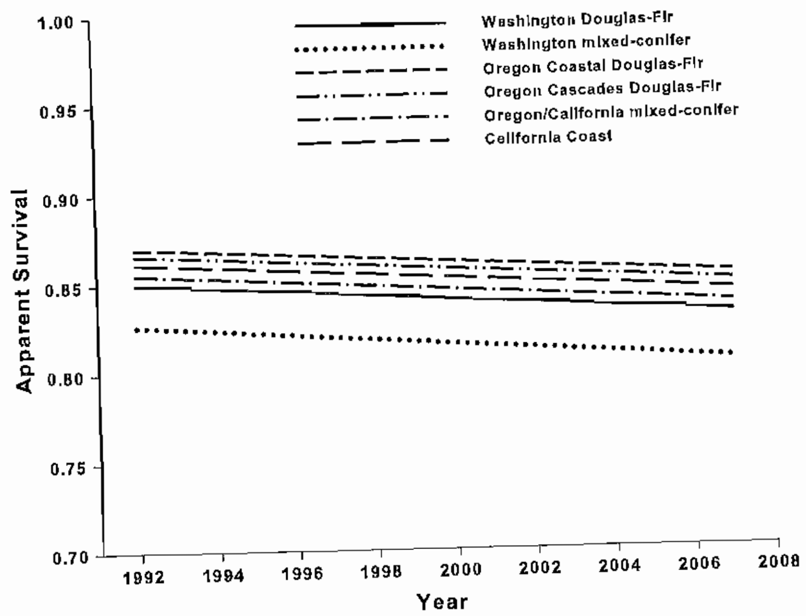


Figure 7. Estimates of apparent annual survival of adult female Northern Spotted Owls in six ecoregions (ECO), based on the linear time-trend model φ(ECO+T) *p*(g+t+s) from the meta-analysis of 11 study areas. Study area effects are represented by g, annual time effects by t, and sex effects by s.

In the meta-analysis of survival, the best or competing models indicated that there was considerable variation in survival rates among study areas, ecoregions, and years (t), and that the variation in survival among study areas and ecoregions was parallel over time (Fig. 6). Because the general trend in survival suggested a slight decline over the period of study (Fig. 6), we investigated the regression coefficients in the best random effects and fixed effects models that included time trends (T). The best random effects model with a time trend [φ(g*t) *p*(g+s+t): RE(g+T)] included a negative effect on survival (β = -0.0016), with a 95% confidence interval that barely overlapped zero (Table 15). The best fixed effects model with a time trend [φ(ECO+T) *p*(g+s+t)] also provided evidence for an overall decline in apparent survival for all study areas combined (Fig. 7).

Several other covariates were included in competitive models for the meta-analysis of apparent survival. There was no evidence from the random effects models that early nesting season temperature (ENT), Southern Oscillation Index (SOI), or percent cover of suitable owl habitat (HAB1) had an effect on survival because the 95% confidence intervals for these covariates included zero (Table 15). In contrast, there was some evidence that presence of Barred Owls (BO), early nesting season precipitation (ENP), and time trends (T) each had an effect on survival rates in the random effects models (Table 15). From the fixed effects models, there was evidence that survival rates differed among ecoregions, with the Oregon Cascades Douglas-fir, Oregon Coast Douglas-fir, and California Coast regions having higher survival rates than the Oregon/California Mixed-conifer and Washington Mixed-conifer regions (Table 15; Fig. 7). There was no evidence from the fixed effects models that ownership, Barred Owls, habitat, or latitude had an effect on survival, but there was evidence that annual survival was negatively related to the mean number of young produced in the previous breeding season (β = -0.200, 95% CI = -0.328 to -0.072). Although the evidence suggested that several of the above covariates influenced apparent survival, they explained little (0 to 5.7%, individually) of the variation among study areas and years. Thus, there was considerable annual variation in survival estimates (Fig. 6), and no covariate, including Barred Owls, percent cover of suitable habitat, climate, or time trends, explained a major portion of this variation. For example, the Barred Owl covariate and time trend explained only 5.7 and 2.3% of the variability in apparent survival, respectively.

TABLE 16

Models selected in the meta-analysis of apparent annual survival of Northern Spotted Owls for eight monitoring areas in Washington, Oregon, and California.

Model[a]	K	Q-Deviance	$QAIC_c$[b]	$\Delta QAIC_c$	w_i
Random effects models					
φ(g*t) *p*(g + s + t): RE (g + R)	152.68	10,811.970	26,028.850	0.000	0.200
φ(g*t) *p*(g + s + t): RE (g + BO)	152.46	10,812.900	26,029.327	0.473	0.158
φ(g*t) *p*(g + s + t): RE (g + Mean)	153.00	10,812.210	26,029.745	0.892	0.129
φ(g*t) *p*(g + s + t): RE (g + PDO)	153.27	10,811.850	26,029.937	1.083	0.117
φ(g*t) *p*(g + s + t): RE (g + T)	153.23	10,812.130	26,030.132	1.279	0.106
φ(g*t) *p*(g + s + t): RE (g + ENP)	153.31	10,811.980	26,030.145	1.291	0.105
φ(g*t) *p*(g + s + t): RE (g + SOI)	153.51	10,811.870	26,030.440	1.586	0.091
φ(g*t) *p*(g + s + t): RE (g + ENT)	153.51	10,811.880	26,030.461	1.607	0.090
φ(g*t) *p*(g + s + t): RE (g + HAB1)	157.84	10,809.420	26,036.809	7.956	0.003
Fixed effects models					
φ(ECO + t) *p*(g + s + t)	58	11,023.270	26,048.455	19.601	0.000
φ(OWN + ECO + t) *p*(g + s + t)	59	11,022.470	26,049.665	20.811	0.000
φ(g + s + t) *p*(g + s + t)	62	11,019.080	26,051.603	22.749	0.000
φ(LAT + t) *p*(g + s + t)	55	11,044.310	26,063.449	34.596	0.000
φ(OWN + t) *p*(g + s + t)	55	11,044.490	26,063.631	34.778	0.000

[a] Model notation indicates structure for study area (g), time (t), linear time (T), ecoregion (ECO), land ownership (OWN), constant (.), proportion of territories with Barred Owl detections (BO), early nesting season precipitation (ENP), early nesting season temperature (ENT), percent cover of suitable owl habitat within 2.4 km of owl activity centers (HAB1), Southern Oscillation Index (SOI), and Pacific Decadal Oscillation (PDO).

[b] $\hat{c}$ values for individual study areas can be found in Table 11.

Meta-analysis of Apparent Survival on the Eight NWFP Monitoring Areas

The two best models in the meta-analysis of apparent survival for the eight NWFP study areas were the same as the analysis of all 11 study areas (Table 16). In the top model, the regression coefficient for the effect of reproduction was negative with a 95% confidence interval that barely overlapped zero. In the second best model, the regression coefficient for the effect of Barred Owls was negative with a 95% confidence interval that did not overlap zero. Six other random effects models that were competitive included mean effects, Pacific Decadal Oscillation (PDO), time trend (T), early nesting season precipitation (ENP), Southern Oscillation Index (SOI), or early nesting season temperature (ENT) in place of the BO covariate (Table 16). The rankings of the random effects and fixed effects models were similar between the analyses of all 11 study areas and the eight NWFP monitoring areas, and none of the fixed effects models were competitive with the best random effects models (Tables 14, 16). Because the results were similar regardless of

TABLE 17

Coefficient estimates ($\hat{\beta}$) for the best models that included an effect of reproduction on apparent survival of non-juvenile Northern Spotted Owls on 11 study areas in Washington, Oregon, and California.

Study area	$\Delta QAIC_c$	$\hat{\beta}$	$\widehat{SE}$	95% CI Lower	95% CI Upper
Washington					
CLE	2.72	0.466	0.220	0.035	0.897
RAI	2.88	-1.030	0.450	-1.910	-0.014
OLY	0.75	-0.420	0.241	-0.893	0.053
Oregon					
COA	22.96	0.088	0.181	-0.267	0.443
HJA	7.30	-0.165	0.194	-0.546	0.216
TYE	8.33	0.317	0.261	-0.195	0.829
KLA	5.69	0.041	0.214	-0.378	0.461
CAS	7.23	-0.129	0.194	-0.509	0.252
California					
NWC	2.65	0.249	0.234	-0.210	0.708
HUP	0.28	0.573	0.447	-0.304	1.450
GDR	5.16	0.556	0.239	0.088	1.024

whether we examined the eight NWFP study areas or all 11 study areas combined, we emphasize only the results from all 11 areas in the following sections.

Potential Cost of Reproduction on Survival

In the analyses of apparent survival for individual study areas, there was no evidence of a negative effect of reproduction on survival rates in the following year at seven of the 11 study areas (COA, HJA, TYE, KLA, CAS, NWC, HUP, Table 17). Confidence intervals for the regression coefficients for reproduction at those seven areas all overlapped zero (Table 17). For two study areas in Washington (RAI, OLY), there was evidence of a negative effect of reproduction on survival in the following year. At RAI, the regression coefficient for the reproductive effect in the best model was negative with a 95% confidence interval that did not overlap zero. At OLY, the effect of reproduction was part of a competitive model in which the 95% confidence interval on $\hat{\beta}$ barely overlapped zero (Table 17). In contrast, there was evidence of a positive effect of reproduction on survival at CLE and GDR, as the regression coefficients for the reproduction covariates were positive, with 95% confidence intervals that did not overlap zero. However, the models for CLE and GDR that included the effect of reproduction were >2 QAICs from the best models, and these latter results were contrary to our original hypothesis.

In the meta-analysis of apparent survival for all 11 study areas, the best random effects model, $\varphi(g{*}t)$ $p(g{+}s{+}t)$: RE(g+R), included the effect of reproduction. The effect of reproduction was negative ($\hat{\beta} = -0.024$) and the 95% confidence interval barely included zero (-0.049 to 0.001). The best fixed effects models with an effect of reproduction were $\varphi(g{*}R)$ $p(g{+}s{+}t)$ and $\varphi(R{+}s)$ $p(g{+}s{+}t)$ (Table 14). Although there was little support for either of these models ($\Delta QAIC_c$'s > 168.0 and $QAIC_c$ weights = 0.000), the regression coefficient for the effect of reproduction in the second model was negative ($\hat{\beta} = -0.200$) with a 95% confidence interval (-0.328 to -0.072) that did not overlap zero (Table 15). Based on this outcome, we concluded that there was evidence for a negative effect of reproduction on survival in the following year in some, but not all, study areas.

Effects of Barred Owls on Recapture and Survival

The BO covariate was included in the best model structure for recapture probability in three (RAI, COA, KLA) of the 11 study areas (Table 12), and the best models that included a BO effect on recapture indicated a negative effect in seven study areas and a positive effect in four areas. However, the 95% confidence intervals on the regression coefficients for the BO effect overlapped zero in seven areas. In the four cases where the 95% confidence intervals did not overlap zero, two cases indicated a negative effect and two cases indicated a positive effect.

In the analysis of individual study areas, we found evidence for a negative effect of Barred Owl presence on apparent survival of Spotted Owls on the RAI, COA, HJA, and GDR study areas (Table 18). There also was some evidence that presence of Barred Owls had a negative effect on apparent survival of Spotted Owls on the OLY and NWC study areas; on those areas the Barred Owl effect was among the competitive models, but the 95% confidence intervals for the regression coefficient barely overlapped zero (Table 18). Inexplicably, there was one study area (CAS) that had weak evidence for a positive effect of Barred Owls on survival (Table 18). The evidence for an effect of Barred

TABLE 18

Estimates of $\Delta QAIC_c$ and parameter estimates ($\hat{\beta}$) for the effects of Barred Owls on apparent annual survival of adult Northern Spotted Owls on 11 demographic study areas in Washington, Oregon, and California.

Estimates were based on the best $QAIC_c$ model that included the Barred Owl effect.

Study area	$\Delta QAIC_c$	$\hat{\beta}$	$\widehat{SE}$	95% CI Lower	95% CI Upper
Washington					
CLE	3.08	-0.815	1.009	-2.793	1.164
RAI	0.00	-5.330	1.960	-9.190	-1.490
OLY	1.17	-1.216	0.748	-2.682	0.250
Oregon					
COA	9.48	-0.908	0.257	-1.412	-0.405
HJA	2.24	-0.753	0.306	-1.352	-0.153
TYE	9.78	0.062	0.332	-0.588	0.712
KLA	5.21	-0.469	0.655	-1.753	0.815
CAS	4.04	1.657	0.878	-0.062	3.378
California					
NWC	1.98	-1.450	1.079	-3.566	0.666
HUP	1.81	-0.688	1.469	-3.567	2.190
GRD	0.00	-2.234	0.670	-3.547	-0.921
Mean		-1.104	0.514	-2.11	-0.097

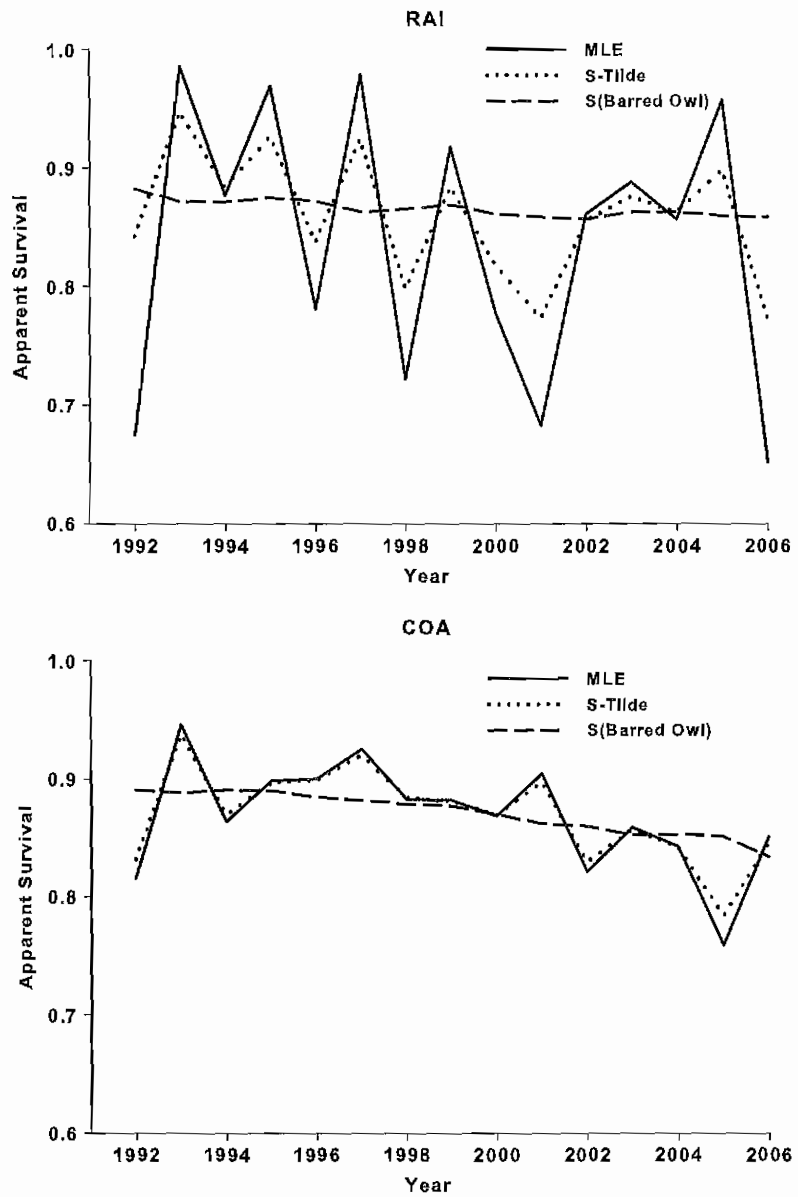


Figure 8. Estimates of the Barred Owl effect (BO) on apparent survival of Northern Spotted Owls. Estimates were generated from the best random effects model [φ(g+t+BO)], plotted with original apparent survival estimates (MLE) and shrinkage estimates (S-tilde) for one study area in Washington (RAI), two study areas in Oregon (CAS, COA), and one study area in California (NWC). Study area effects are represented by g and annual time effects by t.

Owls on survival of Spotted Owls was weak or negligible for CLE, TYE, KLA, and HUP because confidence intervals on regression coefficients overlapped zero (Table 18). With the exception of CLE, the latter areas were all in the southern portion of the range of the Northern Spotted Owl (Fig. 1).

In the meta-analysis of apparent survival, the second best model [φ(g*t) *p*(g+s+t): RE(g+BO)] provided strong evidence that the presence of Barred Owls had a negative effect on apparent survival, as the 95% confidence interval on $\hat{\beta}$ for the Barred Owl effect did not overlap zero (Table 15; Fig. 8). In addition, the g+BO model ranked higher than the g*BO model, indicating that the BO covariate was important across all study areas in explaining time variation in φ. Thus, there was strong evidence that Barred

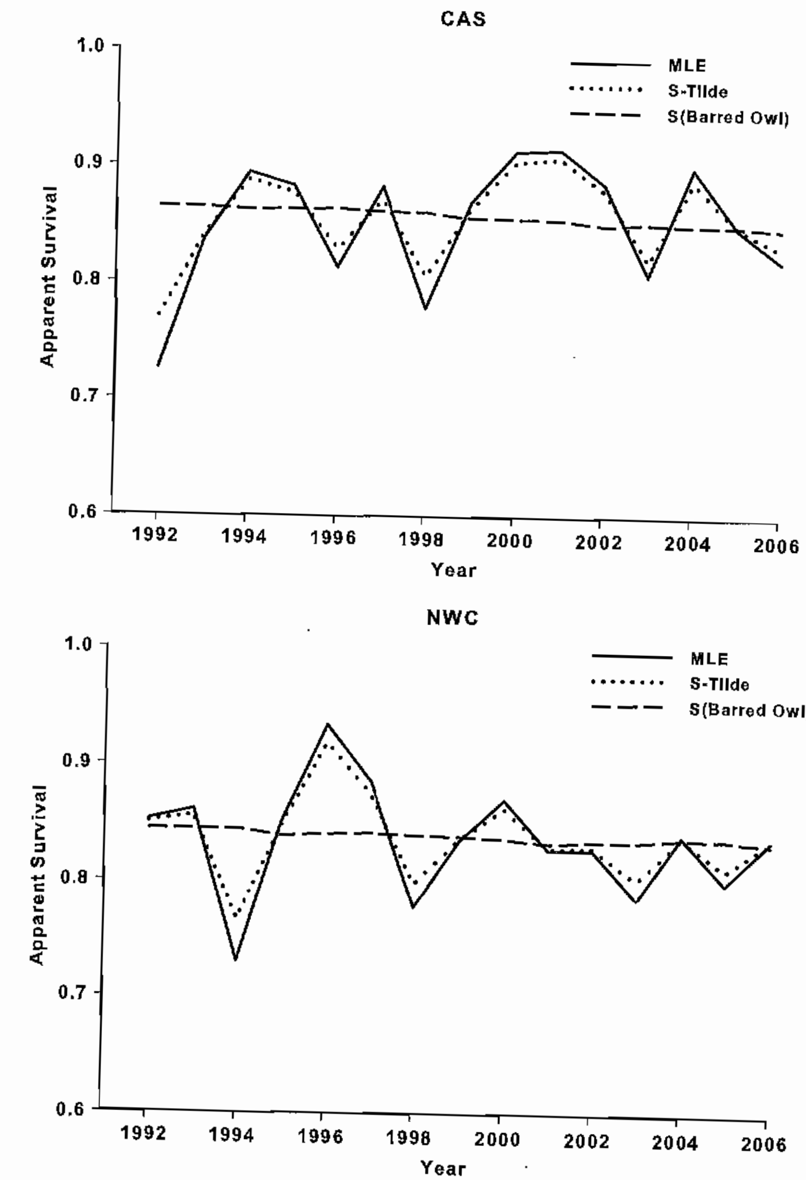


Figure 8. (*continued*)

Owls had a negative effect on apparent survival of Spotted Owls.

Annual Rate of Population Change

Individual Study Areas

We used capture histories of 5,244 banded territorial owls to estimate annual rates of population change (λ) at the 11 study areas. Estimates of goodness-of-fit (χ^2/df) of the capture–recapture data from program RELEASE ranged from 0.69 to 3.02 for individual study areas (Table 11), and the overall estimate of χ^2/df for all of the data combined was 1.61 ($P > 0.10$), indicating good fit of the data to the Cormack–Jolly–Seber model. Estimates of $\hat{c}$ from the median-$\hat{c}$ routine in program MARK ranged from 1.00 to 1.13, indicating little evidence for lack of independence in capture histories (Table 11).

The full sex- and time-specific model $\varphi(s^*t)$ $p(s^*t)$ $f(s^*t)$ for estimation of λ was not appropriate for most study areas based on model selection with $QAIC_c$. Therefore, we used the time-only model $\varphi(t)$ $p(t)$ $f(t)$ for estimating λ and temporal process variation for most study areas (Table 19). The only exception was the OLY study area, where there were differences in φ between males and females. Estimates of λ ranged from 0.929 to 0.996 for the 11 study areas and the time span of the estimates ranged from 12 to 16 years (Table 19). There was strong evidence that populations on the CLE, RAI, OLY, COA, HJA, NWC, and GDR study areas declined during the study, based on 95% confidence intervals for estimates of λ that did not include 1.0 (Table 19, Fig. 9). Estimates of λ for CLE and RAI were especially low, suggesting population declines of 6.3 and 7.1 % per year, respectively (Table 19). Point estimates of λ for the TYE, KLA, CAS, and HUP study areas all indicated declining populations, but had 95% confidence intervals that included 1.0 (Table 19). The weighted mean estimate of λ for all study areas combined was 0.971 (SE = 0.007, 95% CI = 0.960 to 0.983), indicating that the average rate of population decline was 2.9% per year during the study.

TABLE 19

Estimates of λ and temporal process standard deviation ($\hat{\sigma}_{temporal}$) for Northern Spotted Owls on 11 study areas in Washington, Oregon, and California.

Estimates of λ were generated using the best random effects model; estimates of temporal variance are based on random effects models (Means, T, or TT), using time-specific estimates of φ, *p*, and λ, except where noted.

Study	Years	Model[a]	Derived $\hat{\lambda}$	SE	95% CI Lower	95% CI Upper	$\hat{\sigma}_{TEMPORAL}$	95% CI Lower	95% CI Upper
Washington									
CLE[b]	1994–2006	[φ(t) *p*(t) λ(t)]: RE(.)	0.937	0.014	0.910	0.964	0.0000	0.0000	0.0058
RAI	1995–2006	[φ(t) *p*(t) *f*(t)]: RE(.)	0.929	0.026	0.877	0.977	0.0048	0.0000	0.0371
OLY	1992–2006	[φ(s*t) *p*(t) *f*(t)]: RE(T)	0.957	0.020	0.918	0.997	0.0062	0.0000	0.0332
Oregon									
COA	1994–2006	[φ(t) *p*(t) *f*(t)]: RE(T)	0.966	0.011	0.943	0.985	0.0007	0.0000	0.0080
HJA	1992–2006	[φ(t) *p*(t) *f*(t)]: RE(TT)	0.977	0.010	0.957	0.996	0.0000	0.0000	0.0042
TYE	1992–2006	[φ(t) *p*(t) *f*(t)]: RE(TT)	0.996	0.020	0.957	1.035	0.0012	0.0000	0.0087
KLA	1992–2006	[φ(t) *p*(t) *f*(t)]: RE(.)	0.990	0.014	0.962	1.017	0.0019	0.0000	0.0102
CAS	1994–2006	[φ(t) *p*(t) *f*(t)]: RE(.)	0.982	0.030	0.923	1.040	0.0105	0.0022	0.0421
California									
NWC	1990–2006	[φ(t) *p*(t) *f*(t)]: RE(.)	0.983	0.008	0.968	0.998	0.0000	0.0000	0.0012
HUP	1994–2006	[φ(t) *p*(t) *f*(t)]: RE(.)	0.989	0.013	0.963	1.014	0.0000	0.0000	0.0012
GRD	1992–2006	[φ(t) *p*(t) *f*(t)]: RE(TT)	0.972	0.012	0.949	0.995	0.0014	0.0000	0.0076
Weighted mean for 8 monitoring areas			0.972	0.006	0.958	0.985			
Weighted mean for 3 non-monitoring areas			0.969	0.016	0.938	1.000			
Weighted mean for all areas			0.971	0.007	0.960	0.983			

[a] Best capture–recapture model structure from analysis of the *a priori* model set. Model notation indicates structure for effects of time (t), linear time trend (T), quadratic time trend (TT), or constant (.), or random effects (RE). For linear and quadratic time trend models, λ was computed using a mean-centered model.

[b] Random effects model using the survival–recruitment parameterization would not run on derived lambdas for CLE. Therefore, we used the survival–lambda *f*-parameterization instead.

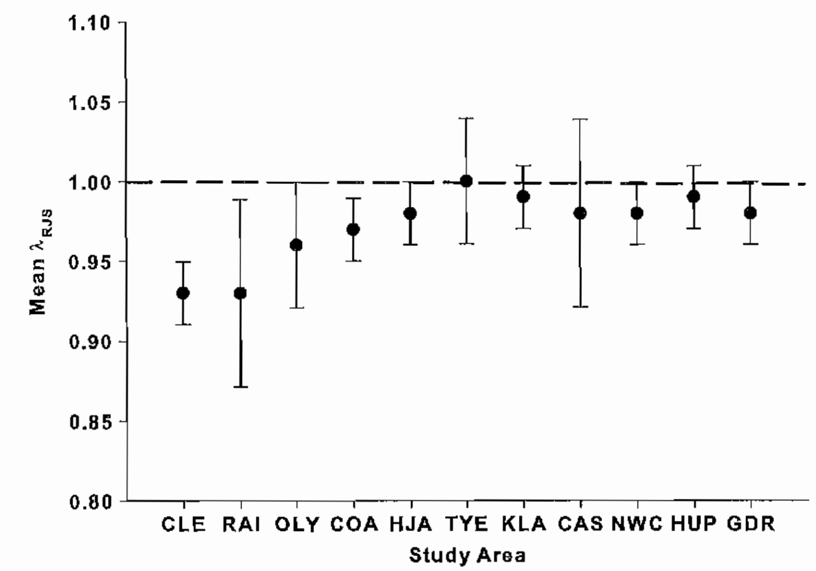


Figure 9. Estimates of mean annual rate of population change ($\hat{\lambda}_{RJS}$), with 95% confidence intervals for Northern Spotted Owls in 11 study areas in Washington, Oregon, and California. Estimates of λ were derived parameters from the recruitment and survival parameterization and the best random effects models based on the best global model [either $f(t)$ $\varphi(t)$ $p(t)$ or $f(s^*t)$ $\varphi(s^*t)$ $p(s^*t)$], where s and t represent sex and annual time changes, respectively.

Results of the variance components analyses for each study area provided little evidence of temporal process variation in λ for most study areas, relative to the magnitude of sampling variation in estimates (Table 19). Estimates of temporal process variation in λ were highest for the RAI, OLY, CAS, and NWC study areas, but the only study area for which the 95% confidence interval on temporal variation did not include zero was CAS (Table 19).

There was evidence that populations were declining on five of the eight monitoring areas (CLE, OLY, COA, HJA, NWC) based on 95% confidence intervals for λ that did not overlap 1.0. Point estimates of λ for the remainder of the study areas (TYE, KLA, CAS) were less than one, but had confidence intervals that overlapped 1.0, so the evidence for declines on those areas was weak. The weighted mean estimate of λ for the eight monitoring areas was 0.972 (SE = 0.006, 95% CI = 0.958 to 0.985), indicating an estimated decline of 2.8% per year on federal lands within the range of the owl. The weighted mean estimate of λ for the other three study areas (RAI, GDR, HUP) was 0.969 (SE = 0.016, 95% CI = 0.938 to 1.000), indicating an estimated decline of 3.1% per year on those areas.

Estimates of Realized Population Change

Estimates of realized population change indicated that populations in Washington and northern Oregon (OLY, RAI, CLE, COA) declined by 40 to 60% during our study (Fig. 10A, B). There was also evidence that populations on HJA,GDR, and NWC declined during the same period, but the 95% confidence intervals around the estimates of Δ_t on the latter three areas slightly overlapped 1.0 (Fig. 10B, C). Estimates of realized population change for the rest of the study areas (CAS, TYE, KLA, HUP) were all <1.0, but the 95% confidence intervals around the estimates of Δ_t substantially overlapped 1.0. Trends in populations for each of the study areas were variable, and declines, if any, occurred at different times on different areas. For example, the decline on HJA occurred primarily during 1992 to 1993 after a year of high reproductive success in 1992, then the population declined about 10% during

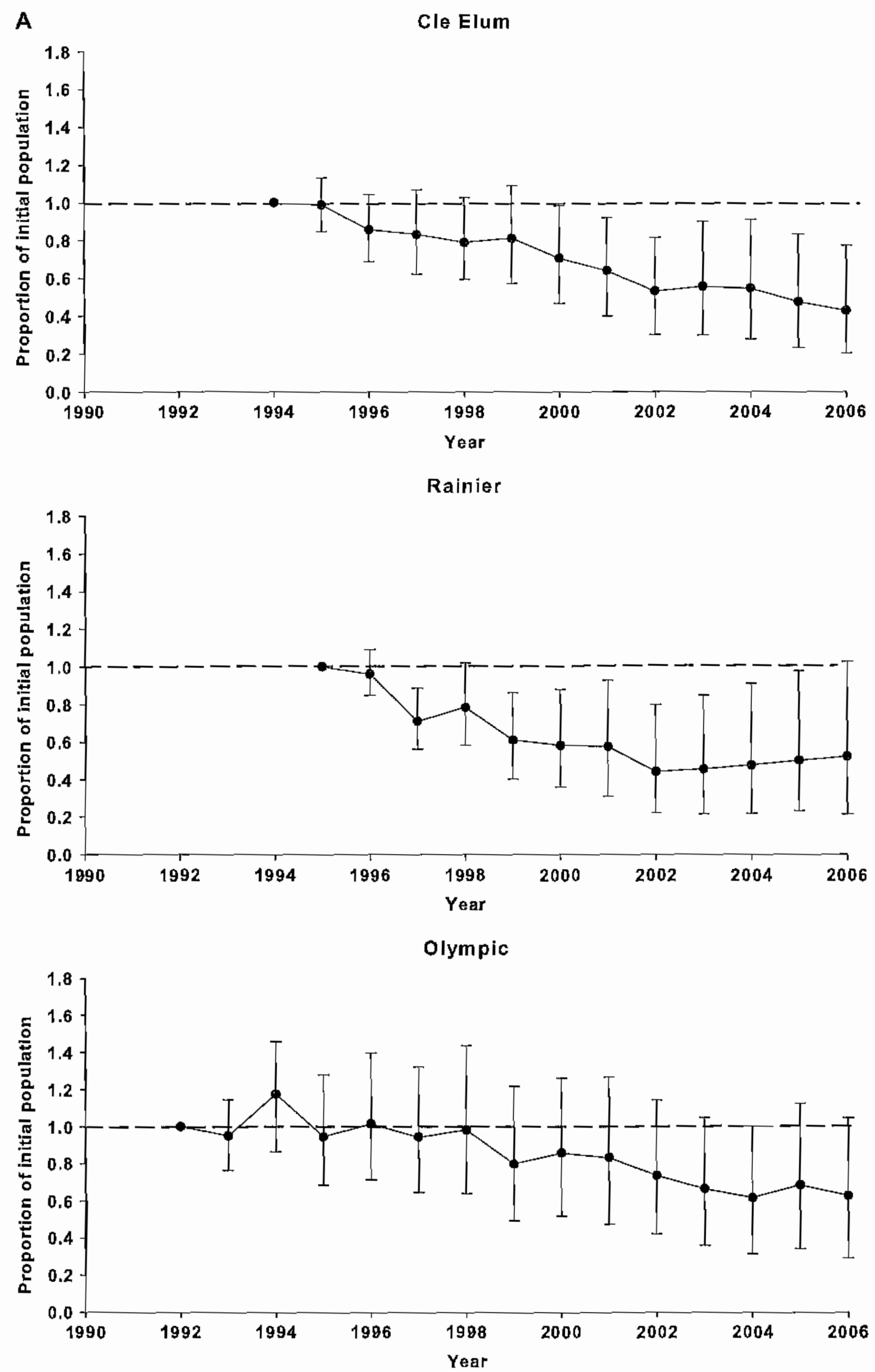


Figure 10. Estimates of realized population change, Δ_t, with 95% confidence intervals for Northern Spotted Owls at three study areas in Washington (A), five study areas in Oregon (B), and three study areas in California (C).

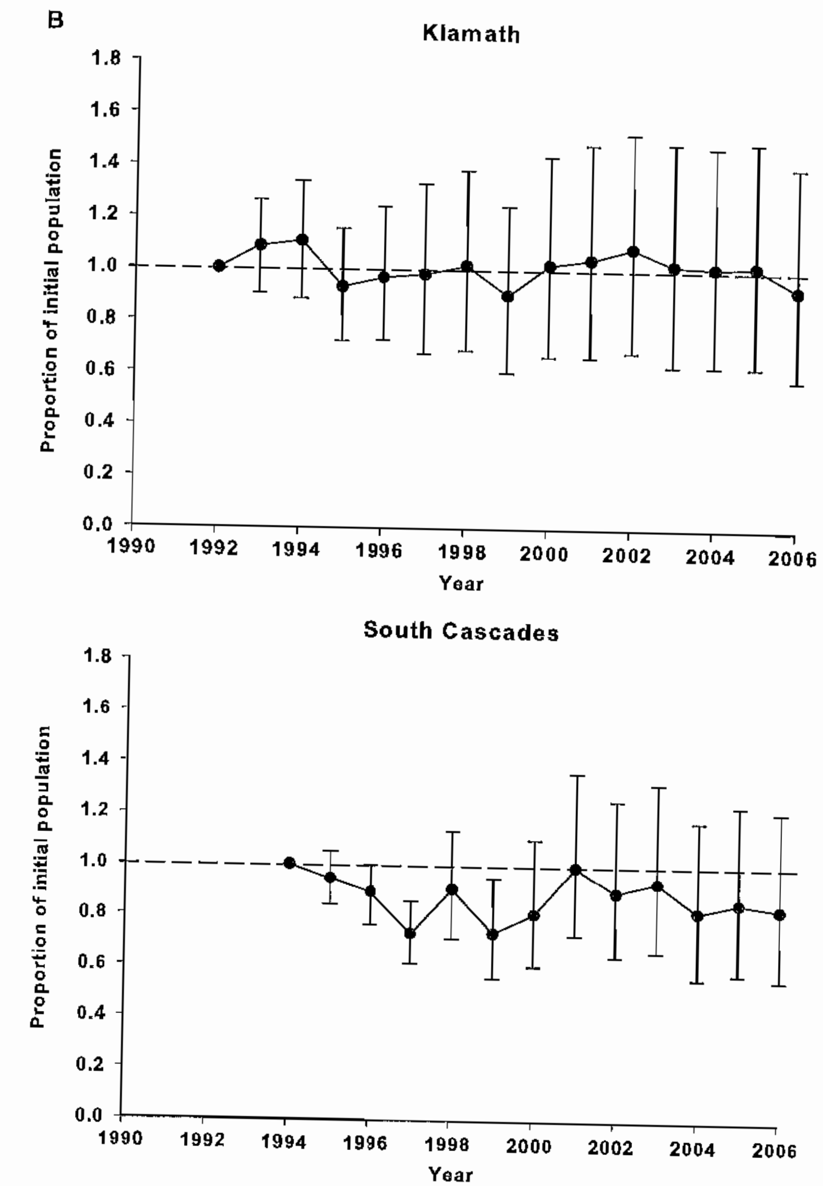


Figure 10. (*continued, for Northern Spotted Owls in Oregon*)

the ensuing decade. In contrast, the decline on COA occurred after 2001 and continued through 2006 (Fig. 10B). Populations in Washington (CLE, RAI, OLY) exhibited a long, gradual decline after the mid-1990s, except that the population on RAI actually increased slightly after 2002 (Fig. 10A). Consequently, there was no evidence for synchrony in timing of population declines among the 11 study areas.

Meta-analysis of Annual Rate of Population Change

Estimates of goodness-of-fit from program RELEASE for individual study areas (Table 11) indicated good fit of the data to the Cormack–Jolly–Seber model for all study areas. In addition, the mean estimate of median-$\hat{c}$ from program MARK was 1.06 with a range of 1.0 to 1.17,

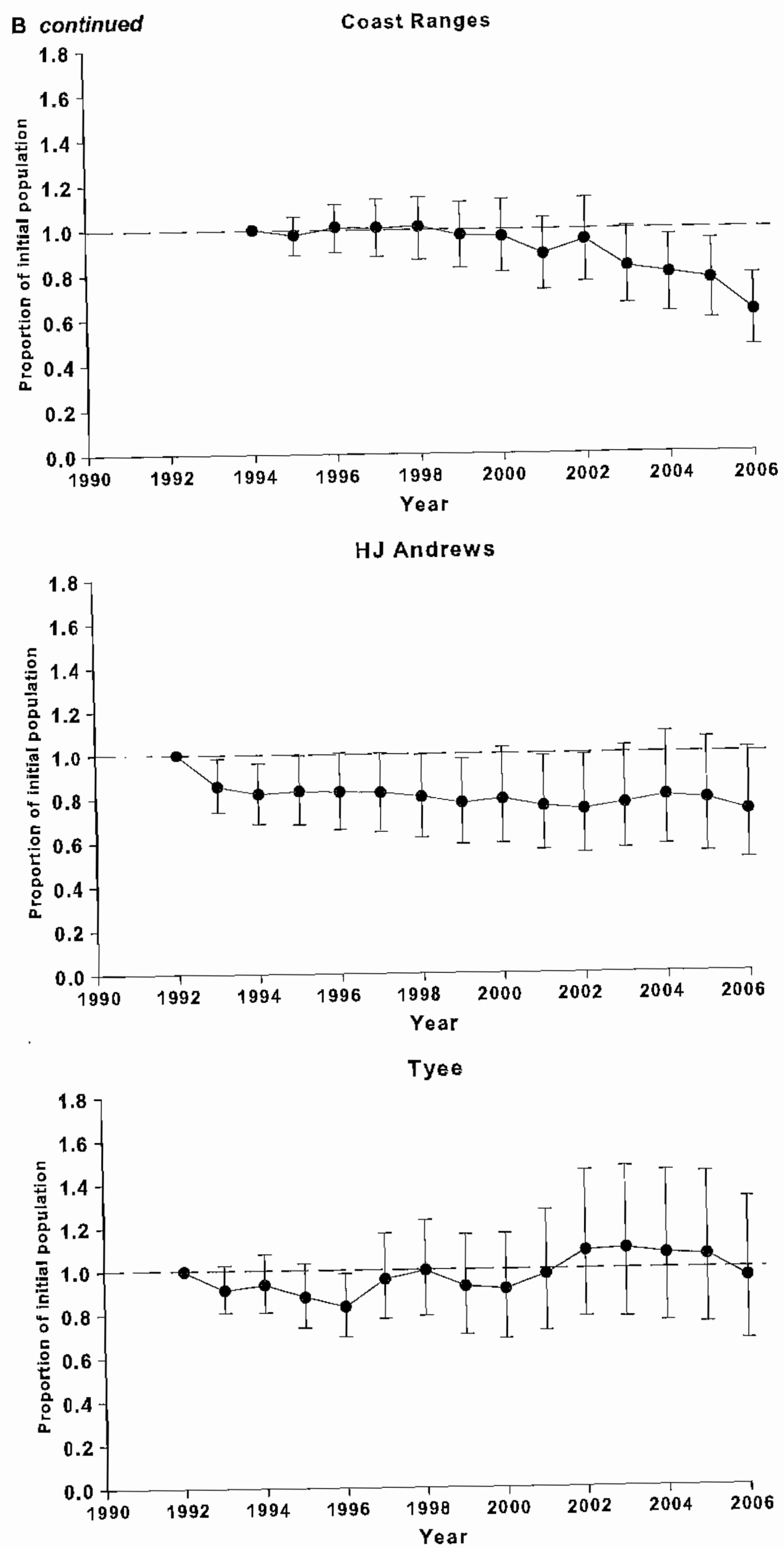


Figure 10. *(continued, for Northern Spotted Owls in Oregon)*

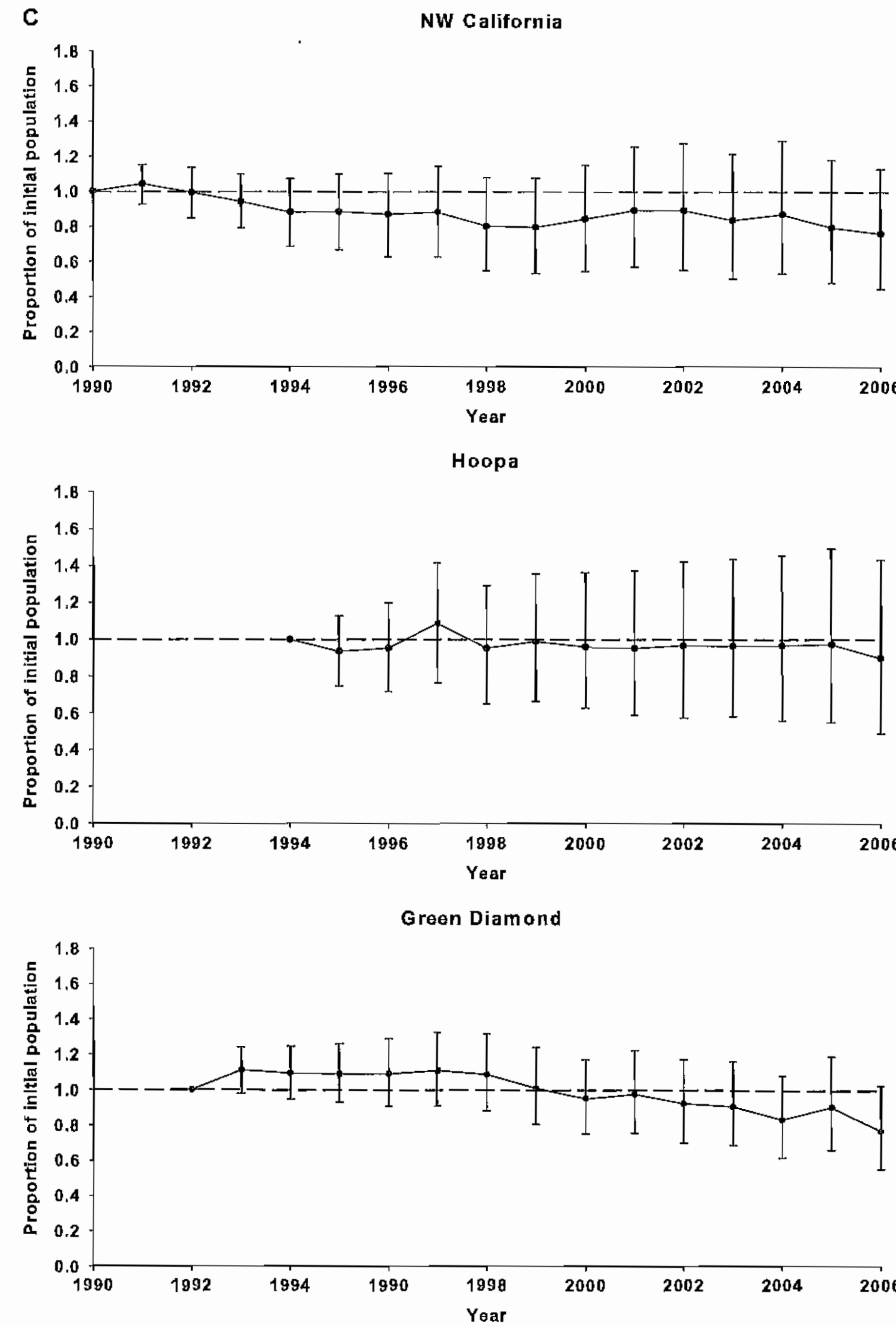


Figure 10. *(continued, for Northern Spotted Owls in California)*

indicating little evidence for overdispersion (i.e., lack of independence) in the capture–recapture data. As a result, we did not use $\hat{c}$ to adjust model selection to $QAIC_c$ or inflate variance estimates of parameters.

The best *a priori* model in the meta-analysis of λ was RE (random effects) model $\varphi(ECO)$ $f(ECO)$, which indicated evidence of an effect of ecoregion on φ and f (Table 20). Two competing random effects models had ΔAIC_c values

TABLE 20

Model selection results from meta-analysis of λ for Northern Spotted Owls in Washington, Oregon, and California.

Model[a]	K	Deviance	AIC_c	ΔAIC_c	w_i
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO + BO) f(ECO)*	500.85	17,924.51	60,812.29		
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO + BO) f(ECO + BO)*	501.01	17,924.65	60,812.76		
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO) f(ECO)	501.44	17,924.22	60,813.25	0.00	0.302
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO) f(ECO*BO)*	501.89	17,923.45	60,813.43		
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO + BO) f(ECO)*	501.53	17,924.33	60,813.54		
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + BO) f(BO)	502.32	17,922.77	60,813.64	0.39	0.248
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO) f(ECO + BO)*	501.60	17,924.37	60,813.73		
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO) f(OWN + ECO)	501.94	17,924.41	60,814.49	1.24	0.162
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO*BO) f(ECO*BO)*	502.36	17,923.74	60,814.69		
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + BO) f(g + BO)	502.63	17,925.46	60,816.98	3.73	0.047
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + BO) f(g*BO)	503.37	17,924.01	60,817.08	3.83	0.044
[φ(g*t) p(g*t) f(g*t)]: RE φ(g) f(g)	503.35	17,925.06	60,818.09	4.84	0.027
[φ(g*t) p(g*t) f(g*t)]: RE φ(g) f(g + TT)	503.76	17,924.24	60,818.14	4.89	0.026
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI) f(g + ENP + ENT)	503.73	17,924.59	60,818.43	5.18	0.023
[φ(g*t) p(g*t) f(g*t)]: RE φ(g) f(g + T)	503.62	17,924.93	60,818.54	5.29	0.021
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI) f(g + LNP)	503.79	17,924.85	60,818.82	5.56	0.019
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI) f(g + PDSI)	503.78	17,924.91	60,818.85	5.59	0.018
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI) f(g + SO + PDO)	503.83	17,924.89	60,818.94	5.69	0.018
[φ(g*t) p(g*t) f(g*t)]: RE φ(g) f(g*T)	505.03	17,922.98	60,819.55	6.30	0.013
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*T) f(g)	504.13	17,924.99	60,819.66	6.41	0.012
[φ(g*t) p(g*t) f(g + t)]	395.00	18,154.00	60,820.54	7.29	0.008
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI) f(g*LNP)	505.93	17,923.27	60,821.73	8.48	0.004
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI) f(g*PDSI)	505.89	17,923.37	60,821.76	8.51	0.004
[φ(g*t) p(g*t) f(g*t)]: RE φ(g) f(g*TT)	508.04	17,919.98	60,822.88	9.63	0.002
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI) f(g*ENP + g*ENT)	508.44	17,921.51	60,825.24	11.99	0.001
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI) f(g*SOI + g*PDO)	508.52	17,922.20	60,826.11	12.86	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*HAB2[b]) f(g + HAB2 + HAB3)	518.79	17,914.06	60,839.59	26.33	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*HAB2) f(g*HAB3)	520.17	17,912.94	60,841.36	28.11	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g)	524.84	17,904.03	60,842.29	29.04	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*HAB2) f(g*HAB2 + g*HAB3)	521.38	17,911.71	60,842.68	29.43	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*TT)	527.03	17,903.49	60,846.36	33.11	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(ECO)	527.08	17,904.21	60,847.17	33.92	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + BO)	527.35	17,904.03	60,847.56	34.31	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*HAB2) f(g + HAB2)	527.19	17,907.03	60,850.23	36.98	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + PDSI)	528.95	17,904.03	60,850.95	37.70	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(BO)	529.32	17,904.28	60,851.96	38.71	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(OWN + ECO)	529.40	17,904.12	60,851.97	38.72	0.000
(φ(g*t) p(g*t) f(g*t)): RE φ(LAT)	529.38	17,904.29	60,852.10	38.85	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + T)	529.60	17,904.03	60,852.30	39.04	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(OWN)	529.62	17,904.24	60,852.56	39.31	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*PDSI)	530.40	17,904.10	60,854.05	40.80	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + SOI + PDO)	529.80	17,905.65	60,854.35	41.09	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*T)	530.78	17,903.78	60,854.54	41.28	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*BO)	530.80	17,903.91	60,854.72	41.46	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + ENP + ENT)	530.11	17,905.61	60,854.95	41.70	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*SOI + g*PDO)	531.57	17,903.55	60,855.99	42.73	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*HAB2)	531.50	17,904.29	60,856.57	43.32	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g*ENP + g*ENT)	531.84	17,905.15	60,858.14	44.89	0.000
[φ(g*t) p(g*t) f(g*t)]:RE φ(g + HAB2)	534.12	17,902.83	60,860.63	47.38	0.000
[φ(g*t) p(g*t) f(g*t)]: RE φ(g + TT)	529.39	17,912.96	60,860.79	47.54	0.000
φ(g*t) p(g*t) f(g*t)	542.00	17,922.47	60,896.89	83.64	0.000

TABLE 20 (*continued*)

TABLE 20 (CONTINUED)

NOTE: Model form was the survival and recruitment parameterization. Notation for random effects (RE) models includes the general model on which the random effects model is based (g = study area, t = time varying). Models ending with asterisks were developed *a posteriori* after seeing the results of the original modeling. Inferences were based on the models in the original *a priori* model set.

[a] Model notation indicates structure for study area (g), time (t), linear time trend (T), quadratic time trend (TT), ecoregion (ECO), land ownership (OWN), proportion of territories with Barred Owl detections (BO), early nesting season precipitation (ENP), early nesting season temperature (ENT), late nesting season precipitation (LNP), late nesting season temperature (LNT), Palmer Drought Severity Index (PDSI), percent cover of suitable owl habitat within a 2.4 km radius of owl activity centers (HAB2), percent cover of suitable owl habitat within 23 km of owl activity centers, minus the area within 2.4 km of owl activity centers (HAB3), latitude (LAT), Southern Oscillation Index (SOI), and Pacific Decadal Oscillation (PDO).

<2.0, one of which indicated evidence of a Barred Owl effect on φ and *f* [φ(g+BO) *f*(BO)], and one [φ(ECO) *f*(ECO+OWN)] that indicated differences in recruitment among different land ownership categories (Table 20). The 95% confidence interval for the effects of ownership on *f* in the latter model included zero, indicating little evidence of an effect of ownership on recruitment (Table 21). Therefore, model selection results for the top two models [φ(ECO) *f*(ECO) and φ(g+BO) *f*(BO)] indicated the most support for models that included Barred Owls (BO) and ecoregions (ECO). Estimates of apparent survival from the best *a priori* model were highest for the Oregon Coast Douglas-fir ecoregion and lowest for the Washington Mixed-conifer ecoregion (Fig. 11). Recruitment was highest in the Oregon/California Mixed-conifer ecoregion ($\hat{f}$ = 0.145, SE = 0.020), but similar among the other ecoregions (Fig. 11). The low estimates of λ for the Washington Douglas-fir and Washington Mixed-conifer ecoregions were a result of both low apparent survival and low recruitment. In contrast, the Oregon/California Mixed-conifer region had the highest estimate of λ, which was a result of high recruitment and intermediate survival rates. Values of φ, *f*, and λ were intermediate for the other ecoregions.

Slope coefficients for the Barred Owl effect in the random effects (RE) model φ(g+BO) *p*(g*t) *f*(BO) were negatively associated with apparent survival and recruitment, although the 95% confidence interval for the effect of Barred Owls on recruitment included zero (Table 21). There was some evidence for differences in apparent survival among different land ownership categories

TABLE 21

Coefficient estimates (β̂) for the best models that included effects of Barred Owls, land ownership, climate, habitat, or latitude in the meta-analysis of λ for 11 study areas in Washington, Oregon, and California.

	Survival				Recruitment			
			95% CI				95% CI	
Covariate[a]	$\hat{\beta}$	$\widehat{SE}$	Lower	Upper	$\hat{\beta}$	$\widehat{SE}$	Lower	Upper
BO	-0.116	0.043	-0.200	-0.032	-0.023	0.037	-0.096	0.050
Ownership								
Federal (intercept)	0.869	0.020	0.829	0.908	0.098	0.020	0.058	0.137
Non-federal	0.023	0.022	-0.020	0.067	-0.027	0.023	-0.073	0.019
Mixed	0.002	0.013	-0.023	0.027	-0.002	0.013	-0.028	0.024
Climate								
ENP	0.007	0.007	-0.006	0.021	0.012	0.007	-0.002	0.026
ENT	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000
LNP	na				0.000	0.001	-0.002	0.002
PDSI	0.002	0.002	-0.002	0.006	-0.001	0.002	-0.006	0.004
SOI	0.007	0.008	-0.009	0.023	-0.010	0.009	-0.027	0.007
PDO	0.017	0.008	0.000	0.033	-0.001	0.009	-0.018	0.017
Habitat								
HAB2					0.559	0.285	0.001	1.117
HAB3					-0.688	0.303	-1.282	-0.093
HAB2-CAS	0.602	1.291	-1.928	3.131				
HAB2-HJA	6.851	4.117	-1.218	14.921				
HAB2-KLA	-0.477	1.060	-2.554	1.600				
HAB2-OLY	-3.749	16.270	-35.638	28.141				
HAB2-RAI	-0.470	0.342	-1.141	0.202				
HAB2-CLE	1.143	1.004	-0.824	3.111				
HAB2-COA	1.155	0.922	-0.651	2.962				
HAB2-TYE	0.763	0.671	-0.554	2.079				
LAT	-0.002	0.002	-0.007	0.002				

[a] Covariates included proportion of territories with Barred Owl detections (BO), early nesting season precipitation (ENP), early nesting season temperature (ENT), late nesting season precipitation (LNP), Palmer Drought Severity Index (PDSI), Southern Oscillation Index(SOI), Pacific Decadal Oscillation (PDO), percent cover of suitable owl habitat within a 2.4-km radius of owl activity centers (HAB2), forest habitat in the ring between HAB2 and a circle defined by the median natal dispersal distance (23 km) (HAB3), and latitude (LAT).

but the differences were minor, and the best model that included the ownership covariate ranked far below the top model ($\Delta AIC_c = 38.72$; Table 20). There was no evidence that latitude or habitat within the study area (HAB2) had an effect on apparent survival, but there was evidence that apparent survival was positively related to the Pacific Decadal Oscillation ($\hat{\beta}$ = 0.017, 95% CI = 0.0002 to 0.033; Table 21), which was consistent with our prediction. Other

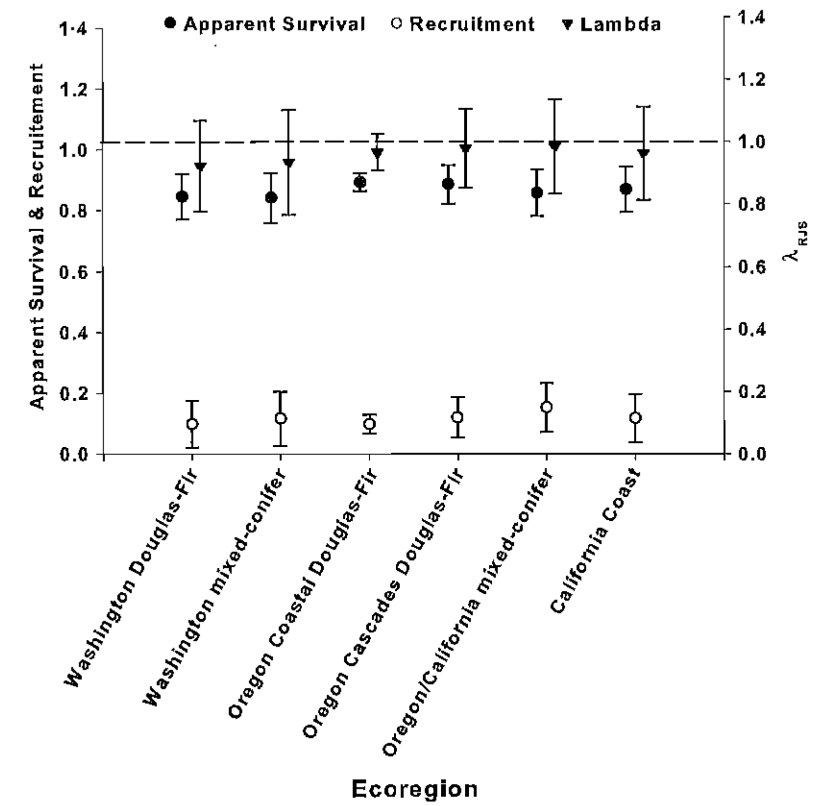


Figure 11. Point estimates and 95% confidence limits of apparent survival, recruitment, and λ of Northern Spotted Owls in different ecoregions based on the best *a priori* model from the meta-analysis of 11 study areas [RE φ(ECO) *f*(ECO)].

climate covariates explained little of the variation in apparent survival rates (Table 21). Lack of evidence of an effect of habitat and weather on apparent survival may represent a true absence of an effect, but we cannot rule out the possibility that the lack of an effect resulted from the covariates being computed at too coarse a scale, or because the definitions we used to map habitat did not accurately reflect suitable habitat.

Examination of the relationship between recruitment and ownership indicated a weak effect, with slightly higher recruitment on federal lands ($\hat{\beta}$ = 0.098, 95% CI = 0.058 to 0.137) than on mixed federal–private and private lands (Table 21). Although habitat covariates did not appear in any of the top models in the meta-analysis of λ, examination of the best models that included habitat covariates provided evidence that the percent of the study area covered by suitable owl habitat had a positive effect on recruitment (covariate HAB2 in Table 21). In contrast, recruitment was negatively related to the percent of the area surrounding the study area that was covered by suitable owl habitat (covariate HAB3 in Table 21). Our results may reflect an interaction or synergistic relationship between recruitment and the percent cover of suitable owl habitat within versus surrounding the study areas on federal lands compared to other land ownerships. We did not include such models in our *a priori* model set, so these relationships should be investigated in more detail in future analyses. There was no evidence that recruitment was influenced by any of our weather or climate covariates as all 95% confidence intervals for these covariates included zero (Table 21).

Plots of year-specific estimates of φ_t and f_t indicated considerable temporal and spatial variation, which produced high temporal and spatial variation in λ (Fig. 12). For example, all

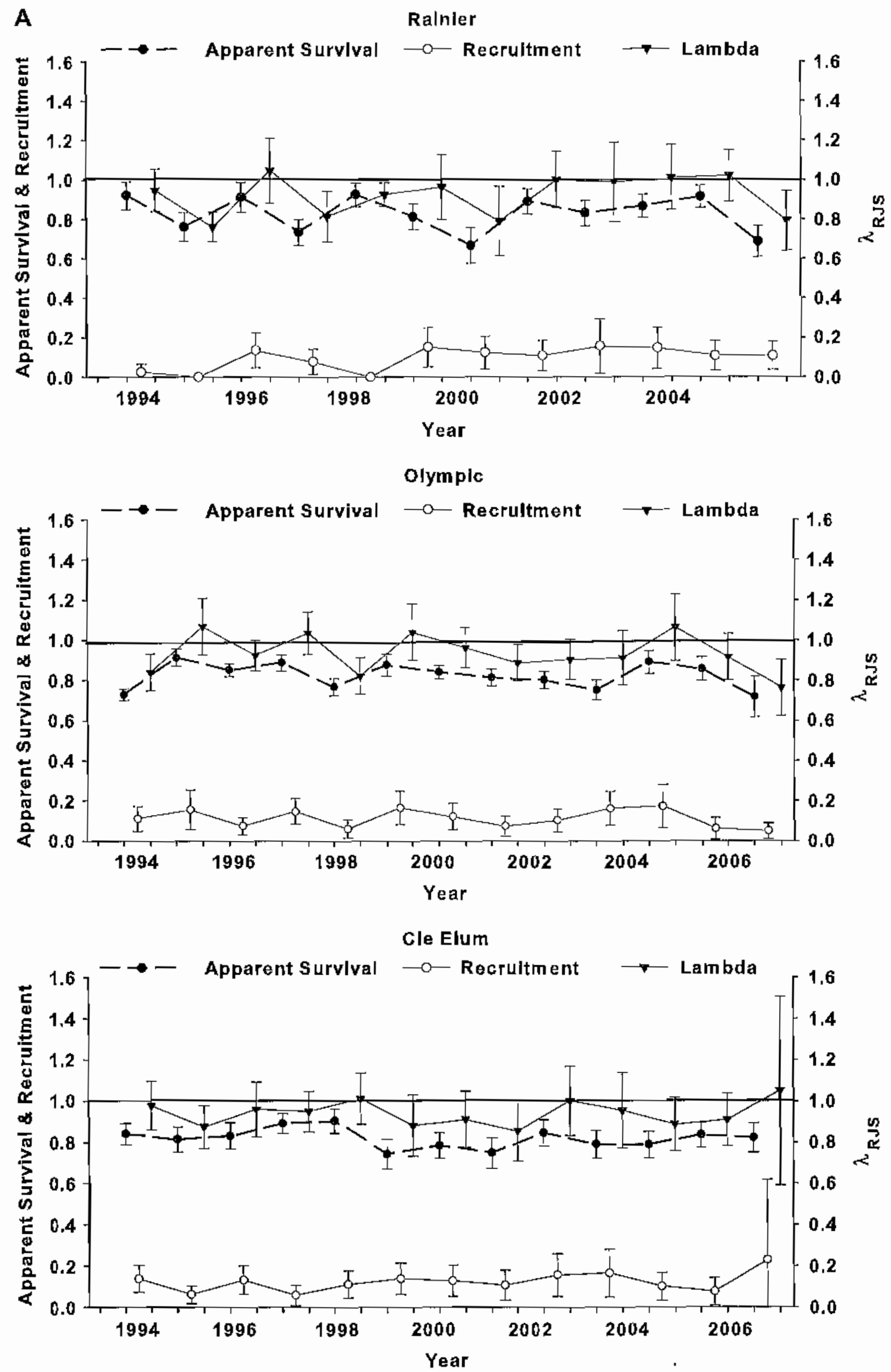


Figure 12. Estimates of apparent survival, recruitment, and λ of Northern Spotted Owls based on the most general model [(g*t) f(g*t)] from the meta-analysis of three study areas in Washington (A), five study areas in Oregon (B), and three study areas in California (C). Vertical bars indicate 95% confidence limits, and g and t represent study area and annual time effects, respectively.

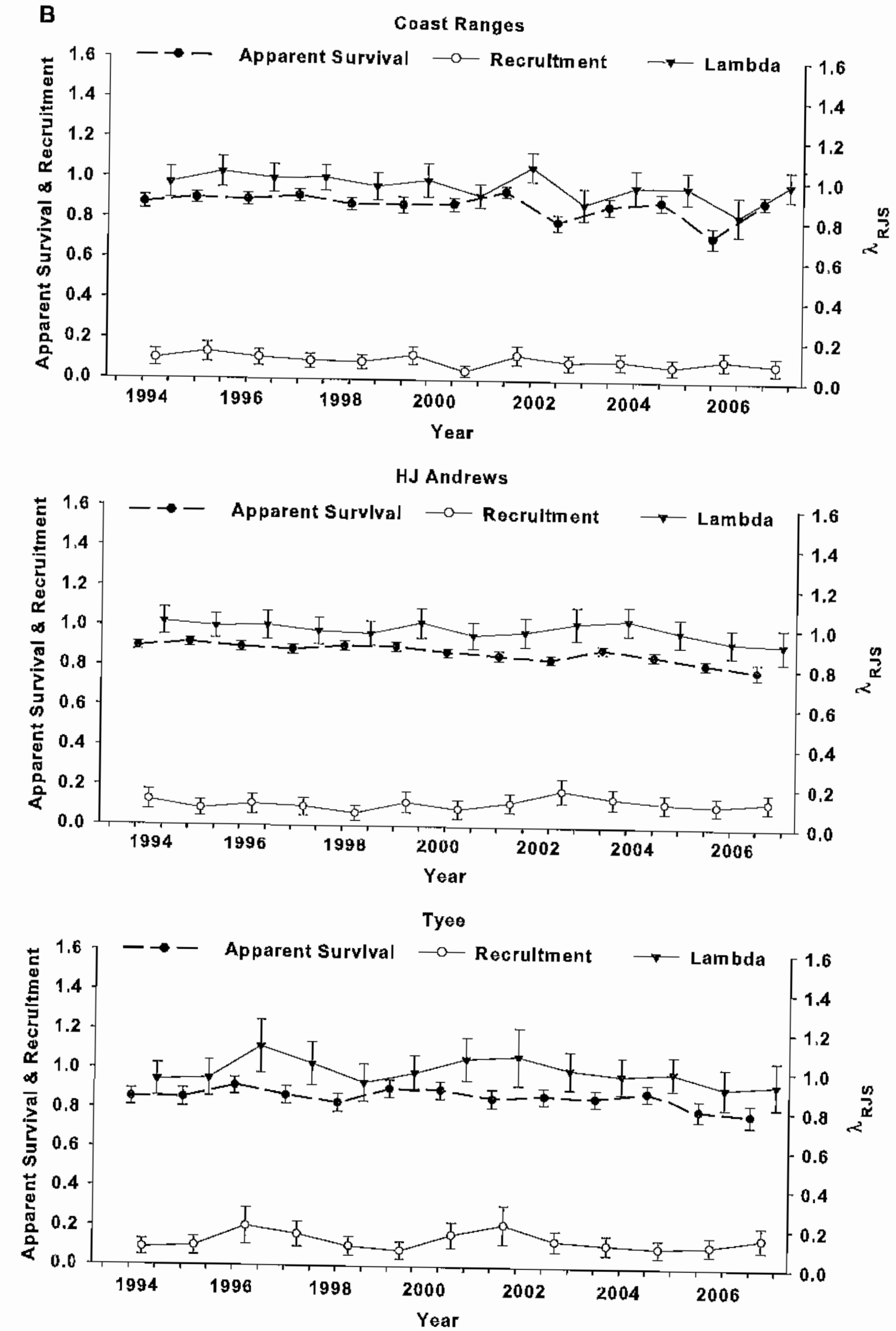


Figure 12. (*continued, for study areas in Oregon*)

B ***continued***

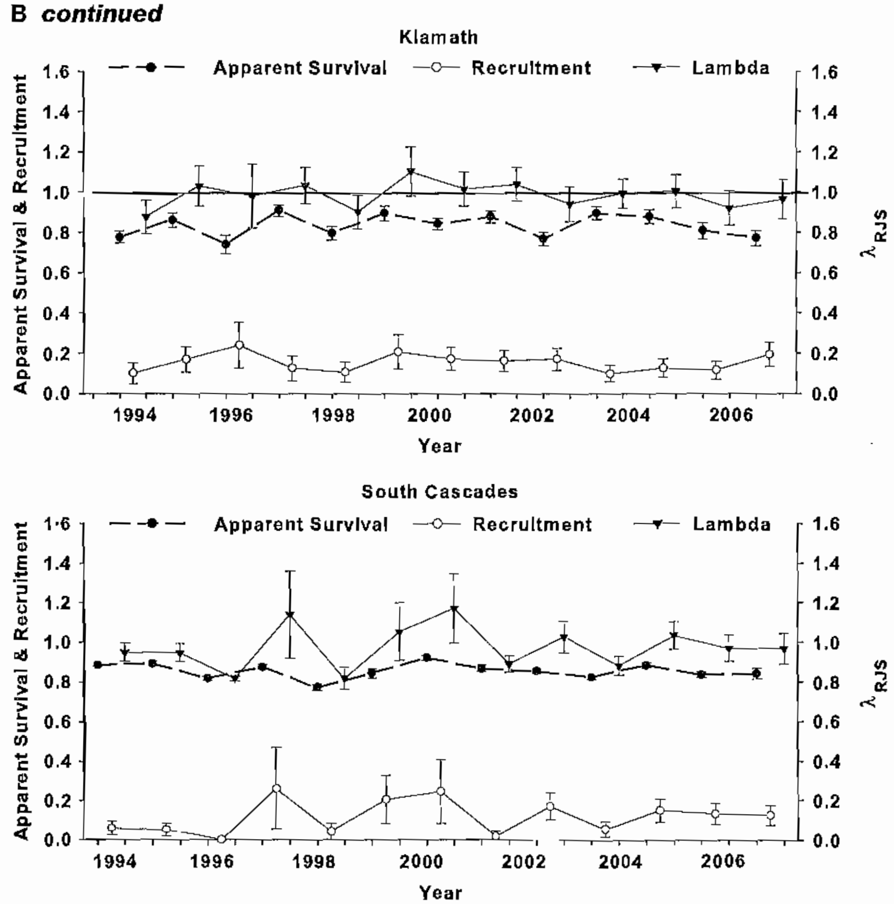


Figure 12. (*continued, for study areas in Oregon*)

three parameters (φ_t, f_t, λ) exhibited considerable variation in Washington where owl populations were declining the most (Fig. 12A), but less variation in most of the other study areas. Temporal variation in φ_t was paralleled by temporal variation in λ_t for most study areas (OLY, CLE, COA, HJA, TYE, KLA, NWC, HUP, GDR), suggesting that changes in λ_t were influenced primarily by changes in survival. However, this pattern was not as evident for RAI and CAS during all years, and there was evidence that recruitment had a substantial influence on λ_t in those two areas, particularly during years when λ_t increased noticeably. In addition, estimated recruitment was essentially zero in some years on the RAI, OLY, and CAS study areas, which resulted in noticeable declines in λ_t, since φ was always <1.0. Overall, the high temporal variation in the annual rate of population change of Spotted Owls was closely associated with apparent survival rates in most cases and with recruitment in a few cases.

DISCUSSION

The Northern Spotted Owl has been the "poster child" for conservation of old-growth and mature forests on federal lands in the Pacific Northwest and has served as an "umbrella species" (Roberge and Angelstam 2004) for conservation of other species associated with old forests (USDA Forest Service and USDI Bureau of Land Management 1994). As a result, numerous conservation plans have addressed the habitat needs of Spotted Owls on federal lands. In conjunction with the listing of the subspecies as threatened in 1990, the Interagency Scientific Committee (ISC) developed and published the first comprehensive conservation

C

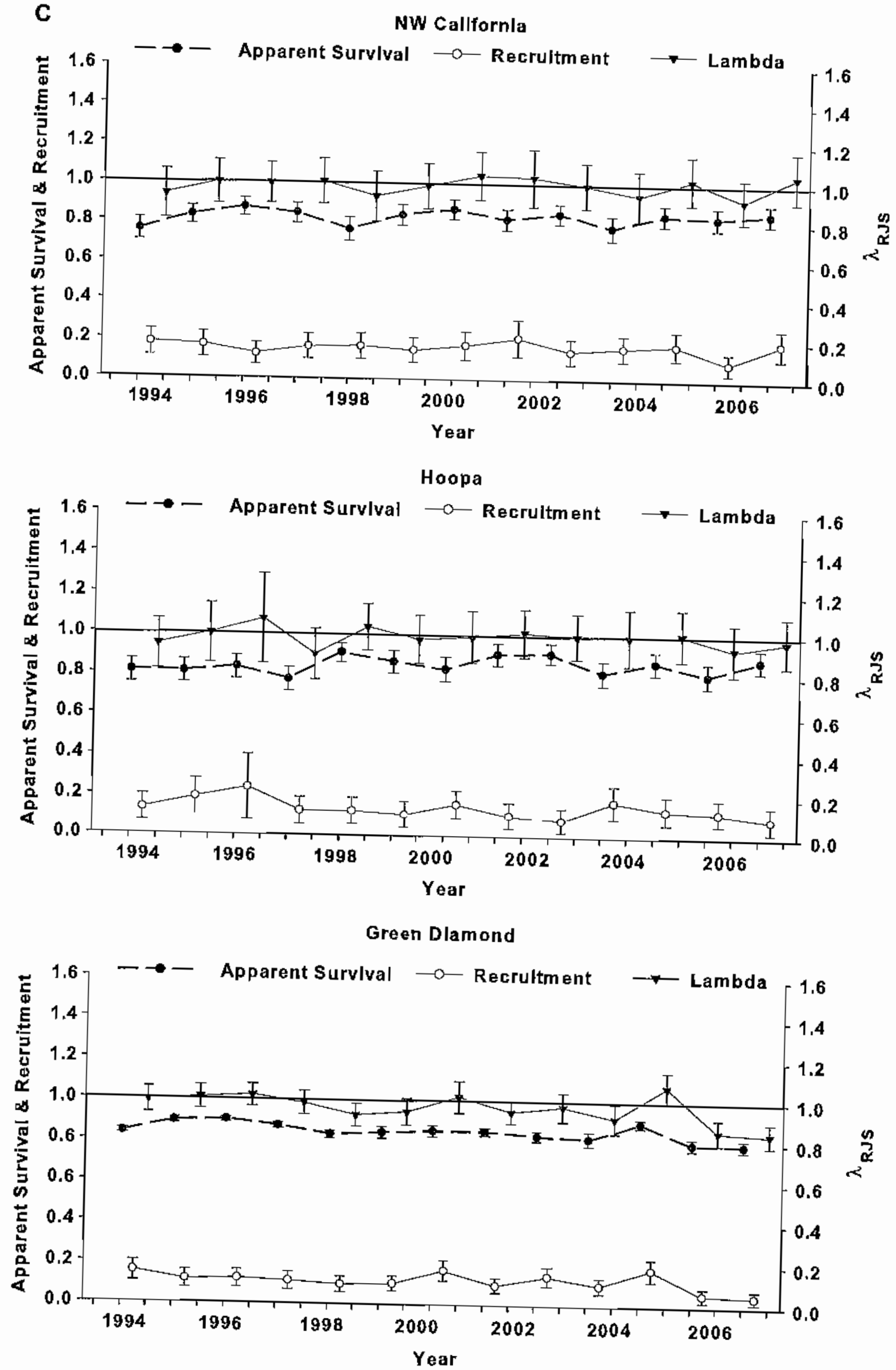


Figure 12. (*continued, for study areas in California*)

plan for the Northern Spotted Owl (Thomas et al. 1990). The ISC plan called for the conservation of an unprecedented amount of old forest in large reserves that were spaced within 19.2 km of each other and large enough to support 20 to 25 pairs of territorial owls. The ISC conservation strategy was the framework, with minor modifications, for the first draft final recovery plan for the Northern Spotted Owl (USDI Fish and Wildlife Service 1992), and also served as a model for the network of old forest reserves that eventually became the Northwest Forest Plan for management of all federal lands within the geographic range of the subspecies (USDA Forest Service and USDI Bureau of Land Management 1994).

The Northwest Forest Plan served as the *de facto* recovery plan for the Northern Spotted Owl for approximately 14 years during which time there was no approved recovery plan for the owl. The situation changed in 2008, when the U.S. Fish and Wildlife Service published a final recovery plan for the Northern Spotted Owl (USDI Fish and Wildlife Service 2008). The 2008 recovery plan included a much-reduced network of old forest reserves compared to the Northwest Forest Plan, and the approach laid out in the recovery plan was criticized by three professional societies concerned about the recovery of the owl (e.g., Wildlife Society 2008). The U.S. Department of Justice subsequently declined to defend the 2008 recovery plan, and it was remanded to the Fish and Wildlife Service with instructions that they address the deficiencies noted by their critics. At this writing, the Fish and Wildlife Service is working on a revision of the 2008 plan, but the situation is still unresolved.

Because the Northern Spotted Owl is federally listed as "Threatened" under the Endangered Species Act (USDI Fish and Wildlife Service 1990), and is the focus of many forest management practices that have been implemented in recent years in the Pacific Northwest, results of our study will be of interest to a number of stakeholders, including state and federal government agencies, conservation groups, private industry, and the public. Consequently, it is important to ask: What is our frame of reference and what kind of inferences can we make from the results of our study? From a statistical standpoint, a formal inference can be made from the sample of marked and recaptured owls to the population of owls in the study areas in which the marked owls were located. Our 11 study areas covered a large portion of the subspecies' geographic range and included substantial variation in latitude, elevation, and land ownership (Appendix A), but they were not selected randomly. Consequently, the results of our analyses cannot be considered representative of demographic trends of Northern Spotted Owls throughout their entire range. For example, there were no study areas in the extensive areas of state and private lands in northwestern Oregon and southwestern Washington or in the California Cascades. However, we believe that our results are representative of most populations of Northern Spotted Owls in the Pacific Northwest that are on federal lands or in areas of mixed federal and private ownership. We do not think that our results can be used to assess demographic trends of Spotted Owls on non-federal lands because the two study areas in our sample that were entirely on non-federal lands (GDR, HUP) were atypical. Both the Green Diamond Resource Company and the Hoopa Tribe managed their lands to protect known Spotted Owl nest areas and to maintain at least part of their lands in suitable foraging habitat for Spotted Owls. Such practices are not universal on private and state lands. If anything, our results probably depict an optimistic view of the overall population status of the Northern Spotted Owl.

This study is the fifth meta-analysis of demographic data from Northern Spotted Owls (Anderson and Burnham 1992, Burnham et al. 1996, Franklin et al. 1999, Anthony et al. 2006); however, only two of these efforts were published as refereed journal articles (Burnham et al. 1996, Anthony et al. 2006). The other articles are not readily available, so we will concentrate our discussion on the two published articles. The second meta-analysis of demographic rates of Northern Spotted Owls was conducted in 1993 and included 11 study areas (Burnham et al. 1996, Forsman et al. 1996a). The three major findings of the second analysis were: (1) Fecundity rates varied among years and ages of owls, with no increasing or decreasing trend over time; (2) survival rates were dependent on age and there was a decreasing trend in adult female survival; (3) the annual rate of population change (λ_{PM}) was <1.0 for 10 of 11 areas examined, and the estimated average rate of population decline was 4.5% per year (Burnham et al. 1996). Results of the first three meta-analyses of demography of Northern Spotted Owls were critiqued by Raphael et al. (1996) and Boyce et al. (2005), who questioned the estimates of annual rate of population change from Leslie matrix models (λ_{PM}), primarily because estimates of juvenile survival from capture–recapture methods were biased by permanent emigration during natal dispersal. Anthony et al. (2006) avoided this problem by using the Pradel (1996) model, which estimates the annual finite rate of population change (λ_{RJS}) of territorial owls without inclusion of juvenile survival rates. In addition, the Pradel (1996) model treats losses due to emigration and mortality and gains due to recruitment and survival in a symmetric way, so it is less subject to biases in the estimate of λ. For more information on this topic, see Anthony et al. (2006), and for a review of the differences between λ_{PM} and λ_{RJS}, see Sandercock and Beissinger (2002).

The most important findings in the Anthony et al. (2006) report were: (1) Fecundity was relatively stable among the 14 study areas examined, (2) survival rates were declining on 5 of the 14 areas, and (3) populations were declining on 9 of 13 study areas for which there was adequate data to estimate λ. The mean λ for the 13 areas was 0.963, which indicated that populations were declining 3.7% annually during the study (Anthony et al. 2006:34). The reasons for declines in Spotted Owl populations in their study were not readily apparent. Therefore, Anthony et al. (2006) recommended the use of additional covariates in future analyses to evaluate the possible influence of Barred Owls, weather, habitat, and reproduction on vital rates and population trends of Spotted Owls.

Fecundity

The results from our analysis of fecundity were consistent with previous analyses in that we found substantial annual variation in fecundity on individual study areas and a biennial cycle of high fecundity in even-numbered years and low fecundity in odd-numbered years (Burnham et al. 1996, Anthony et al. 2006). The cause of this synchronization remains unknown. One hypothesis for alternate year breeding in long-lived species that require many months to produce a single brood is that reproduction every year is physically impossible because of the large investment of time and energy required to produce a single brood. A hypothesis of intermittent breeding makes sense for some long-lived alternate year breeders such as Albatross (*Diomedea exulans, Phoebetria fusca, P. palpebrata*), which have to travel huge distances for many months in order to provision a single young (Tickell 1968, Weimerskirch et al. 1987). Although Spotted Owls also invest many months to produce a single brood (Mar–Aug), there is considerable variation among individuals regarding the alternate year pattern of breeding. In some of our study areas, the majority of owls nested every other year, but there were a few pairs that nested in nearly all years, and there were many that did not follow a predictable pattern. We conclude that breeding in the Spotted Owl is a complex interaction between age, prey abundance, weather, individual variation, and territory quality. However, none of these factors are known to fluctuate on a two-year cycle on our study areas, and prey cycles observed in other studies generally suggest cycles of three years or longer (Korpimaki 1992). Another hypothesis is that the likelihood of breeding is somehow influenced by the molt, which in Spotted Owls is characterized by an alternate year molt of the remiges and rectrices (Forsman 1981). The molt hypothesis seems unlikely, however, as no evidence indicates that the molt was synchronized within the owl populations. The molt hypothesis also does not explain the fact that the even–odd year effect became less evident in the last five years of our study.

Another consistent effect across study areas was variation in fecundity by age class. Fecundity was higher for adults than for 1-yr-olds, and 2-yr-olds were intermediate. A pattern of increasing fecundity with age is typical in birds (Clutton-Brock 1988, Saether 1990), and, in the case of territorial predators like Spotted Owls, probably reflects increased experience and familiarity with a territory and a long-term mate. Spotted Owls in the 1- and 2-yr-old age classes typically comprised <10% of the territorial population, so they contributed little to annual reproduction compared to adults. Age effects were not unexpected and have been well documented in previous studies of Northern Spotted Owls (Burnham et al. 1996, Anthony et al. 2006), California Spotted Owls (*S. o. occidentalis*; Blakesley et al. 2001), and Mexican Spotted Owls (*S. o. lucida*; Seamans et al. 1999, 2001), and are typical of long-lived birds in general (Newton 1989). Compared to the previous meta-analysis of Northern Spotted Owls (Anthony et al. 2006), the addition of five years of data resulted in slightly lower mean fecundity across study areas for adults ($\bar{x}$ = 0.340 vs. 0.372) and 2-yr-olds ($\bar{x}$ = 0.195 vs. 0.208), but slightly higher fecundity for 1-yr-olds ($\bar{x}$ = 0.103 vs. 0.074). However, our fecundity estimates were still well within the range of values reported on the same study areas during 1985 to 1994 (Burnham et al. 1996). Our results suggested that fecundity was declining in five areas (CLE, KLA, CAS, NWC, GDR), stable in three areas (OLY, TYE, HUP), and increasing in three areas (RAI, COA, HJA). Given the variation in trends among study areas, it was not surprising that the best or competitive models in the meta-analyses of fecundity did not include time trends in fecundity. Our results also were in contrast to a previous analysis in which fecundity appeared to be declining in only two study areas in Washington (Anthony et al. 2006).

In our analysis of individual study areas, there was evidence that the proportion of Spotted Owl territories with detections of Barred Owls had a negative effect on fecundity in four study areas (COA, KLA, CAS, GDR) and an unexpected positive effect on fecundity in one area (HJA). The high frequency of study areas with little evidence of effects of Barred Owls on fecundity did not support our hypothesis of competitive interactions, but findings of negative effects of Barred Owls on some study areas were in contrast to Anthony et al. (2006), who found little evidence of a Barred Owl effect on fecundity. In addition, there was weak evidence for a negative effect of Barred Owls on fecundity in both of our meta-analyses of fecundity. One explanation for the relatively weak effect of Barred Owls on fecundity in studies such as ours is that Barred Owls may simply displace Spotted Owls from their territories. When this happens, Spotted Owls enter the non-territorial population, where they are non-breeders and less detectable using the calling surveys used to sample territorial owls (Kelly 2001). Under this scenario, Spotted Owls that are not displaced may continue to breed at levels similar to historic levels, but the net effect of Barred Owls on fecundity is to reduce the total number of young Spotted Owls produced. Displacement of territorial Spotted Owls by Barred Owls may explain seemingly counterintuitive results such as the positive beta associated with the BO covariate in the analysis of fecundity on the HJA study area. In this situation, the Spotted Owls that are monitored are mostly the ones not displaced by Barred Owls, and are likely to be the oldest and most experienced owls. In addition, detections of Barred Owls were more frequent in our study areas in Washington and Oregon, so we did not expect the effects of Barred Owls to be as strong in California.

While climate and weather covariates explained little of the variation in fecundity in the meta-analysis, there was some support for climate or weather effects in the analyses of individual study areas. For example, there was evidence that low temperatures during the early nesting season had negative effects on fecundity in three study areas (RAI, COA, CAS) and had a positive effect on fecundity in one area (HUP). There was also evidence that high precipitation during the early nesting season had negative effects on fecundity in three study areas (CLE, KLA, NWC). Based on a territory-specific study of Spotted Owls on the TYE study area, Olson et al. (2004) also found evidence for a negative effect of precipitation during the early nesting season on fecundity in 1988 to 1999. Cold, wet weather during the incubation, brooding, and early fledgling stages has been reported to be a direct cause of egg and chick mortality through chilling and exposure in Peregrine Falcons (*Falco peregrinus*; Olsen and Olsen 1989, Bradley et al. 1997) and Australian Brown Falcons (*F. berigora*; McDonald et al. 2004). We also observed mortality in cases where recently fledged owlets died from exposure during unseasonal periods of cold, snowy weather in late May or early June. However, it is unclear if the effect of precipitation on fecundity is due primarily to direct loss of eggs or juveniles from exposure, effects on prey abundance or availability, or reduced foraging efficiency of adults (Franklin et al. 2000). Most likely, the effect is due to a combination of all of these factors. Studies of corticosterone levels show that inclement weather can lead to increased stress among adult birds in Dark-eyed Juncos (*Junco hyemalis*; Rogers et al. 1983), Storm Petrels (*Pelecanoides urinatrix*; Smith et al. 1994), Lapland Longspurs (*Calcarius lapponicus*; Astheimer et al. 1995), White-crowned Sparrows (*Zonotrichia leucophrys*; Wingfield et al. 1983), and male Song Sparrows (*Melospiza melodia*; Wingfield 1985). However, some studies also suggest that only unusually severe weather actually results in stress levels high enough to cause birds to forego nesting or to fail after starting to nest (Romero et al. 2000).

Dugger et al. (2005) suggested that a negative relationship between fecundity of Spotted Owls and mean precipitation in the previous winter could reflect climate effects on prey abundance and/or availability. Few studies have linked abundance or availability of Spotted Owl prey to weather conditions, but Lehmkuhl et al. (2006b) reported that annual survival of northern flying squirrels (*Glaucomys sabrinus*) was negatively associated with snow depth. Fecundity of Spotted Owls could also be influenced by prey abundance. Rosenberg et al. (2003) reported a positive correlation between fecundity of Northern Spotted Owls and abundance of deer mice (*Peromyscus maniculatus*) during the nesting season over an eight-year period on the HJA study area. However, deer mice were not the most important prey in the diet on the HJA study area (<10% of prey numbers), so it was unclear if the correlation between owl fecundity and deer mouse numbers was a causal relationship. Similarly, Ward and Block (1995) documented a year of high reproduction by Mexican Spotted Owls (*S. o. lucida*) that occurred in conjunction with an eruption of white-footed mice (*P. leucopus*) in southern New Mexico. Although the data are limited for Spotted Owls, annual variation in prey abundance has strong effects on fecundity of most raptors in northern latitudes, including such diverse species as Tengmalm's Owl (*Aegolius funereus*; Korpimäki 1992, Hakkarainen et al. 1997), Golden Eagle (*Aquila chrysaetos*; Steenhof et al. 1997), Great-horned Owl (*Bubo virginianus*; Rohner 1996), and Northern Goshawk (*Accipiter gentilis*; Salafsky et al. 2005). We suspect, therefore, that we will continue to have difficulty modeling annual variation in fecundity of Northern Spotted Owls without long-term information on the abundance of prey that make up the majority of their diet, especially flying squirrels, woodrats (*Neotoma* spp.), red-backed voles (*Myodes* spp.), deer mice, tree voles (*Arborimus* spp.), and lagomorphs (*Lepus americanus*, *Sylvilagus* spp.).

In Washington and Oregon, the habitat covariate was included in either a top fecundity model or a competitive model in seven of the eight study areas. There was strong evidence for a positive effect of the amount of habitat on fecundity in four study areas (COA, HJA, TYE, CAS), and a negative effect of habitat on fecundity in one area (KLA). We cannot discount the possibility that the absence of a strong effect of habitat on fecundity in all study areas was because our habitat covariate was too simplistic. Other habitat features such as the amount of edge, mean patch size, or amount of interior forest habitat may be important to Spotted Owls (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005), and these variables were not readily available for all of our study areas. Also, in a previous territory-specific study on the NWC study area, Franklin et al. (2000) found that fecundity of Spotted Owls was negatively associated with the amount of interior forest and positively associated with the amount of edge, whereas adult survival was positively associated with the amount of interior old-growth forest and with the amount of edge. Based on these findings, Franklin et al. (2000) postulated that "habitat fitness" for Spotted Owls was greatest in areas that included large amounts of interior mature and old-growth forest, but with considerable amounts of edge as well. However, evidence for a positive effect of edge on fecundity of Spotted Owls is not consistent across the range of the subspecies. For example, Dugger et al. (2005) found a positive relationship between fecundity and the percent cover of old forest within a 730-m-radius circle of Spotted Owl activity centers in southern Oregon but found no evidence that fecundity was positively associated with the amount of edge. Whether spatially explicit covariates such as the amount of edge or amount of interior old forest could be useful or meaningful in a study-area–specific analysis or in a meta-analysis of multiple study areas is questionable but should be explored.

The meta-analysis of adult fecundity also indicated differences among ecoregions and substantial annual variability with no apparent time trend. Our results were virtually identical to those reported by Anthony et al. (2006), including the high fecundity of Spotted Owls in the Washington Mixed-conifer ecoregion compared to all other regions. There was also some evidence for an effect of habitat and presence of Barred Owls on fecundity, but in both cases the confidence intervals for the regression coefficients overlapped zero. The lack of a strong signal regarding the effects of habitat and Barred Owls on fecundity in the meta-analysis was not surprising considering the high variation among study areas regarding the importance of the habitat and the highly variable number of detections of Barred Owls among study areas (Appendix B). The meta-analysis also provided little evidence that ownership, climate, or weather had strong effects on fecundity.

We did not monitor prey abundance on all our study areas, but some lines of evidence suggest that the high fecundity of Spotted Owls on the east slope of the Cascades in Washington could be due to particularly high abundance or availability of preferred prey such as flying squirrels and woodrats (Lehmkuhl et al. 2006a, b). In addition, the understory shrub layer in forests on the east slope of the Cascades tends to be less dense than in forests in western Washington and Oregon, which may make it easier for Spotted Owls to capture prey in forests on the east slope. Tests of the prey abundance and availability hypotheses will likely prove difficult, but one obvious need is to initiate studies to better evaluate annual variation in the total biomass of prey available to Spotted Owls in different study areas.

We identified three major difficulties in the approach we used to model fecundity in the present analysis and previous meta-analyses. First, it was difficult to establish the effects of other variables in the presence of the strong even–odd year fluctuations in fecundity during the 1990s. If no adjustment is made for these even–odd year effects, the residual variation is large and negatively auto-correlated over time, which overwhelms the effects of any other covariate. In addition, because the even–odd year effect started to dissipate after about 2000, models that included the even–odd year effect had large residuals, which in turn made it difficult to detect the effects of other covariates.

Second, some of our covariates were highly correlated and in many cases also reflected time variation. For example, the BO covariate was negatively correlated with temporal trends because the proportion of territories on which Barred Owls were detected increased on most study areas over time (Appendix B). The habitat covariate was also somewhat correlated with time because it mainly reflected habitat loss over time.

Finally, some of the covariates we investigated were likely influential at the level of the individual territory, but in this analysis we modeled average effect across populations (study areas). For example, habitat and Barred Owls may have a strong effect on fecundity of individuals, but this could be masked by using yearly averages, particularly in conjunction with the strong annual variation in fecundity observed in our study. The above problems are likely to be present in any study of a species with a cyclic pattern of fecundity or with highly correlated covariates. There is no easy solution to these problems, except to recognize that they occur, and to avoid the inclusion of highly correlated covariates in the same models.

Apparent Survival

Annual recapture probabilities of territorial Spotted Owls in our study areas generally ranged from 0.70 to 0.90, within the range of estimates reported in previous studies of Spotted Owls (Burnham et al. 1996, Anthony et al. 2006). With the exception of one study area (OLY), our results indicated that male and female Spotted Owls had similar survival rates. Studies of Ural Owls (*Strix uralensis*; Saurola 2003) and Tawny Owls (*S. aluco*; Karell et al. 2009) also indicated no gender differences in survival of these species as well (but see Millon et al. 2009). Gender differences in survival of birds have been attributed to many factors, including sexual differences in dispersal (Croxall et al. 1990), plumage attributes (Møller and Szép 2002), territorial defense (Clobert et al. 1988), and feeding behavior (Clobert et al. 1988). Because male Spotted Owls play the dominant role in territorial defense and feeding of the young, we predicted that, if anything, they would have lower survival than females. The pattern on the OLY study area was opposite to this expected result, which supported the alternative hypothesis that egg production, incubation, brooding, and nest defense had higher costs on the survival and site fidelity of females than did territorial defense and foraging by the male.

Results from our study areas also indicated that apparent survival was influenced by a number of other factors including age, time, Barred Owls, reproduction, and weather, depending on the study area in question. The age-specific pattern that we observed (lower survival in young birds) is typical of many, if not most, species of birds (Clobert et al. 1988; Newton 1989; Saurola 1987, 2003; Martin 1995; Karell et al. 2009). In long-lived, territorial birds like Spotted Owls, higher adult survival is probably attributable to the acquisition of a territory, foraging experience, and familiarity with the foraging area (Newton 1989, Martin 1995), but tests of these hypotheses have not been conducted.

Our estimates of survival were generally comparable to those reported by Burnham et al. (1996) and Anthony et al. (2006) except that the range of estimates for each age group in our study was slightly narrower than in the earlier studies. Our results were also comparable to those for adult California Spotted Owls (Blakesley et al. 2001, Seamans et al. 2001, Franklin et al. 2004) and adult Mexican Spotted Owls in Arizona (Seamans et al. 1999). Results from all three subspecies of Spotted Owls throughout their geographic range indicated that survival rates were high, with relatively low annual variability, while fecundity was highly variable from year to year. This life history strategy has been referred to as "bet hedging" (Stearns 1976, Franklin et al. 2000, Gaillard et al. 2000), where natural selection favors adult survival at the expense of producing fewer young during years with unfavorable conditions. Selection for high and comparatively stable adult survival is important because sensitivity analyses on population dynamics of Northern Spotted Owls (Noon and Biles 1990, Lande 1991) and California Spotted Owls (Blakesley et al. 2001) indicated that annual rates of population change were most influenced by changes in adult survival.

One disturbing finding in our analysis was that estimates of apparent survival were declining on 10 of the 11 study areas (CLE, RAI, OLY, COA, HJA, TYE, CAS, NWC, HUP, GDR, Fig. 5, Table 22). In addition, fecundity was declining in 5 of the 11 areas (Table 22). Declines in apparent survival of Northern Spotted Owls on some study areas have been reported previously (Burnham et al. 1996, Anthony et al. 2006), but, in contrast to those studies, our results indicated that recent declines were occurring across the entire range of the subspecies, including the

TABLE 22

Summary of trends in demographic parameters for Northern Spotted Owls from 11 study areas in Washington, Oregon, and California, 1985–2008.

Study area	No. of territorial owls in 2008[a]	Fecundity	Apparent survival (Model-averaged)	$\hat{\lambda}$	$\Delta\lambda$[b]
Washington					
CLE	18	Declining	Declining	0.937	Declining
RAI	36	Increasing	Declining	0.929	Declining
OLY	54	Stable	Declining	0.957	Declining
Oregon					
COA	105	Increasing	Declining since 1998	0.966	Declining
HJA	152	Increasing	Declining since 1997	0.977	Declining
TYE	123	Stable	Declining since 2000	0.996	Stationary
KLA	136	Declining	Stable	0.990	Stationary
CAS	83	Declining	Declining since 2000	0.982	Stationary
California					
NWC	84	Declining	Declining	0.983	Declining
HUP	51	Stable	Declining since 2004	0.989	Stationary
GDR	125	Declining	Declining	0.972	Declining

[a] Counts are based on banded territorial owls used in the analysis of $\hat{\lambda}$ and do not include owls that were not banded or whose bands were not confirmed.

[b] Population trends are based on estimates of realized population change (Δ_t).

southern portion. Estimated declines in adult survival were most precipitous in Washington, where annual apparent survival rates were <0.80 in recent years (Fig. 5A), a rate that may not allow for sustainable populations with current rates of fecundity and recruitment (Noon and Biles 1990, Lande 1991). In addition, the declines in adult survival and fecundity in Oregon have occurred predominantly within the last five years (Fig. 5B) and were not observed in the previous analysis of data from Oregon (Anthony et al. 2006). Compared to study areas farther north, declines in survival on the GDR and NWC study areas in California were more gradual and over a longer period of years. Collectively, the declines in apparent survival of Northern Spotted Owls across much of the subspecies' range are cause for concern because Spotted Owl populations are most sensitive to changes in adult survival rates (Noon and Biles 1990, Lande 1991).

Anthony et al. (2006) found evidence of a negative Barred Owl effect on apparent survival of Spotted Owls in only 2 of the 14 study areas they examined. In our analysis of data from individual study areas, the percent of Spotted Owl territories with Barred Owl detections had a negative effect on apparent survival of Spotted Owls on 6 of 11 areas examined (RAI, OLY, COA, HJA, GDR, NWC), with a weak or negligible effect on the other five areas (CLE, TYE, KLA, CAS, HUP). Thus, our results suggest that the negative effect of Barred Owls on survival of Spotted Owls may be increasing as Barred Owls continue to invade and increase in numbers in our study areas (Appendix B).

In the meta-analysis of apparent survival, we found differences among study areas and ecoregions, and considerable annual variation in adult survival. Apparent survival rates were higher in the Oregon Cascades Douglas-fir, Oregon Coastal Douglas-fir, and California Coast ecoregions compared to the Mixed-conifer ecoregions in Washington and Oregon/California. The meta-analysis also provided evidence of a downward trend in survival for all study areas, which was expected given that our analyses of the individual study areas indicated declining survival rates on 10 of 11 areas. The overall decline in survival suggests a further deterioration of the situation reported by Anthony et al. (2006), who found that declines in survival were limited primarily to study areas in Washington.

The best random effects models in the meta-analysis suggested that reproduction in the previous year and the proportion of territories with Barred Owl detections both had negative effects on survival. We found some evidence that early nesting season precipitation had a negative effect on apparent survival but there was little to no evidence that the Pacific Decadal Oscillation, Southern Oscillation Index, nesting season temperature, percent cover of habitat, ownership, or latitude were associated with survival. It was not surprising that we did not find much evidence for an effect of weather in the meta-analysis because a previous analysis of demographic data and weather variables from six of our study areas indicated that the association of apparent survival with weather and climate covariates was quite variable among areas (Glenn 2009, Glenn et al. 2010, 2011). The lack of association between survival and most weather covariates suggests that Spotted Owls are able to cope physiologically with a fairly broad range of adverse weather conditions before their survival is affected. Romero et al. (2000) proposed a similar hypothesis regarding the effects of weather on reproduction of three species of Arctic passerines. If survival is affected only by the most extreme weather events, which occur at unpredictable times, detection of these effects will likely require hierarchical analyses to evaluate the influence of within-year or within-season weather events (Rotenberry and Wiens 1991).

Annual Rate of Population Change and Realized Rates of Population Change

Individual Study Areas

Our estimates of λ were <1.0 for all study areas (range = 0.929 to 0.996), and there was strong evidence that populations declined on 7 of the 11 areas that we examined (RAI, OLY, CLE, COA, HJA, NWC, GDR). On the other four areas (TYE, KLA, CAS, HUP), either populations were stable or the precision of the estimates was not sufficient to detect declines. The number of territorial owls detected on all 11 areas was lower at the end of the study than at the beginning, and few territorial owls could be found on some of the study areas in 2008 (Table 22). Estimated rates of decline were highest for study areas in Washington (RAI, OLY, CLE) and the COA study area in Oregon. The weighted mean estimate of λ for all 11 study areas was 0.971, indicating an average population decline of 2.9% per year during the years 1990 to 2006. An average annual decline of 2.9% is lower than the 3.7% reported by Anthony et al. (2006), but the rates are not directly comparable because Anthony et al. (2006) examined a different series of years and because two of the study areas in their analysis were discontinued (WEN, WSR) and not included in our analysis. In our analysis, rates of population decline for individual study areas were slightly higher than those reported by Anthony et al., who found that populations on 9 of 13 study areas were declining. In California, Franklin et al. (2004) found that estimates of λ_{RJS} for California Spotted Owls were negative on four of five study areas examined, but in all five cases the 95% confidence intervals on λ overlapped 1.0. Franklin et al. (2004:33) concluded that either ". . . the populations were stationary or the estimates of λ_t were not sufficiently precise to detect declines if they occurred."

Our estimates of λ apply only to the years from which the data were analyzed, which spanned the 16-year period from 1990 to 2006 (Table 19). Any predictions about past or future trajectories of Spotted Owl populations on our study areas are risky. Also, the estimates of λ are mean estimates of the annual rate of population change in the number of territorial Spotted Owls on the study areas, and the estimates of λ_t for each study area varied considerably. Consequently, we attempted to illustrate how annual changes in λ_t influenced trends in population numbers by estimating realized population changes, Δ_t, for each study area. Based on these estimates, populations on the CLE, RAI, OLY, and COA study areas declined 40 to 60% during the last 15+ years, and populations on HJA, NWC, and GDR declined by 20 to 30%. Populations of territorial owls on the TYE, KLA, CAS, and HUP study areas declined 5 to 15%, but confidence intervals for these estimates substantially overlapped 1.0, and precision of the estimates was not sufficient to detect such small declines. Both the timing of the population declines and the rates of decline differed among study areas (Fig. 10). Thus, there was no evidence that population declines were synchronized among study areas, even though some of the study areas were relatively close together (e.g., COA, TYE, KLA), and marked individuals from one study area were occasionally re-sighted in another study area. The number of populations that declined and the rate of decline on study areas in Washington and northern Oregon were noteworthy and should be cause for concern for the long-term sustainability of Northern Spotted Owl populations throughout the range of the subspecies.

Meta-analysis of Annual Rate of Population Change

In the meta-analysis of λ, we found differences among ecoregions and a negative effect of Barred Owls on survival. Apparent survival was highest in the Oregon Coast Douglas-fir ecoregion, which was expected given that the Oregon Coast Range study area also had higher survival in the meta-analysis of survival. Apparent survival and λ were lowest in the Douglas-fir and Mixed-conifer ecoregion in Washington, and recruitment was highest for the Oregon/California Mixed-conifer region. There was weak evidence that apparent survival was related to the percent cover of suitable owl habitat on four of eight study areas, but there was no evidence that weather or land ownership influenced apparent survival in the meta-analyses of λ. In contrast, there was evidence that the amount of suitable habitat within study areas had a positive influence on recruitment, and recruitment was highest for study areas on federally owned lands that had the highest proportions of suitable owl habitat. Positive associations between the percent cover of suitable owl habitat and survival and recruitment were expected because previous studies (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005) have also found positive associations between apparent survival or fecundity and the amount of older forests surrounding Spotted Owl nest sites. However, given the importance of habitat in most previous studies of Spotted Owls, we were surprised that the percent cover of suitable habitat was not included in the top models for all study areas. Weak effects of habitat in our analysis could be the result of using habitat as a study area covariate as opposed to a site-specific covariate. The area-specific habitat covariate may have obscured relationships that could only be detected with finer-scale analyses of survival and fecundity at the scale of the owl home range.

In the meta-analysis of λ, we asked: Is temporal variation in λ_t determined primarily by variation in φ_t, f_t, or both? This general question is relevant to management because the answer may provide guidance regarding which population parameter(s) managers should focus on most when designing habitat management plans. In addition, there is some basis for prediction regarding the most important population parameters for species like Spotted Owls based on previous research on evolution of life history strategies in animals. In mammals and birds with long life spans, such as Spotted Owls, population dynamics are typically characterized by (1) rates of population change that are most sensitive to changes in adult survival, and (2) adult survival that exhibits a relatively small amount of temporal variation compared to temporal variation in recruitment (Pfister 1998; Gaillard et al. 1998, 2000; Gaillard and Yoccoz 2003). The degree to which annual variation in population change reflects variation in one parameter or another is a function of both the sensitivity of λ to that parameter and temporal variation in the parameter. Based on these patterns, we predicted there would be small temporal variability in adult survival compared to recruitment. The plots of year-specific estimates of λ_t, φ_t, and f_t provided illustrations of the temporal variation in annual population changes and its two primary components (φ_t and f_t; Fig. 12).

Although it was not our objective to draw inferences about whether survival or recruitment was more "important" to population change (see Hines and Nichols 2002 for discussion of this topic), we were interested in whether survival of territorial adults varied so little over time that most temporal variation in λ_t was produced by temporal variation in recruitment. This prediction did not hold true for Northern Spotted Owls because survival of adults varied considerably among years (range ≈ 0.70 to 0.90). Because of the importance of adult survival to annual population change (Lande 1988, Noon and Biles 1990), the observed variation in adult survival often corresponded closely to annual variation in λ and was most noticeable where populations were declining the most, especially study areas in Washington. However, the annual variation in apparent survival in our study was not nearly as great as annual variation in reproduction, so our results do fit the pattern usually observed in long-lived vertebrates, where survival is relatively constant compared to fecundity (Stearns 1976, Franklin et al. 2000, Gaillard et al. 2000).

Status of Owl Populations in the Eight NWFP Monitoring Areas

Eight of the study areas in our analysis (CLE, OLY, COA, HJA, TYE, KLA, CAS, NWC) are part of the effectiveness monitoring program for the Northern Spotted Owl in the Northwest Forest Plan (NWFP; Lint et al. 1999). As such, these areas are of special interest to the federal agencies charged with management of the owl. Our analysis indicated that populations on five of these study areas (CLE, OLY, COA, HJA, NWC) were declining during our study. Point estimates of λ on the other three areas (TYE, KLA, CAS) were <1.0, but the 95% confidence intervals on the estimates of λ broadly overlapped 1.0, so we could not reject the hypothesis that those populations were stationary. The weighted mean λ for the eight monitoring areas was 0.972 (SE = 0.006), which indicated that populations on those areas declined on average 2.8% per year during the 16-year study period.

Our results from the meta-analyses of fecundity and apparent survival were similar regardless of whether we used the entire sample of 11 study areas or limited the analysis to the eight NWFP monitoring areas. Therefore, we suggest that future analyses of the data from Northern Spotted Owl demography study areas be conducted only on the entire sample. Conducting a single analysis of all the data will greatly simplify the cooperative approach without losing any important information.

Associations Between Demographic Parameters and Covariates

Determination of cause–effect relationships is not possible with observational studies like ours. Rather, we attempted to assess the relative strength of associations between vital rates of owls and various environmental parameters such as habitat, weather, and presence of Barred Owls. It is implicit in this type of analysis that strong associations between vital rates and environmental factors are likely indicative of cause–effect relationships. Testing for associations is a common approach in ecology, where experimental tests of cause–effect relationships are difficult or impossible to conduct. Previous meta-analyses of demography of Northern Spotted Owls lacked the ability to assess potential processes responsible for causes of population declines. As a result, Anthony et al. (2006) recommended the development and use of biological covariates to help explain the variability in demographic rates and better understand the possible reasons for population changes. Consequently, we devoted considerable time to the development and refinement of covariates for evaluating the potential effects of reproduction, Barred Owls, climate, and percent cover of suitable owl habitat on fecundity, apparent survival, and recruitment at the population (study area) scale. Reproduction and Barred Owl covariates were previously investigated in the Anthony et al. (2006) analysis, but the climate and habitat covariates were new to our analysis. We also spent considerable time trying to develop a covariate for Barred Owls that was both time- and territory- or individual-specific, but inclusion of such a covariate proved infeasible in our analysis. Use of territory-specific covariates has proven feasible only in studies such as those conducted by Olson et al. (2004, 2005), Bailey et al. (2009), and Dugger et al. (2005), where the frame of reference is the individual territory as opposed to the study area or region. The area-specific Barred Owl covariate that we used differed from the covariate used by Anthony et al. (2006) in that our metric was based on Barred Owl detections anywhere within a 1-km radius of any of the historic activity centers in each Spotted Owl territory (see Methods for more details), as opposed to just the most recently occupied activity center. We used the new Barred Owl covariate because it may be a better indicator of the potential influence of Barred Owls on Spotted Owls in each territory.

Cost of Reproduction on Survival

There have been a number of correlative studies in which researchers found evidence that reproduction had negative effects on survival of breeding birds, including Western Gulls (*Larus occidentalis*; Pyle et al. 1997), Greater Flamingos (*Phoenicopterus ruber*; Tavecchia et al. 2001), Great Tits (*Parus major*; McCleery et al. 1996), and Lesser Scaup (*Aythya affinis*; Rotella et al. 2003). Anthony et al. (2006) found that apparent survival of Northern Spotted Owls was negatively related to the mean number of young produced in the previous summer on some study areas in Washington and higher-elevation areas in Oregon. They hypothesized that negative correlations between survival and reproduction suggested a cost of reproduction, with the ultimate factor being weather-related. Although the reproduction covariate was not included in the top or competitive models for most individual study areas in our analysis, it was a factor in the best random effects model in the meta-analysis of survival. Based on this result, we concluded that there was evidence of a negative effect of reproduction on survival, even though the reproduction covariate did not explain a large amount of the annual variation in adult survival. The potential effect of reproduction on apparent survival did not appear to be related to the recent and widespread declines in Spotted Owl populations; however, it may be a contributing factor to some of the population declines, and this relationship needs further investigation. If a cost of reproduction is important in Spotted Owls, the proximate causes could include increased exposure to predation or increased energy expenditure while foraging, feeding young, and defending the territory. These factors have all been proposed as potential costs associated with reproduction in other birds (Newton 1989), but have been experimentally tested in only a few cases, with mixed results (Cichoń et al. 1998).

Weather and Climate

Several studies have documented associations between fecundity or apparent survival of Northern Spotted Owls and seasonal weather patterns (Wagner et al. 1996, Franklin et al. 2000, Olson et al. 2004, Glenn 2009, Glenn et al. 2010, 2011). Our results indicated that associations between fecundity, apparent survival, or recruitment and weather covariates varied among study areas. Fecundity was positively associated with mean temperature during the early nesting season on four of our study areas (RAI, COA, CAS, GDR). The positive association between fecundity and warm weather during the early nesting season has also been noted in several previous studies in which researchers used territory-based analyses to examine the effects of weather on fecundity of Spotted Owls (Wagner et al. 1996, Franklin et al. 2000, Olson et al. 2004, Glenn et al. *In press*). In addition, there was some evidence that fecundity was negatively associated with mean precipitation during the early nesting season on the KLA, CLE, and NWC study areas, and mean temperature during the late nesting season had a negative association with fecundity on TYE. Our results, and those of others (Franklin et al. 2000, Olson et al. 2004, Glenn et al. *In press*), suggest that years of high precipitation and low temperatures during the early nesting season can have a negative effect on fecundity of Northern Spotted Owls.

In our meta-analysis of survival, we detected a positive association between apparent survival and the Pacific Decadal Oscillation, and a negative association between apparent survival and early nesting season precipitation, but these associations were not strong. Similarly, the meta-analysis of λ indicated a positive association of apparent survival with the Pacific Decadal Oscillation, but no evidence for an association between recruitment and any of the climate covariates. (Glenn et al. 2010) reported a similar association between λ and the Pacific Decadal Oscillation on a subset of the study areas in our analysis. Positive values of the Pacific Decadal Oscillation are associated with lower than average rainfall and higher than average temperatures (Parson et al. 2001). We did not find evidence for any other associations between survival or recruitment of Northern Spotted Owls and weather or climate covariates in the meta-analyses. Lack of effects was not surprising because weather and climate varied considerably across the range of the Northern Spotted Owl, even within the same year (Glenn et al. 2010). Thus, analyses of potential associations between demographic rates and weather and climate covariates on individual study areas may reveal patterns that were obscured in our meta-analysis of multiple study areas.

In summary, our analysis of climate covariates indicated the most evidence for a positive association between fecundity and mean temperature during the early nesting season, and a negative association between fecundity and mean precipitation during the early nesting season. We found little evidence for effects of weather on apparent survival and recruitment, and the only climate variable for which we found a positive association with apparent survival was the Pacific Decadal Oscillation. We concluded that weather and climate may contribute to lower demographic rates for some areas in some years, but the effects were not sufficient to explain the major population declines that have occurred during the last 15 to 20 years.

Barred Owls

The number of Barred Owl detections in our study areas has increased dramatically during the last two decades (Appendix B). The increase in Barred Owls has been most noticeable in Washington and Oregon, but has become apparent in northern California as well (Dark et al. 1998, Kelly 2001, Kelly et al. 2003). Invasion and rapid population growth of this congeneric species throughout the range of the Northern Spotted Owl has led to concerns of high potential for competition between the two species. Recent studies have also documented a negative association between occupancy of nesting territories (Kelly et al. 2003, Olson et al. 2005), fecundity (Olson et al. 2004), and apparent survival (Anthony et al. 2006) in some areas in relation to the presence of Barred Owls near nesting areas of Spotted Owls. Consequently, we hypothesized that demographic rates would be negatively associated with the presence of Barred Owls within 1 km of activity centers of Spotted Owls.

We found evidence that fecundity was negatively associated with the presence of Barred

Owls on the CAS, COA, KLA, and GDR study areas. Moreover, apparent survival was negatively associated with the presence of Barred Owls on the RAI, OLY, COA, HJA, GDR, and NWC study areas in both analyses of individual study areas and the meta-analysis. The meta-analysis of λ also indicated a negative association of apparent survival and recruitment with the proportion of territories with Barred Owl detections, but the evidence for a relationship with recruitment was weak. We also found evidence for a negative association of re-sighting probabilities of Spotted Owls when Barred Owls were detected near Spotted Owl nest areas on some of the individual study areas. In summary, we found evidence of negative relationships between demographic rates of Spotted Owls and the presence of Barred Owls on most study areas; therefore, our initial hypothesis was confirmed at least on some study areas. We suspect that the variable relationships between vital rates of Spotted Owls and the presence of Barred Owls were primarily due to the variable detection rates and arrival dates of Barred Owls invading the study areas (Appendix B). Another explanation for the inconsistent, and in some cases weak, associations between vital rates of Spotted Owls and detections of Barred Owls is that our BO covariate was coarse in scale (year-specific only) and was applied at the population scale and not the individual territory scale. Consequently, we believe the influence of Barred Owls on demography of Spotted Owls is likely stronger than was indicated by our analyses. There is a need to develop a covariate for Barred Owls that is both year- and territory-specific (Anthony et al. 2006). Our results support the findings of previous studies that have also reported evidence for negative associations of demographic performance of Spotted Owls when Barred Owls were detected near their nest areas (Kelly et al. 2003; Olson et al. 2004, 2005; Anthony et al. 2006). In addition, Olson et al. (2005) found evidence that occupancy and colonization rates of Spotted Owl territories were negatively associated with detections of Barred Owls. In another territory-specific study, K. Dugger et al. (In press) found evidence that extinction rates of Spotted Owl territories were higher on territories with Barred Owl detections, and this effect was stronger as the amount of habitat decreased. The latter results suggested an additive effect of decreasing habitat and presence of Barred Owls on demographic performance of Spotted Owls.

Taken together, results of our current study and previous studies do not prove a causal effect of Barred Owls on the demography of Northern Spotted Owls. However, the consistency of the negative associations between Spotted Owl demographic rates and presence of Barred Owls in multiple studies lends support to the conclusion that Barred Owls are having a negative effect on spotted owl populations. Of the various factors we investigated to ascertain potential effects on demographic rates of Northern Spotted Owls, the mostly negative associations with the presence of Barred Owls were the strongest and most consistent factor among study areas. The negative associations with Barred Owls were more numerous and stronger in our analysis than those reported by Anthony et al. (2006), and corresponded with the increase in detections of Barred Owls in the last five years on our study areas. The increasing evidence for a Barred Owl effect suggests that recent declines in fecundity, apparent survival, and populations of Spotted Owls on our study areas are at least partly due to interactions with Barred Owls. However, we cannot rule out the potential influence of continued declines in habitat as another factor contributing to population declines (see below).

Habitat

Our investigation of the potential influence of habitat on demographic rates of Northern Spotted Owls was both challenging and problematic for a number of reasons. First, comparable vegetation maps from satellite imagery for the entire range of the subspecies were not available, and it was clear during the workshop that the imagery for California was developed with different criteria and was different from the vegetation map of Washington and Oregon. As a result, we excluded the California study areas in the meta-analysis of demographic rates with the habitat covariate. Second, the available map for Oregon and Washington did not span the entire length of time that the demographic studies were conducted, so we had to estimate the amount of suitable owl habitat that was present on the study areas both prior to and after 1996, when the best map was available. We estimated the amount of habitat that was lost due to harvest and wildfires during the time of the studies with a change detection algorithm (see Methods section). Third, there may have been some small amount of forest that became suitable owl habitat as a result of forest re-growth during our studies, but we could not readily identify these forests to be able to adjust our estimates accordingly. Fourth, the maps that we used characterized forest vegetation at landscape scales and did not characterize the understory structure, which has been shown to be important for Spotted Owls and their primary prey (Carey et al. 1992, Rosenberg and Anthony 1992, Buchanan et al. 1995, LaHaye and Gutiérrez 1999, Lehmkuhl et al. 2006b).

While the amount of suitable habitat on some study areas in Oregon had a positive effect on reproduction, there was little evidence for a consistent effect of habitat on fecundity for all areas in Washington and Oregon from the meta-analysis. The absence of a strong association between the amount of habitat and fecundity was not entirely surprising considering that two previous studies found evidence that "habitat fitness" for Spotted Owls increased in landscape configurations that included a mixture of old forests and edge (Franklin et al. 2000, Olson et al. 2005, but see Dugger et al. 2005). Whether inclusion of a forest edge covariate in our analysis would have made a difference in the outcome is unclear, but inclusion of such a covariate should be considered in future analyses.

In the meta-analysis of survival, apparent survival was positively related to the percent cover of suitable owl habitat within the study area boundaries, but the 95% confidence intervals overlapped zero, indicating that the evidence for an association was weak. The habitat covariate was not included in the analysis of survival rates for individual study areas, which was an oversight during the development of the protocol (see below). Such analyses should be considered in the next major analysis of demographic data from Spotted Owls. In the meta-analysis of λ, apparent survival was related positively to the percent cover of suitable habitat in the CLE, COA, HJA, and TYE study areas, as 95% confidence intervals for the regression coefficients for the habitat covariate barely overlapped zero. More importantly, we found a positive relationship between recruitment and the percent cover of suitable owl habitat within the study areas in the meta-analysis of λ. Recruitment was also highest on federally owned lands where the amount of suitable habitat was highest (Davis and Lint 2005). One possible explanation for the latter result is that more habitat within the study areas provided areas where non-territorial owls could occupy and survive until they were able to recruit into the territorial population.

A number of territory-specific studies of Spotted Owls have reported fairly strong associations between the amount of suitable habitat and demographic rates of Spotted Owls. The fact that we found relatively weak associations between the amount of habitat and demographic rates suggests that our area-specific covariate was too coarse to reveal actual relationships that were acting at the scale of the individual owl territory. Our conclusion should not be used to infer that the amount of old forest (suitable owl habitat) is not important to the demography of the Spotted Owl, because other studies have documented positive associations between demography and the amount of old forest surrounding nest sites of Spotted

Owls. For example, apparent survival was positively related to the amount of old forest surrounding nest sites in territory-specific studies of Spotted Owls in northwestern California (Franklin et al. 2000) and southern Oregon (Dugger et al. 2005). In the territory-specific studies conducted by Franklin et al. (2000) and Olson et al. (2004), large areas of mature and old forest interspersed with openings provided the best habitat for Northern Spotted Owls in northwestern California and the Oregon Coast Ranges. In southern Oregon, Dugger et al. (2005) found that reproductive rates of Spotted Owls were positively related to the proportion of old-growth forest within a 730-m-radius circle around nest sites. In the Sierra Nevada of California, Seamans and Gutiérrez (2007) observed higher colonization and lower extinction rates for California Spotted Owls on territories with more mature conifer forest. In the above studies, analyses were conducted at the scale of owl territories within study areas and with a smaller scale of habitat mapping from aerial photographs; the results of those studies were more definitive than our study, which was at the scale of entire study areas (populations). Also, recent analyses of occupancy dynamics of Northern Spotted Owls in the southern Cascades of Oregon indicated that there was an additive and negative effect of Barred Owls and decreased amounts of habitat on occupancy and colonization, and a positive effect on extinction of nesting territories (Dugger et al. In press). The latter results suggest that it may be necessary to conserve even more old forest habitat than is currently protected, if the objective is to increase the likelihood that Spotted Owls will be able to persist in the face of potential competition with Barred Owls for space, habitat, or prey. Competition theory predicts that more habitat is necessary if two species are to persist when they are in direct competition (Levins and Culver 1971, Horn and MacArthur 1972), an important consideration in the conservation of Northern Spotted Owls. Carrete et al. (2005) recommended an increase in suitable habitat for two potentially competing raptors, the Golden Eagle (*Aquila chrysaetos*) and Bonelli's Eagle (*A. fasciata*) in southern Spain. Last, it is well documented that Northern Spotted Owls select older forests for nesting (Hershey et al. 1998, Swindle et al. 1999), and roosting and foraging (Forsman et al. 1984, Thomas et al. 1990, Bart and Forsman 1992, Herter et al. 2002, Glenn et al. 2004, Forsman et al. 2005) throughout most of their range, so these forests are important to their survival and population persistence. Selection for the oldest available forest is consistent even within managed forests on private lands in northwestern California, where Diller and Thome (1999) and Thome et al. (2000) found that Spotted Owls usually occurred in the oldest available forests. Researchers studying California Spotted Owls have also reported strong associations with older forests for nesting, roosting, and foraging (LaHaye et al. 1997, LaHaye and Gutiérrez 1999). Consequently, despite the weak associations between demographic rates and habitat in our analysis, it would be incorrect to conclude from our results that old forest vegetation is not important to Northern Spotted Owls.

Potential Biases in Estimates of Demographic Parameters

Numerous authors have discussed possible biases associated with estimates of fecundity or survival from long-term demography studies of Northern Spotted Owls (Raphael et al. 1996, Van Deusen et al. 1998, Manly et al. 1999, Boyce et al. 2005, Loehle et al. 2005). In some cases, these critiques resulted in rigorous rebuttals (Franklin et al. 2006). Because parameter bias could have important effects on development of effective conservation and management strategies, we discuss potential sources of bias in our estimates of fecundity and apparent survival below.

Fecundity

Estimates of fecundity can be biased if territorial females are present on the study area but are not detected in any given year. If the undetected territorial females nest successfully, fecundity could be underestimated. If undetected birds do not nest, or nest and fail, fecundity is overestimated. These two sources of bias may cancel each other out because both scenarios can happen in the same year, but we suspect that the positive bias is slightly more prevalent than the negative bias because non-nesting females and females that nest and fail tend to be more difficult to detect than nesting females. However, re-sighting probabilities of owls in our study were typically >0.75, so the frequency of missing data on reproduction in most years was small. Even if there was a bias in our estimates of fecundity, this bias should have been consistent among years and study areas. Therefore, any small positive or negative bias in our estimates of fecundity should not have confounded any analyses in which we examined the effects of time, age, study area, geographic region, latitude, Barred Owls, climate, or habitat on fecundity.

Apparent Survival

Temporary or permanent emigration, heterogeneity in recapture probabilities, and band loss are the primary factors that may create biases or lack of precision in estimates of apparent survival from analysis of capture-recapture data. Two of these potential biases were investigated by Manly et al. (1999), who used computer simulations with data from Northern Spotted Owls in the eastern Cascades of Washington. Variation in recapture probabilities for nesting and non-nesting owls, temporary emigration, and dependent captures of both members of a breeding pair had little effect on estimates of apparent survival, although temporary emigration can cause lower apparent survival estimates for the last few years of a study. In addition, the combination of high recapture and survival probabilities in our study likely reduced any bias associated with heterogeneity of recapture probabilities (Pollock et al. 1990, Hwang and Chao 1995). As for permanent emigration, Forsman et al. (2002) studied dispersal of territorial Spotted Owls on a subset of our study areas and estimated that only about 6.6% of resident owls dispersed from their territories each year, and most of those individuals were relocated on adjacent territories within the boundaries of our survey areas. Nevertheless, there were undoubtedly some individuals that dispersed and went undetected at the edges of our study areas, and to this extent, our estimates of apparent survival may have been biased low as an index of true survival.

Annual Rate of Population Change

Our use of the reparameterized Jolly–Seber method (RJS; Pradel 1996) to estimate the annual finite rate of population change (λ_{RJS}) was a departure from earlier analyses of Spotted Owls, in which researchers used Leslie projection matrices (PM; Caswell 2001) to estimate λ_{PM} (Anderson and Burnham 1992; LaHaye et al. 1992; Burnham et al. 1996; Seamans et al. 1999, 2002; Blakesley et al. 2001). Estimates of λ_{PM} were thought to be biased low in these studies because of permanent emigration of juveniles from study areas (Raphael et al. 1996, Boyce et al. 2005). In contrast, the Pradel (1996) method of estimating λ_{RJS} uses survival estimates from territorial owls only, so it is subject to less bias than the Leslie projection matrix models (λ_{PM}) for use in capture–recapture studies of Spotted Owls (Hines and Nichols 2002, Franklin et al. 2004, Anthony et al. 2006). Estimation of λ_{RJS} assumes that study area boundaries are fixed throughout the study and that surveys of territorial owls are conducted on the same areas with similar effort each year. In other words, new owls are not recruited into, or previously sampled owls are not lost from the sample because of changes in survey area or methods. We used established protocols for surveying and identifying marked Spotted Owls (Franklin et al. 1996, Lint et al. 1999) to ensure that study areas were surveyed with approximately equal effort each year. In addition, the study areas had fixed geographical boundaries for inclusion of data from individual owls, and any expansion or contraction of study areas (Appendix A) was corrected for by modeling in program MARK (see Methods section). Thus, the primary assumptions for estimating λ_{RJS} from capture–recapture data from Spotted Owls were met. The Pradel method for estimating λ accounts for movement into and out of the study area and is less subject to bias caused by permanent emigration of marked owls, which is why the Pradel models may improve on the Leslie matrix model for estimating the annual rate of population change for Spotted Owls. If movements in and out of the study area are truly asymmetric, then the Pradel method should produce a high or low λ to reflect this (it is not a bias, but an accurate reflection of reality).

Last, band loss in our studies was near zero. Franklin et al. (1996) examined records from over 6,000 Northern Spotted Owls double-banded with a colored band and a numbered metal band, and found only two cases where colored bands were lost and no cases where the numbered metal band was lost. Based on the above assessments, we believe that any biases in our estimates of λ were small.

Estimating Goodness-of-Fit and Overdispersion

There are potential biases in the estimation of overdispersion (c) when the estimate is based on the global goodness-of-fit statistic from program RELEASE. The overall goodness-of-fit chi-square (χ^2) is comprised of three additive components: identifiable outliers, structural lack-of-fit, and lack of independence in capture histories (overdispersion). These three potential components of lack-of-fit have differing effects on bias and precision of parameter estimates.

Outliers and structural lack-of-fit can result in biased estimators of φ and λ_{RJS}, but do not result in inflated variances of these estimators. Moreover, these components of lack-of-fit do not result in, and hence are not part of, overdispersion. In contrast, overdispersion does not cause bias in the estimates of φ, p, or λ_{RJS}, but it does result in estimated sampling variances that are too small. Thus, one needs an estimate of overdispersion (c) to adjust (inflate) the estimated theoretical sampling variances and adjust model selection to $QAIC_c$. Estimates of overdispersion and the variance inflation factor from program RELEASE in previous analyses of capture–recapture data from Spotted Owls were biased high (e.g., Franklin et al. 2004, Anthony et al. 2006). As a result, sampling standard errors from those analyses were conservative in assessing the status of populations from the estimation of λ_{RJS} and corresponding 95% confidence intervals. We corrected for this overestimation of overdispersion in our analysis by using the median-$\hat{c}$ routine in program MARK to estimate overdispersion in addition to using program RELEASE to estimate overall goodness-of-fit. Estimates from the median-$\hat{c}$ routine of program MARK in our analyses ranged from $\hat{c} = 0.97$ to 1.17 compared to the range of estimates for overall goodness-of-fit (χ^2/df) from program RELEASE ($\hat{c} = 0.86$ to 3.02). Our results indicated that there was little overdispersion (lack of independence) in our capture–recapture data sets, and any overall lack-of-fit was due to outliers caused by temporary emigration and perhaps some structural lack-of-fit. Consequently, inflation of our estimates of SE(φ) and SE(λ) was minimal, and the true precision of our estimates was higher than those in previous analyses given equal sample sizes (Franklin et al. 2004, Anthony et al. 2006). Use of the median-$\hat{c}$ routine in program MARK to estimate overdispersion in our analyses was an important improvement over previous analyses. Estimates of goodness-of-fit from program RELEASE also indicated that our data fit the Cormack–Jolly–Seber open population model well, so we did not expect unacceptable biases due to lack-of-fit of the data to the model.

The covariates that we used to assess the effects of Barred Owls, habitat, weather, and climate on demographic parameters of Spotted Owls were all study-area-specific variables, and in some cases they were not measured with the same degree of accuracy on all study areas. Use of area-specific covariates could explain why we sometimes found inconsistent or counterintuitive relationships between the covariates and demographic performance of Spotted Owls. Variable effort was a problem with the Barred Owl covariate because the amount of nocturnal survey varied among years and study areas, depending on whether it was a good nesting year for Spotted Owls. Surveyors sometimes did less night calling for Spotted Owls in good nesting years because many pairs of nesting Spotted Owls were easy to find by simply walking into their traditional nest areas and calling during the day. Variation in the amount of nocturnal calling surveys probably introduced methodological variation into the Barred Owl covariate, and lack of a species-specific survey for Barred Owls undoubtedly caused an underestimate of the number of Barred Owls present in all years. A recent study in which observers conducted a species-specific survey of Barred Owls in a Spotted Owl study area resulted in a ≈40% increase in the estimated number of territorial Barred Owls (Wiens et at. In press). An obvious solution to our problems with the Barred Owl covariate is to do a better job of measuring and standardizing all covariates in the future. For Barred Owls, improved procedures would require initiating species-specific surveys in which Barred Owl surveys are conducted independently of Spotted Owl surveys.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The primary objectives of our investigation were to determine if survival rates and populations of Northern Spotted Owls were still declining, assess the influence of biological and meteorological covariates on demographic rates at the population scale, and provide estimates of recruitment rates. Our analyses indicated that fecundity and populations of Northern Spotted Owls have continued to decline in most parts of the range of the subspecies. Estimates of the annual rate of population change were <1.0 for all 11 study areas. Our finding that apparent survival rates were declining on 10 of the 11 study areas was of special concern because Spotted Owl populations are most sensitive to changes in adult survival (Noon and Biles 1990). We had some success in relating demographic rates to reproduction, weather, habitat, or Barred Owls on some study areas. In the analysis of fecundity, however, the amount of temporal variation explained by any one of these covariates was small due to the large temporal variation in fecundity. Temporal variation was not as problematic in the analyses of apparent survival and λ, because these parameters had much less temporal variation than fecundity. For the first time, we provided estimates of recruitment rates into the territorial population, which indicated that low recruitment in conjunction with low survival resulted in population declines. We also found a negative relationship between recruitment rates and the presence of Barred Owls and a positive relationship between recruitment and the amount of suitable owl habitat in the study areas. Recruitment was higher on federal lands where the amount of suitable owl habitat was generally highest. We concluded that there were several factors that contributed to declines in demographic rates of Northern Spotted Owls in any given year on any particular study area, and that these factors were spatially and temporally variable. Of these factors, the presence of Barred Owls appeared to be the strongest and most consistent factor. However, the reproduction covariate, weather/climate covariates, and percent cover of suitable habitat were also associated with demographic parameters on some study areas. Declining rates of apparent survival were the most likely proximate cause of population declines, but the ultimate factor(s) responsible for the declines in survival remained unclear and warrant further investigation. In addition, recruitment of new owls into the populations was often low on some study areas in some years and contributed to population declines. Future analyses should investigate the factors that affect survival of juvenile owls and their recruitment into the territorial population. All of these demographic parameters and the covariates that may affect them interact in a complex way in influencing annual rates of population change of Northern Spotted Owls. Our overall assessment is that reproduction and recruitment have not been sufficient to balance losses due to mortality and emigration, so many of the populations on our study areas have declined over the last two decades. The continuing decline of the Northern Spotted Owl on federal lands could be at least partly due to lag effects from the extensive harvest of old forest that occurred prior to 1990. However, the lag-effect hypothesis was not supported by ongoing declines among owl populations in national parks, where there was no habitat loss due to harvest at any time in the years before or during our study. Thus, we do not think the lag-effect hypothesis has much explanatory power for the continuing declines of Northern Spotted Owls.

Although the pattern was not consistent in all areas, there was strong evidence for a negative effect of Barred Owls on fecundity or survival of Spotted Owls in many of our study areas. This result was even more significant given that the actual effect of Barred Owls on fecundity of Spotted Owls was underestimated by our data. While our observational results do not demonstrate cause–effect relationships, they provide support for the hypothesis that the invasion of the range of the Spotted Owl by Barred Owls is at least partly the cause for the continued decline of Spotted Owls on federal lands. Our results also suggest that Barred Owl encroachment into western forests may make it difficult to insure the continued persistence of Northern Spotted Owls (see also Olson et al. 2004). The fact that Barred Owls are increasing and becoming an escalating threat to the persistence of Spotted Owls does not diminish the importance of habitat conservation for Spotted Owls and their prey. In fact, the existence of a new and potential competitor like the Barred Owl makes the protection of habitat even more important, since any loss of habitat will likely increase competitive pressure and result in further reductions in Spotted Owl populations (Horn and MacArthur 1972, Olson et al. 2004, Carrete et al. 2005). Manipulative experiments could provide future insights, and some authorities have suggested that removal experiments should be conducted on one or more study areas to better document the potential effects of competition between Barred and Spotted Owls (Courtney et al. 2004, Buchanan et al. 2007, Johnson et al. 2008). If conducted, manipulative experiments will almost certainly shed new light on relationships between Barred Owls and Spotted Owls.

The fact that the amount of spatial and process variation explained by all of the covariates in our analysis was small should not be interpreted to mean that habitat and climate are not important for Spotted Owls. To the contrary, several lines of evidence in our study and in studies conducted by others (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005) show that habitat does influence demographic rates of Northern Spotted Owls. However, the poor performance of fixed effects models, which model temporal variation solely as a function of temporal covariates, should be discouraged in future analyses and replaced with improved random effects models that incorporate both environmental covariate(s) and temporal variation. In addition, we suggest that researchers need to consider the use of other covariates in future analyses. For example, there is considerable evidence that vital rates and population size of northern owls are strongly influenced by prey abundance (Korpimäki 1992, Rohner 1996, Hakkarainen et al. 1997). Unfortunately, we did not have long-term data on annual variation in prey abundance on any of our study areas, so we could not address the possible influence of trophic dynamics on owl demographic rates. We suggest, therefore, that studies of annual variation in numbers of small mammals be implemented on one or more of the demographic study areas in the future, so that the possible influence of prey abundance on owl demographic rates can be evaluated.

So, what can we glean from our results that can be translated into management recommendations? Our results and those of others referenced above consistently identify loss of habitat and Barred Owls as important stressors on populations of Northern Spotted Owls. In view of the continued decline of Spotted Owls in most study areas, it would be wise to preserve as much high quality habitat in late-successional forests for Spotted Owls as possible, distributed over as large an area as possible. This recommendation is comparable to one of the recovery goals in the final recovery plan for the Northern Spotted Owl (USDI Fish and Wildlife Service 2008), but we believe that a more inclusive definition of high-quality habitat is needed than the rather vague definition provided in the 2008 recovery plan. Much of the habitat occupied by Northern Spotted Owls and their prey does not fit the classical definition of "old-growth" as defined by Franklin and Spies (1991), and a narrow definition of habitat based on the Franklin and Spies criteria would exclude many areas currently occupied by Northern Spotted Owls. Second, we believe more information on competitive interactions between Spotted Owls and Barred Owls is needed. A recent study by D. Wiens at Oregon State University (pers. comm.) will provide some of this information for western Oregon, but similar information is needed for other parts of the range of the Spotted Owl. In addition, we support experimental removal of Barred Owls on at least one study area as a research project to test the hypothesis that competition is occurring between the two species. In theory, a Barred Owl removal experiment should result in competitive release of Spotted Owls, with subsequent increases in vital rates and density. Experimental removal of Barred Owls as part of a research program would also address one of the main recovery goals in the final recovery plan for Northern Spotted Owls (USDI Fish and Wildlife Service 2008). Finally, it is important that monitoring of Northern Spotted Owls be continued on study areas throughout the range of the subspecies, so that population status can be assessed periodically for the purposes of recovery planning and monitoring the effectiveness of the Northwest Forest Plan.

Appendices

APPENDIX A

Study areas included in the January 2009 analysis of demographic trends of Northern Spotted Owls.

Study area	Start year[a]	λ Start year	Expansion year[b]	Landowner[c]	Ecoregion	Latitude (°N)
Washington						
CLE	1989	1992	none	Mixed	Washington Mixed-conifer	46.996
RAI	1992	1993	1998	Mixed	Washington Douglas-fir	47.195
OLY	1990	1990	1994	Federal	Washington Douglas-fir	47.800
Oregon						
COA	1990	1992	none	Mixed	Oregon Coastal Douglas-fir	44.381
HJA	1988	1990	2000	Federal	Oregon Cascades Douglas-fir	44.213
TYE	1990	1990	none	Mixed	Oregon Coastal Douglas-fir	43.468
KLA	1990	1990	1998	Mixed	Oregon/California Mixed-conifer	42.736
CAS	1991	1992	2001	Federal	Oregon Cascades Douglas-fir	42.695
California						
NWC	1985	1988	none	Federal	Oregon/California Mixed-conifer	40.848
HUP	1992	1992	none	Tribal	Oregon/California Mixed-conifer	41.051
GDR	1990	1990	1998	Private	California Coast	41.122

[a] The Start year column indicates the first year in which we calculated estimates of fecundity and survival. The λ Start year column indicates the first year in which we calculated estimates of λ.

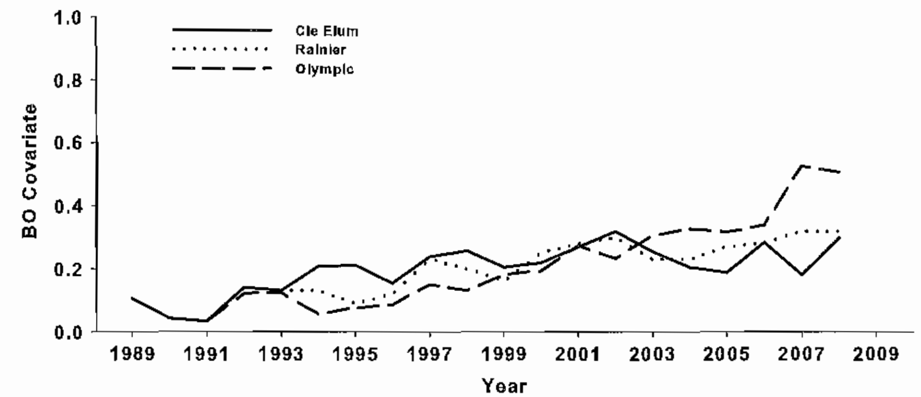
[b] Indicates year that study area was expanded, if any.

[c] Mixed = a mixture of Federal and private or state lands

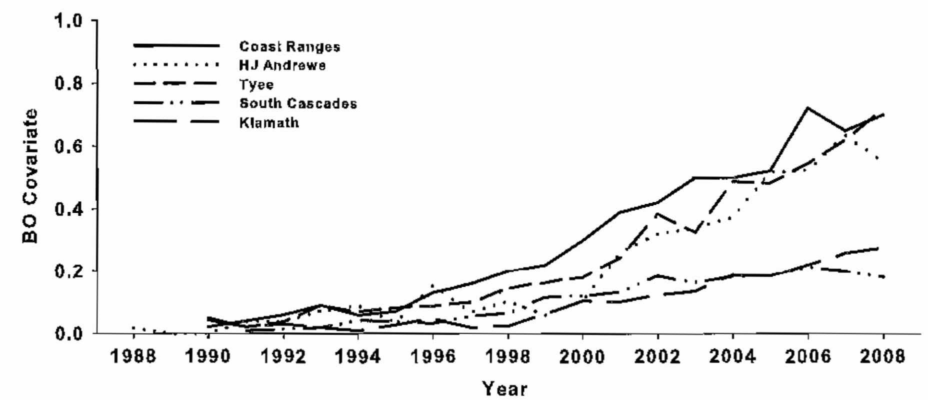
APPENDIX B

Annual proportion of Spotted Owl territories with Barred Owls detections (BO covariate) on study areas in Washington, Oregon, and California.

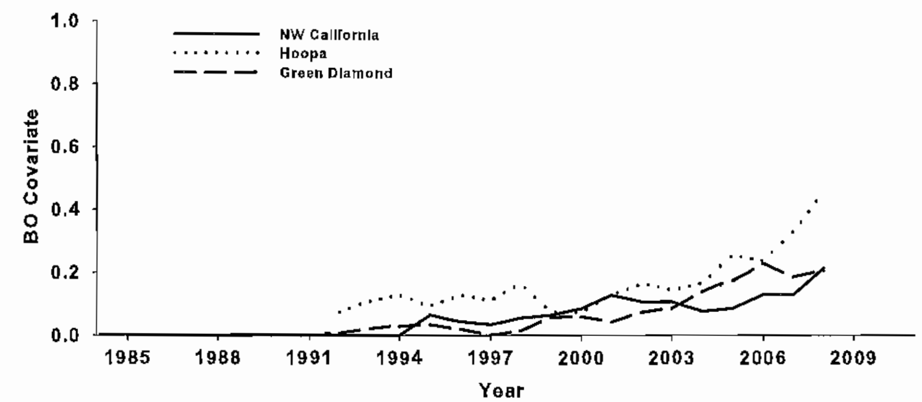
Washington



Oregon



California

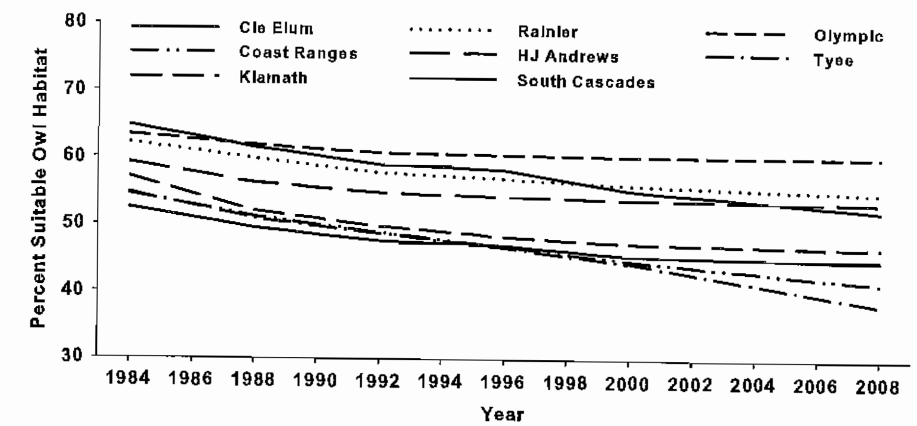


APPENDIX C

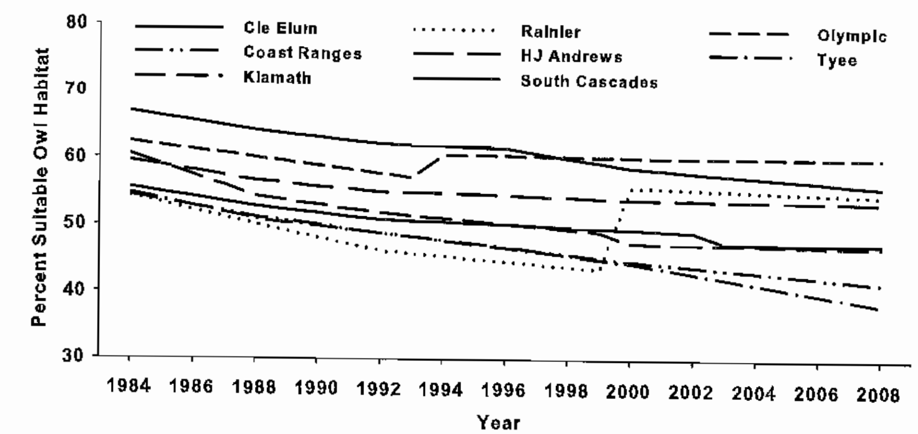
Habitat covariates used in analyses of Northern Spotted Owl vital rates and population growth rates.

Graph A illustrates the percent cover of suitable Spotted Owl habitat within 2.4 km of the annual activity centers of Spotted Owls used in meta-analyses of fecundity and survival (covariate HAB1). Graph B illustrates the percent cover of suitable Spotted Owl habitat within 2.4 km of the annual activity centers of Spotted Owls that were included in the meta-analysis of λ (HAB2). Graph C illustrates the percent cover of suitable Spotted Owl habitat within a 23-km radius of the annual activity centers of Spotted Owls that were included in the meta-analysis of λ, minus the area in HAB2 (HAB3). Abrupt changes in some lines represent one-time study area expansions or reductions included in the meta-analysis of λ.

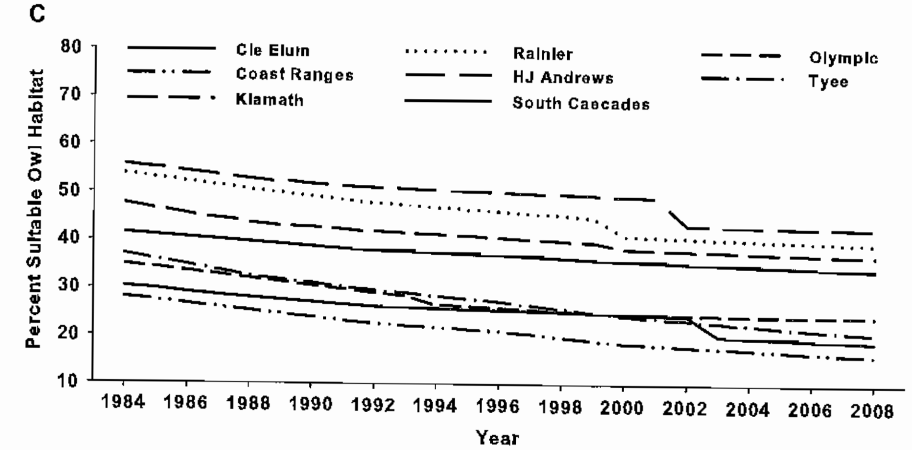
A



B

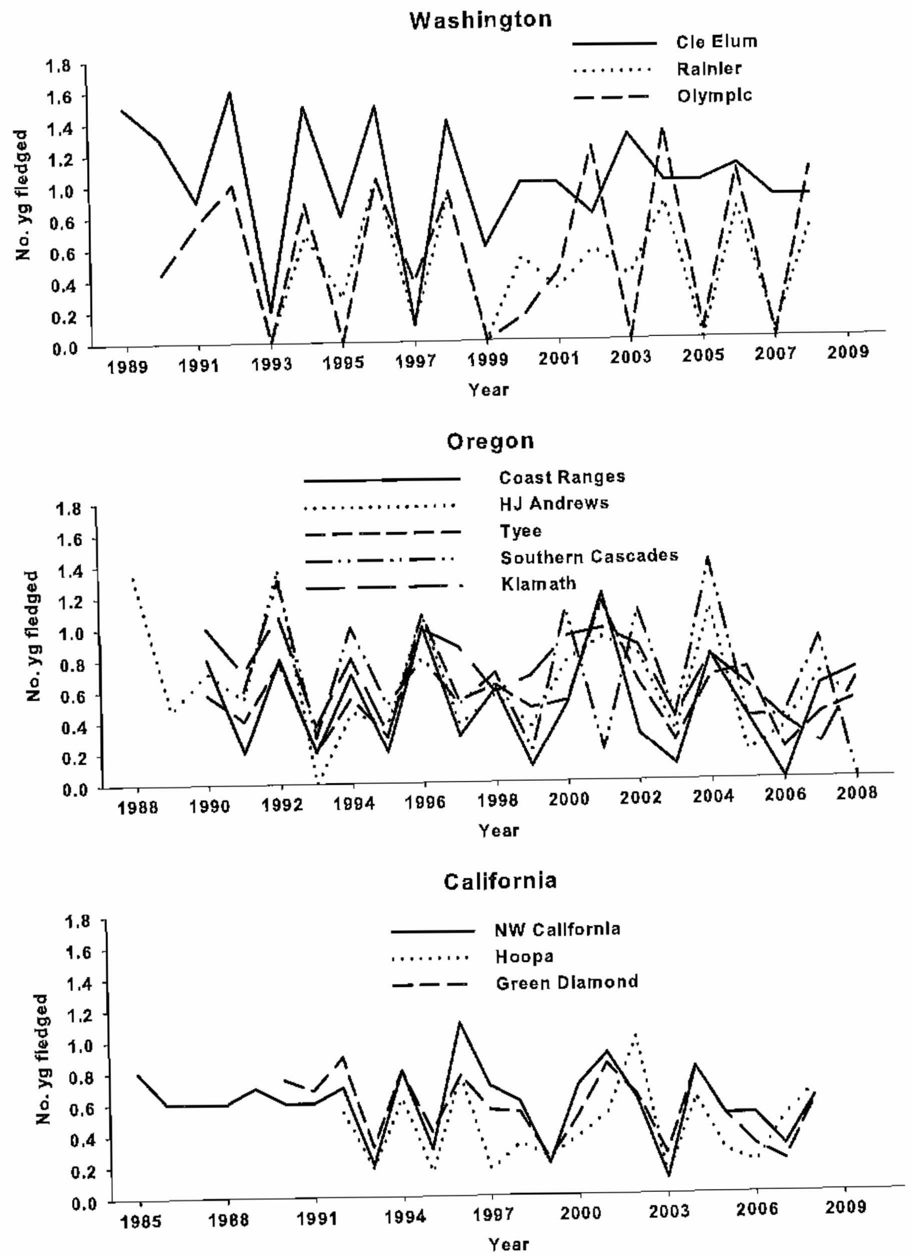


C



APPENDIX D

Reproductive covariate (number of young fledged/pair/yr) used to model survival, and recapture probabilities of Northern Spotted Owls on 11 study areas in Washington, Oregon, and California.



APPENDIX E

A priori models used in analysis of recapture probabilities (p) of Northern Spotted Owls on 11 demographic study areas in Washington, Oregon, and California.

Model[a]	Description of *p* structure
p(A + s*t)	Additive age, sex, and time effects with interactions between sex and time
p(.)	Constant model (no effects)
p(s)	Sex effect
p(R)	Effect of annual reproduction in year t on *p* in year *t*
p(R + s)	Additive reproduction and sex effects
p(t)	Annual time effect
p(s + t)	Additive sex and time effects
p(T)	Linear time trend effect
p(s + T)	Additive sex and linear time trend effects
p(BO)	Barred Owl effect
p(s + BO)	Additive sex and Barred Owl effects
p(R + s + BO)	Additive sex, Barred Owl, and reproduction effects
p(choice)	Biologist's choice

[a] Model notation indicates structure for effects of age (A), sex (s), reproduction (R), time (t), linear time (T), percent of Spotted Owl territories with Barred Owl detections (BO), and biologist's choice (choice). Biologist's choice models included study-area–specific effects such as changes in methodology or subdivisions of study areas based on forest type or ease of access. Additive and interactive effects are indicated by a + sign or asterisk, respectively.

APPENDIX F

A priori models used for analysis of apparent survival (φ) of Northern Spotted Owls on 11 demographic study areas in Washington, Oregon, and California.

Analyses used the best *p* structure from the initial analysis for each area.

Model	Description of φ structure
φ(.)	Constant survival, no age, sex, or time effects
φ[(S1 = S2 = A) + s]	Sex effect only
φ(S1,S2 = A)	Age effect (S2 = A, S1 different)
φ[(S1,S2 = A) + s]	Age effect (S2 = A, S1 different), additive sex effect
φ(S1 = S2, A)	Age effect (S1 = S2, A different)
φ[(S1 = S2, A) + s]	Age effect (S1 = S2, A different), additive sex effect
φ(S1, S2, A)	Age effect (all classes different)
φ[(S1, S2, A) + s]	Age effect (all classes different), additive sex effect
φ[(models 1–8) + t]	Models from 1–8 above with additive time effect (t)
φ[(models 1–8) + T]	Models from 1–8 above with additive linear time trend (T)
φ[(models 1–8) + TT]	Models from 1–8 above with additive quadratic time trend (TT)
φ[(models 1–8) + R]	Models from 1–8 above with additive effect of reproduction in year t on survival in year *t* + 1 (R)
φ[(models 1–8) + BO]	Models from 1–8 above with Barred Owl effect (BO)
φ[(models 1–8) + change-point]	Models from 1–8 above with change-point at 2002 (CP)[a]
φ[(models 1–8) + cubic spline]	Models from 1–8 above with cubic spline (spline)[b]

[a] Change-point in 2004 using best model structure of (.), (T), or (TT).

[b] Cubic spline with knot midway between start year and 2002 and second knot at 2002.

APPENDIX G

A priori models used for meta-analysis of apparent survival (φ) and recapture probabilities (p) of adult Northern Spotted Owls on 11 demographic study areas in Washington, Oregon, and California.

Area effects (g) refer to study areas.

Model	Description of Model Structure
Global model	
1. φ(g*t*s) *p*(g*t*s)	Area, time, and sex with all interactions (global model)
Recapture	
2. φ(g*t + s) *p*(g + t)	φ(Area, time, and sex with area and time interactions) *p*(additive area and time)
3. φ(g*t + s) *p*(R)[a]	φ(Area, time, and sex with area and time interactions) *p*(reproduction)
4. φ(g*t + s) *p*(g + s + t)	φ(Area, time, and sex with area and time interactions) *p*(additive area, time, and sex)
5. φ(g*t + s) *p*(R + s)	φ(Area, time, and sex with area and time interactions) *p*(additive reproduction and sex)
6. φ(g*t + s) *p*[(g + t)*s]	φ(Area, time, and sex with area and time interactions) *p*(additive area and time with different sex effects)
7. φ(g*t + s) *p*(R*s)	φ(Area, time, and sex with area and time interactions) *p*(interactive reproduction and sex)
8. φ(g*t + s) *p*(BO)	φ(Area, time, and sex with area and time interactions) *p*(BO)
9. φ(g*t + s) *p*(BO + g)	φ(Area, time, and sex with area and time interactions) *p*(BO + area)
Survival	
10. φ(g + s) *p*(best)	φ(additive area and sex) *p*(best structure from 2–9 above)
11. φ(g + s + t) *p*(best)	φ(additive area and sex and time) *p*(best structure from 2–9 above)
12. φ(g*T + s) *p*(best)	φ(interactive area and linear time trend with additive sex effect) *p*(best structure from 2–9 above)
13. φ(g + s + T) *p*(best)	φ(additive area, sex, and linear time trend) *p*(best structure from 2–9 above)
14. φ(g*TT + s) *p*(best)	φ(interactive area and quadratic time trend with additive sex effect) *p*(best structure from 2–9 above)
15. φ(g + TT + s) *p*(best)	φ(additive area, quadratic time trend, and sex effect) *p*(best structure from 2–9 above)
16. φ(s + t) *p*(best)	φ(additive sex and time effects) *p*(best structure from 2–9 above)
17. φ(s + T) *p*(best)	φ(additive sex and linear time trend effects) *p*(best structure from 2–9 above)
18. φ(s + TT) *p*(best)	φ(additive sex and quadratic time trend effects) *p*(best structure from 2–9 above)
19. φ(s) *p*(best)	φ(sex) *p*(best structure from 2–9 above)
20. φ(s + BO) *p*(best)	φ(additive sex and BO effects) *p*(best structure from 2–9 above)
21. φ(s + BO + g) *p*(best)	φ(additive sex, BO effects, and area) *p*(best structure from 2–9 above)

APPENDIX G (*continued*)

Model	Description of Model Structure
22. φ(s + BO*g) *p*(best)	φ(interactive BO effects and area effects with additive sex effect) *p*(best structure from 2–9 above)
23. φ(s + R) *p*(best)	φ(additive sex and reproduction effects) *p*(best structure from 2–9 above)
24. φ(s + R + g) *p*(best)	φ(additive sex, reproduction, and area effects) *p*(best structure from 2–9 above)
25. φ(s + R*g) *p*(best)	φ(interactive reproduction and area effects with additive sex effect) *p*(best structure from 2–9 above)
26. φ(s + BO + R) *p*(best)	φ(additive sex, reproduction, and BO effects) *p*(best structure from 2–9 above)
27. φ(s + BO + g + R) *p*(best)	φ(additive sex, BO, reproduction, and area effects) *p*(best structure from 2–9 above)
28. φ(s + BO*g*R) *p*(best)	φ(interactive BO, reproduction, and area effects with additive sex effect) *p*(best structure from 2–9 above)
29. φ(CP) *p*(best)	φ(change-point in 2004 using best of (.), (t) or (T) models) *p*(best structure from 2–9 above)
30. φ(spline) *p*(best)	φ(cubic spline with knot midway between start year and 2002 and second knot at 2002) *p*(best structure from 2–9 above)
Study area surrogates	
31. φ(OWN) *p*(best)	Replace area effect in lowest $QAIC_c$ model from 9–29 with ownership effect
32. φ(ECO) *p*(best)	Replace area effect in lowest $QAIC_c$ model from 9–29 with ecoregion effect
33. φ(OWN*ECO) *p*(best)	Replace area effect in lowest $QAIC_c$ model from 9–29 with ownership and ecological region effects with interactions
34. φ(LAT) *p*(best)	Replace area effect in lowest $QAIC_c$ model from 9–29 with latitude effect
Habitat	
35. φ(s + g + [WA = OR + CA] *HAB1) *p*(best)	Sex included only if important in 1–34. Additive effects of area and habitat in WA and OR with minimum $QAIC_c$ model replacing habitat for CA. *p*(best structure from 2–9 above
36. φ(s + g HAB1) *p*(best)	Sex included only if important in 1–34. Interaction between area and HAB1. *p*(best structure from 2–9 above)
Climate	
37. φ(s + g + SOI + PDO) *p*(best)	φ(additive sex, area, Southern Oscillation Index, and Pacific Decadal Oscillation. *p*(best structure from 2–9 above)
38. φ[s + (g*SOI) + (g*PDO)] *p*(best)	φ(interaction between area and Southern Oscillation Index and area and Pacific Decadal Oscillation, with additive sex effects) *p*(best structure from 2–9 above)
39. φ(s + g + ENP) *p*(best)	φ(additive sex, area, and precipitation during early nesting season) *p*(best structure from 2–9 above)
40. φ(s + g*ENP) *p*(best)	φ(interaction between area and precipitation during early nesting season with additive sex effect) *p*(best structure from 2–9 above)
41. φ(s + g + ENT) *p*(best)	φ(additive sex, area, and temperature during early nesting season) *p*(best structure from 2–9 above)
42. φ(s + g*ENT) *p*(best)	φ(interaction between area and temperature during early nesting season with additive sex effect) *p*(best structure from 2–9 above)
Habitat-climate interactions	
43. φ(best babitat + best climate) *p*(best structure from 2–9 above)	φ(combine best habitat model from 35–36 with best climate model form 37–42 in additive model) *p*(best structure from 2–9 above)
44. φ(best habitat*best climate) *p*(best structure from 2–9 above)	φ(combine best habitat model from 35–36 with best climate model form 37–42 in interactive model) *p*(best structure from 2–9 above)

APPENDIX G (*continued*)

APPENDIX G (CONTINUED)

[a] When reproduction (R) appears as a covariate on recapture, it refers to the effect of reproduction in year *t* on recapture in year *t*. When R appears as a covariate on survival, it refers to the effect of reproduction in year *t* on survival in year *t* + 1.

APPENDIX H

Models used in the meta-analysis of λ of Northern Spotted Owls in Washington, Oregon, and California.

Model form was the apparent survival and recruitment parameterization. Model notation for random effects (RE) models includes the general model on which the random effects model is based. The last six models at the bottom of the list were developed *a posteriori* after looking at the ranking of the *a priori* models.

Model structure[a]
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO) *f*(ECO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + BO) *f*(BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO) *f*(OWN + ECO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + BO) *f*(g + BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + BO) *f*(g*BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g) *f*(g)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g) *f*(g + TT)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI) *f*(g + ENP + ENT)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g) *f*(g + T)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI) *f*(g + LNP)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI) *f*(g + PDSI)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI) *f*(g + SOI + PDO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g) *f*(g*T)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*T) *f*(g)
φ(g*t) *p*(g*t) *f*(g + t)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI) *f*(g*LNP)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI) *f*(g*PDSI)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g) *f*(g*TT)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI) *f*(g*ENP + g*ENT)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI) *f*(g*SOI + g*PDO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*HAB2) *f*(g+HAB2 + HAB3)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*HAB2) *f*(g*HAB3)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*HAB2) *f*(g*HAB2 + g*HAB3)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*TT)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*HAB2) *f*(g + HAB2)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + PDSI)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(OWN + ECO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(LAT)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + T)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(OWN)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*PDSI)

APPENDIX H (*continued*)

APPENDIX H (CONTINUED)

Model structure[a]
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g+SOI + PDO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*T)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + ENP + ENT)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*SOI + g*PDO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*HAB2)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g*ENP + g*ENT)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + HAB2)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(g + TT)
φ(g*t) *p*(g*t) *f*(g*t)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO + BO) *f*(ECO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO + BO) *f*(ECO + BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO) *f*(ECO*BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO*BO) *f*(ECO*BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO) *f*(ECO + BO)
φ(g*t) *p*(g*t) *f*(g*t): RE φ(ECO + BO) *f*(ECO)

[a] Model notation indicates structure for effects of study area (g), time (t), linear time trend (T), quadratic time trend (TT), ecoregion (ECO), proportion of territories with Barred Owl detections (BO), land ownership (OWN), early nesting season precipitation (ENP), early nesting season temperature (ENT), Palmer Drought Severity Index (PDSI), late nesting season precipitation (LNP), Southern Oscillation Index (SOI), Pacific Decadal Oscillation (PDO), percent cover of suitable owl habitat within 2.4 km of owl activity centers used in λ analysis (HAB2), percent cover of suitable owl habitat within 23 km of owl activity centers used in λ analysis, minus the area of HAB2 (HAB3).

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5-YEAR REVIEW

Short Form Summary

Species Reviewed: Northern Spotted Owl (*Strix occidentalis caurina)*

Current Classification: Threatened

FR Notice announcing initiation of this review:
The U.S. Fish and Wildlife Service published in the *Federal Register* on November 24, 2010, a Notice initiating the 5-year status review for this species (75 FR 71726), and reopened the public comment period for this 5-year review on April 20, 2011 (76 FR 22139).

Lead Region/Field Office:
Pacific Region
Sarah Hall, Chief, Division of Recovery – (503) 231-6868

Name of Reviewer(s):
Betsy Glenn, Oregon Fish and Wildlife Office, Northern Spotted Owl Specialist - (503) 231-6970.
Rollie White, Oregon Fish and Wildlife Office, Acting Assistant Project Leader – (503) 231-6179.

Methodology used to complete this 5-year review:
Review of science assessing the current status of the northern spotted owl (NSO) was conducted in conjunction with development of the 2011 Revised Recovery Plan for the Northern Spotted Owl. Development of the Revised Recovery Plan involved over 20 Fish and Wildlife Office staff reviewing NSO science, consultation with spotted owl experts, input from working groups, scientific peer-review, and 2 public comment periods. The Revised Recovery Plan addresses current status, population trends, threats (including the five listing factors), recovery objectives, recovery criteria, and recovery actions needed for this species.

Application of the 1996 Distinct Population Segment (DPS) Policy:
Not applicable. Not listed as a DPS.

Review Analysis:
Please refer to the 2011 Revised Recovery Plan for the northern spotted owl for a complete review of the species status (including biology, population trends, and habitat), threats, and recovery actions. The following is a summary of findings and recommendations from the 2011 Revised Recovery Plan.

Reasons for Listing and Assessment of Threats

The Endangered Species Act identifies five listing factors for determining whether a species merits Federal listing as threatened or endangered:

*This short form is to be used ONLY when there is no new information, or when the 5-year review is being done concurrent with another range-wide status review (such as a 12-month finding on a delisting petition) that completely addresses all the questions outlined in the standard 5-year review template. Attach a copy of the final 12-month finding or other status review to this form.

A. The present or threatened destruction, modification, or curtailment of its habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms;
E. Other natural or manmade factors affecting its continued existence.

The northern spotted owl was listed as threatened throughout its range "due to loss and adverse modification of spotted owl habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USFWS 1990). More specifically, threats to the spotted owl included low populations, declining populations, limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of populations within physiographic provinces, predation and competition, lack of coordinated conservation measures, inadequacy of regulatory mechanisms and vulnerability to natural disturbance (USFWS 1992). These threats were characterized for each province as severe, moderate, low or unknown (USFWS 1992). The range of the spotted owl is divided into 12 physiographic provinces from Canada to northern California and from the Pacific Coast to the eastern Cascades. Declining habitat was recognized as a severe or moderate threat to the spotted owl throughout its range, isolation of populations was identified as a severe or moderate threat in 11 provinces, and a decline in population was a severe or moderate threat in 10 provinces. Together, these three factors represented the greatest concerns about range-wide conservation of the spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces, and low populations was a severe or moderate concern in eight provinces, suggesting that these factors were also a concern throughout the majority of the spotted owl's range. Vulnerability to natural disturbances was rated as low in five provinces.

The Service conducted a 5-year review of the spotted owl in 2004 (USFWS 2004), based in part on the content of an independent scientific evaluation of the status of the spotted owl (Courtney *et al.* 2004) performed under contract with the Service. For that evaluation, an assessment was conducted of how the threats described in 1990 might have changed by 2004. Some of the key ideas relative to threats identified in 2004 were: (1) "Although we are certain that current harvest effects are reduced, and that past harvest is also probably having a reduced effect now as compared to 1990, we are still unable to fully evaluate the current levels of threat posed by harvest because of the potential for lag effects" (Courtney and Gutiérrez 2004:11-7); (2) "Currently the primary source of habitat loss is catastrophic wildfire, although the total amount of habitat affected by wildfires has been small" (Courtney and Gutiérrez 2004:11-8); and (3) "We are convinced that Barred Owls are having a negative impact on Spotted Owls at least in some areas" (Gutiérrez *et al.* 2004:7-43) and "there are no grounds for optimistic views suggesting that Barred Owl impacts on Northern Spotted Owls have been already fully realized" (Gutiérrez *et al.* 2004:7-38).

On June 1, 2006, the Service convened a meeting of seven experts to help identify the most current threats facing the species. Six of the seven were experts on the biology of the spotted owl, and a seventh was an expert on fire ecology. The workshop was conducted as a modified Delphi expert panel in which the seven experts scored the severity of threat categories. The baseline assumption of this meeting was that existing habitat conservation strategies (*e.g.*, the NWFP) would be in place. With that assumption, the experts identified and ranked threats to the spotted owl. The 2007 Recovery Team then had an opportunity to interact with them to discuss their individual rankings and thoughts on spotted owl threats. The experts re-ranked the threats if they felt this was relevant given the substance of the discussion.

These experts identified past habitat loss, current habitat loss, and competition from barred owls as the most pressing threats to the spotted owl, even though timber harvest recently has been greatly reduced on Federal lands. They noted that evidence of these three threats is presented in the scientific literature. The range of threat scores made by the individual experts was narrowest for barred owl competition and slightly greater for habitat threats, indicating that there was more agreement about the threat from barred owls. The experts identified disease and the effect of climate change on vegetation as potential and more uncertain future threats.

The experts also ranked the threats by importance in each province. Among the 12 physiographic provinces, the more fire-prone provinces (Eastern Washington Cascades and Eastern Oregon Cascades, California Cascades, Oregon and California Klamath) scored high on threats from ongoing habitat loss as a result of wildfire and the effects of fire exclusion on vegetation change. West-side provinces (Western Washington Cascades and Western Oregon Cascades, Western Washington Lowlands, Olympic Peninsula, and Oregon Coast Range) generally scored high on threats from the negative effects of habitat fragmentation and ongoing habitat loss as a result of timber harvest. The province with the fewest number of threats was Western Oregon Cascades, and the provinces with the greatest number of threats were the Oregon Klamath and the Willamette Valley.
(end excerpt)

Between 2006 and 2011, additional scientific research has indicated that northern spotted owl populations have continued to decline at a rate of 2.7% per year, with declines being associated with both habitat loss and barred owl presence (Forsman et al. 2011). The northern spotted owl is doing poorer than at the time of the last 5-year review, and observed population declines indicate an increased possibility for this species to become endangered in the future. At this time, we do not know what the outcome of barred owl-spotted owl competition will be. Barred owls generally have a greater negative impact on spotted owls in northern areas; however, the relationship between the two species is highly variable across range of the northern spotted owl. While populations are declining, spotted owls are still present across the majority of the species range.

Given the declining population trends, habitat loss, and threats from barred owls, the northern spotted owl meets the definition of a threatened species. The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The term "endangered species" means any species which is in danger of extinction throughout all or a significant portion of its range.

Recommendations for Future Actions:
The 2011 Revised Recovery Plan identifies 33 Recovery Actions that have been developed to meet Recovery Objectives and Criteria. The recovery objectives of the 2011 Revised Recovery Plan for the northern spotted owl include the following:

1. Spotted owl populations are sufficiently large and distributed such that the species no longer requires listing under the ESA;
2. Adequate habitat is available for spotted owls and will continue to exist to allow the species to survive without the protection of the ESA; and
3. The effects of threats have been reduced or eliminated such that spotted owl populations are stable or increasing and spotted owls are unlikely to become threatened again in the foreseeable future.

Recovery Criteria include the following:

Recovery Criterion 1 – Stable Population Trend: The overall population trend of spotted owls throughout the range is stable or increasing over 10 years, as measured by a statistically reliable monitoring effort.

Recovery Criterion 2 – Adequate Population Distribution: Spotted owl subpopulations within each province (*i.e.*, recovery unit) (excluding the Willamette Valley Province) achieve viability, as informed by the HexSim population model or some other appropriate quantitative measure.

Recovery Criterion 3 – Continued Maintenance and Recruitment of Spotted Owl Habitat: The future range-wide trend in spotted owl nesting/roosting and foraging habitat is stable or increasing throughout the species range, from the date of Revised Recovery Plan approval, as measured by effectiveness monitoring efforts or other reliable habitat monitoring programs.

Recovery Criterion 4 – Post-delisting Monitoring: To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation within the States of Washington, Oregon, and California, as required in section 4(g)(1) of the ESA.

Recovery actions developed to meet these objectives and criteria include increased protection of spotted owl sites and habitat, encouraging forest management practices that will develop future spotted owl habitat, examination of effectiveness of removing barred owls from areas to enhance spotted owl recovery, and continued demographic monitoring of spotted owl populations to assess effectiveness of recovery actions.

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U.S. FISH AND WILDLIFE SERVICE
SIGNATURE PAGE for 5-YEAR REVIEW on *Northern Spotted Owl*

Pre-1996 DPS listing still considered a listable entity? ______N/A________

Recommendation resulting from the 5-year review:

__________ Delisting
__________ Reclassify from Endangered to Threatened status
__________ Reclassify from Threatened to Endangered status
_____X_____ No Change in listing status

Lead Field Supervisor, Fish and Wildlife Service

______________________________ **Date** 9/29/11
Oregon Fish and Wildlife Office

Cooperating Field Supervisor, Fish and Wildlife Service

Concur ______________________________ **Date** 9/29/11
Washington Fish and Wildlife Office

Cooperating Field Supervisor, Fish and Wildlife Service

Concur ______________________________ **Date** [illegible]
Arcata Fish and Wildlife Office, Region 8

Cooperating Field Supervisor, Fish and Wildlife Service

Concur ______________________________ **Date** 9-28-11
Yreka Fish and Wildlife Office, Region 8

U.S. FISH AND WILDLIFE SERVICE

SIGNATURE PAGE for 5-YEAR REVIEW on *Northern Spotted Owl*

(page 2 of 2)

Lead Regional Office, Fish and Wildlife Service

[signature] Date 10/26/11

Acting ARD Ecological Services
Portland, Oregon

Cooperating Regional Office, Fish and Wildlife Service

Concur [signature] Date 10.24.2011

Sacramento, California

Ecological Monographs, 70(4), 2000, pp. 539–590

CLIMATE, HABITAT QUALITY, AND FITNESS IN NORTHERN SPOTTED OWL POPULATIONS IN NORTHWESTERN CALIFORNIA

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Abstract. A controversy exists in the Pacific Northwest of the United States between logging of old-growth coniferous forests and conservation of Northern Spotted Owl (*Strix occidentalis caurina*) populations. This species has a strong association with old-growth forests that also have economic value as timber. Research questions relevant to conservation of this species include how temporal trends in Northern Spotted Owl populations are influenced and how spatial configuration of old-growth forests affects these populations. To address these questions, we studied a population of marked Northern Spotted Owls on 95 territories in northwestern California from 1985 through 1994. We examined the magnitude of temporal and spatial variation in life history traits (survival, reproductive output, and recruitment), the effects of climate and landscape characteristics on temporal and spatial variation in these traits, respectively, and how this variation affected aspects of population dynamics. We used a components-of-variation analysis to partition sampling from process variation, and a model selection approach to estimate life history traits using capture–recapture and random-effects models. Climate explained most of the temporal variation in life history traits. Annual survival varied the least over time, whereas recruitment rate varied the most, suggesting a ''bet-hedging'' life history strategy for the owl. A forecast of annual rates of population change (λ), estimated from life history traits, suggested that Northern Spotted Owl populations may change solely due to climate influences, even with unchanging habitat conditions. In terms of spatial variation, annual survival on territories was positively associated both with amounts of interior old-growth forest and with length of edge between those forests and other vegetation types. Reproductive output was negatively associated with interior forest, but positively associated with edge between mature and old-growth conifer forest and other vegetation types. A gradient existed in territory-specific estimates of fitness derived from these life history estimates. This gradient suggested that a mosaic of older forest interspersed with other vegetation types promoted high fitness in Northern Spotted Owls. Habitat quality, as defined by fitness, appeared to buffer variation in annual survival but did not buffer reproductive output. We postulated that the magnitude of λ was determined by habitat quality, whereas variation of λ was influenced by recruitment and reproductive output. As habitat quality declines, variation in λ should become more pronounced.

Key words: California; climate effects; components of variation; environmental stochasticity; fitness; fragmentation; habitat effects; habitat mosaics; model selection; Northern Spotted Owl; population rates of change; Strix occidentalis caurina.

Introduction

The Northern Spotted Owl (*Strix occidentalis caurina*) is a medium-sized owl that inhabits conifer forests of the Pacific Northwest, including northwestern California, USA (Forsman et al. 1984, Gutiérrez et al. 1995). Pairs of Northern Spotted Owls occupy large home ranges ($\geq$1200 ha), portions of which are actively defended against conspecifics (see review in Thomas et al. 1990). This species exhibits strong affinities for mature and old-growth forests (reviewed in Thomas et al. 1990), and may incorporate large tracts ($\geq$400 ha) of these forests into its home range (Forsman et al. 1984, Carey et al. 1990, Solis and Gutiérrez 1990). Thus, mature and old-growth coniferous forest has been considered equivalent to Northern Spotted Owl habitat (see Thomas et al. 1990). Forests potentially suitable for spotted owls in the Pacific Northwest have declined by 61% since the 18th century because of logging; most of this decline has occurred in the last 60 yr (U.S. Forest Service 1992). In addition to reduction in size, once-contiguous blocks of mature and old-growth forests have become increasingly fragmented into mosaics of different seral stages.

A major conflict developed in managing spotted owl populations because of the high economic value of the remaining timber present within spotted owl habitat (Dixon and Juelson 1987). This conflict escalated when the Northern Spotted Owl was federally listed as a threatened subspecies in 1990 (U.S. Fish and Wildlife

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Service 1990). Various assessments predicted declines among females in Northern Spotted Owl populations (Marcot and Holthausen 1987, Lande 1988, Noon and Biles 1990, Franklin 1992). Compelling evidence indicated that population declines were a function of loss of mature and old-growth forests (U.S. Fish and Wildlife Service 1990).

Long-term research questions regarding Northern Spotted Owls have been based primarily on conservation agendas. Such questions include: ''What influences population trends in Northern Spotted Owls over time?'' and ''How does the spatial distribution and extent of mature and old-growth forests affect Northern Spotted Owl populations?'' (after Noon and McKelvey 1996). These and other questions regarding Northern Spotted Owl populations can be addressed with empirical data because demographic parameters for this species are relatively easy to estimate from field data, compared with most avian predators (see Franklin et al. 1996*a*). In this paper, we attempted to address these questions by examining (1) the magnitude of variation in life history traits, (2) the factors that may influence variation in life history traits, and (3) how this variation might affect population dynamics.

The role of variation in population dynamics

Populations of organisms, and the life history traits that characterize them, vary over space and time. Understanding this variation is necessary for understanding life history strategies and population dynamics, as well as for developing conservation strategies (Rhodes and Odum 1996). In addition to spatial and temporal variation, individuals within populations also vary in their abilities to cope with their environment (Łomnicki 1988). Thus, three sources of variation—temporal, spatial, and individual—affect population dynamics and the life history traits (e.g., survival, reproductive output, and recruitment) that define those dynamics. These sources of variation are also important for determining population persistence over time and space (White 2000). In this paper, we concentrate only on temporal and spatial variation. Although we consider individual attributes, such as age and sex, we do not incorporate individual variation resulting from phenotypic and genetic variation.

There are important considerations regarding spatial and temporal variation in biological systems. First, a distinction must be made between *process variation* ($\sigma^2_{process}$), the variation in a given parameter ($\hat{\theta}$) over time and space, and *sampling variation* ($\mathrm{var}(\hat{\theta}|\theta)$), the variation attributable to estimating a parameter from sample data (Box et al. 1978, White 2000). Here, we are interested in the natural variability, estimated as process variation, of life history traits and measures of fitness. Sampling variation is of little interest, except that it must be properly dealt with to estimate process variation.

If no sampling variation is associated with parameter values measured over time or space, then process variation can be estimated as follows:

$$\hat{\sigma}^2_{process} = \frac{1}{n}\sum_{i=1}^{n}(\theta_i - \bar{\theta})^2 \quad (1)$$

(Burnham et al. 1987). However, parameters such as life history traits are never measured without sampling variance, although sampling variance is often ignored. Therefore, the total variation (σ^2_{total}) estimated in a set of parameter estimates over time or space is a combination of process and sampling variation, which can be generally viewed as follows (Skalski and Robson 1992):

$$\hat{\sigma}^2_{total} = \hat{\sigma}^2_{process} + \widehat{\mathrm{var}}(\hat{\theta}\,|\,\theta). \quad (2)$$

Typically, the relationship in Eq. 2 becomes more complex as process or sampling variation is temporal, spatial, or both (see Burnham et al. 1987). Process variation in population parameters can be further decomposed into additional components of interest, such as temporal and spatial process variation, where

$$\sigma^2_{process} = \sigma^2_{temporal} + \sigma^2_{spatial}. \quad (3)$$

Such decomposition of variance components is termed components of variance analysis (Box et al. 1978, Searle et al. 1992). Although knowing the relative magnitude of temporal and spatial variance components is necessary to understand population dynamics, the factors that cause temporal and spatial variation are also important, especially for understanding ecological relationships and developing conservation strategies. If climate and habitat quality are considered to be useful starting points for examining the determinants of temporal and spatial variation, respectively (see *Climate and temporal variation* and *Habitat quality and spatial variation*), a sound, statistically based model can be developed that relates these factors to life history traits using meaningful covariates. Once such models are developed, process variation can be partitioned as

$$\sigma^2_{process} = \sigma^2_{model} + \sigma^2_{residual} \quad (4)$$

where $\sigma^2_{process}$ is either temporal or spatial process variation in a life history trait; σ^2_{model} is the amount of that process variation theoretically explainable by some model incorporating the factors thought to be responsible for that variation; and $\sigma^2_{residual}$ is the amount of $\sigma^2_{process}$ not explained by the model. For example, explainable variation in temporal process variation due to climatic factors can be viewed as $\sigma^2_{temporal} = \sigma^2_{climate} + \sigma^2_{residual}$, where $\sigma^2_{residual}$ is the amount of temporal variation not explained by climatic factors in the model.

Once an understanding of the magnitude of process variation in life history traits and the factors that affect it has been achieved, an approach relating this process variation to overall population dynamics is needed. We chose the finite rate of population change (λ) as the common currency to relate temporal variation to population growth rates (Caswell 1989*a*) and spatial variation to fitness (Caswell 1989*b*, McGraw and Caswell 1996). Ricklefs (1983) and Nur (1987) suggest that the finite rate of population change (λ) is a good estimate of fitness because it explicitly incorporates age-specific survival and fecundity. Although interpretations of λ may differ slightly when it is used as a measure of population growth rate or as fitness, at least the effects of temporal and spatial variation can be compared using the same metric. For example, the finite rate of population change can be viewed as the average fitness across individuals within a year, as well as the growth rate of the population (Danchin et al. 1995).

Climate and temporal variation

Temporal variation is important in defining life history tactics and understanding the evolutionary processes that may shape life history traits. Much of life history theory ignores the influence of temporal variation when, in fact, the influence of temporal variability on life history traits, such as survival and recruitment, can have different consequences for life history tactics (Stearns 1976, 1992). The effect of temporal variation on life history tactics depends on several factors such as the amount of variation, the covariation among life history traits, the life history being considered, and factors that also affect long-term rates of population change (Tuljapurkar 1989, Benton and Grant 1996).

Temporal variation in population dynamics is often represented as environmental stochasticity, a nearly continuous series of perturbations over time that simultaneously affect birth and death rates of all individuals in a population (Shaffer 1987, Lande 1993). Extremes in environmental stochasticity are viewed as random catastrophic events when they produce sudden and large reductions in population size (Mangel and Tier 1993). Environmental stochasticity can accelerate the risk of extinction even in large populations (Goodman 1987, Shaffer 1987), especially in populations whose long-term growth rate is near zero (Lande 1993). However, understanding how environmental stochasticity affects population processes and extinction probabilities requires an understanding of the effects of environmental stochasticity on organisms (Boyce 1992). Models attempting to approximate population processes have progressed from simple, deterministic forms to increasingly complex, stochastic forms that induce random temporal variation on model parameters. Population viability analyses, in particular, incorporate forms of environmental stochasticity when predicting the probability of persistence of a given population. However, Boyce (1992) points out that environmental stochasticity is usually approximated poorly in such models because it is represented as unstructured, random noise rather than as a structured temporal process. If environmental stochasticity is, in reality, a structured process, then it becomes predictable to some degree and should no longer be represented as random noise. This implies that changes in temporal conditions can be explained in some manner. Thus, there is a real need for empirical understanding of whether environmental stochasticity can be represented as structured variation, and how this variation affects populations, especially through its influence on life history traits.

Climatic variation is one structured source of temporal variation that may affect avian populations through its influence on life history traits, largely in a density-independent manner (Boyce 1984). Extremes in climatic variation also can function as catastrophic events and have been associated with sudden large-scale mortality in avian populations (Tompa 1971, Johnson et al. 1991, Rogers et al. 1991, Smith et al. 1991). Most studies have focused on the effect of climatic variation on reproductive output (Kostrzewa and Kostrzewa 1990, 1991, Rotenberry and Wiens 1991, Cooper and Lutjeharms 1992, Dykstra and Karasov 1993, Neal et al. 1993, Swenson et al. 1994), with less emphasis on the effect of this variation on survival (e.g., Martinson and Grondahl 1966, Peach et al. 1994, Cézilly et al. 1996). Few studies empirically examine the effects of climate, as a source of temporal variation, on the collective suite of life history traits of a single avian species (but see Grant and Grant 1989, Jouventin and Weimerskirch 1991), and the overall influence of such variation on population growth rates.

Rotenberry and Wiens (1991) identify two major scales over which climatic variation could affect life history traits: within-year effects reflecting day-to-day variation, and among-year effects attributed to variation over larger temporal and spatial scales. In this study, we deal solely with among-year effects as a measure of temporal variation. When considering annual temporal variation, one can express the total variation (σ^2) in an *estimated* life history trait ($\hat{\theta}$) as $\sigma^2_{\text{temporal}} + \overline{\text{var}}(\hat{\theta}|\theta)$ in its simplest form, where $\sigma^2_{\text{temporal}}$ is temporal process variation (the variance of the parameter θ among years) and $\overline{\text{var}}(\hat{\theta}|\theta)$ is the mean sampling variation due to estimation of θ within years. Temporal process variation can be partitioned further into variation due to climate ($\sigma^2_{\text{climate}}$) and residual, unexplained variation ($\sigma^2_{\text{residual}}$) such that

$$\sigma^2_{\text{temporal}} = \sigma^2_{\text{climate}} + \sigma^2_{\text{residual}}. \tag{5}$$

If climate is a primary mechanism governing temporal variation, then $\sigma^2_{\text{climate}}$ should be large relative to $\sigma^2_{\text{residual}}$; the reverse suggests that other influences are responsible for temporal variation.

When estimating the effects of climatic variation on Northern Spotted Owl populations, we addressed three questions in a step-wise fashion, using 10 yr of data on marked spotted owls in northwestern California. First, we asked: *What is the magnitude of temporal process variation in key life history traits of Northern Spotted Owls?* We approached this question by estimating $\sigma^2_{\text{temporal}}$ in capture–recapture estimates of survival, recruitment (the number of new individuals in the population per individual from the previous year), and reproductive output (the number of young fledged per pair), using components of variance analysis that accounted for sampling variance in the parameter estimates. Second, we asked: *Is temporal process variation explained primarily by climatic variation?* That is, does $\hat{\sigma}^2_{\text{climate}}$ explain a large portion of $\hat{\sigma}^2_{\text{temporal}}$. Finally, we asked: *What are the long-term consequences of climatic variation on population growth and stability if climatic variation strongly influences life history traits?* We evaluated this last question by applying climate models describing variation in life history traits and rates of population change to a 30-yr climate trace. In this way, we attempted to assess the probable behavior of these climate models in describing temporal variation, given that selected climate models were reasonable approximations of nature.

Habitat quality and spatial variation

Habitat for a particular organism can be defined as an area with the combination of resources and environmental conditions necessary to allow occupancy, survival, and reproduction of individuals (Morrison et al. 1992). Habitat use by an organism can be described at four nested scales (Johnson 1980): the overall geographic range of the species, the home range or territory within the geographic range, various habitat components within the territory, and specific foraging locations within those habitat components. This study focuses on the territory scale, specifically in terms of macrohabitat (Block and Brennan 1993): the extent and configuration of vegetation stands within territories.

Habitat occupied by a particular species often spans a gradient from low to high quality, in which quality can be defined based on the habitat's effect on the survival and reproductive performance of individuals occupying particular grades of habitat. High-quality habitat promotes some combination of survival and reproductive performance that increases an individual's contribution to future generations (Van Horne 1983). As such, habitat is a key component in shaping an individual's fitness. Individual fitness can be loosely defined as a composite measure of reproduction and survival (Stearns 1992): a measure of the relative genetic contribution by an individual to the next generation (Charlesworth 1970, Nur 1987). Fitness is generally considered to be an individual measure; as an individual's probability of survival and offspring production increases, so does its fitness. However, Fretwell and Lucas (1970) combined the concepts of habitat and individual fitness into the idea that habitat quality confers fitness on individuals where the quality of habitat occupied by individuals of a given species is related to the average potential contribution from that habitat to the gene pool of succeeding generations. According to density-dependent habitat selection, individuals should occupy only habitats that maximize their fitness (Morris 1989). Wiens (1989*a*:301) referred to this effect of habitat quality on an individual as the *fitness potential* of habitat, denoted here as λ_H. However, λ_H can be a reflection of either habitat quality or some interaction between the individual and the habitat it occupies (Newton 1989*a*). At two extremes, individual fitness and fitness realized only when an individual occupies a certain habitat can be either additive or compensatory. If additive, λ_H is a combination of individual fitness and realized fitness that may also include interactions. If compensatory, then individual fitness is only realized when some optimal habitat is occupied; λ_H is then a direct measure of individual fitness. In either case, habitat fitness potential is a useful measure for both defining the quality of an animal's habitat and determining the relative contributions to the overall population of individuals occupying those habitats.

For territorial species, two competing theories of habitat selection have been proposed to explain how habitat quality affects habitat fitness potential in territorial species: the ideal-free distribution and the ideal-despotic distribution (Fretwell and Lucas 1970). Under the ideal-free distribution, high-quality habitats are occupied first. As the density of individuals increases, the fitness potential of high-quality habitats declines because of density-dependent influences and habitats of lesser quality are occupied. Habitat fitness potential in lower quality habitat now becomes equivalent to that of the high-quality habitat. When the entire habitat quality gradient is occupied, habitat fitness potential becomes similar across the whole gradient. Under the ideal-despotic distribution, habitat selection is constrained by the activities of dominant individuals. Dominant individuals achieve higher habitat fitness potential by occupying higher quality habitats, whereas less dominant individuals are relegated to lower quality habitat. In both distributions, ''ideal'' refers to the assumption that individuals have the dispersal and cognitive abilities to locate the best available territory (Pulliam and Danielson 1991).

If the gradient of all potentially suitable habitats for a species is assumed to be fully occupied, then a prediction from the ideal-free distribution is that habitat fitness potential among territories exhibiting different habitat characteristics should be relatively uniform (Morris 1989); spatial process variation (the variation among territories) in habitat fitness potential should be essentially zero. Under the ideal-despotic distribution, habitat fitness potential should be unequal among territories of differing habitat configurations; spatial process variation should be greater than zero. Whether a species follows the ideal-free or ideal-despotic model has important implications for population dynamics. Under the ideal-free distribution, individuals are assumed to have similar individual fitness (Fretwell and Lucas 1970); fitness is a function of habitat and density. However, under the ideal-despotic distribution, individuals in high-quality habitat are inherently more fit;

fitness is a function of both the individual and the habitat it occupies.

In field studies, fitness, whether individual or habitat-realized, is often poorly defined using either surrogate indices (such as behavioral responses) or only a single component (such as survival, reproduction, or some index of either) to represent fitness (Nur and Clobert 1988). However, fitness is a function of both survival and reproduction. Variation in external factors (such as habitat) can affect each of these components differently, with different combinations yielding different fitness values.

Here, we attempt to address a series of questions relating landscape habitat configuration in spotted Owl territories to survival, reproduction, and, ultimately, fitness. We examine spatial process variation in terms of habitat quality, ignoring the influence of temporal variation discussed previously. First, we address *whether Northern Spotted Owl survival and reproductive output vary with respect to landscape habitat covariates at the individual territory scale.* Noon and McKelvey (1996) considered that a within-population scale, with reproductive pairs as the sampling unit, was more relevant than a between-subpopulations scale for assessing relationships between demography and habitat in Northern Spotted Owls. Here, we are particularly interested in the effects of fragmentation of mature and old-growth forest on life history traits and fitness of Northern Spotted Owls. We define fragmentation as the conversion of continuous patches into smaller patches surrounded by a matrix of other vegetation types (after Wiens 1989*b*). Second, we ask *whether a compromise exists in these components of fitness.* Does one habitat element favor survival and another favor reproductive output, or is there a unifying habitat element that favors both? Third, *is there spatial process variation in fitness, or is fitness relatively uniform across territories?* In other words, does spatial variation in fitness among Northern Spotted Owl territories follow an ideal-free or an ideal-despotic distribution?

When considering only spatial variation, estimated variation ($\hat{\sigma}^2$) in estimates of fitness can be approximated as $\hat{\sigma}^2 = \hat{\sigma}^2_{\text{spatial}} + \widehat{\overline{\text{var}}}(\hat{\lambda}_H | \lambda_H)$, where $\hat{\sigma}^2_{\text{spatial}}$ is the estimated spatial process variation of fitness among territories, and $\widehat{\overline{\text{var}}}(\hat{\lambda}_H | \lambda_H)$ is average estimated sampling variation due to estimating fitness. Given some model and measures of habitat, spatial process variation can be further expressed as

$$\sigma^2_{\text{spatial}} = \sigma^2_{\text{habitat}} + \sigma^2_{\text{residual}} \tag{6}$$

where $\sigma^2_{\text{habitat}}$ is the spatial process variation of fitness attributed to habitat differences among territories; and $\sigma^2_{\text{residual}}$ is residual variation attributed to other factors, such as individual variation. Similarly, variation in survival and reproductive output, the components of fitness, can be estimated. Understanding variation in fitness among spotted owl territories provides insights into how differences in habitat quality influence spotted owl populations, and into conservation strategies to manage those populations.

Influences of climate and habitat on population dynamics

Blondel (1991) suggests that effects of extreme climatic events may be overcome by habitat heterogeneity, in which high-quality habitat buffers some individuals from such extreme events. This concept of buffering by high-quality habitats has little empirical support except for Van Horne et al. (1997), who found differential demographic responses to a drought and a prolonged winter by Townsend's ground squirrels (*Spermophilus townsendii*) in two different habitats.

Strategies proposed for organisms dealing with both climatic and habitat variation include short-term responses, such as large-scale spatial shifting of populations within a landscape in response to temporal shifts in climate (Karr and Freemark 1983, Kindvall 1995), and long-term, adaptive responses, such as increasing longevity of individuals to encompass as much temporal variation as possible, thus ensuring that a number of ''good'' years will be included in an individual's life-span (Newton 1989*b*). In the first strategy, population responses are based on changes in habitat quality for a given species in relation to climate; changes in climate alter habitat quality and individuals move in response to those changes. The second strategy assumes that habitat quality is more stable over time and that organisms are responding to this habitat stability in the face of temporal variation. Although the first strategy is probably irrelevant for nonmigratory, territorial species such as the Northern Spotted Owl, the second strategy is relevant for territorial species. A third strategy is that individuals should compete for habitats that dampen climatic variation, if climatic variation is important in determining variation in life history traits. This latter hypothesis is particularly relevant to territorial species and incorporates protection from extremes in climatic variation as a component of habitat quality.

Regarding effects of climate and habitat in population dynamics, we first asked the question: *What proportion of the total process variation in life history traits is explained by variation in climate, habitat, and other unknown factors?* For example, does climate account for only a minor proportion of the variation in survival and reproductive output, or does it contribute a proportion similar to that contributed by habitat? In addition, we examined whether there was sufficient residual process variation not accounted for by either habitat or climate that may be caused by other factors not examined in this study. We then asked the question: *Are survival and reproductive output impacted by an interaction between climate and habitat variation?* This can be rephrased as: *Do territories containing habitat that promotes high survival and reproduction buffer the occupants of those habitats from extremes*

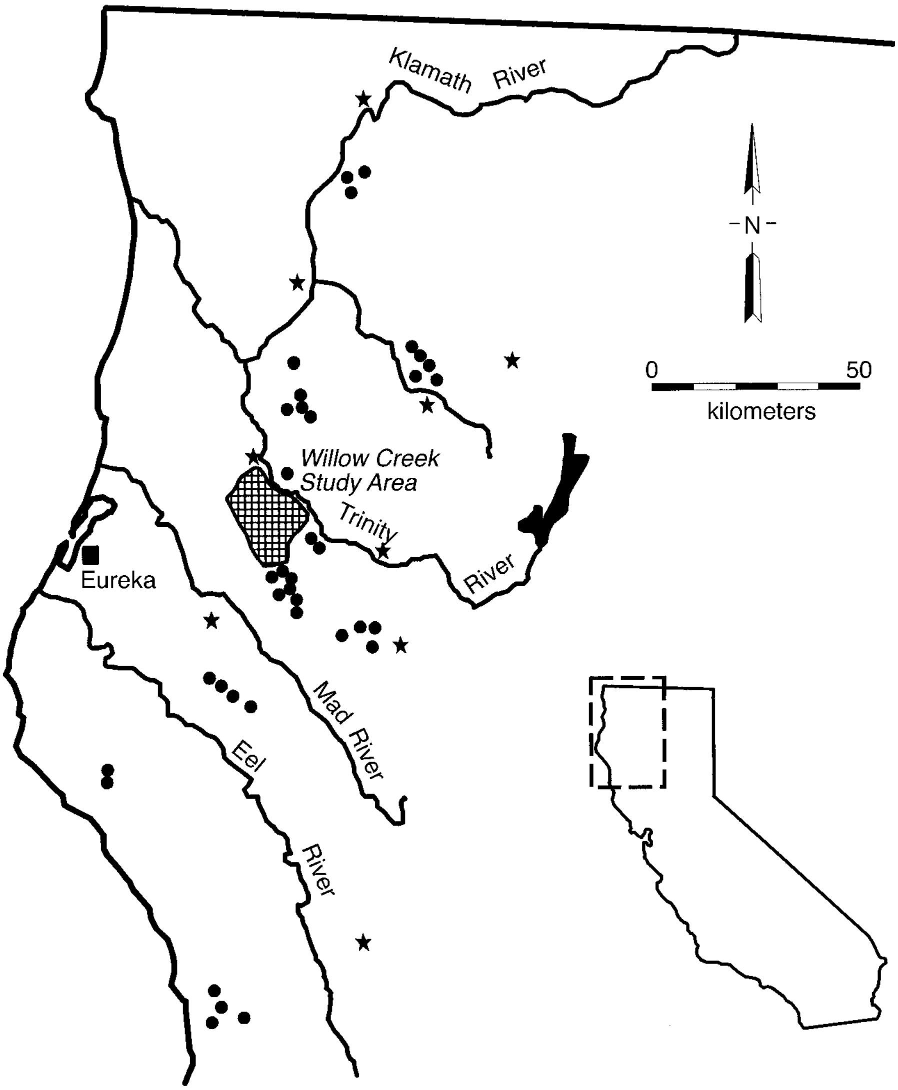

FIG. 1. Location of the Willow Creek study area (hatched area), satellite Northern Spotted Owl sites (dots), and weather stations (stars) in northwestern California.

in climatic variation? An interaction between habitat and climate would be expressed in which individuals occupying territories with "good" habitat quality maintain higher survival and reproduction during periods of "bad" climatic extremes than do those individuals occupying territories of "inferior" habitat quality. Both of these questions are relevant to conservation strategies because habitat variation can, theoretically, be controlled and predicted to some extent, whereas climate variation cannot. In addition, we evaluated what roles climatic and habitat variation may play in the population dynamics of Northern Spotted Owls.

STUDY AREA

We studied Northern Spotted Owls within a 10 000-km^2 area in the North Coast Range and Klamath Mountains of northwestern California, USA (Fig. 1) that included portions of three National Forests and isolated parcels administered by the Bureau of Land Management. Within this area, a 292-km^2 study area, near Willow Creek, Humboldt County, California, was established and was systematically surveyed each year from 1985 through 1994 to estimate density of Northern Spotted Owls (Franklin et al. 1990). The Willow Creek study area contained 49 Northern Spotted Owl sites (areas where owls exhibited territorial behavior sensu Franklin et al. 1996*a*). Twelve 10–30 km^2 satellite survey areas were also used, containing an additional 41 owl sites. These satellite areas were selected to increase sample size over a wider geographic area, and were surveyed from 1987 through 1994.

Elevations in the study area ranged from 200 to 1700 m. The study area was located within the Klamath physiographic province (Küchler 1977), which has

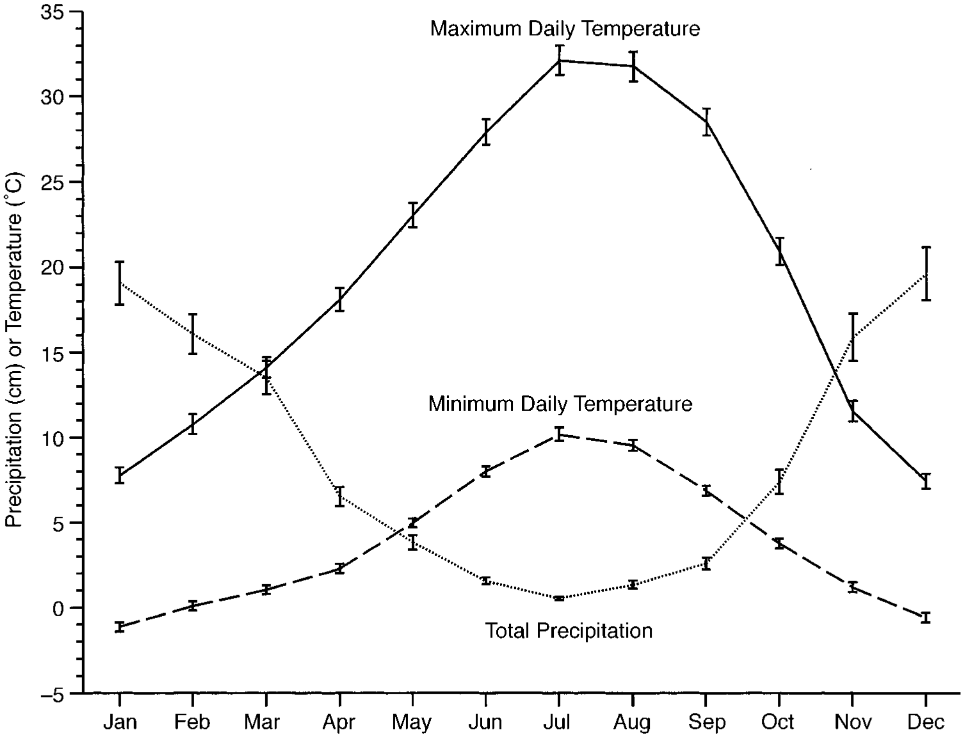

FIG. 2. Seasonal variation in climate in northwestern California. Data are means with 95% confidence intervals for nine weather stations distributed within the study area (see Fig. 1) from April 1954 through April 1994.

unique characteristics not found in other parts of the Northern Spotted Owl's range. This physiographic province encompassed southern Oregon and northern California, where forests were generally characterized by 3–5 major conifer species, often mixed with several hardwood species. Early-seral stages were often dominated by hardwoods, whereas older seral stages were dominated by a conifer overstory, a midstory of hardwood trees, and an understory of hardwood shrubs. As elevations increased, forested stands tended to be dominated solely by conifers. Below 1200 m, forests were dominated by a Douglas-fir (*Pseudotsuga menziesii*) overstory and a hardwood subcanopy dominated by madrone (*Arbutus menziesii*), tanoak (*Lithocarpus densiflora*), and canyon live oak (*Quercus chrysolepis*). Above 1200 m, forests were dominated by white fir (*Abies concolor*) associated with pines (*Pinus* spp.). Because of differing site qualities, pure hardwood stands also occurred, dominated by Oregon white oak (*Quercus garryana*), tanoak, or canyon live oak. Whittaker (1960) considered this forest region to be one of the most complex and diverse in the western United States, because of this blend of conifer and hardwood species.

The climate was mediterranean (Major 1977), characterized by cool, wet winters and hot, dry summers (Fig. 2). The growing season for vegetation was limited by the cool temperatures in winter and lack of precipitation during the summer. This climate was subject to periodic droughts at 10–15 yr intervals (Major 1977). The Klamath physiographic province has the highest patterns of lightning strikes in the Pacific Northwest; and pre-settlement fire-return rates averaged 11–20 yr at lower elevations and 37 yr at higher elevations (Agee 1993). Most pre-settlement fire appeared to be of low-to-moderate severity, resulting in hardwood understory removal, but retention of large overstory trees. High-severity fires, resulting in removal of most overstory trees, occurred infrequently (Agee 1993). Hardwood brush often became established first after severe fires, and could persist for decades before conifers eventually dominated (Thornburgh 1982).

Since the exclusion of fire by intentional suppression, logging has had the greatest influence on forests in this region (Beardsley and Warbington 1996). Logging patterns of mature and old-growth coniferous forests are similar to those in Oregon, which Spies et al. (1994) described as follows. Dominant silvicultural practices are to develop even-aged plantations, primarily of Douglas-fir (*Pseudotsuga menziesii*), in a dispersed fashion. This is achieved primarily through clear-cutting in regularly shaped blocks of ~16 ha, although earlier clear-cutting practices led to clearcuts of 32–41 ha. Hardwood species that become established after clear-cutting are usually removed through thinning. Logging on public lands began in the 1960s in our study area. In the 1930s and 1940s, ≥56% of productive coniferous forest land in California was considered to be old growth prior to commercial logging on public lands (Bolsinger and Waddell 1993). Approximately 31% of the four National Forests in northwestern California is now covered by mature and old-growth conifer forests, defined as having trees >53 cm diameter at breast height (Beardsley and Warbington 1996). Much of the remaining old-growth in the Pacific Northwest is on National Forests within the Klamath Mountains province in southern Oregon and northwestern California, USA (Bolsinger and Waddell 1993).

Study Species

Previous studies in our study area have demonstrated a strong association between Northern Spotted Owls and mature and old-growth forests at the scales of (1) home ranges within the geographical distribution (Blakesley et al. 1992, Hunter et al. 1995), and (2) habitat components within home ranges (Lahaye 1988, Solis and Gutiérrez 1990).

The primary prey of spotted owls in the study area are, in decreasing importance: dusky-footed woodrat (*Neotoma fuscipes*), northern flying squirrel (*Glaucomys sabrinus*), red tree vole (*Phenacomys longicaudus*), and deer mice (primarily *Peromyscus maniculatus*) (see Franklin 1997). *Neotoma* and *Glaucomys* are the most important prey taken, in terms of both frequency and biomass. Based on a number of studies with similar climatic regimes (Howell 1926, Linsdale and Tevis 1951, Tevis 1956, Sadleir 1974, Van Horne 1981, Wells-Gosling and Heaney 1984, Carey 1991, Witt 1991), these four prey species reproduce primarily in the spring and early summer. Breeding seasons of prey are probably determined by availability of high-quality forage during the spring. The primary plant species providing forage for Northern Spotted Owl prey in the spring are oaks, conifers, and hypogeous fungi. *Neotoma* forages heavily on evergreen schlerophyll vegetation, such as tanoak and *Quercus* species in northern California (Linsdale and Tevis 1951, Atsatt and Ingram 1983). In southwestern Oregon, *Glaucomys* eats almost exclusively hypogeous fungi (Maser et al. 1986), whereas *Phenacomys* feeds exclusively on conifer needles, principally from Douglas-fir (Howell 1926, Carey 1991). *Peromyscus* consumes primarily conifer seeds in spring (Jameson 1952, Tevis 1956). In general, phenology of important plant species coincides with the breeding seasons of spotted owl prey. Leaf production for oaks and conifers (Douglas-fir) begins in early spring (Burns and Honkala 1990). Flower production for oaks and other hardwoods extends from May through August, whereas seed production occurs between August and November (Burns and Honkala 1990), providing important food sources for overwintering *Neotoma* and *Peromyscus*. Sporocarp biomass of hypogeous fungi used by *Glaucomys* is highest in March–September (Luoma et al. 1991).

There is conflicting evidence as to whether Northern Spotted Owls are dependent primarily on interior mature and old-growth coniferous forest, are edge dependent, or are dependent on a mixture of interior habitat and edge. *Neotoma* attains its highest densities in early-seral stages where dense hardwood brush is abundant, and achieves low densities in mature and old-growth forests (Sakai and Noon 1993). Other small mammals important in the diet of Northern Spotted Owls are also found in higher densities in early- to mid-seral stages (Raphael 1988). For this reason, Carey and Peeler (1995) suggest that the mixed-conifer forests of the Klamath Mountains have the greatest diversity and biomass of prey for Northern Spotted Owls. In northern California, Zabel et al. (1995) found spotted owls foraging near edges of late- and early-seral stage forests more often than expected. Ward et al. (1998) reported that woodrat abundance was greatest at spotted owl foraging sites at the ecotone between late- and early-seral stages. Thus, there is a dichotomy between the strong association for spotted owls with late-seral stage forests and the primary prey source for owls that are associated with early-seral stages.

The link between older forests and life history traits, such as survival and reproductive output, is currently tenuous in Northern Spotted Owls. Using turnover rates as an index of survival, Bart and Earnst (1992) found that persistence of adults was significantly correlated with the proportion of mature and old-growth forest within Northern Spotted Owl territories. Bart and Forsman (1992) and Ripple et al. (1997) found similar positive correlations between amounts of mature and old-growth forest and reproductive output in Northern Spotted Owls, on the scale of aggregations of territories and individual territories, respectively. However, in all cases, relationships with other habitat configurations were not considered, and Bart and Earnst (1992) and Ripple et al. (1997) used indices of life history traits, rather than direct parameter estimates. In addition, the link between habitat and fitness is still lacking. The problem with studies that examine only the components of fitness (survival and fecundity) is that potential trade-offs maximizing long-term survival and fecundity are often ignored. In other words, factors that maximize either survival and fecundity may be different, and neither component by itself may reflect fitness.

Methods

We used the following general analytical approach in assessing the effects of variation in climate covariates on the three life history traits of Northern Spotted Owls. After developing the biological background for potential effects of climate on Northern Spotted Owls, we divided the annual cycle into specific life history periods to identify when climatic stresses may affect spotted owls. We relied on existing biological information to identify these periods. In dividing the annual cycle into specific periods, we reduced the number of climatic covariates from arbitrary weekly or monthly intervals to those included in fewer, more biologically meaningful, intervals (Appendix A). We used these steps to develop a priori verbal hypotheses, which we then expressed as models that could be fit to the available data. In these models, the response variables were life history traits (survival, reproductive output, and recruitment) and the explanatory variables were climate covariates (temperature and precipitation during life history periods) and individual covariates (age and sex). Thus, we had suites of candidate statistical models for each life history trait that were developed prior to analyzing the empirical data and that related the respective life history trait to climatic covariates. These suites of candidate models were analogous to the 26 predator–prey models suggested by Berryman et al. (1995), some of which represented competing theories. The importance of a priori model development in data analysis, as opposed to analyzing data by iteratively searching the data for relationships (i.e., data dredging), has been alluded to by Hofacker (1983) and Chatfield (1995), and more recently has been formalized by Burnham and Anderson (1998).

After a priori hypothesized models were developed, we used an objective model selection criterion (AICc; see *Selection of hypothesized models*) to rank and calibrate the candidate hypothesized models in terms of their ability to explain the empirical data. In this way, a ''best approximating'' model was selected from each suite of candidate models as the most parsimonious explanation of the data. Other candidate models were then ranked below in terms of their plausibility to explain the same data. Model selection based on AIC has an advantage in that multiple hypotheses can be ranked according to their importance in explaining the data; a hypothesis-testing approach only allows for rejection or failure to reject two models at a time (Akaike 1974). Burnham and Anderson (1998) present other, numerous reasons for using AIC-based model selection rather than hypothesis testing when dealing with data collected in an observational study such as this one. Model selection, based on AIC, has been used extensively in capture–recapture studies (see Lebreton et al. 1992).

The analytical strategy that we outline here avoids models with more covariates than can be supported by the data, which often results in imprecise parameter estimates, and excessive data dredging, which can result in spurious explanatory models (Freedman 1983). Thus, the strategy that we use here balances precision and bias when selecting an appropriate model to relate variation in life history traits to climatic covariates (Burnham and Anderson 1992).

Data collection

Life history traits.—The general design for collection of field data to estimate survival, reproductive output, and recruitment was to monitor marked individuals over time. Each year, we attempted to locate and individually identify all spotted owls in the Willow Creek and satellite study areas. Territorial spotted owls were located with multiple surveys, using vocal imitations of their calls to elicit responses (Forsman 1983, Franklin et al. 1996*a*), from April through August of each year. Surveys were not conducted on days when precipitation occurred. Northern Spotted Owls were aged by plumage characteristics as fledged young of the year, 1-, 2-, or ≥3-yr old (Moen et al. 1991); sexes were distinguished by vocalizations (Forsman et al. 1984). Once located, owls ≥1 yr old were checked for reproductive output. Using specific criteria outlined in Franklin et al. (1996*a*), each pair of owls visited was categorized as having 0, 1, 2, or (rarely) 3 fledged young. Individuals were uniquely identified through capture, recapture, or resighting of colored leg bands using several techniques (see Forsman 1983, Franklin et al. 1996*a*). Locking numbered aluminum bands were placed on one leg of each captured owl, and a colored plastic leg band with colored vinyl tabs (Forsman et al. 1996) was placed on the opposing leg to identify individuals without recapturing in subsequent years. If identification of color marks was ambiguous, birds were recaptured and the numbered band was read. We used the term ''recapture'' to describe physical recapture of marked individuals or resighting of previously color-marked individuals. Although juveniles were recaptured as ≥1-yr olds, these data were not used to estimate juvenile survival because of potential biases (see Franklin et al. 1996*a*).

Climate covariates.—To estimate climatic covariates, we first divided the annual cycle experienced by spotted owls into critical periods based on weather conditions and specific life history stages (see Appendix A for details). These critical periods were the *winter stress period* (November–February), the *early nesting period* (March–April), the *late nesting period* (May), the *heat stress period* (July–August), and the *dispersal period* (September–October).

Within each defined life history period, we obtained daily measurements for amounts of precipitation and minimum and maximum temperatures from nine weather stations operated by the U.S. Weather Service (Fig. 1). These stations were selected because they provided adequate spatial coverage of the study areas and had complete records both during and before the study. The range of weather station elevations included 83% of the elevational distribution for owl capture locations. Therefore, we assumed that data from the weather stations were representative of conditions experienced by spotted owls in the study area. We also assumed that changes between years adequately represented real changes as long as climate conditions within years were reasonably represented, because the relationship of interest was year-to-year variation.

Climate covariates had to be biologically meaningful in their effects on owls, and had to be precisely estimated (CV < 10%) when averaged across stations within years, because we did not incorporate sampling variances of covariates into statistical analyses. For precipitation, we used the number of days of measurable precipitation (≥0.03 cm) within each life history period because we felt that the duration of precipitation was more important in its effects than the absolute amount. Regardless, the annual number of days of precipitation was highly correlated with annual precipitation amount within the life history periods ($r = 0.87–0.94$, df = 8, $P < 0.001$). The number of days with precipitation averaged across stations within years was precise (CV = 2.5–7.1%).

Estimating daily temperature only from daily maximum and minimum temperatures can be problematic. Means of maximum and minimum temperature in a given day fail to account for the duration of temperatures, and typically underestimate the actual mean daily temperature, based on hourly data (Lindsey and Newman 1956). Therefore, we estimated degree-hours (the product of temperature and the time over which temperatures occur; Lindsey and Newman 1956, Tuhkanen 1980) by modeling hourly temperature over the course of a 24-h day using a cosine model (from Allen 1976):

$$\text{Hourly temperature} = T_{\min} + \left(\frac{T_{\max} - T_{\min}}{2}\right)\left[1 - \cos\left(\frac{\gamma\pi}{24}h - \frac{\delta\pi}{24}\right)\right] \quad (7)$$

where $T_{\max}$ and $T_{\min}$ were daily maximum and minimum temperatures, respectively; h was the hour of the day; and γ and δ were parameters controlling phase angle and width, respectively. Daily degree-hours were estimated by integrating Eq. 7 from $h = 0$ to 24. Parameters γ and δ were estimated for life history periods using Eq. 7 in nonlinear regression (Proc NLIN; SAS Institute 1990) with hourly data available from two weather stations. Degree-hours were estimated for each day and were then averaged within the life history periods for each year. Daily temperature models explained a high proportion of the variation in hourly temperature over the course of a day ($R^2 = 0.912–0.995$) within the life history periods. Estimates of γ (CV = 1.4–5.0%) and δ (CV = 5.2–11.2%) from Eq. 7 were precise. Degree-hours averaged across stations within years were precise (CV = 1.2–3.6%). As an additional covariate during the heat stress period, we estimated surplus stress units, in terms of increased oxygen consumption by the owls (mL O_2/g/h), attributed to daily temperatures, and the length of time that they were maintained, according to:

$$\text{cc } O_2 \text{ g}^{-1} \text{ h}^{-1} = \int_{h_a}^{h_b} [0.649 + 0.008(f(H)) - 0.905]\, dt \quad (8)$$

where $f(H)$ was Eq. 7, h_a was the hour when temperatures began exceeding the 32°C threshold temperature when owls exhibited heat stress, and h_b was the hour when temperatures decreased below the 32°C threshold temperature. The linear equation in Eq. 8 is the regression equation estimated by Ganey et al. (1993) for oxygen consumption in Mexican Spotted Owls (*Strix occidentalis lucida*) above their thermal neutral zone. In using the equation from Ganey et al. (1993), we assumed that Northern Spotted Owls had a physiological response to temperature similar to that of Mexican Spotted Owls.

Landscape habitat covariates.—We used a digital vegetation map, developed by the California Timberland Task Force (TTF), that covered both private and public lands over the extent of our entire study area (Geographic Resource Solutions 1996). This map was developed from 1990 Landsat Thematic Mapper imagery that was resampled to a pixel size of 25 × 25 m. Pixels were aggregated into polygons with a minimum polygon size of 2 ha. Polygon attributes pertinent to this study were (1) average quadratic mean diameter (Husch et al. 1982) at breast height of all conifer trees in the polygon, (2) average quadratic mean diameter at breast height of all hardwood trees in the polygon, (3) canopy closure of all trees in the polygon, and (4) percentage of conifers in the total canopy closure. This vegetation map was chosen because it covered all lands regardless of ownership, it covered the entire study area, and it contained polygon attributes classifiable into vegetation types relevant to spotted owls. Although other vegetation maps existed, they lacked one or more of these attributes.

We initially defined two habitats: spotted owl habitat and high-density dusky-footed woodrat habitat. Based on previous experience with Landsat coverages that were used to define habitats on the Willow Creek study area (Hunter et al. 1995), these were the only two habitats that we felt could be reliably estimated. Spotted owl habitat was based on the strong association of the owl with mature and old-growth forests for nesting, roosting, and foraging on the study area (Solis and Gutiérrez 1990, Blakesley et al. 1992, Hunter et al. 1995). Woodrat habitat was based on vegetation characteristics associated with high densities of dusky-footed woodrats (Sakai and Noon 1993). However, Northern Spotted Owls were not known to forage within this habitat (Solis and Gutiérrez 1990), but possibly along its edges (Zabel et al. 1995). Therefore, we initially distinguished woodrat habitat from spotted owl habitat based on the definition of habitat used here (Morrison et al. 1992). Both habitats were defined using the polygon attributes in the TTF vegetation map. Two phases of field verification were used to iteratively assess the accuracy of our definitions for the two habitats (Franklin 1997). However, woodrat habitat was poorly classified (68.6% probability that stands on the ground were correctly classified in the TTF coverage). In addition, analyses including this habitat did not suggest that woodrat habitat was important in explaining spatial variation in spotted owl survival and reproductive output. Therefore, we did not consider this habitat further. In the end, we used two habitats: spotted owl habitat vs. other vegetation types. Spotted owl habitat was mature and old-growth forest with a quadratic mean diameter of conifers ≥53 cm, quadratic mean diameter of hardwoods ≥15 cm, percentage of conifers ≥40%, and overstory canopy coverage ≥70%. This definition corresponded to other classifications used to define spotted owl habitat (Solis and Gutiérrez 1990) and to definitions used in other studies in this area (Blakesley et al. 1992, Hunter et al. 1995). By including hardwood tree species, our definition of spotted owl habitat indirectly reflected multiple canopy layers, an important component identified in previous studies (Solis and Gutiérrez 1990). Based on both phases of field verification (Franklin 1997), spotted owl habitat was correctly classified 89.0% of the time using the TTF vegetation coverage.

We used a 0.71 km radius circle around territory centers to represent spotted owl territories. Landscape habitat characteristics were then measured within these circles as covariates, when estimating survival and reproductive output of individual spotted owls occupying territories represented by the circles. Rationales and methods used to derive the 0.71 km radius circles as sampling units are described as follows. First, territory centers were estimated for all territories by averaging the UTM (Universal Transverse Mercator) coordinates representing roost and nest locations at each site. Multiple roosts at the same territory within the same year were included only once when averaging. However, if individuals roosted or nested at the same location in different years, those locations were included because they represented choices by individuals between years. In general, roost and nest locations at individual territories were tightly clustered; coefficients of variation for mean Easting and Northing UTM coordinates were ≤0.1 for 90% of the territories. Second, the radius of the circle was estimated as one-half of the median nearest neighbor distance (Hunter et al. 1995) between 37 territory centers in the Willow Creek Study area only. We assumed that the locations of almost all territories were known in the Willow Creek study area, to provide an adequate measure of territory adjacency. This median measure (0.71 km) was similar to the mean (0.75 km), with a range of 0.21–1.21 km.

We considered the 0.71 km radius circles as territory core areas for spotted owls in this study because of the small area (1.58 km^2) relative to expected home range size in northwestern California (4.2–5.9 km^2; Zabel et al. 1995). Hunter et al. (1995) and Meyer et al. (1998) found that landscape characteristics had the highest levels of significance between random sites and sites used by Northern Spotted Owls in the Klamath province when 0.8-km circles were used as a sampling unit, as opposed to larger diameter circles centered around the same sites. Meyer et al. (1998) suggested that characteristics of the inner core represented by these size circles may be most influential in determining territory locations for Northern Spotted Owls.

In describing landscape characteristics within territories, we chose not to use indices such as fractal dimension, contagion, evenness, and the variety of patch indices commonly used in landscape ecology to describe fragmentation and landscape pattern. Often these indices do not capture obvious differences in landscape pattern (Ripple et al. 1991, Groom and Schumaker 1993, Li and Reynolds 1994), are ad hoc (thus lacking an appropriate theoretical basis as meaningful measures), and are highly correlated with each other (Li and Reynolds 1994). In addition, we did not use metrics that included area in the denominator, such as patch density, because all territory circles were the same size. The metrics that we chose to describe landscape characteristics within spotted owl territories were those that we considered to be the fundamental characteristics describing habitat amounts, patch size, patch abundance, patch shape, and patch spacing. Together, the patch characteristics accounted for varying degrees of fragmentation.

Within the 0.71 km radius circles around territory centers, we chose nine habitat covariates and one topographic covariate (elevation) to examine with respect to spotted owl survival and reproduction (Table 1). We estimated mean elevation (ELEV) for each spotted owl territory by averaging the elevations of each roost and nest site used to estimate the centers of each territory. SOHAB and SOMP were estimates of amounts of spotted owl habitat, whereas SODIS was an estimate of the spatial distribution of patches of owl habitat (Ripple et al. 1991, Groom and Schumaker 1993). SOEDG, in conjunction with SOCOR, was a measure of patch shape (Groom and Schumaker 1993). For example, patches with little SOCOR and high SOEDG indicated linear patch shapes. The core habitat covariates, SOCOR and SONCA, are additional measures of general patch shape because they account for relative amounts of interior habitat vs. edge (Groom and Schumaker 1993). The combination of SOCOR and SONCA also measures fragmentation (Temple 1986) by measuring the amount and distribution of interior habitat; many small patches will have little or no core habitat. We used a 100-m distance from the edge to define core habitat area, because ecological characteristics of old-growth coniferous forests begin to stabilize beyond this distance (Spies et al. 1994, Chen et al. 1995), and the negative edge-associated impacts on forested habitats, in general, have been ameliorated after this distance (Temple 1986).

We estimated covariates for each spotted owl territory using operations in the ARC/INFO geographic information system (ESRI 1987). We first made a new coverage from the TTF vegetation map, which only included polygons of either spotted owl habitat or other vegetation types. Territory centers were circumscribed by the 0.71-km sampling radius and coverages for each

TABLE 1. Age and landscape habitat covariates used in models to estimate survival and reproductive output for Northern Spotted Owls in northwestern California.

Variable	Definition	Original metric†	Rescaled metric‡
*a*2	Dummy variable with 1-yr-old age class vs. ≥2-yr-old age class		
*a*2′	Dummy variable with 1- and 2-yr-old age class vs. ≥3-yr-old age class		
*a*3	Dummy variables with 1-yr-old age class vs. 2-yr-old age class vs. ≥3-yr-old age class		
SOHAB	Total amount of Northern Spotted Owl habitat	ha	ha ÷ 10
SONP	No. discrete patches of spotted owl habitat	*n*	*n*
SOMP	Maximum patch size of spotted owl habitat	ha	ha ÷ 10
SOEDG	Total amount of edge between spotted owl habitat and all other vegetation types	m	km
SODIS	Mean nearest neighbor distance between patches of spotted owl habitat measured from edge to edge of patches	m	m ÷ 10
SOCOR	Total amount of spotted owl core habitat, defined as the amount of spotted owl habitat ≥ 100 m from an edge	ha	ha
SONCA	No. patches of spotted owl core habitat	*n*	*n*
ELEV	Mean elevation of spotted owl territory	m	m ÷ 100

† Original scale on which the covariate was measured.
‡ Rescaling factor used for analyses with covariates.

territory were then developed, containing the two categories within each circle. We used program FRAGSTATS (McGarigal and Marks 1995) to estimate each of the habitat covariates for each spotted owl territory. We manually checked measurements of a subsample ($n = 15$) of the territories to ensure that FRAGSTATS was correctly estimating the habitat covariates. Prior to analyses, covariates were rescaled in order to avoid large values in quadratic terms and interactions (Table 1).

Logging occurred within the sampling circle on nine territories over the course of the study. We adjusted polygons for loss of habitat due to timber harvest, based on U.S. Forest Service timber harvest records and aerial photographs, made new coverages of these territories, and estimated habitat covariates for both before and after logging.

Formulation of hypothesized models

Model development.—Prior to analyzing the empirical data, we explored ways in which climate and habitat configuration might affect spotted owls, based on the existing literature. We used this information to develop qualitative, potential effects of climate and habitat conditions on the owls, and incorporated these into statistical models as a priori hypotheses for analyzing the empirical data on the three life history traits. We used three forms of models when translating ideas into statistical models: a linear, a pseudothreshold, and a quadratic form (Fig. 3). For survival analyses, these model forms were incorporated using a logit link function (see *Modeling survival*).

The linear form of models could be written as

$$\theta = \beta_0 + \beta_1(x_1) + \cdots + \beta_n(x_n) \tag{9}$$

and the quadratic form as

$$\theta = \beta_0 + \beta_1(x_1) + \beta_2(x_1^2) + \ldots + \beta_{2n-1}(x_n) + \beta_{2n}(x_n^2) \tag{10}$$

where θ was the life history trait and x_i was the ith covariate. For the sake of parsimony in quadratic forms of the models, we used the squared differences of covariate values from their mean (denoted by preceding the covariate name with a *D*), which were calculated as

$$Dx_{ij} = (x_{ij} - \bar{x}_i)^2 \tag{11}$$

where x_{ij} was the jth value of the ith covariate. By using the squared differences, we could rewrite Eq. 10 as

$$\theta = \beta_0 + \beta_1(Dx_1) + \cdots + \beta_n(Dx_n). \tag{12}$$

This saved an extra parameter for each covariate used in the quadratic form of the models. However, the form in Eq. 12 was a restricted quadratic because it assumed that the curve was centered on the covariate mean. Therefore, quadratic models using the squared differences were also examined with the full quadratic terms ($x_i + x_i^2$) as a check.

The pseudothreshold form of models was

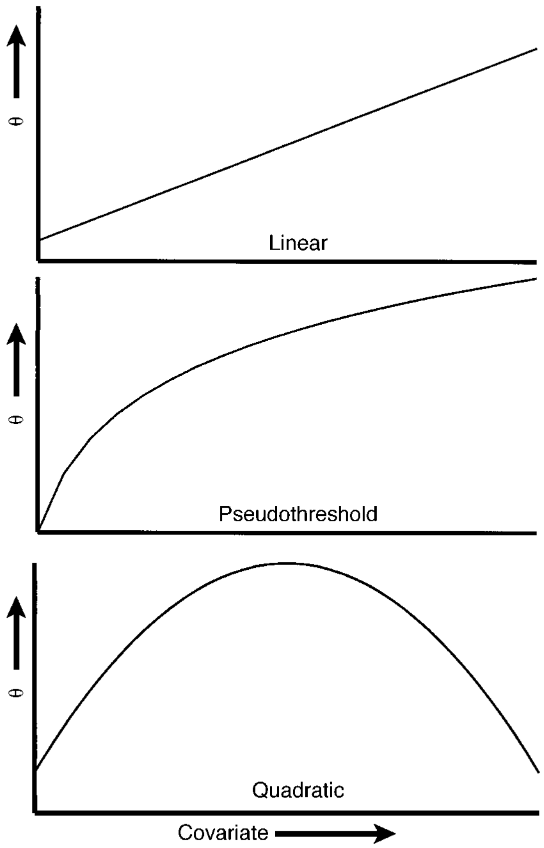

FIG. 3. Model forms used in hypothesized models relating landscape habitat covariates to life history traits (θ).

$$\theta = \beta_0 + \beta_1 \log_e(x_1 + 0.5) + \cdots + \beta_n \log_e(x_n + 0.5). \quad (13)$$

Covariate names in these models were preceded by an L (e.g., LSOCOR). In using log transforms, we added 0.5 to covariate values to account for values of zero. This was considered a pseudothreshold because an asymptote (threshold) was approached, but never reached, using the log transform. However, we considered this a parsimonious approximation to a true threshold model.

Each model structure indicated different predictions for each of the hypothesized models. A linear structure predicted that effects of the covariates changed at some constant rate; a pseudothreshold structure predicted that effects changed at a constant rate to some point and then approached (but did not reach) an asymptote; and a quadratic structure predicted some optimal maximum at intermediate effects, and lower effects at the extremes (Fig. 3). In denoting combinations of effects in models, we used ''+'' to denote an additive effect, where no interactions were considered, and used ''*'' to denote inclusion of interactions (Lebreton et al. 1992).

Climate models.—We hypothesized that variation in precipitation and ambient temperature can affect spotted owls directly through energetic constraints, and indirectly through the population dynamics and activity patterns of their prey, and the food resources required by those prey. Collectively, we referred to models examining the relationship between the life history traits and climate covariates as climate models. The underlying biological rationale for developing the following hypothesized climate models is detailed in Appendix A.

Prior to data analysis, we developed eight hypothetical climate models for survival (Table 2). The late nesting period was not included in survival models because of overlap with sampling periods when owls were captured. Models 1–6 in Table 2 examined climate effects within each period based on biological characteristics outlined previously, but with no drought effects. Longer term drought effects were considered in model 7, using a quadratic model in which survival could be negatively affected at either end of the drought–mesic continuum. Model 8 in Table 2 hypothesized that optimal growing conditions (e.g., wet winters followed by warm springs) in one year can positively influence prey populations in the following year and, hence, may increase spotted owl survival over the winter stress period. Additional variations of the hypothesized models included quadratic forms of the covariates and inclusion of age and sex effects.

We proposed 11 a priori climate models for reproductive output (Table 2) in which only the winter stress, early nesting, and late nesting periods were considered relevant. The complexity of hypothesized models for reproductive output was constrained by the existing sample of 10 yr, because annual means were used as the response. In Northern Spotted Owls, we presumed that food during the winter stress, early nesting, and late nesting periods was crucial for determining reproductive success, based on food supplementation experiments with other raptor species (Ward and Kennedy 1994, 1996, Wiehn and Korpimäki 1997). Models 1–3 in Table 2 reflected the effects of high precipitation alone on the ability of males to provide adequate food for incubating females or nestlings. Model 4 hypothesized that cold, wet winters negatively affected a female's ability to attain adequate body condition for reproduction, whereas models 5 and 6 examined the effects of both temperature and precipitation on hunting success of males and their ability to provide females with sufficient food during the early and late nesting periods. Lacking sufficient food, we surmised that females would leave nests for extended periods to forage, exposing eggs and young to the chilling effects of cold, wet weather. Models 7 and 8 examined the combined effects of wet and cold on the postulated effects from models 4–6. Models 9–11 hypothesized that optimal climatic conditions promoting the production of plant forage for prey led to increased reproductive output by the owls (see Appendix A).

We hypothesized six additional models to explain the effects of climate on recruitment (Table 2). Model

TABLE 2. Description and representation of a priori models concerning the effects of precipitation and ambient temperature on survival, reproductive output, and recruitment rates of Northern Spotted Owls in northwestern California.

Hypothesis	Model	Model structure	Expected result†
Survival (logit ϕ)			
1) Negative effects of high temperatures in H.	ϕ_{T_H}	$\beta_0 + \beta_1(T_H)$	$\beta_1 < 0$
2) Negative effects of high precipitation and cold temperatures in W (no drought effect).	$\phi_{P_W+T_W}$	$\beta_0 + \beta_1(P_W) + \beta_2(T_W)$	$\beta_1 < 0, \beta_2 > 0$
3) Negative effects of high precipitation and cold temperatures in E (no drought effect).	$\phi_{P_E+T_E}$	$\beta_0 + \beta_1(P_E) + \beta_2(T_E)$	$\beta_1 < 0, \beta_2 > 0$
4) Negative effects of combined precipitation in both W and E.	$\phi_{P_W+P_E}$	$\beta_0 + \beta_1(P_W) + \beta_2(P_E)$	$\beta_1 < 0, \beta_2 < 0$
5) Positive effects of high precipitation in W followed by warm temperatures in E.	$\phi_{P_W+T_E}$	$\beta_0 + \beta_1(P_W) + \beta_2(T_E)$	$\beta_1 > 0, \beta_2 > 0$
6) Negative effects of high precipitation and cold temperatures in both W and E (no drought effect).	$\phi_{P_W+T_W+P_E+T_E}$	$\beta_0 + \beta_1(P_W) + \beta_2(T_W) + \beta_3(P_E) + \beta_4(T_E)$	$\beta_1 < 0, \beta_2 > 0$ $\beta_3 < 0, \beta_4 > 0$
7) Negative effects of high precipitation or drought, both combined with temperatures, in both W and E.	$\phi_{P_W+P_W^2+P_E+P_E^2+T_W+T_E}$	$\beta_0 + \beta_1(P_W) + \beta_2(P_W)^2 + \beta_3(P_E) + \beta_4(P_E)^2 + \beta_5(T_W) + \beta_6(T_E)$	$\beta_1 > 0, \beta_2 < 0$ $\beta_3 > 0, \beta_4 < 0$ $\beta_5 > 0, \beta_6 > 0$
8) Lagged positive effect of high precipitation in W and warm temperatures in E in time *t* on survival in $t + 1$.	$\phi_{P'_W+T'_E}$	$\beta_0 + \beta_1(P'_W) + \beta_2(T'_E)$	$\beta_1 > 0, \beta_2 > 0$
Reproductive output (*R*)			
1) Negative effects of high precipitation in E.	R_{P_E}	$\beta_0 + \beta_1(P_E)$	$\beta_1 < 0$
2) Negative effects of high precipitation in L.	R_{P_L}	$\beta_0 + \beta_1(P_L)$	$\beta_1 < 0$
3) Negative effects of high precipitation in both E and L.	$R_{P_E+P_L}$	$\beta_0 + \beta_1(P_E) + \beta_2(P_L)$	$\beta_1 < 0, \beta_2 < 0$
4) Negative effects of high precipitation and cold temperatures in W (no drought effect).	$R_{P_W+T_W}$	$\beta_0 + \beta_1(P_W) + \beta_2(T_W)$	$\beta_1 < 0, \beta_2 > 0$
5) Negative effects of high precipitation and cold temperatures in E.	$R_{P_E+T_E}$	$\beta_0 + \beta_1(P_E) + \beta_2(T_E)$	$\beta_1 < 0, \beta_2 > 0$
6) Negative effects of high precipitation and cold temperatures in L.	$R_{P_L+T_L}$	$\beta_0 + \beta_1(P_L) + \beta_2(T_L)$	$\beta_1 < 0, \beta_2 > 0$
7) Negative effects of high precipitation and cold temperatures in both E and L.	$R_{P_E+T_E+P_L+T_L}$	$\beta_0 + \beta_1(P_E) + \beta_2(T_E) + \beta_3(P_L) + \beta_4(T_L)$	$\beta_1 < 0, \beta_2 > 0$ $\beta_3 < 0, \beta_4 > 0$
8) Negative effects of high precipitation and cold temperatures in both W and E.	$R_{P_W+T_W+P_E+T_E}$	$\beta_0 + \beta_1(P_W) + \beta_2(T_W) + \beta_3(P_E) + \beta_4(T_E)$	$\beta_1 < 0, \beta_2 > 0$ $\beta_3 < 0, \beta_4 > 0$
9) Positive effects of high precipitation in W followed by warm temperatures in E.	$R_{P_W+T_E}$	$\beta_0 + \beta_1(P_W) + \beta_2(T_E)$	$\beta_1 > 0, \beta_2 > 0$
10) Positive effects of high precipitation in W followed by warm temperatures in L.	$R_{P_W+T_L}$	$\beta_0 + \beta_1(P_W) + \beta_2(T_L)$	$\beta_1 > 0, \beta_2 > 0$
11) Positive effects of high precipitation in W followed by warm temperatures in E and L.	$R_{P_W+T_E+T_L}$	$\beta_0 + \beta_1(P_W) + \beta_2(T_E) + \beta_3(T_L)$	$\beta_1 > 0, \beta_2 > 0$ $\beta_3 > 0$
Recruitment rate (*b*)			
1) Negative effects of high precipitation in D.	b_{P_D}	$\beta_0 + \beta_1(P_D)$	$\beta_1 < 0$
2) Negative effects of high precipitation in both D and W.	$b_{P_D+P_W}$	$\beta_0 + \beta_1(P_D) + \beta_2(P_W)$	$\beta_1 < 0, \beta_2 < 0$
3) Negative effects of high precipitation and cold temperatures in D.	$b_{P_D+T_D}$	$\beta_0 + \beta_1(P_D) + \beta_2(T_D)$	$\beta_1 < 0, \beta_2 > 0$
4) Negative effects of high precipitation in D, W, and E.	$b_{P_D+P_W+P_E}$	$\beta_0 + \beta_1(P_D) + \beta_2(P_W) + \beta_3(P_E)$	$\beta_1 < 0, \beta_2 < 0$ $\beta_3 < 0$
5) Negative effects of high precipitation and cold temperatures in D with high precipitation in W.	$b_{P_D+T_D+P_W}$	$\beta_0 + \beta_1(P_D) + \beta_2(T_D) + \beta_3(P_W)$	$\beta_1 < 0, \beta_2 > 0$ $\beta_3 < 0$
6) Negative effects of high precipitation and cold temperatures in both D and W.	$b_{P_D+T_D+P_W+T_W}$	$\beta_0 + \beta_1(P_D) + \beta_2(T_D) + \beta_3(P_W) + \beta_4(T_W)$	$\beta_1 < 0, \beta_2 > 0$ $\beta_3 < 0, \beta_4 > 0$

Notes: *P* and *T* indicate precipitation and temperature covariates, respectively. Abbreviations for life history periods where covariates apply are: W, winter stress; E, early nesting; L, late nesting; D, dispersal; and H, heat stress period.

† Expected direction in regression coefficients, given that the hypothesized model is correct to use.

1 was a hypothesis that high precipitation would negatively affect recruitment by negatively affecting the hunting success of juveniles when they first disperse. We based models 2 and 4 on a similar supposition, but over the longer period of time when young owls must first fend for themselves during dispersal. In models 3, 5, and 6, we considered the effects of temperature in addition to precipitation. Because recruitment is a function of survival and reproduction, we tested all of the Table 2 hypothesized models related to those parameters. We made an additional prediction based on potential population dynamics: if floaters were present in sufficient numbers, then climate covariates that negatively affect the survival of territory holders should

TABLE 3. A priori hypothesized models used to relate the effects of landscape habitat characteristics with survival and reproduction of Northern Spotted Owls in northwestern California; θ represents either apparent survival or reproductive output.

Hypothesized model	Predicted effects		
	Linear structure	Pseudothreshold structure	Quadratic structure†
1) θ_{SOHAB}	$\beta_{SOHAB} > 0$	$\beta_{ln(SOHAB)} > 0$	$\beta_{SOHAB} > 0$, $\beta_{(SOHAB)^2} < 0$
2) θ_{SOMP}	$\beta_{SOMP} > 0$	$\beta_{ln(SOMP)} > 0$	$\beta_{SOMP} > 0$, $\beta_{(SOMP)^2} < 0$
3) $\theta_{SOMP+SONP}$	$\beta_{SOMP} > 0$, $\beta_{SONP} < 0$	$\beta_{ln(SOMP)} > 0$, $\beta_{ln(SONP)} < 0$	$\beta_{SOMP} > 0$, $\beta_{(SOMP)^2} < 0$ $\beta_{SONP} > 0$, $\beta_{(SONP)^2} < 0$
4) $\theta_{SOMP+SODIS}$	$\beta_{SOMP} > 0$, $\beta_{SODIS} < 0$	$\beta_{ln(SOMP)} > 0$, $\beta_{ln(SODIS)} < 0$	$\beta_{SOMP} > 0$, $\beta_{(SOMP)^2} < 0$ $\beta_{SODIS} > 0$, $\beta_{(SODIS)^2} < 0$
5) $\theta_{SOMP+SONP+SODIS}$	$\beta_{SOMP} > 0$, $\beta_{SONP} < 0$, $\beta_{SODIS} < 0$	$\beta_{ln(SOMP)} > 0$, $\beta_{ln(SONP)} < 0$, $\beta_{ln(SODIS)} < 0$	$\beta_{SOMP} > 0$, $\beta_{(SOMP)^2} < 0$ $\beta_{SONP} > 0$, $\beta_{(SONP)^2} < 0$ $\beta_{SODIS} > 0$, $\beta_{(SODIS)^2} < 0$
6) $\theta_{SOMP+SOEDG}$	$\beta_{SOMP} > 0$, $\beta_{SOEDG} < 0$	$\beta_{ln(SOMP)} > 0$, $\beta_{ln(SOEDG)} < 0$	$\beta_{SOMP} > 0$, $\beta_{(SOMP)^2} < 0$ $\beta_{SOEDG} > 0$, $\beta_{(SOEDG)^2} < 0$
7) θ_{SOCOR}	$\beta_{SOCOR} > 0$	$\beta_{ln(SOCOR)} > 0$	$\beta_{SOCOR} > 0$, $\beta_{(SOCOR)^2} < 0$
8) $\theta_{SOCOR+SONCA}$	$\beta_{SOCOR} > 0$, $\beta_{SONCA} < 0$	$\beta_{ln(SOCOR)} > 0$, $\beta_{ln(SONCA)} < 0$	$\beta_{SOCOR} > 0$, $\beta_{(SOCOR)^2} < 0$ $\beta_{SONCA} > 0$, $\beta_{(SONCA)^2} < 0$
9) $\theta_{SOCOR+SODIS}$	$\beta_{SOCOR} > 0$, $\beta_{SODIS} < 0$	$\beta_{ln(SOCOR)} > 0$, $\beta_{ln(SODIS)} < 0$	$\beta_{SOCOR} > 0$, $\beta_{(SOCOR)^2} < 0$ $\beta_{SODIS} > 0$, $\beta_{(SODIS)^2} < 0$
10) $\theta_{SOCOR+SONCA+SODIS}$	$\beta_{SOCOR} > 0$, $\beta_{SONCA} < 0$, $\beta_{SODIS} < 0$	$\beta_{ln(SOCOR)} > 0$, $\beta_{ln(SONCA)} < 0$, $\beta_{ln(SODIS)} < 0$	$\beta_{SOCOR} > 0$, $\beta_{(SOCOR)^2} < 0$ $\beta_{SONCA} > 0$, $\beta_{(SONCA)^2} < 0$ $\beta_{SODIS} > 0$, $\beta_{(SODIS)^2} < 0$
11) $\theta_{SOCOR+SOMP}$	$\beta_{SOCOR} > 0$, $\beta_{SOMP} > 0$	$\beta_{ln(SOCOR)} > 0$, $\beta_{ln(SOMP)} > 0$	$\beta_{SOCOR} > 0$, $\beta_{(SOCOR)^2} < 0$ $\beta_{SOMP} > 0$, $\beta_{(SOMP)^2} < 0$
12) $\theta_{SOCOR+SOEDG}$	$\beta_{SOCOR} > 0$, $\beta_{SOEDG} < 0$	$\beta_{ln(SOCOR)} > 0$, $\beta_{ln(SOEDG)} < 0$	$\beta_{SOCOR} > 0$, $\beta_{(SOCOR)^2} < 0$ $\beta_{SOEDG} > 0$, $\beta_{(SOEDG)^2} < 0$
13) $\theta_{SOCOR+SOMP+SOEDG}$	$\beta_{SOCOR} > 0$, $\beta_{SOMP} > 0$, $\beta_{SOEDG} < 0$	$\beta_{ln(SOCOR)} > 0$, $\beta_{ln(SOMP)} > 0$, $\beta_{ln(SOEDG)} < 0$	$\beta_{SOCOR} > 0$, $\beta_{(SOCOR)^2} < 0$ $\beta_{SOMP} > 0$, $\beta_{(SOMP)^2} < 0$ $\beta_{SOEDG} > 0$, $\beta_{(SOEDG)^2} < 0$

Note: Subscripted covariates represent the structure of the model, and covariates are described in Table 1.
† Represented as $\beta_0 + \beta_1 x + (-\beta_2 x^2)$.

positively affect recruitment; otherwise, covariates negatively affecting survival also should negatively affect recruitment. This prediction applied to all of the Table 2 hypothesized models for survival and recruitment.

Habitat models.—We developed 13 base hypothesized models to examine the effects of the 10 covariates on Northern Spotted Owl survival and reproduction (Table 3). The response variable (θ) was either apparent survival or reproductive output, and the independent variables were combinations of the nine habitat covariates, age, and elevation effects. These models were centered around three basic themes: habitat amounts only, distribution of habitat patches, and shape of habitat patches (i.e., edge effects). In addition, there were two general effects, which we felt could influence all of the base hypothesized models. The first was age: we predicted that 1–2 yr old owls would have lower apparent survival and lower reproductive output than owls ≥3 yr old. Based on a limited sample, Carey et al. (1992) found that radio-tagged 1-yr-old Northern Spotted Owls suffered high mortality in highly fragmented landscapes. Therefore, the initial age effect in survival analyses included a 1-yr-old class vs. a class with owls ≥2 yr old (denoted as *a*2 in models; Table 1). Franklin et al. (1996*b*) found that 1- and 2-yr-old owls fledged fewer young, on average, than did owls ≥3 yr old on this study area. Therefore, the initial age effect in reproductive output analyses included a class with 1- and 2-yr old owls vs. a class with owls ≥3 yr old (denoted as *a*2′ in models). During modeling procedures, we also examined the age effect by separating owls into 1-, 2-, and ≥3-yr-old classes (denoted as *a*3; see Table 1). The second general effect was ELEV: we predicted that both survival and reproductive output would be negatively affected as elevation increased, because of harsher climatic conditions at higher elevations, and a shift from Douglas-fir/hardwood forests at lower elevations to more pure fir stands at higher elevations, which were less productive in terms of prey biomass (Carey et al. 1992).

Alternate forms (Eqs. 9, 10, and 13) of the same model represented alternate hypotheses as to whether the Northern Spotted Owl is primarily an interior, edge, or mixed interior–edge species. For example, a life history trait positively associated with SOCOR and negatively associated with SOEDG in a linear or pseudothreshold relationship suggests an interior species; the opposite trend would indicate an edge species; and a quadratic relationship would indicate a mixed interior–edge species.

Model 1 in Table 3 was based on the hypothesis that survival and reproductive output increase as the amount of spotted owl habitat increases, as suggested by Bart and Earnst (1992) and Bart and Forsman (1992). The quadratic form of this model suggested some optimal amount of vegetation type (such as mature and old-growth forest) that promotes high survival or reproductive output, with too much or too little of the vegetation type being suboptimal. Hypothesized models 2–5 incorporated patch dynamics in which a single large patch promotes higher survival or reproductive output than do many small, distantly spaced patches under the linear and pseudothreshold forms, and some optimal maximum under the quadratic forms. Hypothesized models 6–13 incorporated amounts of habitat, patch distribution, and patch shape to varying degrees, and included the possibility of alternate hypotheses concerning the juxtaposition of edge and interior spotted owl habitats and their distribution within the territory.

Estimation of life history traits

Modeling survival.—Capture–recapture models were used to estimate conditional survival probabilities (ϕ) for Northern Spotted Owls from the banding data (Franklin et al. 1996*a*). Capture–recapture estimates of juvenile survival (probability of fledged young surviving their first year) are not considered here because of likely biases due to permanent emigration from study areas (Franklin et al. 1996*b*). Instead, recruitment was estimated with the climate covariates (see *Modeling recruitment*).

We examined capture–recapture data for goodness-of-fit to a global model, using tests in program RELEASE (Burnham et al. 1987:71–77). Goodness-of-fit for reduced models was assessed by computing likelihood ratio tests between global and reduced models, and then adding the χ^2 values and degrees of freedom from these tests to global model values (Lebreton et al. 1992). The requisite assumptions of capture–recapture models are outlined in Burnham et al. (1987), most of which can be tested in program RELEASE. No loss of bands was observed through double banding of owls with both color and U.S. Fish and Wildlife Service (USFWS) bands. Permanent emigration probably was negligible for owls $\geq$1 yr old (Franklin et al. 1996*b*). We used program MARK (White and Burnham 1999) for analysis of capture–recapture data. We used 95% confidence intervals to assess the degree to which the signs of estimated slope parameters (β_i) in models were reliably estimated (Graybill and Iyer 1994).

In climate models, estimates of ϕ represent apparent survival, defined as the probability that an owl survives and remains within the study area to year $t + 1$, given that it was alive at the start of year t. Recapture probabilities (p) must also be modeled and are the probability that an animal alive in year t is captured in year t. Recapture probabilities are nuisance parameters, but must be properly treated; otherwise, estimators of survival probabilities will be biased or imprecise (Lebreton et al. 1992). Parameter estimation was based on Fisher's method of maximum likelihood (Lebreton et al. 1992). Relationships of estimated survival probabilities to climatic covariates were modeled using the logit transformation, which constrains $0 \leq \theta \leq 1$, where θ represents either ϕ or p (Lebreton et al. 1992). These parameters could then be modeled as a linear logistic function, e.g., $\text{logit}(\theta_w) = \beta_0 + \beta_1(w)$, where w is a categorical (e.g., age class) or a continuous (e.g., precipitation) covariate. In addition to climate covariates, we included age (a), sex (s), and time effects in the models. Time was modeled both as a categorical (t) and linear (lt) effect without any climate covariates. In addition to modeling the same effects on p, we also modeled the structure of p constrained by different capture methods used during the study, denoted as p_c. During 1985–1987, birds were physically recaptured each year to read their USFWS bands, whereas from 1988 through 1994, owls were primarily resighted using color bands. Models with p_c represented a single estimate of p for 1986–1987 and a single estimate of p for 1988–1994.

In climate models, precipitation was denoted as P and temperature degree-hours as T. Life history periods were denoted with subscripts; W for the winter stress period, E for the early nesting period, L for the late nesting period, H for the heat stress period, and D for the dispersal period. This notation was also used for models of recruitment and reproductive output.

In terms of habitat covariates, we estimated apparent survival (ϕ), defined as the probability that an owl on territory i survives and remains on territory i to year $t + 1$, given that it was alive at the start of year t. We used the same capture history matrix used with the climate models, except for two adjustments. These adjustments were necessary because we examined effects on individuals rather than on annual cohorts of individuals (as with the climate models). First, ''losses on capture'' (Jolly 1965) were used to account for movements of individuals between territories. For example, a capture history for individual 1 that occupied territory A for the first five years and territory B for the second five years might appear as follows:

	1	2	3	4	5	6	7	8	9	10	Frequency
Capture occasion:	1	2	3	4	5	6	7	8	9	10	Frequency
Territory:	A	A	A	A	A	B	B	B	B	B	
Capture history:	1	1	1	0	1	1	1	1	0	1	1

where frequency is the number of capture histories. However, using ''losses on capture,'' the capture history for this individual was rewritten as two capture histories, one for territory A and one for territory B:

Capture occasion:	1	2	3	4	5	6	7	8	9	10	Frequency
Territory:	A	A	A	A	A	B	B	B	B	B	
Capture history 1	1	1	1	0	1	0	0	0	0	0	−1
Capture history 2:	0	0	0	0	0	1	1	1	0	1	1

Second, territories in which timber harvest had occurred during the study were considered to be a movement from the pre-harvest territory to the post-harvest territory after the year when harvest had occurred. Capture histories on these territories were dealt with in the same manner, using ''losses on capture'' as movements of individuals between territories. Use of losses on capture resulted in the loss of information on survival between the occasions when movements or timber harvest occurred. However, in losing this information, no assumption was required as to which territory affected survival during these intervening periods. For each individual capture history, we attached landscape covariates associated with the territory occupied by that individual. Thus, the sampling unit to which inferences were made was individuals on territories.

Modeling reproductive output.—In counting the number of fledged young within each year, we assumed detection probabilities of fledged young equal to 1.0 after two visits to a site. There are numerous biases that may affect estimation of reproductive output (see Franklin et al. 1996*a*). As long as biases were unaffected by climate and did not vary from year to year, our estimates of reproductive output provided a reasonable approximation as a basis for examining temporal effects.

Data analysis for climate models was performed on mean annual reproductive output, R_t ($t = 1, 2, \ldots, 10$ yr), which was defined as the mean annual number of young fledged per pair and which was estimated from the number of owl pairs assessed for reproductive output each year ($n = 38$–74). To examine the effects of climate covariates, we used linear regression models with expected annual reproductive output (R) as the response. The use of linear regression assumed normally distributed subpopulations within years and similar subpopulation variances across years (Graybill and Iyer 1994:110). Our data probably met the first assumption because means, in general, are normally distributed under the Central Limit Theorem, regardless of the underlying distribution (Johnson 1995). The second assumption could not be met. Annual sampling variances were proportional to their means, but were not distributed as Poisson ($P < 0.01$) because fewer broods of one young were observed relative to broods of zero and two young. To deal properly with the lack of homogeneity of variances in estimating $\sigma^2_{\text{residual}}$, we used a maximum likelihood equivalent of least squares regression (Sakamoto et al. 1986:181), which accounted for separate variance components. The generalized linear model we used was $\hat{R}_i = \mathbf{X\beta} + \varepsilon_i + \gamma_i$, where $\mathbf{X}$ was the design matrix, $\boldsymbol{\beta}$ was the vector of parameters, $\varepsilon_i \sim \mathcal{N}(0, \sigma^2_{\text{residual}})$ that incorporated residual variation unexplained by the model, and $\gamma_i \sim \mathcal{N}(0, \text{var}(\hat{R}_i \mid R_i))$ that incorporated sampling variation around the R_i. Solution of this model was expressed as the likelihood to be maximized (McCullagh and Nelder 1989:24, 254):

$$\ln \mathcal{L}(\boldsymbol{\beta}, \sigma^2_{\text{residual}}) = -\frac{1}{2}\ln|\mathbf{D}| - \frac{1}{2}\mathbf{Y}'[\mathbf{D}^{-1} - (\mathbf{D}^{-1}\mathbf{X})(\mathbf{X}'\mathbf{D}^{-1}\mathbf{X})^{-1}(\mathbf{D}^{-1}\mathbf{X})']\mathbf{Y} \quad (14)$$

where $\mathbf{D}$ was the dispersion matrix with $\sigma^2_{\text{residual}} + \widehat{\text{var}}(\hat{R}_i \mid R_i)$ as the diagonal elements and $\sigma^2_{\text{residual}} + \widehat{\text{covar}}(\hat{R}_i, \hat{R}_j \mid R_i, R_j)$ as the off-diagonal elements, and $|\mathbf{D}|$ was the determinant of $\boldsymbol{D}$. Eq. 14 was solved numerically for $\sigma^2_{\text{residual}}$ at the maximum log likelihood, which was equivalent to minimizing the sum of the squared ε_i under least squares estimation procedures (Draper and Smith 1981:88). The β_i were estimated as $\hat{\boldsymbol{\beta}} = (\mathbf{X}'\mathbf{D}^{-1}\mathbf{X})^{-1}\mathbf{X}'\mathbf{D}^{-1}\mathbf{Y}$, with the corresponding variance–covariance matrix as $\hat{\mathbf{V}} = (\mathbf{X}'\mathbf{D}^{-1}\mathbf{X})^{-1}$. This procedure was a regression model that included random measurement error and allowed for direct estimation of $\sigma^2_{\text{residual}}$.

In addition to the climate covariates included in the hypothesized reproduction models (Table 2), we included age and sex effects in models as the proportion of the pairs checked each year that had males (m) and females (f) $\geq$3 yr old. We evaluated the goodness-of-fit of models to the data, based on deviance estimates and examination of residual plots. Deviance was estimated as $2(\ln \mathcal{L}_{\max} - \ln \mathcal{L}_{\text{model}})$, where $\ln \mathcal{L}_{\max}$ is the maximum achievable log likelihood, given the data, and $\ln \mathcal{L}_{\text{model}}$ is the log likelihood for the model of interest (McCullagh and Nelder 1989:33). We used deviance to test whether a given model adequately fits the data relative to the saturated model (in which the number of parameters equals the number of data points), which is asymptotically distributed as χ^2 with $n - K$ degrees of freedom. We also visually examined plots of standardized residuals against time, the predictors, and $\hat{R}$ for indications of lack of normality or heteroscedasticity (Graybill and Iyer 1994:251).

To examine the effects of landscape habitat covariates, we estimated reproductive output (mean annual number of young fledged per territory, again denoted as R) using general linear mixed models. Mixed models were used to appropriately estimate the standard error of the sex, age, and landscape covariates that were considered fixed effects. Territory was considered a random effect, such that standard errors of the fixed effects were estimated using the number of territories ($n = 95$) rather than the total number of reproductive outcomes occurring over all territories ($n = 598$). In addition, mixed models allowed for direct estimation of variance components, notably the spatial process variation in reproductive output among owl territories. Ideally, territories should have been randomly sampled from a larger population in order to be considered random effects, but they were not. However, the focus of the analysis was on habitat effects, where the territories acted as blocks, and not on territory effects. Therefore, we considered territories to be a random effect, recognizing that they were not randomly drawn from a larger population.

The form of the general linear mixed model we used was

$$\mathbf{Y} = \mathbf{X\beta} + \mathbf{Zu} + \mathbf{e} \quad (15)$$

where **Y** is an n-vector of observed reproductive output over t years and s territories; **X** was an n by p known design matrix representing p effects; $\boldsymbol{\beta}$ was a p-vector of unknown fixed-effect regression parameters; **Z** was an n by q known design matrix for the random-effects portion of the model; **u** was the q-vector of unknown random coefficient parameters; and **e** was the n-vector of random (often measurement) errors whose elements were not required to be independent (Wolfinger 1993, Littell et al. 1996). The variance of y is $\sigma^2_{\text{spatial}} + \sigma^2_{\epsilon}$, where $\sigma^2_{\text{spatial}}$ is the spatial process variance component among spotted owl territories, and σ^2_{ϵ} is the variance due to random errors. The covariance matrix of **Y** is denoted as: $\mathbf{V}(\mathbf{Y}) = \mathbf{ZGZ}' + \mathbf{E}$, where **G** is the diagonal matrix containing variance components (i.e., $\sigma^2_{\text{spatial}}$), and **E** contains the error variances, i.e., σ^2_{ϵ} (Jennrich and Schluchter 1986, Wolfinger 1993). The random variable **u** and error vector **e** are assumed to be distributed as multivariate normal with a mean vector of zero and covariance matrix **E**. Thus, **Y** is assumed to be distributed as multivariate normal with mean $\mathbf{X}\boldsymbol{\beta}$ and variance $\mathbf{ZGZ}' + \mathbf{E}$. Several lines of evidence support the use of a normal-based approach in analyzing these data. ANOVA methods are robust to fairly severe departures from normality and heterogeneity in sampling variances, even with data distributed as a negative binomial (Mitchell 1977, White and Bennetts 1996). Although Poisson regression in a generalized linear model may adequately deal with overdispersion in count data, such as that used in estimating reproductive output, ANOVA is more robust to considerable departures from non-normality and heterogeneity of sampling variances than is Poisson regression when count data are not distributed as Poisson (White and Bennetts 1996).

The error variance matrix **E** can be structured to account for heterogeneous sampling variance structures using maximum likelihood approaches (Littell et al. 1996), which are analogous to a weighted regression (Draper and Smith 1981:108). Thus, the problem of heterogeneous sampling variances discussed previously can be dealt with adequately. We used a maximum likelihood-based approach in PROC MIXED of program SAS (SAS Institute 1997) to model first the covariance structure of **E** and then to examine the fixed effects in the hypothesized models and their variants. Following Diggle (1988) and Wolfinger (1993), we used restricted maximum likelihood estimation in an over-fitted model that included all of the fixed effects to explore various covariance structures in **E** to model annual sampling variances. Selection of an appropriate covariance structure was based on AICc (see *Model selection*) using the number of estimated covariance parameters, but not the number of estimated fixed effects, because restricted maximum likelihood estimation is based solely on the covariance parameters. Once an appropriate covariance structure was achieved for properly weighting the years, full maximum likelihood estimation, rather than restricted maximum likelihood estimation, was used as the basis for examining hypothesized models because the latter eliminates the fixed effects (Wolfinger 1993).

We modified the data slightly to estimate reproductive output with the landscape habitat covariates. First, we excluded eight Northern Spotted Owl territories in which reproductive output had not been adequately estimated for at least three years. This reduced the number of territories included in the analysis to 87. In addition, we included only reproductive outcomes in which the female age was known (to allow for adequate modeling of female age effects). Female age has a strong effect on reproductive output (Franklin et al. 1996*b*), whereas male age seems to have little effect (Franklin 1992). Thus, reproductive output was redefined as the mean annual number of young fledged per female of known age.

Modeling recruitment.—Recruitment is a function of survival of young through their first year, reproductive output, and immigration. Immigration in Northern Spotted Owls may be from interterritorial movements or from a surplus population of nonterritorial birds, i.e., floaters (Franklin 1992). Spotted owls are highly territorial and tend to exhibit high site and mate fidelity (Forsman et al. 1984, Gutiérrez et al. 1995), suggesting that spacing behavior may limit the number of individuals that are able to breed. Thus, recruitment is an important parameter because it represents the successful integration of young into the breeding population, even when that entry is delayed by several years (young may enter a floating, surplus population before attaining a territory; Franklin 1992). Recent developments in capture–recapture theory (e.g., Schwarz and Arnason 1996) allowed recruitment to be modeled using the approach previously outlined.

Recruitment was estimated from a subset of the capture–recapture data using modeling procedures in program POPAN-4 (Arnason et al. 1995). This subset included data from the Willow Creek study area and 12 sites from satellite areas that had been consistently surveyed since 1985. Recruitment was modeled with the climate covariates under a framework similar to that for survival probabilities, with some exceptions. In the most general model under POPAN-4, maximum likelihood estimates are computed simultaneously for ϕ_t, p_t, and two new parameters: ψ_t, the fraction of total net births that enter the system between t and $t + 1$ (called entry probabilities), and N_{tot}, the total number of animals that enter the system and survive until the next sample time (Schwarz and Arnason 1996) during the 10-yr study period. Population size, N_t, is then estimated from these parameters. Parameter estimates of, ϕ, p, and ψ can be constrained by external covariates. Model selection procedures followed those described in *Modeling survival.* However, POPAN-4 does not allow the inclusion of group effects, such as sex, so we were unable to estimate recruitment separately for males and females.

In all recruitment models, ϕ and p were structured based on the best climate model selected from the survival analysis. Hypothesized models were first analyzed in terms of ψ. After selection of the ''best'' model in terms of ψ, we estimated recruitment rate (b) as

$$\hat{b}_t = \frac{\hat{\psi}_t \hat{N}_{\text{tot}}}{\hat{N}_{t-1}} \tag{16}$$

where $\hat{N}_{t-1}$ was the estimated territorial population size from the previous year, and $\hat{\psi}_t \hat{N}_{\text{tot}}$ represented the number of new recruits into the territorial population at time t. Thus, b was the number of new recruits in the territorial population at time $t + 1$ per territory holder in time t. The variance–covariance matrix for $\hat{b}$ was estimated using the delta method (Bajpai et al. 1978: 146). The estimates of b and their sampling variance–covariance matrix were used in Eq. 14 with the climatic covariates from the selected model to obtain regression coefficients, and their standard errors, in terms of b rather than ψ.

Selection of hypothesized models for life history traits

The most critical problem in analyzing empirical data is selecting an appropriate model that is supported by the science of the situation, by the data, and that has enough parameters to avoid bias, but not so many that precision is lost (Burnham and Anderson 1992). We used a bias-corrected version of Akaike's Information Criterion, AICc (Akaike 1973, Hurvich and Tsai 1989, Burnham et al. 1995) as the basis for objectively ranking models and selecting an appropriate ''best approximating'' model. AICc was defined as

$$\text{AICc} = -2(\ln \mathcal{L}) + 2K + \frac{2K(K+1)}{n-K-1} \tag{17}$$

where $\ln(\mathcal{L})$ is the natural logarithm of the likelihood function evaluated at the maximum likelihood estimates for a given model; K is the number of estimable parameters from that model; and n is sample size. In the capture–recapture models, n was the sum of the total number of animals captured and released in each year. The ''best approximating'' model for each life history trait was selected based on minimum AICc.

Models were ranked and compared using ΔAICc (Lebreton et al. 1992, Burnham and Anderson 1998) and Akaike weights (Buckland et al. 1997). ΔAICc was computed as

$$\Delta\text{AICc}_i = \text{AICc}_i - \text{AICc}_{\min} \tag{18}$$

where AICc_i was the AICc value for the ith model in a suite of models being compared, and $\text{AICc}_{\min}$ was the minimum AICc value among those models. In short, ΔAICc_i is an estimate of the relative distance between the best approximating model and model i. Akaike weights (w_i) were computed for each ith model as follows:

$$w_i = \frac{\exp\left[-\left(\frac{\Delta\text{AICc}_i}{2}\right)\right]}{\sum \exp\left[-\left(\frac{\Delta\text{AICc}_i}{2}\right)\right]}. \tag{19}$$

ΔAICc and Akaike weights were used to address model selection uncertainty. In general, models within 1–2 AICc units of the selected model were considered competing models. Because standard errors estimated for the life history traits are conditional on the selected model, there was another element of uncertainty in selecting an appropriate model when evaluating estimates of precision (Buckland et al. 1997). Therefore, estimates of precision in the parameters may have been somewhat optimistic. We were unable to account for this uncertainty due to model selection using current methods (Buckland et al. 1997), because we were interested in $\hat{\beta}_i$ and $\widehat{\text{SE}}(\hat{\beta}_i)$, which corresponded to different effects among models.

We had a number of variations that represented the specified effects of the base hypothetical models in Tables 2 and 3; of these variations on the same model, we selected the best approximating model based on minimum AICc. Thus, each hypothesized model was represented by a suite of models that included age and elevation effects, interactions between effects, and different forms (i.e., linear, pseudothreshold, and quadratic) of the covariates. We then used the model with minimum AICc from each suite to represent each of the hypothesized models. After model selection, the influence of additional effects, such as sex, on the ''best'' model selected was assessed by examining Akaike weights for the best approximating model, using models that included or excluded pertinent effects of interest. The utility of slope parameters (β_i) in models was assessed based on the degree to which 95% confidence intervals overlapped zero (Graybill and Iyer 1994).

We examined potential correlations between covariates after the analysis of hypothesized models to avoid subjective biases in formulation of the models. Information on correlations between covariates was then used to explore better models for the data than those initially hypothesized. Sensitivity of either $\hat{\phi}$ or $\hat{R}$ to changes in covariates in the best approximating models was assessed by (1) setting covariate values to their mean, (2) changing the covariate of interest by 25% of its mean value, (3) estimating percentage change in $\hat{\phi}$ or $\hat{R}$ due to the 25% change in the covariate of interest, and (4) ranking covariates based on the percentage change in $\hat{\phi}$ or $\hat{R}$. Sensitivities were expressed as percentage change in the parameter.

Estimation of fitness

Rates of population change.—We estimated annual rates of population change (λ) as a function of both recruitment rate and apparent survival. Population size can be expressed in terms of the difference equation:

$$N_{t+1} = (\beta + i)N_t + (1 - d - e)N_t \qquad (20)$$

where, β *d*, *i*, and *e* are rates of birth, death, immigration, and emigration, respectively. Because our estimates of recruitment rate and apparent survival can be expressed as $\hat{b} = \hat{\beta} + \hat{\imath}$ and $\hat{\phi} = 1 - \hat{d} - \hat{e}$, Eq. 20 can be rewritten as $\hat{N}_{t+1} = \hat{b}\hat{N}_t + \hat{\phi}\hat{N}_t$. By definition, annual estimates of λ can be expressed as $\hat{\lambda}_t = \hat{N}_{t+1}/\hat{N}_t$, which can then be rewritten, in terms of recruitment rates and apparent survival, as

$$\hat{\lambda}_t = \hat{b}_t + \hat{\phi}_t. \qquad (21)$$

Sampling variances for $\hat{\lambda}_t$ were estimated as $\widehat{\text{var}}(\hat{\lambda}_t) = \widehat{\text{var}}(\hat{b}_t) + \widehat{\text{var}}(\hat{\phi}_t) + 2\widehat{\text{cov}}(\hat{b}_t,\hat{\phi}_t)$ (Bajpai et al. 1978).

To evaluate potential long-term consequences of climate variation on life history traits and rates of population change, we examined the behavior of climate models for each life history trait using a long-term record of climatic observations from 1955 through 1984 obtained from the same weather stations used to develop the climate models. We examined model behavior using a forecasting philosophy (what could happen, given that a particular empirical model is correct and underlying conditions remain similar) rather than as prediction (what will happen) (Caswell 1989*a*:20). We also used the same covariates as those used to develop the models, and that appeared in the final selected climate models. Sampling variances of estimates from before the study period were estimated using the delta method (Bajpai et al. 1978).

Habitat fitness potential.—To estimate fitness, we used the Leslie matrix approach outlined by McGraw and Caswell (1996), but with some modifications. We estimated the necessary components of fitness (survival and reproductive output) based on landscape habitat characteristics, not on individual attributes. Therefore, we defined *habitat fitness potential* (λ_H) as the fitness conferred on an individual occupying a territory of certain habitat characteristics. This definition does not imply that territories have fitness themselves, because territories with high habitat fitness potential may not always be occupied; occupancy was not included in the estimation of fitness. Rather, λ_H can be viewed as the potential fitness that an individual can achieve if it occupies a particular territory with certain habitat characteristics.

To estimate λ_H, we used the best approximating models for survival and reproductive output to estimate survival, fecundity, and their sampling variances for each of the 95 Northern Spotted Owl territories. Sampling variances were estimated using the delta method (Bajpai et al. 1978), which incorporated the covariance matrix from the best approximating model. Fecundity (the mean number of female young fledged per female) was estimated by dividing estimates of reproductive output by two; the sampling variances for fecundity were calculated by dividing the sampling variances for reproductive output by 4 (see Franklin et al. 1996*a*). Because fecundity was female based, λ_H was applicable to female fitness only.

Once survival and fecundity had been estimated for each of the 95 territories, λ_H was estimated for each territory as the dominant, real eigenvalue of an estimated stage-based Leslie matrix. This matrix took the following form:

$$\begin{bmatrix} \hat{\phi}_{1,2}\hat{m}_{1,2} & \hat{\phi}_{1,2}\hat{m}_3 & \hat{\phi}_3\hat{m}_3 \\ \hat{\phi}_{1,2} & 0 & 0 \\ 0 & \hat{\phi}_{1,2} & \hat{\phi}_3 \end{bmatrix} \qquad (22)$$

where $\hat{\phi}$ was apparent survival; and $\hat{m}$ was fecundity, with subscripts ''1, 2'' representing parameter estimates for 1- and 2-yr-old owls, and subscript ''3'' representing estimates for owls >3 yr old. The form of the matrix was based on the age effects found in the best models for survival and reproductive output (see *Results*). For example, estimates of ϕ and reproductive output for territory A were obtained from the best models for survival and reproductive output, respectively, using the habitat covariates from territory A. After transforming reproductive output to fecundity, we then used these estimates in matrix 22 to estimate λ_H for territory A.

The final form of the matrix depended on the age structure in the best approximating models for survival and reproductive output. Standard errors of territory-specific estimates of λ_H were estimated using the delta method, which incorporated the standard errors for territory-specific estimates of the survival and fecundity estimates. Incorporation of age structure into the estimates of λ_H further complicated its interpretation. If age structure was incorporated into the best approximating models for either survival or reproductive output, then λ_H was based on a female first colonizing a territory as a 1- or 2-yr-old.

Components of variation analysis

We used the annual means estimated directly from the data as a basis for estimating temporal process variation ($\sigma^2_{\text{temporal}}$) in reproductive output. The capture–recapture data were initially modeled with time effects to determine whether temporal process variation existed. If a time-dependent model (ϕ_t or b_t) explained the data better than did a model with time-invariant parameters ($\phi_\cdot$ or $b_\cdot$), the annual estimates from that model were used to estimate $\sigma^2_{\text{temporal}}$. Temporal process variation in each of the life history parameters and rates of population change was estimated as the numerical solution of the following equation for $\sigma^2_{\text{temporal}}$ (after Burnham et al. 1987:263):

$$\left[\frac{1}{n-1}\right]\left[\left(\mathbf{P} - \hat{\bar{\theta}}\,\mathbf{1}\right)'\mathbf{D}\left(\mathbf{P} - \hat{\bar{\theta}}\,\mathbf{1}\right)\right]' = 1 \qquad (23)$$

where

$$\hat{\bar{\theta}} = [(\mathbf{DP})'\ \mathbf{1}][(\mathbf{D1})'\ \mathbf{1}]^{-1} \quad (24)$$

and $\mathbf{D} = (\sigma^2_{\text{temporal}}\ \mathbf{I} + \mathbf{V})^{-1}$; **P** is a vector containing the annual estimates of either ϕ, R, b, or λ; n is the number of annual estimates; **1** is a vector of 1's; **I** is an identity matrix; **V** is the conditional (sampling) variance–covariance matrix for the estimates; and $\hat{\bar{\theta}}$ is the weighted mean of the parameter of interest. We used the relationship for temporal variation where $\hat{\sigma}^2_{\text{temporal}} = \hat{\sigma}^2_{\text{climate}} + \hat{\sigma}^2_{\text{residual}}$ to estimate the amount of variation due to climate ($\sigma^2_{\text{climate}}$). Because $\sigma^2_{\text{residual}}$ was estimated when modeling reproductive output, $\sigma^2_{\text{climate}}$ was estimated as $\hat{\sigma}^2_{\text{temporal}} - \hat{\sigma}^2_{\text{residual}}$ where $\sigma^2_{\text{temporal}}$ was estimated using Eq. 23. For survival and recruitment, the contribution of $\hat{\sigma}^2_{\text{climate}}$ in explaining $\hat{\sigma}^2_{\text{temporal}}$ was estimated by regressing annual estimates of logit(ϕ) or b, including their sampling variances and covariances, obtained from the time-dependent models (ϕ_t or b_t) against the climatic covariates included in the ''best'' climatic model selected for each life history trait. The form of the regression followed Eq. 14 to estimate $\sigma^2_{\text{residual}}$. The estimated amount of variation explained by the best climate model ($\sigma^2_{\text{climate}}$) could be assessed as $\hat{\sigma}^2_{\text{temporal}} - \hat{\sigma}^2_{\text{residual}}$. Weighted means of parameters were estimated using Eq. 24.

To estimate the amount of spatial process variation ($\sigma^2_{\text{spatial}}$) in survival, we first estimated survival probabilities for each territory, using the same structure on the capture probabilities as the best approximating model. We estimated $\sigma^2_{\text{spatial}}$ using Eqs. 23 and 24. The amount of this variation explained by the best approximating model ($\hat{\sigma}^2_{\text{model}}$) was estimated as the empirical variance of the predicted estimates of $\phi(\tilde{\phi}_i)$ from the following model:

$$\hat{\sigma}^2_{\text{model}} = \frac{\sum_{i=1}^{95} (\tilde{\phi} - \bar{\tilde{\phi}})^2}{n - 1} \quad (25)$$

where $n = 95$ territories. We estimated 95% confidence intervals as:

$$\frac{\sum_{i=1}^{95} (\tilde{\phi} - \bar{\tilde{\phi}})^2}{\chi^2_{94,\,0.975}} \le \sigma^2_{\text{model}} \le \frac{\sum_{i=1}^{95} (\tilde{\phi} - \bar{\tilde{\phi}})^2}{\chi^2_{94,\,0.025}} \quad (26)$$

following Burnham et al. (1987:265).

In the general linear mixed model approach for estimating reproductive output, we estimated $\sigma^2_{\text{spatial}}$ using an intercepts-only (''means'') model in PROC MIXED in SAS (SAS Institute 1997). This model retained the best covariance structure for **E** (Eq. 15) used in the hypothesized model, included territories as a random effect, and used restricted maximum likelihood procedures (Wolfinger 1993). We also ran the best approximating model again, using restricted maximum likelihood procedures to obtain an estimate of the spatial process variation not accounted for by the fixed effects ($\hat{\sigma}^2_{\text{residual}}$). At this point, restricted maximum likelihood procedures estimated variance components based on the residuals after the fixed effects had been fit to the model (Searle et al. 1992:250). Thus, the use of these two models allowed decomposition of $\hat{\sigma}^2_{\text{spatial}}$ into the component explained by the fixed-effects model ($\hat{\sigma}^2_{\text{model}}$) and the component not explained by the fixed-effects model ($\hat{\sigma}^2_{\text{residual}}$). If the best approximating model included only habitat covariates, then the amount of $\hat{\sigma}^2_{\text{spatial}}$ explained by habitat variation ($\hat{\sigma}^2_{\text{habitat}}$) equaled ($\hat{\sigma}^2_{\text{model}}$). However, if age effects were included in the best approximating model, then the amount of spatial process variation due to the age of individuals ($\hat{\sigma}^2_{\text{age}}$) was partitioned by estimating $\hat{\sigma}^2_{\text{residual}}$, using the design matrix for an age effects model and estimating $\hat{\sigma}^2_{\text{age}}$ as $\hat{\sigma}^2_{\text{spatial}} - \hat{\sigma}^2_{\text{residual}}$. An estimate of $\hat{\sigma}^2_{\text{habitat}}$ was then found similarly, using the design matrix containing habitat covariates only from the best approximating model. Log-based 95% confidence intervals for $\hat{\sigma}^2_{\text{spatial}}$ were estimated using $\widehat{\text{SE}}(\hat{\sigma}^2_{\text{spatial}})$ from PROC MIXED and formulas in Burnham et al. (1987:212). We directly estimated $\sigma^2_{\text{spatial}}$ for habitat fitness potential using Eqs. 22 and 23. Log-based 95% confidence intervals were also estimated for $\hat{\sigma}^2_{\text{spatial}}$ of habitat fitness potential.

Coefficients of process variation were estimated as

$$\frac{\sqrt{\hat{\sigma}^2_{\text{process}}}}{\hat{\bar{\theta}}} \quad (27)$$

where $\hat{\bar{\theta}}$ was the weighted mean (based on Eq. 24) of parameters of interest. Coefficients of process variation were used to estimate the degree to which parameters varied over time or space.

Relative contributions of climatic and habitat variation

We examined the importance of climatic and habitat variation by comparing models explaining variation due to climate and habitat, and by comparing components of process variation. In a model selection approach, we combined the effects in the best approximating model used to describe the effects of climate and habitat, respectively, on apparent survival and reproductive output. We used the model selection approach in the following manner to address the question of whether habitat quality buffered individuals from the extremes of climate. For each life history parameter, we analyzed models that combined the climate and habitat covariates from the best approximating models in additive models. We compared these models to ones that included all possible combinations of interactions between climate and habitat covariates. Only the full interactions between climate and habitat covariates were included. We used the notation of (climate covariates)*(habitat covariates) to indicate both main effects and their interactions.

Models with interactions between climate and habitat suggest that habitat might buffer or intensify the effects of climate on individuals, depending on the sign of the slope parameter for the interaction. AICc and Akaike weights were used to determine whether an additive model (one indicating that habitat quality did not buffer climate effects) or a model with interactions (one indicating that habitat quality buffered climate effects) was the best approximating model for the data. In models examining effects on reproductive output, year was considered a fixed effect. Model selection was based on comparisons of AICc and Akaike weights computed for each model. If either of the models containing the climate or habitat covariates alone was strongly selected as the best approximating model, then this suggested that either climatic variation or habitat variation alone was responsible for variation in the life history trait being examined. However, if the model containing both sets of covariates was selected as the best approximating model, this suggested that both climate and habitat were important in influencing process variation of life history traits. This approach examined the relative importance of climate and habitat effects on survival and reproductive output.

In order to estimate the magnitude of the effects of climate and habitat on variation of survival and reproductive output, we used a components of process variation approach. We compared the estimates of the components of process variation separately for survival and reproductive output. The total process variation examined in this study for each life history trait (σ^2_{total}) can be expressed as

$$\sigma^2_{\text{total}} = \sigma^2_{\text{temporal}} + \sigma^2_{\text{spatial}} = \sigma^2_{\text{model}} + \sigma^2_{\text{residual}} \qquad (28)$$

where $\sigma^2_{\text{temporal}}$ and $\sigma^2_{\text{spatial}}$ are the estimates of total temporal and spatial process variation, respectively; σ^2_{model} is the amount of process variation explained by both the models relating the life history trait to climate, habitat, and other effects; and $\sigma^2_{\text{residual}}$ is the amount of process variation unexplained by any of the modeled effects. The estimate of σ^2_{model} can be further partitioned into

$$\sigma^2_{\text{model}} = \sigma^2_{\text{climate}} + \sigma^2_{\text{habitat}} + \sigma^2_{\text{other}} \qquad (29)$$

where $\sigma^2_{\text{climate}}$ was estimated based on the best approximating model containing climate covariates; $\sigma^2_{\text{habitat}}$ was estimated from the best approximating model containing landscape habitat covariates; and σ^2_{other} was any other effects, such as age or sex, that were included in the final models. The proportion of σ^2_{model} accounted for by climate, habitat, or other effects can then be expressed as

$$\frac{\sigma^2_x}{\sigma^2_{\text{model}}} \qquad (30)$$

where x is climate, habitat, or other. In this way, we estimated the relative contributions of climate, habitat, and other effects to total process variation.

Results

Effects of climate on temporal variation in population processes

Survival probabilities.—From 1985 through 1994, we marked 57 1-yr-old, 45 2-yr-old, and 206 ≥3-yr-old Northern Spotted Owls; these were roughly equal by sex (150 females and 158 males ≥1 yr old). A global model $\{\phi_{s*a*t}, p_{s*a*t}\}$ allowing survival and recapture probabilities to vary over time by sex (s) and age classes (a) with all interactions was found to adequately fit the data ($\chi^2 = 50.02$, df = 79, $P = 0.99$). No overdispersion was evident in the data ($\chi^2_{\text{gof}}/\text{df} = 0.633$).

Before modeling with the climatic covariates, we first examined the capture–recapture data for significant time variation, in addition to sex and age class effects, and the interactions between those effects on ϕ and p. These models ranged from the global model with 84 parameters to the simplest model $\{\phi_., p_.\}$ with only two parameters. Intermediate models included various combinations of pooled age classes with and without sex and time effects. Based on minimum AICc, model $\{\phi_t, p_{s+c}\}$ was selected as the best approximating model ($K = 12$ parameters), given only the sex, age, and time effects examined. This model indicated that survival probabilities varied over time, with no sex or age effects, and that recapture probabilities were best structured based on differences in recapture methods during the study that varied by sex. The next four time-only models ranked by AICc (ΔAICc = 0.461–1.667) also included a year-dependent (t) structure in ϕ and included p_c.

We then examined the eight hypothesized climatic models (Table 2) in addition to 79 climatic models representing variations on the hypothesized models (e.g., quadratic structure on, ϕ, different structures on p). Of these models, $\{\phi_{P_E+T_E}, p_{s+c}\}$ was selected as the best approximating model based on AICc (Table 4), where the annual estimates of P_E and T_E explained time variation better than just the time model $\{\phi_t, p_{s+c}\}$. The data did not support inclusion of sex effects or a quadratic term in the selected model to simulate the negative effects of drought (Table 5). Model $\{\phi_{P_E+T_E}, p_{s+c}\}$ still exhibited adequate goodness-of-fit to the capture–recapture data ($\chi^2 = 125.63$, df = 157, $P = 0.97$). Therefore, we retained $\{\phi_{P_E+T_E}, p_{s+c}\}$ as the most parsimonious explanation of survival in spotted owls ≥1 yr old. This model was a better explanation of the data than those based on variable or linear time models (Table 4). Model $\{\phi_{P_E+T_E}, p_{s+c}\}$ explained variation in survival as

$$\hat{\phi} = \frac{1}{1 + \exp[-(0.11164 - 0.06753P_E + 0.01035T_E)]} \qquad (31)$$

where $\widehat{\text{SE}}(\hat{\beta}_0) = 1.0844$; $\widehat{\text{SE}}(\hat{\beta}_1) = 0.0346$ (95% CI = -0.1353, 0.0003); and $\widehat{\text{SE}}(\hat{\beta}_2) = 0.0038$ (95% CI = 0.0029, 0.0178). Confidence intervals for both slope pa-

TABLE 4. Ranking of a priori hypothesized models relating climate covariates to apparent survival probabilities (owls ≥ 1 yr old), reproductive output, and recruitment for Northern Spotted Owls in northwestern California.

Model	Hypothesis†	K‡	AICc	ΔAICc_i	w_i
Apparent survival models (all models with p_{s+c})					
$\phi_{P_E+T_E}$	3	6	1293.93	0.00	0.426
$\phi_{P_W+P_E}$	4	6	1294.19	0.27	0.373
$\phi_{P_W+T_W+P_E+T_E}$	6	8	1296.73	2.81	0.105
$\phi_{P_W+T_E}$	5	6	1298.15	4.22	0.052
$\phi_{P'_W+T'_E}$	8	6	1299.33	5.40	0.029
$\phi_{P_W+P_W^2+T_W+P_E+P_E^2+T_E}$	7	10	1300.80	6.88	0.014
ϕ_H	1	5	1303.72	9.80	0.003
$\phi_{P_W+T_W}$	2	6	1303.99	10.07	0.003
Reproductive output models					
$R_{P_L^2}$	2	3	−28.62	0.00	0.971
$R_{P_L+T_L}$	6	4	−21.19	7.42	0.024
$R_{P_E+P_L}$	3	4	−17.59	11.02	0.004
R_{P_E}	1	3	−14.99	13.63	0.001
$R_{P_W+T_W}$	4	4	−12.04	16.58	0.000
$R_{P_E+T_E}$	5	4	−9.16	19.46	0.000
$R_{P_W+T_L}$	10	4	−8.74	19.88	0.000
$R_{P_W+T_E}$	9	4	−8.01	20.61	0.000
$R_{P_W+T_E+T_L}$	11	5	0.26	28.88	0.000
$R_{P_E+T_E+P_L+T_L}$	7	6	2.04	30.65	0.000
$R_{P_W+T_W+P_E+T_E}$	8	6	11.69	40.31	0.000
Recruitment models (all models include $\phi_{P_E+T_E}$, p_c)					
$\psi_{P_W^2+P_E^2}$	φ4	9	965.99	0.00	0.498
$\psi_{P_W+T_W+P_E+T_E}$	φ6	11	967.11	1.11	0.286
$\psi_{P_D+P_W+P_E}$	4	10	968.51	2.51	0.142
$\psi_{P_D+T_D+P_W}$	5	10	972.18	6.18	0.023
$\psi_{P_D+P_W}$	2	9	972.64	6.65	0.018
$\psi_{P_W+T_W}$	φ2	9	972.84	6.84	0.016
$\psi_{P_D+T_D+P_W+T_W}$	6	11	974.11	8.11	0.009
$\psi_{P_D+T_D}$	3	9	976.48	10.48	0.003
ψ_{P_E}	R1	8	976.90	10.90	0.002
$\psi_{P_L^2}$	R2	8	977.68	11.68	0.001
ψ_{P_D}	1	8	977.80	11.80	0.001

Note: Ranking is based on AICc values; W_i values are Akaike weights.
† Numbers correspond to those in Table 2; φ indicates an a priori climate model proposed for survival probabilities; R indicates a model proposed for reproductive output (see Table 2).
‡ Number of estimable parameters.

rameters suggested that the effects were real. Recapture probabilities were high, with $\hat{p} = 0.723$ ($\widehat{\text{SE}}(\hat{p}) = 0.050$) and 0.797 ($\widehat{\text{SE}}(\hat{p}) = 0.058$) for females and males in 1986–1987, respectively, and $\hat{p} = 0.912$ ($\widehat{\text{SE}}(\hat{p}) = 0.018$) and 0.940 ($\widehat{\text{SE}}(\hat{p}) = 0.022$) for females and males in 1988–1994, respectively. Under $\{\phi_{P_E+T_E}, p_{s+c}\}$, annual survival was negatively affected by increased precipitation (P) and positively affected by increased temperature (T) during the early nesting period (E). Thus, cold, wet springs had a negative effect on survival, whereas warm, dry springs had a positive effect (Fig. 4a). Changes in apparent survival predicted from Eq. 31 were most sensitive to changes in T_E (17.8% change in $\hat{\phi}$) followed by changes in P_E (4.5% change in $\hat{\phi}$). The model selected accounted for a substantial amount of the temporal process variation in survival probabilities (Table 6). However, the coefficient of temporal variation based on $\hat{\sigma}^2_{\text{temporal}}$ was relatively small, suggesting that temporal process variation in annual survival probabilities was low (Table 6).

One model, $\{\phi_{P_W+P_E}, p_{s+c}\}$, was weighed almost equally with $\{\phi_{P_E+T_E}, p_{s+c}\}$ and was considered a potential competitor to this model (Table 4), representing another possible explanation for survival that was still negatively affected by increased precipitation in the early nesting period, but positively affected by increased precipitation during the winter. The covariates P_E and P_W were not highly correlated ($r = 0.29$), which suggested that model $\{\phi_{P_W+P_E}, p_{s+c}\}$ was not competitive because of colinearity between P_E and P_W. However, inclusion of the covariate P_W in model $\{\phi_{P_E+T_E}, p_{s+c}\}$ (e.g., as $\{\phi_{P_W+P_E+T_E}, p_{s+c}\}$) was not well supported (Table 5). Therefore, we retained the selected model $\{\phi_{P_E+T_E}, p_{s+c}\}$ in analyses of population rates of change, but suspected that model $\{\phi_{P_W+P_E}, p_{s+c}\}$ may be important in future analyses when more data have been collected, or in other data sets.

Reproductive output.—Annual estimates of R varied from 0.150 to 0.810 (Fig. 4b). Estimation of R did not require the intermediate modeling process used with

TABLE 5. Ranking of the best approximating models for apparent survival, reproductive output, and recruitment for Northern Spotted Owls in northwestern California, relative to models in which specific effects were included, excluded, or changed.

Model	Change in best approximating model	AICc	ΔAICc$_i$	w_i
Apparent survival (ϕ)				
$\phi_{P_E+T_E}$, p_{s+c}	Best model (no change)	1293.93	0.00	0.291
$\phi_{P_E+T_E}$, p_c	Exclusion of sex in p	1294.60	0.68	0.207
$\phi_{P_W+P_E+T_E}$, p_{s+c}	Inclusion of p_W in ϕ	1294.89	0.96	0.180
$\phi_{P_E+P_E^2+T_E}$, p_{s+c}	Additional quadratic term for P_E in ϕ	1295.93	2.00	0.107
$\phi_{s+P_E+T_E}$, P_{s+c}	Inclusion of sex on ϕ	1295.94	2.01	0.106
ϕ_{T_E}, p_{s+c}	Exclusion of P_E in ϕ	1296.14	2.21	0.096
ϕ_{P_E}, p_{s+c}	Exclusion of T_E in ϕ	1300.38	6.45	0.012
ϕ_t, p_{s+c}	Random time	1304.66	10.74	0.001
$\phi.$, p_{s+c}	No effects (means model)	1306.89	12.97	0.000
ϕ_{lt}, p_{s+c}	Linear effect on time	1308.68	14.76	0.000
ϕ_{a2+t}, p_{s+c}	Inclusion of age (1–2 vs. $\geq$ 3-yr-old)	1310.55	16.62	0.000
$\phi_{a2'+t}$, p_{s+c}	Inclusion of age (1- vs. $>$ 2-yr-old)	1313.37	19.45	0.000
Reproductive output (R)				
$R_{P_L^2}$	Best model (no change)	−28.62	0.00	0.638
$R_{P_L^2+m}$	Inclusion of male age	−26.05	2.57	0.177
$R_{P_L+P_L^2}$	Additional quadratic term for P_L	−25.31	3.31	0.122
$R_{P_L^2+f}$	Inclusion of female age	−22.68	5.94	0.033
R_{P_L}	Exclusion of quadratic effect	−22.35	6.27	0.028
$R.$	No effects (means model)	−17.14	11.48	0.002
R_{lt}	Linear effect on time	−14.18	14.44	0.000
Recruitment models (ψ). All models include $\phi_{P_E+T_E}$, p_c				
$\psi_{P_W^2+P_E^2}$	Best model (no change)	965.99	0.00	0.355
$\psi_{P_W+P_E}$	No quadratic effect	966.42	0.42	0.288
$\psi_{P_W+P_W^2+P_E+P_E^2}$	Additional quadratic terms for P_W and P_E	967.11	1.11	0.204
ψ_t	Random time	968.51	2.51	0.101
$\psi.$	No effects (means model)	972.18	6.18	0.016
ψ_{lt}	Linear effect on time	972.64	6.65	0.013

Note: Ranking is based on AICc values; w_i values are Akaike weights.

the capture–recapture data. Therefore, resulting estimates were used directly in the components of variance analysis. We examined the 11 hypothesized climate models (Table 2) in addition to 56 intermediate models that included the age and sex covariate (m and f) and different nonlinear structures of the climatic covariates. Of the models examined, model $\{R_{P_L^2}\}$ had the lowest AICc (Table 4) and was selected as the best approximating model given the data. We were unable to compare other models with model $\{R_t\}$ using AICc because model $\{R_t\}$ was saturated (i.e., $K = n$). The form of model $\{R_{P_L^2}\}$ was

$$\hat{R} = 0.8394 - 0.0030\ (P_L)^2 \qquad (32)$$

where R was mean annual reproductive output and P_L was the number of days of measurable precipitation during the late nesting period. The goodness-of-fit test based on deviance indicated no evidence for lack of fit of the data to the model selected ($\chi^2 = 6.051$, df = 7, $P = 0.534$). Examination of residual plots did not suggest any violation of the key assumptions in linear regression. Therefore, model $\{R_{P_L^2}\}$ was considered an appropriate model for relating mean annual reproductive output with climatic variation in the linear modeling framework. Parameter estimates were precise for this model, with $\widehat{\text{SE}}(\hat{\beta}_0) = 0.0538$ and $\widehat{\text{SE}}(\hat{\beta}_1) = 0.0004$ (95% CI = −0.0040, −0.0021). Confidence intervals for $\hat{\beta}_1$ did not overlap zero, supporting a negative trend in reproductive output with respect to precipitation during the late nesting period.

Model $\{R_{P_L^2}\}$ represented hypothesized model 2 (Table 2), which predicted a negative relationship between reproductive output and precipitation during the late nesting period. The quadratic effect in this, and in model $\{R_{P_L+P_L^2}\}$, was not indicative of a drought effect, as proposed in some of the models. Rather, it appeared to describe more of a plateau effect in reproductive output at lower levels of precipitation (Fig. 4b). The one extreme point in Fig. 4b was not considered an outlier, but a real event that represented a region-wide reduction in reproductive output throughout the range of the Northern Spotted Owl (see Burnham et al. 1996). In not including the P_L term in the quadratic, model $\{R_{P_L^2}\}$ restricts maximum reproductive output at zero number of days of precipitation. However, lack of this term in the selected model suggests that this was an appropriate restriction (Table 5). Based on Akaike weights, the selected model was heavily weighted (Table 4), suggesting that the other hypothesized models were not competitive with the selected model. Inter-

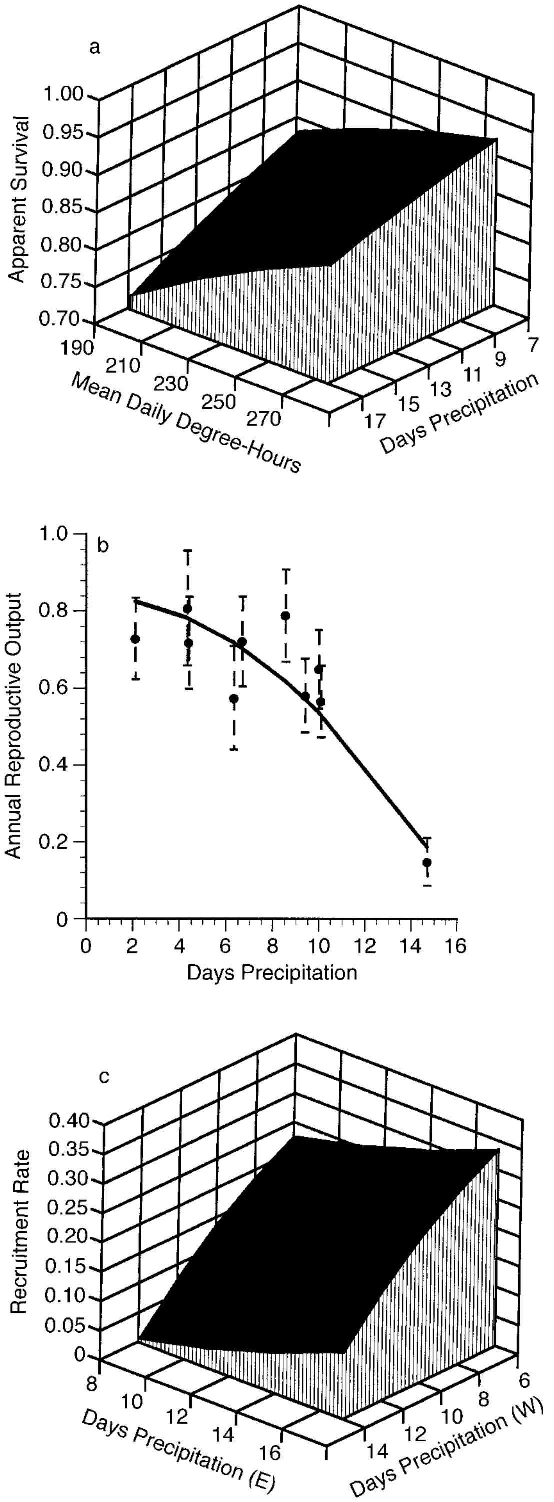

FIG. 4. Predicted values of (a) apparent survival of Northern Spotted Owls ≥1 yr old in relation to precipitation and temperature in the early nesting period; (b) annual reproductive output (mean ± 1 $\widehat{\mathrm{SE}}$) of Northern Spotted Owls relative to number of days of precipitation in the late nesting period; and (c) recruitment rate of Northern Spotted Owls relative to number of days of precipitation in the winter stress period (W) and early nesting period (E) in northwestern California.

estingly, the covariate P_L was present in the first three models ranked by AICc (Table 4), suggesting that it was an important covariate for explaining reproductive output.

Model $\{R_{P_L^2}\}$ estimated no significant residual variation (Table 6), indicating that this model explained all of the estimable temporal process variation. The 95% confidence intervals for $\sigma^2_{\mathrm{temporal}}$ for reproductive output did not overlap zero, and the coefficient of temporal process variation was much greater relative to survival probabilities (Table 6). All of these suggested that $\sigma^2_{\mathrm{temporal}}$ in reproductive output was large and was mostly explained by climatic variation, primarily precipitation during the late nesting period.

Recruitment rate.—We relied on the results of the goodness-of-fit procedures used for the survival analysis as the basis for assessing goodness-of-fit in the recruitment models. Survival and recapture probabilities were modeled as $\{\phi_{P_E+T_E}, p_c\}$, the best climate model describing survival, in all models used to estimate recruitment. Recapture probabilities were structured as p_c rather than p_{s+c} (as in the best climate model for ϕ) for recruitment models because POPAN-4 did not allow for group (i.e., sex) effects in estimation procedures. When we examined time effects only, model $\{\psi_t, \phi_{P_E+T_E}, p_c\}$ had the lowest AICc among models with linear time $\{\psi_{lt}, \phi_{P_E+T_E}, p_c\}$ and no time $\{\psi., \phi_{P_E+T_E}, p_c\}$ (Table 5). Estimates of ψ from the time-dependent model were then transformed into recruitment rates (b), which were used to estimate components of temporal process variation in recruitment rates.

We examined 33 additional recruitment models that included the hypothesized models describing climatic effects on survival, reproductive output, and recruitment (see Table 2). Model $\{\psi_{P_W^2+P_E^2}, \phi_{P_E+T_E}, p_c\}$ was selected as the most parsimonious model based on minimum AICc (Table 4). Model $\{\psi_{P_W+T_W+P_E+T_E}, \phi_{P_E+T_E}, p_c\}$ was a potential competitor based on Akaike weights (Table 4). This model differed from the selected model by including temperature covariates, T_W and T_E. Otherwise, it included the same precipitation covariates as the selected model. We concluded that model $\{\psi_{P_W^2+P_E^2}, \phi_{P_E+T_E}, p_c\}$ was best supported by the data based on minimum AICc, but that inclusion of covariates T_W or T_E might be supported in models based on additional data. Estimates of ψ from the selected model were transformed into recruitment rates ($\hat{b}$), which were regressed against the same climate covariates to yield (using random-effects models)

$$\hat{b} = 0.24732 - 0.00139(P_W)^2 + 0.00048(P_E)^2 \qquad (33)$$

as the model explaining variation in recruitment rates, with $\widehat{\mathrm{SE}}(\hat{\beta}_0) = 0.04121$, $\widehat{\mathrm{SE}}(\hat{\beta}_1) = 0.00037$ (95% CI = -0.00212, -0.00067), and $\widehat{\mathrm{SE}}(\hat{\beta}_2) = 0.00021$ (95% CI = 0.00007, 0.00089). Confidence intervals for the slope parameters did not overlap zero, suggesting that the trends were meaningful. In this model, recruitment rates were negatively affected by increased winter precipitation and positively affected by increased precipitation during the

TABLE 6. Components of temporal variation for apparent survival, mean reproductive output, recruitment rate, and rate of population change for Northern Spotted Owls in northwestern California, with 95% confidence limits in parentheses.

Parameter	Apparent survival ($\hat{\phi}$)	Reproductive output ($\hat{R}$)	Recruitment rate ($\hat{b}$)	Rate of population change ($\hat{\lambda}$)
$\hat{\bar{\theta}}$†	0.8755	0.6129	0.1379	1.0086
$\widehat{SE}(\hat{\bar{\theta}})$	0.0173	0.0640	0.0300	0.0224
$\hat{\sigma}^2_{temporal}$	0.0013	0.0291	0.0063	0.0031
	(0, 0.0087)	(0.0105, 0.1128)	(0.0015, 0.0309)	(0.0008, 0.011)
CV($\hat{\bar{\theta}}$)‡	0.0410	0.2784	0.5755	0.0552
$\hat{\sigma}^2_{climate}$§	0.0013	0.0291	0.0063	
$\hat{\sigma}^2_{residual}$	0	0	0	
	(0, 0.0008)	(0, 0.0103)	(0, 0.0036)	

Note: Survival probabilities are for owls ≥ 1 yr old.
† Weighted mean (see text for details).
‡ Coefficient of temporal process variation estimated as $\hat{\sigma}_{temporal}/\hat{\bar{\theta}}$ and represented as proportions.
§ Estimated as $\hat{\sigma}^2_{climate} = \hat{\sigma}^2_{temporal} - \hat{\sigma}^2_{residual}$.

early spring (Fig. 4c). Changes in recruitment predicted from Eq. 33 were most sensitive to changes in P_W (516.1% change in $\hat{b}$) followed by changes in P_E (51.8% change in $\hat{b}$).

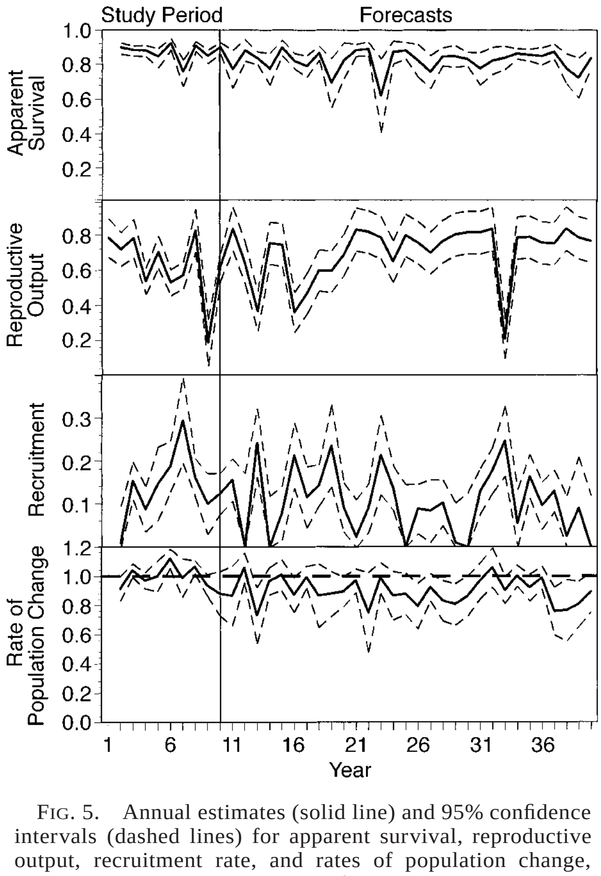

FIG. 5. Annual estimates (solid line) and 95% confidence intervals (dashed lines) for apparent survival, reproductive output, recruitment rate, and rates of population change, based on selected climate models for Northern Spotted Owls in northwestern California. The solid vertical line separates estimates for the study period and forecasts from a 30-yr climate trace recorded from 1955 to 1984, which does not represent future predictions beyond the study period. The horizontal dashed line represents $\lambda = 1$.

The climate model selected explained variation in ψ significantly better than did the random or linear time models (Table 5), with little residual variation estimated (Table 6). The coefficient of temporal process variation for b was substantially higher than those for the other life history parameters (Table 6), suggesting that it exhibited the greatest year-to-year variation relative to survival and reproductive output. Model $\{\psi_{P^2_W+P^2_E}, \phi_{P_E+T_E}, p_c\}$ explained all of the estimable temporal process variation, suggesting that the climatic covariates were primarily responsible for temporal process variation.

Population rates of change.—We used parameter estimates from the models selected to explain survival probabilities and recruitment rates to estimate annual rates of population change λ from Eq. 21 and their standard errors. Based on $\hat{\lambda}$ and $\widehat{SE}(\hat{\lambda})$, $\lambda = 1$ was contained within the 95% confidence intervals for $\hat{\lambda}$ (0.9594, 1.0578), suggesting that the population could be stationary during the study period. The level of temporal process variation in λ was low based on its coefficient of temporal process variation (Table 6).

Forecasts with climate models.—Fig. 5 shows the forecasts of point estimates, and their 95% confidence intervals, from the models selected to represent climatic variation in the demographic parameters and rate of population change, based on the 30-yr period from 1955 through 1984. These forecasts are properly interpreted as what might occur if a similar trend in climate were observed in the future, given that the models used are reasonably correct and other conditions affecting the estimates remain the same. Thus, the traces in Fig. 5 represent what could happen, given the conditions stated previously, rather than what will happen in future years. Therefore, inferences about small-scale variation in the long-term trends are limited. However, large-scale trends can provide some insights into how climate may affect these life history traits over time.

Three important results are evident in examining trends forecasted over 30 yr. First, point estimates of survival and recruitment, the parameters used to estimate λ, were negatively correlated (Pearson's $r = -0.340$, $P = 0.07$), but not strongly so. This may reflect the influence of precipitation during the early nesting period, which negatively affected survival but positively affected recruitment. However, there is also inherent sampling covariance between survival and recruitment because these two parameters were estimated from the same data. As expected, both survival and recruitment were positively correlated with λ. However, recruitment had a stronger correlation ($r = 0.705$, $P < 0.001$) than survival ($r = 0.412$, $P = 0.024$). Second, long-term variation in life history traits differed among the three traits examined. Both survival and reproductive output appear to have longer periods of relative stability punctuated by shorter periods exhibiting severe declines in both survival and reproduction, which represent catastrophic events for each of these parameters. Forecasts of survival estimates revealed two years in which survival estimates dropped below 0.70, with survival in one year as low as 0.62. Reproductive output reached extremely low levels (<0.4) in at least three years. Thus, the probability of catastrophic events (C) can be crudely estimated as $\hat{C} = 2/30 = 0.067$ for survival probabilities and $\hat{C} = 3/30 = 0.10$ for reproductive output. Catastrophic periods did not occur simultaneously for both survival and reproduction, suggesting that events causing variation in these parameters may not be linked. In contrast, recruitment rate was highly and consistently variable, reaching extremely low levels (<0.01) in six of the 30 yr ($\hat{C} = 0.20$). Finally, an average $\hat{\lambda}$ of 0.9118 (based on Eq. 24 from the annual estimates from Eq. 21) for the 30-yr climate trace was less than that estimated during the study period. Annual estimates of λ were significantly lower than a stationary population in 11 of those years, based on 95% confidence intervals (Fig. 5).

Effects of landscape habitat configuration on spatial variation in population processes

Survival probabilities.—We analyzed 280 models to evaluate the effects of habitat, age, and elevation covariates and their interactions on apparent survival. The best approximating a priori hypothesized model for survival was $\{\phi_{a2+LSOCOR+LSOMP+LSOEDG}, p_{c*ELEV}\}$ (model 13 in Table 7), which was twice as likely, based on Akaike weights, as the next ranked model, $\{\phi_{a2'+SOCOR+(SOCOR)^2+SODIS+(SODIS)^2}, p_{c*ELEV}\}$ (model 9 in Table 7). The c*ELEV structure on the recapture probabilities (p) was arrived at early in the modeling process where annual differences in capture technique interacted with mean elevation of territories. This structure on the p's was checked again at the later stages of the modeling process, and remained the best structure for all models.

The effects of SOCOR and SOEDG on ϕ appeared to be most important in the pseudothreshold form (i.e., LSOCOR) because (1) they were more precise (coefficients of variation = 0.37–0.50); (2) 95% confidence intervals of their slope parameters never overlapped zero in the other hypothesized models; and (3) one or both of these covariates appeared in the top three ranked hypothesized models (Table 7). However, slope parameters for the two covariates overlapped zero to a greater degree when they appeared in the squared difference form (i.e., DSOCOR), although the slope parameters for SOCOR as a quadratic (SOCOR + SOCOR^2) did not overlap zero (Table 7). The quadratic form of SOCOR had a shape similar to a pseudothreshold model, suggesting that SOCOR + SOCOR^2 was explaining the data as a pseudothreshold model similarly to LSOCOR.

The covariates SOMP, SOCOR, and SOHAB were all highly correlated ($r = 0.82$–0.96). The covariates LSOCOR and LSOMP in the best a priori hypothesized model also were highly correlated ($r = 0.88$). Therefore, we examined another model that incorporated all of the effects included in the top two a priori hypothesized models, $\{\phi_{a2+LSOCOR+LSOMP+LSOEDG}, p_{c*ELEV}\}$ and $\{\phi_{a2'+SOCOR+(SOCOR)^2+SODIS+(SODIS)^2}, p_{c*ELEV}\}$. This model $\{\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}, p_{c*ELEV}\}$ (starred model in Table 7) was 2.4 times as likely, based on Akaike weights, as the best a priori hypothesized model. All of the covariates were more precise (coefficients of variation = 0.30–0.56) in this combined model, and none of the 95% confidence intervals of the slope parameters overlapped zero except for LSOEDG, which overlapped only slightly (Table 7). In addition, none of the covariates included in the combined model was highly correlated pairwise ($r = -0.22$ to -0.48). Models including sex-, and age-covariate, and between-covariate interactions were not supported by the data as well as was model $\{\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}, p_{c*ELEV}\}$ (Table 8). However, the ΔAICc value between the model with an a2 vs. an a2′ age effect was very small, suggesting that either structure may be appropriate. This was also the case with the a priori hypothesized models in which the $\Delta AICc_i$ values between the same models, with one including an a2 and the other an a2′ structure, ranged from 0.01 to 5.61 with the a2′ structured model having a lower AICc value in 17 of 19 models. For this reason, we chose to retain the a2′ structure in model $\{\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}, p_{c*ELEV}\}$. Further exploration of this model with additional covariates did not yield a better model. Although it resulted from some data exploration, model $\{\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}, p_{c*ELEV}\}$ represented a minor alteration from two of the hypothesized models and, thus, retained much of the a priori thinking used to develop the models. Therefore, this model was retained for making inferences concerning the effects of landscape habitat features on survival. The form of the model was as follows:

TABLE 7. Rankings, based on AICc, and estimated slope parameters for the a priori hypothesized models used to relate landscape habitat features with apparent survival (ϕ) for Northern Spotted Owls in northwestern California.

Hypothesized model†	AICc	K‡	δAICc$_i$	w_i	Estimated slope parameters (95% CI)§
★$\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}$	1132.45	10	0.00	0.427	β_1 = −0.503 (−0.986, −0.019)
					β_2 = 0.213 (0.038, 0.388)
					β_3 = 0.547 (−0.051, 1.144)
					β_4 = 0.085 (0.030, 0.141)
					β_5 = −0.001 (−0.002, −0.0004)
13) $\phi_{a2+LSOCOR+LSOMP+LSOEDG}$	1134.19	9	1.74	0.179	β_1 = −0.811 (−1.500, −0.122)
					β_2 = 0.493 (0.153, 0.833)
					β_3 = −0.779 (−1.520, −0.039)
					β_4 = 0.790 (0.221, 1.359)
9) $\phi_{a2'+SOCOR+(SOCOR)^2+SODIS+(SODIS)^2}$	1135.44	10	2.99	0.096	β_1 = −0.480 (−0.963, 0.003)
					β_2 = 0.022 (0.003, 0.041)
					β_3 = −0.002 (−0.0004, −0.00002)
					β_4 = 0.067 (0.013, 0.121)
					β_5 = −0.001 (−0.002, −0.0004)
12) $\phi_{a2'+LSOCOR+LSOEDG}$	1136.20	8	3.75	0.065	β_1 = −0.527 (−1.005, −0.049)
					β_2 = 0.163 (0.016, 0.310)
					β_3 = 0.652 (0.095, 1.209)
4) $\phi_{a2'+DSOMP+DSODIS}$	1136.63	8	4.18	0.053	β_1 = −0.500 (−0.981, −0.019)
					β_2 = −0.010 (−0.024, 0.005)
					β_3 = −0.305 (−0.596, −0.139)
1) $\phi_{a2'+DSOHAB}$	1137.74	7	5.29	0.030	β_1 = −0.526 (−1.002, −0.049)
					β_2 = −0.019 (−0.034, −0.003)
6) $\phi_{a2'+DSOMP+DSOEDG}$	1137.86	8	5.41	0.029	β_1 = −0.506 (−0.985, −0.027)
					β_2 = −0.006 (−0.023, 0.011)
					β_3 = −0.015 (−0.031, 0.001)
8) $\phi_{a2'+DSOCOR+DSONCA}$	1137.89	8	5.44	0.028	β_1 = −0.535 (−1.013, −0.058)
					β_2 = −0.0001 (−0.0003, 0.0001)
					β_3 = −0.048 (−0.089, −0.006)
5) $\phi_{a2'+SOMP+(SOMP)^2+SONP+(SONP)^2+SODIS+(SODIS)^2}$	1137.94	12	5.49	0.027	β_1 = −0.454 (−0.939, 0.030)
					β_2 = 0.208 (−0.028, 0.445)
					β_3 = −0.013 (−0.029, 0.002)
					β_4 = −0.224 (−0.587, 0.139)
					β_5 = 0.016 (−0.020, 0.052)
					β_6 = 0.099 (0.037, 0.161)
					β_7 = −0.001 (−0.002, −0.0007)
2) $\phi_{a2'+DSOMP}$	1139.02	7	6.57	0.016	β_1 = −0.523 (−0.999, −0.047)
					β_2 = −0.014 (−0.028, −0.0005)
11) $\phi_{a2'+LSOCOR+LSOMP}$	1139.16	8	6.71	0.015	β_1 = −0.538 (−1.016, −0.061)
					β_2 = 0.367 (0.043, 0.692)
					β_3 = −0.517 (−1.223, 0.190)
7) $\phi_{a2'+LSOCOR}$	1139.91	7	6.74	0.015	β_1 = − 0.525 (−1.001, −0.049)
					β_2 = 0.155 (0.002, 0.308)
3) $\phi_{a2'+DSOMP+DSONP}$	1140.79	8	8.34	0.007	β_1 = −0.521 (−0.997, −0.045)
					β_2 = −0.014 (−0.028, −0.0004)
					β_3 = −0.008 (−0.036, 0.021)
$\phi_{a2'}$	1140.94	6	8.49	0.006	β_1 = −0.534 (−1.008, −0.059)
10) $\phi_{a2'+LSOCOR+LSONCA+LSODIS}$	1140.98	9	8.53	0.006	β_1 = −0.535 (−1.011, −0.058)
					β_2 = 0.193 (0.025, 0.361)
					β_3 = 0.147 (−0.156, 0.450)
					β_4 = 0.139 (−0.073, 0.350)
$\phi.$	1143.41	5	10.96	0.002	

Notes: Models {$\phi_{a2'}$} and {$\phi.$} are included for comparison. All models have capture probabilities structured as {p_{c*ELEV}}. The starred model represents a combination of a priori hypothesized models 13 and 9. Covariates are described in Table 1.

† Numbers correspond to hypothesized models in Table 3.

‡ Number of estimated parameters.

§ Slope parameters based on rescaled covariates (see Table 1).

$$\hat{\phi} = 1/\{1 + \exp[-(0.5489 - 0.5025(\text{AGE}) + 0.2129(\text{LSOCOR}) + 0.5465(\text{LSOEDG}) + 0.0853(\text{SODIS}) - 0.0011(\text{SODIS})^2]\} \quad (34)$$

where AGE (the a2′ structure) is a dummy variable (1 is 1–2-yr-olds, 0 is ≥3-yr-olds), LSOCOR is $\log_e$(SOCOR + 0.5), and LSOEDG is $\log_e$(SOEDG + 0.5). Standard errors for the parameter estimates were $\widehat{SE}(\hat{\beta}_0) = 0.8676$, $\widehat{SE}(\hat{\beta}_1) = 0.2465$, $\widehat{SE}(\hat{\beta}_2) = 0.0895$, $\widehat{SE}(\hat{\beta}_3) = 0.3050$, $\widehat{SE}(\hat{\beta}_4) = 0.0283$, and $\widehat{SE}(\hat{\beta}_5) =$ 0.0003. This model suggested that apparent survival

TABLE 8. Ranking of best approximating model of apparent survival (ϕ) or reproductive output (R) for Northern Spotted Owls in northwestern California relative to models where specific effects in the best approximating model were included, excluded, or changed.

Change in effect	Model	ΔAICc$_i$	w_i
Apparent survival (ϕ)			
None (best approximating model)	$\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}$, p_{c*ELEV}	0.00	0.19
Change of age effect to a2 on ϕ	$\phi_{a2+LSOCOR+LSOEDG+SODIS+(SODIS)^2}$, p_{c*ELEV}	0.07	0.19
Addition of LSOMP effect on ϕ	$\phi_{a2'+LSOCOR+LSOMP+LSOEDG+SODIS+(SODIS)^2}$, p_{c*ELEV}	0.51	0.15
Exclusion of LSOEDG effect on ϕ	$\phi_{a2'+LSOCOR+SODIS+(SODIS)^2}$, p_{c*ELEV}	1.02	0.12
Exclusion of age effect	$\phi_{LSOCOR+LSOEDG+SODIS+(SODIS)^2}$, p_{c*ELEV}	1.83	0.08
Exclusion of c*ELEV interaction in p	$\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}$, p_{c+ELEV}	1.96	0.07
Addition of sex effect	$\phi_{s+a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}$, p_{c*ELEV}	2.03	0.07
Change of SODIS+SODIS² to DSODIS on ϕ	$\phi_{a2'+LSOCOR+LSOEDG+DSODIS}$, p_{c*ELEV}	4.06	0.03
Change of SODIS+SODIS² to LSODIS on ϕ	$\phi_{a2'+LSOCOR+LSOEDG+LSODIS}$, p_{c*ELEV}	4.46	0.02
Change of SODIS+SODIS² to DIS on ϕ	$\phi_{a2'+LSOCOR+LSOEDG+SODIS}$, p_{c*ELEV}	5.74	0.01
Exclusion of c effect on p	$\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}$, p_{ELEV}	11.59	0.00
Exclusion of ELEV effect on ***p***	$\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}$, p_{c}	106.3	0.00
Reproductive output (R)			
None (best approximating model)	$R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2}$	0.00	0.34
Exclusion of quadratic form in SONP	$R_{a2'+LSOCOR+LSOEDG+SONP}$	1.25	0.18
Inclusion of ELEV effect	$R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2+ELEV}$	1.81	0.14
Exclusion of LSOCOR	$R_{a2'+LSOEDG+SONP+(SONP)^2}$	2.02	0.12
Exclusion of SONP	$R_{a2'+LSOCOR+LSOEDG}$	2.39	0.10
Inclusion of 3 age-class effect	$R_{a3+LSOCOR+LSOEDG+SONP+(SONP)^2}$	3.36	0.06
Change of age effect to a2	$R_{a2+LSOCOR+LSOEDG+SONP+(SONP)^2}$	3.68	0.05
Exclusion of age effect (a2′)	$R_{LSOCOR+LSOEDG+SONP+(SONP)^2}$	9.18	0.00
Exclusion of SOEDG effect	$R_{a2'+LSOCOR+SONP+(SONP)^2}$	9.85	0.0
Exclusion of SOCOR and SOEDG effect	$R_{a2'+SONP+(SONP)^2}$	12.12	0.0

Note: Covariates are described in Table 1.

increased in parallel for both age classes with increasing amounts of spotted owl habitat, increasing edge between spotted owl and other habitats, and increasing mean nearest neighbor distance between patches of spotted owl habitat at ~400 m, after which apparent survival declined with increasing distance (Fig. 6). Owls 1–2 yr old had lower survival than owls ≥3 yr old, and this difference was constant across changes in the habitat covariates (i.e., there was no interaction between age class and habitat covariates). Changes in apparent survival predicted from the model in Eq. 34 were most sensitive to changes in edge between spotted owl habitat and other habitats (11.1% change in $\hat{\phi}$), followed by changes in spotted owl core habitat (5.4% change in $\hat{\phi}$), mean nearest neighbor distance between spotted owl habitat patches (3.8% change in $\hat{\phi}$) and age class of the territorial occupants (2.0% change in $\hat{\phi}$).

In estimating $\sigma^2_{spatial}$ for apparent survival, we encountered problems with some of the estimates of sampling variances for ϕ (see Appendix B). Based on the estimates of $\sigma^2_{spatial}$ and the weighted mean survival probability across territories (Table 9), the coefficient of spatial process variation was 0.085, suggesting that spatial process variation in ϕ was relatively low. The habitat covariates in model $\{\phi_{a2'+LSOCOR+LSOEDG+SODIS+(SODIS)^2}, p_{c*ELEV}\}$ accounted for 66.7% of $\hat{\sigma}^2_{spatial}$, whereas age accounted for 8.8% of $\hat{\sigma}^2_{spatial}$. There was considerable uncertainty in the estimates of spatial process variation in survival based on the 95% confidence intervals, all of which included zero for each of the variance components (Table 9). This uncertainty was probably due to large sampling variation in the territory-specific estimates of ϕ relative to $\hat{\sigma}^2_{spatial}$ (Table 9). The cause of this large sampling variation was probably due to some territory-specific estimates based on only one or two individuals.

Reproductive output.—In running the general linear mixed models for reproductive output, we found a covariance structure that used low, medium, and high variance years to have the best approximating structure, based on minimum AICc computed from the restricted maximum log likelihood. This structure was used on all subsequent models examining the fixed effects in the hypothesized models and their variations.

We examined 122 models that included the 13 a priori hypothesized models in addition to variations on those models, which included effects due to age, elevation, and interactions. From this suite of models, the best approximating a priori model was $\{R_{a2'+SOCOR+SOEDG}\}$, based on minimum AICc (model 12 in Table 10). However, model $\{R_{a2'+SOMP+SOEDG}\}$ was a close competitor based on approximately equal Akaike weights. In these two models, the estimated slope parameter for SOEDG had greater precision (CV = 0.298–0.383), and was different from zero, based on confidence intervals, than slope parameter estimates for the habitat amount covariates, SOMP and SOCOR, which were much less precise (CV = 1.231–6.402), with confidence intervals that overlapped zero considerably (Table 10). The poor es-

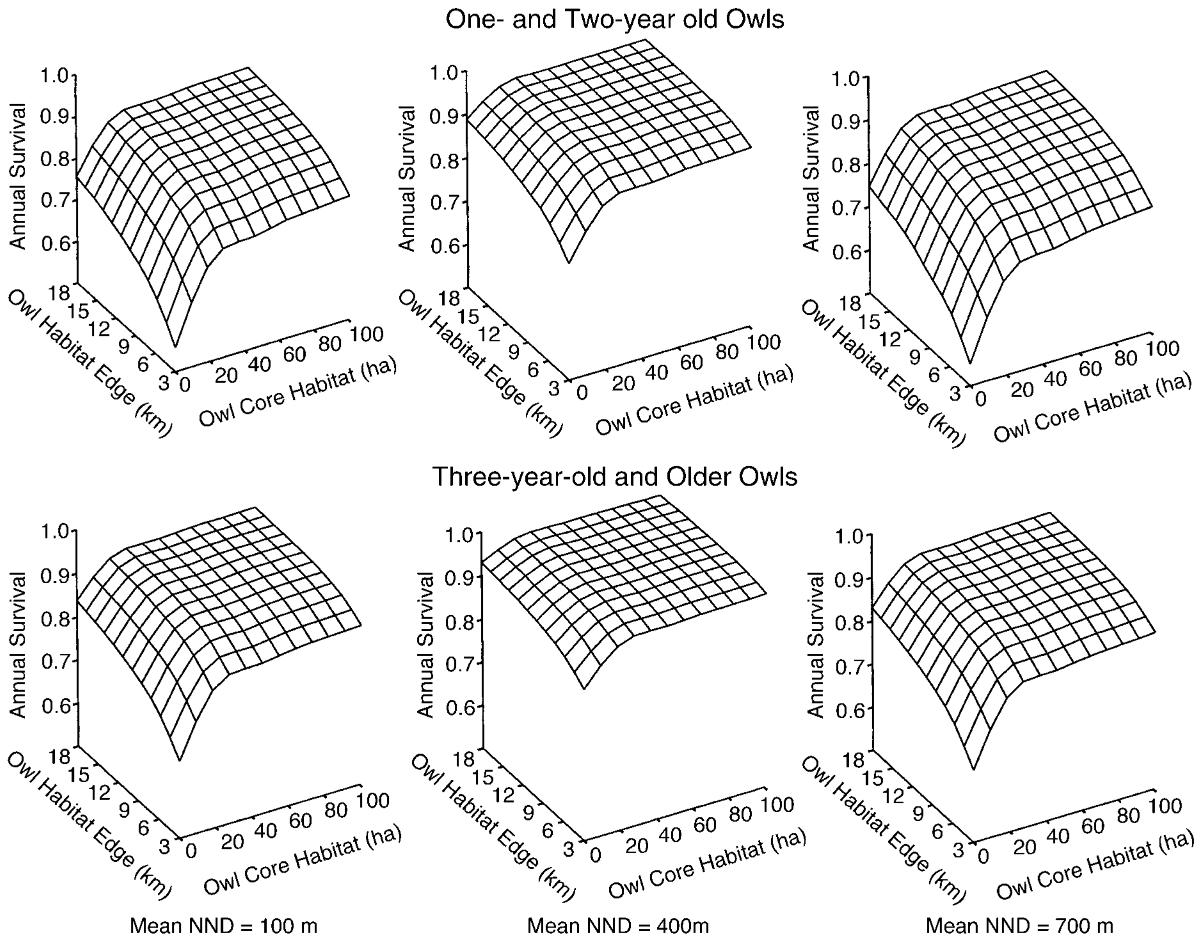

FIG. 6. Annual apparent survival (ϕ) of 1- and 2-yr-old and ≥3-yr-old Northern Spotted Owls in relation to the amount of core habitat, edge between spotted owl and other habitats, and nearest neighbor distance (NND) between patches of spotted owl habitat on territories in northwestern California. Estimates of apparent survival are based on model $\{\phi_{a2'+\mathrm{LSOCOR}+\mathrm{LSOEDG}+\mathrm{SODIS}+(\mathrm{SODIS})^2}, p_{c*\mathrm{ELEV}}\}$.

TABLE 9. Components of spatial variation for apparent survival (ϕ), reproductive output (R), and habitat fitness potential (λ_H) in Northern Spotted Owls in northwestern California.

Parameter†	Apparent survival ($\hat{\phi}$)	Reproductive output ($\hat{R}$)	Habitat fitness potential ($\hat{\lambda}_H$)
$\hat{\bar{\theta}}$	0.8822	0.6006	1.0750
$\widehat{\mathrm{SE}}(\hat{\bar{\theta}})$	0.0141	0.0412	0.0100
$\hat{\sigma}^2_{\mathrm{spatial}}$	0.0057 (0.0003, 0.0165)	0.0302 (0.0090, 0.1017)	0.0031 (0.0019, 0.0051)
$\hat{\sigma}^2_{\mathrm{habitat}}$	0.0038 (0.0029, 0.0052)	0.0226 (0.0058, 0.0882)	‡
$\hat{\sigma}^2_{\mathrm{age}}$	0.0005 (0.0004, 0.0007)	0.0008 (0.0002, 0.0040)	
$\hat{\sigma}^2_{\mathrm{residual}}$	0.0013 (0.0001, 0.0269)	0.0068 (0, 0.0408)	

Note: Ninety-five percent confidence intervals are in parentheses.
† The parameter $\hat{\sigma}^2_{\mathrm{spatial}}$ is an estimate of spatial process variation, $\hat{\sigma}^2_{\mathrm{habitat}}$ is the amount of $\hat{\sigma}^2_{\mathrm{spatial}}$ explained by variation in selected habitat covariates, $\hat{\sigma}^2_{\mathrm{age}}$ is the amount of $\hat{\sigma}^2_{\mathrm{spatial}}$ explained by age of territory occupants, and $\hat{\sigma}^2_{\mathrm{residual}}$ is the unexplained amount of $\hat{\sigma}^2_{\mathrm{spatial}}$.
‡ Not estimated.

TABLE 10. Rankings, based on AICc, and estimated slope parameters for the a priori hypothesized models used to relate landscape habitat features to reproductive output (R) in Northern Spotted Owls in northwestern California.

Hypothesized model†	AICc	K‡	$\Delta AICc_i$	w_i	Estimated slope parameters (95% CI)§
★$R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2}$	1317.31	9	0.00	0.532	β_1 = 0.344 (0.145, 0.544) β_2 = −0.074 (−0.145, −0.003) β_3 = 0.473 (0.220, 0.727) β_4 = −0.151 (−0.280, −0.022) β_5 = 0.013 (−0.001, 0.026)
12) $R_{a2'+SOCOR+SOEDG}$	1319.88	8	2.58	0.147	β_1 = 0.349 (0.147, 0.550) β_2 = −0.002 (−0.005, 0.002) β_3 = 0.042 (0.011, 0.074)
6) $R_{a2'+SOMP+SOEDG}$	1320.28	8	2.97	0.121	β_1 = 0.354 (0.153, 0.556) β_2 = −0.006 (−0.029, 0.017) β_3 = 0.047 (0.019, 0.075)
13) $R_{a2'+SOCOR+SOMP+SOEDG}$	1321.83	9	4.52	0.056	β_1 = 0.345 (0.142, 0.547) β_2 = −0.003 (−0.010, 0.005) β_3 = 0.023 (−0.037, 0.054) β_4 = 0.040 (0.006, 0.074)
1) $R_{a2'+SOHAB+(SOHAB)^2+ELEV+ELEV*SOHAB+ELEV*(SOHAB)^2}$	1322.98	11	5.67	0.031	β_1 = 0.333 (0.131, 0.532) β_2 = −0.544 (−1.179, 0.091) β_3 = 0.028 (−0.010, 0.065) β_4 = −0.347 (−0.645, −0.049) β_5 = 0.082 (0.009, 0.155)
9) $R_{a2'+SOCOR+SODIS}$	1323.54	8	6.23	0.024	β_1 = 0.341 (0.139, 0.544) β_2 = −0.005 (−0.008, −0.001) β_3 = −0.010 (−0.022, 0.002)
3) $R_{a2'+SOMP+(SOMP)^2+SONP+(SONP)^2}$	1323.60	10	6.28	0.023	β_1 = 0.345 (0.144, 0.546) β_2 = 0.083 (−0.013, 0.179) β_3 = −0.008 (−0.014, −0.002) β_4 = −0.188 (−0.330, −0.046) β_5 = 0.017 (0.002, 0.031)
7) $R_{a2'+SOCOR}$	1324.14	7	6.83	0.017	β_1 = 0.335 (0.132, 0.538) β_2 = −0.427 (−0.007, −0.001)
11) $R_{a2'+SOCOR+SOMP}$	1324.73	8	7.41	0.013	β_1 = 0.325 (0.122, 0.528) β_2 = −0.007 (−0.014, −0.001) β_3 = 0.028 (−0.016, 0.071)
8) $R_{a2'+SOCOR+SONCA}$	1324.93	8	7.62	0.012	β_1 = 0.337 (0.134, 0.539) β_2 = −0.002 (−0.007, 0.0001) β_3 = 0.026 (−0.019, 0.070)
10) $R_{a2'+SOCOR+SONCA+SODIS}$	1325.04	9	7.72	0.011	β_1 = 0.342 (0.140, 0.544) β_2 = −0.004 (−0.008, −0.001) β_3 = 0.018 (−0.028, 0.063) β_4 = −0.009 (−0.021, 0.003)
2) $R_{a2'+SOMP+(SOMP)^2}$	1326.29	8	8.98	0.006	β_1 = 0.343 (0.140, 0.546) β_2 = 0.0781 (−0.022, 0.179) β_3 = − 0.006 (−0.013, 0.0002)
4) $R_{a2'+SOMP+SODIS}$	1327.43	8	10.11	0.003	β_1 = 0.355 (0.151, 0.558) β_2 = −0.022 (−0.047, 0.003) β_3 = −0.010 (−0.022, 0.003)
5) $R_{a2'+SOMP+SONP+SODIS+SONP*SODIS}$	1328.65	11	11.34	0.002	β_1 = 0.356 (0.154, 0.559) β_2 = 0.008 (−0.059, 0.076) β_3 = −0.037 (−0.067, −0.007) β_4 = 0.004 (−0.022, 0.031) β_5 = −0.007 (−0.018, 0.004)
$R_{a2'+DELEV}$	1328.97	7	11.66	0.002	β_1 = 0.350 (0.146, 0.555) β_2 = −0.004 (−0.014, 0.007)
$R.$	1336.18	5	18.87	0.000	

Notes: Models {$R_{a2+DELEV}$}, and {$R.$} are included for comparison. The starred model was achieved after further exploration. Covariates are described in Table 1.

† Numbers correspond to hypothesized models in Table 2.

‡ Number of estimated parameters.

§ Slope parameters based on re-scaled covariates (see Table 1).

timation of SOMP and SOCOR effects suggested that the top three a priori models may have been the best from the suite of models examined, but did not model the data very well. Therefore, we explored additional models that included other combinations of the covariates, with the best approximating a priori model as a starting point. We did not explore any additional models that included the covariates SOCOR, SOMP, and SOHAB together, because of the high correlations among these covariates.

We examined 55 additional models outside of the hypothesized models. From this suite of models, the best

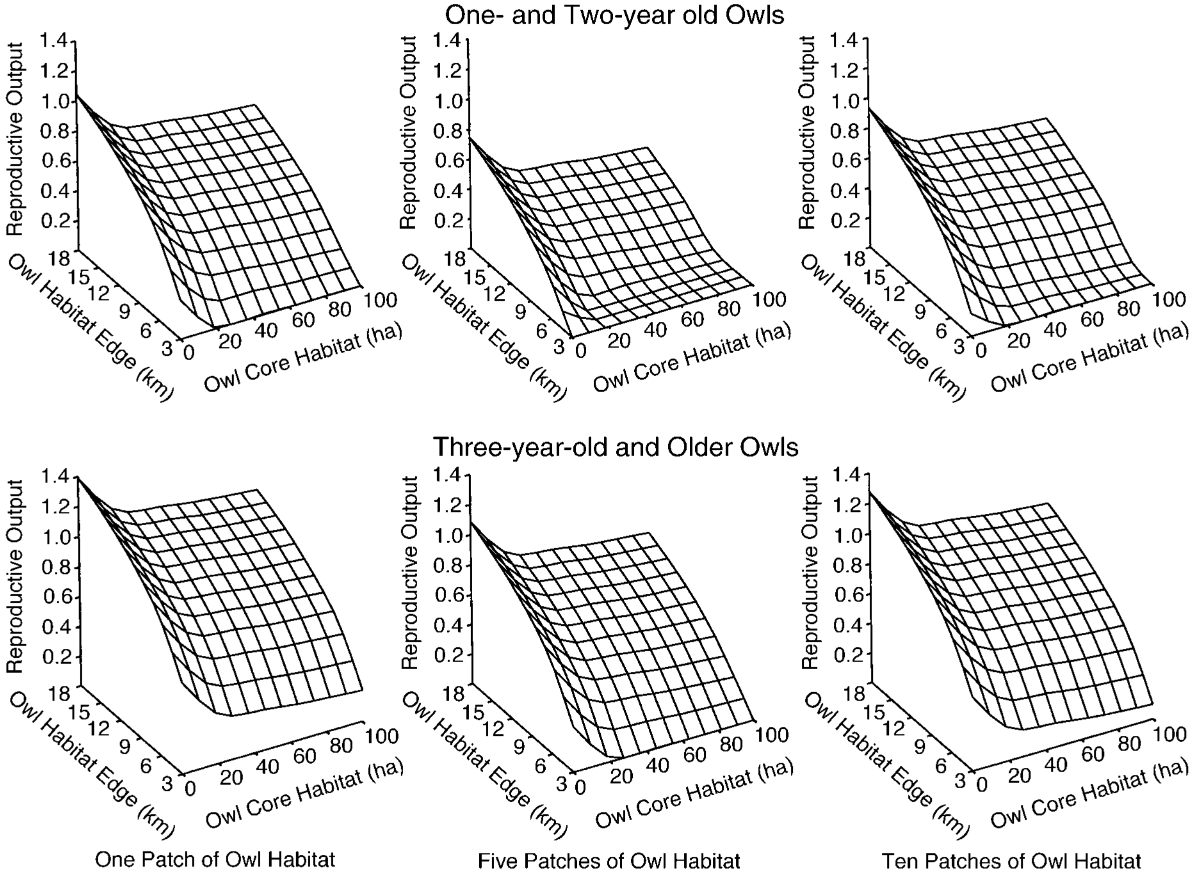

FIG. 7. Reproductive output (R) of 1- and 2-yr-old and ≥3-yr-old Northern Spotted Owls in relation to amount of core spotted owl habitat, edge between spotted owl and other habitats, and number of patches of spotted owl habitat on territories in northwestern California. Estimates of reproductive output are from model $\{R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2}\}$.

approximating model based on minimum AICc was $\{R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2}\}$, which was also a much better approximating model than any of the a priori hypothesized models (starred model in Table 10). The Akaike weight for model $\{R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2}\}$ indicated that it was 3.6 times more likely than the nearest a priori hypothesized model. Close competitors within one AICc unit of this model, within the suite of models involved in data exploration, retained a similar structure but without the log effects and with some age interactions (Table 8). The form of model $\{R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2}\}$ was

$$\hat{R} = -0.245 + 0.344(\text{AGE}) - 0.074(\text{LSOCOR}) + 0.473(\text{LSOEDG}) - 0.151(\text{SONP}) + 0.013(\text{SONP})^2 \quad (35)$$

where AGE was a dummy variable (0, either 1 or 2 yr old; 1, ≥3 yr old). The standard errors for the parameter estimates were $\widehat{\text{SE}}(\hat{\beta}_0) = 0.377$, $\widehat{\text{SE}}(\hat{\beta}_1) = 0.102$, $\widehat{\text{SE}}(\hat{\beta}_2) = 0.036$, $\widehat{\text{SE}}(\hat{\beta}_3) = 0.129$, $\widehat{\text{SE}}(\hat{\beta}_4) = 0.066$, and $\widehat{\text{SE}}(\hat{\beta}_5) = 0.0068$. All of the slope parameters were relatively precise (CV = 0.27–0.54).

This model was similar to the best hypothesized model $\{R_{a2'+SOCOR+SOEDG}\}$, except that there was a pseudothreshold effect on SOCOR and SOEDG, and the model included SONP. We used model $\{R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2}\}$ with the understanding that inferences were somewhat limited because this model was developed by further exploration beyond the a priori hypothesized models. However, this model was based mostly on one of the a priori hypotheses (model 12 in Table 3). This model indicated that reproductive output was (1) negatively associated with female age class, with 1- and 2-yr-old owls fledging fewer young than owls ≥3 yr old (the dummy variable was scored 1 for owls ≥3 yr old); (2) negatively associated with the amount of core spotted owl habitat in a nonlinear fashion; (3) positively associated with the amount of edge between spotted owl habitat and other habitats in a nonlinear fashion; and (4) associated with the number of patches of spotted owl habitat by an inverse quadratic relationship in which reproductive output was highest when the number of patches was either few or many, and lowest when the number of patches was intermediate (Fig. 7). Changes in reproductive output predicted from Eq. 35 were most sensitive to changes in edge between spotted owl habitat and other habitats (382.0% change in $\hat{R}$), followed by changes in spotted owl core habitat (30.4% change in $\hat{R}$), number of spotted owl habitat patches (23.9% change in $\hat{R}$), and age class of the territorial occupants (22.4% change in $\hat{R}$).

Using the weighted mean for reproductive output (Table 9), the coefficient of spatial variation was 0.289, suggesting that reproductive output was relatively variable among territories, much more so than survival. The habitat covariates in model $\{R_{a2'+\mathrm{LSOCOR+LSOEDG+SONP+(SONP)^2}}\}$ explained 74.8% of this spatial process variation, whereas the age effect explained 2.7% (see Table 9).

Habitat fitness potential.—We estimated the habitat fitness potential of each spotted owl territory using the Leslie stage projection matrix in (22). As inputs to (22) for each territory, we estimated apparent survival ($\hat{\phi}$) using Eq. 34, and we estimated fecundity ($\hat{m}$) from Eq. 35 using the relevant landscape covariates from each of the territories. For example, we used the measures of LSCOR, LSOEDG, and SODIS from territory A to estimate age-specific ϕ for that territory using Eq. 34, and we used the measures of LSCOR, LSOEDG, and SONP from territory A to estimate age-specific R for that territory using Eq. 35. Estimates of m were derived by dividing $\hat{R}$ by 2. An estimate of λ_H was then obtained for territory A using the age-specific estimates of ϕ and m as inputs to matrix 22.

Estimated values of territory-specific habitat fitness potential ($\hat{\lambda}_H$) varied from 0.438 to 1.178 (Fig. 8a), with a weighted mean (using Eq. 24 with territory-specific estimates from matrix 22) of 1.075 (95% CI = 1.061, 1.089). The median coefficient of sampling variation among territories was 0.028, indicating that estimates of λ_H were quite precise. Based on estimates in Table 9, the coefficient of spatial process variation for $\hat{\lambda}_H$ was 0.052, suggesting that spatial process variation in the predicted habitat fitness potential among territories was relatively low. However, territory-specific estimates of λ_H followed a smooth progression from territories with relatively high fitness (with point estimates substantially greater than one), to territories that had low fitness (with values less than one; Fig. 9a). Based on the 95% confidence intervals of $\hat{\lambda}_H$ for each territory, three territories (3.2%) had point estimates less than one, with confidence intervals that did not overlap one; 26 territories (27.4%) had estimates either less than or greater than one, with confidence intervals that overlapped one; and 66 territories (69.4%) had estimates that were greater than one and confidence intervals that did not overlap one. This indicated that females on at least two-thirds of the territories more than replaced themselves and were potentially contributing a surplus to the population.

The components used to estimate λ_H, age-specific apparent survival and age-specific fecundity, appeared to contribute differently to the spatial process variation among territory-specific λ_H. First, $\hat{\lambda}_H$ was highly correlated with apparent survival (r = 0.83), but less so with fecundity (r = 0.57). Estimates of apparent survival used in estimating λ_H varied little when compared with fecundity estimates (Table 9, Fig. 8b, c). This was also apparent when estimates of apparent survival and fecundity for owls ≥3 yr old were compared along the gradient of territories ranked by $\hat{\lambda}_H$; apparent survival appeared to be relatively constant except for owls in territories that had very low fitness (Fig. 9b), whereas fecundity declined (Fig. 9c). This suggested that small changes in apparent survival were responsible for relatively large changes in $\hat{\lambda}_H$.

The combination of effects of landscape habitat characteristics on apparent survival and fecundity (and, hence, habitat fitness potential) can be illustrated by examining territories with relatively high, medium, and low habitat fitness potentials (Fig. 10). There are evident trade-offs in landscape habitat configurations

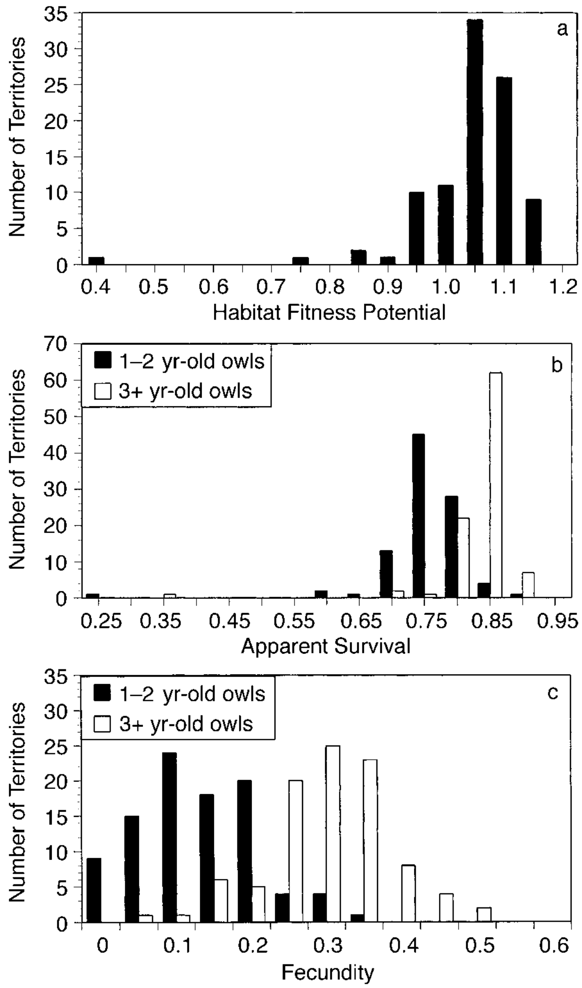

FIG. 8. Distributions of (a) estimated habitat fitness potential ($\hat{\lambda}_H$), (b) predicted estimates of apparent survival used to estimate λ_H, and (c) predicted estimates of fecundity used to estimate λ_H for 95 Northern Spotted Owl territories in northwestern California.

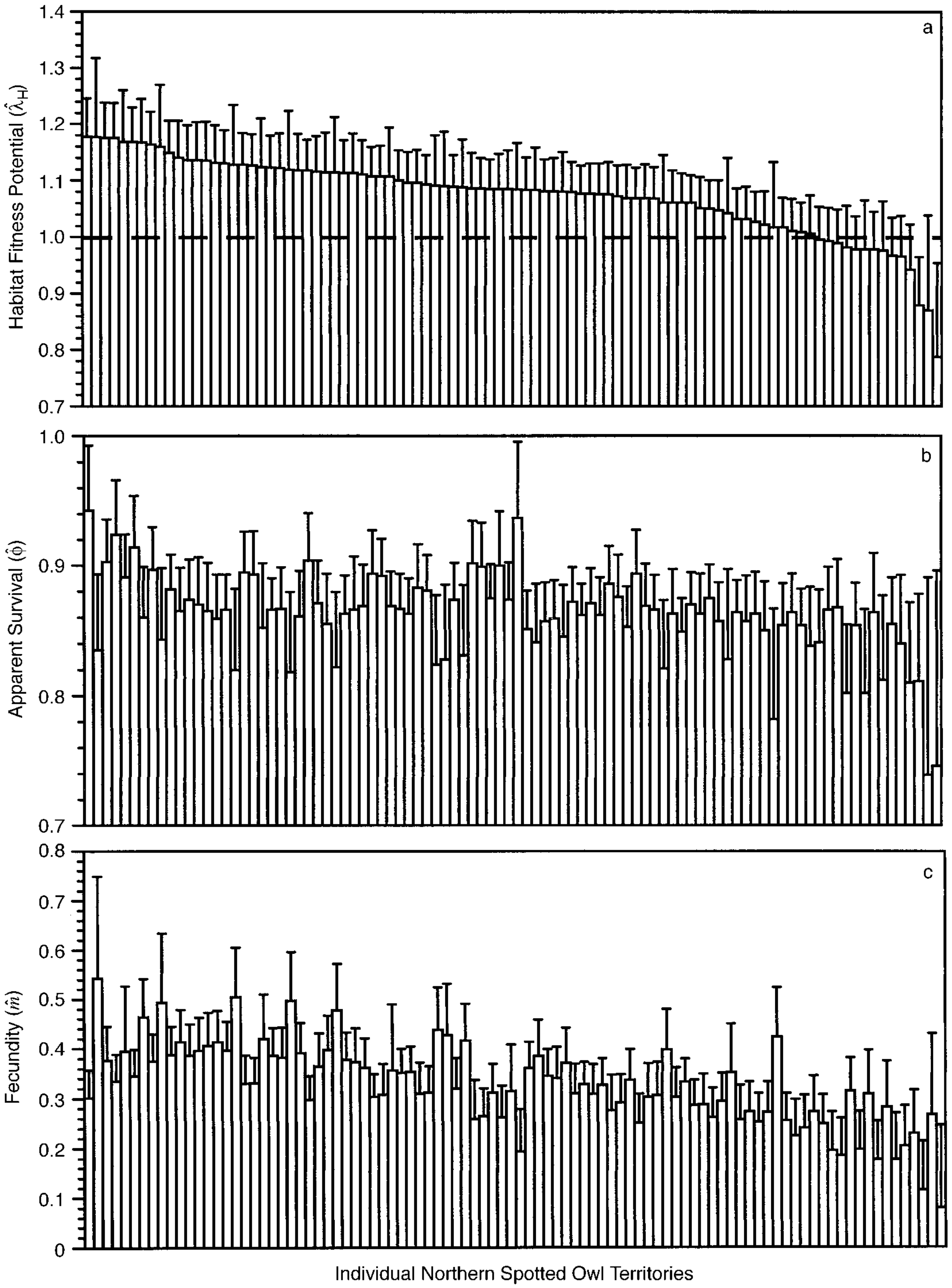

FIG. 9. Northern Spotted Owl territories in northwestern California (a) sorted by descending habitat fitness potential values with (b) corresponding estimates of apparent survival for owls ≥3 yr old, and (c) estimates of fecundity for owls ≥3 yr old. Each histogram bar is an individual territory. Error bars represent +2 SE of the mean. One territory with $\hat{\lambda}_H$ = 0.44 was not included, for ease in comparisons.

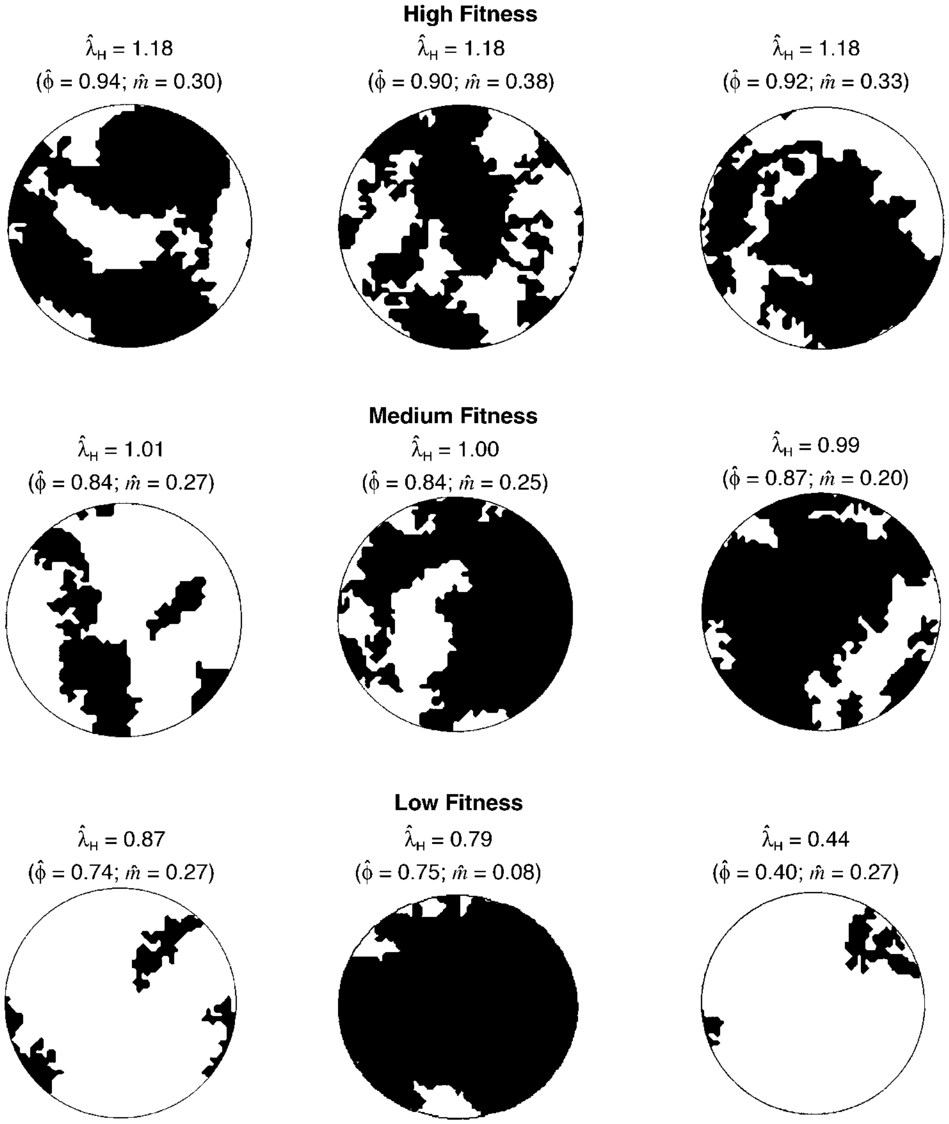

FIG. 10. Landscape habitat characteristics (within 0.71 km radius circles used to define Northern Spotted Owl territories) at three levels of habitat fitness potential in northwestern California. Dark areas are Northern Spotted Owl habitat; white areas are other vegetation types. Estimates of ϕ (apparent survival) and m (fecundity) are for owls $\geq$3 yr old.

within spotted owl territories where survival is maximized by maintaining relatively large core areas of habitat with some edge (see Eq. 34). In contrast, fecundity was maximized by minimizing the core area of spotted owl habitat, maximizing the amount of edge between spotted owl and other habitats, and either minimizing or maximizing the number of discrete patches of spotted owl habitat (see Eq. 35). In territories with high $\hat{\lambda}_H$, it appears that both adult survival and fecundity were high (Fig. 10). In territories with medium and low $\hat{\lambda}_H$, $\hat{\lambda}_H$ was a function of low survival and high fecundity, high survival and low fecundity, or low survival and low fecundity. Thus, the landscape configurations in territories with medium and low values of $\hat{\lambda}$ could maximize either one or the other of the components used to estimate $\hat{\lambda}_H$, but not necessarily both. In addition, high $\hat{\lambda}_H$ in territories appears to be associated with a mixture of spotted owl habitat vs. other vegetation types (e.g., some degree of heterogeneity). On the other hand, too much homogeneity in either spotted owl habitat or other vegetation types appears to result in low $\hat{\lambda}_H$.

Relative contributions of climatic and habitat variation to population processes

The coefficient of total process variation for apparent survival was 9.5%, based on the weighted mean for either temporal (Table 6) or spatial (Table 9) variation. Spatial process variation accounted for most of the total process variation in apparent survival (Table 11). The

TABLE 11. Sources of process variation in apparent survival and reproductive output in Northern Spotted Owls in northwestern California, with 95% confidence intervals in parentheses.

Type of variation	Survival probability		Reproductive output	
	Estimate	Percentage	Estimate	Percentage
Total process				
$\hat{\sigma}^2_{\text{total}}$†	0.0070 (0.0021, 0.0227)	100.0	0.0593 (0.0215, 0.1635)	100.0
$\hat{\sigma}^2_{\text{temporal}}$	0.0013 (0, 0.0087)	18.6	0.0291 (0.0105, 0.1128)	49.1
$\hat{\sigma}^2_{\text{spatial}}$	0.0057 (0.0003, 0.0165)	81.4	0.0302 (0.0090, 0.1017)	50.9
Modeled process				
$\hat{\sigma}^2_{\text{model}}$	0.0056 (0.0041, 0.0077)	100.0	0.0525 (0.0141, 0.1959)	100.0
$\hat{\sigma}^2_{\text{climate}}$	0.0013 (0, 0.009)	23.2	0.0291 (0.0105, 0.1128)	55.4
$\hat{\sigma}^2_{\text{habitat}}$	0.0038 (0.0029, 0.0052)	67.9	0.0226 (0.0058, 0.0882)	43.1
$\hat{\sigma}^2_{\text{age}}$	0.0005 (0.0001, 0.0269)	8.9	0.0008 (0.0002, 0.0040)	1.5

† Total variation accounted for by temporal and spatial process variation only (residual variation not included).

variation in apparent survival that was accounted for by the climate and habitat models ($\hat{\sigma}^2_{\text{model}}$) explained 80.0% of the total process variation ($\hat{\sigma}^2_{\text{model}}/\hat{\sigma}^2_{\text{total}}$ in Table 11), suggesting that these influences were primarily responsible for the observed process variation in this study. This left little residual variation (20.0%) to be explained by other factors not modeled here. Based on model selection, both climate and habitat influences appeared to be important in explaining variation in apparent survival; the additive model $\{\phi_{a2'+P_E+T_E+\text{LSOCOR}+\text{LSOEDG}+\text{SODIS}+(\text{SODIS})^2}\}$ containing both climate and habitat effects was ≥52 times as likely (based on Akaike weights) as either the habitat-only model $\{\phi_{a2'+\text{LSOCOR}+\text{LSOEDG}+\text{SODIS}+(\text{SODIS})^2}\}$ or the climate-only model $\{\phi_{P_E+T_E}\}$ (Table 12).

Spatial and temporal process variation accounted for roughly equal amounts of the total process variation in reproductive output (Table 11). The coefficient of total process variation was 39.7–40.5%, depending on whether we used the weighted mean for temporal (Table 6) or spatial (Table 9) variation. The variation in reproductive output that was explained by the climate and habitat models ($\hat{\sigma}^2_{\text{model}}$) accounted for 88.5% of the total observed process variation ($\hat{\sigma}^2_{\text{model}}/\hat{\sigma}^2_{\text{total}}$ in Table 11). Again, little residual variation (11.5%) was left to be explained by factors other than

TABLE 12. Comparison of climate, habitat, and combined climate and habitat models for apparent survival and reproductive output in Northern Spotted Owls in northwestern California. Models with problems in identifiability of parameters are not included (see Appendix B).

Model	AICc	K	ΔAICc_i	w_i
Apparent survival (ϕ)				
$\phi_{a2'+(P_E+T_E)*(\text{LSOEDG}+\text{SODIS})+\text{LSOCOR}+(\text{SODIS})^2}$	1121.46	16	0.00	0.627
$\phi_{a2'+P_E+T_E+\text{LSOCOR}+\text{LSOEDG}+\text{SODIS}+(\text{SODIS})^2}$	1124.23	12	2.77	0.157
$\phi_{a2'+(P_E+T_E)*(\text{LSOEDG})+\text{LSOCOR}+\text{SODIS}+(\text{SODIS})^2}$	1125.42	14	3.96	0.087
$\phi_{a2'+(P_E+T_E)*(\text{LSOCOR})+\text{LSOEDG}+\text{SODIS}+(\text{SODIS})^2}$	1125.48	14	4.02	0.084
$\phi_{a2'+(P_E+T_E)*(\text{LSOCOR}+\text{LSOEDG})+\text{SODIS}+(\text{SODIS})^2}$	1126.87	16	5.41	0.042
$\phi_{a2'+\text{LSOCOR}+\text{LSOEDG}+\text{SODIS}+(\text{SODIS})^2}$	1132.45	10	10.99	0.003
$\phi_{P_E+T_E}$	1136.01	7	14.55	0.000
Reproductive output (R)				
$R_{a2'+P_L^2+\text{LSOCOR}+\text{LSOEDG}+\text{SONP}+(\text{SONP})^2}$	1291.73	11	0.00	0.438
$R_{a2'+P_L^2*\text{LSOCOR}+\text{LSOEDG}+\text{SONP}+(\text{SONP})^2}$	1293.65	12	1.92	0.168
$R_{a2'+P_L^2*\text{LSOEDG}+\text{LSOCOR}+\text{SONP}+(\text{SONP})^2}$	1293.82	12	2.09	0.154
$R_{a2'+P_L^2*[\text{SONP}+(\text{SONP})^2]+\text{LSOCOR}+\text{LSOEDG}}$	1294.88	13	3.15	0.090
$R_{a2'+P_L^2*(\text{LSOCOR}+\text{LSOEDG})+\text{SONP}+(\text{SONP})^2}$	1295.75	13	4.02	0.059
$R_{a2'+P_L^2*[\text{LSOCOR}+\text{SONP}+(\text{SONP})^2]+\text{LSOEDG}}$	1296.31	14	4.58	0.044
$R_{a2'+P_L^2*[\text{LSOEDG}+\text{SONP}+(\text{SONP})^2]+\text{LSOCOR}}$	1296.96	14	5.23	0.032
$R_{a2'+P_L^2*[\text{LSOCOR}+\text{LSOEDG}+\text{SONP}+(\text{SONP})^2]}$	1298.42	15	6.69	0.015
$R_{P_L^2}$	1314.72	10	22.99	0.000
$R_{a2'+\text{LSOCOR}+\text{LSOEDG}+\text{SONP}+(\text{SONP})^2}$	1317.31	6	25.58	0.000

TABLE 13. Estimates of slope parameters ($\hat{\beta}$) for habitat and climate covariates, with their coefficients of variation (CV) and 95% confidence intervals, in the best approximating models (including both climate and habitat covariates) of apparent survival (ϕ) and reproductive output (R) for Northern Spotted Owls in northwestern California.

Effect	$\hat{\beta}$†	CV	95% CI
Model $\{\phi_{a2'+(P_E+T_E)*(LSOEDG+SODIS)+LSOCOR+(SODIS)^2}\}$			
P_E	5.799	0.50	0.093, 911.151
T_E	7.186	0.44	1.005, 13.367
LSOCOR	0.214	0.44	0.031, 0.397
LSOEDG	8.765	0.44	1.212, 16.317
P_E × LSOEDG	−2.452	0.48	−4.736, −0.168
T_E × LSOEDG	−2.250	0.57	−4.748, 0.247
SODIS	0.053	0.35	0.017, 0.091
P_E × SODIS	−0.060	0.69	−0.142, 0.021
T_E × SODIS	−0.158	0.45	−0.298, −0.018
SODIS^2	−0.091	0.49	−0.178, −0.003
Model $\{R_{a2'+P_L^2+LSOCOR+LSOEDG+SONP+(SONP)^2}\}$			
P_L^2	−0.003	0.19	−0.004, −0.002
LSOCOR	−0.075	0.48	−0.144, −0.005
LSOEDG	0.495	0.26	0.245, 0.744
LSONP	−0.146	0.44	−0.273, −0.019
LSONP^2	0.012	0.56	−0.001, 0.025

† Based on rescaled climate covariates: $P_E/10$ and $T_E/100$. Habitat covariates are re-scaled as in Table 1.

climate or habitat. The importance of both temporal and spatial process variation in explaining total process variation was supported by model selection. Model $\{R_{a2'+P_L^2+LSOCOR+LSOEDG+SONP+(SONP)^2}\}$, which contained the additive effects of the best climate and habitat models, was >400 times as likely as either model $\{R_{P_L^2}\}$, with climate effects only, or model $\{R_{a2'+LSOCOR+LSOEDG+SONP+(SONP)^2}\}$, with habitat effects only (Table 12).

Effects of variation in climate on habitat quality.—In survival estimation, we used a structure on recapture probabilities (p) of p_{c*ELEV} for all models that differed from the structure of p_{s+c} used in models relating survival to climatic covariates. We used the p_{c*ELEV} structure in this analysis because it was used in models relating survival to habitat covariates, and it still incorporated some of the structure of p's used in the climate models.

Four models supported interactions between climate and habitat in apparent survival better than did model $\{\phi_{a2'+P_E+T_E+LSOCOR+LSOEDG+SODIS+(SODIS)^2}\}$, which included only additive effects between climate and habitat (Table 12). However, there were a number of problems encountered in modeling interactions with these data, because the form of the sample data did not allow for unique identifiability of parameters in models that contained certain interactions (see Appendix B). Thus, the best approximating model for apparent survival was $\{\phi_{a2'+(P_E+T_E)*(LSOEDG+SODIS)+LSOCOR+(SODIS)^2}\}$ (Table 12), which contained interactions between both climate covariates and habitat covariates LSOEDG and SODIS (Table 13). Based on Akaike weights, this model was four times as likely as the additive model containing both climate and habitat covariates but no interactions between the two sets of covariates (Table 12). Inferences from model $\{\phi_{a2'+(P_E+T_E)*(LSOEDG+SODIS)+LSOCOR+(SODIS)^2}\}$ were very limited because of the problems encountered in modeling interactions and the removal of the quadratic effect from any interactions with climate covariates (see Appendix B). The precision of slope parameters in model $\{\phi_{a2'+(P_E+T_E)*(LSOEDG+SODIS)+LSOCOR+(SODIS)^2}\}$ (Table 13) was similar to the best approximating models that included only climate effects or only habitat effects.

Model $\{\phi_{a2'+(P_E+T_E)*(LSOEDG+SODIS)+LSOCOR+(SODIS)^2}\}$ indicated that higher quality Northern Spotted Owl habitat, as described by the habitat covariates, buffered the adverse effects of climate (Fig. 11). In Fig. 11, we arbitrarily defined ''good'' habitat as habitat covariates (SOCOR = 65 ha of interior forest, SOEDG = 9 km, SODIS = 100 m) yielding $\hat{\phi}$ = 0.91; ''medium'' habitat as habitat covariates (SOCOR = 25 ha, SOEDG = 9 km, and SODIS = 50 m) yielding $\hat{\phi}$ = 0.86; and ''poor'' habitat as habitat covariates (SOCOR = 5 ha, SOEDG = 6 km, and SODIS = 50 m) yielding $\hat{\phi}$ = 0.78 when climate effects are ignored. The effects of interactions between climate and habitat covariates were examined in this more qualitative manner along a hypothetical climate gradient, because of the poor support for the best approximating model, $\{\phi_{a2'+(P_E+T_E)*(LSOEDG+SODIS)+LSOCOR+(SODIS)^2}\}$. The climate gradient used in Fig. 11 was based on data within the range of conditions observed during the study.

Of the three different habitat qualities, apparent survival declined 7.1% in good habitat as the climate gradient progressed from an optimal warm, dry spring to a cold, wet spring. Along the same climate gradient,

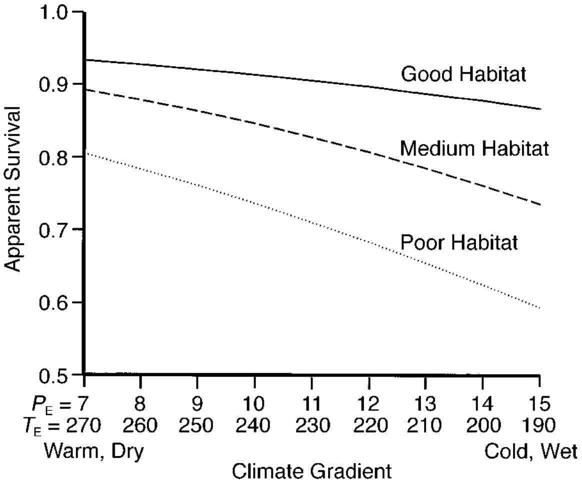

FIG. 11. Effects of climate on apparent survival of Northern Spotted Owls in three qualities of habitat in northwestern California. Predicted effects on apparent survival are based on model $\phi_{a2'+(P_E+T_E)*(LSOEDG+SODIS)+LSOCOR+(SODIS)^2}$. The climate gradient is a function of both P_E and T_E. Habitat quality is defined in *Results: Effects of variation in climate on habitat quality.*

apparent survival decreased 17.5% and 26.3% in medium and poor habitats, respectively (Fig. 11). These results indicate that individuals in good habitat had a much slower decline in survival as climatic conditions deteriorated than did individuals in poorer habitats. Thus, high habitat quality, as defined in this study, buffered the survival of territory occupants from the negative effects of climate. Aspects of habitat quality that buffered apparent survival were the habitat covariates LSOEDG ($\log_e$ transform of SOEDG) and SODIS, both of which describe patch configurations of mature and old-growth forest. In addition, predicted estimates of survival had $\tilde{\sigma}^2_{\mathrm{temporal}} = 0.0005$ for ''good'' habitat, $\tilde{\sigma}^2_{\mathrm{temporal}} = 0.0029$ for ''medium'' habitat, and $\tilde{\sigma}^2_{\mathrm{temporal}} = 0.0053$ for ''poor'' habitat. Thus, survival in ''poor'' habitat varied more than 10 times as much as survival in ''good'' habitat under the same conditions.

The best approximating model for reproductive output, $\{R_{\mathrm{a2'}+P_L^2+\mathrm{LSOCOR}+\mathrm{LSOEDG}+\mathrm{SONP}+(\mathrm{SONP})^2}\}$, was an additive model that included both climate and habitat covariates (Table 12). Based on the best approximating model, interactions between the climate and habitat covariates were not supported by the data. Based on Akaike weights, model $\{R_{\mathrm{a2'}+P_L^2+\mathrm{LSOCOR}+\mathrm{LSOEDG}+\mathrm{SONP}+(\mathrm{SONP})^2}\}$ was more than twice as likely as the next ranked model, which included interactions between the climate covariates and the habitat covariate LSOCOR (the $\log_e$ transform of SOCOR) (Table 12). The selection of model $\{R_{\mathrm{a2'}+P_L^2+\mathrm{LSOCOR}+\mathrm{LSOEDG}+\mathrm{SONP}+(\mathrm{SONP})^2}\}$ suggested that reproductive output of individuals was similarly affected by climate changes, regardless of the quality of the habitats they occupied. In other words, if habitat were classified similar to Fig. 11, then slopes of the three lines would be parallel for reproductive output and would differ by the slope parameter for P_L^2 (Table 13).

Discussion

Magnitude of temporal process variation in life history traits

Based on coefficients of temporal process variation, survival of adult Northern Spotted Owls varied the least, whereas recruitment varied the most, >15 times more than adult survival. In a variable environment, Northern Spotted Owls appear to follow a pattern in life history traits in which (1) adult survival is high with low temporal variation, (2) recruitment is low with high temporal variation, and (3) survival of territory holders and recruitment into the territorial population appear to be negatively correlated. Variation in reproductive output was intermediate between survival and recruitment, and was characterized more by infrequent catastrophes than by regular rises and falls in rates, such as in recruitment. Such a pattern suggested that spotted owls may employ a life history strategy similar to ''bet hedging,'' by which selection favors adult survival at the expense of present fecundity when the recruitment of offspring is unpredictable from year to year (Stearns 1976). This strategy does not necessarily impose a cost of reproduction when negative correlations exist between survival and recruitment, based on simulations by Benton and Grant (1996). However, the negative correlation in our study includes both process and sampling variation because of the sampling covariances between survival and recruitment estimates.

At least six scenarios underlie the bet-hedging tactic (Boyce 1988), and application of the observed pattern in Northern Spotted Owls to any one of these scenarios (or other patterns in life history traits) is premature without additional work. In a broad sense, the life history pattern exhibited by this owl does follow the trend of increased iteroparity in response to environmental stochasticity (Orzack and Tuljapurkar 1989), in which a long reproductive life-span allows for some eventual recruitment of offspring even if that recruitment does not occur each year.

Role of climatic variation in temporal process variation of life history traits

After accounting for sampling and demographic variation, climate explained almost all of the temporal process variation observed in the life history traits estimated for Northern Spotted Owls. This suggested that temporal variation in these populations may be driven primarily by annual variation in climate. The lack of sex and age effects within years was consistent with previous analyses of these data (Franklin et al. 1996*b*). The climate models developed here have the advantage of being empirically based, with good statistical rigor. However, the complexity of these models depended on the amount of available data and the observed climatic variation during the study. We expect that future parsimonious models will support additional climatic covariates with additional years of study. Therefore, the climate models that we developed to describe environmental variation here should be considered first approximations.

The climate models that we described do not demonstrate cause and effect. Unfortunately, neither the climate models nor the effects that they describe can be adequately tested with experiments because of the uncontrollable nature of climatic variation. Model validation is possible only through additional observations within the Klamath province of the Pacific Northwest, or by using a similar approach in other study areas. This also makes it difficult to test forecasts of the model back in time; no adequate estimates of reproductive output exist for northern California prior to 1983, and survival probabilities and recruitment rates were not estimated prior to this study. With additional years of data, we predict that the form of the climate models may change, as well as the importance of some of the covariates.

Based on the climate models selected, the period when life history traits for Northern Spotted Owls are generally affected by climate is during the spring rather than the winter. In terms of energetic costs, owls have their highest daily energy expenditures during the breeding season rather than the winter (Wijnandts 1984, Meczewa 1986). A plausible mechanism during this energetically stressful period is that precipitation may decrease hunting efficiency, prey activity, and prey populations, as we proposed during the formulation of the models that were ultimately selected as explanations of climatic variation. Extreme climate conditions during the early nesting period may exacerbate an energetic stress on an individual by decreasing its time to starvation. At a body mass of 550–650 g (Blakesley et al. 1990), Northern Spotted Owls would reach starvation levels, about 25% of their body mass (Handrich et al. 1993), within about 8 d at maintenance metabolic rates (based on an allometric equation in Kirkwood 1981). This rate is similar to those observed for captive Barn Owls, *Tyto alba* (Handrich et al. 1993). As energetic stress due to reproductive effort is added to maintenance metabolic rates, time to starvation will decrease and, hence, will increase the potential for lowered survival probabilities. In several other species of raptors, extremes in precipitation affect reproductive output, after young have hatched, by preventing efficient foraging by adults, reducing prey supplies, and causing direct mortality of young through chilling (Schipper 1979, Davis and Newton 1981, Village 1986, Mearns and Newton 1988, Kostrzewa and Kostrzewa 1990). These are the same mechanisms that were proposed for our hypothesized climate model, which was selected as the most appropriate model. However, we have the least confidence in the ability of the selected climate model to explain variation in reproductive output, because of the lack of additional extreme values and the absence of positive extreme values (e.g., very high reproductive output). Although the selected model may adequately explain negative effects of climate, this model does not encompass unknown climate effects that positively affect reproductive output.

The winter period was only important for explaining variation in recruitment. The negative effects of winter precipitation may have resulted through impacts on survival of young experiencing their first year of independence. The positive relationship of recruitment with spring precipitation supported the prediction that factors negatively affecting survival of territory holders would positively affect recruitment if floaters were present in sufficient numbers in the population; floaters would fill immediate vacancies resulting from the deaths of territory holders.

Long-term consequences of climatic variation on population growth and stability

The pattern of variation in rates of population change under the 30-yr climate trace suggested that Northern Spotted Owl populations may experience periods of decline caused solely by climatic variation. However, the inferences that we made here are relevant only if conditions other than climate remain the same as when the models were developed. Inferences here do not include what will occur, regardless of changes in other conditions that may affect Northern Spotted Owl populations. Thus, even if habitat conditions remain unchanged, Northern Spotted Owl populations may experience declines. Whether or not these long periods of decline would lead to extinction is unknown.

Despite the highly variable nature of recruitment, estimates of rates of population change have very low coefficients of temporal process variation. Recruitment may be the dynamic that controls Northern Spotted Owl populations, because of its highly variable nature. Noon and Biles (1990) and Lande (1991) found λ estimated for Northern Spotted Owls with deterministic, empirically based matrix models to be highly sensitive to small changes in adult survival. However, this type of model sensitivity does not necessarily imply that survival contributes much to variation in rates of population change (Boyce 1994) and, hence, to population dynamics. We argue that rates of population change in Northern Spotted Owls are at least as sensitive to recruitment as to survival, in the presence of temporal variation. Survival of $\geq$1-yr-olds exhibits little temporal process variation and, thus, sets the relative magnitude for rates of population change (e.g., λ can never be less than the $\geq$1-yr-old survival rate in Eq. 21). In this study, variation at or above the baseline value of λ set by $\geq$1-yr-old survival is determined by recruitment rates. Therefore, variation in recruitment determines the variation in λ above its relative magnitude set by $\geq$1-yr-old survival. For this reason, rates of population change were more correlated with recruitment in forecasts with the 30-yr climate trace than with $\geq$1-yr-old survival. If certain long-term climate trends can cause negative rates of population change, as suggested in this study, then climatic variation has the potential to negatively affect Northern Spotted Owl populations, even if no further habitat loss occurs. Thus, we conclude that temporal variation, as influenced by climate, is an additional factor to strongly consider in developing conservation strategies.

Most conservation plans for the Northern Spotted Owl assume that their overall population will decline from habitat loss and then stabilize as habitat amount eventually stabilizes (Gutiérrez et al. 1996). However, as populations decrease in size, the effects of catastrophes on life history traits will gain increasing importance in determining rates of population change. Catastrophic events can be characterized as density-independent, physical catastrophes (Boyce 1984) that may reduce the number of territorial holders in an unpredictable manner. The extent to which these catastrophic events in parameters affect the population as a whole is dependent on population size, spatial distribution, and regulatory mechanisms (Mangel and Tier 1993). In addition, climatic conditions that will catastrophically affect all parameters simultaneously over several years will occur with some unknown probability at some unpredictable time. Such a ''megacatastrophe'' will have a much stronger impact on a reduced population (Lande 1993).

Effects of landscape habitat characteristics on life history traits

There are many levels of uncertainty in the estimates of survival, reproductive output, and, hence, habitat fitness potential. First, there is model uncertainty, which was expressed in terms of the Akaike weights. Whenever a model is developed from empirical data, there is uncertainty as to whether the model selected is indeed the best model. Second, there was some data dredging used to select a best approximating model for both survival and reproductive output. However, data dredging here was limited, and was closer to the a priori approach rather than an approach based on unlimited data exploration. Third, there is the issue of scale. These results are scale dependent in both habitat and landscape extent. In terms of habitat within a territory scale, scale is relevant only to discrete habitat patches and not to within-patch variation. In addition, landscape extent in this study is limited to the territory scale and not to larger or smaller scales. Therefore, differences (or lack thereof) can only be attributed to the territory scale. Other scales such as a home range scale or cluster of territories may produce different results and should be appropriately analyzed. Fourth, there is uncertainty in the classifications of habitats and their distribution (see also Mowrer et al. 1996). Although we were able to classify Northern Spotted Owl habitat with a high level of certainty, we were unable to classify other habitats well. In addition, we were unable to determine whether estimated habitat patch configurations accurately matched those existing on the ground.

Although these levels of uncertainty do not negate the results of this study, our results should be considered more as working hypotheses from an observational study that require further experimental verification. Clearly, part of the value of this work is in reducing the number of potential landscape configurations that might affect Northern Spotted Owls in this area to a small subset, which then can form the basis of field experiments.

The habitat covariates in the best approximating models for apparent survival and reproductive output explained a large proportion of spatial process variation in these two life history traits. The best approximating models explaining variation in both apparent survival and reproductive output contained two covariates in common: the amount of core spotted owl habitat and the amount of edge between spotted owl and other habitats. However, the relationship between these two life history traits was reversed with respect to the amount of core spotted owl habitat; apparent survival was positively associated with the amount of core habitat, whereas reproductive output was negatively associated with core habitat. However, both life history traits were positively associated with the amount of edge between spotted owl and other habitats. In addition, the models relating habitat to both survival and reproductive output were strongly sensitive to the amount of edge.

Apparent survival among territories appeared to vary little in terms of spatial process variation. There may be several reasons for this low variation in survival among territories. First, high sampling variation of among-territory estimates increased the uncertainty in estimating process variation, even though some extremes (survival below 0.80) were noted on certain territories. Second, Northern Spotted Owls may only select a territory to defend that will promote high survival (T. Shenk, *personal communication*). Hunter et al. (1995) found that, at the territory scale of this study, areas used for nesting and roosting by Northern Spotted Owls in our study area contained larger amounts of mature and old-growth forests than did random areas. Thus, an owl has the following options: it defends an area that contains sufficient mature and old-growth forest to maintain high survival, it does not bother defending a territory, it disperses, or it dies. Once the owl selects a territory to defend, variation in its expected survival rate should be low if the habitat is of sufficient quality. We call this the ''all-or-nothing defense'' hypothesis. Our surveys included only owls exhibiting territorial behavior; hence, we estimated survival only for territorial individuals. Owls that did not acquire territories were not included in the sample because they were rarely found.

The spatial process variation in reproductive output among spotted owl territories was large compared with variation in survival. Reproductive output was dependent on a high degree of spotted owl habitat edge, a low amount of core area, and either few or many patches of spotted owl habitat. Although a high degree of spotted owl habitat edge implies large amounts of spotted owl habitat within a finite territory size, the requisite amount of edge can be also be achieved with minimal amounts of interior spotted owl habitat and numerous small patches or a highly convoluted single patch that minimizes the amount of interior habitat. However, low amounts of spotted owl habitat within a territory will not supply the high degree of edge predicted to support high reproductive output.

Gutiérrez (1985) outlined four hypotheses as alternative explanations for why Northern Spotted Owls require mature and old-growth forests, three of which are relevant to the ''all-or-nothing'' defense hypothesis: predation, thermoregulation, and sufficiency of prey. The predation hypothesis suggests that mature and old-growth forests provide sufficient cover for spotted owls to avoid predation from other avian predators such as Great Horned Owls, which are a primary predator of Northern Spotted Owls (Johnson 1992). Carey et al.

(1992) found densities of Great Horned Owls encountered near Northern Spotted Owls to be highest in the mixed-conifer forests of the Klamath Mountains province in southern Oregon. Great Horned Owls hunt primarily using vision (Johnsgard 1988) and probably lack the auditory morphology used by spotted owls to hunt effectively by sound alone in a vertically structured habitat such as mature and old-growth forests (see Volman and Konishi 1990). Therefore, Northern Spotted Owls may use areas of mature and old-growth forests that are not useable by Great Horned Owls, thus minimizing their risk of predation.

Under the thermoregulation hypothesis, mature and old-growth forests provide a more stable microclimate, and the complex vertical structure of these forests provides protection from inclement weather (Forsman et al. 1984, Ting 1998).

Under the prey hypothesis, mature and old-growth forests provide an abundant and accessible source of prey not available in other habitats. However, the primary prey species of Northern Spotted Owls in this study area is the dusky-footed woodrat (*Neotoma fuscipes*), which is most abundant in brush areas that are inaccessible to the owl, and has low abundance in mature and old-growth forests (Sakai and Noon 1993). Another important prey item, the northern flying squirrel (*Glaucomys sabrinus*), achieves high densities in both mid- and late-seral stage forests in northeastern California (Waters and Zabel 1995) and southern Oregon (Carey et al. 1992, Rosenberg and Anthony 1992). Northern flying squirrels have about one-half of the biomass of woodrats (Ward et al. 1998), and owls eating a high proportion of woodrats have smaller home ranges than those eating flying squirrels (Zabel et al. 1995). In addition, spotted owls in the Klamath Mountains province hunt along edges of mature and old-growth forests (Zabel et al. 1995). Ward et al. (1998) suggested that some degree of fragmentation within their territories may provide an energetic benefit to the owls; Northern Spotted Owls in California first selected dusky-footed woodrats over other species, and then selected foraging areas near ecotones between late- and early-seral forests where woodrats were both abundant and accessible. Our results corroborate this. Woodrats are probably more accessible at ecotones because of their lateral nocturnal movements from early-seral stages and other vegetation types with dense understories to late-seral stages with more open understories (Sakai and Noon 1997). By remaining within late-seral stage forests at these ecotones, spotted owls may avoid predation by Great Horned Owls while gaining access to prey in the ecotones (Zabel et al. 1995). Thus, sufficient core area interspersed with other vegetation types may provide protection from predators while offering a source of large, accessible prey. In addition, White (1996) found that owls on our study area that successfully fledged young ate significantly more large prey (mostly woodrats) than did unsuccessful owls. Thus, there appears to be a direct link from landscape habitat configuration, to the ability of owls to successfully capture large prey, to reproductive output. Here, we were able to establish a link between landscape habitat configuration on individual territories and survival and reproductive output of owls. This link seems plausible, based on interactions among owls, woodrats, and the juxtaposition of habitats supporting both.

At some level, all three of the hypotheses outlined by Gutiérrez (1985) probably account for the use of mature and old-growth forests by spotted owls, and also support the ''all-or-nothing defense'' hypothesis. For example, the presence of sufficient core habitat may allow Northern Spotted Owls to actively defend an area while avoiding predation, whereas sufficient edge may provide foraging opportunities where prey are both abundant and accessible. The age effect seen in both survival and reproductive output may be due to differences in the ability of the two age classes to survive (such as experience or hunting ability), and physiological differences in terms of reproduction, rather than differences in habitat. Interactions between age of the owls and habitat were not supported by the best approximating model; apparently, younger birds were not necessarily relegated to poorer habitat that lowered their potential for survival.

Effects of landscape habitat on fitness

Estimates of habitat fitness potential are female-based and a territory must necessarily be occupied by a pair in order for habitat fitness potential to be realized. Territory occupancy is best estimated where detectability of birds can be modeled, such as in a capture–recapture framework. We were unable to estimate occupancy because detectability, territory abandonment, and territory reoccupation were all confounded. Although ad hoc estimators could be used, we chose not to do this because such estimators ignore detectability.

There appears to be a dichotomy between the effects of landscape habitat characteristics on survival and on reproductive output. Survival seems positively associated with some level of interior mature and old-growth coniferous forest and the edge between those forests and other vegetation types, whereas reproductive output is enhanced by convoluted edge with little interior habitat. Thus, there is evidently a trade-off in potential need for interior habitat and potential need for ecotones within a territory. This trade-off was expressed in estimates of habitat fitness potential in Northern Spotted Owls, where high fitness balanced having both core owl habitat for maintaining high survival and having some mosaic of older forest and other vegetation types for maximizing reproduction and maintaining high survival. This mosaic was expressed as small patches of other vegetation types with convoluted edges, dispersed within and around a main patch of mature and old-growth forest (Fig. 10). Examining the effects of just one of the components of habitat fitness potential as a surrogate for fitness would be misleading. A landscape pattern within a territory that promotes either high survival or high fecundity alone does not necessarily promote high fitness (Fig. 10). McGraw and Caswell (1996) found a similar problem in relating lifetime reproductive output with individual fitness of the European Sparrowhawk (*Accipiter nisus*); lifetime reproductive output was a poor surrogate for fitness.

Based on differences in estimates of spatial process variation, habitat-related variation in fecundity is probably most responsible for variation in fitness. Reproductive output had much higher spatial variation than did survival. However, this qualitative assessment is tempered by the fact that Leslie matrix models, such as those used here to estimate fitness, tend to be most sensitive to changes in adult survival (Noon and Biles 1990). Low spatial variation in survival can still have large effects on estimates of fitness because the matrix model used to estimate habitat fitness potential tends to be sensitive to small changes in adult survival (Noon and Biles 1990). The high positive correlation between point estimates of survival and habitat fitness potential suggests that changes in habitat fitness potential were tracking smaller changes in survival.

Thus, we propose that, once a territory with suitable habitat characteristics is selected for defense, individuals enjoy high survival. The quality of that territory then determines the reproductive output of individuals. Habitat fitness potential is then determined more by within-territory landscape configurations that control reproductive output than by survival rates, as long as the landscape configuration controlling survival remains intact.

Forest fragmentation and fitness

In conservation biology, forest fragmentation generally has a negative connotation, especially with respect to potentially interior forest species such as the Northern Spotted Owl (Wiens 1994). In the early years of wildlife management, edge (and hence fragmentation) was often promoted as generally beneficial for wildlife (Yoakum and Dasmann 1971). Fragmentation can be beneficial for populations of some species and deleterious for others. Andrén (1992) found that densities of five sympatric species of corvids differed along a gradient of landscape fragmentation; differing degrees of fragmentation were beneficial to some species but not to others. Other organisms appear to react little to fragmentation at different scales (Beyer et al. 1996, Johannesen and Ims 1996).

The mosaics of older forest and other vegetation types that we observed on spotted owl territories resulted from human-caused (e.g., logging) and natural disturbances (e.g., fire), as well as edaphic and topographic factors. Heterogeneity of vegetation types within spotted owl territories in the Klamath Mountains province has been determined by both past and present landscape disturbances. Past disturbances were governed primarily by wildfires, and present disturbances by logging. Thus, our measures of fragmentation do not strictly conform to the definition of Wiens (1989*b*) for habitat fragmentation, because the mosaics that we observed were not entirely due to conversion of continuous habitat into smaller patches through some disturbance process. Although edge between mature and old-growth forest and other vegetation types appeared to be a key habitat component, we emphasize that this component is still poorly understood because of our inability to discriminate among other vegetation types. For example, edge, as we measured it, could represent ecotones with a clearcut from logging, or an oak forest resulting from edaphic conditions.

Two key questions are (1) to what degree are the mosaics observed in Northern Spotted Owl territories having a high habitat fitness potential due to fine-scale fragmentation of mature and old-growth forest from disturbance; and (2) can logging practices mimic this fine-scale fragmentation? Current logging practices probably do not generate the type of mosaic that we observed in high-fitness territories; clear-cut logging leaves large, regularly shaped patches with clean edges. Fire disturbance, on the other hand, tends to leave smaller, irregularly shaped patches having convoluted edges (see Agee 1991). In addition, fire disturbance leaves a variety of seral stages based on the frequency of low, moderate, and severe burns over time. However, it is poorly understood how fire shaped past landscape mosaics. The appearance of landscape mosaics prior to fire suppression and logging would greatly increase our ability to develop silvicultural practices that might be neutral or possibly beneficial to Northern Spotted Owls in the Klamath Mountains province. In addition, our definition of edge needs to be further examined in terms of which seral stages adjacent to mature and old-growth forest most strongly affect spotted owl reproduction.

Are Northern Spotted Owls ideal-free or ideal-despotic?

The presence of spatial process variation among habitat fitness potentials estimated for individual territories suggested that Northern Spotted Owls follow an ideal-despotic distribution. Although the coefficient of spatial process variation for habitat fitness potential was small (5%), spatial process variation in habitat fitness potential differed from zero and there was a clear gradient in habitat fitness potential. However, extremes were not great in terms of relative magnitude. Unfortunately, no other studies have directly estimated habitat fitness potential for a species with a life history similar to that of the Northern Spotted Owl. The closest was McGraw and Caswell (1996), who estimated individual fitness for European Sparrowhawks, which ranged from 0.75 to 3.00. However, these estimates of fitness were on an individual basis rather than a habitat basis, and comparisons with our estimates are difficult. If reproductive output is considered the primary driving force in defining habitat fitness potential, then the larger spatial process variation in reproductive output could be considered sufficient evidence that Northern Spotted Owls follow an ideal-despotic distribution. The possibility also exists that habitat fitness potential has been reduced on spotted owl territories because of past changes in the landscape caused by logging. To assess this possibility requires examination of the patch characteristics on territories with different estimated habitat fitness potentials, e.g., assessing the source and timing of disturbance that created other habitats within the mature and old-growth forest matrix.

An ideal-despotic distribution suggests that there is a source–sink relationship among Northern Spotted Owl territories. Territories with habitat fitness potentials >1 act as sources of recruits, whereas territories with habitat fitness potentials <1 act as sinks, in that birth rates by individuals in those territories do not compensate for mortality (Pulliam 1988). However, source–sink models are usually based on discrete habitats. Northern Spotted Owls, and probably a number of other species as well, seem to follow a continuous gradient of habitat quality in which territories may be considered sources at one end of the gradient and sinks at the other end with a number of territories in between that can be relative sources or sinks, or simply balance birth and death rates with $\lambda_H \approx 1$. Regardless, territories at one end of the spectrum are those that contribute surplus recruits to the population, whereas those at the other end may act as sinks if occupied on a regular basis.

An important but unresolved question is: how does habitat fitness potential, λ_H, relate to the overall population rate of change (λ)? If a 1:1 correspondence is assumed, the weighted average of habitat fitness potential that we estimated would be a measure of the overall population rate of change in the absence of temporal variation. In this study, the estimate of λ would be 1.075, the weighted mean of λ_H, which indicates a growing population. On the other hand, the rate of population change estimated using more conventional means was $\hat{\lambda} = 1.009$, which indicates that this same population was stationary over the same time period. The reason for the discrepancy between the two estimates is due to occupancy. For λ_H and λ to be roughly equivalent, all territories need to be occupied. Therefore, to understand the relationship between λ_H and λ, some measure of occupancy on territories needs to be included in some function that also includes λ_H. Such a function might be simply $\lambda = (\lambda_H)(p_o)$, where p_o is some measure of occupancy. However, as discussed previously, we were unable to estimate occupancy appropriately.

Although theoretical models have been developed integrating ideal-free and ideal-despotic distributions with source–sink dynamics (Pulliam and Danielson 1991), they include only discrete habitats and use only reproductive success as a measure of habitat quality. Thus, these models need to be extended to include continuous gradients of habitat quality and estimates of survival.

Sources of variation in Northern Spotted Owl populations

Based on estimated total process variation, apparent survival varied the least, whereas reproductive output varied the most during this study. Two factors, climate and habitat, appeared to have the greatest effect on these two life history traits. However, the effects of these two factors were not similar on apparent survival and reproductive output. Apparent survival exhibited more spatial variation than temporal variation, whereas temporal and spatial variation contributed about equally to total observed variation in reproductive output. Based on our results, spatial and temporal variation appeared to operate independently on reproductive output because of the lack of interaction between climate and habitat covariates. Habitat quality did not appear to buffer the effects of climatic variation on reproductive output of individuals. In other words, temporal variation in reproductive output would be similar if habitat quality were uniformly ''good'' or uniformly ''bad'' among territories. However, temporal and spatial variation did not appear to be independent in their effects on survival, based on the interactions between the climate covariates and the habitat covariates, edge between mature and old-growth forest, and distance between patches of these forests. As habitat quality decreased, the effects of climatic variation on survival increased.

One source of variation that we did not consider was individual variation, which is a function of phenotypic or genotypic differences among individuals (White 2000). Although age effects were accounted for in the models, they contributed little in explaining total process variation. In reality, age effects probably account for little in terms of individual variation, which is more related to individual fitness. A better expression of individual variation would be variation in true individual fitness, those individuals genetically predisposed to surviving better and producing more offspring and, hence, contributing more to future generations. If an ideal-despotic distribution were operating in spotted owls, then habitat quality, as defined by habitat fitness potential, was probably confounded with individual fitness. Individuals with higher intrinsic fitness would be more competitive (despotic) and able to garner the best resources to ensure that their fitness was realized. Partitioning individual fitness from habitat fitness potential requires identification of genetic or phenotypic traits to allow for separation of individual fitness from fitness bestowed on individuals by habitat quality.

Climatic variation and habitat quality

For apparent survival, the best approximating model included interactions between climate and habitat covariates (SOEDG and SODIS) that described the mosaic of mature and old-growth forests and other vegetation types. There appears to be an optimal type of mosaic that defines high-quality spotted owl habitat. In the face of climatic variation, these areas may also provide a more stable prey base by providing more distinct patches of prey populations and, possibly, greater prey diversity if other habitats are a mosaic of different seral stages. Radio-marked Northern Spotted Owls traverse their home ranges less, and hence expend less energy, in areas of older forest mixed with different seral stages than do owls in areas with similar amounts of older forest mixed with clearcuts (Carey and Peeler 1995). The period when climatic variation affects spotted owls is during the early breeding season, when energetic stress is high. Increased movements would only add to an already stressed energetic burden. In addition, spotted owls may exhaust patches of prey through repeated visits (Carey et al. 1992). Thus, dispersed patches of different vegetation types and seral stages within a matrix of mature and old-growth forest may provide a stable prey resource that buffers against the effects of climate on prey populations and, hence, spotted owls. Although speculative, this argument suggests a link in the interaction of climate and habitat quality, with prey abundance and availability as a potential mechanism behind that interaction. This also suggests that habitat maintenance is essential at landscape scales because excessive loss of key landscape habitat components, such as mature and old-growth forest, can exacerbate the effects of unfavorable climatic conditions on survival.

The best approximating model for reproductive output does not support any interactions between climate and habitat covariates. Climate affects reproductive output during the late breeding season. We surmise that climatic effects during this period could inhibit prey populations or the ability of parents to capture prey for their offspring, or could cause direct mortality of young owls. The lack of interaction between climate and habitat supports the idea that increased precipitation during the late breeding season may directly affect survival of young outs before they fledge and are counted during surveys. However, we cannot discount the possibility that, although these particular data during this time period did not support climate–habitat interactions, they might have been present given a longer time period.

Implications for Northern Spotted Owl population dynamics

Dennis and Taper (1994) and Turchin (1995) define a regulated population as one with a long-term stationary probability distribution of population densities. This definition implies some mean level of density around which a regulated population fluctuates with some bounded variance (Turchin 1995). Thus, this definition of a regulated population can be rephrased in terms of rates of population change (λ) as *a population with a long-term mean* λ *of one* ($\bar{\lambda} = 1$) *that follows some probability distribution with variance* σ^2_λ. From this, limitation can be defined as the process that sets long-term $\bar{\lambda} = 1$, and regulation as the process that maintains the population at $\bar{\lambda} = 1$ within σ^2_λ. Density dependence can then be viewed as the dependence of population rates of change on past and/or present population densities (Murdoch and Walde 1989). We were only able to speculate about the role of density-dependent factors with respect to Northern Spotted Owl populations. We did not incorporate density into our analyses, largely because of the problems in detecting density dependence from only 10 yr of field data (see Shenk 1997). The following discussion attempts to integrate simple population dynamics with our empirical evidence on life history traits, their process variation influenced by climate and habitat variation, and their relationship to population rates of change.

Based on estimates of apparent survival and recruitment, the spotted owl population in this study appeared to be stationary ($\bar{\lambda} \approx 1$) during the 10-yr study period. This population was stationary under fluctuating climate conditions and habitat quality that varied spatially, but varied little over time. The stationary nature of the study population suggested that this population was regulated. In addition, temporal process variation in λ for this population was low, suggesting little variation around $\bar{\lambda}$. This evidence suggested a well-regulated population, which may be typical of bird populations (Murdoch 1994), especially raptor populations (Newton 1989*c*).

Habitat may proximally limit spotted owl populations in northwestern California. Here, we use the term *habitat* in reference to the landscape configurations of mature and old-growth forests at the territory scale, which collectively defined the life history traits and habitat fitness potential. Ultimately, the abundance and availability of prey within spotted owl habitat may limit populations, because the habitat covariates most closely associated with survival and reproduction are best explained in terms of prey abundance and availability. Lack (1954, 1966) argues that food supply ultimately limits avian populations. Newton (1980) extends this argument to limitation in raptor populations. Field experiments using food supplementation of raptors support this argument in terms of reproductive output, which increases with increasing available food (Ward and Kennedy 1996, Wiehn and Korpimäki 1997). Unfortunately, empirical evidence is scant concerning the effects of food supply on survival of territory holders. If habitat configurations within Northern Spotted Owl territories are limiting, then both survival and fecundity may be density dependent *if* habitat selection is density dependent, as suggested by an ideal-despotic distribution in spotted owls (Morris 1989). However, this idea needs further empirical examination.

Previously, we argued that survival of territorial individuals determines the magnitude of λ in Northern Spotted Owls, whereas recruitment determines temporal variation in λ above the relative magnitude set by survival. In terms of total process variation, survival varied little, relative to reproductive output, over the course of this study. However, most of the variation in survival was based on habitat variation, whereas variation in reproductive output was based equally on climatic and habitat variation. By affecting apparent survival, habitat quality may determine the magnitude of λ, whereas reproductive output and recruitment may determine variation around λ. If habitat conditions remain unchanged, then density-dependent factors (habitat) control the magnitude of λ, and combined density-independent (climate) and density-dependent factors (habitat) control the variation around λ. However, if habitat conditions change, e.g., from less ''good'' habitat to more ''poor'' habitat, then density-independent factors influence the variation in survival and, hence, variation around λ. In other words, as habitat quality decreases, density-independent factors become more important in determining variation around λ. Thus, there is probably some range of habitat quality where $\bar{\lambda}$ will remain at 1 but variation around $\bar{\lambda}$ will increase. Theoretically, an increase in variation around $\bar{\lambda}$, with a greater proportion of this variation caused by climate, will increase the probability of extinction (Lande 1993). At some point, lower habitat quality will cause the population to be unregulated (i.e., $\bar{\lambda} < 1$), and it will decline, eventually to extinction.

The argument as to whether a single general factor, such as habitat quality or climate, regulates or limits populations becomes moot when interactions are considered (Holmes 1995). These two factors can increase or decrease in importance, depending on changes in the other factor. We believe that understanding the magnitude, strength, and relative importance of different factors under varying conditions provides a deeper understanding of population dynamics.

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APPENDIX A

Biological Background

Biological basis for delineation of life history periods

The *winter stress period* (November–February) and the *heat stress period* (July and August) were defined based on when maximum climatic stresses occurred. The winter stress period averaged the highest precipitation and coldest temperatures during the year, whereas the heat stress period averaged the highest maximum temperatures ≥32°C (Fig. 2). The winter stress period is when female owls may develop fat reserves prior to laying eggs in the spring. Hirons (1982) observed that ovarian follicles failed to develop in Tawny Owl (*Strix aluco*) females that had insufficient fat reserves from the winter. Although individuals do not undergo stresses from rearing young and molting during this period, they may encounter stress from poor hunting conditions during extended periods of rain. Thus, climatic conditions during the winter stress period can affect reproductive output in the following spring, as well as over-winter survival. Extremely hot conditions during the heat stress period, regardless of precipitation, could negatively affect survival in fledged young and ≥1-yr-olds. Although counting of most fledged young occurs before this period, survival of fledged young during this period might affect estimates of recruitment of young birds into the territorial population the following year.

Two periods were defined in which reproduction may require additional energetic demands on individuals. The *early nesting period* (March and April) occurs when owls initiate nesting and incubate eggs, and the *late nesting period* (May) occurs when young are brooded with decreasing frequency until they fledge in late May and early June (Forsman et al. 1984). These two periods can be optimal, given appropriate conditions, for plant growth that optimizes maintenance and production of prey populations. However, severe inclement weather may affect reproductive output during these two periods. In addition, conditions during the early nesting period may affect survival of owls ≥1 yr old, because winter-like conditions can still occur. The last period we considered was the *dispersal period* in September and October, when juveniles disperse from their natal territories and first begin fending for themselves (Gutiérrez et al. 1995). This period is relevant only to recruitment, because juvenile survival affects potential recruitment of these individuals into the territorial population.

Biological basis for development of hypothesized climate models

In terms of direct effects, it is unlikely that cold temperatures alone affect survival of Northern Spotted Owls ≥1 yr old because they have plumage characteristics similar to those of boreal owl species (Barrows 1981). However, young owls have poor thermoregulatory ability while still in the nest (Howell 1964, Wijnandts 1984) and may be negatively affected by cold temperatures, especially in combination with precipitation. Conversely, Northern Spotted Owls may be prone to heat stress. They appear to have a lower upper critical temperature (25.2°C) than do Great Horned Owls, exhibiting heat stress at ~32°C under laboratory conditions and in the wild (Barrows 1981, Ganey et al. 1993).

In terms of indirect effects, precipitation combined with cold temperatures may inhibit the owls' ability to forage successfully at night when they rely primarily on hearing to locate and capture prey (Forsman et al. 1984). Although precipitation does not inhibit nocturnal movements of radio-tagged Northern Spotted Owls (Forsman 1980), it reduces the hunting success of Tawny Owls (*Strix aluco*), presumably by limiting the owls' ability to hear prey movement at night (Hirons 1982). Therefore, precipitation may not inhibit movements of owls, but may inhibit their success in capturing prey. Large prey may also limit their movements during rainy weather (Linsdale and Tevis 1951, Wells-Gosling and Heaney 1984, Gentry et al. 1966), whereas small prey may increase their activity (Gentry et al. 1966, Marten 1973, Vickery and Bider 1981, Scheibe 1984). However, small prey may decrease their activity during low ambient temperatures (Marten 1973, Vickery and Bider 1981, Scheibe 1984). We postulate that hunting success for Northern Spotted Owls is lowest during cold, rainy periods when prey activity and the hearing ability of owls are both suppressed. Hunting success determines both individual survival and reproductive success. Female owls do all of the incubation and early brooding of young, with the male providing food (Forsman et al. 1984). Nest desertion in Tawny Owls is influenced by the inability of the male to provide sufficient food for the female during bad weather (Southern 1970). Conversely, hunting success should be highest during dry, warm conditions and neutral during wet, warm or dry, cold conditions that represent trade-offs between detection ability of owls and activity of prey (Table A1).

We also postulate that (1) wet, cold conditions and severe drought conditions, in general, would negatively effect prey survival; (2) drought conditions, regardless of temperature, would negatively affect prey reproduction and plant production; and (3) only warm, wet conditions would have a positive effect on both (Table A1). Extended rainy periods increase parasitism and disease in *Neotoma* (Linsdale and Tevis 1951), whereas *Peromyscus* has reduced body mass under drought conditions (Nelson 1993). Prey reproduction can be inhibited by both drought conditions and reduced ambient temperatures, which reduce sperm production and litter size (Meyers et al. 1985, Nelson 1993) and delay breeding seasons (Sadleir 1974). Production of forage also affects successful reproduction in prey species because of increased energetic demands during breeding (Bronson 1989). In northern California, the vegetative growing season is restricted to the spring when higher temperatures coincide with adequate water supplies, which are lacking in the summer (Major 1977). Fitter et al. (1995) suggest that ambient temperature may be the most important determinant of flowering in the spring.

TABLE A1. Potential indirect effects of climate conditions on Northern Spotted Owls and their prey that were used to develop statistical models of the effects of climate on life-history traits: 0 indicates a neutral effect, − a negative effect, and + a positive effect.

Climate condition	Hunting success	Prey survival	Prey reproduction	Prey forage production	Net effect
Warm wet	0	0	+	+	+
Cold wet	−	−	−	−	−
Warm drought	+	−	−	−	−
Cold drought	0	−	−	−	−

However, lack of available water also has a direct inhibitory effect on photosynthesis (Larcher 1980). Hypogeous fungi reach higher biomass in mesic conditions (Luoma et al. 1991), whereas tanoak requires relatively high levels of moisture and mild temperatures for production, even though it is adapted to withstand drought conditions (McDonald and Tappeiner 1987). There could also be lag effects of climate on plant production, which in turn could affect spotted owl prey. Overwinter survival and density of small mammals have been positively correlated with forage production in the previous year (Watts 1969, Jensen 1982). For example, acorn production of *Quercus* oaks in California is positively associated with total precipitation during the previous growing season (Kundel 1980). Therefore, life history parameters of Northern Spotted Owls in time $t + 1$ may be indirectly affected by the growing season in time t.

APPENDIX B

A further consideration of survival models, including models with problems in identifiability of parameters, is available electronically in ESA's Electronic Data Archive: *Ecological Archives* M070-003.

NORTHWEST FOREST PLAN
THE FIRST 15 YEARS (1994–2008)

Status and Trends of Northern Spotted Owl Populations and Habitats

Raymond J. Davis, Katie M. Dugger, Shawne Mohoric, Louisa Evers, and William C. Aney

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Cover: Photo by Peter Carlson.

Preface

This report is one of a set of periodic reports produced by the Northwest Forest Plan (the Plan) interagency monitoring program. These reports attempt to answer questions about the effectiveness of the Plan using the latest monitoring methods and research results. The reports focus on establishing baseline information from 1994, when the Plan was approved, and reporting changes that have occurred since then. The series includes late-successional and old-growth forests, northern spotted owl (*Strix occidentalis caurina*) population and habitat, marbled murrelet (*Brachyramphus marmoratus*) population and habitat, watershed condition, government-to-government tribal relationships, socioeconomic conditions, and project implementation. These monitoring reports are also intended to identify potential issues and to recommend solutions for future adaptive management changes and, as noted in the first reporting cycle, to resolve information management issues that inevitably surface during these analyses.

Abstract

Davis, Raymond J.; Dugger, Katie M.; Mohoric, Shawne; Evers, Louisa; Aney, William C. 2011. Northwest Forest Plan—the first 15 years (1994–2008): status and trends of northern spotted owl populations and habitats. Gen. Tech. Rep. PNW-GTR-850. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 147 p.

This is the second in a series of periodic monitoring reports on northern spotted owl (*Strix occidentalis caurina*) population and habitat trends on federally administered lands since implementation of the Northwest Forest Plan in 1994.

Here we summarize results from a population analysis that included data from long-term demographic studies during 1985–2008. This data was analyzed separately by study area, and also in a meta-analysis across all study areas to assess temporal and spatial patterns in fecundity, apparent survival, recruitment, and annual rates of population change. Estimated rates of annual population decline ranged from 0.4 to 7.1 percent across federal study areas (weighted average of 2.8 percent). Covariates for barred owls (*Strix varia*), weather, climate, habitat, and reproductive success were analyzed and had varying degrees of association with owl demographic parameters. We now have more evidence that increasing numbers of barred owls and loss of nesting/roosting habitat contributed to demographic declines in some study areas.

We also summarize results from a habitat analysis that used the above data in conjunction with remotely sensed data from 1994 to 2007 to develop "habitat suitability" models and habitat maps. These maps were used to quantify the amount and distribution of owl habitats. We also report on causes of habitat change during this period. On federal lands, nesting/roosting habitat declined by 3.4 percent rangewide, with some physiographic provinces experiencing losses of 10 percent. Dispersal habitat increased by 5.2 percent, but dispersal-capable landscapes declined by 1 percent.

Wildfire remains the leading cause of habitat loss. We developed a rangewide "wildfire suitability" model and map to illuminate the portions of the owl's range where suitable nesting/roosting habitat overlaps with landscapes suitable for the occurrence of large wildfires.

Barred owls and management of owl habitat in fire-prone areas continue to be topics for future monitoring, research, and management consideration.

Keywords: Northwest Forest Plan, effectiveness monitoring, northern spotted owl, geographic information system, owl habitat, habitat suitability, wildfire suitability, demographic study, remote sensing, predictive model, habitat model.

Summary

For the eight federal study areas associated with the Northwest Forest Plan (the Plan) effectiveness monitoring program, the average rate of population decline was 2.8 percent per year. Strong evidence of declines in annual rates of population change were reported for five of the eight individual effectiveness monitoring area study sites, but confidence limits on point estimates for three areas in the center of the northern spotted owl (*Strix occidentalis caurina*) range (southwest Oregon) overlapped lambda = 1.0, suggesting these three populations may not be declining. Rates of population decline were highest in the northern portions of the owl's range (Washington and northern Oregon) where populations are estimated to have declined 40 to 60 percent since the Plan's implementation.

A variety of covariates including presence of barred owls (*Strix varia*), weather and long-term climate cycles, the amount of suitable nesting/roosting habitat on and adjacent to each study area, and the previous year's reproductive success, were included in the analysis of demographic data to explore associations between them and observed population trends. These covariates had varying degrees of association with owl demographic parameters, but at least one vital rate (i.e., fecundity, apparent survival, or population) was declining on all study areas.

The long-term demographic data we continue to collect are the key to understanding the range of factors that are affecting the recovery of spotted owl populations. At present, the invasion of the competitive barred owl and the amount of suitable nesting/roosting habitat are the factors most associated with spotted owl vital rates. Directly managing barred owl encroachment into spotted owl habitats may be beyond the scope of the Plan, but maintaining large blocks of suitable spotted owl habitat will likely play a key role in decreasing negative interactions between the two species and increasing the likelihood of the persistence of spotted owl populations.

On federal lands, we estimated nesting/roosting habitat losses for 1994 through 2007 in California, and 1996 through 2006 in Oregon and Washington at 3.4 percent rangewide. Although rangewide losses have not yet exceeded what was anticipated under the Plan, some physiographic provinces have incurred losses up to 10 percent. This and the fact that most of the nesting/roosting habitat loss occurred within reserved land use allocations, and not within the federal matrix outside of these reserves, raises some concern. But in spite of this paradox, the large, repetitive design of reserves appears to still be functioning as intended. Of the 12 million ac of nesting/roosting habitat remaining, 71 percent occurs on federally administered lands, and approximately 70 percent of this is in reserved land use allocations (not including riparian reserves). Over half of the nesting/roosting habitat occurs in the central (core) portions of the owl's range, within the Klamath Mountain provinces of Oregon and California (27 percent) and the western Cascades of Oregon (26 percent). Not enough time has yet elapsed for us to accurately detect or estimate any significant recruitment of nesting/roosting habitat; however, increases were observed in "marginal" (younger) forests indicating that future recruitment of nesting/roosting habitat is on track to occur, as anticipated, within the next few decades.

In addition to providing potential future nesting/roosting habitat, some younger forests function as dispersal habitat. Forest succession accounted for some dispersal habitat recruitment, especially in the more productive tree-growing portions of the range (i.e., Oregon Coast Range). Partial disturbances of nesting/roosting habitat also accounted for some of this recruitment as well. Loss of dispersal habitat, primarily from wildfires, was observed, but recruitment rates exceeded losses, resulting in a net increase in dispersal habitat of 5.2 percent (rangewide). In spite of this net gain, dispersal-capable landscapes actually decreased by 1 percent within the owl's range because of the spatial distribution of this habitat. Even with this small decrease, the network of large reserves remains fairly well connected, with the exception of the northern portion of the eastern Cascades of Washington and also within the southern tip of the range where some large reserves appear to be isolated (including the Marin County population).

Recent improvements in remotely sensed vegetation and change-detection mapping has resulted in better habitat maps to replace the baseline versions produced for the first monitoring report. Progress in habitat "niche" modeling methods and software has improved our ability to map not only habitat for spotted owls, but also "suitable habitat" for large wildfires. Wildfire remains the leading cause of owl habitat loss. About 3.6 million ac of nesting/roosting habitat remain in landscapes that are naturally prone to large wildfires. Most of this "fire-prone" habitat (85 percent) occurs within the "core" of the owl's range (i.e., the Klamath Mountains and the western Cascades of Oregon). Not all habitat burned is lost to owls, as fire intensity and frequency play a role in the effect of fire on owl habitat use. Our monitoring showed that large wildfires resulted in 30 to 62 percent loss of the nesting/roosting owl habitat within their perimeters.

Wildfire is a natural ecological process under which northern spotted owls have evolved, but the landscapes in which this occurred were heavily altered during the 20th century. Most remaining nesting/roosting habitat is now contained on federal land, and its fragmented condition makes it, and the populations that rely on it, more vulnerable to future large wildfires. Conservation management for northern spotted owls in relation to wildfire will involve understanding (1) where suitable owl habitats overlap suitable habitat for large wildfire; (2) the effect of fuel reduction treatments to reduce fire risk on owl habitat use and demographics; and (3) the relationships of fire frequency, severity, and extent with owl habitat use and demographics.

Contents

Chapter 1: Introduction and Background

Raymond J. Davis, Katie M. Dugger, and Shawne Mohoric

In 1994, the Northwest Forest Plan (referred to hereafter as the Plan) amended 19 existing Forest Service and 7 Bureau of Land Management resource management plans within the range of the northern spotted owl (*Strix occidentalis caurina*). An interagency effectiveness monitoring framework was implemented to meet requirements for tracking the status and trends for late-successional and old-growth forests, northern spotted owl populations and habitat, marbled murrelet (*Brachyramphus marmoratus*) populations and habitat, watershed condition, social and economic conditions, and tribal relationships. Monitoring results are reported at 1-year intervals and evaluated at 5-year intervals. The first regional monitoring reports roughly covered the first 10 years of Plan implementation and were documented in a series of General Technical Reports posted at http://www.fs.fed.us/pnw/publications/gtrs.shtml. The first northern spotted owl population and habitat monitoring report was produced in 2005 covering status and trends of populations up to 2003 and habitat up to 2002 (Lint 2005). This report is the second in the series of northern spotted owl effectiveness monitoring reports (Lint et al. 1999) and covers population status and trend up to 2008 and habitat status and trend up to 2007.

The goal of the northern spotted owl monitoring program is to evaluate the success of the Plan in arresting the downward trends in populations and habitats that were largely responsible for the establishment of the Plan. In part, the Plan was designed to maintain and restore habitat conditions necessary to support viable populations of the northern spotted owl on federally administered lands throughout the owl's range (fig. 1-1). The objectives for northern spotted owl effectiveness monitoring are as follows:

1. Assess changes in population trends and demographic rates of spotted owls on federal lands within the owl's range.
2. Assess changes in the amount and distribution of nesting, roosting, foraging and dispersal habitat for spotted owls on federal lands.

The first monitoring effort reporting on status and trends of northern spotted owl populations and habitat (Lint 2005) included a summary of the fourth northern spotted owl meta-analysis (Anthony et al. 2006) and produced a habitat baseline map using the latest technology and best available data at the time. This report covers the first 15 years of implementation under the Plan, including a summary of the fifth northern spotted owl population meta-analysis (Forsman et al. 2011) and the development of new habitat maps based on new vegetation data, analytical methods, and habitat modeling technologies.

Lint (2005) realized that as technology advances, there will be a need to refine or adapt old monitoring methods for new analytical approaches. With the help of leaders in the fields of statistics and wildlife demographics, the analytical methods for conducting the population meta-analysis continue to advance. Barred owl (*Strix varia*), climate, and habitat covariates were included in the latest analysis for the first time in 2009 (Forsman et al. 2011). The habitat covariates used were products from the 10-year report (Davis and Lint 2005). The inclusion of these new modeling techniques and covariates allowed us to investigate relationships between them and owl demographics for the very first time.

Likewise, the habitat analysis has evolved to incorporate new habitat modeling and forest pattern analysis software that can be used for identifying habitat conditions, characterization of change to those conditions, and the recruitment of those conditions through forest succession. Improvements were made to the vegetation data used to characterize owl habitat, including the addition of more variables for habitat modeling and analysis. Most notable, a consistent vegetation data set was produced for the entire range of the northern spotted owl, which has never been available before. This new vegetation data set replaces the two previously used data sets (IVMP and CALVEG) and, along with new modeling software, allowed us to refine the previous baseline habitat map. Therefore the baseline amounts and distribution of owl habitat reported in the 10-year report are replaced by results presented in this report.

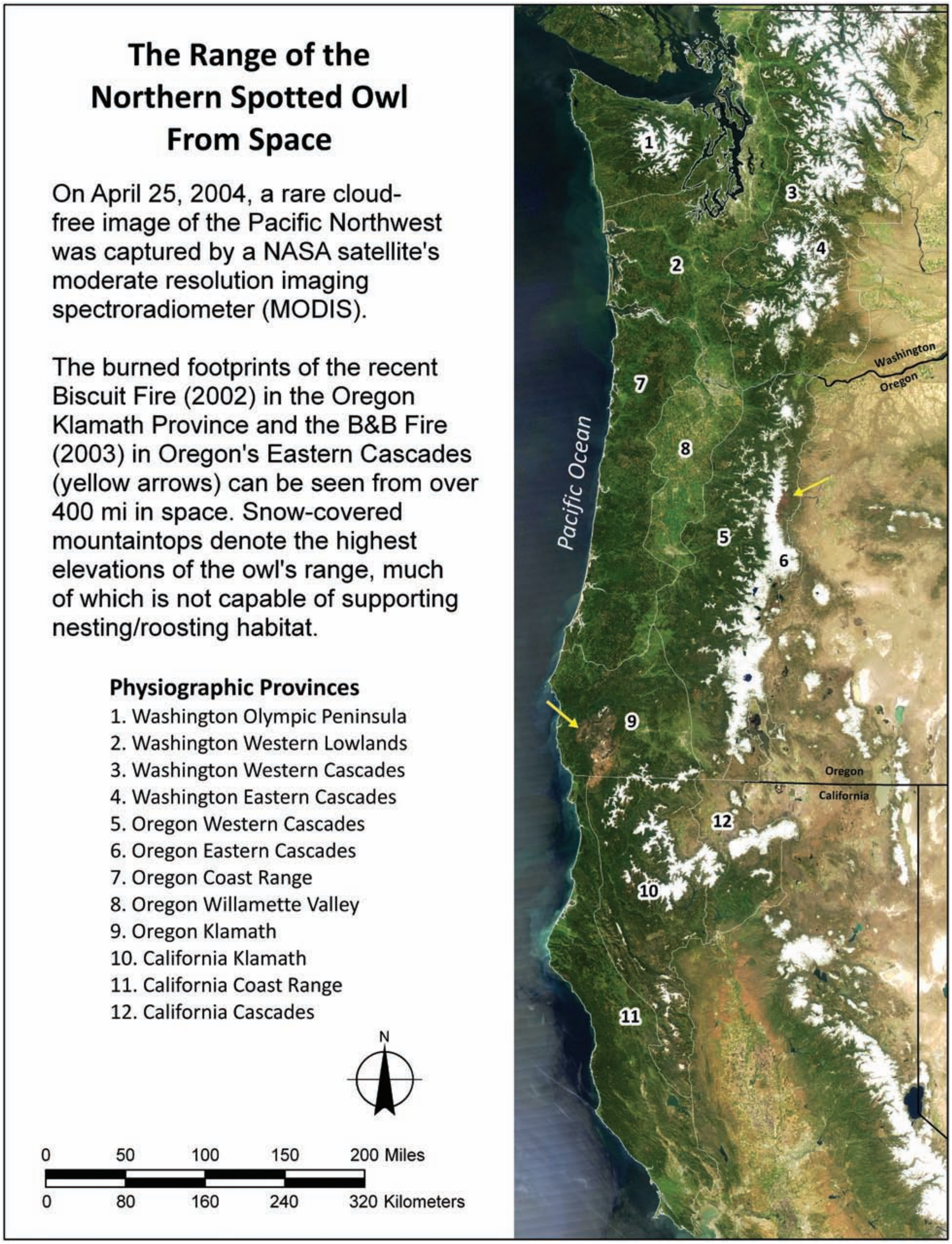

Figure 1-1—The range of the northern spotted owl. NASA = National Aeronautics Space Administration.

Improvements were also made to the remotely sensed data used for estimating habitat changes. These improvements include a finer time sequence of change-detection (annual versus 4- to 5-year intervals) and an improved ability to detect lower intensity disturbances (i.e., thinning, insects, and disease). Another improvement in our ability to detect habitat changes came from the creation of a vegetation data set that contains the same variables as the baseline data set, but for a later period. We called these vegetation data sets "bookends." Our first bookend is from 1994 in California and from 1996 in Oregon and Washington. The other bookend is from 2007 in California and from 2006 in Oregon and Washington. Therefore our habitat maps and our analysis of habitat status and trends cover the period from 1994/96 to 2006/07.

The spotted owl monitoring plan includes two phases of monitoring (Lint et al. 1999). Phase I entails demographic monitoring of individual territorial owls on eight federal study areas to estimate population demographics including survival, fecundity, and rate of population change while also tracking habitat conditions rangewide. The eight federal study areas that are part of phase I occur on federal lands administered by the U.S. Forest Service, Bureau of Land Management, and the National Park Service. They provide population trend data for a representative mix of areas considered key to the success of owl management under the Plan. The scientists who developed the monitoring plan determined that these eight study areas were the minimum number needed to be able to make scientifically credible and defensible inferences of population trends to the broader federal landscape within the owl's range (Lint et al. 1999, Mulder 1997). It is hoped that eventually the demographic monitoring data can be combined with the habitat monitoring data to develop predictive models of owl occurrence and demographic performance based on observed habitat conditions. This would allow for implementation of phase II, which increases emphasis on habitat monitoring and decreases the population monitoring to a minimum of four study areas, which would provide a means to validate the population predictions of the habitat models. Implementation of phase II depends on our ability to relate owl demography to habitat conditions such that we can relate habitat status and trends directly to population status and trends with acceptable confidence. To date, attempts to develop predictive models have had mixed results (Dugger et al. 2005, Franklin et al. 2000, Olson et al. 2004) and have generally been unsuccessful across the range of the owl; however, some progress has been made as noted above and, as technology continues to advance, this remains our goal.

After 15 years, agency managers continue to be proactive and supportive of the monitoring program. As Lint (2005) stated, this support is, "of utmost importance to the future of the effectiveness monitoring program." The Northwest Forest Plan's effectiveness monitoring program (Mulder et al. 1999) has received national and international attention (Gosselin 2009) and has been noted as the largest and most comprehensive regional forest plan monitoring ever conducted (McAlpine et al. 2007). The monitoring data created and the analysis results presented in the 10-year monitoring report have provided valuable information for managers and policymakers in making informed decisions. Examples include northern spotted owl recovery planning (USDI 2008b) and designation of critical habitat (USDI 2008a) and increased emphasis by regulatory and management agencies to reduce risk of owl habitat and old forests from high-severity fire in dry provinces (Spies et al. 2006).

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Chapter 2: Population Status and Trend

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Introduction

The collection of demography data is the foundation of the effectiveness monitoring program for northern spotted owls (*Strix occidentalis caurina*) (Lint et al. 1999), designed to monitor the effect of the Northwest Forest Plan (the Plan) on populations. Demographic surveys for spotted owls following standardized data collection protocols began on some study areas as early as 1985 (northwest California: Franklin et al. 1996a, 1996b) even before the monitoring plan was actually finalized. The first rangewide meta-analysis was conducted in 1991 (Anderson and Burnham 1992), then again in 1993 (Burnham et al. 1996), and every 5 years thereafter (1998: Franklin et al. 1999; 2004: Anthony et al. 2006; 2009: Forsman et al. 2011). This long history of owl surveys and demographic data collection represents the single largest, long-term mark-recapture data set in the world for a threatened species (Courtney et al. 2004), and these data are invaluable for monitoring spotted owls under the Plan.

The goal of the population component of the monitoring program is to determine if the Plan is arresting or slowing the declining trend in northern spotted owl populations on federally administered lands throughout the owl's range. This is accomplished with annual data collection on eight federal study areas associated with the effectiveness monitoring plan (Lint et al. 1999). For the 10-year report (Lint 2005), these eight areas and data from three other independent study areas provided relevant data to address this question on federal lands managed under the Plan (Anthony et al. 2006). After 15 years, we report results from the eight federal demographic study areas and one independent study area. These nine areas are spread throughout the owl's range (fig. 2-1) and data on owl occupancy, survival, and productivity were gathered annually from each to estimate apparent adult survival, reproduction, and annual rate of change of owl populations. Detailed results of the analyses of these data and data from two other, independent study areas within the range of the owl are reported by Forsman et al. (2011). The objectives of the most recent population status and trend meta-analysis were as follows:

- Estimate age-specific survival and fecundity rates and their sampling variances for individual study areas.
- Determine if any trends in adult female survival and fecundity exist across study areas.
- Estimate annual rates of population change (λ) and their sampling variances for individual study areas.
- Determine if the declines in apparent survival and populations, which were documented previously (Anthony et al. 2006), have continued or stabilized.
- Determine whether changes in the amount of suitable habitat, the presence of barred owls (*Strix varia*), or climate explain the observed annual variability in owl vital rates.
- Estimate components of the rate of population change, including apparent survival and recruitment rates that were not done in previous analyses (Anthony et al. 2006, Burnham et al. 1996, Franklin et al. 1999).

Data Sources and Methods

Data from eight demographic study areas in Washington, Oregon, and California were used to estimate status and trends of owl populations on federal lands (fig. 2-1). Although it is not part of the monitoring plan, data from the Rainier study area in Washington were also included because the study area occurs primarily on federal land. The two additional study areas in the latest meta-analysis are the Hoopa on tribal lands and the Green Diamond Resource study area on private timber company lands (Forsman et al. 2011). Because Hoopa and Green Diamond Resources did not include any lands managed under the Plan, they were excluded from this monitoring report, except when meta-analysis results including all 11 study areas are presented.

This monitoring report is based on nine study areas managed under the Plan that include variation in climate, vegetation, and topography and encompass most of the

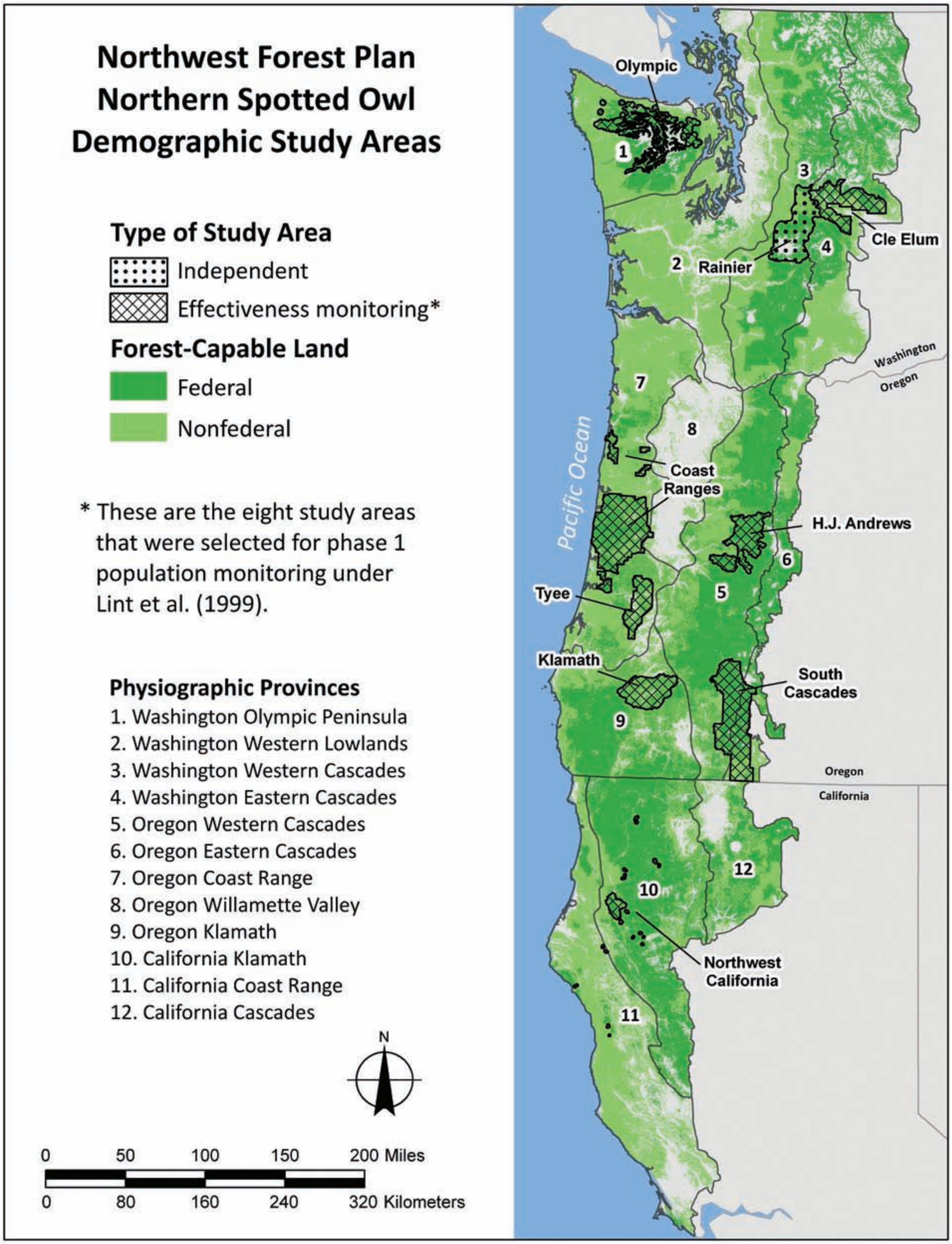

Figure 2-1—Location of nine demography study areas comprising primarily federal lands administered under the Northwest Forest Plan and included in the 2009 northern spotted owl meta-analysis. Source: Forsman et al. (2011).

northern spotted owl's geographic distribution. The forests on all study areas are dominated by conifers or mixtures of conifers and hardwoods, although there are regional differences in species composition (for more details, see Forsman et al. 2011). The nine study areas range from 396 to 1514 mi^2; the median study area size was 691 mi^2, and the mean was 829 mi^2 (table 2-1). These nine study areas encompassed 7460 mi^2 or approximately 8 percent of the owl's range, and the numbers of years included in these data sets ranged from 17 (Rainier) to 24 (Northwest California). Four of these study areas (Olympic, H.J. Andrews, South Cascades, and Northwest California) primarily comprised federal lands administered by USDA Forest Service, the USDI Bureau of Land Management, and the USDI National Park Service (table 2-1). The other five (Cle Elum, Rainier, Coast Ranges, Tyee, and Klamath) included a mixture of federal, private, and state lands intermixed in a checkerboard pattern of ownership (table 2-1).

Field Data Collection

Data on individually identifiable (i.e., banded) owls were collected from the nine demographic study areas annually. During each breeding season (March through August), multiple visits (usually > three per season) were made to owl territories to locate banded owls; confirm band numbers, sex, and age; and band any unmarked owls. In addition, the number of young produced was documented for each territorial owl, and fledglings were banded resulting in a known-age population of spotted owls on each study area. For details on the standardized field methods used to capture, mark, age, sex, and estimate productivity, see Franklin et al. (1996a). These methods resulted in complete capture histories over time of every owl banded during this study and the number of young fledged per territorial female (NYF) located each year. From these data, annual apparent survival (φ) by sex and age, annual productivity (NYF) by age, and the annual rate of population change (λ) were estimated (Forsman et al. 2011).

Data Analysis

During a 9-day period in January 2009 (9^{th} through 17^{th}), a workshop was held at Oregon State University in Corvallis, Oregon, to analyze the data from 11 study areas. This workshop was led by research scientists with internationally recognized expertise in population dynamics, statistics, and the analysis of capture-recapture data. The analyses were conducted under the direct guidance of these scientists. Consistent with the previous four workshops convened since 1991 to analyze spotted owl demographic data, all participants adopted formal protocols for error-checking data sets and for the development of a priori model sets for each parameter of interest (Anderson et al. 1999). Thus, the data were collected and prepared in a consistent manner among study areas, and there were no analyses of additional models after post hoc examination of initial results (i.e., all data sets were analyzed the same way). Detailed results from this workshop (summary presented here) are reported in Forsman et al. (2011), and these analyses represent a retrospective, observational study, which assesses the strength of association between owl vital rates and a variety of explanatory covariates rather than addressing direct cause-effect relationships.

Error Checking

Crew leaders from each study area compiled survival, fecundity, and rate of population change data sets in a consistent manner, following specific instructions provided by workshop organizers. When digital files were completed, data entry was error checked by independent members of the workshop organizing team. The capture-history files for estimation of survival and annual rate of population change were error checked by randomly drawing 10 capture histories from each study area file and comparing them to paper copies of the field data that supported each of these capture histories. Fecundity data entry was error checked in a similar way, with 10 records of reproductive success for a specified female in a given year compared to paper copies of the field data forms. If errors were found in the first round of checking, the errors were corrected and the process was repeated with another sample of 10 records. If errors were found in the second round of data checking, the entire file was returned to the crew leader and principal investigator for review and correction. This sequence of error checking and correction was continued until no errors were found

Table 2-1—Descriptions of nine demographic study areas associated with land managed under the Northwest Forest Plan

Study area	Physiographic province	Years	Land-owner class	Ecological region	Study size	Number of banded owls				Total encounters[b]
						S1[a]	S2[a]	Adults[a]	Total	
					mi²					
Washington:										
Cle Elum[c]	Eastern Cascades	1989–2008	Mixed	Washington mixed conifer	689	31	32	148	211	1,170
Rainier	Western Cascades	1992–2008	Mixed	Washington Douglas-fir	837	8	12	133	153	583
Olympic[c]	Olympic Peninsula	1990–2008	Federal	Washington Douglas-fir	861	19	32	337	388	1,510
Oregon:										
Coast Ranges[c]	Coast Ranges	1990–2008	Mixed	Oregon coastal Douglas-fir	1,514	66	97	486	649	3,306
H.J. Andrews[c]	Western Cascades	1988–2008	Federal	Oregon Cascades Douglas-fir	619	28	91	457	576	3,082
Tyee[c]	Coast Range	1990–2008	Mixed	Oregon coastal Douglas-fir	396	137	110	243	490	2,315
Klamath[c]	Klamath	1990–2008	Mixed	Oregon/California mixed conifer	549	169	134	347	650	2,800
South Cascades[c]	Western and Eastern Cascades	1991–2008	Federal	Oregon Cascades Douglas-fir	1,304	43	80	479	602	2,364
California:										
Northwest California[c]	Klamath	1985–2008	Federal	Oregon/California mixed conifer	691	114	80	280	474	2,550
Totals					7,460	615	668	2,910	4,193	19,680

[a] Age class codes indicate age at which owls were banded and became part of the mark-recapture data set: S1 = 1 year old, S2 = 2 years old, and adults ≥ 3 years old.
[b] All captures, recaptures, and resightings, excluding multiple encounters of individuals in the same year.
[c] One of eight study areas monitored under the northern spotted owl effectiveness monitoring program for the Northwest Forest Plan.
Source: adapted from Forsman et al. (2011).

in 10 randomly drawn records, although it is possible that a low level of data entry error might still persist. Copies of error-checked records and field data forms submitted to confirm these records were archived, and all crew leaders signed statements before submitting data for analysis certifying the accuracy of their data.

Estimating Survival

Cormack-Jolly-Seber open population models (CJS) (Franklin et al. 1996a, Lebreton et al. 1992) in Program MARK (White and Burnham 1999) were used to estimate apparent survival of owls each year. Because survival estimates from CJS models cannot separate losses of individuals who died from losses owing to permanent emigration, these models estimate apparent survival, which incorporates the annual site fidelity of individuals (true survival x site fidelity = apparent survival). Spotted owls show high annual site fidelity (Forsman et al. 2002), so permanent emigration does not seriously bias model estimates, and apparent survival is believed to be very close to true survival (Anthony et al. 2006, Forsman et al. 2011). The general approach used to generate survival estimates from capture-recapture data on individual study areas was as follows:

- Decide on a set of a priori models for analysis and the order in which models will be run.
- Evaluate goodness-of-fit of the data to the general CJS model and estimate an over-dispersion parameter (c-hat = $\hat{c}$) using the median c-hat approach in Program MARK.
- Use the estimated c-hat to adjust covariance matrices for over-dispersion and to obtain quasi-Akaike's information criteria ($QAIC_c$) for model selection.
- Run all models for capture probability and apparent survival developed in the pre-analysis a priori model set.
- Select appropriate models for inference based on $QAIC_c$ model selection results (Burnham and Anderson 2002).

Several covariates expected to affect survival, including age, sex, the cost of reproduction, the proportion of territories where barred owls were detected each year, and climate covariates, were also included in the analysis. The nature (positive or negative) of these effects was hypothesized a priori, and the appropriate models reflecting these effects were included in the initial model sets prior to analysis.

The meta-analysis of all 11 study areas combined was conducted in a similar fashion, but in addition to study area, time trends, the cost of reproduction, and the barred owl covariate, models also included land ownership, ecological region, latitude, climate, and habitat change.

Estimating Fecundity

All analyses of reproductive rate were based on the annual number of young produced per territorial female (NYF), but to be consistent with previous reports (Anthony et al. 2006, Forsman et al. 1996, Franklin et al. 1999), estimates from these models were presented as "fecundity," where fecundity is the average annual number of **female** young produced per female owl (NYF/2). This adjustment assumes a 1:1 sex ratio at birth, which has been supported by previous genetic analyses of blood collected from juveniles (Fleming et al. 1996). Models were developed a priori to investigate the effects of age, general time variation, a variety of time trends, the proportion of owl territories where barred owls were detected each year, and an even-odd year effect, which has previously been shown to reflect a temporal cycle in spotted owl reproduction (i.e., Anthony et al. 2006). In addition, climate and habitat covariates were included in the analysis. The general approach used to generate fecundity estimates was as follows:

- Decide on a set of a priori models for analysis and the order in which models will be run.
- Determine whether spatial variance (the random effect of territory) should be included in the modeling process.
- Use Proc Mixed in SAS (SAS Institute Inc. 2008) to fit all a priori models to the annual averages of NYF using a regression model based on a normal distribution.
- Select appropriate models for inference based on $QAIC_c$ model selection results (Burnham and Anderson 2002).

There was no consistent pattern regarding the best model for fecundity among study areas, so a nonparametric approach was used to estimate mean NYF by age class. The mean NYF was computed for each year and age class. Then these means were averaged across years within each age class. The estimated standard error was computed as the standard error of the average of the averages among years. This method gave equal weight to all years, regardless of the number of birds actually observed, and it did not force a model for changes over time.

As was done for survival, a meta-analysis of fecundity with all 11 study areas combined was conducted, and in addition to the covariates included in the individual study area analysis, land ownership, latitude, climate, and ecological region were also included. Analysis details and meta-analysis results are reported in Forsman et al. (2011).

Estimating Annual Rate of Population Change and Realized Population Change

The reparameterized Jolly-Seber method (Pradel 1996) was used to estimate annual rates of population change (λ_{RJS}) in Program MARK using capture-recapture data. A parameterization was used to generate annual estimates of λ (λ_t) for each study area, which allowed for decomposition of λ into two components, apparent survival (φ) and recruitment (f), where:

$$\lambda_t = \varphi_t + f_t$$

Apparent survival (φ_t) reflects both survival of territory holders within study areas and site fidelity at time t (year), so both death and permanent emigration are included in this parameter. Recruitment (f_t) is the number of new owls in the population at time t+1 per animal in the population at time t and reflects both individuals born on the study area that become established territory holders, and immigration of recruits from outside the study area. Thus, the estimate of λ_t accounts for all of the losses and gains in the study area populations during each year and results in minimum bias in estimation of the annual rate of population change (Anthony et al. 2006).

In addition to an analysis of annual population change for each individual study area, a meta-analysis was conducted with all 11 study areas combined, where landownership, latitude, climate and weather, and ecological region were also included. Analysis details and meta-analysis results are reported in Forsman et al. (2011).

Estimates of realized population change (Δ_t) were also computed and reflect the proportional change in estimated population size relative to population size in the initial year of analysis, and were computed following the methods of Franklin et al. (2004). On each study area, annual estimate of realized population change was calculated as:

$$\widehat{\Delta}_t = \prod_{i=x}^{t-1} \hat{\lambda}_i$$

where x was the year of the first estimated λ_t. For example, given three, year-specific lambdas of say 0.9 in 1993, 1.2 in 1994, and 0.7 in 1995, the realized population change would be 0.9 x 1.2 x 0.7 = 0.756. This value means that at the end of 1995, the population was 75.6 percent of the starting population in 1993. Thus, estimates of realized population change clearly illustrate the long-term, cumulative trends in annual population changes.

Results

The following is a summary of the demographic analysis of apparent survival, fecundity, annual rate of population change, and realized population change for the northern spotted owl reported by Forsman et al. (2011). These analyses are the most long-term and comprehensive to date across the range of the owl; however, although the 11 study areas included in this analysis covered a large portion of the owl's geographic range, they were not randomly selected. Thus, results cannot be considered representative of owl populations throughout its entire range and cannot be used to assess demographic trends on nonfederal lands because only two study areas on nonfederal lands were included in the analysis. However, Forsman et al. (2011) believed their results to be representative of most owl populations on federal lands as they include nine large study areas, with comprehensive geographic coverage and a variety of landownership and management strategies. Thus, the results from the nine study areas associated with federal land managed under the Plan can be used to make inferences to populations on those lands.

Survival

For the nine individual study areas, the number of banded owls included in the survival analysis were 615 1-year-olds, 668 2-year-olds, and 2,910 adults (>3 years old) with 19,680 total encounters across all individuals and age classes (table 2-1). The number of recaptures in this data set was 4.5 times the number of initial captures.

In general, survival was similar between sexes (except for Olympic where survival was higher for males) and higher for adults compared to subadults (table 2-2). Factors including time and time trends, the proportion of territories where barred owls were detected each year, reproductive rate (fledglings per pair) in the previous year, and weather had varying effects on survival depending on the study area. Mean annual estimates of model-averaged apparent survival of female owls ranged from 0.529 to 0.794 for 1-year-olds, 0.674 to 0.864 for 2-year-olds, and 0.819 to 0.865 for adults (≥3 years old) (table 2-2). Most notably, survival was declining on all but the Klamath study area, and in some cases, the declines occurred primarily in the last 10 years or so (Coast Ranges, H.J. Andrews, Tyee, South Cascades). Declines were most evident in Washington and strongest in the last 5 years for the Cle Elum and Rainier study areas. The Klamath study area was the only one for which no trend in survival was observed, although large amounts of annual variation in adult survival were observed (see fig. 5b in Forsman et al. 2011).

For the Rainier and Olympic study areas in Washington, survival was negatively associated with high rates of reproduction in the previous year, but this effect was not evident on any of the other study areas. In the meta-analysis

Table 2-2—Average survival rates with standard errors (SE) for female northern spotted owls by age class in the nine demographic study areas associated with land managed under the Northwest Forest Plan

		Age class					
	Landowner	1 year old		2 years old		≥3 years old	
Study area	class	Survival[a]	SE	Survival[a]	SE	Survival[a]	SE
Washington:							
Cle Elum[b]	Mixed	0.794	0.051	0.820	0.023	0.819	0.013
Rainier	Mixed	0.541	0.181	0.674	0.156	0.841	0.019
Olympic[b]	Federal	0.529	0.148	0.786	0.081	0.828	0.016
Oregon:							
Coast Ranges[b]	Mixed	0.742	0.072	0.864	0.031	0.859	0.009
H.J. Andrews[b]	Federal	0.717	0.084	0.830	0.042	0.865	0.010
Tyee[b]	Mixed	0.761	0.043	0.864	0.020	0.856	0.008
Klamath[b]	Mixed	0.788	0.040	0.858	0.020	0.848	0.008
South Cascades[b]	Federal	0.692	0.069	0.733	0.053	0.851	0.010
California:							
Northwest California[b]	Mixed	0.774	0.031	0.784	0.031	0.844	0.009

Note: See table 2-1 for data years.

[a] Average survival is the arithmetic mean of model-averaged annual survival estimates for females. Standard errors were calculated using the delta method.

[b] One of eight study areas monitored under the northern spotted owl effectiveness monitoring program for the Northwest Forest Plan.

Source: adapted from Forsman et al. (2011).

of all 11 study areas, the negative cost of reproduction on survival was an important covariate and a consistent effect across all study areas. The analyses of individual study areas supported the negative effect of barred owls on survival, but the effect was variable among study areas: decreased survival was associated with higher proportions of territories where barred owls were detected for Rainier, Coast Ranges, and H.J. Andrews, with weaker evidence found for the Olympic and Northwest California, and negligible evidence of a barred owl effect for Cle Elum, Tyee, and Klamath study areas. The results of the meta-analysis support much stronger negative effects of barred owl presence on spotted owl survival. The model with an additive barred owl effect ranked higher compared to the model with an interaction between barred owl presence and study area, supporting the importance of a consistent barred owl effect across all study areas, rather than an effect that varies in magnitude among areas.

The effects of climate, weather, and the amount of suitable owl habitat on survival were only investigated during the meta-analysis. There was some support for decreasing time trends in survival and a negative relationship between early nesting season precipitation and survival, but the amount of suitable habitat had no effect (Forsman et al. 2011). In addition, there was also some support for differences in survival among ecological regions, with the lowest survival rates reported for study areas in Washington mixed-conifer regions and highest survival for the Coast Ranges. The meta-analysis suggested several factors affected survival, but none of the covariates explored in this analysis explained a substantial portion of the variation among years and study areas (between 0.0 and 5.7 percent only).

Fecundity

The analysis across all 11 study areas by Forsman et al. (2011) included 11,450 observations of the number of young produced by territorial females, and 90 percent of those observations were from adult females (>3 years old). The younger age classes were observed breeding much less frequently (3.8 percent for 1-year-olds, 6.1 percent for 2-year-olds), and age had a strong effect on productivity (Forsman et al. 2011). Mean fecundity was highest for adults (0.330, SE = 0.025), lower for 2-year-olds (0.202, SE = 0.042), and nearly negligible (0.07, SE = 0.015) for 1-year-olds (Forsman et al. 2011).

Fecundity differed greatly by study area, and adult fecundity was highest on Cle Elum (0.553, SE = 0.052) and lowest in the Coast Ranges (0.263, SE = 0.04) (table 2-3). There was considerable annual variation in fecundity, but the patterns in variation were not consistent among study areas. A cyclic, even-odd-year effect where fecundity was high in even years and low in odd years was still important for some study areas (Forsman et al. 2011), but has generally become less evident since the last analysis (Anthony et al. 2006). Overall, fecundity was declining in four areas (Cle Elum, Klamath, South Cascades, Northwest California), stable in two areas (Olympic, Tyee), and increasing in three areas (Rainier, Coast Ranges, H.J. Andrews) (table 2-4).

The effects of several covariates on owl fecundity were also reported by Forsman et al. (2011). The proportion of owl territories on each study area where barred owls were detected at least once during a breeding season had a negative effect on fecundity for three study areas (Coast Ranges, Klamath, South Cascades), a positive effect on fecundity in one study area (H.J. Andrews), and no effect on the other five areas. There was also evidence that low temperatures during the early nesting season had negative effects on fecundity in three study areas (Rainier, Coast Ranges, South Cascades); late nesting season temperatures had a negative effect on fecundity on one study area (Tyee); and high precipitation during the early nesting season had negative effects on fecundity in three study areas (Cle Elum, Coast Ranges, Northwest California). Support for a negative effect of barred owls and effects of climate and weather on fecundity was generally weak. In Oregon, increased fecundity on four of five study areas (Coast Ranges, H.J. Andrews, Tyee, South Cascades) were associated with higher annual estimates of the amount of suitable habitat associated with each study area; however, more suitable habitat resulted in decreased productivity on the Klamath study area (Forsman et al. 2011). There was little indication of any association between the amount of suitable habitat and fecundity on the Washington study areas, and this association was not

Table 2-3—Mean ($\bar{x}$), age-specific fecundity (number of female young produced per female) with standard errors (SE) for northern spotted owls in the nine demographic study areas associated with land managed under the Northwest Forest Plan

		Age class					
	Landowner	1 year old		2 years old		≥3 years old	
Study area	class	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Washington:							
Cle Elum[a]	Mixed	0.115	0.083	0.517	0.109	0.553	0.052
Rainier	Mixed	0.100	0.100	0.111	0.111	0.302	0.065
Olympic[a]	Federal	0.150	0.100	0.361	0.162	0.300	0.060
Oregon:							
Coast Ranges[a]	Mixed	0.000	0.000	0.094	0.039	0.263	0.040
H.J. Andrews[a]	Federal	0.083	0.083	0.110	0.043	0.323	0.041
Tyee[a]	Mixed	0.018	0.013	0.218	0.065	0.305	0.034
Klamath[a]	Mixed	0.056	0.024	0.289	0.045	0.377	0.033
South Cascades[a]	Federal	0.060	0.038	0.210	0.064	0.347	0.052
California:							
Northwest California[a]	Mixed	0.088	0.054	0.152	0.038	0.324	0.027

Note: See table 2-1 for data years.
[a] One of eight study areas monitored under the northern spotted owl effectiveness monitoring program for the Northwest Forest Plan.
Source: adapted from Forsman et al. (2011).

Table 2-4—Trends in fecundity and survival, and mean rate of population change ($\bar{x}$) with standard errors (SE) and 95-percent confidence limits (95% CI) for northern spotted owls from nine demographic study areas associated with land managed under the Northwest Forest Plan

				Estimated annual rate of population change (λ_{RJS})[a]			
Study area	Landowner class	Fecundity	Survival	$\bar{x}$	SE	95% CI	Population trend[b]
Washington:							
Cle Elum[c]	Mixed	Declining	Declining	0.937	0.014	0.910–0.964	Declining
Rainier	Mixed	Increasing	Declining	0.929	0.026	0.877–0.977	Declining
Olympic[c]	Federal	Stable	Declining	0.957	0.020	0.918 – 0.997	Declining
Oregon:							
Coast Ranges[c]	Mixed	Increasing	Declining since 1998	0.966	0.011	0.943–0.985	Declining
H.J. Andrews[c]	Federal	Increasing	Declining since 1997	0.977	0.010	0.957–0.996	Declining
Tyee[c]	Mixed	Stable	Declining since 2000	0.996	0.020	0.957–1.035	Stationary
Klamath[c]	Mixed	Declining	Stable	0.990	0.014	0.962–1.017	Stationary
South Cascades[c]	Federal	Declining	Declining since 2000	0.982	0.030	0.923–1.040	Stationary
California:							
Northwest California[c]	Federal	Declining	Declining	0.983	0.008	0.968–0.998	Declining

[a] λ_{RJS} = reparameterized Jolly-Seber estimate of population change (Pradel 1996).
[b] Population trends based on estimates of realized population change.
[c] One of eight study areas monitored under the northern spotted owl effectiveness monitoring program for the Northwest Forest Plan.
Source: adapted from Forsman et al. (2011).

investigated for California study areas because comparable maps to develop the covariate were not available (Forsman et al. 2011).

Annual Rate of Population Change

Estimates of the annual rate of population change (λ) on the nine study areas ranged from 0.929 to 0.996 (table 2-4). There was strong evidence that populations on the Cle Elum, Rainier, Olympic, Coast Ranges, H.J. Andrews, and Northwest California study areas declined during the study (table 2-4, fig. 2-2), with particularly low estimates of λ for Cle Elum and Rainier, which suggested population declines of 6.3 and 7.1 percent per year, respectively (table 2-4). Point estimates of λ for the Tyee, Klamath, and South Cascades study areas were all <1.0, but 95-percent confidence intervals (CIs) included 1.0 (table 2-4), suggesting populations may be stationary. The weighted mean estimate of λ for all the study areas included in the analysis by Forsman et al. (2011) was 0.971 (SE = 0.007, 95-percent CI = 0.960 to 0.983), which indicated that the average rate of population decline was 2.9 percent per year during the study. The weighted mean estimate of λ for the eight federal effectiveness monitoring areas (excluding Rainier) was 0.972 (SE = 0.006, 95-percent CI = 0.958 to 0.985), which indicated an estimated decline of 2.8 percent per year.

Results from the meta-analysis on the annual rate of population change indicated that both survival and recruitment differed by ecological region, with the highest survival in the Oregon Coast Douglas-fir region and lowest survival in Washington mixed-conifer region (Forsman et al. 2011). Recruitment was highest in the Oregon/California mixed-conifer region and lower elsewhere (Forsman et al. 2011). A negative association between barred owl detections and survival in the rate of population change analysis was also evident and consistent with results from the meta-analysis of survival (see above). A weak association between sur-

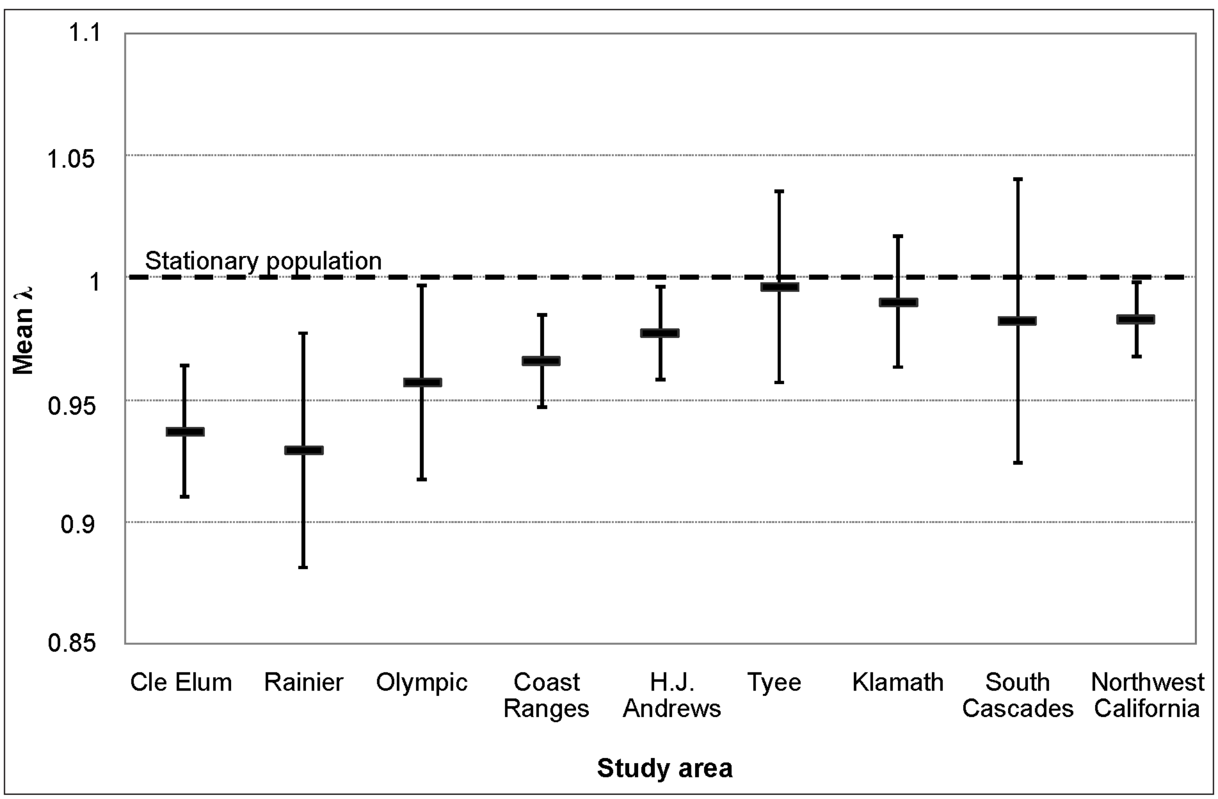

Figure 2-2—Estimates of mean annual rate of population change (λ), with 95-percent confidence intervals for northern spotted owls in nine study areas associated with lands managed under the Northwest Forest Plan in Washington, Oregon, and California. Source: Forsman et al. (2011).

vival and the Pacific Decadal Oscillation was also evident, with higher survival observed during warmer phases of this regional climate cycle. No other climate or weather covariates were important. Estimates of recruitment were higher on study areas comprising primarily federal lands (Olympic, H.J. Andrews, South Cascades, Northwest California) compared to mixed or private ownerships. Recruitment was also higher when the proportion of suitable owl habitat was higher within study areas, but was lower in association with higher proportions of suitable habitat outside study area boundaries.

Realized Population Change

Estimates of realized population change reflected the trend in the proportion of the population remaining each year, based on annual changes in λ in relation to the population at the beginning of the study (Forsman et al. 2011). Populations in Washington and northern Oregon (Olympic, Rainier, Cle Elum, Coast Ranges) declined by 40 to 60 percent during this study (fig. 2-3), and there is some evidence that populations on the H.J. Andrews and Northwest California study areas were also declining (20 to 30 percent) although 95-percent CIs around estimates of realized population change overlapped 1.0 slightly (fig. 2-3). There was less evidence that populations on South Cascades, Tyee, and Klamath areas were in decline (5 to 15 percent), but many point estimates of realized population change for these areas were less than 1.0 even though 95-percent CIs broadly overlapped 1.0 (fig. 2-3).

Discussion

These demographic results are a summary of Forsman et al. (2011) and they represent the fifth meta-analysis of demographic data from northern spotted owls (Anderson and Burnham 1992, Anthony et al. 2006, Burnham et al. 1996, Franklin et al. 1999). The second meta-analysis of demographic rates of northern spotted owls was conducted in 1993 and included 11 study areas (Burnham et al. 1996, Forsman et al. 1996). At that time, owl fecundity rates varied among years and with owl age, and exhibited no increasing or decreasing trend over time (Burnham et al. 1996). Survival rates were dependent on age, and there was a decreasing trend in adult female survival. The annual rate of population change was <1.0 for 10 of 11 areas examined, with an estimated average rate of population decline of 4.5 percent per year (Burnham et al. 1996). By 2004, owl fecundity was relatively stable among the 14 study areas examined, survival rates were declining on 5 of the 14 areas, and populations were declining on 9 of 13 study areas for which there were adequate data to estimate λ (Anthony et al. 2006). However, the annual rate of decline was less, as mean λ for the 13 areas was 0.963, indicating populations were declining 3.7 percent annually during the study (Anthony et al. 2006).

Declines in fecundity, survival, and rate of population change were observed across most study areas in this most recent analysis by Forsman et al. (2011). Over the last 15 years, populations on all 11 areas included in the recent meta-analysis declined on average 2.9 percent per year (Forsman et al. 2011). This is a lower rate of decline than the 3.7 percent reported in the last meta-analysis (Anthony et al. 2006), but the rates of decline are not directly comparable between analyses. The current analysis represents a different time series than past efforts, and data collection on two of the study areas included in past analyses was discontinued (Wenatchee, Warm Springs Reservoir), so these areas could not be included in the most recent analysis (Forsman et al. 2011). In addition to the Rainier study area, apparent survival rates of owls were declining on seven (Cle Elum, Olympic, Coast Ranges, H.J. Andrews, Tyee, South Cascades, Northwest California) of the eight study areas associated with the Plan (table 2-4) and fecundity was also declining in four of these populations (table 2-4) (Forsman et al. 2011). In Washington and northern Oregon, the number of declining populations and the rate of decline raises concern about the long-term sustainability of the owl throughout its range (Forsman et al. 2011).

The reasons for declines in spotted owl populations were not readily apparent in any of the previous meta-analyses (Anthony et al. 2006, Burnham et al. 1996, Franklin et al. 1999). The analysis done by Forsman et al. (2011) incorporated covariates to investigate the influence of barred owls, weather and climate, and habitat on fecundity, survival, and rate of population change. As a result, we now

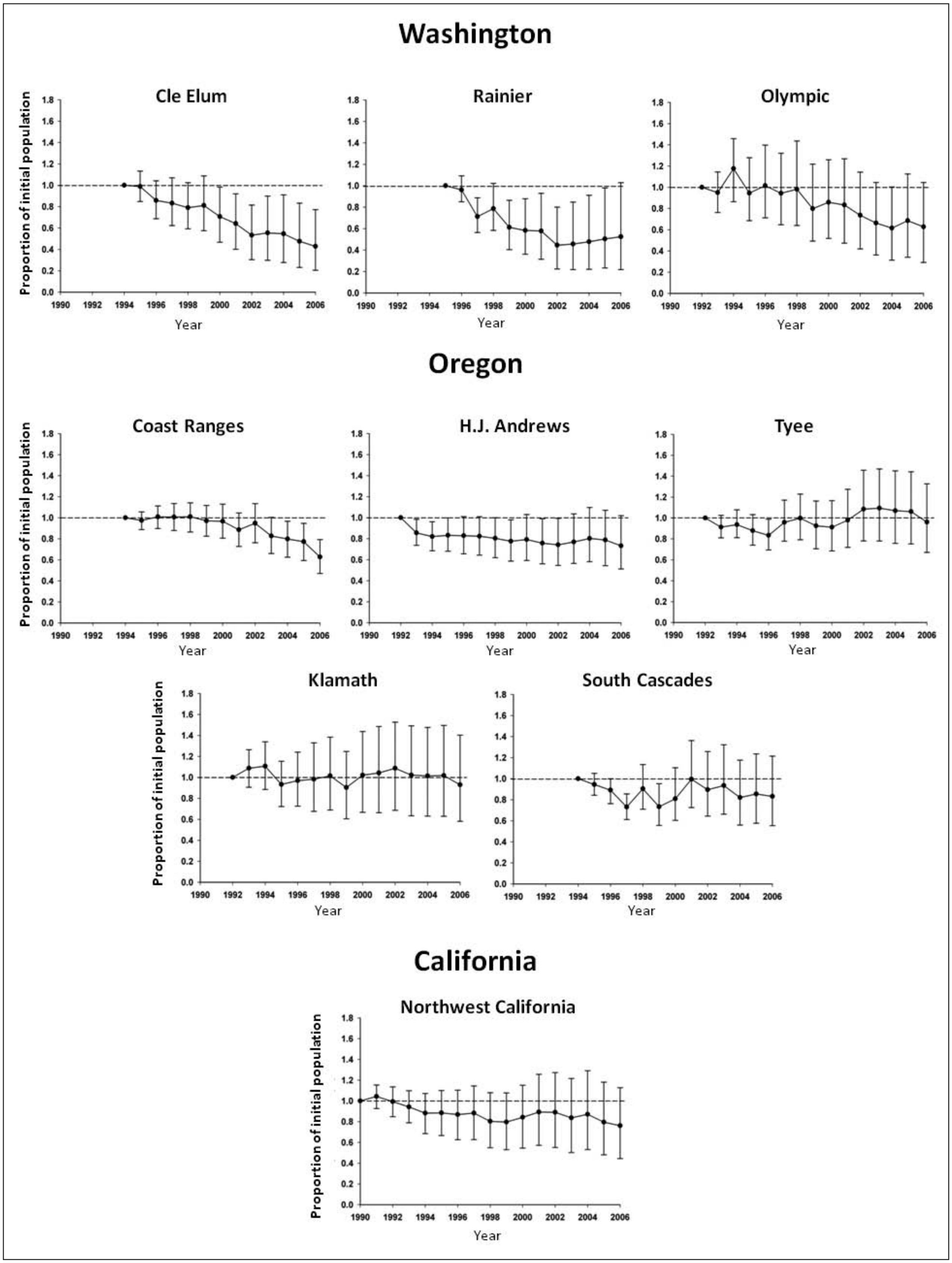

Figure 2-3−Estimates of realized population change, Δ_t, with 95-percent confidence intervals for northern spotted owls on nine study areas associated with lands managed under the Northwest Forest Plan in Washington, Oregon, and California, 1990–2006.

have some evidence that increasing numbers of barred owls and loss of habitat contributed to demographic declines reported in some study areas (Forsman et al. 2011). The presence of barred owls appeared to be the strongest and most consistent negative factor relating to spotted owl survival, but the strength of the response was variable among study areas. Forsman et al. (2011) concluded that although their results do not represent cause-effect relationships, they certainly suggest that barred owl invasion into the range of the spotted owl is at least partly to blame for the continued decline of the owl on federal lands. However, recovery of habitat lost over the last century is a slow process and likely continues to negatively impact owl populations.

From the perspective of evaluating the effectiveness of the Plan on the conservation and recovery of the owl, the relationship between demographic rates and habitat are of particular importance. Because of the differences in the vegetation data used to develop habitat models for the 10-year report, as discussed in chapter 3 of this report, the development of the habitat covariate in California was not possible, and its effect on demographic rates could only be investigated for Washington and Oregon (see Forsman et al. 2011 for details). From this analysis, there was evidence that the percentage cover of suitable owl habitat had a positive influence on recruitment of owls in the meta-analysis of λ (Forsman et al. 2011); however, this relationship was not strong or prevalent for all demographic parameters or among all study areas.

Based on the meta-analysis of λ, there was some evidence that apparent survival was related positively to the percentage cover of suitable habitat in the Cle Elum, Coast Ranges, H.J. Andrews, and Tyee study areas in Washington and Oregon (Forsman et al. 2011). Also, a positive relationship between recruitment and the percentage cover of suitable owl habitat within the study area in the meta-analysis of λ was also found (Forsman et al. 2011). Recruitment was also highest on federally owned lands where the amount of suitable habitat was highest compared to private lands (Davis and Lint 2005). One possible explanation for this result is that more suitable habitat within the study areas provided areas where nonterritorial owls could survive until they were able to recruit into the territorial population.

Summary

After 15 years of population monitoring, we continue to observe significant annual declines in spotted owl populations (2.9 percent all ownerships, 2.8 percent federal ownership) (Forsman et al. 2011). Our ability to monitor the trend in owl populations is improving with newer technologies, the inclusion of explanatory covariates, and more years of data. We now have some evidence to support the suggestions of Anthony et al. (2006) that possible causes for declines in owl survival and populations may include high densities of barred owls and loss of habitat. However, a lot of uncertainty remains, and we are just beginning to understand the effects of these two factors on owl demography. We also must continue to stress the caution put forth in the Plan for projecting current estimates of population decline into the future.

At its implementation, the Plan's assumption was that owl populations across the range would continue to decline for the first three to five decades, eventually stabilizing at lower levels as losses of habitat lessen and habitat is restored in the network of large reserves scattered throughout its range. Since the Plan's inception, the rate of habitat loss has certainly lessened, and here we report an overall habitat decline of 3.4 percent on federal lands in the last 15 years (see chapter 3 in this report), which is less than the anticipated rate of habitat loss of 5 percent per decade. We also report an overall 2.8 percent annual population decline on federal lands, with higher declines in the northern portions of the range and stationary populations in the central portion of the range as first noted by Anthony et al. (2006). These stationary populations were also not expected at the Plan's implementation (Lint 2005). Although habitat is being maintained, the restoration of habitat under the Plan is still a few decades away. Forest succession is a slow process, but there are suggestions that it can be accelerated through well-designed silviculture (Garman et al. 2003, Muir et al. 2002). We were not yet able to accurately measure recruitment of nesting/roosting habitat with current technologies; however, we were able to detect recruitment of the younger forests that serve as dispersal habitat (see chapter 3 in this report). We speculate that declining spotted owl populations will not begin to stabilize across the range at least until nesting/roosting habitat begins to increase significantly. And although habitat is a key element in the conservation of spotted owls (Lint 2005), it may no longer be the primary factor affecting population stability in either the short or long term. The rapidly increasing trend in barred owl populations has produced an unanticipated and confounding influence, as these species may compete for resources.

The answer to the question, "Will the Plan reverse the declining population trend and maintain the historical geographic range of the northern spotted owl?" still eludes us. Five more years of monitoring has shed more light on the subject, but a definitive answer will require more long-term monitoring to better understand the temporal and spatial variability in owl demographics and the factors that affect owl vital rates. Until then, we believe that habitat maintenance and restoration, as currently envisioned under the Plan, remains essential to the owl's recovery. However, additional conservation measures (i.e., barred owl control) that were not envisioned under the Plan may ultimately be needed to recover the species in the face of the barred owl expansion into the Pacific Northwest.

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Peter Carlson

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Chapter 3: Habitat Status and Trend

Raymond J. Davis and Katie M. Dugger

Introduction

The first rangewide northern spotted owl (*Strix occidentalis caurina*) habitat map was developed for the Forest Ecosystem Management Assessment Team (FEMAT) in 1993. It was constructed through a combination of digital maps derived from satellite imagery and maps derived from aerial photo interpretation. The team used the best available data and geographical information system (GIS) technologies at that time to represent owl habitat conditions at the start of the Northwest Forest Plan (the Plan), which we call the "baseline." However, the authors acknowledged that the map was an estimate and had not been assessed for accuracy (FEMAT 1993). Six years later, the northern spotted owl effectiveness monitoring plan concluded that this map lacked the spatial resolution and accuracy needed for a baseline spotted owl habitat map for monitoring purposes (Lint et al. 1999). They proposed the development of a new rangewide baseline habitat map to "provide the landscape-scale view of habitat conditions at different resolutions."

Having a good baseline habitat map is essential to the effectiveness monitoring program because it provides a snapshot in time of what conditions were like when the Plan was implemented. Without an understanding of baseline conditions, we would not be able to answer the primary question of whether owl habitat and dispersal habitat are being maintained and restored under the Plan. The first rangewide baseline habitat monitoring map was developed by Davis and Lint (2005) for the 10-year monitoring report (Lint 2005). The data sources and methods used to develop that map are fully described in Davis and Lint (2005) and are not repeated in this report. Limitations in the first baseline map were noted by Davis and Lint (2005) and Raphael (2006) and are reviewed in the following discussion.

The Northwest Forest Plan effectiveness monitoring program was in its early stages of development at the time of the 10-year reporting analysis. A consistent rangewide vegetation data set as described in Lint et al. (1999) did not exist. Instead, two distinctly different vegetation data sources covered the owl's range: Interagency Vegetation Mapping Project (IVMP) data (Oregon and Washington) and Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG) data (California) (Davis and Lint 2005, Moeur et al. 2005). The choice of vegetation variables provided by these two sources was limited and included only tree size class and cover attributes, which were not mapped consistently between the two products. Other habitat mapping "core elements" discussed by Lint et al. (1999), such as stand age and tree species data, were not available, resulting in omission of important habitat relationship variables in the models used to create the first baseline map. To compensate for lack of tree species data, Davis and Lint (2005) used elevation as a variable in their habitat modeling and also built a "habitat-capable" GIS layer, largely based on a rangewide elevation isopleth that would "mask out" subalpine forests, in which spotted owls avoid nesting. There was no way to "mask" pine-dominated forests or to include evergreen hardwoods, which are important components of owl habitat in the southern physiographic provinces. As a result, where tree size and cover conditions were otherwise similar to those used by nesting and roosting territorial owls, the models classified them as suitable, even when they probably were not because of tree species composition.

Another problem was the coarse spatial resolution and lack of continuous attribution in the CALVEG data (Davis and Lint 2005). This resulted in poorer estimates of habitat in the California physiographic provinces and habitat maps that were not directly comparable to the Oregon and Washington maps. The lack of a consistent rangewide habitat map resulted in our inability to fully model associations between spotted owl demography rates and habitat during the 2009 population meta-analysis (Forsman et al. 2011).

Additional limitations of the 10-year report's baseline owl habitat map (Davis and Lint 2005) included the use of the median algorithm in the BioMapper habitat modeling software (Hirzel et al. 2002), which was the only algorithm available at the time (Davis and Lint 2005). This algorithm assumed species distribution along the environmental factors was normal (see fig. 3-8 on page 36 in the 10-year report); however, in reality, this is not always the case, and nonnormal relationships resulted in the overestimations of habitat suitability. In general, profile models like BioMapper are known to sometimes overpredict habitat suitability (Engler et al. 2004). To compensate for this, Davis and Lint (2005) provided a habitat map with a continuous scale from 0 to 100, where a value close to zero signified that an individual map unit (pixel) had little in common with the conditions found where territorial owls are present, and those with values close to 100 had much in common with sites having territorial owl presence. During this initial effort, a threshold value that designated a cutoff between "suitable" and "not suitable" habitat was not chosen. Instead, Davis and Lint (2005) reported on status and trend of the spectrum of habitat suitability (HS) divided into equal-interval bins, and areas with HS >40, which "had characteristics similar to areas where territorial owls have been found."

Based on our latest work (presented here), we now conclude that the baseline habitat map developed for the 10-year report did overestimate owl habitat suitability in portions of the range. Overestimations occurred within pine-dominated forests of the eastern Cascades for reasons discussed above, and, as noted by Raphael (2006), habitat suitability scores greater than 40 were achieved in stands as young as 30 years in the Coast Range of Oregon and 50 years in Oregon western Cascades, providing further evidence of profile model overpredictions. Based on visual comparisons of the former baseline maps and the new one, we also believe that the use of the coarser scale CALVEG data in the 10-year habitat modeling resulted in considerably more habitat suitability >40 estimated for California.

Since the 10-year report, much progress has been made in developing a consistent rangewide vegetation data layer, with a larger suite of vegetation attributes to be used as "core elements" for habitat mapping, including tree species information (Ohmann and Gregory 2002). These new rangewide vegetation data are produced by the Landscape Ecology, Modeling, Mapping, and Assessment group (LEMMA) based at the Pacific Northwest Research Station in Corvallis, Oregon (link to Web page: http://www.fsl.orst.edu/lemma/). Detailed attributes of forest composition and structure were mapped for all forests in the Plan area for two "bookend" dates. The bookend dates were 1996 and 2006 in Washington and Oregon, and 1994 and 2007 in California. This marks the first application of using multiple satellite imagery dates to create "bookend" vegetation maps for habitat monitoring purposes (Ohmann et al. 2010).

In addition to improved vegetation map products, the science of habitat modeling has evolved since the 10-year report. Species distribution and habitat suitability modeling has been the subject of much current research and discussion in ecology (Elith et al. 2006, Guisan and Zimmermann 2000, Hirzel and Le Lay 2008), so we spent a substantial amount of time reviewing modeling options and testing several types of software used for habitat modeling before deciding on the approach presented here.

One thing we have observed through these efforts is that regardless of the methods used, the map products are visually similar at the rangewide scale (fig. 3-1). Therefore, it is important to test the map's accuracy with actual spotted owl nesting and roosting location data. This is one area where the population monitoring and habitat monitoring efforts connect, as we used different subsets of the demographic data to first train and then test the accuracy of our habitat model mapped predictions.

The use of the new rangewide vegetation data set and the latest habitat modeling software has resulted in an improved baseline habitat map that has tested well with actual owl pair location data (including independent data sets). These improvements included better discrimination of habitat in the eastern Cascades, where pine-dominated forests mostly occur, and the use of the "habitat-capable" layer from Davis and Lint (2005) was no longer required for habitat modeling with the inclusion of a subalpine forest type variable. We use this new baseline map (1994/96) and the other bookend map (2006/07) for conducting our habitat status and trend analysis.

The development of bookend maps was an innovative advancement in our monitoring methods, but aspects of it remain to be tested. Given its novelty, we restricted our use of the 2006/07 bookend to only inform us on habitat changes within areas that were identified as having experienced a disturbance by the LandTrendr data. It is important to make sure that the bookend maps used for later analyses are generated with the same data sets and methods, and tested so that the detection of change from one to the other

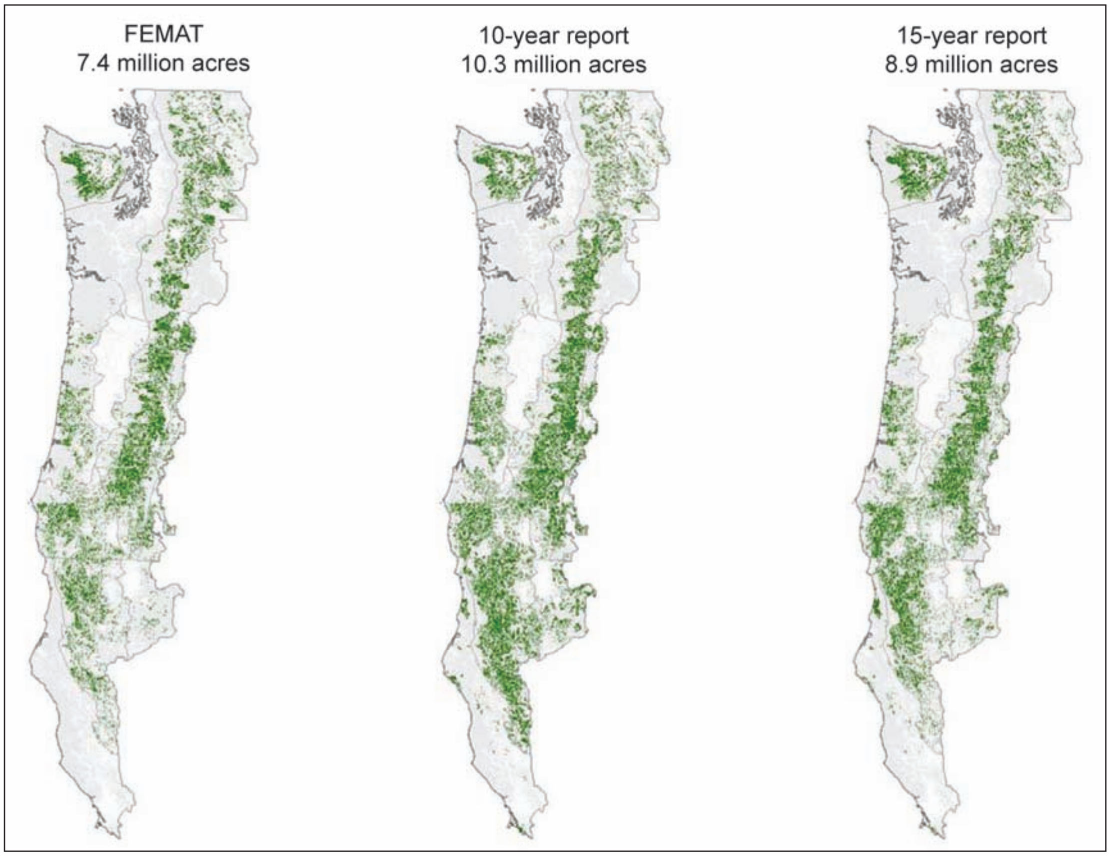

Figure 3-1—Baseline maps are representative of habitat at the implementation of the Northwest Forest Plan. They evolve with new mapping technology. Even so, at the range scale, the general spatial patterns of habitat between them are similar. FEMAT = Forest Ecosystem Management Assessment Team.

is a fair comparison of "real" change and not one caused by analytical or data differences. In future monitoring cycles, we anticipate more advancements in both vegetation data mapping and habitat modeling science; therefore, we anticipate that future modifications will be made to the baseline map, including the use of 1994 satellite imagery for the entire range. This is appropriate as the status and trend analysis is based on the use of the best available vegetation and change-detection data and technologies.

Habitat Monitoring Under the Plan

Under the monitoring plan, habitat status and trends are to be estimated approximately every 5 years after the baseline map was developed because it was believed that changes in forest vegetation conditions would not be discernable from the remote sensed vegetation data on more frequent intervals (Lint et al. 1999). The intent of habitat monitoring is to determine if assumptions made during the development of the Plan are holding true. Testing the assumption that habitat will not decline faster than predicted in the final environmental impact statement (USDA and USDI 1994) is of particular interest. The initial list of assumptions is as follows (Lint et al. 1999):

1. Habitat conditions within late-successional reserves (LSRs) will improve over time at a rate controlled by successional processes in stands that currently are not habitat. However, this is not expected to produce any significant changes in habitat conditions for several decades.
2. Habitat conditions outside of reserved allocations will generally decline because of timber harvest and other habitat-altering disturbances, but the vegetation structure across the landscape will continue to facilitate owl movements.

3. Catastrophic events are expected to halt or reverse the trend of habitat improvement in some reserves; however, the repetitive design of reserves should provide resiliency, and not result in isolation of population segments.

Central to these questions is the federal network of reserved land use allocations designed to support groups of reproducing owl pairs across the species' range. These reserves include LSRS, adaptive management reserves, congressionally reserved lands, managed late-successional areas, and larger blocks of administratively withdrawn lands. It is also important to monitor the lands between these reserves because they provide for recruitment of new owls into the territorial populations (see chapter 2, this report) and are important for dispersal and movement of owls between larger reserves. These dispersal habitats occur in a combination of matrix, adaptive management areas, riparian reserves, small tracts of administratively withdrawn lands, and other small reserved areas such as 100-ac owl core areas. To understand whether the Plan is contributing to the conservation and restoration of owl habitat, the condition and trends of owl habitat must be regularly assessed. The specific questions that were addressed in the 10-year report and that will be addressed here as well include:

1. What proportion of the total landscape on federal lands are owl habitat and dispersal habitat?
2. What are the trends in amount and changes in distribution of owl habitat, particularly in large, reserved blocks?
3. What are the trends in amount and distribution of dispersal habitat outside of the large, reserved blocks?
4. What are the primary factors leading to loss and fragmentation of both owl habitat and dispersal habitat?

Following the approach of Davis and Lint (2005), the condition of owl habitat will be reported at three broad geographic scales: (1) the physiographic province, (2) the state, and (3) the geographic range of the owl. However, because of changes that have occurred in federal land use allocations since the 10-year report (fig. 3-2), we will no longer report status and trends within every land use allocation. Instead, we will report by broad federal land use allocations representing "reserved" and "nonreserved" landscapes (fig. 3-3), which we feel is a more consistent and appropriate scale for monitoring. Because the "large block" reserves (see fig. 3-13, page 44 in the 10-year report) make up about 90 percent of the reserved landscape, we now consider our reporting of status and trend in the reserved landscape as one entity, whereas in the 10-year report we separated them. Although the effectiveness monitoring is focused to address questions about the Plan, its developers realized that the status and trends of the subjects being monitored are often influenced by conditions on the surrounding nonfederal lands. Therefore, we will report on habitat conditions on nonfederal lands at the state and range scales because these were included in the 10-year monitoring synthesis report by Raphael (2006).

As stated in the 10-year report, our objective was to produce maps of forest stands (regardless of patch size and spatial configuration) that showed the level of similarity to stand conditions known to be used for nesting and roosting by spotted owls. Forest stands with conditions most similar to what is used by nesting and roosting owl pairs are what we will refer to as "nesting/roosting habitat" throughout this document. We will also report on forest stand conditions that are known to be used by dispersing owls, which we refer to as "dispersal habitat."

Methods and Data Sources

Land Use Allocation Data

An updated map of the Plan's land use allocations (LUA) was produced in 2002 for the 10-year monitoring reports (Huff et al. 2005, Lint 2005, Moeur et al. 2005). It updated the original 1994 version, which was mapped with older GIS technology and had a 40-ac resolution. This first update corrected some mapping inconsistencies, but more importantly, incorporated allocation changes that occurred between 1994 and 2002. Although this map was considered an improvement from the earlier version, some limitations still remained (Davis and Lint 2005, Huff et al. 2005). The major limitations were the inability to map riparian reserves

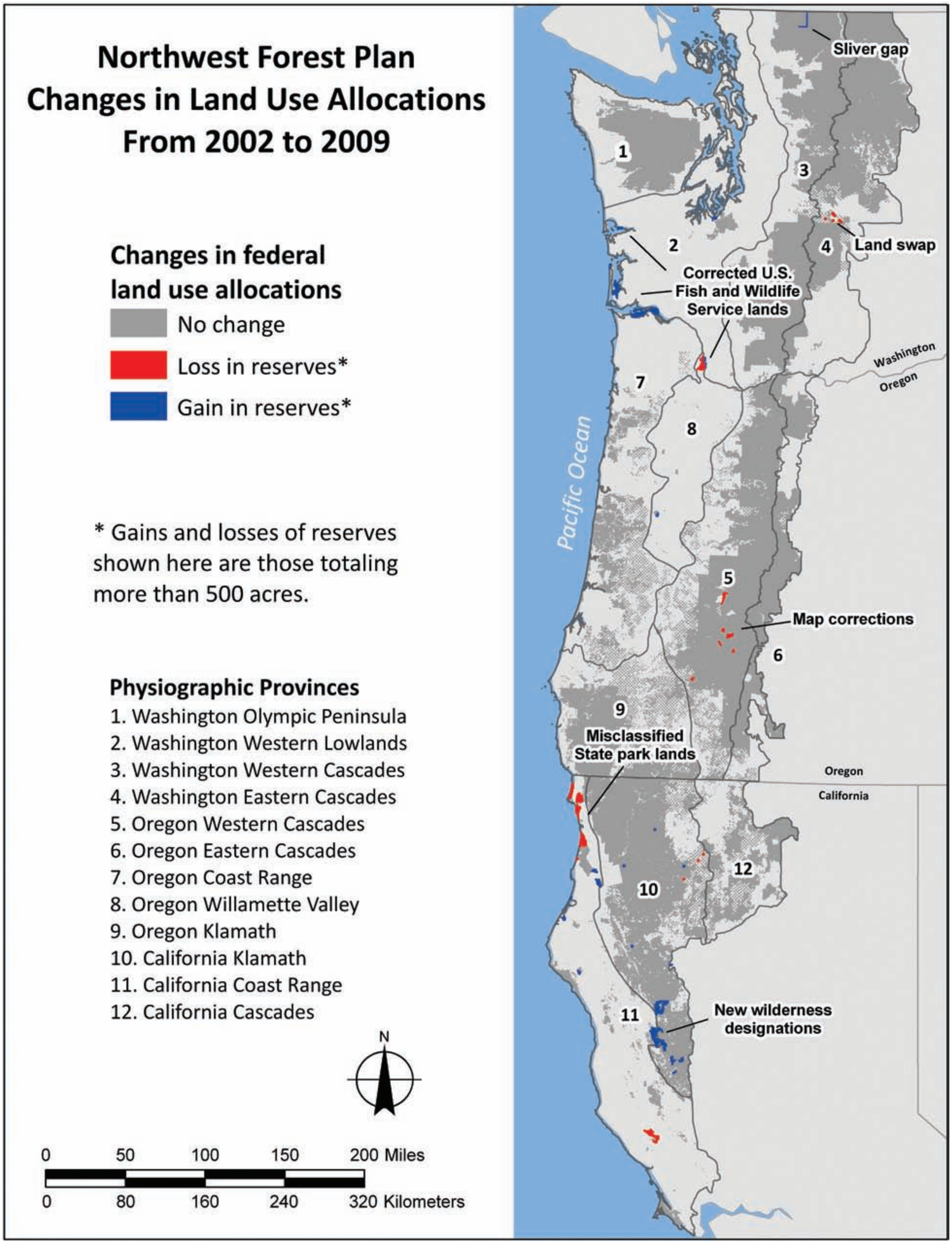

Figure 3.2—Changes made to the land use allocations since the 10-year report (Lint et al. 2005).

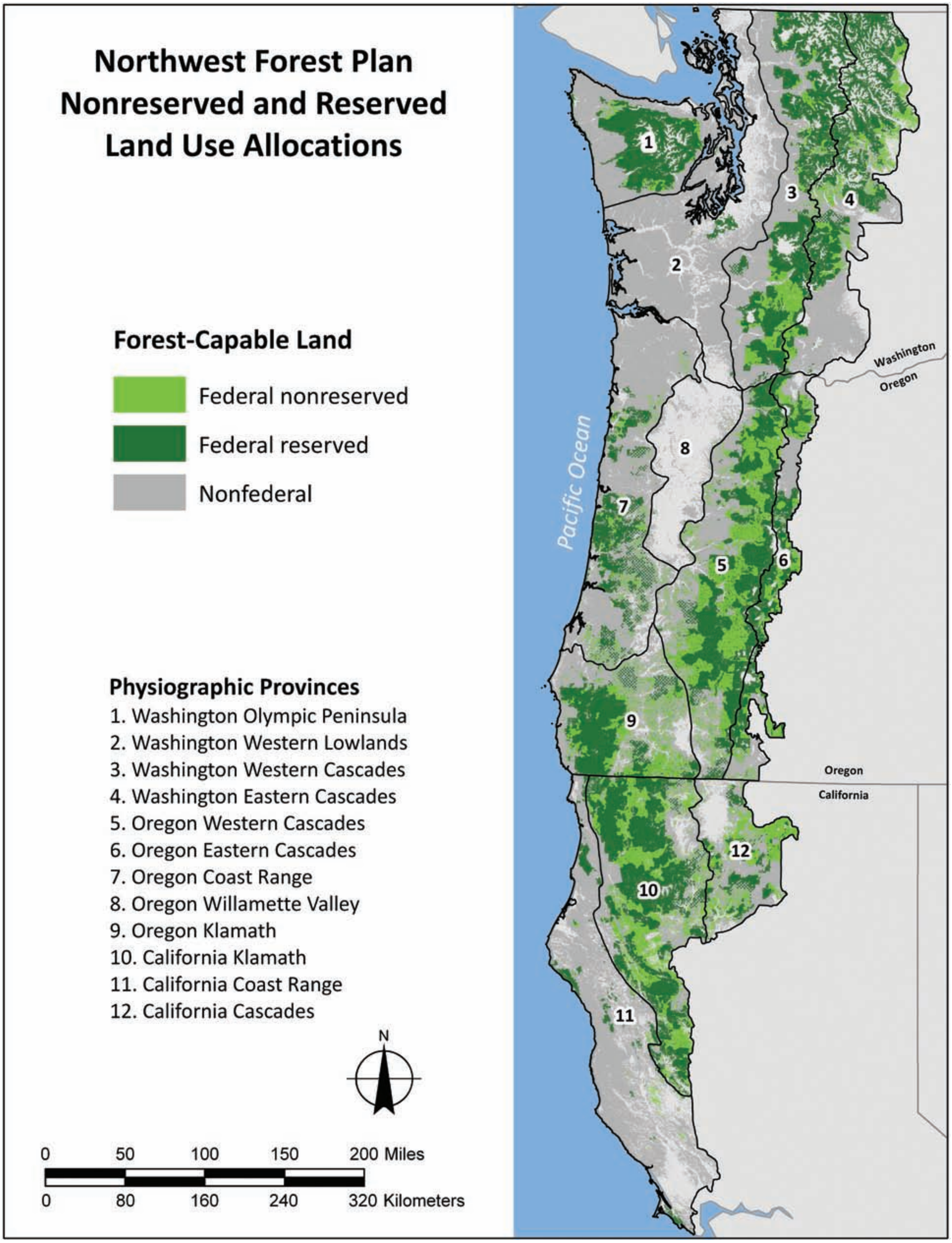

Figure 3-3—Federally administered lands within the range of the northern spotted owl.

(which can cover significant amounts of land where stream densities are high) and inconsistencies in how administratively withdrawn areas were delineated. Errors that remained after the 2002 update included the misidentification of a state-owned park in the redwood region of California as federally owned National Park Service land and inaccurate or missing boundaries of national wildlife refuges, mainly in Washington and Oregon. Other minor mapping issues included edge matching inconsistencies that caused "sliver gaps" and inconsistent attribution of large water bodies.

A second update of LUAs performed in 2009 (fig. 3-2) produced a new version that is used for this 15-year report. The new version incorporates major LUA changes that occurred between 2002 and 2009, and it also corrects the errors identified above. Minor issues with inconsistent mapping of administratively withdrawn areas still remain, and a small amount (<1 percent) of federally administered lands are awaiting official LUA designations and are identified as "not designated" in the 2009 map. Riparian reserves still remain unmapped because, as Moeur et al. (2005) noted, "…at the Plan scale, they cannot be reliably distinguished from matrix because of a lack of consistency in defining intermittent stream corridors and varying definitions for riparian buffers."

The Plan allowed for land exchanges involving LSRs if they provide benefits equal to or better than current conditions, such as to improve area, distribution, and connectivity of the LSR system (USDA and USDI 1994). It also acknowledges that future changes would occur for the administratively withdrawn allocation. At the end of the 15-year monitoring period, we note a net increase of about 25,000 ac in reserved allocations, and a net decrease of about 17,000 ac in nonreserved allocations. Most of the changes that occurred were designations of otherwise reserved allocations into 237,000 ac of congressionally designated reserves, and most of this (83 percent) occurred in northern California. Because some of the changes included land exchanges or acquisitions, the increase in reserved allocations and decrease in nonreserved allocations are not equal.

Land use allocations will continue to change, and we will continue to update this map with the intent of improving it for each monitoring effort. For monitoring purposes, we archive the previous versions and report vegetation and habitat changes for all monitoring modules within the reference frame of the most up-to-date allocation map. Major LUA changes that are important for us to note include changes that cover thousands of acres and involve gains or losses of reserved allocations. We will discuss these changes in relationship to the standard and guidelines within the record of decision (USDA and USDI 1994). Given the most recent information, the latest changes in reserved allocations (fig. 3-2) have resulted in a slightly increased area and improved distribution and connectivity of the reserved allocation system.

Vegetation Data

The vegetation data used for habitat modeling and mapping were developed through a method for predictive vegetation mapping using direct gradient analysis (Gauch 1982, ter Braak 1986) and nearest-neighbor imputation (Moeur and Stage 1995) to assign detailed forest vegetation plot information to every pixel in a GIS raster map. The combining of these methods to develop vegetation maps was termed "gradient nearest neighbor" (GNN) and is thoroughly described in Ohmann and Gregory (2002). The GNN maps developed in the Pacific Northwest have previously been applied to broad-scale vegetation mapping efforts across a wide range of forest ecosystems (Ohmann et al. 2007, Pierce et al. 2009). Forest attributes from regional inventory plots are assigned to map pixels where data are missing, on the basis of a modeled relationship between the detailed forest attributes from plots and a combination of spatial predictor variables derived from Landsat satellite imagery, climate variables, topographic variables, and soil parent materials. The assumption behind GNN methods is that two locations with similar combined spatial "signatures" should also have similar forest structure and composition. Plot data are from regional forest inventory plots: Forest Inventory and Analysis (FIA) periodic inventories on nonfederal lands, FIA annual inventory on all ownerships, and Current Vegetation Survey inventories. The GNN data used for habitat modeling and mapping covers the entire breadth of the owl's range from Washington to northern California for two points in time. We call these two data sets “bookends” because the changes in habitat that we analyzed and report on occurred between them. The satellite imagery from which GNN was created covers the period from 1994 to 2007 in California and 1996 to 2006 in Oregon and Washington. The on-the-ground plot data used to create the vegetation maps covers the period 1991 to 2000 for bookend 1, and 2001 to 2007 for bookend 2. The GNN products are 30-m (98.4-ft) grids that were specifically developed for mid- to large-scale spatial analysis (Ohmann and Gregory 2002).

The primary challenge was to develop GNN model-based maps for the two bookend dates that minimized spectral differences owing to different image dates that might produce false vegetation changes. To achieve this, the GNN models used Landsat imagery that was geometrically rectified and radiometrically normalized through time using the LandTrendr algorithms (Kennedy et al. 2007). A full description of the GNN bookends methodology can be found in Moeur et al. (2011).

The accuracy assessment for GNN continuous variables was based on the correlation of observed plot values against predicted (modeled) values. Ohmann et al. (2010) used a modified leave-one-out cross-validation approach that yields results similar to those of a true cross-validation approach, but probably slightly underestimates the true accuracy. The accuracy assessments are based on pooled plots for each modeling region. Canopy characteristics are usually the most easily determined via space-borne remote sensing instruments, and the most accurate GNN variable was conifer canopy cover, with an average plot correlation of 0.74 (±1 standard deviation [SD] = 0.07). Inferring vegetation characteristics underneath the canopy is more difficult, and the correlation coefficients for the structural and age vegetation variables we chose to use ranged from 0.38 to 0.82, with an average plot correlation of 0.63 (±1 SD = 0.12). The accuracy assessment for the species composition variables is based on Cohen’s kappa coefficient, which is a measure of agreement between predicted and actual conditions (in this case dominant tree species), taking into consideration agreement occurring by chance (Cohen 1960). We combined several species to produce “forest type” basal area variables as shown in appendix A. The average kappas for these species groups, or forest-type, variables ranged from 0.30 to 0.46, with an average kappa of 0.40 (±1 SD = 0.07). Oak woodland was the most accurate species group, followed by subalpine, evergreen hardwoods, and pine.

Change-Detection Data

A new approach to monitoring landscape vegetation change was implemented to map forest disturbances in the owl’s range. Landsat-based detection of trends in disturbance and recovery (LandTrendr) produces yearly maps of forest disturbance using a new analysis of annual Landsat Thematic Mapper satellite imagery (Kennedy et al. 2010). In general, LandTrendr detects spectral trajectories from Landsat time-series stacks and correlates them to land surface changes. The time series of Landsat imagery that was assembled for the Plan area was processed using basic atmospheric correction, cloud screening, and radiometric normalization to separate imagery noise (i.e., cloud cover, smoke, snow, or shadows) from actual vegetation change. Predictions of vegetation cover change were then evaluated using a statistical model of vegetation cover developed from photointerpreted plots (Cohen et al. 2010). The results of this evaluation found that LandTrendr detected vegetation disturbances as well as or better than two-date change-detection methods, and that it detects with reasonable robustness a range of other dynamics such as insect-related disturbance and growth (Kennedy et al. 2010). Errors in LandTrendr predictions were generally confined to very subtle change phenomena (Kennedy et al. 2010). In summary, LandTrendr improved the temporal frequency of disturbance maps used for monitoring, better separates subtle changes from background noise, and detects a wider range of vegetation change phenomena than was possible with previous technologies (Kennedy et al. 2010, Moeur et al. 2011).

We used the LandTrendr data to verify habitat losses between our bookend maps and to attribute the most likely cause of habitat loss (fig. 3-4). The data covered the entire analysis area and period (1994–2007) and provided information by 30- by 30-m pixels on initial year of disturbance. LandTrendr classified the cause of disturbance (vegetation cover loss) into three types: (1) timber harvest, (2) insect

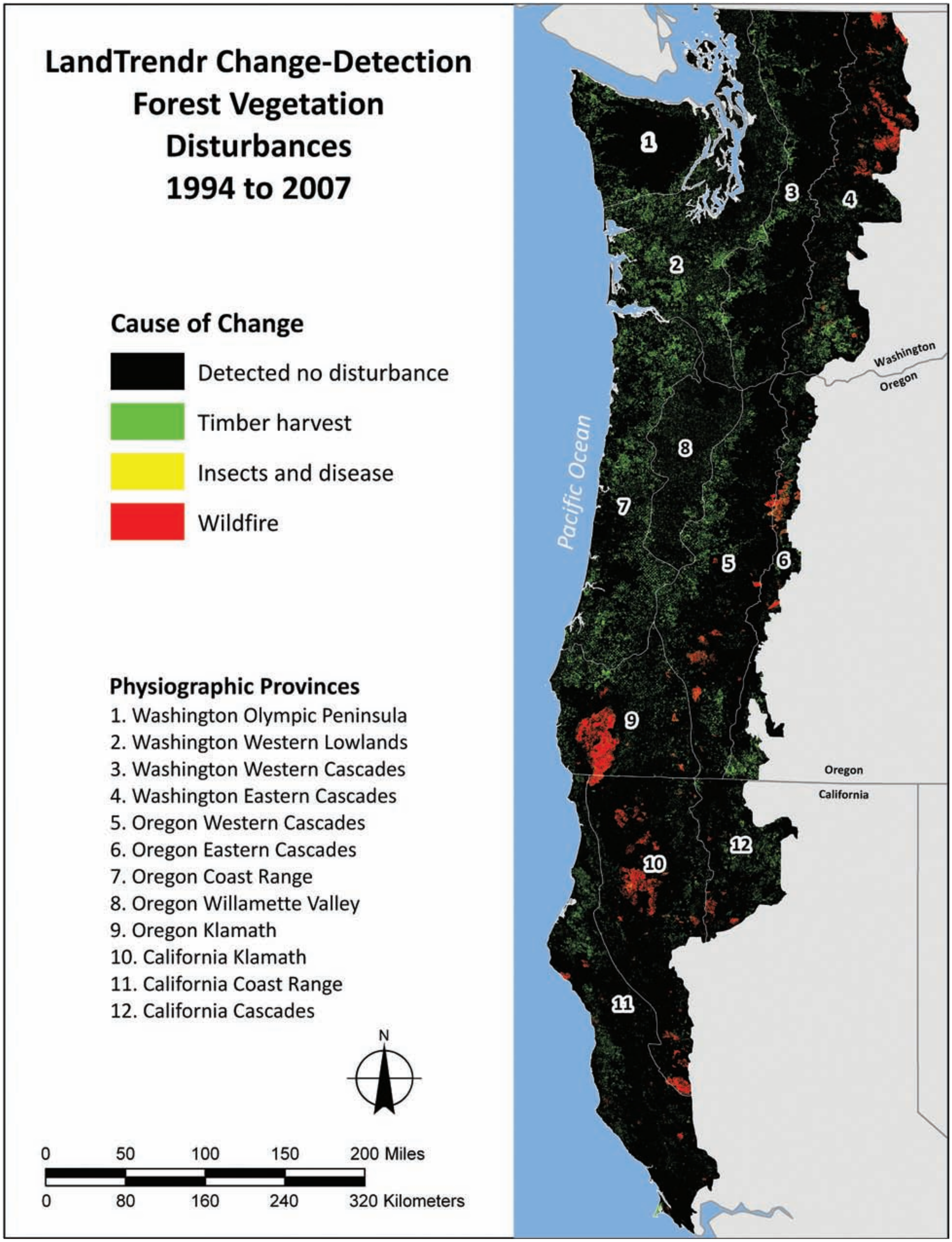

Figure 3-4—LandTrendr change-detection data (Kennedy et al. 2010).

and disease (can also include pathogens and other nonabrupt processes), and (3) wildfire. Fire locations were identified based on fire perimeter GIS data from Monitoring Trends in Burn Severity (MTBS[1]) data, Geospatial Multi-Agency Coordination (GeoMAC[2]) data, and other sources (i.e., individual forest data). The remaining short-term disturbances were assigned "harvest" as the probable cause of disturbance, although wind may account for a small percentage.

Spotted Owl Presence Data

The owl survey data collected under the effectiveness monitoring program are important not only for population monitoring (chapter 2, this report), but also for monitoring suitable habitat. The owl pair location data (presence only spatial data) from demographic study areas are collected annually and are spatially very accurate. This made such data ideal for habitat suitability modeling; thus, we used them as the foundation for training our habitat models. However, the results of our preliminary model testing indicated that using only demographic study area data was problematic for modeling habitat in some modeling regions. Confining our model training data to the demography areas produced a "geographically clumped" distribution of model training points within the boundaries of our larger modeling regions. This clumping violated the basic assumption of habitat modeling methods that require independence and sampling without bias for presence data (training data) from the modeling region (Gillison and Brewer 1985, Phillips et al. 2009, Williams et al. 2002). We therefore matched our modeling regions to the boundaries of the demographic study areas, trained the habitat model to those areas, and then extrapolated the model results to the larger geographic regions. This produced mixed results, with some models testing well, while others could not be projected (extrapolated) successfully when the larger geographic area did not contain all the environmental variables that were used for habitat modeling. Our solution was to supplement the owl location data from demography study areas with the owl presence location from the broader geographic areas surrounding them to reduce sampling bias issues and produce a training data set that was better distributed within the modeling region. To do this we used the data set used for the 10-year report (Davis and Lint 2005).

The first step in this process was to conduct a nearest neighbor distance analysis on owl pair site centers from study areas within each modeling region (app. B). We used the average nearest neighbor distances calculated from the 50-percentile harmonic cores (to remove outlier sites) from each of the study areas as a minimum distance parameter for randomly selecting a number (equal in size to the demographic study area data) of northern spotted owl pair sites from the 10-year report training data set (Davis and Lint 2005) that was outside of the study area boundaries. Both the demographic study area sites and the random selection of owl pair locations outside of them were combined to form the habitat suitability model training data set. This provided a well-distributed and nonclumped training data set for each modeling region.

We also attempted to match the date of our training data to the date of the satellite imagery used to create the vegetation data set that provided habitat variables for modeling. And finally, because we suspected interspecific competition between spotted owls and barred owls (*Strix varia*) to potentially confound the spotted owl/habitat use relationship, we used activity centers from the study areas based on surveys done between 1994 and 1996 because barred owl densities were lower than in 2006 and 2007. Our training data outside of the study area cover a broader period that roughly frames that period as discussed in Davis and Lint (2005).

Habitats, the Niche Concept, and Habitat Modeling

Understanding where animals live and the myriad factors associated with how and why they make the choices as to where to live has been the subject of extensive research (Stauffer 2002). As stated by Morrison et al. (1992), "an

[1] Data accessible thru the Forest Service's Remote Sensing Applications Center (RSAC) Web site http://www.fs.fed.us/eng/rsac/.

[2] Geospatial Multi-Agency Coordination Group or GeoMAC, is an Internet-based mapping application originally designed for fire managers to access online maps of current fire locations and perimeters in the conterminous 48 states and Alaska. Data are available at http://www.geomac.gov/.

animal's habitat is, in the most general sense, the place where it lives." This seems simple enough: an animal can only live in an area that meets its basic needs for resources (food, water, nest sites, etc.), includes competitors and predators with which it can coexist, and in climatic extremes it can withstand (Morrison et al. 1992). This is maybe best articulated within the niche concept, which has a long evolution in the science literature (see Morrison et al. 1992 for review) and has become a useful construct for conceptualizing and quantifying wildlife-habitat relationships. The multivariate, or n-dimensional, niche as defined by Hutchinson (1957) lends itself well to current attempts to model wildlife-habitat interactions, as it allows us to conceptualize all the complexities associated with how and why animals choose where they live. A species potential or "fundamental" niche includes a subset of all the environmental conditions required for a species long-term survival; however, this "fundamental niche" can be further restricted by predators and competitors resulting in a "realized niche" (Hutchinson 1957). This realized niche reflects a subset of the conditions found in the fundamental niche and is the set of environmental conditions that characterize the space a species actually occupies (Hutchinson 1957) and is reflected in the observed distribution of a species.

Many types of species distribution models are available for estimating a species' realized niche (and producing a geographic distribution map of it) using species presence data that are correlated to environmental data of relevance to the species occurrence. For the 10-year report (Davis and Lint 2005), we used modeling software called BioMapper (Hirzel et al. 2002). However, species distribution modeling is a rapidly evolving field of study, so before conducting the spotted owl habitat modeling, we conferred with some of the species distribution modeling software developers (A. Hirzel and S. Phillips) and evaluated various habitat modeling methods (i.e., BioMapper: Hirzel et al. 2002; MaxEnt: Phillips et al. 2006, Phillips and Dudík 2008; Mahalanobis distance method: Jenness 2003; resource selection functions: Manley et al. 1993). We also ran comparison tests between BioMapper (all algorithms) and MaxEnt using "virtual species" data sets provided by Dr. Alexandre Hirzel (the developer of BioMapper) with known species occurrence and distributions. The details of these tests are not provided in this report; however, our conclusions were similar to those of Braunisch and Suchant (2010) who found that BioMapper and MaxEnt produced models with similar accuracy, but that MaxEnt performed better when trained with systematically sampled data that were well-distributed within the modeling region. However, BioMapper outperformed MaxEnt when the model results were extrapolated to areas outside of the model training data area (Braunisch and Suchant 2010). In summary, our tests found that as long as species presence [training] data were fairly well distributed within a modeled region, MaxEnt outperformed the other modeling methods, and we selected it as the habitat modeling tool for this reporting cycle. Several other comparisons between MaxEnt and a number of other habitat modeling approaches are available in the scientific literature, and in most cases, distribution models generated by MaxEnt performed as well or better than the other methods (Baldwin 2009).

Other notable factors associated with our selection of MaxEnt included its user-friendly interface, its ability to run replicated models for testing purposes and to provide information on the importance of the environmental variables used for modeling, and most importantly, its ability to "project" or "transfer" model results. Model transferability is the term given for applying the results of a model that is calibrated for specific location or period, to a different geographic location or period (Turner et al. 1989). The concept is based on the idea that calibrated model parameters from one area or time may provide useful information in estimating conditions in a different time or place. In our situation, we attempted to transfer our models, which were trained in 1994/96 to the same geographic location, but in a different period—2006/07. Model transferability is a fairly new concept, and one that is rarely assessed (Randin et al. 2006). Issues with MaxEnt projections documented by Braunisch and Suchant (2010), our model testing, and the current literature advise for caution in its use and interpretation (Jiménez-Valverde et al. 2009, Peterson et al. 2007, Phillips 2008).

Habitat Modeling Process

MaxEnt uses a machine learning process and a suite of potential response functions to estimate the most uniform distribution (maximum entropy) of the "average" environmental conditions at known species locations compared to what is available across the modeled area (background) (Phillips et al. 2006). The modeling process does not require an a priori specification of a set of models, but instead fits training data (presence locations of owl pairs) to environmental covariates using various combinations of response functions (features) such as linear, quadratic, product, hinge, and threshold structures. However, the use of all feature types may lead to model overfitting depending on the sample size of the training data (Phillips et al. 2006); therefore, the "auto feature" (default) restricts the model to simpler features, such as linear, quadratic, and hinge, for smaller sample sizes (Elith et al. 2011). In our preliminary model tests, overfitting seemed to occur from the use of the threshold feature, which requires a minimum of 80 training samples and produced sharp jumps (both up and down) in the variable response curves. Modeling with just the hinge feature produces models with simpler or smoother functions and is generally a useful simplification that can reduce overfitting (Phillips 2010). Our final selection incorporated a combination of linear, product, and hinge features because most of our hypothesized variable responses fit those choices. We considered using the quadratic feature; however, during our model testing, MaxEnt applied this feature to variables in which the response function did not make ecological sense (i.e., tree diameter). This was most apparent in modeling regions where the variables had outlier values at the extreme high end of the distribution histogram. The inclusion of the hinge and product features compensated for the omission of the quadratic feature, because in combination, they can conform to a quadratic shape. We also selected the "auto features" option, which allows MaxEnt to further limit the subset of response features from those we selected above by retaining only those with some effect.

Other techniques can be used to control overfitting the data, such as reducing the number of parameters in the model. To do this, MaxEnt provides a "regularization feature" that performs a function similar to Akaike's information criterion (Akaike 1974) by penalizing the complexity of the model. The regularization multiplier affects the fit of the model training data to the modeling variable empirical means. A smaller value results in a tighter fit but potentially leads to overfitting the model to the data. The default setting of 1.0 is believed to be an appropriate setting for most modeling efforts (Phillips and Dudík 2008). A higher regularization multiplier setting reduces the number of model parameters, allowing for a more spread out fit around the mean, and simplifies the model.

Observing the statistical performance on test (versus training) data is the best approach to final model calibration (Phillips 2010). We therefore evaluated our model's performance beginning with the model test gain, which indicates how different the testing data are from the background data. It is similar to "deviance" as used in generalized linear modeling (Phillips et al. 2006) and higher gains indicate larger differences between occurrence location environmental conditions and average background environmental conditions. The exponent of gain produces the mean probability value of predicted species occurrence compared to a random location selected from the surrounding modeled landscape. Or in other words, an average testing gain of 0.80 indicates that the model predicted owl occurrence 2.2 times what would be expected by chance. In addition, observing the differences between model testing gain and regularized training gain can be used to control model overfitting, as a large difference between the two is an indication of model overfitting (Phillips 2010).

Using more than just one evaluation statistic to evaluate habitat model performance is highly recommended (Liu et al. 2005), so in addition to gain, we evaluated the area under the receiver operating curve (AUC) statistic to determine model accuracy and fit to the testing data (Fielding and Bell 1997). The AUC statistic is a measure of the model's predictive accuracy, and it was originally developed for evaluations using presence and absence data, producing an index value from 0.5 to 1 with values close to 0.5 indicating poor discrimination and a value of 1 indicating perfect predictions. The AUC values can be interpreted similarly to the traditional academic point system where values between

0.9 and 1.0 indicate an excellent model (A), 0.8 to 0.9 is good (B), 0.7 to 0.8 is fair (C), 0.6 to 0.7 is poor (D), and AUC values between 0.5 and 0.6 represent failure (F), or models that don't predict much better than a random guess. An example of this interpretation in the field of niche-based species distribution models can be found in Araújo et al. (2005) and Randin et al. (2006). In our situation, MaxEnt uses 10,000 randomly selected background locations (map pixels) instead of true absence data, so it is not possible to achieve an AUC value of 1.0 (Wiley et al. 2003). However, interpretation is similar, with higher AUCs indicating better model predictions (Phillips et al. 2006). Specific to our case, AUC values represent the percentage of times a spotted owl nest site location would have a higher habitat suitability value than a randomly selected location from the modeling region.

Our third measure of model performance was the continuous Boyce index (CBI) as described by Hirzel et al. (2006). This index and methodology is designed specifically for testing habitat suitability models produced from presence-only data. The index is based on the Spearman rank correlation coefficient (R_S) that compares the ranks of modeled species occurrence with the area available to "binned" modeled prediction ranks (Boyce et al. 2002). A good model would predict an increasing ratio of the percentage of species occurrence to the percentage of the modeled landscape in each model bin as the bin values increase. An R_S of 1.0 indicates a strong positive correlation (Boyce et al. 2002).

We produced 10 bootstrapped random replicates for each modeling region using 25 percent of the training data held out to test the model. We reviewed the jackknife graphs for mean test gain and AUC from these replicates, which are produced by MaxEnt. These graphs illustrated the contribution that each variable made to the overall model (Phillips et al. 2006). Based on these graphs, we dropped variables that significantly increased mean test gain and AUC when excluded. Once this decision was made, a final check for model overfitting (see above) was conducted. This process entailed increasing the regularization multiplier by increments of 0.5 from the default setting of 1.0 (once the final list of variables was agreed to) to minimize the difference between the regularized training gain and test gain, while maximizing the test AUC and CBI using the held-out testing points.

The final models used for reporting status and trends are the average summary statistic model outputs from these replicates. MaxEnt also produced other summary statistic grids, such as the standard deviation for each cell within the modeling region. We used these maps to calculate a 95-percent confidence interval (CI) for each cell and produced upper and lower limit maps based on it. These summary maps were used to generate histograms of the model predictions uncertainty for each model region and for each bookend (app. C). The maps produced are also useful to see where within the modeling region the model predictions are less robust.

Environmental Variables

The environmental variables that influence the spotted owl's distribution in the Pacific Northwest have been well studied, and a wealth of information exists in the literature on important vegetation characteristics associated with owl habitat use. As previously noted, we were restricted to only a few basic factors (i.e., tree diameter, canopy cover) for the habitat modeling done in the 10-year monitoring cycle (Davis and Lint 2005); however, the GNN map products provided us a more extensive "menu" of forest vegetation variables to consider. Our initial selection of vegetation characteristics and environmental variables for habitat modeling was based on three things: (1) habitat relationship information in the literature or expert knowledge, (2) on-the-ground plot accuracies of the variable, and (3) correlations between the covariates. We chose not to use any GNN structural or age variables that had plot correlations less than 0.3 for an individual modeling region and <0.5, averaged across all modeling regions. For species composition variables, we chose not to include any variables that had kappas <0.2 for individual modeling regions or <0.3, averaged (as a species group) across all modeling regions. In cases where variables were highly correlated (Pearson correlation >0.7) with each other we dropped the variable with the lower plot accuracy.

From our initial list of GNN variables, we dropped basal area of conifers ≥20 in diameter at breast height (d.b.h.) because it was highly correlated with the mean stand conifer diameter, stand height, and the diameter diversity index, but had the lowest plot accuracies. We also dropped the standard deviation of d.b.h. of all live trees for similar reasons. We also did not include total canopy cover or stand density index variables because both had high correlations with conifer cover, which had the highest plot accuracy of all GNN variables. We considered, but did not use any GNN variables for snags and down wood because of low plot accuracies for those types of variables.

We ended up with a consistent set of five variables that reflected forest structure and one forest age variable that we included in all of our modeling regions. The accuracy of the variables we used is shown in appendix A (table A-2), along with Pearson correlations between covariates we selected for habitat modeling. We also developed five forest species composition variables (i.e., subalpine, pine, evergreen hardwoods, oak woodlands, and redwoods) and included them as appropriate for each modeling region (app. A, table A-2). For instance, we did not include a subalpine variable in the California Coast Range modeling region, because none exists in that area. Likewise, we did not include the redwood variable in the western Washington/Olympic Peninsula modeling region. The final list of variables used in each modeling region is provided in appendix C.

Modeling Regions

Based on recommendations from the 10-year report (Davis and Lint 2005), we developed habitat modeling regions that removed some administrative boundaries (i.e., state lines) and framed areas based more on ecological rather than sociopolitical divisions. Our modeling regions were modified versions of the standard physiographic provinces developed in FEMAT (1993) and used for reporting monitoring results (fig. 3-5). Our intent was not to further split the existing delineations into smaller areas, but to combine the existing delineations based on two things: (1) ecological similarities between physiographic provinces and (2) occurrence and distribution of spotted owl location data being used for model training and testing. We used the ecological region (a.k.a. geographic region) information from the population monitoring work (app. A in Anthony et al. 2006, Forsman et al. 2011) to combine some provinces and Environmental Protection Agency level III ecoregions (Omernik 1987) to guide final delineations of modeling regions. Modeling regions were only used for habitat modeling purposes, but we still report on habitat status and trend conditions within the physiographic provinces to maintain consistency with previous reports.

Within these modeling regions, our modeling background (the area for which MaxEnt compares the combinations of environmental variables that underlay owl locations to the broader area that is available for use) was based on a "habitat-capable" mask that we generated specifically for habitat modeling purposes. The GNN environmental data are modeled from detailed field plot data from forest-capable areas only, and a non-forest-capable "mask" is provided by GNN using ancillary land class data from the Gap Analysis Program (GAP) and National Land Cover Data (NLCD) data sets (Vogelmann et al. 2001). The GAP data are based on multiseason satellite imagery (Landsat ETM+) from 1999 to 2001 used in conjunction with other data sets (i.e., elevation, landform, aspect, etc.) to model the distribution of ecological systems (Comer et al. 2003) and land cover classes at a 1-ha (2.47-ac) resolution. However, upon review, the GNN mask included inconsistent masking of urban areas and roads, and also did not mask out areas that we felt were not capable of developing into habitat (i.e., subalpine parklands and steppes). Therefore, we used the "unmasked" GNN data set and applied our own customized mask specific to our purposes. The mask we developed included the use of the "impervious layer" from NLCD (Herold et al. 2003) to consistently exclude areas that have been converted into non-habitat-capable conditions (i.e., urbanized areas, major roads, etc.) and refined the developed open space designations. We then modified the existing GNN mask classes to exclude a few additional land classes or ecological systems that we felt were not habitat capable. Isolated areas less than 2/3 ac (pixel map noise) of both mask and nonmask were removed. The intent of our mask was to frame our modeling area such that it contained lands capable of producing closed-canopy forests that could

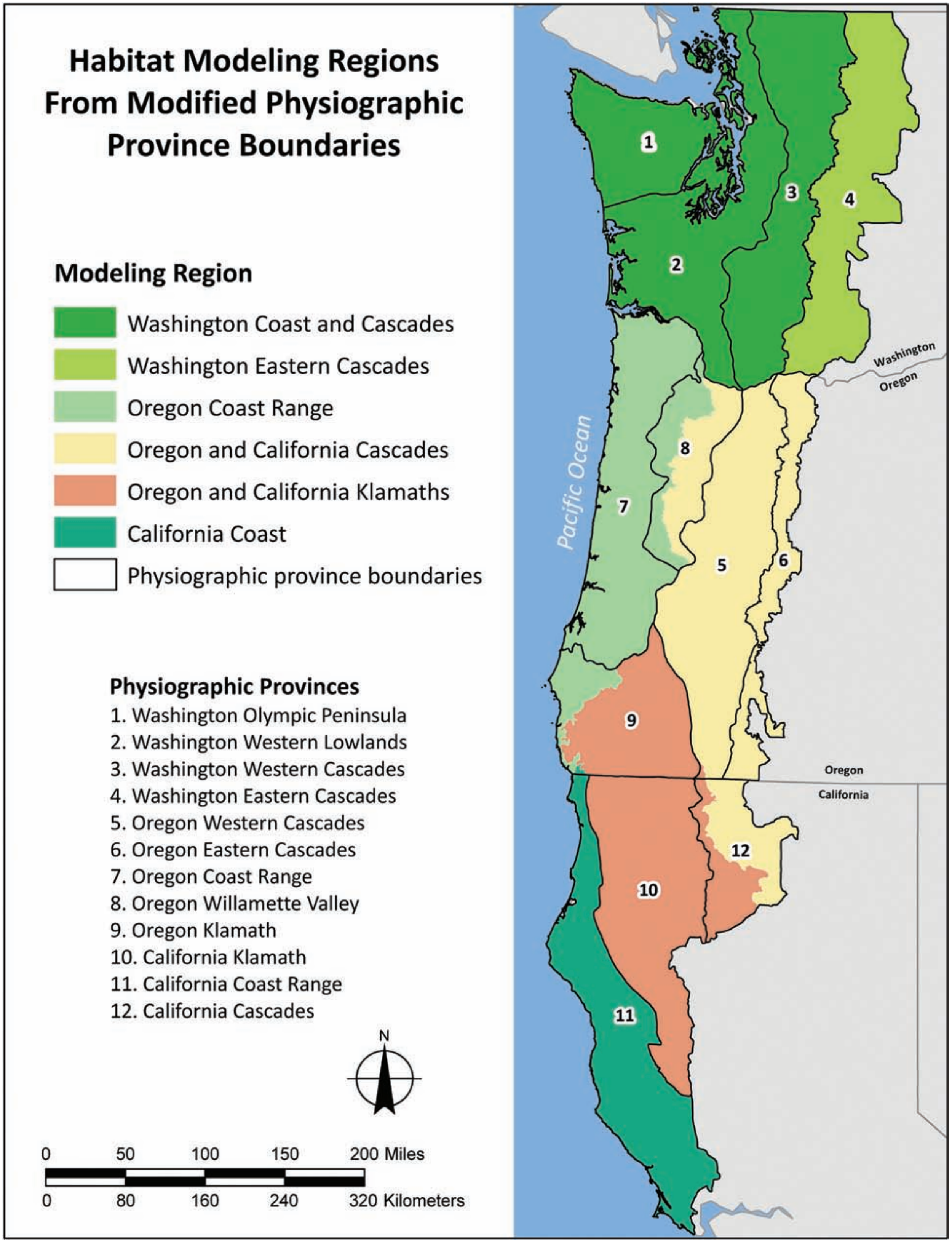

Figure 3-5—Modeling regions used for modeling northern spotted owl habitat.

be potentially suitable for spotted owl nesting, roosting, foraging, or dispersal; however, we suspect that this mask contains areas, especially in the higher elevations, that might not actually be capable of developing habitat under the current climate.

Habitat Map Development and Evaluation

The MaxEnt model output is a logistic probability estimate of a site's suitability for species presence based on environmental conditions from where the species are found, and their differences from the surrounding background environmental conditions within the modeling region (Phillips and Dudík 2008). In our case, the environmental predictor variables used were based on stand-level structural and forest-type species conditions associated with nesting and roosting use by spotted owls. Therefore, our raw model output maps show a scale of nesting/roosting suitability (from low to high) for forested stands based on the stand structure and species composition conditions described by the GNN data. The mapped logistic probability values will be higher where these stand-level conditions are more similar to the conditions observed where we have documented nests and territorial pair centers (i.e., the training data). A mapped logistic probability of 0.5 represents the "average" condition where the species occurred (Phillips 2008).

Our charge is to develop habitat maps that work well and to then measure and report on amounts and distribution of habitat. The latter requires that we select a threshold from the probability values described above to represent "suitable" owl nesting/roosting habitat for summarization purposes. In the 10-year report, we used the area-adjusted frequency (AAF) curves (Boyce et al. 2002) associated with the habitat suitability output from BioMapper to evaluate our habitat models. These curves are among the few diagnostic measures designed specifically for measuring the accuracy of habitat models based on presence-only data (Hirzel et al. 2006). But in addition to model evaluation, these curves also provide information that can be used to reclassify habitat models into discrete habitat classes (Hirzel et al. 2006). To conform to the new terminology, we now refer to AAF curves as "continuous predicted versus expected (P/E) ratio curves" (Hirzel et al. 2006). The continuous P/E curves provide three indications of a model's performance (Hirzel et al. 2006):

1. For replicated model runs that use held-out testing methods (i.e., bootstrap or jackknife), the variance along the curve gives information about the model's robustness along its range of probabilities. Smaller variances indicate more reliable prediction points. Large variances indicate the range of prediction values that are the least robust. This information allows a better understanding of the model's strengths and weaknesses.
2. The shape of the curve provides clues about the model's predictive power. The Spearman rank correlation coefficient (R_s) is used to help us judge the shape of the curve and the model's performance. For fluctuating curves, each time the curve dips as the ranks increase, R_s decreases. A higher R_s indicates a consistently increasing larger proportion of species presence (versus available) being predicted as the model prediction output increases. This is indicative of a good model; however, note that one can get the same R_s for many different-shaped curves (i.e., linear, exponential, and sigmoid), and curves with flatter slopes can have the same ranks as curves with steep slopes. According to Hirzel et al. (2006), a perfect model would have a linear P/E curve that monotonically increases as probability increases because a perfectly straight line allows for an infinite number of classes along the scale of probability (i.e., "resolution"). A wavy line lowers the resolution because classifying the line depends on these changes in the shape and slopes. For exponential models (like MaxEnt), an exponentially increasing curve is indicative of a good model.
3. The maximum y-axis value reached by the P/E curve reflects how much the model differs from chance expectation, or deviation from randomness. This score reflects the model's ability to differentiate the species niche characteristics from those of the modeled region. Caution is needed because this maximum value is sensitive to the species niche breadth within the context

of the modeled region. In other words: Does the species just use a small percentage of what is available in the modeled region or is its habitat use more generalized within the modeling region? If there is abundant habitat available in the modeling region that is being used by the species, the model will usually produce a flatter curve with lower P/E values. Also, the selection and resolution of the environmental variables used for modeling can influence the maximum P/E value.

Once the habitat model evaluation process has been completed, the P/E curve provides a method for classification of a model into discrete habitat classes (Hirzel et al. 2006). The point along the model prediction axis (x-axis) where the curve crosses P/E = 1 along the y-axis (fig. 3-6) is the threshold where the model predicted species occurrence is higher than would be expected if there were no selection (i.e., habitat use was random). This threshold is often used to classify habitat models into binary maps, where logistic probability values greater than the P/E = 1 threshold represent "suitable" habitat (Hirzel et al. 2006). We also note that in our case, the P/E = 1 threshold was similar to the "maximum specificity and sensitivity threshold"[3] (Phillips and Dudík 2008) for all model regions. We provide these and additional thresholds, that are commonly used, in appendix C. We also note that the 10-percentile threshold (app. C) is equivalent to where we reported that 90 percent of the owl training data occurred in the 10-year report habitat models (see fig. 3-11 and table 3-4 in the 10-year report).

We further divided the continuous scale of probability of occurrence from our habitat models into four habitat classes that represent from the least to the most suitable habitat conditions (fig. 3-6). This was done to produce histograms (app. F) similar to the five-class histograms used to profile the continuum of habitat suitability in the 10-year report (Davis and Lint 2005). As in the 10-year report, tracking the changes in these habitat profiles (app. F) is expected to provide useful information for visualizing where habitat may be recruited (first two habitat classes) via forest succession over the next few decades. The only difference between the two reports is that the classes in the 15-year report are based on commonly used thresholds and have more biological meaning. These habitat classes are defined as follows:

- Unsuitable—MaxEnt logistic output from zero to the mean value between zero and the P/E = 1 threshold. This habitat class represents the lowest suitability class and owls will normally avoid using it for nesting and roosting.
- Marginal—MaxEnt logistic output from the mean value between zero and the P/E = 1 threshold to the P/E = 1 threshold. This habitat class represents a condition approaching what owls will nest and roost in. Occasionally, these habitat characteristics are associated with nesting and roosting owls; however, this could be due to occurrence of legacy habitat features such as large trees, extreme rarity of suitable nesting/roosting habitat, or perhaps interspecific competition with barred owls.
- Suitable—MaxEnt logistic output from the P/E = 1 threshold to 0.5. A MaxEnt logistic output value of 0.5 represents the "average" environmental condition associated with the owl training data. This habitat class represents habitat conditions where the probability of owl presence is higher than expected by random chance and up to average conditions associated with nesting and roosting.
- Highly suitable—MaxEnt logistic output from 0.5 to the highest output from the habitat model. This habitat class represents the most suitable, or "above average," conditions used by nesting and roosting territorial owl pairs.

In some of the modeled regions, the 10-percentile threshold occurs within the "marginal" habitat class indicating some owl nesting/roosting use of younger, mid-aged stands as noted by Thomas et al. (1990) who stated that as forests develop along the continuum from young to old, they gradually become more suitable for spotted owl nesting/roosting. To show this continuum of conditions, and to help interpret what these habitat classes represent on the ground,

[3] Minimizes omission (false absence predictions) and commission (false presence predictions) errors.

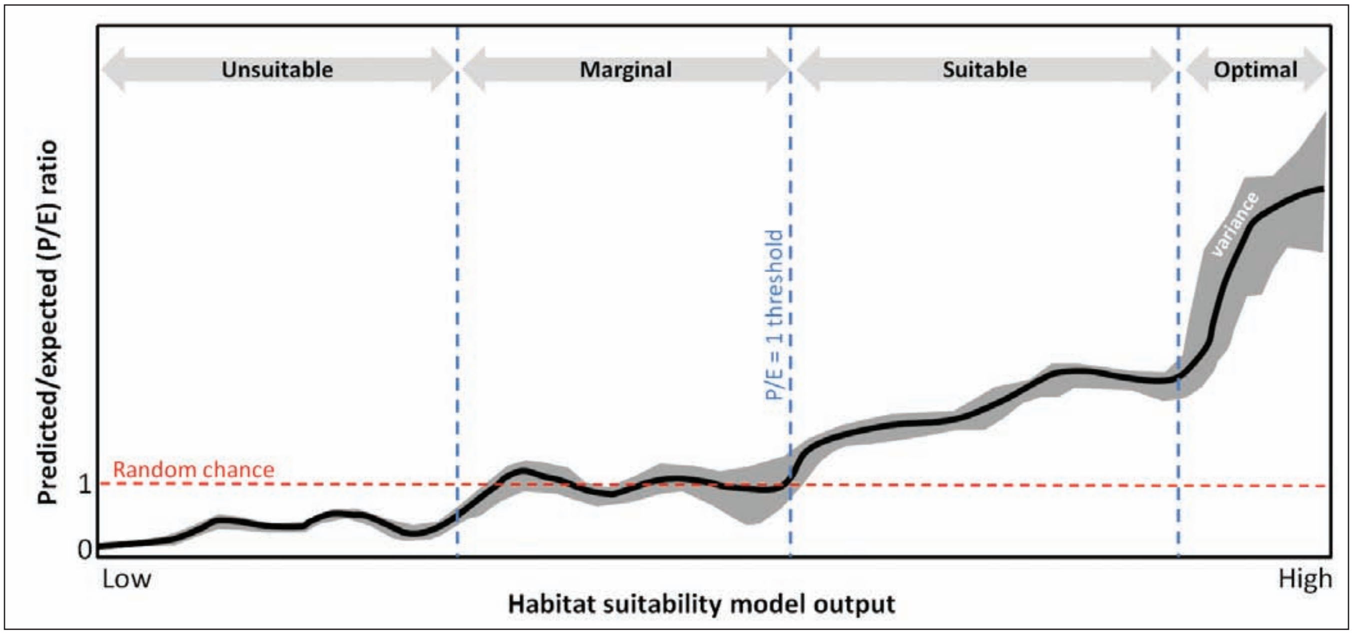

Figure 3-6—The predicted versus expected ratio curve (modified from fig. 6 in Hirzel et al. 2006).

we also provide average stand structure and age attributes (table 3-1). It appears that the lowest class of habitat includes early- to mid-successional forests and the highest suitability class includes the oldest and most structurally complex forests (table 3-1). However, we stress that these simple combinations of forest attributes do not fully describe habitat, and it is the complex interaction between them that does.

Nesting/Roosting Habitat

The importance of mature or late-successional forests for nesting, roosting, and foraging of owls in the Pacific Northwest is clear (see reviews in Thomas et al. 1990), with numerous studies documenting both selection of these habitats by owls (Carey et al. 1990, Forsman et al. 1984, Glenn et al. 2004, Gutiérrez et al. 1984, Hamer et al. 1989) and now more recent research linking greater amounts of older forest in owl territories to owl fitness (i.e., increased survival and/or reproductive success) (Dugger et al. 2005, Franklin et al. 2000, Olson et al. 2004). High-quality owl habitat was described by Thomas et al. (1990) and generally includes older, multilayered, structurally complex forests characterized by large-diameter trees, high amounts of canopy cover, numerous large snags, and lots of downed wood and debris.

Although late-successional and old-growth forests are often equated with spotted owl habitat, they are not always the same. As noted by Thomas et al. (1990), the redwood zone in northwestern California is unique in terms of owl habitat development. In that portion of the owl's range, the structural conditions that constitute nesting/roosting habitat develop quicker, with suitable conditions occurring in 40 to 60 years on some sites and superior conditions in 80 to 100 years. Habitat development is not a mechanistic process, and there is considerable variability in predictions of habitat (Courtney et al. 2004). As can be seen in table 3-1 and appendix C, the transition from unsuitable to suitable conditions is more complex than a simple increase in a stand's average tree diameter and canopy closure. In addition, species composition is also important; for instance, late-successional/old-growth ponderosa pine forests do not function as nesting/roosting habitat, nor do older subalpine forests.

We consider our "suitable" and "highly suitable" habitat classes, as described above, as nesting/roosting habitat. It is important to emphasize that our maps are not attempting to predict owl occupancy or other demographics across the landscape, but rather describe stand-level habitat characteristics that are associated with owl pair use that

Table 3-1–Average (± standard deviation) habitat variable values (gradient nearest neighbor) for nesting/roosting habitat classes in each modeling region

Model region	Habitat class	Habitat suitability	Conifer cover	Average conifer d.b.h.[a]	Large conifers (≥30-in d.b.h.)	Diameter diversity	Average stand height	Average stand age
			Percent	*Inches*	*Trees/acre*	*Index*	*Feet*	*Years*
Washington Coast and Cascades	Unsuitable	0–6	42±29	11±10	1±3	2±2	42±30	40±57
	Marginal	7–25	79±12	17±7	3±6	5±2	76±26	73±76
	Suitable	26–50	85±8	24±9	9±8	6±1	94±32	137±89
	Highly suitable	51–86	89±5	30±9	15±8	7±1	114±28	205±78
Washington Eastern Cascades	Unsuitable	0–11	48±31	13±7	1±3	3±2	45±25	87±65
	Marginal	12–35	60±15	16±6	2±3	4±1	57±20	88±47
	Suitable	36–50	75±10	17±6	3±5	5±1	70±20	106±54
	Highly suitable	51–93	81±9	20±7	6±7	6±1	85±23	128±58
Oregon Coast Range	Unsuitable	0–9	37±31	8±9	0±1	2±2	36±26	23±20
	Marginal	10–28	61±19	19±9	1±2	4±1	74±22	46±21
	Suitable	29–50	65±15	26±8	7±6	6±1	106±25	74±26
	Highly suitable	51–91	70±10	36±8	19±8	7±1	143±26	137±45
Oregon California Cascades	Unsuitable	0–9	38±26	11±9	1±2	2±2	37±26	50±49
	Marginal	10–30	70±15	17±6	2±5	5±1	68±24	82±60
	Suitable	31–50	76±11	22±7	7±8	6±1	91±31	123±65
	Highly suitable	51–88	82±8	29±6	16±8	7±1	115±31	185±83
Oregon California Klamaths	Unsuitable	0–15	24±22	13±10	1±3	2±2	33±21	52±45
	Marginal	16–37	51±20	19±10	3±5	4±2	50±24	76±47
	Suitable	38–50	60±18	25±11	7±7	6±2	66±25	111±102
	Highly suitable	51–86	65±17	29±9	11±7	7±1	95±27	151±80
California Coast	Unsuitable	0–12	16±21	11±12	1±2	3±2	38±16	35±32
	Marginal	13–35	44±20	18±9	1±2	5±2	48±20	47±22
	Suitable	36–50	64±20	24±16	5±7	5±2	63±31	57±74
	Highly suitable	51–86	78±15	24±14	7±8	6±1	84±30	78±88

Note: This table is intended to provide a general sense of stand structure variable gradients from unsuitable to highly suitable.
[a] d.b.h. = diameter at breast height.

approximates a species' realized niche within a specific environmental space (Phillips et al. 2006).

Dispersal Habitat

Dispersal habitat is used by juvenile owls moving away from natal areas or by subadults and adults moving between territories (Forsman et al. 2002). Spotted owls are capable of dispersing long distances, and gene flow from one portion of the range to another can occur in a few generations (Forsman et al. 2002). The network of large reserves established under the Plan appeared suitable for maintaining interconnected populations of spotted owls (Lint et al. 2005); however, concern remained for disjunct small populations that are isolated by large nonforested areas or expanses of young managed forests (Forsman et al. 2002).

Thomas et al. (1990) predicted that much of the forested area between owl conservation areas would be suitable for passage by dispersing spotted owls as long as at least 50 percent of the landscape was forested with conifer stands with an average d.b.h. of ≥11 in with at least 40 percent canopy closure. This definition of a dispersal-capable landscape became known as the "50-11-40 rule" (Thomas et al. 1990) and was based on information of habitat conditions for dispersing juvenile owls (Miller 1989). Older forest habitat is more frequently used for natal dispersal, but closed-canopy (>60 percent cover) younger forests are also used, whereas younger open-canopied (<40 percent cover) forests are generally avoided (Miller et al. 1997). Dispersal distance is also negatively associated with the amount of clearcut forest in the landscape, and large urban and agricultural areas appear to be barriers to dispersal (Forsman et al. 2002, Miller et al. 1997). Spotted owls use a wide variety of forest habitats for dispersal and will traverse very fragmented landscapes (Forsman et al. 2002), but little information exists on how the amount or fragmentation of habitat influences dispersal. The results of the latest meta-analysis suggest that recruitment into the territorial breeding population may depend on the presence of sufficient amounts of high-quality dispersal habitat, enough to ensure survival of dispersing owls until they recruit into the territorial population (Forsman et al. 2011).

We did not use presence locations and MaxEnt to model dispersal habitat. Instead we developed dispersal habitat maps for both bookend periods using simple GIS queries of our GNN variables for conifer d.b.h. ≥11 in and conifer cover ≥40 percent, similar to what was done in the 10-year report (Davis and Lint 2005). We also included both suitable habitat classes from our nesting/roosting habitat models, because owls obviously disperse through nesting/roosting habitat. We then analyzed the status and trend of this habitat within federal reserved and nonreserved LUAs, as well as nonfederal lands.

To detect changes in amounts of dispersal habitat that might affect owl movement across the landscape, we conducted a landscape-scale analysis using a spatial framework based on Forsman et al. (2002). Only 8.7 percent of dispersing individuals moved more than 31 linear mi and only "large expanses" of nonforested or younger forested areas appear to pose significant barriers to this movement (Forsman et al. 2002). We used this distance to define the radius (15.5 mi) for a circular analysis window within which we quantified the percentage of dispersal habitat for both bookend periods and included all landownerships. This distance is also comparable to the root-mean-square dispersal distance (a measure of gene flow) estimated by Barrowclough et al. (2005). We then overlaid linear owl dispersal paths from the 10-year report (Lint et al. 2005) on the baseline version to measure underlying percentages of dispersal habitat in the landscape through which they dispersed (fig. 3-7). The mean percentage of dispersal habitat for both juvenile and nonjuvenile owls was 55 percent. We combined results across age classes and used the 10-percentile value (40 percent) from all owl dispersal paths as a threshold to create binary maps from the roving window analysis maps. Thus, the binary maps show where there appears to be enough dispersal habitat at the landscape scale (≥40 percent within a 15.5-mi radius) to accommodate 90 percent of known owl movements. We call this footprint the "dispersal-capable landscape" and used it to identify potential disconnects or bottlenecks for owl movement between large block reserves. We also identified areas across the range of the owl where the footprint shrank or expanded between our bookends.

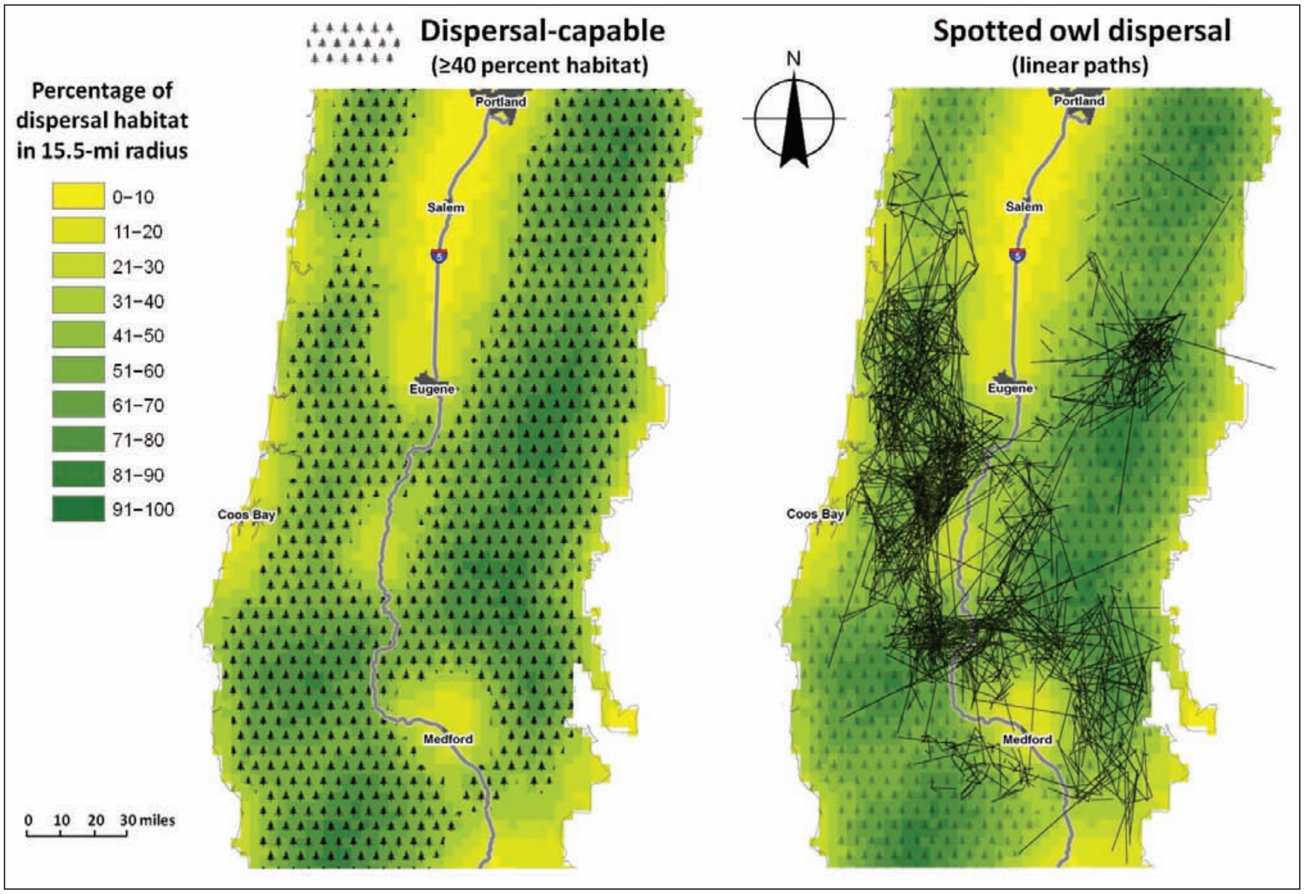

Figure 3.7—Juvenile and nonjuvenile dispersal straight-line paths from Lint et al. (2005) in relation to the amount of dispersal habitat within a 15.5-mi radius that was based on information from Forsman et al. (2002) where only 8.7 percent of dispersing individuals moved more than 31 linear mi.

Habitat Fragmentation

Although large blocks of contiguous, high-quality habitat provide the best configuration for long-term persistence of owl populations (Thomas et al. 1990), smaller blocks or patches of owl habitat can also be important as dispersal habitat (Forsman et al. 2002). These smaller patches help to maintain connectivity between the larger blocks of habitat that will eventually develop in the reserve system designed under the Plan. At the time of the owl's listing, habitat fragmentation was believed to be a stressor for spotted owls because it is associated with habitat loss, and was also thought to improve habitat conditions for spotted owl predators, such as the great horned owl (*Bubo virginianus*) (Carey et al. 1992). There is no clear evidence of indirect effects of fragmentation through predation, but it remains as a possible threat (Courtney et al. 2004). A compilation of the recent research on this subject shows that habitat fragmentation can affect occupancy and other demographic factors, and may result in isolated populations and interruption of gene flow (Courtney et al. 2004).

In a general sense, habitat can be divided into two broad landscape morphological categories: (1) core habitat, which occurs only in larger habitat patches and is some distance away from the patch edge (sometimes referred to as "interior habitat"); and (2) edge habitat, which occurs along the margins of larger habitat patches surrounding the core habitat or occurs in patches that are too small to contain core habitat.

It is not clear how habitat fragmentation affects owl demographics; however, survival and reproduction are higher on owl territories with more old-forest habitat centered on the nest tree or activity center (Dugger et al. 2005, Franklin et al. 2000, Olson et al. 2004). Edge habitat also appears to be important to spotted owls in some portions of their range, probably as a source of prey (Franklin et al. 2000, Olson et al. 2004; but see exception in Dugger et al. 2005).

Here we define core habitat as the internal portion of a stand of nesting/roosting habitat that is farther than 100 m from the stand edge. Edge habitat is defined as all noncore nesting/roosting habitat and is always adjacent to non-habitat. We do, however, distinguish between two types of edge habitat: (1) core-edge habitat, which is the amount of nesting/roosting habitat adjacent to and surrounding core patches (i.e., the edges of large habitat patches), and (2) all other edge habitat that is not directly adjacent to core habitat (i.e., small, isolated habitat patches). In juxtaposition, core and core-edge habitat reflect more contiguous habitat blocks, whereas large amounts of non-core-edge habitat occur in landscapes that are highly fragmented, with patch sizes too small to contain core habitat.

We used GUIDOS v1.3 (Soille and Vogt 2009) to conduct a morphological spatial pattern analysis (MSPA) on 100-m (2.47-ac)-resolution binary raster (grid) maps of nesting/roosting habitat for both 1994/96 and 2006/07 to assess status and trend in habitat configurations. GUIDOS was specifically developed for analysis of forest spatial patterns extracted from satellite images (Soille and Vogt 2009, Vogt et al. 2007). It produces simple-to-interpret maps of core and edge patterns from binary raster maps, and the outputs are pixels with specific core or edge classifications (fig. 3-8). From this product, we conducted an area analysis that quantifies the area represented by both types of pixels (“core” or “edge”); thus, in our analysis, edge is not quantified as a perimeter. Specifically, edge habitat only occurs within 1 pixel width, or 100 m (328 ft), from a nonhabitat pixel, and, therefore, core habitat pixels are greater than 328 ft from nonhabitat pixels. This distance is similar to that used by Franklin et al. (2000) and Zabel et al. (2003) to define their core habitat. Using 100-m (2.47-ac)-resolution maps requires a patch of contiguous habitat to be greater than 22 ac before it can contain core habitat. Therefore, the combination of core plus core-edge pixels shows patterns of habitat patches that are at least that large. All patches of nesting/roosting habitat smaller than that are essentially

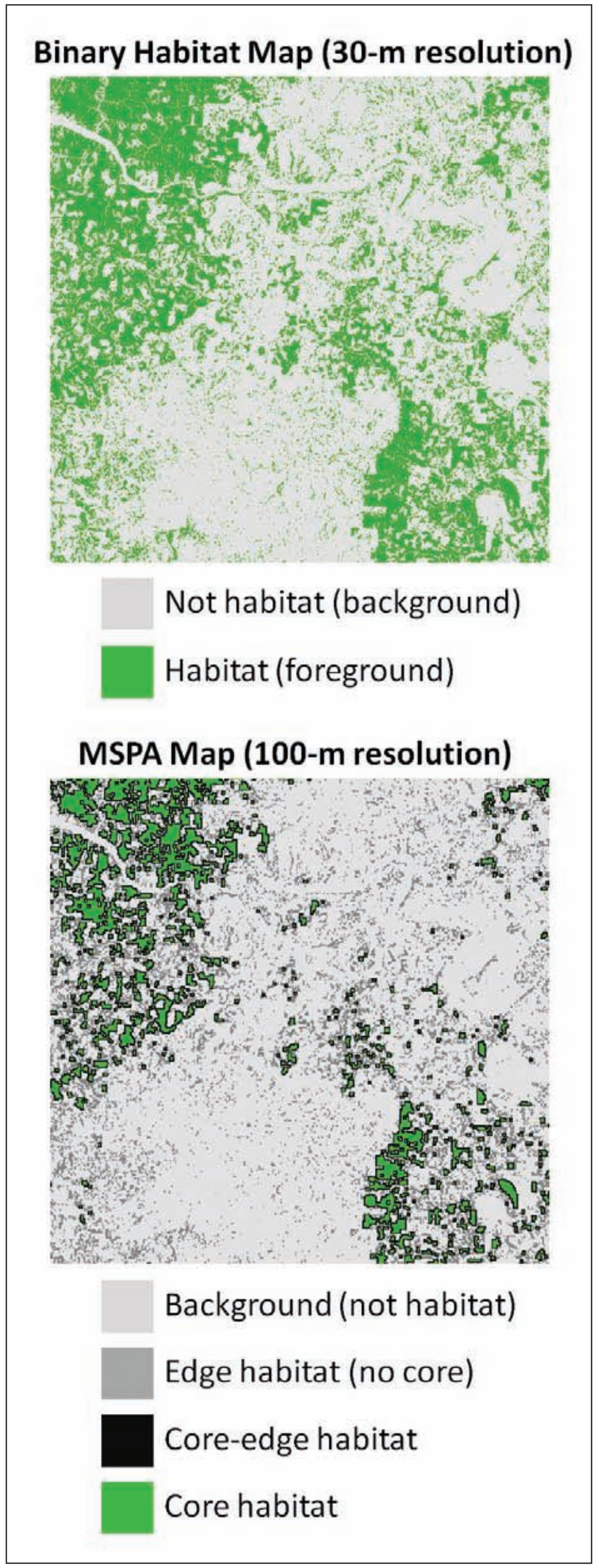

Figure 3-8—Example of the morphological spatial pattern analysis (MSPA) on binary maps of nesting-roosting habitat.

edge habitat. We report on the status and trend of core habitat and changes in the percentage of the sum of [core] + [core-edge] habitat to all nesting/roosting habitat. This percentage can serve as an index of landscape habitat fragmentation, as the higher the percentage, the more contiguous the habitat is within the landscape and the lower the percentage, the more fragmented the habitat (fig. 3-8).

Results

Habitat Suitability Modeling

Our final habitat models and map products (fig. 3-9) represent the mean from 10 bootstrapped replicates. We decided to use the means as our product, because the P/E curves that are generated for the means provide the users with valuable information on how to interpret the model (see the "Habitat Map Development and Validation" section and fig. 3-6). We also provide the summary statistic maps (i.e., 95-percent CI) to supplement this interpretation with area-specific information as discussed in the methods section.

Performance of bookend 1 (1994/96) models was fair to good (i.e., C+ to B+ grades) with AUCs ranging from 0.78 to 0.88 and Spearman rank correlation coefficients >0.9 ($P < 0.001$) (app. C). Our lowest performing models occurred in the Oregon and California Klamath and California Coast modeling regions, and our best models were in the Washington Coast and Cascades and Oregon Coast modeling regions. We suspect this is because of the rich vegetative diversity in that area that (1) confounds remotely sensed data development and (2) produces a more complex "definition" of habitat because of the complex variable interactions. Regardless of the reason, the model AUCs for these regions were 0.78 and 0.81, respectively, and therefore provide useful information (Swets 1988).

Our projected models (bookend 2, 2006/07) were tested using the 2006/07 owl location data sets not used for model training. Spearman ranks based on the continuous Boyce index (Hirzel et al. 2006) ranged from 0.63 to 0.98. The best model projection [extrapolation] occurred in the Oregon Cascades modeling region, followed in order by the Oregon Coast Range ($R_S = 0.95$), western Washington and Olympic ($R_S = 0.93$), and, surprisingly, the Klamath Mountain modeling region ($R_S = 0.92$). The poorest model projections occurred within the Washington Cascades modeling region ($R_S = 0.74$) and California Coast Range ($R_S = 0.63$). During this testing process, we noted interesting differences between the average habitat suitability values where spotted owls in the demographic study areas occurred in 1994/96 compared to where they occurred in 2006/07 (fig. 3-10). We observed consistently lower than average habitat suitability values in 2006/07 compared to 1994/96; however, 95-percent CIs overlap between periods. We speculate that spotted owls might be using lower quality habitat in 2006/07 because they are being displaced from higher quality habitats by barred owls, whose density has increased steadily since the late 1990s (Forsman et al. 2011). The potential for displacement of spotted owls by barred owls in the current bookend is the reason we trained our models using the 1994/96 spotted owl locations. However, given the aforementioned issues on model projection [extrapolation], these results, based on our bookend 2 models, should be interpreted with some caution.

Nesting/Roosting Habitat

We estimate a rangewide gross loss of about 298,600 ac[4] of spotted owl nesting/roosting habitat on federal lands (app. D). This amounts to about 3.4 percent of what was present in 1994/96 (bookend 1). Most of the loss (79 percent) occurred within the reserved allocations, which amounted to about 3.7 percent of the reserved areas under the Plan, whereas nonreserved allocations experienced a 2.7 percent loss of habitat. Wildfires remain the primary cause of habitat loss, accounting for about 90 percent of the loss in reserved allocations (203,900 ac), and about half of the loss in nonreserved allocations (32,600 ac). Timber harvesting accounts for about 45 percent of the loss in nonreserved allocations (37,400 ac) and 7 percent within reserved allocations (16,600 ac), and insects and disease outbreaks account for about 3 percent of the loss in all allocations (fig. 3-11). Relative to the baseline maps, and based on

[4] Acres are rounded up to the nearest 100 ac.

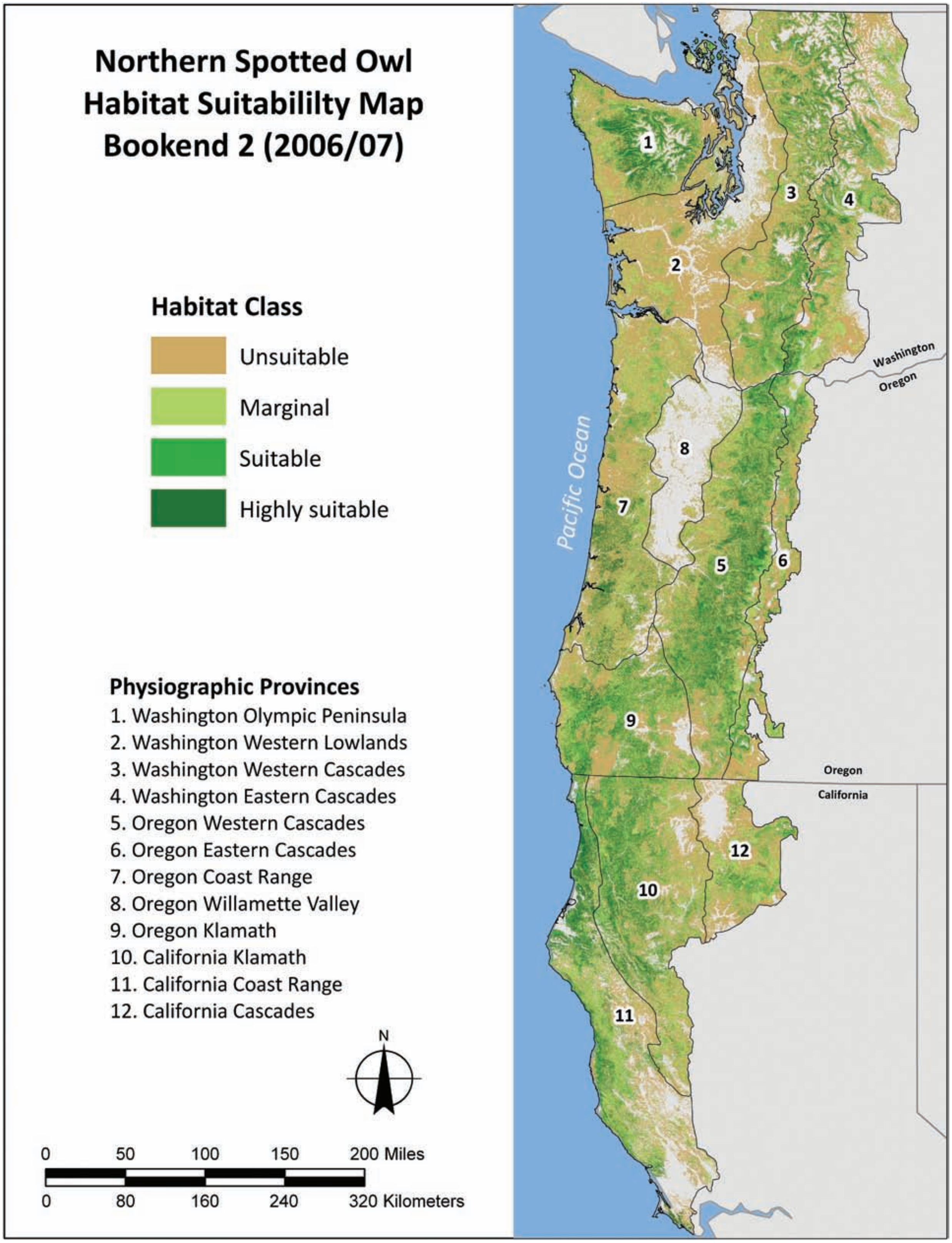

Figure 3-9—Northern spotted owl habitat suitability map showing the spatial distribution of nesting/roosting habitat as of 2006 (in Oregon and Washington) and 2007 (in California).

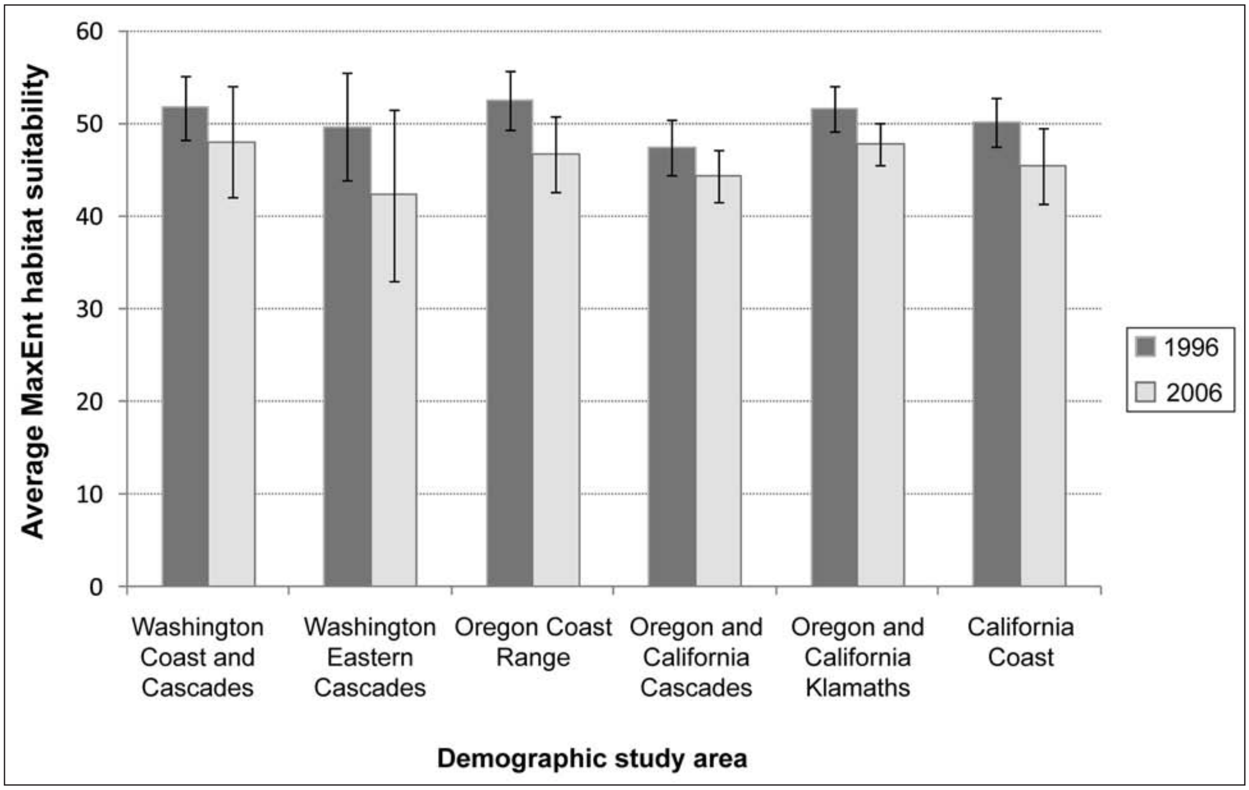

Figure 3-10—Observed differences in average modeled habitat suitability for spotted owl pair locations within demographic study areas between 1994/96 and 2006/07.

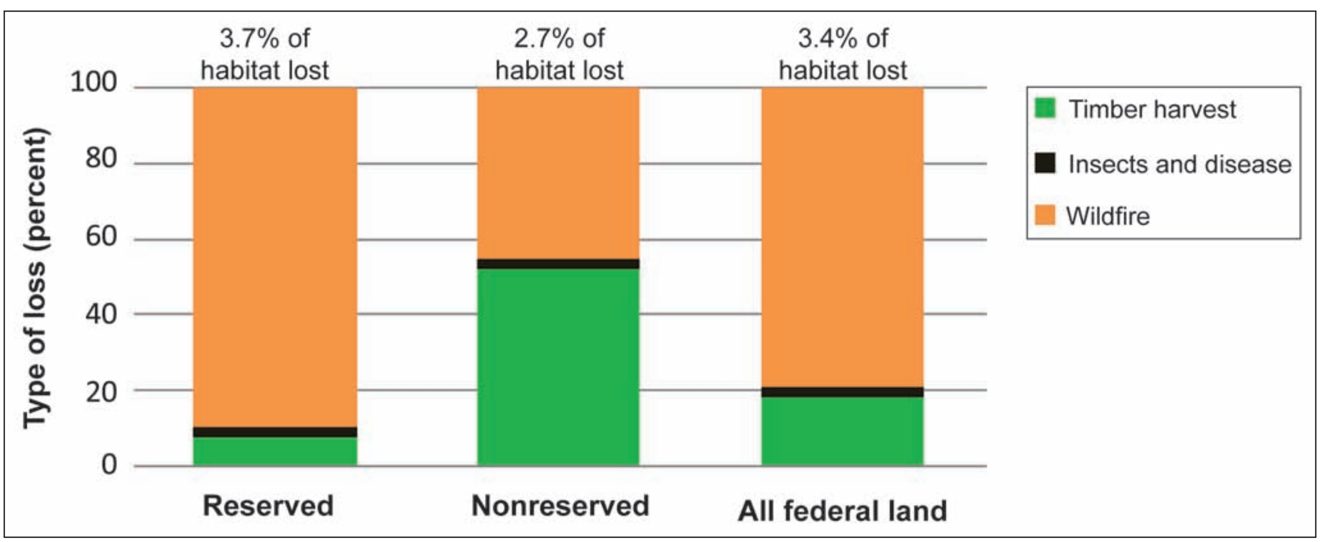

Figure 3-11—Causes of nesting/roosting habitat loss on federally administered lands.

LandTrendr change-detection data, the physiographic province that experienced the greatest loss of habitat was the Oregon Klamath province because of the large Biscuit Fire that occurred in 2002. In general, the Klamath and eastern Cascades physiographic provinces experienced the largest percentage losses of habitat related to wildfires (fig. 3-12); however, in terms of absolute acreage of habitat lost, the Oregon Klamath ranked first (93,600 ac), California Klamath ranked second (71,600 ac), and the Oregon western Cascades ranked third (28,900 ac) (app. D). Most of the habitat loss in the Oregon western Cascades occurred in the southern half of that province.

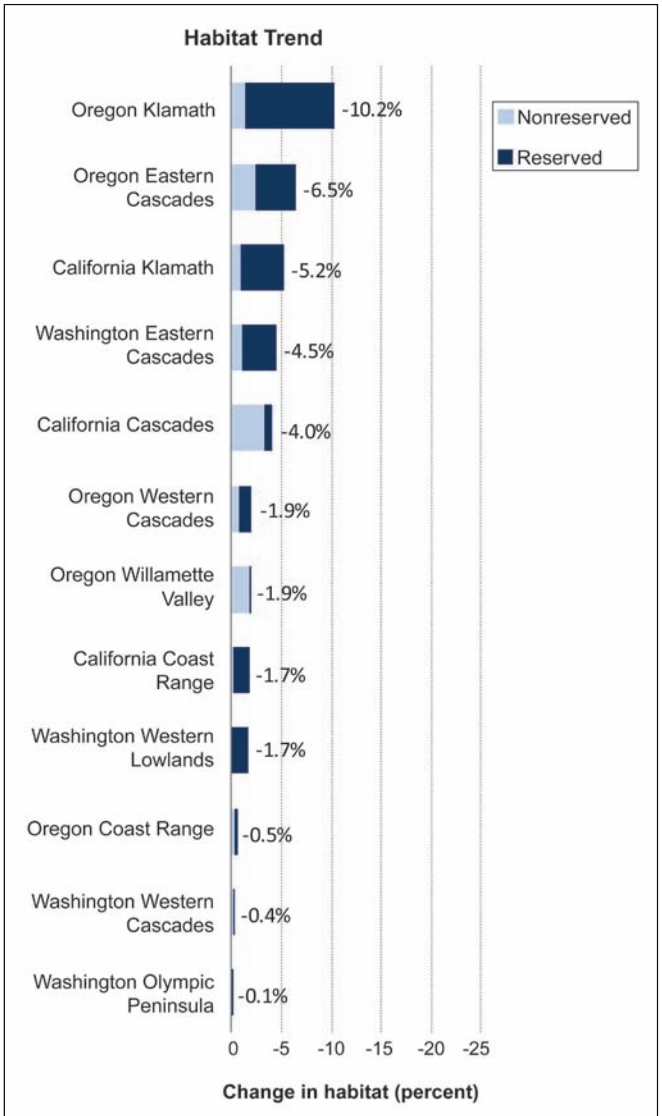

Figure 3-12—Nesting/roosting habitat trends (based on the LandTredr analysis) from 1994/96 to 2006/07 by physiographic province for reserved and nonreserved federal lands.

Because wildfires appear to be the number one cause of habitat loss, we conducted a more indepth analysis of the 20 largest wildfires that occurred within the owl's range between 1996 and 2006 (years with satellite data across the range). Table 3-2 lists these fires in descending order of estimated acres of owl habitat lost. Overall, these 20 fires accounted for almost 200,000 ac of habitat lost. The percentage of owl habitat lost within their fire perimeters differed among the east and west Cascades (Washington and Oregon) and the Klamath Mountains (Oregon and California) physiographic provinces (fig. 3-13). The percentage lost per fire in the Klamath Mountains and the west Cascade provinces were not significantly different (overlapping 90-percent CIs); however, percentage of habitat loss per fire was notably higher in the eastern Cascades. However, in terms of the amount of nesting/roosting habitat burned by these 20 fires, the vast majority of acres lost occurred in the Klamath Mountains (143,000 ac), followed by the east side of the Cascades (36,000 ac) and the western Cascades (20,000 ac).

Based on Climate, Ecosystem, and Fire Applications (CEFA) program data (Brown et al. 2002) and wildfire perimeter data (MTBS and GeoMac), wildfires burned an estimated 2.6 million ac within the owl's range between 1994 and 2007, which frames our analysis period. From our observations, it is clear that wildfires do not remove all owl nesting/roosting habitats within their perimeters. Fires of low to moderate severity can alter this habitat, but do not necessarily result in its loss. The commonly used term to define this effect is "habitat degradation." We estimated owl habitat degradation, as the number of acres that changed from the "highly suitable" to the "suitable" habitat class between our bookends (1994/96 to 2006/07). For habitat degradation, our analysis showed the reverse trend from what we observed for habitat loss (fig. 3-14). These results suggest that wildfires in the east Cascades have been more destructive (higher amount of habitat loss, lower amount of degradation) and that wildfires in the west Cascades and Klamath Mountains were less severe, producing a mosaic of fire effects indicative of a moderate-severity regime.

Table 3-2—Estimated fire effects on northern spotted owl nesting/roosting habitat from the 20 largest wildfires between 1996 and 2006

Fire name	Year	Broad physiographic province	Habitat in wildfire perimeter	Habitat lost		Habitat degraded	
			Acres	*Acres*	*%*	*Acres*	*%*
Biscuit Fire	2002	Klamath Mountains	226,230	93,730	41	12,019	5
Megram Fire	1999	Klamath Mountains	76,337	27,520	36	4,589	6
B&B Complex	2003	East Cascades	26,269	16,403	62	907	3
Bake-oven Fire	2006	Klamath Mountains	23,946	8,873	37	581	2
Boulder Fire	2002	West Cascades	34,059	8,460	25	2,074	6
Davis Fire	2003	East Cascades	8,050	6,943	86	5	0
Pigeon Fire	2006	Klamath Mountains	13,896	5,634	41	327	2
Rex Complex	2001	East Cascades	8,548	4,750	56	278	3
Timbered Rock	2002	West Cascades	10,216	4,539	44	569	6
Spring Fire	1996	West Cascades	13,504	3,931	29	858	6
Deep Harbor Fire	2004	East Cascades	5,761	3,930	68	64	1
Hancock Fire	2006	Klamath Mountains	12,712	3,132	25	336	3
Apple Fire 2	2002	West Cascades	12,227	2,810	23	928	8
Fischer Fire	2004	East Cascades	4,479	2,340	52	34	1
Fork Fire	1996	Klamath Mountains	2,962	2,113	71	14	0
Needles Fire	2003	East Cascades	1,946	874	45	1	0
Trough Fire	2001	Klamath Mountains	1,851	798	43	4	0
Hunter Fire	2006	Klamath Mountains	2,236	789	35	40	2
Deer Point Fire	2002	East Cascades	505	380	75	0	0
Tatoosh Complex	2006	East Cascades	666	378	57	0	0

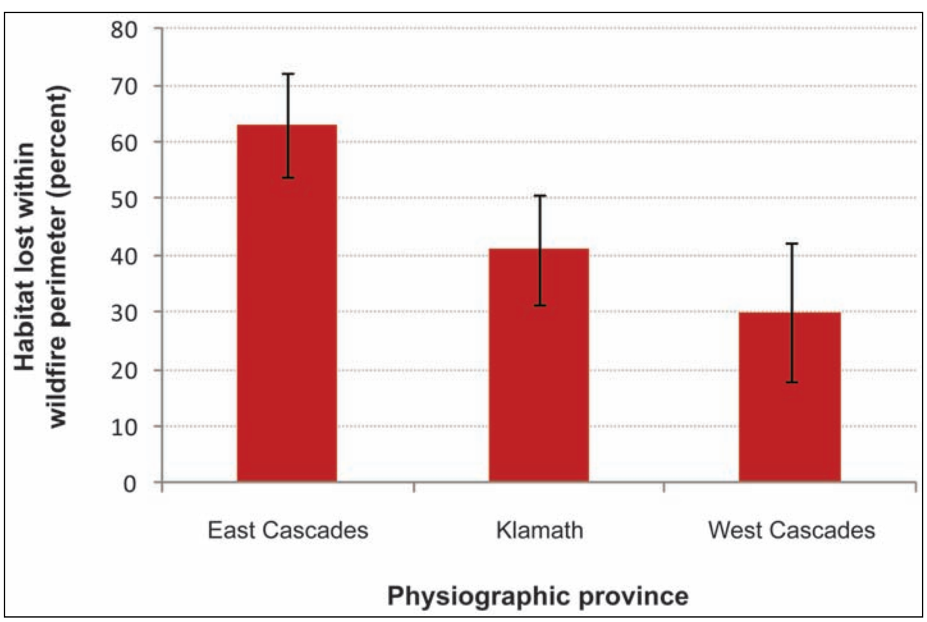

Figure 3-13—Provincial differences in nesting/roosting habitat losses from the fires in table 3-2.

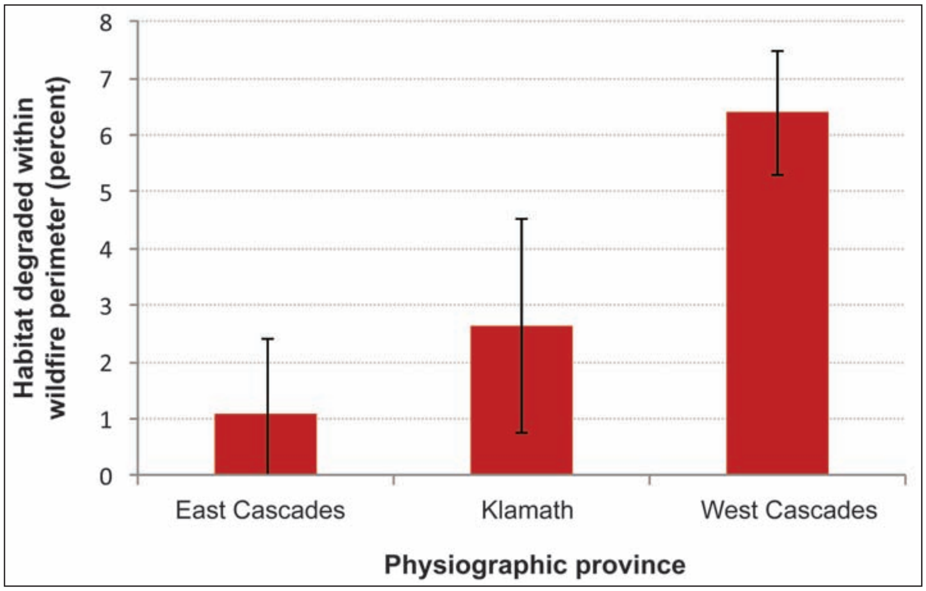

Figure 3-14—Provincial differences in nesting/roosting habitat degradation from the fires in table 3-2.

For this report, we were cautious in our use of the new GNN/LandTrendr data for measuring gains in nesting/roosting habitat. Although the products we used for our analysis (and other remote sensing approaches) have demonstrated their ability to detect both losses and gains in forest cover (Coops et al. 2010; Hais et al. 2009; Kennedy et al. 2007, 2010; Staus et al. 2002), the underlying measurements from passive optical satellite sensors (i.e., those that take pictures of sunlight reflected from the Earth's surface) place constraints on the subtlety of coniferous forest change that can be reliably captured over a short period (i.e., 10 to 12 years). Disturbances that result in substantial removal or reduction of vegetation cover (usually abrupt changes) are easier to discern during change-detection than minor disturbances that cause more subtle change, or gradual disturbances that occur over a longer period, such as insect and disease disturbances. Vegetation recovery can also be more difficult to detect (depending on the type of vegetation and timeframe), as it usually recovers gradually over a longer period. Increases in tree bole diameter and forest canopy cover happen at a faster rate in younger coniferous forests than in older forests, however, and the satellite-measured signal changes faster as well. Within the 10- to 12-year period of this investigation, mapping of such changes in early successional, pre-canopy-closure conditions are relatively robust (Kennedy 2010). Much more subtle, however, are the satellite signals associated with the structural changes as forests progress to maturity and old age. Moreover, small-scale forest canopy gap dynamics cannot be directly observed with the sensors used in our analysis (Frolking et al. 2009). Rather, all structural changes associated with maturing forests often must be inferred from changes in the spectral signal caused by proxy effects, such as within-canopy shadowing. Therefore, it is difficult to distinguish at a given location small changes in forest structure (and any associated variables, such as age) from background random noise caused by differing sun angles, atmospheric effects, and phenological differences, particularly when the interval of change is short (as for the 10- to 12-year period here) (Kennedy 2010).

During our analysis, we conducted visual and GIS examinations of our nesting/roosting habitat maps and variable maps using aerial imagery and noted that commercial thinning of young plantations created suspicious changes in some of our habitat modeling variables in the bookend 2006/07 data set. For instance, in some modeling regions, stand age increased by three to five decades, or density of large conifer (>30 in d.b.h) increased by as much as three to four trees per ac, which is not likely within the timeframe of our analysis. We suspect that canopy shadowing increased owing to the thinning and may have caused some stands to appear older than they actually were, thus making them appear as habitat when the modeling results from the 1994/96 bookend were extrapolated (projected) to the 2006/07 bookend.

We also conducted an analysis of the regional inventory plot data, similar to what was done in the 10-year report (Davis and Lint 2005), to determine if there were significant gains of forest stand conditions that were similar to spotted owl nesting/roosting habitat (see table 3-5, page 47 in Davis and Lint 2005). The results of this analysis did not show any significant gains in "habitat classes" between the initial plot measurement and the remeasurement data, which roughly covers the same periods as our bookend models (app. H). In addition, the net changes between the bookend models were well within the 95-percent CIs between periods; therefore, it is not possible to state with certainty that we observed "real" net changes in nesting/roosting habitat between our bookend maps (app. C). For these reasons (plus the need for caution when transferring or projecting models discussed earlier), we focused on habitat losses, which are more accurately detected with current technologies and were verified by LandTrendr change-detection data. For the next round of monitoring (20-year report), we hope to use LandTrendr for verification of both nesting/roosting habitat losses and gains.

Dispersal Habitat

Although we were cautious in our interpretation of gains in nesting/roosting habitat, we feel that the GNN/LandTrendr data were better suited for detecting gains in younger forests (as described above), such as dispersal habitat, plus we did not develop and then project (extrapolate) a dispersal habitat model from one period to another as we did for nesting/roosting habitat (i.e., no model transferability issues). Examination of the bookend changes in the two variables that were used to define dispersal habitat (d.b.h. and conifer cover), and visual examination of the dispersal habitat maps overlaid on high-resolution color aerial imagery showed realistic changes that one might expect in a 10-to 12-year timeframe.

Rangewide, we report an estimated gross loss of about 417,000 ac of dispersal habitat, most (82 percent) from wildfire (341,800 ac). The causes for dispersal habitat loss were similar to those for nesting/roosting habitat losses, with wildfire being the main cause in reserved allocations and about half of the loss in nonreserved allocations (fig. 3-15). Timber harvesting accounts for the other half of the loss in nonreserved allocations, and insects and disease account for a small percentage of loss in all allocations (fig. 3-15). However, these losses were offset by a 1.26-million-ac gross gain in dispersal habitat on federal land from forest

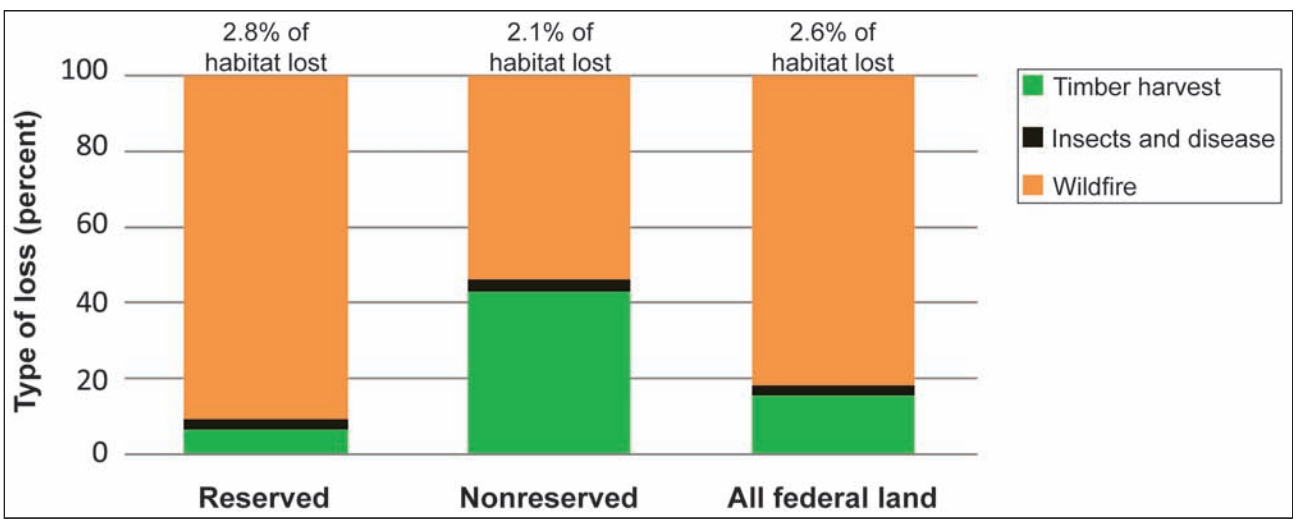

Figure 3-15—Causes of dispersal habitat loss on federally administered lands.

succession, resulting in a 5.2-percent overall net gain of dispersal habitat coverage across the owl's range (app. E). In general, the gains in dispersal habitat were higher in federal nonreserved allocations than in reserved allocations. Only the Oregon Klamath experienced a net decrease in the amount of dispersal habitat (-2.6 percent) owing to the large Biscuit Fire, which removed more dispersal habitat than was recruited for this period (app. E). The biggest net gain (13.1 percent) in federal dispersal habitat occurred in the Oregon Coast Range, which has some of the most productive forests in the owl's range. An example of this recruitment is clearly seen in the maps from 1996 and 2006 for the large Oxbow Fire of 1966 (fig. 3-16). In 1996, this area was forested with stands just about 30 years of age. Based on tree diameter growth data for fully stocked, site class 1, Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) forests, stands of this age have an average d.b.h. of 9 in and can put on 3 in of diameter growth in one decade (McCardle et al. 1961), thus crossing the threshold from nondispersal to dispersal habitat in a relatively short timeframe. However, not all sources of gain for dispersal habitat come from forest succession. Sometimes disturbances, such as a moderate-severity wildfire, can alter (i.e., opening up the canopy) suitable nesting/roosting habitat, making it unsuitable for nesting and roosting, but still suitable enough for owl dispersal (see table 3-1).

At the landscape scale, we detected a 5-percent gross loss of dispersal-capable landscape, mostly around the periphery of the federal forests. We suspect this may be due to regeneration timber harvesting occurring in dispersal habitats on nonfederal lands that border federal lands. Large wildfires on federal lands played a role in this decrease in the eastern Cascade provinces and the Oregon Klamath Mountain province. We also detected a 4-percent gross gain in dispersal-capable landscapes along the periphery of some federal forests caused by forest succession in younger forests, resulting in an overall net decrease of 1 percent in dispersal-capable landscape area (fig. 3-17).

The most noticeable change in dispersal-capable landscapes, that we detected, occurred in the northeastern portion of the Washington eastern Cascades; the losses of dispersal-capable landscape caused by large wildfires in

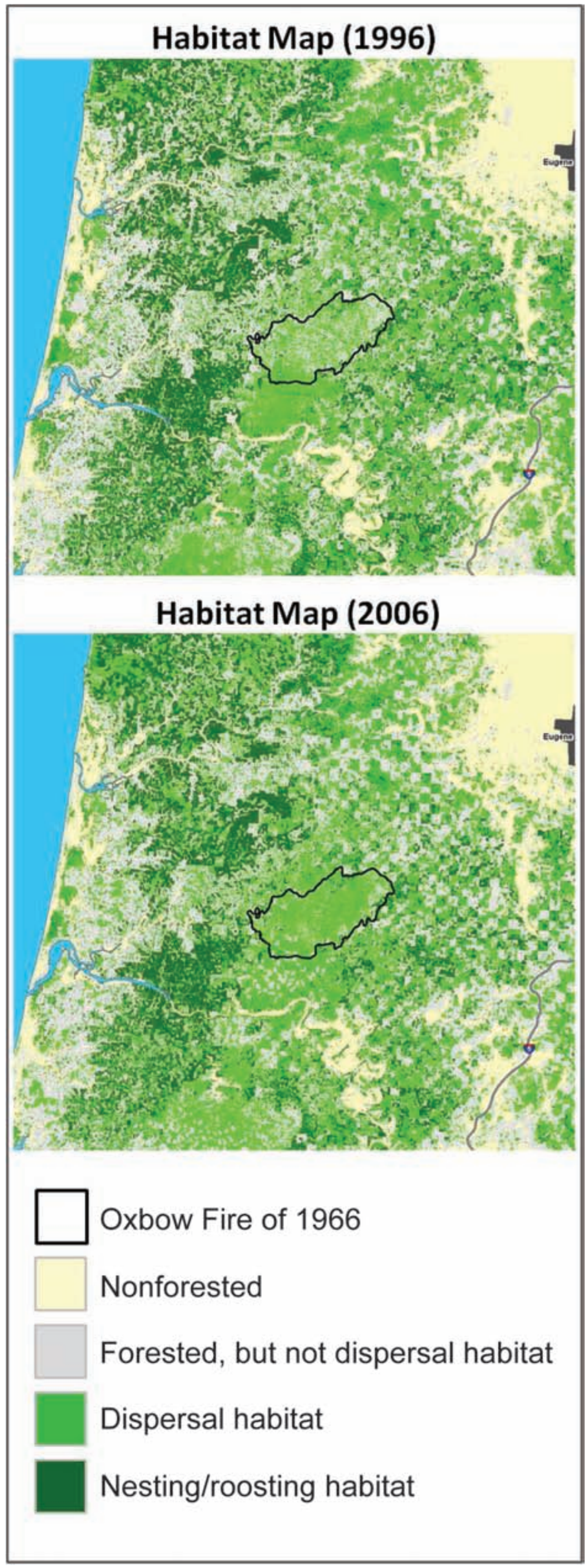

Figure 3-16—Recruitment of dispersal habitat in the Oxbow Fire (1966) in the Oregon Coast Range.

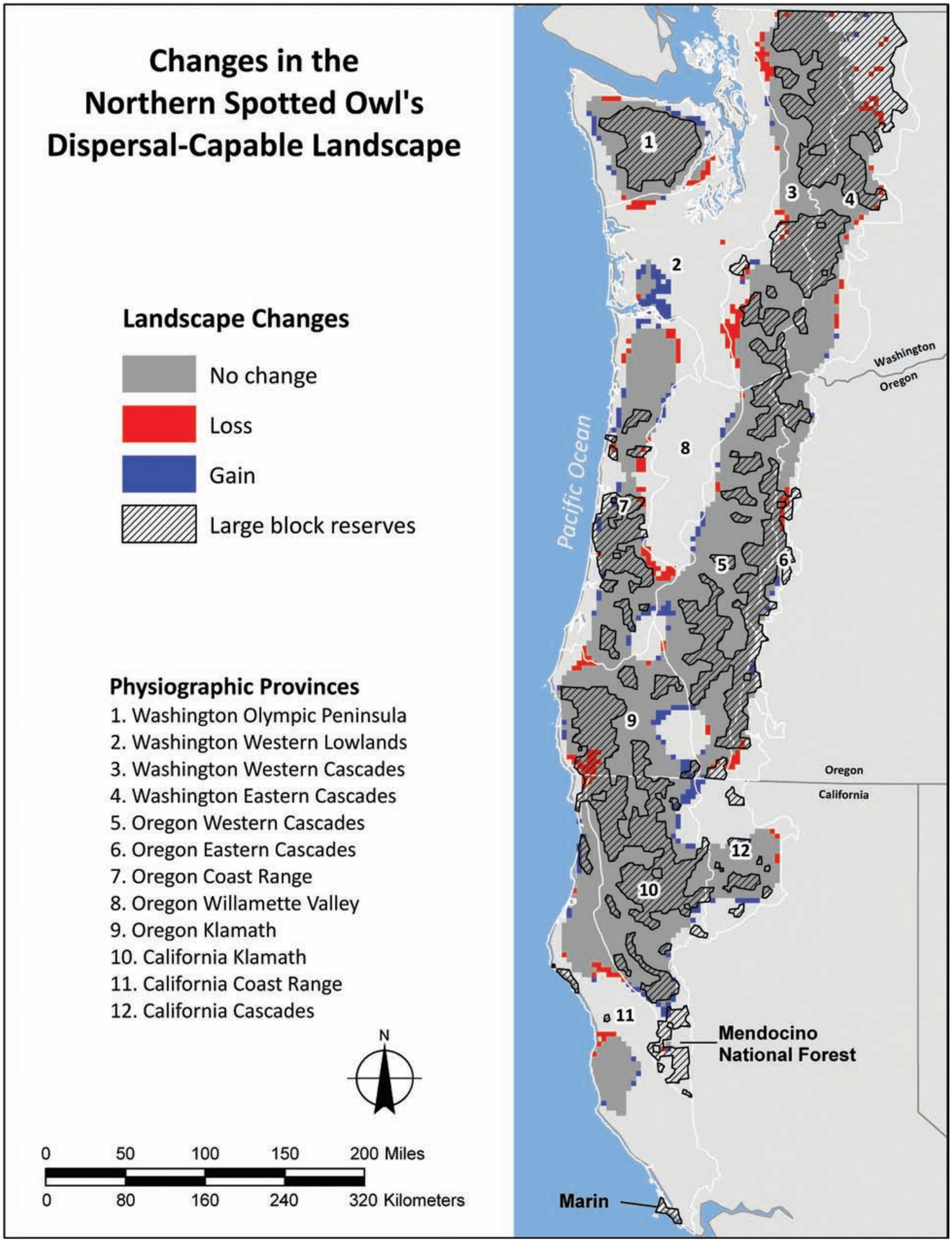

Figure 3-17—Changes in dispersal-capable landscapes across the owl's range.

that area may have isolated some of the large LSRs established at the Plan's implementation (fig. 3-17). This may also be the case for the LSR just to the east of the B&B Fire where it appears that there has been a 3- to 6-mi contraction of dispersal-capable landscape in that area. Overall, the large reserved network still appears to be well connected, with the exception of three areas. Of primary concern are the federal reserved lands on the Olympic Peninsula, which are separated from the Cascades by about 75 mi of landscape with poor dispersal conditions (fig. 3-17). These federal lands are also separated from federal reserves that occur about 90 mi to the south in the northern Oregon Coast Range physiographic province. The federal reserves in the most northern part of the Oregon Coast Range are the second area of concern. It appears that regeneration timber harvesting on nonfederal land may be narrowing the dispersal connection to the rest of the Coast Range's large federal reserved allocations. Finally, the southernmost large reserves, which are mainly located on the Mendocino National Forest in the California Klamath Mountains physiographic province, appear to occur in poor dispersal landscapes, and the Marin County northern spotted owl population, in particular, appears isolated at the extreme southern tip of the owl's range (fig. 3-17).

Habitat Fragmentation

At the range scale, core habitat accounted for about 19 and 29 percent of baseline nesting/roosting habitat within nonreserved and reserved allocations, respectively, indicating that reserved allocations contain larger patches of suitable habitat. Between 1994/96 and 2006/07, the amount of core habitat on federal lands decreased by 6 percent at the range scale, with 4.6 percent of this decrease occurring in reserved allocations. The largest decrease (-20.6 percent) occurred in the Oregon Klamath province and was largely owing to the Biscuit Fire (fig. 3-18). The percentage loss of core habitat by physiographic province shown in figure 3-18 generally follows the same pattern among provinces as for nesting/roosting habitat loss (fig. 3-12); however, percentage of loss is larger for core habitat, because it is a subset of nesting/roosting habitat and confined to a smaller portion of the landscape.

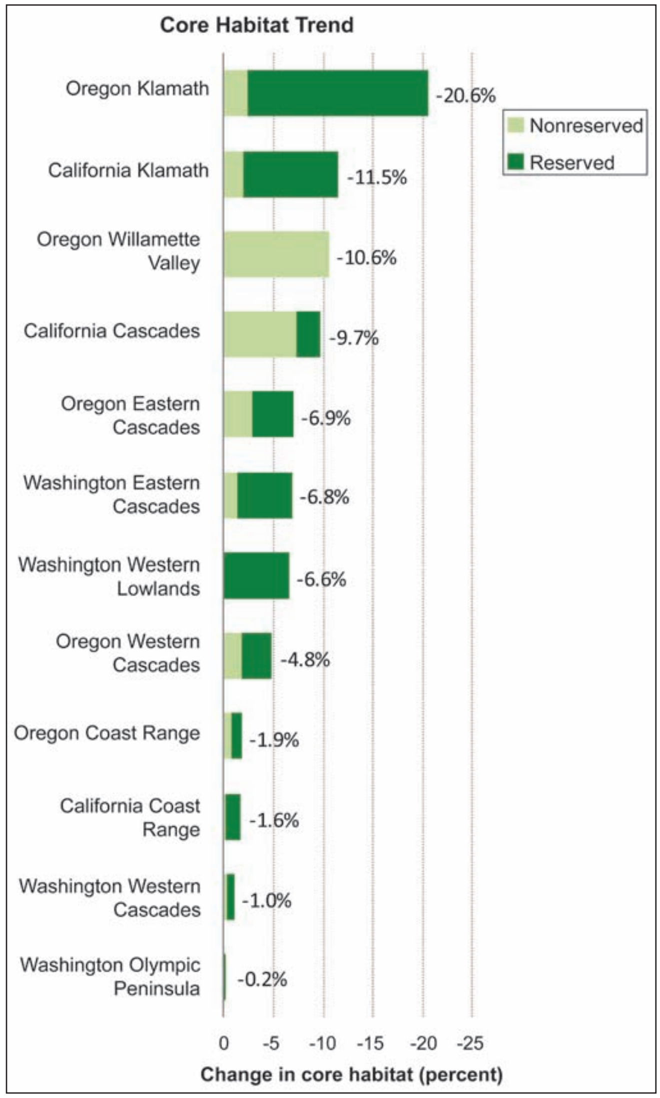

Figure 3-18—Nesting/roosting "core" habitat trends from 1994/96 to 2006/07 by physiographic province for reserved and nonreserved federal lands.

The combination of core and core-edge habitat constituted about 50 percent of the baseline nesting/roosting habitat in nonreserved allocations and 61 percent in reserved allocations at the range scale, indicating that reserved allocations contain more contiguous habitat than nonreserved allocations (table 3-3). We report an average rangewide decrease of 1 percent in these ratios, signifying a small but measureable increase in habitat fragmentation. The largest decreases occurred within the federally reserved portions of the Klamath provinces in Oregon (-4.3 percent) and California (-2.7 percent) and California Cascades (-3.1 percent), again because of wildfires (table 3-3).

Table 3-3–Habitat fragmentation status and trends based on the percentage of nesting/roosting habitat in core and core-edge habitat

	Reserved			Nonreserved		
Physiographic province	**1994/96**	**2006/07**	**Trend**	**1994/96**	**2006/07**	**Trend**
			Percent			
Washington Olympic Peninsula	72.76	72.75	-0.01	33.22	32.86	-0.36
California Coast Range	68.77	68.81	0.04	46.64	47.19	0.55
Oregon Western Cascades	68.77	67.72	-1.05	59.51	58.39	-1.12
Oregon Coast Range	62.83	62.53	-0.30	39.41	37.77	-1.64
Oregon Klamath	61.69	57.35	-4.34	38.51	36.80	-1.71
Washington Western Cascades	59.23	59.06	-0.17	49.77	49.44	-0.33
Washington Eastern Cascades	55.69	54.39	-1.30	50.89	50.20	-0.69
Oregon Eastern Cascades	55.00	55.04	0.04	48.94	47.28	-1.66
California Cascades	51.70	50.67	-1.03	48.30	45.16	-3.14
California Klamath	49.01	46.31	-2.70	42.22	41.14	-1.08
Washington Western Lowlands	31.34	30.28	-1.06	0.00	0.00	0.00
Oregon Willamette Valley	25.74	25.93	0.19	27.83	26.13	-1.70

Note: Physiographic provinces are listed in order of least- to most-fragmented federal reserved land allocations based on the status in 1994/96. Negative trend values indicate increased fragmentation.

Discussion

Substantial progress has been made in 5 years to overcome some of the previous limitations of habitat monitoring (Davis and Lint 2005). Most importantly among these advancements is the development of a consistent set of vegetation data that now covers the entire range of the owl. As suspected by Davis and Lint (2005), the finer resolution (in both spatial scale and attributes) of this new vegetation data resulted in lower, but more accurate, estimates of the amount of northern spotted owl habitat in California. In addition, the development of bookend maps (using the same vegetation and modeling techniques) has increased our ability to detect trends of habitat losses and gains. For the first time, we can estimate not only habitat losses, but also habitat degradation—where habitat is altered by a disturbance, but still remains suitable for owl nesting and roosting. The new LandTrendr change-detection data (Kennedy et al. 2010) were critical for verifying the habitat losses we detected with the bookends and also for assigning a cause for the habitat changes.

Although we were able to detect, measure, and report on nesting/roosting habitat loss and degradation, we were not able to detect and measure its recruitment during the 10- to 12-year timeframe of our analysis data. The expectation was that validation of habitat development would be part of the new habitat suitability maps developed by the interagency monitoring program (Courtney et al. 2004). However, validation of habitat development is a difficult task, and the transition of a forest age class or size class into the next higher class does not always equate to recruitment of owl habitat (Courtney et al. 2004). As seen from the combinations of vegetation variables we used for habitat modeling (app. A and table C-1 in app. C), the definition of nesting/roosting habitat is not a simple combination of one or two attributes. In reality, it is much more complex, and the transition of habitat from unsuitable to suitable likely happens over multiple decades (Courtney et al. 2004). This was not the case for the younger forest types through which owls can disperse. We cautiously accounted for gains in dispersal habitats after examination of the dispersal habitat maps on aerial imagery and through GIS analysis of changes in the tree diameter and canopy cover variables that were used in its definition.

So, although Raphael et al. (1994a, 1994b) and Lint et al. (1999) did not expect to see any significant gains in nesting/roosting habitat for a few decades, an examination of our habitat histograms (app. F) shows some gains in the "marginal" suitability class, which is similar to dispersal habitat (see table 3-1). Within the next three decades, the transition of habitat from the marginal suitability class to the suitable habitat class may be detectable given current remote sensing technology. In addition, the use of light detection and ranging (LIDAR) imagery, which is able to map forest canopy biomass, height, and vertical distribution, may provide us the ability to detect and monitor changes in the older stages of succession with improved accuracies (Falkowski et al. 2009).

Maintaining and restoring habitats that keep owl populations well connected across their range is a central goal of the Plan and should remain a priority. Our dispersal-capable landscape analysis was based on known linear dispersal distances (Forsman et al. 2002, Lint et al. 2005), and the analysis window we used to quantify amounts of dispersal habitat across the landscape had a diameter of 31 mi. This distance exceeds both the mean natal dispersal distance for males and females (Forsman et al. 2002) and the root-mean-square dispersal distance, which may be the more appropriate measure of gene flow (Barrowclough et al. 2005). Thus, our results indicate that most of the large reserved network is currently well connected (fig. 3-17) with a few exceptions, such as the Olympic Peninsula, the northern Oregon Coast Range, and the California Klamath, which we suggest might serve as focal areas for future studies on population connectivity and genetics, particularly as recent genetic work suggests northern spotted owls have undergone population bottlenecks resulting in reduced genetic diversity in several parts of their range, including the northern Oregon Coast Ranges, and the Klamath Mountains (Funk et al. 2010). Strong evidence for population bottlenecks in the Washington eastern Cascades were also reported (Funk et al. 2010) consistent with recent population declines in that region (Anthony et al. 2006, Forsman et al. 2011), but there is no definitive evidence that dispersal habitat is limited (this study) or that gene flow is restricted in that region (Barrowclough et al. 2005).

Summary

Rangewide owl habitat losses on federal lands were expected to be about 5 percent per decade, with a loss of 2.5 percent from timber harvest (USDA and USDI 1994) and 2.5 percent from wildfire (FEMAT 1993). We report a rangewide loss of 3.4 percent, between 1994/97 to 2006/07 and conclude that [rangewide] habitat is not declining faster than predicted under the Plan. Timber harvesting accounted for 0.6 percent of this loss, insects and disease 0.1 percent, and wildfire 2.7 percent of the habitat loss. Loss from timber harvesting is occurring at a fraction of what was predicted at Plan implementation, but habitat losses from wildfire are very close to what was predicted (FEMAT 1993). Although rangewide habitat losses have not exceeded what was anticipated under the Plan, the trend of habitat loss has been greater than 5 percent per decade in some physiographic provinces (i.e., Oregon Klamath). If localized habitat losses continue at the current rates within some provinces, it is unclear what effect this may have on the effectiveness of the Plan to maintain well-distributed and connected populations of northern spotted owls throughout their entire range, specifically the assumption that the large reserve network is resilient enough to incur these losses and not result in isolation of population segments (Lint et al. 1999).

Since implementation of the Plan, the majority of habitat loss on federally administered lands has been caused by wildfire, and most of that loss has occurred in reserved allocations. This seems counter to the Plan's goal of habitat maintenance and restoration within the reserved network. However, the reserve network was designed to function despite losses to wildfire, which were anticipated (FEMAT 1993, Murphy and Noon 1992). Although Lint et al. (1999) assumed that habitat conditions within large reserves would improve over time at a rate controlled by successional processes in stands that are not currently nesting/roosting habitat, they did not expect it to happen quickly, but over a period of several decades (Lint et al. 1999). Our latest monitoring shows that maintenance of nesting/roosting habitat within some of the large reserves is being challenged by the occurrence of large wildfires, and also that large-scale restoration of reserved nesting/roosting habitat has not yet occurred.

The monitoring assumption that habitat conditions outside of reserved allocations would continue to decline because of timber harvesting and other habitat-altering disturbances but would still facilitate owl movement across the landscape (Lint et al. 1999) is validated by the latest monitoring. The rate of nesting/roosting habitat loss outside of the reserves from timber harvesting has been lower than expected, and we observed both losses and gains in dispersal habitat. In our monitoring, we did not observe any isolation of owl population segments caused by large-scale disturbance; however, we did note both expansions and contractions of dispersal-capable landscape and that some large reserves in portions of the range have poor dispersal conditions and might be focal areas for further investigation of population isolation studies.

Although not included within the timeframe of this latest monitoring analysis, the southern portion of the owl's range experienced another 615,000 ac (approx.) of wildfire between 2008 and 2009, with most of it occurring within reserved land use allocations. If this trend persists, the actual decadal loss of habitat from wildfire will continue to push against the Plan's assumption of 2.5 percent per decade and, to reemphasize the point made at the beginning of this summary, may have unexpected consequences on the effectiveness of portions of the large reserved network. Outside of the reserved network, the lack of timber harvesting in the nonreserved allocations over the past 15 years has provided some cushion from these losses. And finally, although we still anticipate that recruitment of nesting/roosting habitat from forest succession will eventually begin to offset habitat losses from wildfire, forests grow slowly, and, where they occur in landscapes prone to wildfire, the nesting/roosting habitat conditions may take much longer to develop.

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Kristian Skybak

Chapter 4: Large Wildfires Within the Owl's Range

Raymond J. Davis, William C. Aney, Louisa Evers, and Katie M. Dugger

Introduction

When Franklin and Dyrness created their map of physiographic provinces in 1973, they noted that the lines drawn to reduce the complexity of large geographic areas into more manageable proportions are sometimes arbitrary, whereas in nature the transition from one condition to another is often gradual. A modified version of the Franklin and Dyrness (1973) physiographic provinces was used to divide the northern spotted owl's (*Strix occidentalis caurina*) range, which covers 57 million ac that stretch from Canada to northern California, into 10 areas that represented different forest vegetation and environmental characteristics (Thomas et al. 1990). Agee and Edmonds (1992) made the first attempt to delineate fire disturbance regimes within the owl's range during the initial stages of northern spotted owl recovery planning. The spotted owl recovery team (USDI 1992) used this and other information to further subdivide the range into 12 physiographic provinces, which currently provide the framework for monitoring the Northwest Forest Plan (the Plan) (FEMAT 1993, Lint et al. 1999). More recent attempts to map the "dry, fire-prone" portion of the owl's range (Healey et al. 2008, Rapp 2005, Spies et al. 2006) are mainly delineated along these physiographic province boundary lines, which were not drawn specifically to define the underlying nature of wildfire within the owl's range. The result is a line that often shifts, sometimes considerably, between mapping efforts (fig. 4-1).

This desire to map fire-prone areas in the owl's range stems from a concern by many that wildfire will destroy spotted owl habitat. The recent increase in frequency of large wildfire occurrence (and area burned) since the mid-1980s in the Western United States (Schwind 2008, Westerling et al. 2006), and within the owl's range (fig. 4-2)

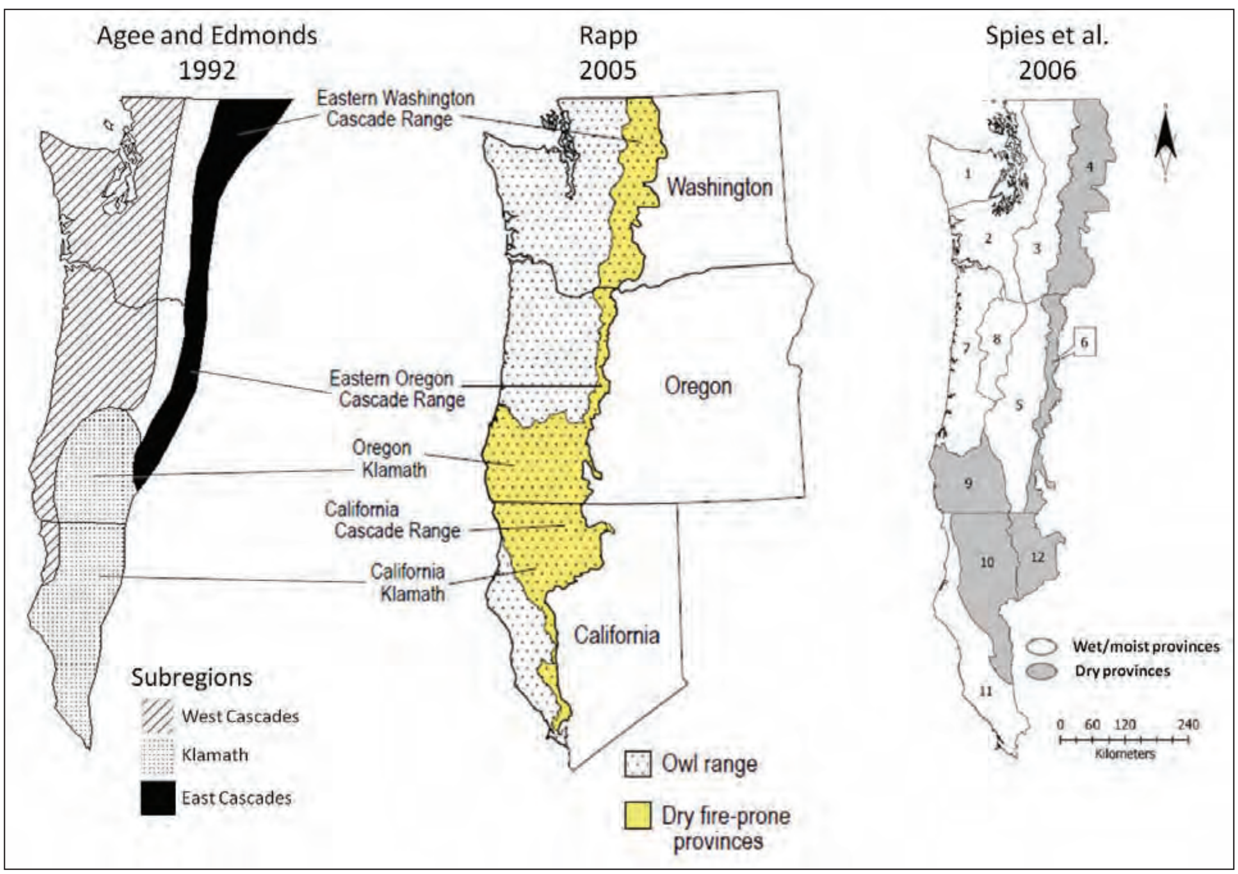

Figure 4-1—Various depictions of the "fire-prone" areas within the range of the northern spotted owl (Agee and Edmonds 1992, Rapp 2005, Spies et al. 2006).

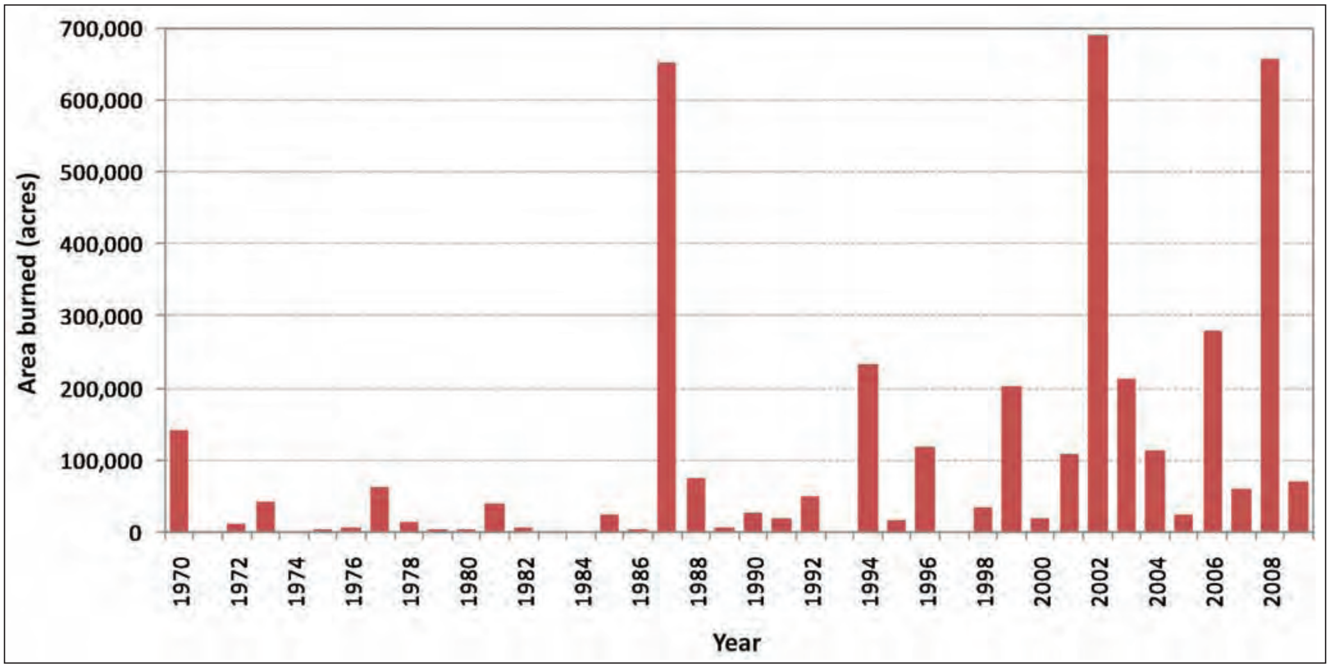

Figure 4-2—Frequency histogram of acres burned by wildfires within the range of the northern spotted owl between 1970 and 2009 (data sources from large wildfire data from this analysis).

has only heightened this concern. There is also evidence that along with this increased frequency there has also been an increase in the amount of high-severity wildfire (Miller et al. 2009, Schwind 2008; but see Hanson et al. 2009). However, evidence from recent studies reveals that the effects of wildfire on owl habitat and demography are mixed (Bond et al. 2009, Clark 2007). In the short term, large wildfires may be detrimental to spotted owls by decreasing survival and occupancy rates because high-severity[1] fire that caused loss and fragmentation of suitable nesting and roosting habitat contributed to existing spotted owl sites becoming unoccupied (Clark 2007). In addition, California spotted owls avoided roosting [breeding season] in forests that had experienced moderate to high-severity[2] fire effects and nested only in stands that were unburned or had experienced low- to moderate-severity fire (Bond et al. 2009). However, spotted owls did forage in areas of high-severity fire, possibly because prey species are more abundant and accessible in these high-severity burn patches (Bond et al. 2009, Clark 2007, Franklin et al. 2000). Thus, although stand-replacing wildfires certainly remove nesting/roosting habitats described in chapter 3, they may not prevent foraging by owls, and only a very large fire that creates a large-scale loss of forest canopy and habitat would have a significant effect on owl demography and dispersal (see the discussion on dispersal habitat in chapter 3). Much more research is needed to fully understand the effects of wildfire frequency and severity on owls and their prey sources (see chapter 5 in this report), but some adaptation to wildfire is expected given that this species has evolved with it in some parts of its range.

Although the relationship between wildfire frequency and severity on owl demography is not fully understood, habitat loss is the primary reason for the owl's decline and subsequent listing as "threatened" under the Endangered Species Act (USDI 1990). The habitat monitoring results presented in chapter 3 (this report) identified wildfire as the leading cause of current spotted owl nesting and roosting habitat loss (3.4 percent) and its future recruitment on federal lands. This was also the finding in the 10-year

[1] Clark (2007) defined high-severity as > 70 percent of the overstory removed by fire.

[2] Bond et al. (2009) defined high-severity as areas where dominant vegetation had high to complete mortality owing to fire.

monitoring report (Davis and Lint 2005), and since completion of that report, several more large wildfires have occurred within the owl's range and more nesting/roosting habitat has been lost. Thus, loss of habitat to wildfire remains a significant concern for the management and conservation of the spotted owl. In response, the current species recovery planning process for the owl (USDI 2008) established working groups to develop recovery actions for fire-prone areas based on the current map of physiographic provinces (USDI 1992).

Here we present a novel modeling method to map areas within the owl's range that are prone to large wildfires. The result is a rangewide map of likelihood (or suitability) gradients for large wildfire occurrence. Instead of using physiographic province boundaries to define fire-prone areas within the owl's range, the gradient map is further classified into a binary map that we believe better represents the fire-prone areas. However, the raw model output (fig. 4-3) maintains the gradual transitions from one condition to another so succinctly alluded to by Franklin and Dyrness (1973).

Methods and Data Sources

There are several modeling approaches and methods available for modeling spatial distributions of environmental phenomenon, each with their own strengths and weaknesses (Guissan and Zimmermann 2000). A recent paper by Elith et al. (2011) summarizes many of these issues, including an ecological explanation of MaxEnt (Phillips and Dudík 2008, Phillips et al. 2006) and discussion on the issue of using presence-only versus presence-absence data (also see page 35 of Davis and Lint 2005). For consistency, we chose to use MaxEnt, the same modeling tool used for mapping spotted owl habitat suitability in chapter 3 (this report), to model and map wildfire suitability (fig. 4-3). This spatial distribution modeling software is commonly used to create predictive maps of habitat suitability (or likelihood of use) based on species location data and a set of environmental predictor variables that contribute to the definition of the species' niche (Phillips et al. 2006). The term "niche" is used to describe the environmental requirements needed for a species to exist (Grinnell 1917). It is the "hypervolume" in the multidimensional environmental space (the number of dimensions are based on the number of environmental variables used to describe the niche) that permits positive growth (Hutchinson 1957). Habitat suitability models are operational applications of the ecological niche, and use multiple environmental variables to predict the likelihood of species occurrence (Hirzel and Le Lay 2008).

Based on our understanding of northern spotted owl ecology, we expect them to nest in landscapes that are heavily forested with older or structurally diverse stands of conifer with relatively closed canopies (see chapter 3 in this report). We call this combination of environmental conditions owl "habitat." Similarly, environmental conditions commonly associated with large wildfires include steep slopes, warm and dry aspects, hot and dry weather, and limited access for ground-based firefighting resources (hand crews, engines, etc.). These have long been identified in the literature as key elements in the development of large wildfires (Albini 1976, Albini et al. 1982, Brown and Davis 1973, Countryman 1964, Deeming et al. 1977, Garfin and Morehouse 2001, Gisborne 1936, Hayes 1941, Rothermel 1983, Schroeder and Buck 1970, Scott and Reinhardt 2001, Sugihara et al. 2006, Van Wagner 1977); in decision-support planning tools for wildfire response such as the National Fire Management Analysis System (NFMAS) and its successor, Fire Program Analysis (FPA); and in practice. It is no surprise that wildfires grow rapidly and become larger in landscapes that have an abundance of these conditions. The combination of these environmental conditions might also be considered a "habitat," not for an animal, but one that is suitable for large wildfires as alluded to by Pyne (2001, 2004). The analogy of wildfire as a "living organism" is not unheard of (Bond and Keeley 2005, Parisien and Moritz 2009), and it seems reasonable that the principles for describing the niche of a plant or animal species should be no different than for defining the "niche" of large wildfires, or for that matter any other natural phenomenon that is associated with unique combinations of environmental conditions.

Our ability to accurately map the environmental conditions that constitute the niche allows us to use modeling software to map the pattern of the relationship between

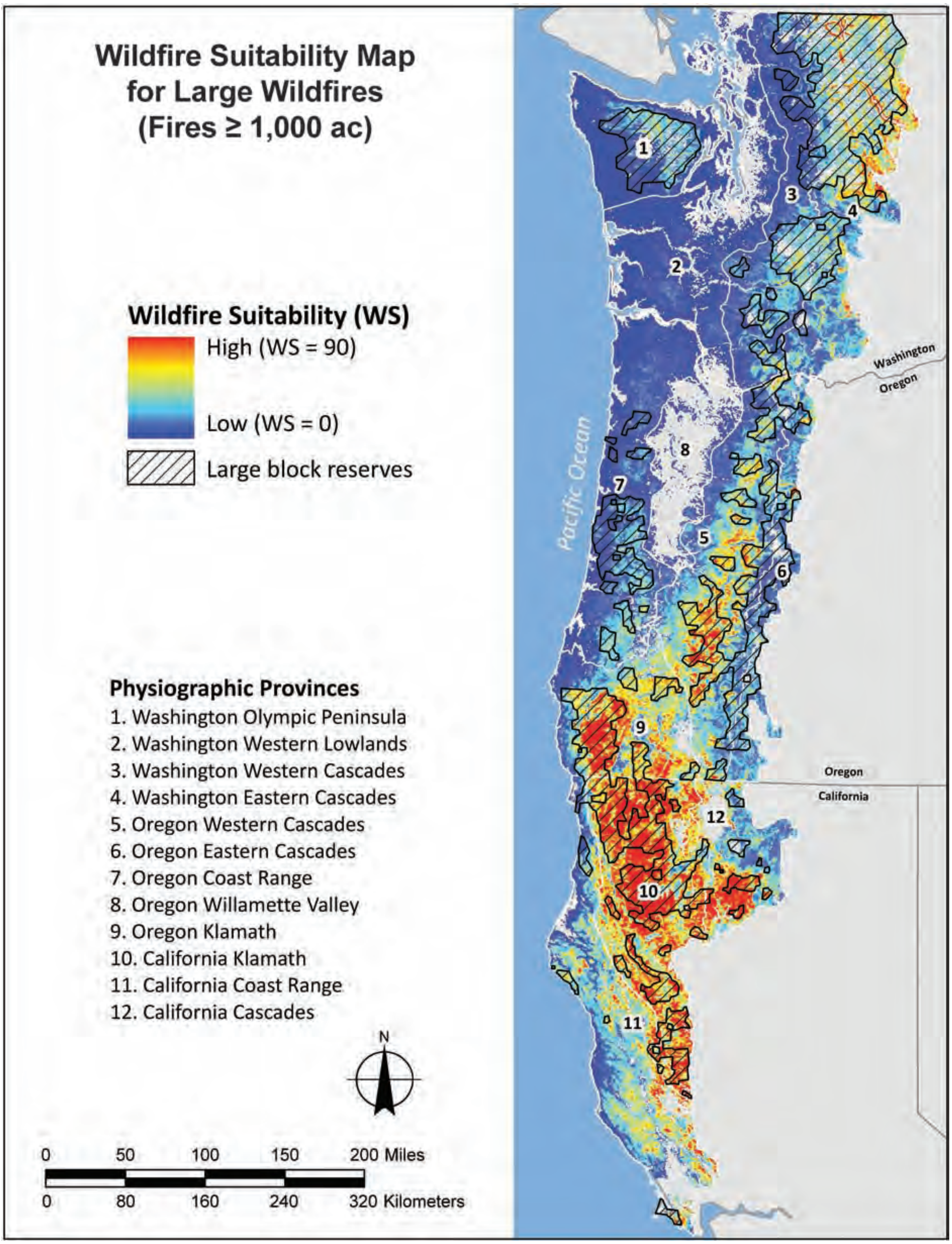

Figure 4-3—Although large (≥ 1,000 ac) wildfires are known throughout the entire range of the owl, this wildfire suitability map represents the likelihood for occurrence of these fires based on three decades of large wildfire occurrence and the underlying combination of "fire environment" variables from where they occurred (see fig. 4-4).

these environmental factors and large wildfire occurrence. This approach has been used recently to model wildfire's broad geographical distribution patterns across the conterminous United States, the state of California, and five wildfire-prone ecoregions within California (Parisien and Moritz 2009). To our knowledge, this marks the first time that "habitat suitability" software was used to map spatial patterns of wildfire likelihood over large landscapes as a function of multiple environmental variables. Coarse-scale maps of global fire patterns that discriminated between "fire-prone" and "fire-free" areas of the world were also produced using similar methods (Krawchuk et al. 2009). Maps produced by this method have been called "wildfire suitability" maps (Parisien and Moritz 2009), and this is the term we use to describe our map (fig. 4-3).

It is not uncommon for wildfires that range from 500 to 1,000 ac and greater to be defined as "large" in the recent fire ecology literature (Potter 1996, Eidenshink et al. 2007, Preisler and Westerling 2007, Westerling et al. 2003). In the 10-year report, a "large wildfire" was defined as a fire that would affect multiple owl territories (Davis and Lint 2005). Here we define "large wildfire" as one that exceeds 1,000 ac, which is larger than the estimated size of a northern spotted owl home range core area[3] throughout most of its range (Bingham and Noon 1997, Courtney et al. 2004, USDI and USDA 2008).

Environmental Data

At an intermediate spatial scale, weather and topography make up two legs of the fire behavior (or environment) triangle (Agee 1993, Countryman 1966), whereas at the larger (regional) spatial scale, climate, ignitions, and broad vegetation patterns define fire regimes (see fig. 1 in Parisien and Mortiz 2009). Our spatial scale of modeling combines both the intermediate and regional scales, and our set of environmental data reflects this, with the exception of fuels and vegetation variable groups. We did not include any fuel variables in our modeling, but the model's geographic background consisted only of forest-capable areas, which represent "vegetation" in the larger spatial scale. Because forest fires are what we were attempting to model, the use of this modeling background allowed us to confine the interactions of environmental variables to locations where forest vegetation and fuels occur. An advantage of not using a fuel variable is that we avoided the difficulties that arise in accurately mapping them (Stratton 2006). Fuels are a dynamic component of the ecosystem, very temporal in nature and always changing in response to forest succession and disturbances (Agee 1993). The inclusion of a fuel variable would produce a map that would only be good as long as the fuel condition remained exactly as modeled. Instead, we wanted to produce a model that was relatively stable, and based on the underlying conditions of topography and climate that support large wildfires.

The set of environmental variables we used for modeling was based on fire climate[4] and environment relationships in the literature and on expert advice (fig. 4-4, app. G). Matching the temporal scale of these environmental data with the fire training data was an important factor. Fire climate variables were derived from "parameter elevated regression on independent slope model" (PRISM) maps (Oregon Climate Service 2008) that provide averaged weather conditions between 1971 and 2000. This timeframe coincides with the 1970 to 2002 timeframe of the fire training data set. As our fire climate variables, we initially chose average maximum temperature in August and summer moisture stress (the ratio of summer temperature and precipitation). However, because of the high correlation between these two variables ($r > 0.7$), we replaced the moisture stress variable with a summer precipitation variable, which is the average amount of precipitation that fell between May and September, corresponding to the average fire season.

Lightning is the primary ignition source for wildfires around the world (Agee 1993) including the forested regions of the Pacific Northwest, especially when it occurs without

[3] An area of concentrated use within a home range that commonly includes nest sites, roost sites, refuges, and regions with the most dependable food sources (Kaufmann 1962, Samuel et al. 1985).

[4] Defined by the National Wildfire Coordinating Group (NWCG) as a "composite pattern of weather elements over time that affect fire behavior in a given region."

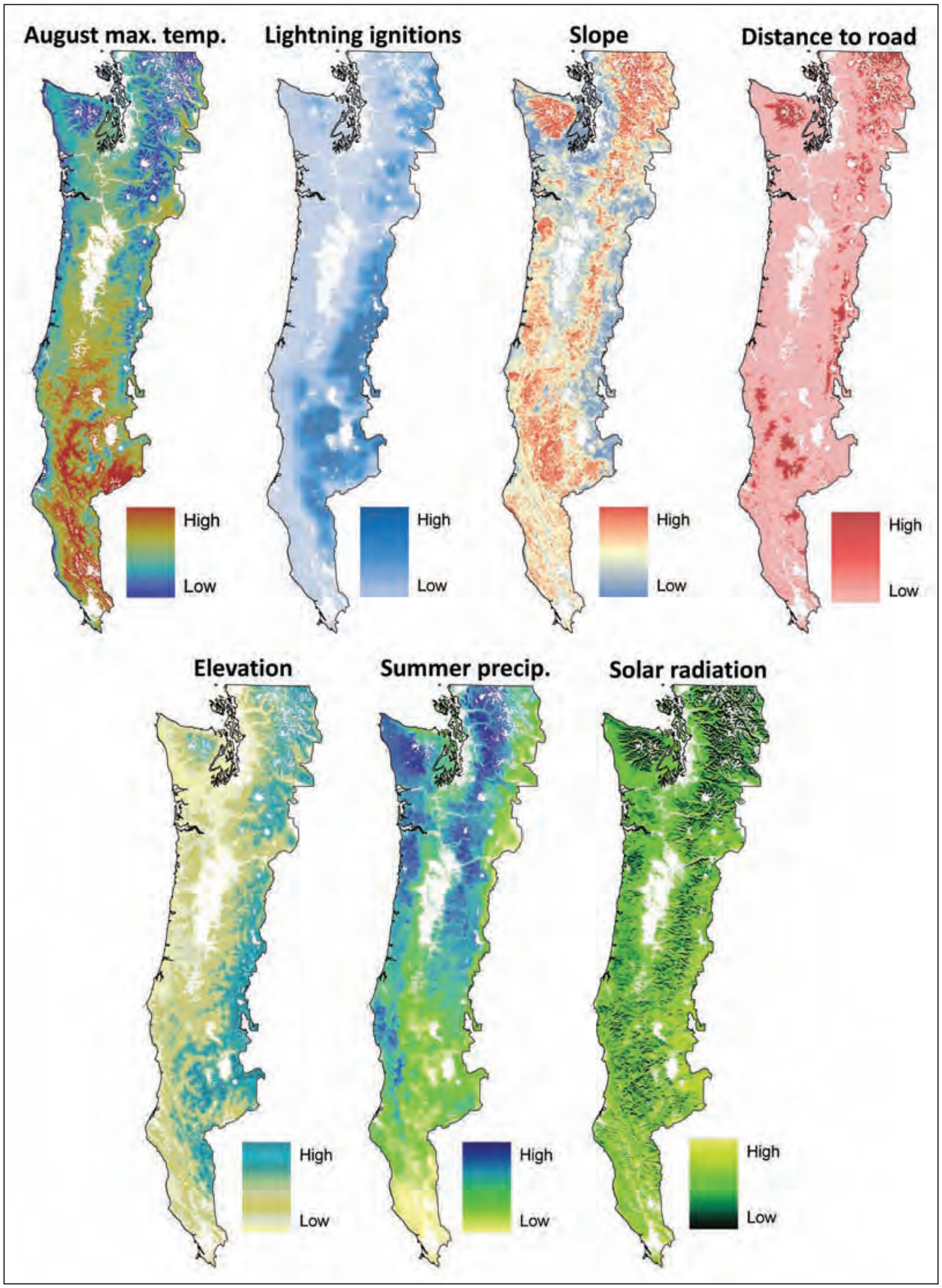

Figure 4-4—Environmental variables used in the model to define the "niche" of large wildfires in the owl's range.

significant rainfall (Rorig and Ferguson 1999). Based on data from the Climate, Ecosystem, and Fire Applications (CEFA) Program (Brown et al. 2002), lightning was the cause for approximately 25,000 wildfires within the range of the owl from 1970 to 2002. Lightning accounted for 68 percent of the wildfires that grew to larger than 1,000 ac and accounted for 75 percent of the total area burned within the owl's range from 1994 through 2002 (Davis and Lint 2005). The geographic patterns of lightning-ignited wildfires in the Pacific Northwest are similar today to what they were throughout the 1900s (Agee 1993, Komarek 1967, Morris 1934, Rorig and Ferguson 1999, Sensenig 2002). Therefore, a lightning-ignited fire density map was created using the CEFA data from 1970 to 2002 and included as one of the environmental variables.

Topographic variables for elevation, slope, and aspect were also used in the model. Elevation provides an environmental gradient that relates to local climate conditions and vegetation zones, which can affect fire behavior and growth (Hayes 1941, Rothermel 1983). Slope is related to fire spread rate, and its orientation, or aspect, relates to the amount of solar radiation, which also affects the local microclimate and vegetation. Southerly aspects in the Northern Hemisphere usually receive more annual solar radiation and are hotter and drier than northerly aspects. We used the potential relative radiation (PRR) index developed by Pierce et al. (2005) as a more realistic measure for solar radiation than simple aspect.

The spatial resolution of our environmental data was 250- by 250-m (15-ac) pixels, which was averaged within a 1,000-ac circular moving window to correspond with our minimum definition of a large wildfire. All "nonforested" (i.e., water, rock, etc.) areas were "masked out" to constrain the modeling background to only those areas where large wildfires are possible. All variables were analyzed for spatial correlations and one variable was dropped or replaced for Pearson correlations > 0.7.

Large Wildfire Data

We chose to train our model using historical occurrence data from only large wildfires (as defined above). Wildfires of this size are relatively rare occurrences, but are responsible for the vast majority of area burned each year. For example, of the roughly 25,000 lightning-ignited wildfires recorded within the owl's range between 1970 to 2002, less than 1 percent were ≥1,000 ac; but these fires accounted for 96 percent of the total 2.5 million ac that burned (based on CEFA data) (Brown et al. 2002). This pattern of large areas of land being burned by a small percentage of large wildfires is a global phenomenon that fits power law distributions (Cui and Perera 2008, Stocks et al. 2003, Westerling and Bryant 2008). It therefore made more sense to focus our modeling on large wildfires because of their disproportionate effect on the environment.

To train the distributional model, the spatial point locations where large wildfires have occurred are linked to the underlying combinations of environmental variable grid cells over which they lay. This relationship between fire occurrence and environmental gradients is then extrapolated to the rest of the modeled region to "score" environmental conditions based on their similarity to where the training data occur. To create a point layer representing large wildfires, we assembled 250 polygons of large wildfire perimeters that, in total, burned about 2.6 million ac of forest lands across the owl's range between 1970 and 2002. Using a geographic information system (GIS), we overlaid these polygons on a grid of randomly generated points that was produced using Hawth's Tools (Beyer 2009). Each grid point was separated by 1.6 mi to reduce spatial autocorrelation issues, as the modeling environmental variables were averaged over a 0.7-mi radius that covered about 1,000 ac, representing a "large wildfire unit" (fig. 4-5). A total of 1,499 random grid points occurred within a large-wildfire perimeter; of these, 104 (about 7 percent) were within overlapping wildfire perimeters, representing sites that had been burned twice during the 32 years represented by our training data. Because these points represent separate large wildfire occurrence from different years, they were included as additional points in the training data set for a total of 1,603 training points. We also generated an independent model-testing data set in the same manner, using 146 large wildfires that had burned 1.4 million ac between 2003 and 2009 (n = 903).

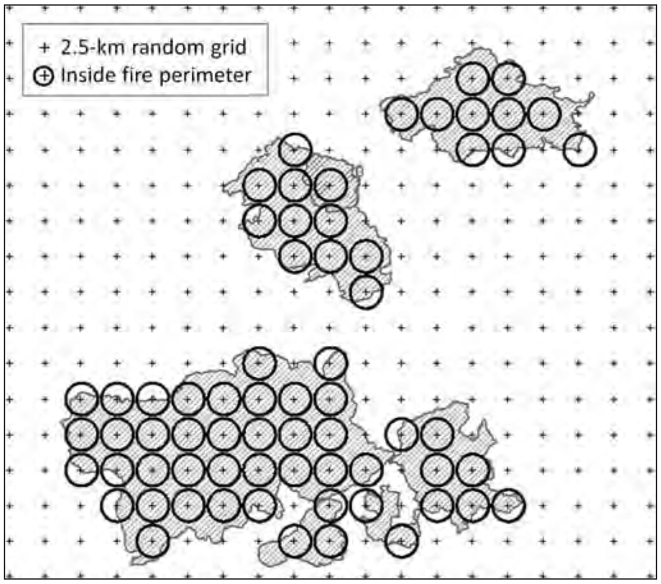

Figure 4-5—Model training and testing data came from grid points that occurred within large-fire perimeters. Points were spaced by 2.5 km to reduce spatial autocorrelation of environmental data, which were averaged within 1,000-ac circles as shown in this figure.

It is likely that without wildfire suppression, there would have been more large wildfires (Sensenig 2002) that burned between 1970 and 2002; thus our training data are likely biased. However, we are uncertain how this bias may have affected our model. It is possible that the training data better represent large wildfires that were more difficult to suppress or contain because of inaccessibility owing to geography or absence of roads. To address this issue, we also included a variable that represents distance from roads. We assumed that wildfires were more apt to get bigger when farther away from a road because it was more difficult to get people and equipment into the area to fight the fire.

Wildfire Suitability Modeling

We chose the same modeling features in MaxEnt that we used for habitat modeling (linear, product, and hinge features) because this combination works well in fitting the environmental data to known or expected relationships between the environmental variables and wildfires based on visual review of response curves generated during the modeling procedure. This combination is also a compromise between using features that may be too restrictive for complex environmental relationships (i.e., only linear) while avoiding features that might allow overfitting the model to the data (i.e., threshold).

Phillips and Dudík (2008) defined the logistic output of their modeling software as an "estimate" of probability of presence, conditioned on the environmental variables used in the modeling. In our case, we used only training data from large wildfires and environmental variables that are commonly associated with wildfire ignition and growth (Albini 1976, Deeming et al. 1977, Gisborne 1936, Hayes 1941, Rothermel 1991). Therefore, the model's logistic output represents a scale of probability (from low to high) of a large wildfire occurring as a function of physical, topographic, climatic, and fire ignition history patterns in the owl's range. Where combinations of these variables are more similar to where large wildfires have occurred in the past, the logistic probability values will be higher. Likewise, underlying patterns of environmental variables that do not commonly occur where large wildfires have burned will have lower probability values.

We ran 10 bootstrapped model replicates using half of the training data set for each replicate, and holding out the other half to test the model's predictions. In other words, MaxEnt produced 10 models using 10 randomly generated subsets of the 1970–2002 large-fire data, each consisting of 802 points. Then each of these models was tested using the subset of large-fire points held out (n = 801). During this process, we increased the regularization multiplier from its default of 1.0, which helps to prevent model overfitting, by increments of 0.5 to minimize the difference between the regularized training gain and test gain, while tryng to maximize the test area under the curve (AUC) statistic and Spearman rank (R_S) correlation coefficient on our held-out test data. These three statistics (gain, AUC, and R_S) are commonly used to measure the discriminative and predictive power of these sorts of models (Boyce et al. 2002, Fielding and Bell 1997, Hirzel et al. 2006).

The gain relates to how different the training or testing data are from the background data. It is similar to "deviance" as used in generalized linear modeling (Phillips et al. 2006), and higher gains indicate larger differences between occurrence location environmental conditions and average background environmental conditions. The exponent of gain produces the mean probability value of occurrence compared to random locations selected from the surrounding modeled landscape. Large differences between the regularized training and testing gains indicates model overfitting.

The AUC statistic is a measure of the model's predictive accuracy, and it was originally developed for evaluations using presence and absence data, producing an index value from 0.5 to 1 with values close to 0.5 indicating poor discrimination and a value of 1 indicating perfect predictions. The AUC values can be interpreted similarly to the traditional academic point system where values between 0.9 and 1.0 indicate an excellent model (A), 0.8 to 0.9 is good (B), 0.7 to 0.8 is fair (C), 0.6 to 0.7 is poor (D), and AUC values between 0.5 and 0.6 represent failure (F), or models that don't predict much better than a random guess. Examples of this interpretation in the field of niche-based species distribution models can be found in Araújo et al. (2005) and Randin et al. (2006). In our situation, MaxEnt uses 10,000 randomly selected background locations (map pixels) instead of true absence data, so it is not possible to achieve an AUC value of 1.0 (Wiley et al. 2003). However, interpretation is similar, with higher AUCs indicating better model predictions (Phillips et al. 2006). Specific to our case, AUC values represent the percentage of times a large wildfire location would have a higher wildfire suitability value than a randomly selected location from the modeling region.

The Spearman rank correlation coefficient is a nonparametric statistic that, in our situation, compares the ranks of large fire occurrence vs. area available to "binned" modeled prediction ranks (Boyce et al. 2002). A good model would predict an increasing ratio of the percentage of fire occurrence to the percentage of the modeled landscape in each model bin as the bin values increase, and an R_S of 1.0 indicates a strong positive correlation (Boyce et al. 2002).

The best model using the training data, and based on these statistics was produced using a regularization multiplier of 1.5. We then reran the same model, using the entire training data set (n = 1,603) and conducted a final test of the model using 7 years of independent test data from large fires that occurred between 2003 and 2009. Following the same rationale and modeling approach used in chapter 3 (this report), our final model product is the "average" model from our bootstrapped replicates. The predictive qualities of the "average" map can be better explained by the diagnostic predicted versus expected (P/E) curve (fig. 4.6) (Hirzel et al. 2006), and this curve allows users to better interpret the modeled values.

We also analyzed the importance of each environmental variable and its relationship with large wildfire occurrence by running jackknifed models (Phillips et al. 2006) for each of the 10 replicates. For each environmental variable, this jackknifing procedure produces a model that excludes the variable, and another model based on only that variable. The gain and AUC model performance statistics from the jackknifed models then inform us on the relationship and importance of each variable in explaining large-wildfire occurrence in the area being modeled.

Results

An average testing gain of 0.80 indicates that our model predicted large-wildfire occurrence 2.2 times that expected by chance. The testing gain was also similar to the regularized training gain of 0.77 indicating that our model was not over-fit to the environmental data. The mean testing data AUC, based on 10 bootstrapped replicates, was 0.83, and using independent test data from large wildfires from 2003 to 2009, the AUC was 0.78. The replicate mean predicted versus expected (P/E) curve (Hirzel et al. 2006) had an R_S = 1.0 ($P < 0.001$) and the test data P/E curve had an R_S = 0.987 ($P < 0.001$). The highest mean logistic probability for our model was 0.90, which we converted into an integer value (90) for GIS mapping purposes by multiplying by a factor of 100. The threshold of 31 along this probability gradient marks where the predicted probability of large-wildfire occurrence is greater than what would be expected by chance (fig. 4-6). One can use that threshold to define the owl's range in binary terms, where mapped values above this threshold represent geographic areas that are more prone to large wildfire occurrence, based on our 32-year training data timeframe, and areas below that threshold are not normally prone to large wildfires during that timeframe.

The strongest environmental variables were August maximum temperature, slope, and lightning ignition

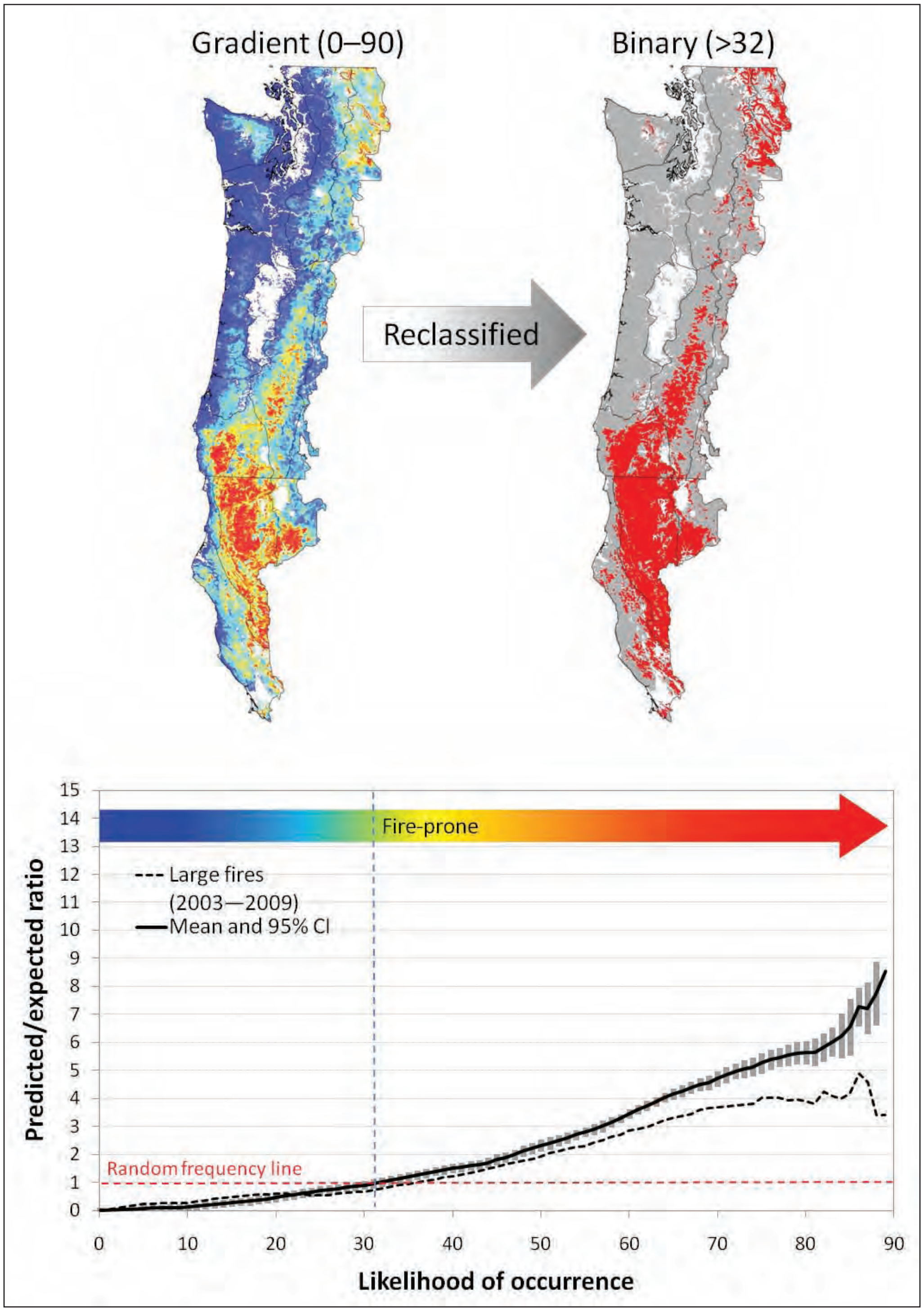

Figure 4-6—Results of model bootstrapped replicates (based on fire data from 1970 to 2002) and independent testing (dashed-line based on fire data from 2003 to 2009) are shown in this predicted vs. expected curve (Hirzel et al. 2006). The curves indicate that the model performed well in both tests. The point at which the mean curve crosses the random frequency line (predicted/expected = 1) is used as the threshold modeled likelihood value (>32) for delineating the "fire-prone" areas of the binary map from the full gradient map. The gray-shaded area along the mean curve represents the 95-percent confidence intervals (95% CI) from the bootstrapped replicates.

density, explaining 76 percent of the geographical patterns of large wildfires. Distance to roads contributed another 15 percent, and, together, these four variables account for 91 percent of the information that relates to wildfire suitability in our model. Response curves (app. G) suggest suitability for large wildfires increases (in almost a logistic fashion) as August maximum temperature and slope increases. The response curves for lightning ignition density and distance to road variable response curves are quadratic in shape, showing sharp increases in suitability as the variable value increases, but then reaching a wide plateau and eventually decreasing (app. G). We suspect this decrease in suitability at the high end is related to elevation effects, which also exhibited a similar quadratic response curve. Extreme distances from roads occurred in many wilderness areas located along the Cascades crest, and these remote areas tend to be at the highest elevations where late snowmelt produces cooler and moister conditions during the fire season. Likewise, lightning ignitions tend to be highest at high elevations. Of the six model variables used, slope had the highest gain when modeled by itself. It also decreased the gain the most when omitted from the model, and therefore is an important variable in our model and appears to have the most information that is not present in the other environmental variables.

Discussion

Four decades of history on large-wildfire occurrence fit well within our map of "wildfire suitability" gradients (fig. 4-7). The binary version of our map (fig. 4-8) has some distinct similarities to previously mapped versions of "fire-prone" areas in the owl's range, especially the map by Agee and Edmonds (1992). But, it also has some distinct differences; most notably, it includes the considerable portions of the western Cascades of Oregon, and it excludes large areas of the eastern Cascades that are commonly shown on previous map versions (fig. 4-1). Based on our map, only the northern half of the Washington Eastern Cascades physiographic province has substantial land area that appears suitable for large-wildfire occurrence. South of this, our map indicates a patchy distribution of high-suitability areas along the eastern Cascades; yet, much of this area historically was covered with ponderosa pine forests, known for its dependency on wildfire. This, and recent occurrences of large wildfires in these areas (i.e., B&B Complex, Link Fire, Davis Lake Fire, and the Eyerly Fire) may point to potential model limitations, which we discuss below.

To begin with, our map represents suitability for what we defined as "large" wildfires, and perhaps ones that are harder to suppress and contain, given the potential bias of our training data. The map does not represent a suitability gradient for all wildfire occurrences, nor behaviors, such as fire severity. Secondly, our map was trained with about three decades of large wildfire data and therefore, represents the likelihood of large wildfire occurrence within that specific timeframe. If we go further back in time, the fire history record within the owl's range clearly shows the occurrence of large wildfires in the lower suitability areas ("bluer areas") of our map (fig. 4-3), such as the Yacolt and Columbia Fires of 1902, the Tillamook Fire of 1933, and the more recent Oxbow Fire of 1966 (see fig. 3-16 in chapter 3). As noted above, our model is based on climate and topographic variables that have been relatively stable over the last century. The large wildfires that have occurred within the lower suitability areas of our map have been consistently associated with extreme weather (i.e., high winds) or heavy, contiguous, dry fuel (McClure 2005, Morris 1935), which could not be included in the model. We suspect a map characterizing long-term means of these extreme, episodic climatic events would be even more difficult to produce than a rangewide fuel map. However, fire ecologists have recently divided the range of the owl into five "fire regime groups,"[5] which represent a coarse spatial integration of fire frequency and severity (Keane et al. 2002, Morgan et al. 2001, Schmidt et al. 2002). Whereas fire regimes relate to the frequency, severity, and spatial distribution of historical wildfire in the ecosystem (Rollins et al. 2002), our map sheds light only on the latter of these three characteristics. However, it still shows spatial similarities to the fire regime group map, and, in particular, the lower suitability areas complement Fire Regime Group V, which represents infrequent fires (>200-year intervals) and mostly occurs in the

[5] LANDFIRE data products and their descriptions are available online at http://www.landfire.gov/products_overview.php.

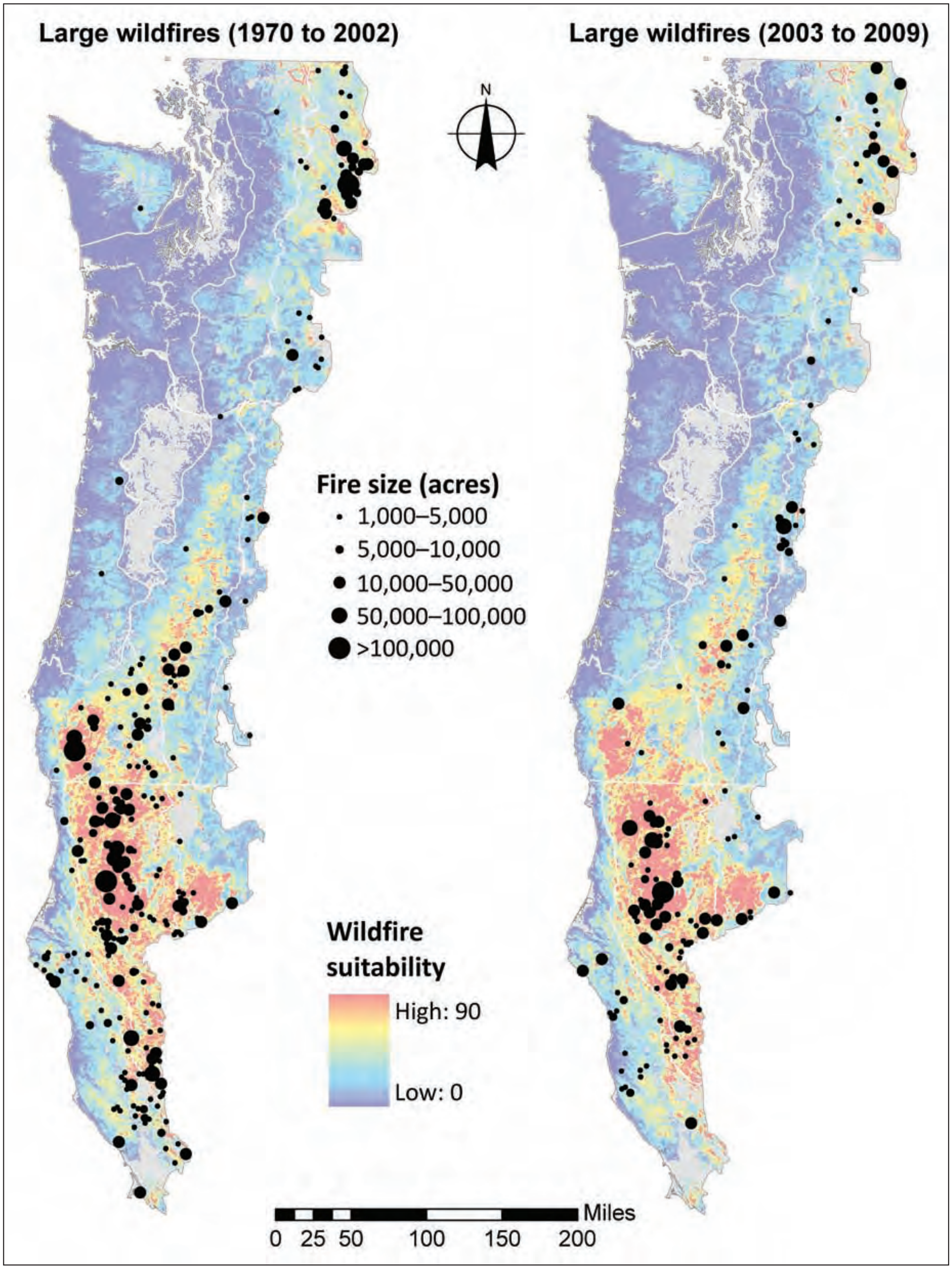

Figure 4-7—The full gradient version of the wildfire suitability model showing locations of large wildfires used to train the model (left) and locations of large wildfires that occurred after 2002 (right) that served as our independent testing data.

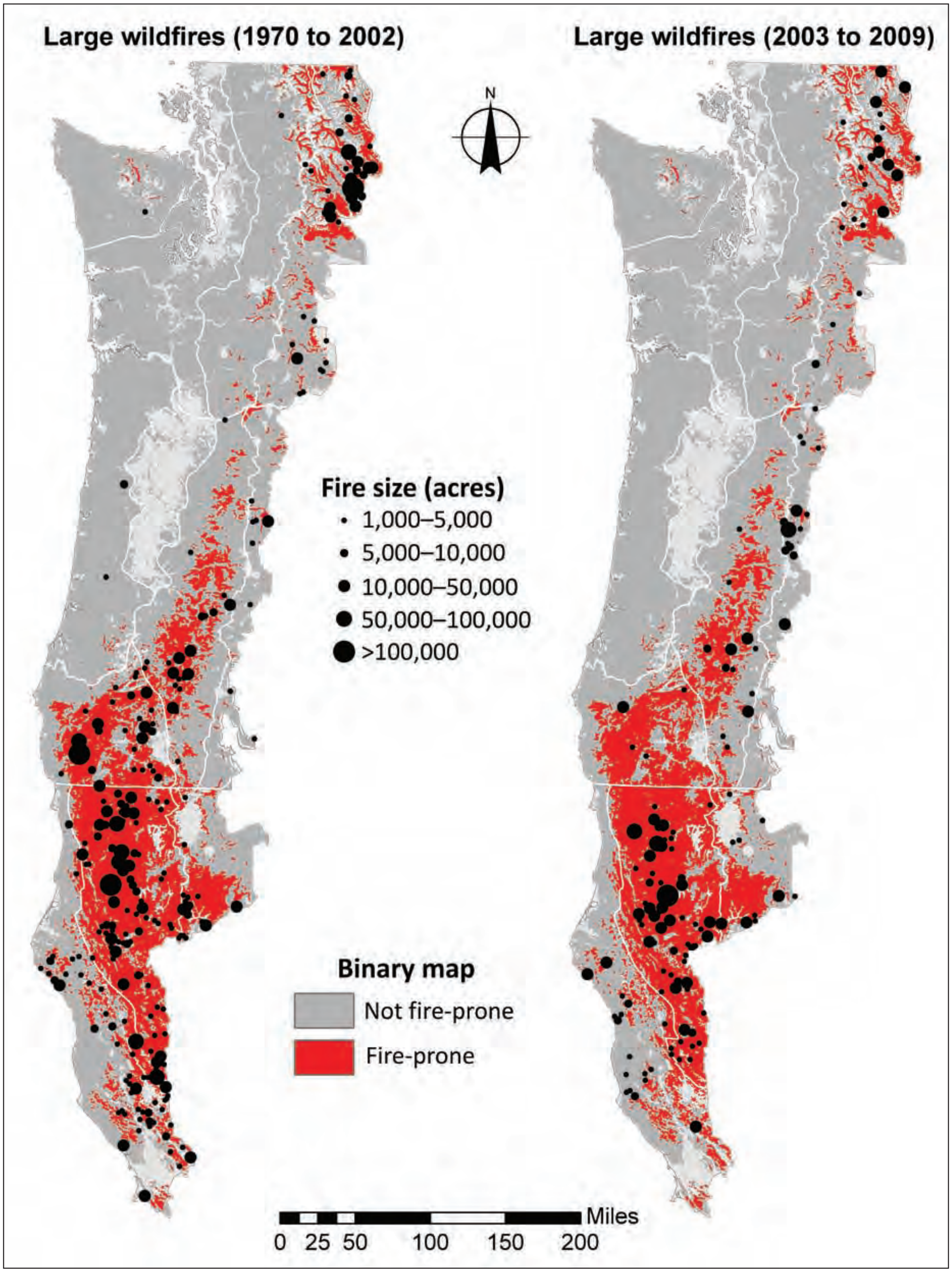

Figure 4-8—The binary version of the wildfire suitability model showing locations of large wildfires used to train the model (left) and locations of large wildfires that occurred after 2002 (right) that served as our independent testing data.

coastal zones and highest elevations of the mountain ranges. These areas have been defined as incurring infrequent wildfires that, when they do happen, tend to be extremely large and severe (Agee 1993, 1998; Morgan et al. 2001; Noss et al. 2006).

On the other end of the fire regime group spectrum, wildfires were more frequent (<35-year intervals) and less severe, maintaining open forests, or a mosaic of different-aged forest seral stages (Hann and Strohm 2003). On our map, portions of the Cascades east of the high-elevation crest, where ponderosa pine forests historically dominated, fit this description. These pine forests were once dependent on frequent surface fires that burned heterogeneously through the landscape, creating open, parklike distributions of trees that were often clumped into small groups (Agee 1994, Graham and Jain 2005). Historically, wildfires in ponderosa pine forests were relatively easy to contain (Munger 1917). Fire suppression and exclusion in ponderosa pine forests produced changes that have been well documented by scientists since the 1990s (Agee 1990, Deeming 1990, Kauffman 1990, Mitchell 1990, Mutch et al. 1993, Wickman 1992). The lack of natural wildfires allows understory development of shade-tolerant vegetation that produces resource-stressed stands, making them more susceptible to insects and disease. This, in turn, leads to weakened or dead trees, generating fuel loadings that are unnaturally heavy and also contiguous over large areas (Hessburg et al. 2005). The understory development also creates ladder fuels that can lead to crown fires, and this fuel combination produces conditions ripe for large wildfires (Hessburg et al. 2005). Today, these areas have developed fuel characteristics that support larger, and more severe, wildfires (Hessburg et al. 2005), and the recent wildfires in central eastern Oregon Cascades have been larger than those of historical records (Eckert et al. 2008).

To what extent fire suppression may have biased our map is uncertain. We suspect fire suppression has likely affected the frequency of large wildfires, but it is much less clear that it has affected the distribution of large wildfires on the landscape. Studies of large wildfires in the large wilderness areas of the southwest and northern Rockies (Rollins et al. 2002, 2004) suggest there has not been an effect on the distribution, although that evidence is indirect as distribution on the landscape was not the focus of any of these studies. Because we have almost no data on how the distribution of large fires might have differed in the absence of suppression actions within the study area, we cannot characterize any model bias in that regard.

Using forest health protection aerial survey data from 1983 to 2008 (USDA 2008), spatial patterns of recent western spruce budworm (*Choristoneura occidentalis*) and mountain pine beetle (*Dendroctonus ponderosae*) outbreaks become apparent (fig. 4-9). In 1983, the spruce budworm began expanding its distribution in the eastern Cascades of Oregon, spreading northward into Washington. It mostly ran its course in the eastern Oregon Cascades by 1993, and then became more active in the southern portions of the Washington Eastern Cascades province. The increased fuel loads created by severe insect outbreaks certainly increase suitability for large wildfires, especially if the fuels are concentrated in a contiguous fashion. In general, the spatial pattern of concentrated spruce budworm outbreaks correspond highly with the B&B Complex and Link Fires from 2003 (fig. 4-9), and also the Lake George, Puzzle, and Black Crater Fires from 2006, and the loss of owl habitat in these areas has largely been attributed to this spruce budworm epidemic and its contribution to the wildfire’s size and severity (Courtney et al. 2004). In addition, the Davis Fire of 2003 occurred in a concentrated area of recent mountain pine beetle outbreaks, and we consider it is likely these episodic insect infections added to the suitability of those specific areas to support these large wildfires.

Agee (1993) pointed out that fire regimes are dependent on the interaction of all parts of the fire behavior triangle—weather, topography, and fuel. Parisien and Moritz (2009) described the fire regime triangle as the interaction of climate, ignitions, and vegetation. Our map spans both the spatial and temporal scales that these triangles represent (see fig. 1 in Parisian and Moritz 2009) and appears to reasonably reflect the last four decades of wildfire history within the range of the owl. However, we suspect that additional spatial information on long-term means of episodic climatic events or insect outbreaks would likely increase its accuracy.

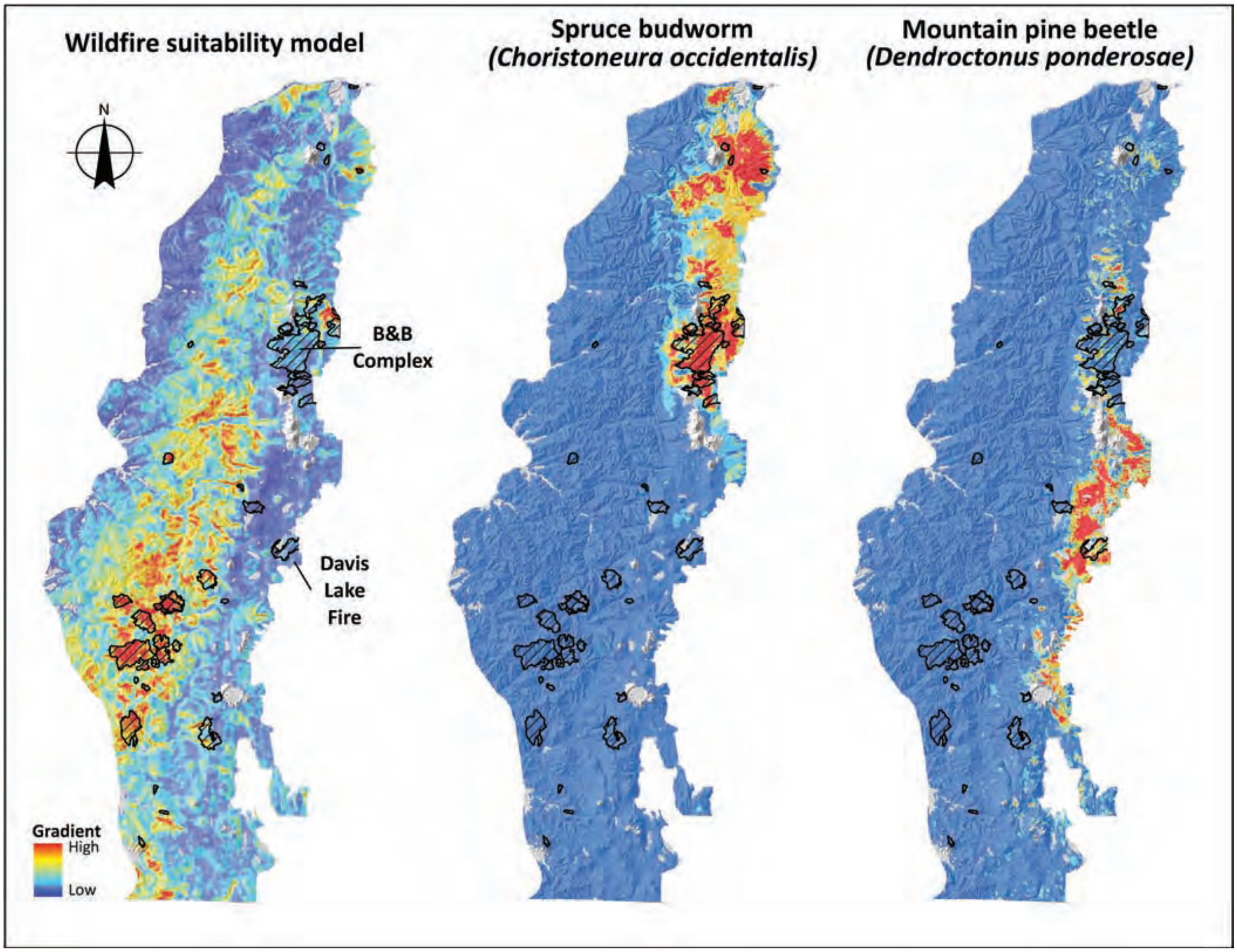

Figure 4-9—Episodic outbreaks of insects in the Oregon Cascades provinces beginning in the 1980s, shown above, may help explain why portions of the eastern Cascades of Oregon have experienced recent large wildfires in areas where the wildfire suitability map indicates lower wildfire suitability (blue indicates lower amounts in the maps above, such as wildfire suitability or years of insect detection, whereas red indicates higher amounts). Large wildfires from 1970 to 2009 are shown as black cross-hatched polygons.

Perhaps one of the most compelling validations of our wildfire suitability map is the relationship of the distributions of three fire-dependent pine species (Little 1971, USDI 1999) with our binary characterization of wildfire suitability (fig. 4-10). As a group in general, pines are associated with forests where wildfire is an integral part of the environment (Fonda 2001). In the range of the owl, sugar pine (*Pinus lambertiana* Dougl.), Jeffrey pine (*P. jeffreyi* Grev. & Balf.), and ponderosa pine (*P. ponderosa* P. & C. Lawson) are common associates with fire-prone ecosystems having shorter fire-return intervals (Skinner and Chang 1996, Taylor and Skinner 1998). These species are members of the "fire-resistant" group of pines (McCune 1988) that evolved in fire-prone environments and developed characteristics like thick bark to insulate the cambium and long needles to insulate buds from the heat of wildfires. Using a map comparison technique[6] (Visser and de Nijs 2006), we

[6] This analysis was performed by using the Map Comparison Kit software (version 3.2) (Netherlands Environmental Assessment Agency) developed by the Research Institute for Knowledge Systems, and available online at http://www.riks.nl/mck/.

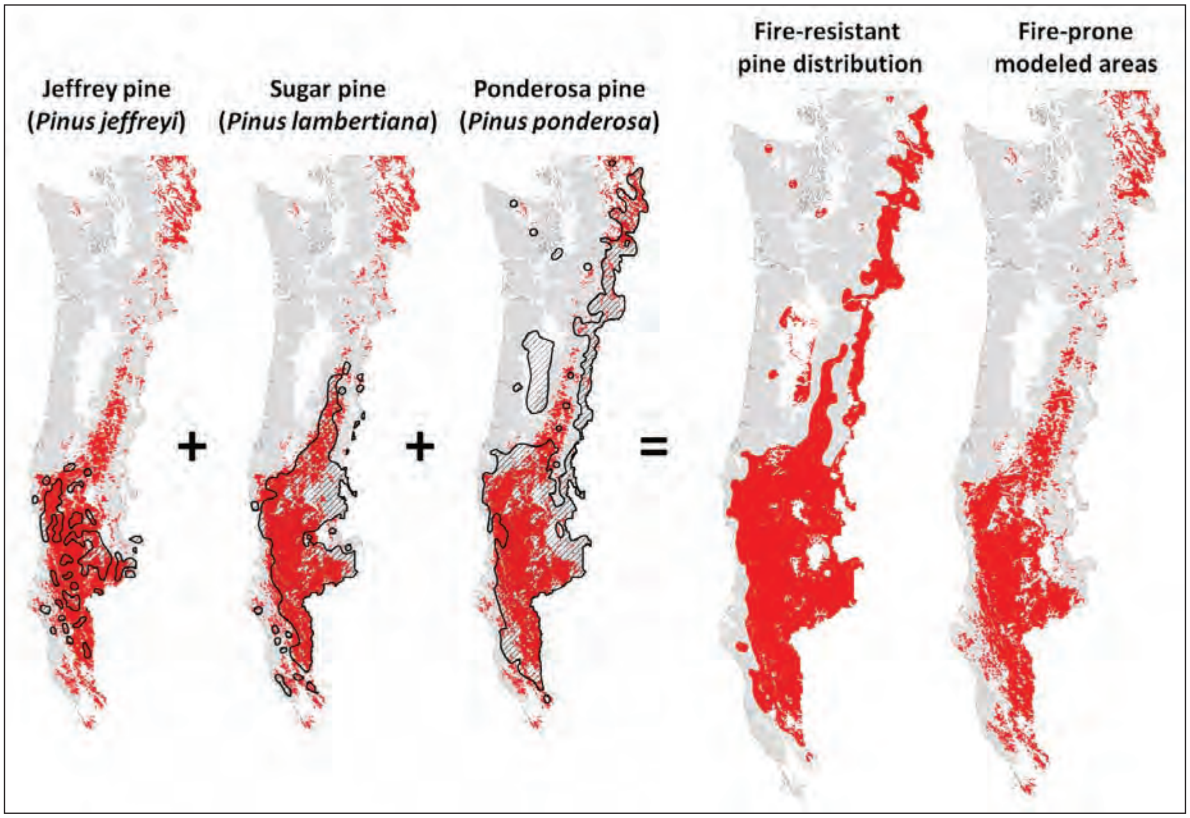

Figure 4-10—Fire-resistant pine distribution maps that were delineated in 1971 (Little 1971, USDI 1999) overlaid on the wildfire suitability binary map.

found that their combined geographic distributions (Little 1971) coincide (cell to cell) moderately well (kappa = 0.46, K_{LOC} = 0.76, K_{HISTO} = 0.60) with the fire-prone areas of the binary version of our model. We believe the historical distributions of these fire-resistant conifers provide further evidence that our binary map effectively identifies portions of the owl's range that wildfire regularly "inhabits."

Countryman (1966) described "fire environment" as the complex of fuel, topographic, and weather (air mass) factors that influences the inception, growth, and behavior of fire. He realized that it was a "pattern phenomena," and advised that its pattern "must be considered in order to understand and predict a fire's behavior." Our map of wildfire suitability is essentially a modeling application of the concept Countryman first described over 40 years ago and is well-validated by almost 40 years of large wildfire data.

Summary

Our goal was to identify landscape-scale areas within the owl's range where large wildfires are more probable over time using factors that are mostly spatially and temporally stable. The use of topographic and climate variables that summarized weather patterns over multiple years (1970–2000) resulted in a map that we believe met this goal, as evidenced by the map's moderate to good correlations (AUC of 0.78 to 0.83 and $R_s \geq 0.987$) with large wildfire locations that post-date the wildfire data used to train the model as well as historical distribution maps of fire-dependent pine species (fig. 4-10). A binary classification of our map (based on the threshold where the map predicts large wildfires more often than would be expected by chance) provides a less arbitrary way to identify "fire-prone" areas of the northern spotted owl's range that normally experience large wildfires.

With this knowledge, we can overlay our wildfire suitability map on the current habitat suitability map produced in chapter 3, to confirm that the physiographic province with the most owl habitat in fire-prone landscapes is the California Klamath province (fig. 4-11). The next highest province is the Oregon Western Cascades province. However, the recent occurrence and trends of insect outbreaks in the eastern Cascades needs to be considered as well. The effects of past management practices combined with these outbreaks have probably increased the suitability for large wildfires of areas that otherwise have underlying physical and climatic factors that are not suitable. If this is the case, our results suggest that once the current fuel build-ups in the eastern Cascade provinces are reduced to more natural levels, the occurrence of large wildfires in that area should decline.

The effects of wildfire on owl biology are difficult to assess and will likely remain a source of uncertainty (Courtney et al. 2004) for some time. Yet, the latest estimates of wildfire's effect on current and future owl habitat, as displayed in chapter 3, indicate wildfires are the major source of habitat loss and future recruitment on federal lands in certain parts of the owl's range. Fortunately, our capabilities to map owl habitat suitability, wildfire effects on vegetation, and wildfire suitability are improving; informing us better on what the habitat effects might be and where this interaction is most likely to happen.

A limitation of our map is that, by itself, it does not provide information on where within the range, large wildfires may occur as a result of atypical or unusual, infrequent conditions or events such as extreme fire weather (Bessie and Johnson 1995; Westerling et al. 2003, 2006), fuel conditions, or a combination of the two. There are other tools available to monitor and track those conditions. However, our map can be used in conjunction with this ancillary data, such as insect outbreak maps, to better inform us on where the next large wildfires might happen.

Finally, the inclusion of climate variables that summarize fire weather in our model may give us the ability to explore climate change scenarios (Carroll 2010) and what effect they may have on patterns of wildfire suitability in the future.

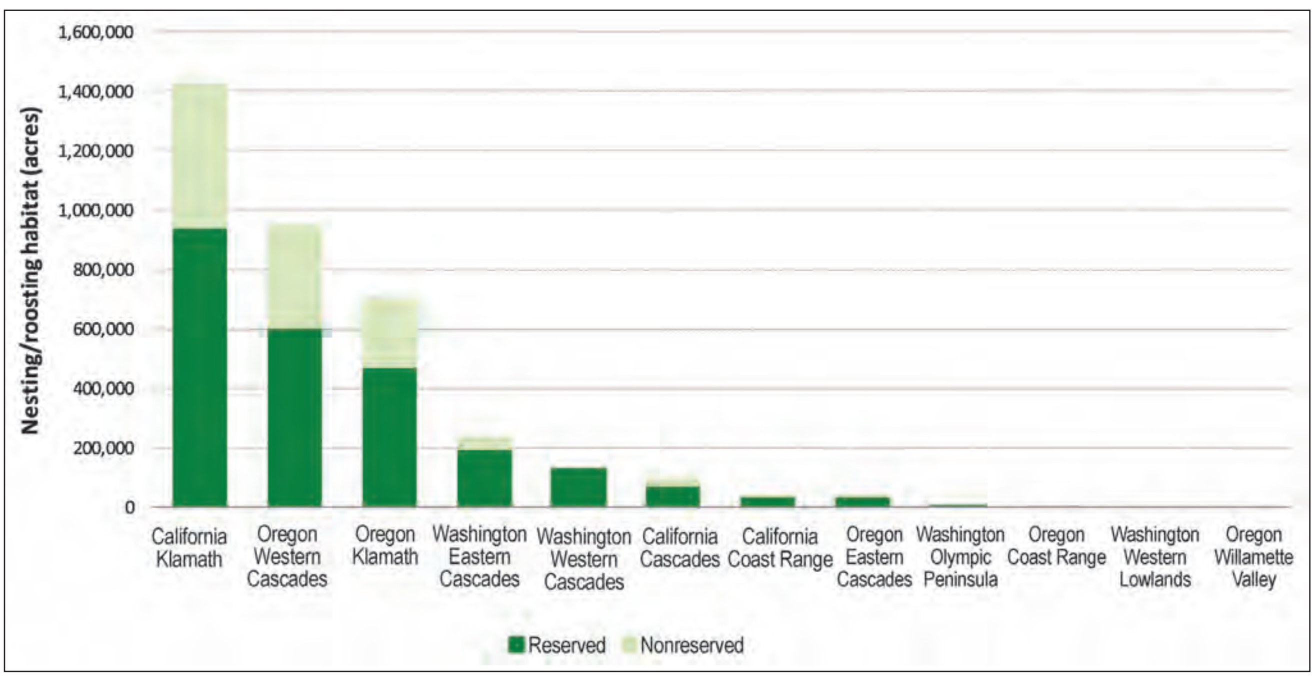

Figure 4-11—Fire-prone spotted owl nesting/roosting habitat, both reserved and nonreserved, by physiographic province, 2006/07. The majority of the fire-prone habitat occurs within the Klamath provinces, and the southern portions of the Oregon Western Cascades. Over half is in reserved land use allocations.

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Ray Davis

Chapter 5: Emerging Issues, Related Research, and Research Needs

Katie M. Dugger and Raymond J. Davis

Emerging Issues

The 10-year report on the status and trends of northern spotted owl (*Strix occidentalis caurina*) populations and habitat recognized that the conservation and recovery of the owl is not solely related to the amount and quality of habitat across its range (Lint 2005). Other factors including interactions with prey and prey biology, competition with barred owls (*S. varia*), and the emergence of West Nile virus in the Pacific Northwest were noted as emerging issues (Lint 2005). The potential threat of West Nile virus infections to spotted owl populations has not been realized, despite early evidence that owls in the wild were susceptible to natural infection (Fitzgerald et al. 2003). For unknown reasons, outbreaks of the West Nile virus in spotted owls that were anticipated 5 years ago have not occurred, although the virus is present throughout the owls range (Franklin 2010). Although West Nile virus has not developed into as much of a threat to owl populations as predicted previously (Lint 2005), documentation of the negative association between the invasive barred owl and spotted owl vital rates has con-tinued over the last 5 years (Anthony et al. 2006, Dugger et al. 2008, Forsman et al. 2011, Glenn et al. 2010, Kroll et al. 2010). The barred owl is now found at significant densities throughout the entire range of the northern spotted owl (Livezey 2009), and the range expansion of this species constitutes a significant threat to northern spotted owl persistence, which was not evident when the spotted owl was first listed (Courtney et al. 2004). The proportion of spotted owl territories where barred owls have been detected has increased steadily since the early 1990s in the eight effectiveness monitoring areas administered under the Northwest Forest Plan (the Plan) (fig. 5.1) along with increased evidence of negative interactions, presumably owing to competition or interference between the two species (Dugger et al. 2008, 2009; Kroll et al. 2010; Olson et al. 2005).

The invasion of barred owls into the range of the northern spotted owl has been associated with a decreased ability to detect and monitor spotted owls when barred owls are present (Dugger et al. 2009, Glenn et al. 2010, Kroll et al. 2010, Olson et al. 2005). In addition, the detection of barred owls on spotted owl territories is associated with decreased site occupancy by spotted owls and changes in extinction and colonization rates (Dugger et al. 2008, 2009; Kroll et al. 2010; Olson et al. 2005). The strongest association is between detections of barred owls and increased extinction rates across the entire range of the spotted owl, and decreased colonization rates have been reported for some study areas as well (Dugger et al. 2008, 2009; Kroll et al. 2010; Olson et al. 2005). The most recent meta-analysis of spotted owl population dynamics reports a clear negative association between barred owl presence and spotted owl survival (Forsman et al. 2011; chapter 2, this report). Effects on fecundity are less apparent, but declines in spotted owl recruitment on four demographic study areas (Olympic, H.J. Andrews, Coast Ranges, Tyee) in association with barred owl presence has been reported (Glenn et al. 2010). Thus, researchers continue to compile negative associations between barred owl presence and spotted owl vital rates strengthening the evidence that barred owls are negatively affecting spotted owl demography.

Climate change is another emerging issue that may affect spotted owl habitat, populations, and the functionality of the network of reserved land use allocations across the owl's range (Carroll 2010, Carroll et al. 2009, Glenn et al. 2010, Spies et al. 2010). Forest Service research objectives include developing projections for changes in fire regimes and shifts in habitat distributions because altered forest structures with increased threats from wildfire and insect and disease outbreaks are anticipated in association with predicted climate change (USDA 2009). Rate of change in spotted owl population was negatively associated with hot, dry growing seasons and wet, stormy winters (Glenn et al. 2010). Climate models for the first half of the 21st century predict warmer, wetter winters and hotter, drier summers, which could potentially have negative consequences for spotted owls (Glenn et al. 2010). Considering the potential effects of different climate change scenarios in models predicting wildfire suitability (see chapter 4 in this report) may help estimate potential changes in the fire regime within the owl's range and thus potential threats to habitat. In addition,

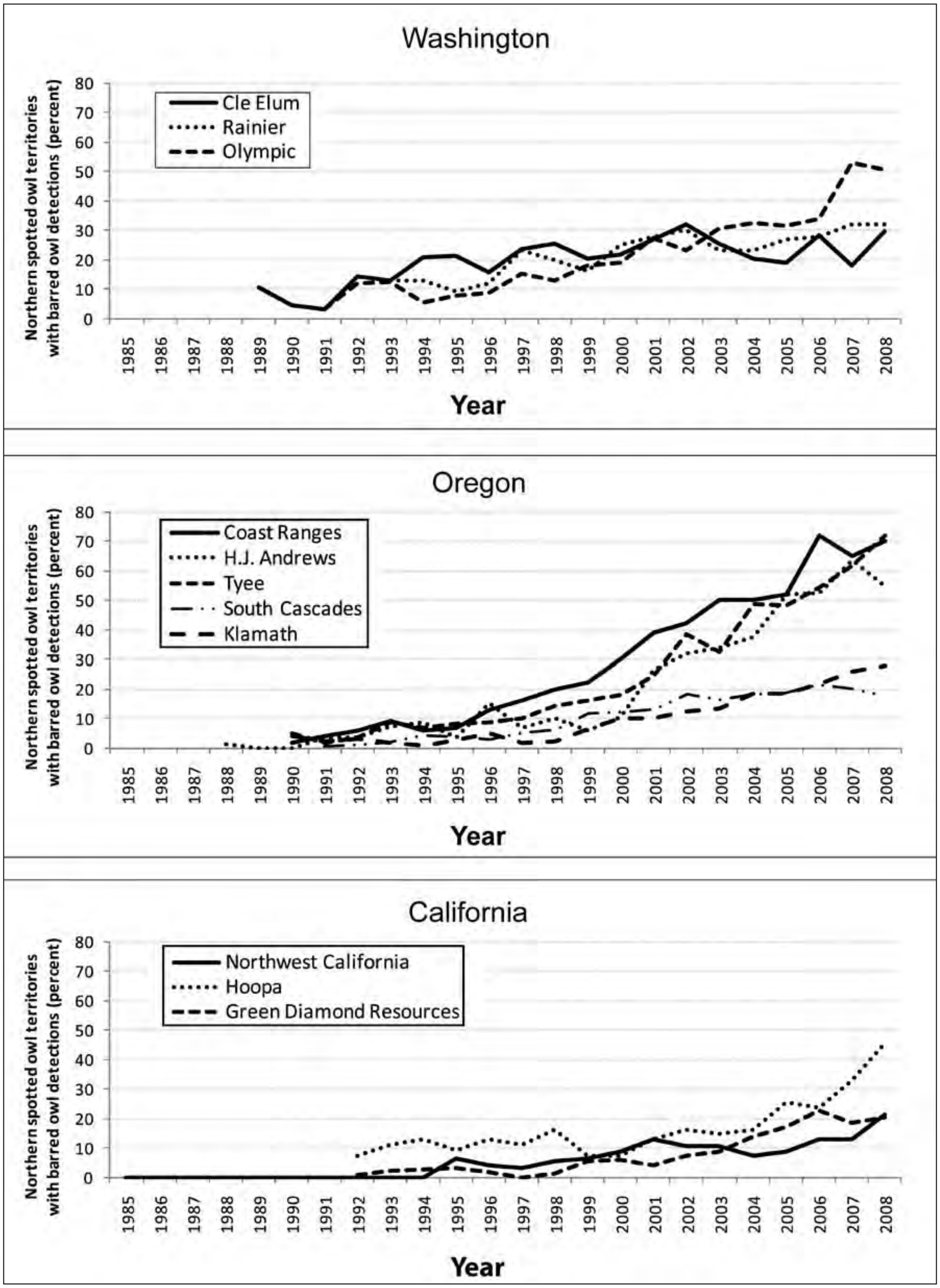

Figure 5-1—Annual proportion of northern spotted owl territories with barred owl detections on study areas in Washington, Oregon, and California. Source: adapted from Forsman et al. (2011).

the inclusion of forest type variables in the owl habitat models can also be modified based on climate change scenarios and used to explore the effects of climate change on suitable owl habitat. As noted by Glenn et al. (2010), however, in the face of climate change and barred owl persistence, the best management strategy for conserving spotted owl populations is to maintain sufficient, high-quality, suitable habitat throughout the species' range.

Related Research and Research Needs

Current research efforts to further understand the competitive interactions between barred and spotted owls are ongoing by D. Wiens, an Oregon State University Ph.D. student. In addition, the U.S. Fish and Wildlife Service (FWS) is proceeding with a proposal to clarify interactions between the two species using an experimental approach as part of Recovery Action 29 in the *Final Recovery Plan for the Northern Spotted Owl* (USDI 2008). This recovery action calls for the FWS to "Design and implement large-scale control experiments in key spotted owl areas to assess the effects of barred owl removal on spotted owl site occupancy, reproduction, and survival." By removing barred owls from spotted owl territories, researchers will be able to document a clear cause-effect relationship between barred owl presence and spotted owl demography (Gutiérrez et al. 2007). The information gained from this experiment may aid in the management and conservation of spotted owls in the face of the continued threat posed by the invasion and establishment of the barred owl in the Pacific Northwest. This proposed research may elucidate new management actions or clarify management and conservation limitations regarding the negative interactions of these two species.

The extent to which habitat management can affect interactions between barred and spotted owls is not clear, but barred owls are habitat generalists that can occupy a wide variety of forest conditions including late-successional forests (Herter and Hicks 2000, Pearson and Livezey 2003, Singleton et al. 2010). In addition, their territories are only 1/4 to 1/9 the size of spotted owl territories (Singleton et al. 2010), so the ratio of the number of barred to spotted owls can be as high as 9 to 1 in some areas. This argues for the increased importance of high-quality, contiguous blocks of nesting/roosting habitat for spotted owls, and the effects of habitat loss cannot be decoupled from the additional stressor imposed by the barred owl range expansion (Dugger et al. 2008).

In particular, the relationship between spotted owl fitness and habitat characteristics may have become disconnected through interspecific competition with barred owls in the landscape (Dugger et al. 2008). Our comparison of habitat suitability at spotted owl pair locations between 1994/96 and 2006/07 (see chapter 3 in this report) showed an average decrease in habitat suitability value of 9.4 percent across the owl's range, suggesting that the quality of habitat at spotted owl pair locations has decreased over time. As loss of suitable nesting/roosting habitat since 1994/96 has been low (3.4 percent), it is unlikely this decline in habitat quality of owl pair locations is the result of general habitat loss, so it is possible this change reflects competition for space with barred owls. Barred owls will use a wide variety of forested landscapes (Hamer et al. 2007, Singleton et al. 2010) and may be excluding spotted owls from the best spotted owl habitat in places where their densities are high (Dugger et al. 2008), but this hypothesis needs to be tested directly with barred owl removal experiments. It is possible that competition with barred owls also might be the reason we have had difficulty developing predictive models (see following discussion) that provide a clear understanding of the relationship between habitat characteristics and spotted owl demographics across the species' range (Anthony et al. 1998, 2002a, 2002b; but see Dugger et al. 2005, Olson et al. 2004).

The effectiveness monitoring plan for spotted owls recommended the development of predictive models linking survival, fecundity, and occupancy to observed vegetation characteristics of owl habitat (Lint et al. 1999). The expectation was that these predictive models could be validated and proved to generate owl vital rate predictions with acceptable error. If so, then there would be a shift from intensive collection of mark-recapture data via annual field surveys to the use of remotely sensed habitat data to monitor owl populations on at least some of the eight study areas (Lint et al. 1999). The spotted owl monitoring program funded a 5-year study to explore the development and feasibility of predicting occupancy and demographic performance of spotted owls using remotely sensed habitat data (Anthony et al. 1998), and most of that work has been completed (Anthony et al. 2002a, 2002b; Dugger et al. 2005, 2006, 2008; Olson et al. 2004, 2005).

Unfortunately, this component of the effectiveness monitoring program has produced mixed results, with only a few strong relationships between habitat characteristics and survival and fecundity noted for some of the demographic study areas (Dugger et al. 2005, Franklin et al. 2000, Olson et al. 2004). As noted by Lint (2005) in the 10-year report, results at that point did not warrant moving on to phase II monitoring, where models would be substituted for mark-recapture studies. However, although simple, universal models linking habitat characteristics to survival and fecundity of owls are likely not possible, these efforts have provided more insight into the effects of climate and habitat characteristics on owl demography. Some general findings include the strong positive effect of late-successional forest at the core of an owl's territory (around the nest site or activity center) on survival and fecundity (Dugger et al. 2005, Franklin et al. 2000, Olson et al. 2004). In addition, at least on some study areas in the southern portion of the owls' range, some component of edge habitat may be important, probably as a source of prey (Franklin et al. 2000, Olson et al. 2004).

Since the 10-year report, models for two study areas have been developed linking occupancy dynamics of spotted owls to habitat characteristics (Dugger et al. 2008; Sovern, 2010). The effect of barred owls and habitat characteristics on extinction and colonization rates can be modeled using multiseason, single-species occupancy models (MacKenzie et al. 2006) or even multiple-species models within seasons (Bailey et al. 2009, MacKenzie et al. 2006). Estimates of annual site occupancy can also be derived from these models, which rely on a mark-recapture framework with a "site" or owl territory as the sample unit and presence/absence data across multiple visits within and between years to allow the separation of occupancy dynamics and detection probabilities (MacKenzie et al. 2006). Accounting for variations in detection rates of spotted owls is important for developing accurate estimates of site occupancy (MacKenzie et al. 2006, Olson et al. 2005). In addition, understanding the mechanisms or processes that drive site occupancy, like the factors that affect the probability that an occupied site becomes unoccupied (i.e., local extinction rate) or the probability that an unoccupied site becomes occupied (i.e., local colonization rate) are proving vital to understanding the impact of barred owls and habitat characteristics on spotted owl persistence (Olson et al. 2005; Kroll et al. 2010; Dugger et al., in press). Based on these models, strong relationships between the amount of old-forest habitat at the core scale (410-ac circle around nest tree or activity center) and extinction rates were observed for the South Cascades study area; spotted owl territories with small amounts of old forest near the site center experienced higher extinction rates of owl pairs (Dugger et al. 2008). In addition, increased fragmentation of old forest at the home range scale (3,700-ac circle around nest site or activity center) decreased colonization rates by owl pairs, and both occupancy parameters were affected by barred owl presence as well (Dugger et al. 2008).

It is unclear why we observed stronger associations between habitat characteristics and occupancy parameters as compared to habitat characteristics and survival or fecundity (Anthony et al. 2002a, 2002b; Dugger et al. 2005, 2006, 2008; Olson et al. 2004, 2005), but it is possible that occupancy reflects the first level of selection by a species, and this is where the strongest selections for habitat are being made. In other words, an area of habitat selected for defense and maintenance of a territory by an owl also meets some minimum standard of suitability for survival and reproduction; thus, habitat quality most strongly affects territory selection, but other factors (climate, age/experience of individuals, individual variation) are more important for explaining the variation in survival and fecundity.

Recent advances in the development of remotely sensed vegetation (Ohmann and Gregory 2002) and change-detection data (Kennedy et al. 2007) may provide an opportunity to investigate habitat relationships across the range of the species in conjunction with barred owl influences. Previous efforts included a range of map products based on a single point in time, or limited temporally and of varying quality (Glenn and Ripple 2004), precluding a meta-analysis using data from all the study areas. The development of this new vegetation layer will now allow us to search for and quantify consistent relationships between habitat characteristics and owl demography, particularly occupancy across the entire range of the species within a meta-analysis framework. In addition, the change-detection data provide an annual time sequence of vegetation changes that can now be linked to annual demographic data. This kind of analysis based on data from eight effectiveness monitoring areas and conducted in a workshop format as a meta-analysis following previous efforts for survival and fecundity (Anthony et al. 2006, Burnham et al. 1996, Forsman et al. 2011, Franklin et al. 1999) should be a priority for future research.

A better understanding of the population dynamics of many of the important spotted owl prey species across the range of the owl will likely be essential to understanding patterns and variation in spotted owl fecundity (Courtney et al. 2004, Forsman et al. 2011). New monitoring and research programs should be initiated to investigate prey cycles and their relationship to spotted owl demographics while incorporating the potential competitive effects of barred owls. This remains a large gap in our understanding of spotted owl ecology, and our lack of baseline information increases the difficulty we face trying to manage spotted owl populations in conjunction with the barred owl, most likely a direct competitor for food resources.

Another area of much needed research includes the effect of fire on owls and their prey, and how fuel reduction treatments proposed to reduce wildfire risk affect owl demography. Fire suppression over the last century has reduced wildfire's presence in its "natural habitats" (Agee 1993, Atzet and Martin 1992, Sensenig 2002), and although wildfire risk has not increased dramatically in the moister/cooler forests, this suppression is believed to have increased the risk for severe wildfires in the fire-prone, or drier/warmer forests. The increased frequency of large wildfires since the mid-1980s in the Western United States (Westerling et al. 2006, Schwind 2008) and within the owl's range (see chapter 4 in this report) have created concern about how wildfires might affect efforts to conserve the owl. Hotter, drier climates associated with climate change are believed to be at least partially responsible for this increase in large-wildfire frequency (Westerling et al. 2006), and there is also evidence that the amount of high-severity wildfire has increased (Miller et al. 2009, Schwind 2008; but see Hanson et al. 2009), in some cases, as the result of accumulated fuels and higher stand densities (Sensenig 2002).

The relationship between wildfire and owl demography is not well understood, but likely includes a complex interaction of fire frequency and severity (Bond et al. 2009, Clark 2007). Owls use forest stands that have burned understories or partially removed overstories, but they tend to avoid areas of complete stand replacement for nesting and roosting (Clark 2007), although use of high-severity burn areas for foraging has been documented for the California spotted owl (*Strix occidentalis occidentalis*) (Bond et al. 2009). This species has likely evolved the ability to adapt and utilize forests that have been subjected to light to moderate fire severity, particularly in the fire-prone portions of its range (chapter 4, this report), but again short-term vs. long-term effects on demography and dispersal are unknown.

Although wildfire has long been a natural agent of disturbance, owls evolved with it in historically forested landscapes that could accommodate the habitat changes caused by it. Today, much of the spotted owl habitat that remains has been "squeezed" into federally managed lands, covers a much smaller portion of the owl's historical range, is highly fragmented (Davis and Lint 2005), and may no longer be able to accommodate large wildfires without incurring adverse consequences to the owl. To lessen the chances of adverse impacts from occurring, the *Final Recovery Plan for the Northern Spotted Owl* (USDI 2008) advocated landscape-level treatments to reduce the risk of large-scale habitat loss to high-severity wildfire for Eastern Cascades and Klamath provinces of the owl's range (USDI 2008). However, it is currently unclear what short- or long-term effects these forest thinning and fuel reduction treatments will have on northern spotted owl populations.

A case study on a single owl territory in second-growth forests in the northern Oregon Coast Range suggests commercial thinning may cause northern spotted owls to alter their habitat use and increase the size of their home ranges, particularly during the nonbreeding season (Meiman et al. 2003). This one case study suggested that thinning operations within core-use areas may be detrimental for northern spotted owls, at least in the short term. But it is not known whether thinning produces long-lasting adverse impacts or long-term benefits associated with owl vital rates. No other published literature is available on thinning and the effects of fuel reductions on habitat use and demography of threatened spotted owls. Understanding the relationship between wildfire and owl demography and the effect of both commercial and noncommercial thinning activities (to reduce fire fuel loads) on owl vital rates should be high research priorities.

Summary

As we have summarized above, there are several large gaps in our understanding of spotted owl ecology, particularly in relation to cycles of prey distribution and abundance, disturbance by fire, and forest management activities associated with developing future habitat or reducing fire risk. Emerging issues, primarily the competitive interactions with the barred owl, are also of very high concern, particularly as the negative effect of this invasive species may be in addition to, or somewhat independent of, maintenance of high-quality spotted owl habitat. The information we have on these issues is dependent on continued research and, in particular, the continued long-term monitoring of owl vital rates throughout this species' range. The effectiveness monitoring program for spotted owls was designed to monitor the long-term results of the Plan and its effect on owl populations (Lint et al. 1999). This monitoring program has done much more, however, as the unique, large-scale demography data set resulting from this program has not only allowed resource managers to document the effects of management activities, but has also contributed valuable information regarding basic owl ecology and the factors that affect vital rates. In large part, the effectiveness monitoring program has been responsible for documentation of the barred owl expansion southward into the spotted owl's range and the negative effects of this invasion on spotted owls (Dugger et al. 2008, 2009; Olson et al. 2005). Recovery goals and actions associated with the *Final Recovery Plan for the Northern Spotted Owl* (USDI 2008) and proposed revisions have been informed directly by or are reliant on the demography data collected on the eight effectiveness monitoring study areas, as well as the remotely sensed data developed for habitat monitoring. Data from this long-term monitoring program have also aided researchers in the development of new analytical approaches for answering complex demography questions (Bailey et al. 2009, MacKenzie et al. 2006). These examples illustrate how the value of the spotted owl effectiveness monitoring program reaches far beyond the original objectives and is truly vital to management and conservation of this species.

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Metric Equivalents

When you know:	Multiply by:	To find:
Inches (in)	25.4	Millimeters (mm)
Inches (in)	2.54	Centimeters (cm)
Feet (ft)	.305	Meters (m)
Miles (mi)	1.609	Kilometers (km)
Square miles (mi^2)	2.59	Square kilometers (km^2)
Acres (ac)	.405	Hectares (ha)
Degrees Fahrenheit (°F)	(F-32)/1.8	Degrees Celsius (°C)

Peter Carlson

Barred owl.

Appendix A: Environmental Variables Used for Habitat Suitability Modeling

Table A-1—Environmental variables that were used for habitat modeling

Variable	Description	Units
Diameter diversity index	A measure of the structural diversity of a forest stand based on tree densities in different diameter at breast height (d.b.h.) classes. Calculation procedures are described in appendix 1 of McComb et al. (2002)[a]	Index
Canopy cover of all conifers	Percentage of conifer cover in the canopy as calculated using methods in the Forest Vegetation Simulator	Percentage
Stand height	Average height of dominant and codominant trees	Meters
Mean conifer diameter	Basal area weighted mean diameter of all live conifers	Centimeters
Density of large conifers	Estimated tree density for all live conifers ≥ 30 in d.b.h.	Trees/ha
Stand age (no remnants)	Average stand age based on field-recorded ages of dominant and codominant tree species, and excluding remnant trees	Years
Subalpine forest	Stand component of Pacific silver fir (*Abies amabilis* Dougl. ex Forbes), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), noble fir (*Abies procera* Rehd.), Shasta red fir (*Abies shastensis* (Lemmon) Lemmon), Alaska cedar (*Chamaecyparis nootkatensis* (D. Don) Spach), Engelmann spruce (*Picea engelmannii* Parry ex Engelm.), whitebark pine (*Pinus albicaulis* Engelm.), and mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.)	Percentage of total basal area
Pine forest	Stand component of lodgepole pine (*Pinus contorta* Dougl. ex Loud.), Jeffrey pine (*Pinus jeffreyi* Grev. & Balf.), Bishop pine (*Pinus muricata* D. Don), and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.)	Percentage of total basal area
Oak woodlands	Stand component of blue oak (*Quercus douglasii* Hook. & Arn.), Oregon white oak (*Quercus garryana* Dougl. ex Hook.), and California black oak (*Quercus kelloggii* Newb.)	Percentage of total basal area
Evergreen hardwoods	Stand component of Pacific madrone (*Arbutus menziesii* Pursh), tanoak (*Lithocarpus densiflorus* Rehd.), California live oak (*Quercus agrifolia* Née), canyon live oak (*Quercus chrysolepis* Liebm.), and California laurel (*Umbellularia californica* (Hook. & Arn.) Nutt.)	Percentage of total basal area
Redwood forest	Stand component of redwood (*Sequoia sempervirens* D. Don) Endl.)	Percentage of total basal area

[a] McComb, W.C.; McGrath, M.T.; Spies, T.A.; Vesely, D. 2002. Models for mapping potential habitat at landscape scales: an example using northern spotted owls. Forest Science. 48(2): 203–216.

Correlation coefficient (mean ±1SD) ⇨		0.739 ± 0.065	0.567 ± 0.133	0.574 ± 0.135	0.585 ± 0.081	0.677 ± 0.093	0.559 ± 0.132
⇩		Canopy cover conifer	Stand height	Stand age	Large conifer density	Diameter diversity index	Mean conifer d.b.h.
0.739 ± 0.065	Canopy cover conifer	1.000	0.466	0.373	0.532	0.651	0.225
0.567 ± 0.133	Stand height	0.466	1.000	0.489	0.649	0.633	0.593
0.574 ± 0.135	Stand age	0.373	0.489	1.000	0.493	0.536	0.437
0.585 ± 0.081	Large conifer density	0.532	0.649	0.493	1.000	0.659	0.555
0.677 ± 0.093	Diameter diversity index	0.651	0.633	0.536	0.659	1.000	0.596
0.559 ± 0.132	Mean conifer d.b.h.	0.225	0.593	0.437	0.555	0.596	1.000

Figure A-1–Stand structure and age habitat variable correlation matrix with averaged accuracy plot Pearson correlations (SD = standard deviation, d.b.h. = diameter at breast height). These six environmental variables were used in all modeling regions.

Table A-2—Stand species composition variable groupings, with local scale accuracy assessments, used in applicable modeling regions (MR) (GNN DOM SPP = gradient nearest neighbor, dominant species models)

Species grouping	GNN DOM SPP	Scientific name	Common name	Washington Coast and Cascades (MR 221)	Washington Eastern Cascades (MR 222)	Oregon Coast Range (MR 223)	Oregon and California Cascades (MR 224)	Oregon and California Klamaths (MR 225)	California Coast (MR 226)	Average kappa
				– Kappa coefficients –						
Subalpine forest	ABAM	*Abies amabilis*	Pacific silver fir	0.53	0.66	n/a	0.59	n/a	n/a	***0.59***
	ABLA	*Abies lasiocarpa*	Subalpine fir	0.48	0.58	n/a	0.39	n/a	n/a	***0.48***
	ABPRSH	*Abies procera/shastensis*	Noble fir/Shasta red fir	0.32	0.29	n/a	0.52	0.47	n/a	***0.40***
	CHNO	*Chamaecyparis nootkatensis*	Alaska cedar	0.28	0.29	n/a	0.19	n/a	n/a	***0.25***
	PIEN	*Picea engelmannii*	Engelmann spruce	0.38	0.38	n/a	0.22	n/a	n/a	***0.33***
	PIAL	*Pinus albicaulis*	Whitebark pine	0.32	0.46	n/a	0.34	n/a	n/a	***0.37***
	TSME	*Tsuga mertensiana*	Mountain hemlock	0.50	0.53	n/a	0.62	0.26	n/a	***0.48***
Pine forest	PICO	*Pinus contorta*	Lodgepole pine	n/a	0.26	n/a	0.57	0.28	0.21	***0.33***
	PIJE	*Pinus jeffreyi*	Jeffrey pine	n/a	n/a	n/a	0.27	0.28	0.14	***0.23***
	PIMU	*Pinus muricata*	Bishop pine	n/a	n/a	n/a	n/a	n/a	0.28	***0.28***
	PIPO	*Pinus ponderosa*	Ponderosa pine	n/a	0.62	n/a	0.58	0.34	0.48	***0.51***
Oak woodlands	QUDO	*Quercus douglasii*	Blue oak	n/a	n/a	n/a	n/a	0.68	0.41	***0.55***
	QUGA4	*Quercus garryana*	Oregon white oak	n/a	0.56	0.29	0.52	0.35	0.34	***0.41***
	QUKE	*Quercus kelloggii*	California black oak	n/a	n/a	0.27	0.53	0.38	0.52	***0.42***
Evergreen hardwoods	ARME	*Arbutus menziesii*	Pacific madrone	n/a	n/a	0.49	0.45	0.43	0.29	***0.41***
	LIDE3	*Lithocarpus densiflorus*	Tanoak	n/a	n/a	0.72	n/a	0.58	0.55	***0.61***
	QUAG	*Quercus agrifolia*	California live oak	n/a	n/a	n/a	n/a	n/a	0.31	***0.31***
	QUCH2	*Quercus chrysolepis*	Canyon live oak	n/a	n/a	0.46	0.17	0.35	0.22	***0.30***
	UMCA	*Umbellularia californica*	California laurel	n/a	n/a	0.43	n/a	0.29	0.30	***0.34***
Redwood forest	SESE3	*Sequoia sempervirens*	Redwood	n/a	n/a	n/a	n/a	n/a	0.59	***0.59***

Note: n/a = not applicable.

Stan Sovern

Appendix B: Nearest Neighbor Distance Analysis of Demographic Study Area Data

An analysis of nearest neighbor distances (Clark and Evans 1954) was conducted on several demographic study area owl pair location (fig. B–1) data sets from 1994 through 1997 to correspond with the baseline satellite imagery. The purpose of this analysis was to determine biologically relevant distances for use as minimum distance parameters in the random sampling of owl pair locations from the 10-year report owl presence data set (Davis and Lint 2005). The purpose of this sampling was to provide additional habitat model training data points, outside of demographic study areas, for the habitat modeling described in chapter 3.

Only one location was used to represent each owl territory center. To minimize erroneous results, we only used owl locations from the 50-percent harmonic mean core (Dixon and Chapman 1980) of each study area's data set. This removed outlier locations that would introduce errors in the analysis, especially for study areas that have disjunct areas or survey areas that are separated by several miles. The analysis was conducted in ArcView Spatial Analyst using the Animal Movement extension (v2.0) by Hooge and Eichenlaub (2000).

Results show a decreasing trend in distance between owl pair territories from north to south (fig. B-2). The greatest mean nearest neighbor distance occurs in the Washington Eastern Cascades (4.5 km), and the shortest mean distance occurs within the California Coast (1.4 km). The longer distances in the northern portions of the range may relate to more limited prey resources. Likewise the shorter distances in the southern portion of the range may be due to increased prey base diversity and abundance associated with the presence of mast-producing evergreen hardwoods that occur in the coniferous forests of that region.

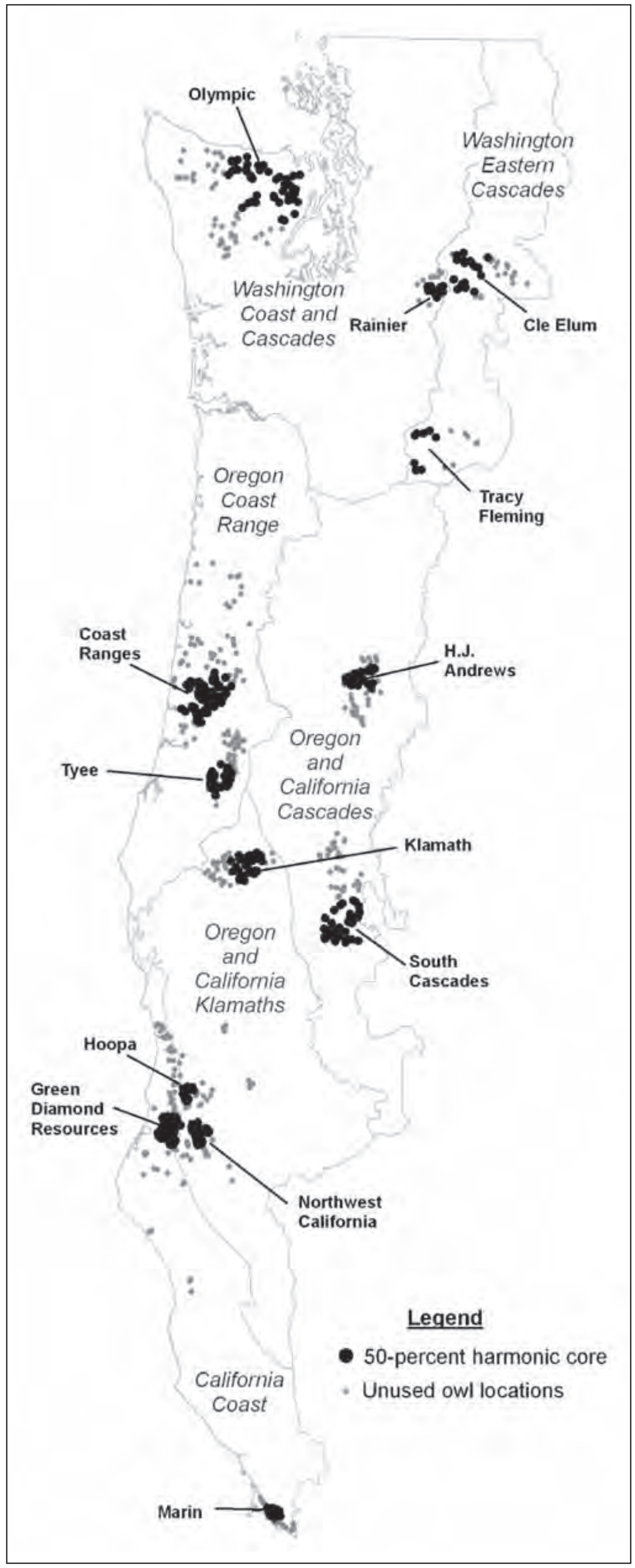

Figure B-1—Owl territories, 1994 through 1997.

Table B-1–Summary statistics from the nearest neighbor analysis for each habitat modeling region

Modeling region	Data sets used	n[a]	Mean distance	Median distance	StDev
			– – – – – Kilometers – – – – –		
Washington Eastern Cascades	Cle Elum and T. Fleming study areas	26	4.5	3.9	2.4
Washington Coast and Cascades	Olympic and Rainier study areas	53	3.6	3.1	1.7
Oregon and California Cascades	H.J. Andrews and Southern Cascades study areas	57	3.1	2.9	1.5
Oregon Coast Range	Oregon Coast Ranges and Tyee study areas	79	2.7	2.5	1.2
Oregon and California Klamaths	Klamath, Northwest California, and Hoopa study areas	70	2.4	2.1	1.1
California Coast	Green Diamond Resources and Marin study areas	77	1.4	1.3	0.6

[a] Only locations from the 50-percent harmonic core of the study area data set were used. StDev = standard deviation.

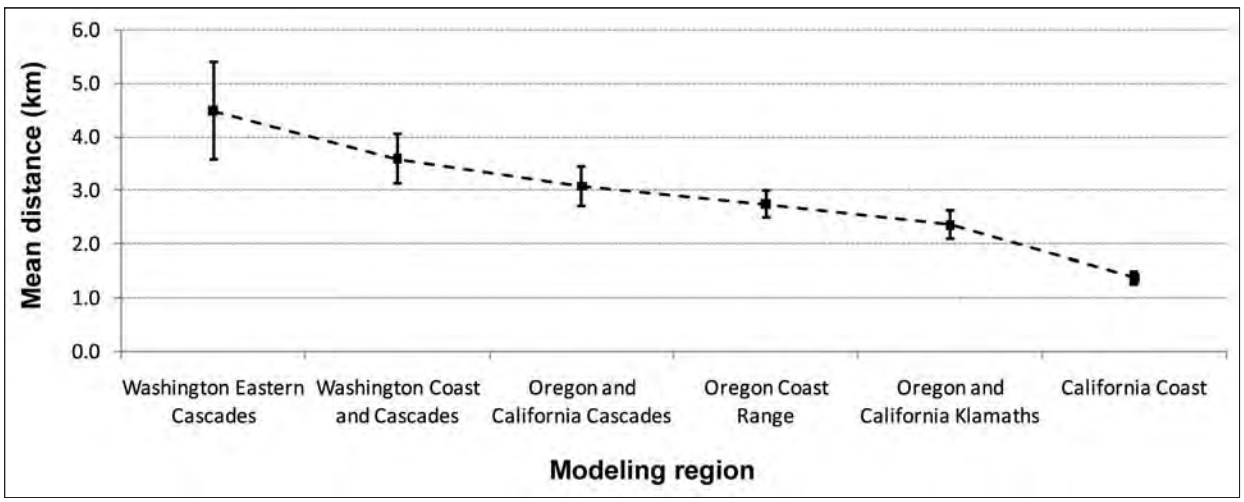

Figure B-2—Results of the nearest neighbor distance analysis showing mean distances between northern spotted owl territory centers with 95-percent confidence intervals for each habitat modeling region.

References

Clark P.; Evans, F.C. 1954. Distance to the nearest neighbor as a measure of spatial relationship in populations. Ecology. 35: 445–453.

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Dixon, K.R.; Chapman, J.A. 1980. Harmonic mean measure of animal activity areas. Ecology. 61: 1040–1044.

Hooge, P.N.; Eichenlaub, B. 2000. Animal movement extension to ArcView, 2.0. Anchorage, AK: Alaska Science Center—Biological Science Office, U.S. Geological Survey.

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Table C-1–Results of the MaxEnt bootstrapped replicate habitat suitability models (10 replicates for each modeling region) showing mean percentage for environmental variable model contributions and changes in model test gain associated with inclusion or exclusion of specific environmental variables

	Stand structure and age variables						Species composition variables						
Modeling region	**Conifer cover**	**Mean conifer d.b.h.**	**Large conifer density**	**Diameter diversity index**	**Stand height**	**Stand age**	**Subalpine forest**	**Pine forest**	**Oak woodland**	**Evergreen hardwood**	**Redwood forest**	**Highest gain by itself**	**Lowered gain the most when removed**
	Percentage of contribution												
Washington Coast and Cascades	21.0	1.7	35.2	7.8	3.2	20.2	10.8	n/a	n/a	n/a	n/a	Diameter diversity	Subalpine forest
Washington Eastern Cascades	34.6	0.5	11.0	6.0	7.4	2.7	31.8	4.9	1.3	n/a	n/a	Diameter diversity index	Subalpine forest
Oregon Coast Range	13.3	4.6	58.1	5.4	4.6	11.2	n/a	n/a	0.9	1.9	n/a	Stand age	Conifer cover
Oregon and California Cascades	15.6	5.2	33.4	21.7	3.8	4.7	6.3	5.5	1.1	2.6	n/a	Diameter diversity index	Subalpine forest
Oregon and California Klamaths	19.1	1.8	15.0	14.1	8.9	5.1	2.4	18.3	4.4	10.9	n/a	diversity index	Pine forest
California Coast	43.7	7.1	3.0	2.6	6.3	2.3	n/a	5.7	13.0	10.2	6.2	Conifer cover	Evergreen hardwood

Note: MaxEnt replicate variable response curve information for each modeling region is available upon request.
d.b.h. = diameter at breast height.

The following sections in this appendix summarize the MaxEnt modeling regions and the modeling results of the bootstrapped replicates. Model region descriptions are largely based on information from the Landscape Ecology Modeling, Mapping and Analysis Web site (http://www.fsl.orst.edu/lemma/main.php?project=nwfp&id=home).

Washington Coast and Cascades Modeling Region (MR 221)

This modeling region conforms to the Washington Douglas-fir ecological region used in the demographic meta-analyses, and contains the Olympic Peninsula and the Rainier demographic study areas. It encompasses the Washington Olympic Peninsula, Washington Western Lowlands, and the Washington Western Cascades physiographic provinces. The Olympic Peninsula is dominated by moist, productive coniferous rain forest on the western slope, and drier Douglas-fir forest in the rain shadow on the eastern slope. Wildfire frequency is very low. Federally managed lands occupy the interior half of the province, the core being Olympic National Park girded by the Olympic National Forest. Most of the Western Lowlands are in private and state ownership, with extensive urban and agricultural areas. It is dominated by wide, glaciated valleys, except for the Willapa Hills in the coastal section. Lowland coniferous forest, deciduous forest, and native prairie were its natural dominant vegetation types. The Western Cascades lower elevation forests are dominated by Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) grading into Pacific silver fir (*Abies procera* Rehd.) at midelevations, and mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.) and subalpine vegetation at higher elevations. Wildfire frequencies are low to moderate. About two-thirds of the province is administered by federal agencies.

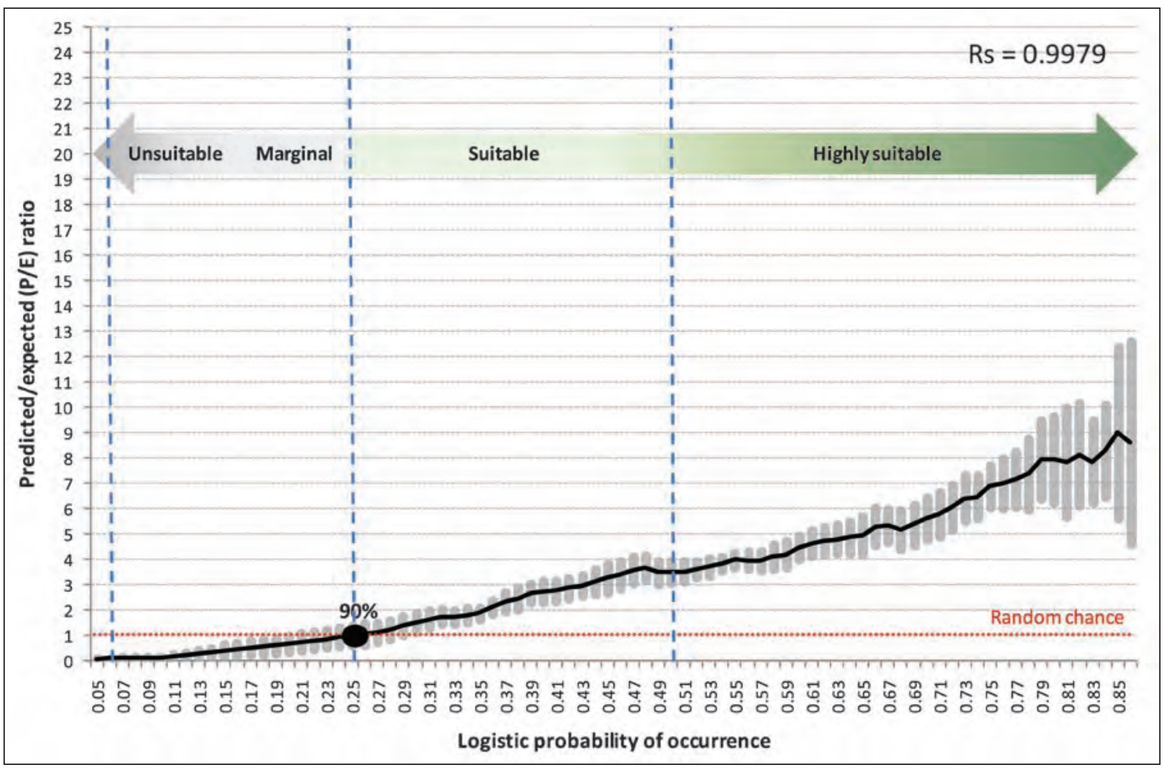


Figure C-1–The mean predicted vs. expected curve (solid black line) from the model replicates, showing 95-percent confidence intervals (gray-shaded vertical bars) for the Washington Coast and Cascades modeling region. The logistic thresholds used to define the four-class habitat map are represented by vertical blue-dashed lines. The P/E = 1 threshold is where the curve crosses the random chance line (red-dashed line). The solid black dot represents the 10-percentile threshold (see fig. C-2 below) indicating where 90 percent of the training data (owl pair site centers) occured above that threshold. The mean Spearman rank correlation (Rs) is shown in the upper right-hand corner. See Hirzel et al. (2006) for more information.

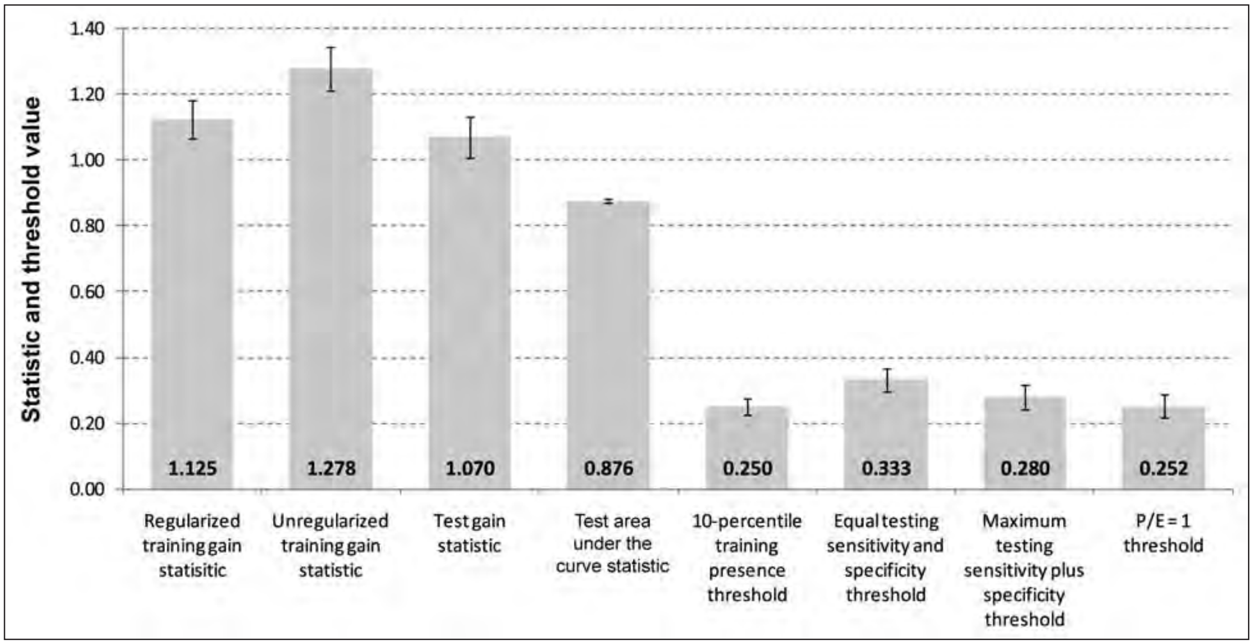


Figure C-2–Habitat modeling statistics produced during the MaxEnt model bootstrapped replicates for the Washington Coast and Cascades modeling region. Bars represent the mean statistic value, and error bars show the 95-percent confidence intervals. The first four bars represent model fit and discrimination statistics; the last four bars are common "thresholds" used to classify continuous habitat suitability models into binary maps of "not-suitable" and "suitable" habitat. P/E = predicted vs. expected.

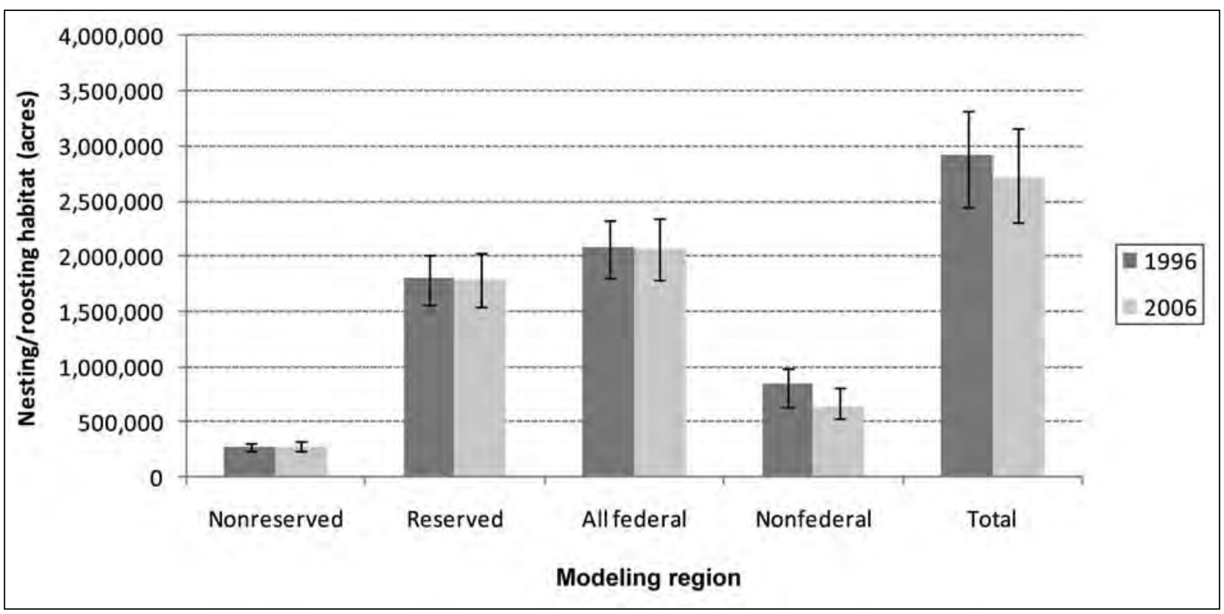


Figure C-3–Bookend habitat model area of suitable nesting/roosting habitat for northern spotted owls for the Washington Coast and Cascades modeling region. The bars represent the mean estimate of suitable habitat, and error bars show the 95-percent confidence intervals. This histogram shows net change (losses and gains) between 1996 and 2006.

Washington Eastern Cascades Modeling Region (MR 222)

This modeling region conforms to the Washington Mixed-Conifer ecological region used in the demographic meta-analyses, and contains the Cle Elum demographic study area. It also conforms to the Washington Eastern Cascades physiographic province. The slopes of the Washington Eastern Cascades province are dominated by mixed-conifer forest and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) forest at lower to midelevations, and by true fir (*Abies* spp.) and mountain hemlock at higher elevations. Forest productivity is low in places owing to poor soils and high elevations. Historically, fire frequencies were high (≤35-year fire-return intervals). Intensive fire suppression practices since the latter half of the 20th century have resulted in areas with significant accumulations of fuel and shifts in species composition and stand structure. About two-thirds of the area is federally managed.

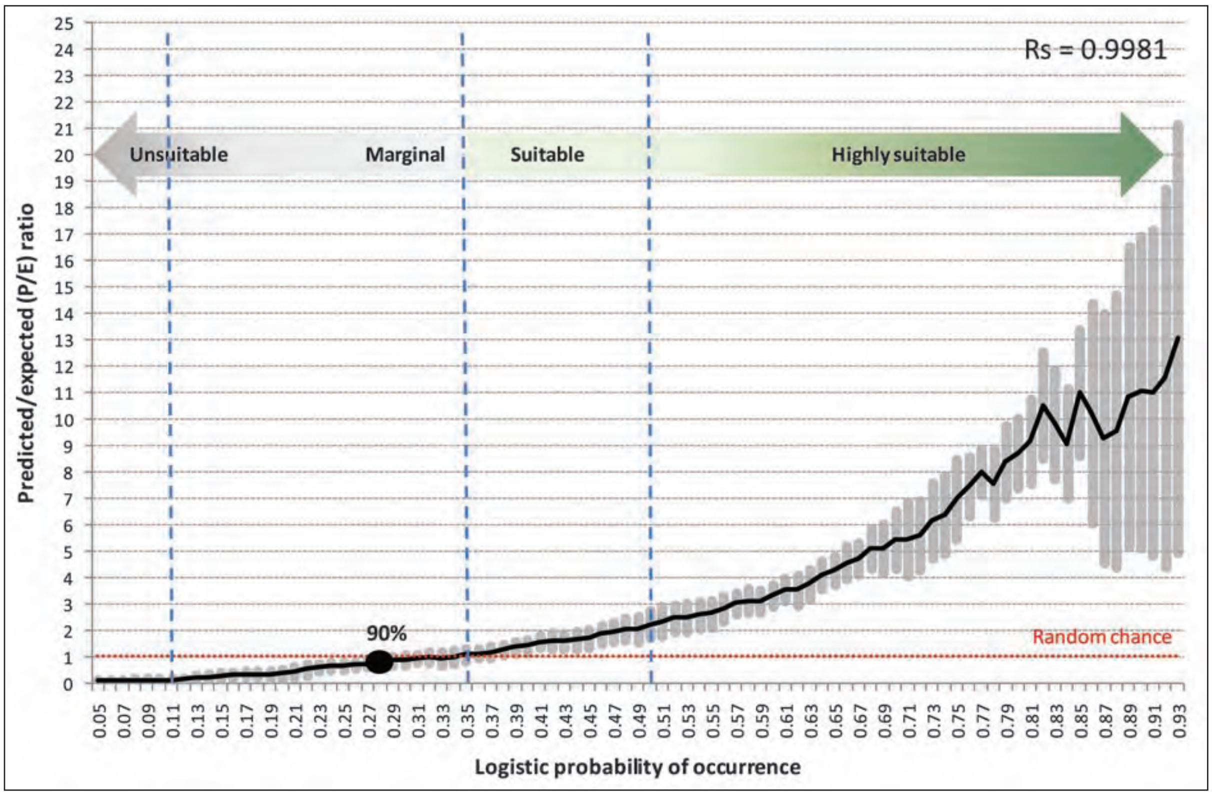


Figure C-4–The mean predicted vs. expected curve (solid black line) from the model replicates, showing 95-percent confidence intervals (gray-shaded vertical bars) for the Washington Eastern Cascades modeling region. The logistic thresholds used to define the four-class habitat map are represented by vertical blue-dashed lines. The P/E = 1 threshold is where the curve crosses the random chance line (red-dashed line). The solid black dot represents the 10-percentile threshold (see fig. C-5 below) indicating where 90 percent of the training data (owl pair site centers) occured above that threshold. The mean Spearman rank correlation (Rs) is shown in the upper right-hand corner. See Hirzel et al. (2006) for more information.

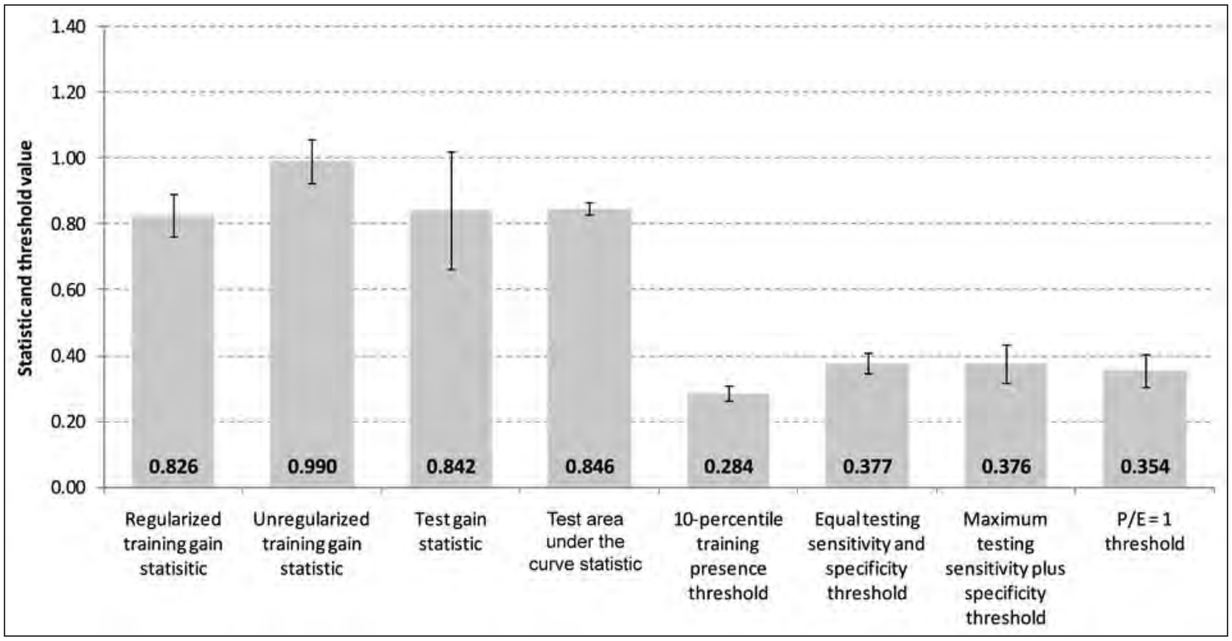


Figure C-5–Habitat modeling statistics produced during the MaxEnt model bootstrapped replicates for the Washington Eastern Cascades modeling region. Bars represent the mean statistic value, and error bars show the 95-percent confidence intervals. The first four bars represent model fit and discrimination statistics; the last four bars are common "thresholds" used to classify continuous habitat suitability models into binary maps of "not-suitable" and "suitable" habitat. P/E = predicted/expected ratio.

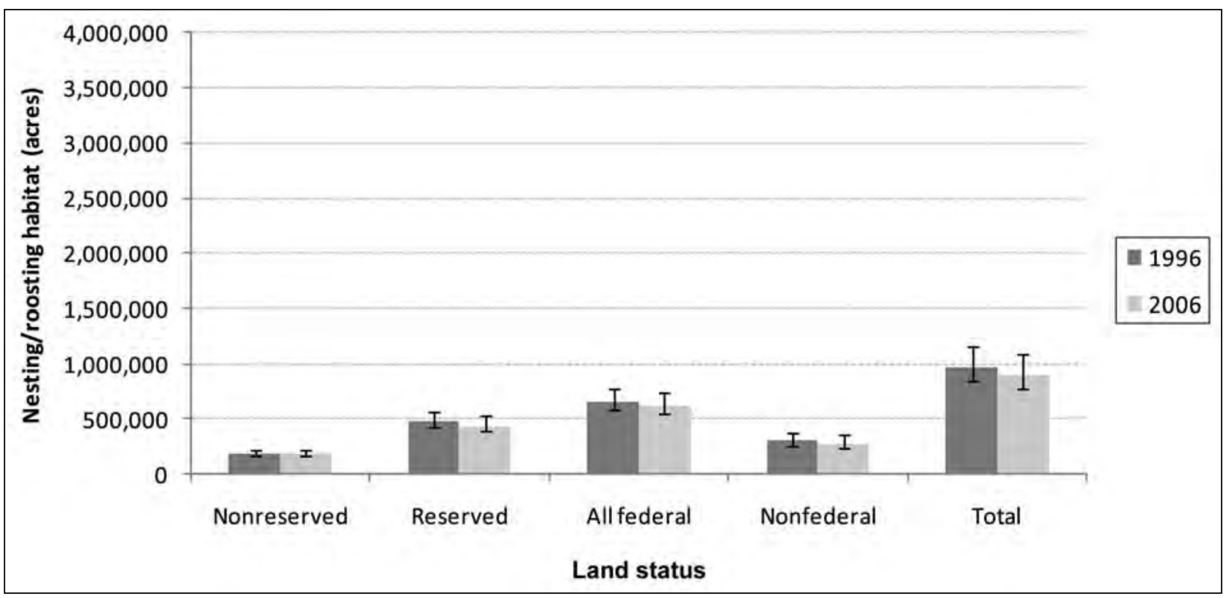


Figure C-6–Bookend habitat model area of suitable nesting/roosting habitat for northern spotted owls for the Washington Eastern Cascades modeling region. The bars represent the mean estimate of suitable habitat, and error bars show the 95-percent confidence intervals. This histogram shows net change (losses and gains) between 1996 and 2006.

Oregon Coast Range Modeling Region (MR 223)

This modeling region conforms to the Oregon Coastal Douglas-fir ecological region used in the demographic meta-analyses, and contains the Oregon Coast Ranges and Tyee demographic study areas. It contains the Oregon Coast physiographic province, and also the Willamette Valley physiographic province west of the Willamette River, as well as the coastal margins of the Oregon Klamath physiographic province. The moist, productive forests in this modeling region are dominated by Douglas-fir, western hemlock, and western redcedar (*Thuja plicata* Donn ex D. Don). The Forest Service and Bureau of Land Management together manage about one-quarter of the land in the region. Older forests are highly fragmented, largely as a result of infrequent but very large wildfires in the 1800s and 1900s, and heavy cutting, as well as checkerboard ownership patterns. Most of the Willamette Valley is in private ownership and includes extensive urban and agricultural areas. Lowland coniferous forest, deciduous forest, and native prairie were the natural dominant vegetation types.

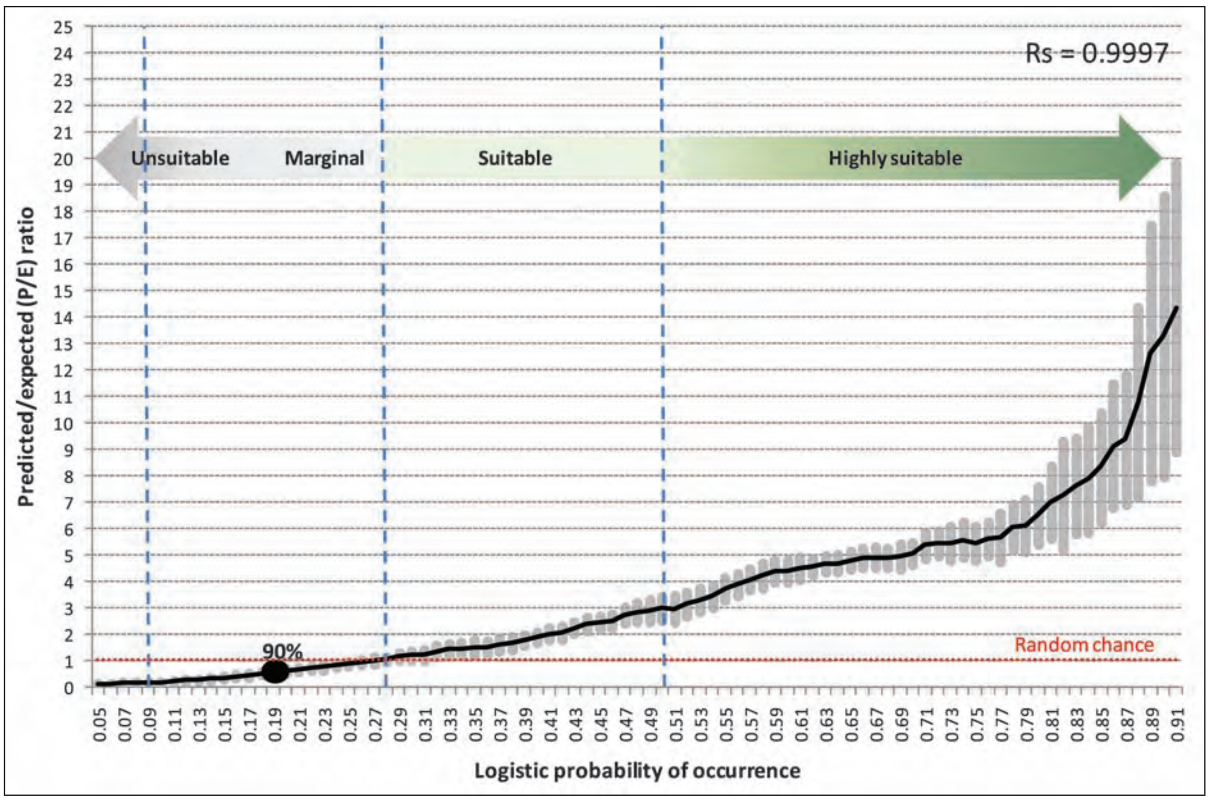


Figure C-7–The mean predicted vs. expected curve (solid black line) from the model replicates, showing 95-percent confidence intervals (gray-shaded vertical bars) for the Oregon Coast Range modeling region. The logistic thresholds used to define the four-class habitat map are represented by vertical blue-dashed lines. The P/E = 1 threshold is where the curve crosses the random chance line (red-dashed line). The solid black dot represents the 10-percentile threshold (see fig. C-8 below) indicating where 90 percent of the training data (owl pair site centers) occured above that threshold. The mean Spearman rank correlation (Rs) is shown in the upper right-hand corner. See Hirzel et al. (2006) for more information.

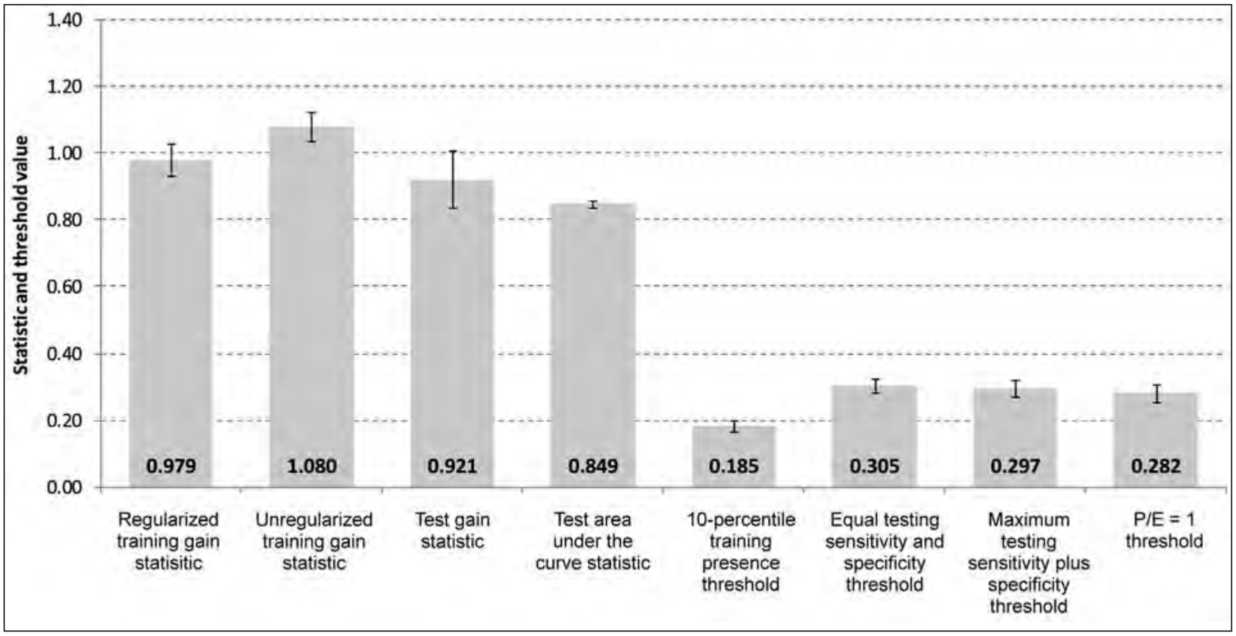


Figure C-8–Habitat modeling statistics produced during the MaxEnt model bootstrapped replicates for the Oregon Coast Range modeling region. Bars represent the mean statistic value, and error bars show the 95-percent confidence intervals. The first four bars represent model fit and discrimination statistics; the last four bars are common "thresholds" used to classify continuous habitat suitability models into binary maps of "not-suitable" and "suitable" habitat.

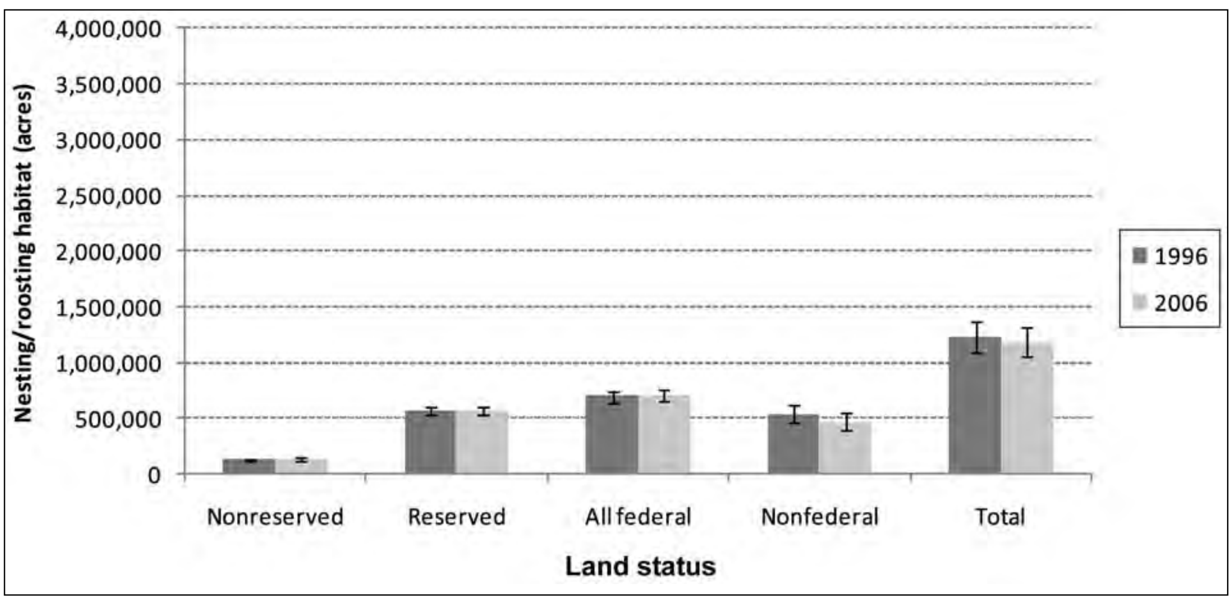


Figure C-9–Bookend habitat model area of suitable nesting/roosting habitat for northern spotted owls for the Oregon Coast Range modeling region. The bars represent the mean estimate of suitable habitat, and error bars show the 95-percent confidence intervals. This histogram shows net change (losses and gains) between 1996 and 2006.

Oregon and California Cascades Modeling Region (MR 224)

This modeling region conforms to the Oregon Cascades Douglas-fir ecological region used in the meta-analyses, and contains the H.J. Andrews and South Cascades demographic study areas. It encompasses the east and west Cascades provinces in Oregon and portions of the California Cascades province as delineated along level III ecoregion lines. Although there are differences between the east and west Cascades, our decision to lump them into one modeling region was based on how the east Cascades province was originally drawn to define the eastern margin of the owl's range, which extends into the larger eastern Cascades ecoregion (as delineated by the Environmental Protection Agency). This thin delineation represents the ecotone between the East and West Cascades, and not the entire East Cascades province. On the west slope, Douglas-fir and western hemlock give way to Pacific silver fir at midelevations, and mountain hemlock and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) at high elevations. The east slope is covered by mixed-conifer and ponderosa pine forest at lower elevations, and true firs and mountain hemlock at higher elevations. The southern portion is mixed-conifer and pine forests in fire-adapted landscapes. Fire frequencies range from low to high along a north-to-south moisture gradient. Fire suppression has resulted in shifts in species composition and stand structure. About two-thirds of the land is administered by federal agencies.

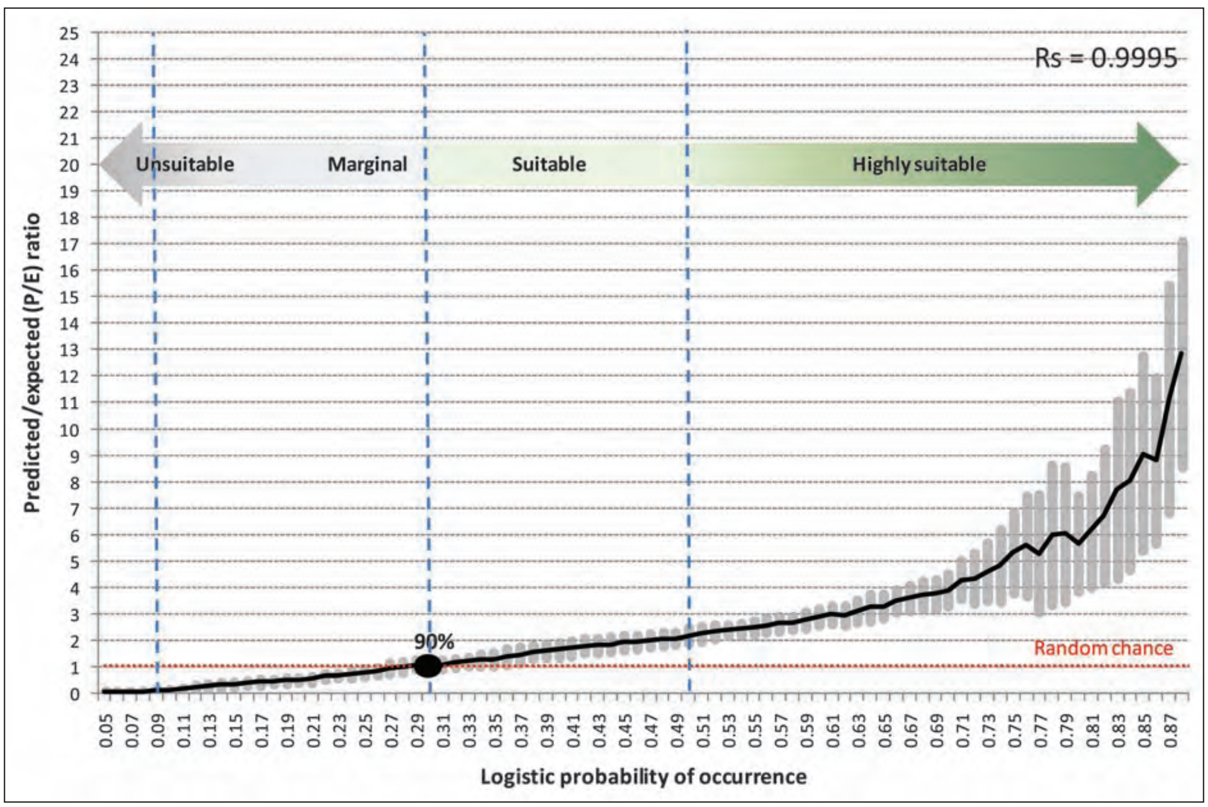


Figure C-10–The mean predicted vs. expected curve (solid black line) from the model replicates, showing 95-percent confidence intervals (gray-shaded vertical bars) for the Oregon and California Cascades modeling region. The logistic thresholds used to define the four-class habitat map are represented by vertical blue-dashed lines. The P/E = 1 threshold is where the curve crosses the random chance line (red-dashed line). The solid black dot represents the 10-percentile threshold (see fig. C-11 below) indicating where 90 percent of the training data (owl pair site centers) occured above that threshold. The mean Spearman rank correlation (Rs) is shown in the upper right-hand corner. See Hirzel et al. (2006) for more information.

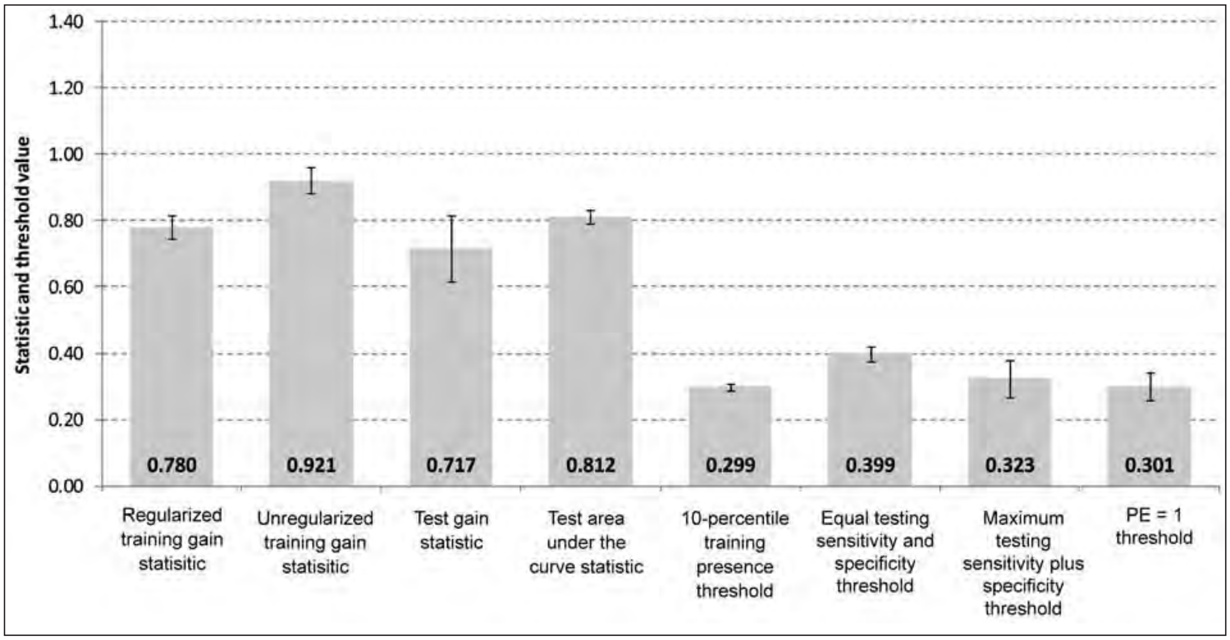


Figure C-11–Habitat modeling statistics produced during the MaxEnt model bootstrapped replicates for the Oregon and California Cascades modeling region. Bars represent the mean statistic value, and error bars show the 95-percent confidence intervals. The first four bars represent model fit and discrimination statistics; the last four bars are common "thresholds" used to classify continuous habitat suitability models into binary maps of "not-suitable" and "suitable" habitat.

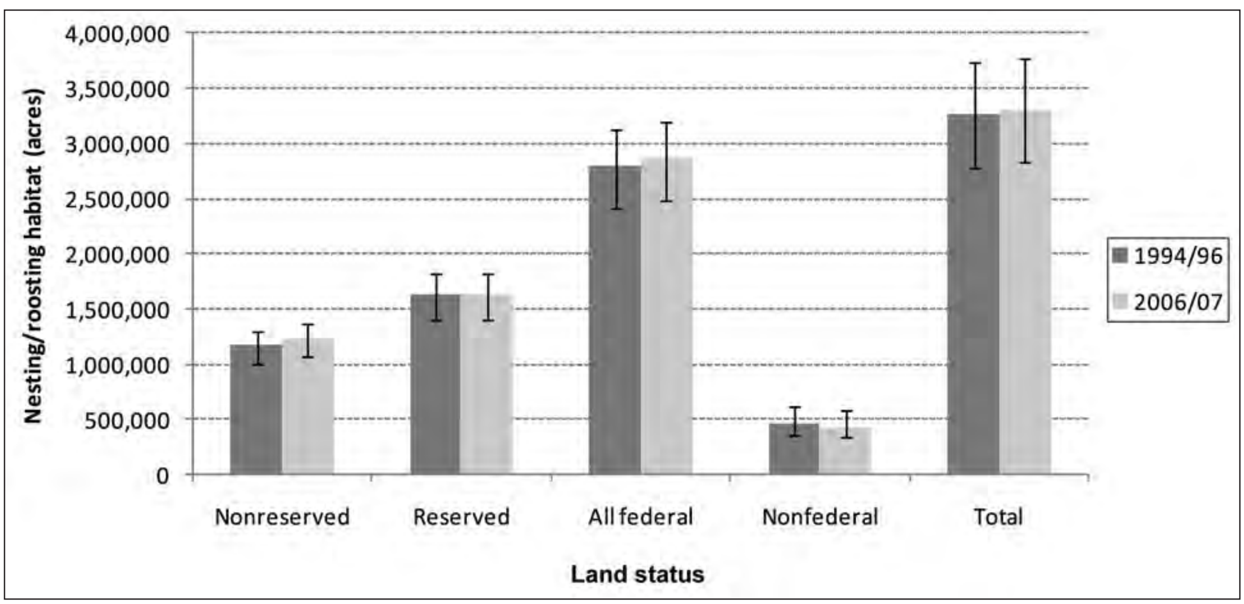


Figure C-12–Bookend habitat model area of suitable nesting/roosting habitat for northern spotted owls for the Oregon and California Cascades modeling region. The bars represent the mean estimate of suitable habitat, and error bars show the 95-percent confidence intervals. This histogram shows net change (losses and gains) between 1994/96 and 2006/07.

Oregon and California Klamaths Modeling Region (MR 225)

This modeling region conforms to the Oregon/California Mixed-Conifer ecological region used in the demographic meta-analyses, and contains the Klamath and Northwest California demographic study areas. It encompasses the Klamath physiographic provinces of Oregon and California. It is influenced by unique geologic conditions. In many areas, serpentine soils formed by the accretion of rocks onto the continent control the native vegetation, which is dominated by mixed-conifer and mixed-conifer and hardwood forest such as Douglas-fir mixed with tanoak (*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.), and Pacific madrone (*Arbutus menziesii* Pursh). The region is characterized by historically high fire frequencies (≤35-year fire-return intervals), and fire suppression has resulted in areas with significant accumulations of fuel, shifts in species composition, and changes in stand structure. Forests are highly fragmented as a result of dry climate, poor soils, and past harvest practices, as well as ownership patterns, especially in areas of "checkerboard" ownership. Slightly over half of the province in Oregon is federally managed. In California, national forests cover about three-quarters of the region.

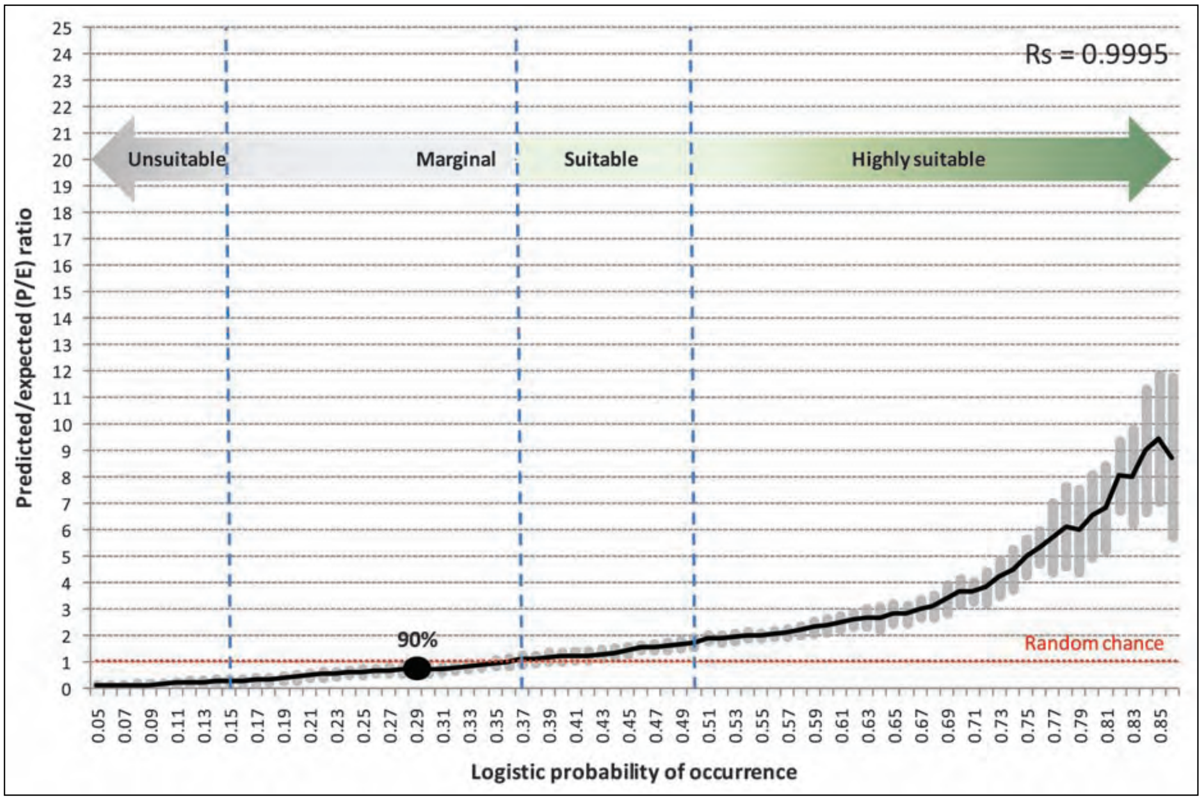


Figure C-13–The mean predicted vs. expected curve (solid black line) from the model replicates, showing 95-percent confidence intervals (gray-shaded vertical bars) for the Oregon and California Klamaths modeling region. The logistic thresholds used to define the four-class habitat map are represented by vertical blue-dashed lines. The P/E = 1 threshold is where the curve crosses the random chance line (red-dashed line). The solid black dot represents the 10-percentile threshold (see fig. C-14 below) indicating where 90 percent of the training data (owl pair site centers) occured above that threshold. The mean Spearman rank correlation (Rs) is shown in the upper right-hand corner. See Hirzel et al. (2006) for more information.

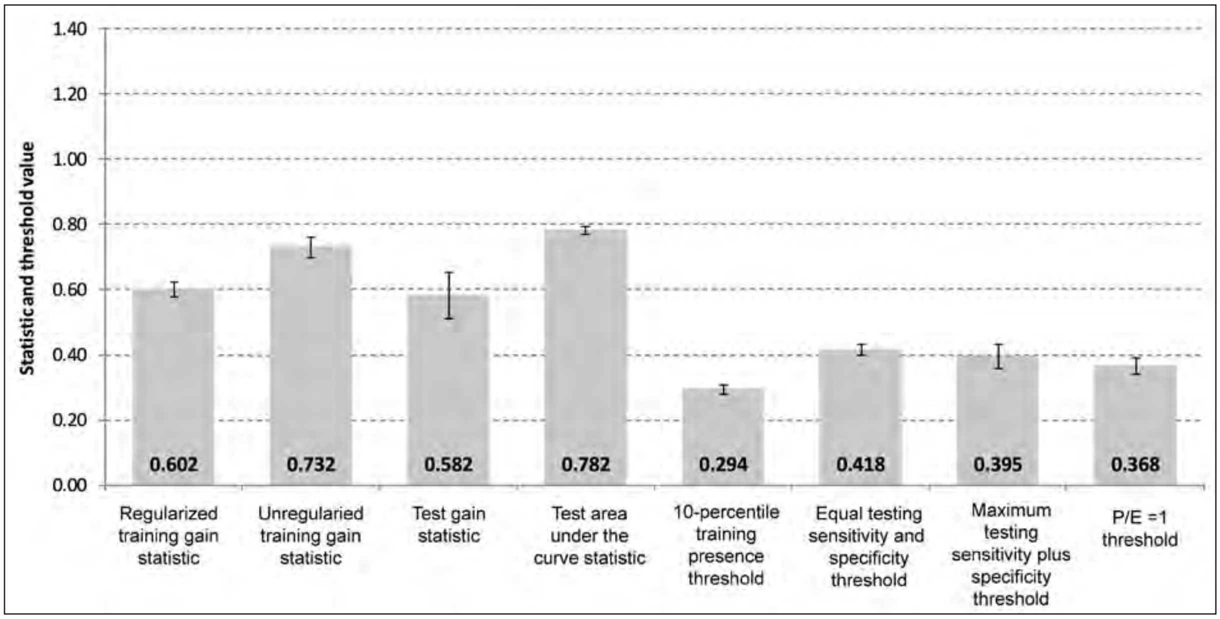


Figure C-14–Habitat modeling statistics produced during the MaxEnt model bootstrapped replicates for the Oregon and California Klamaths modeling region. Bars represent the mean statistic value, and error bars show the 95-percent confidence intervals. The first four bars represent model fit and discrimination statistics; the last four bars are common "thresholds" used to classify continuous habitat suitability models into binary maps of "not-suitable" and "suitable" habitat.

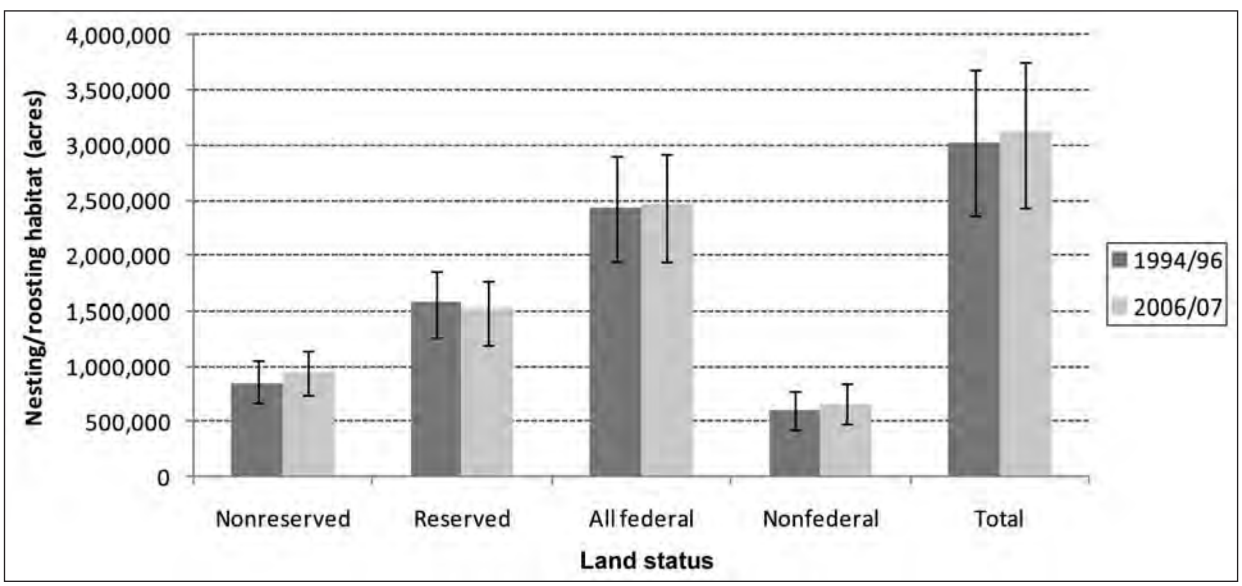


Figure C-15–Bookend habitat model area of suitable nesting/roosting habitat for northern spotted owls for Oregon and California Klamaths modeling region. The bars represent the mean estimate of suitable habitat, and error bars show the 95-percent confidence intervals. This histogram shows net change (losses and gains) between 1994/96 and 2006/07.

California Coast Modeling Region (MR 226)

This modeling region conforms to the California Coast ecological region used in demographic meta-analyses, and contains the independently operated Green Diamond Resources and Hoopa Reservation demographic study areas. It conforms to the California Coast Range physiographic province, extending slightly into coastal Oregon Klamath physiographic province to encompass the coastal redwood forests in that area. Moist, productive forests in the California Coast region are dominated by Douglas-fir and western hemlock, and contain most of the coastal redwood forests. The southeastern portion of this modeling region falls within the Central California Chaparral and Oak Woodlands ecoregion. Only a small proportion of the California Coast region is administered by federal agencies.

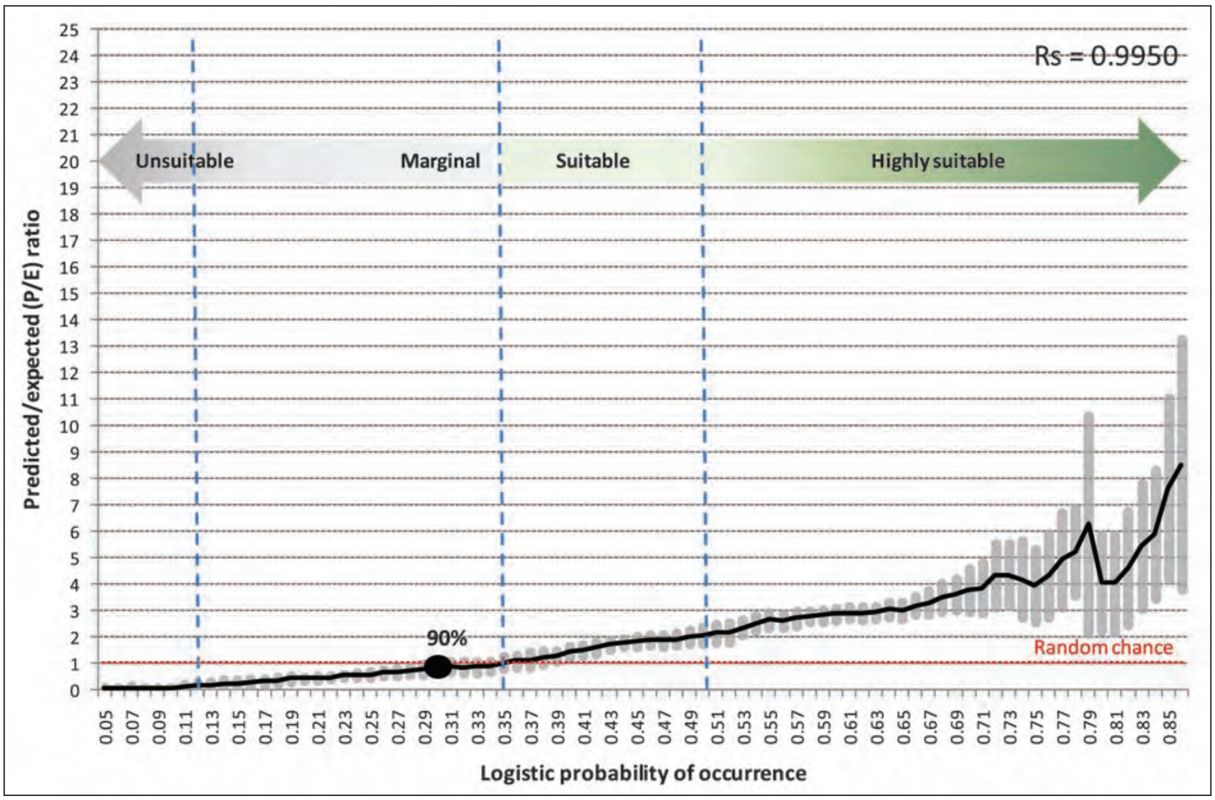


Figure C-16–The mean predicted vs. expected curve (solid black line) from the model replicates, showing 95-percent confidence intervals (gray-shaded vertical bars) for the California Coast modeling region. The logistic thresholds used to define the four-class habitat map are represented by vertical blue-dashed lines. The P/E = 1 threshold is where the curve crosses the random chance line (red-dashed line). The solid black dot represents the 10-percentile threshold (see fig. C-17 below) indicating where 90 percent of the training data (owl pair site centers) occured above that threshold. The mean Spearman rank correlation (Rs) is shown in the upper right-hand corner. See Hirzel et al. (2006) for more information.

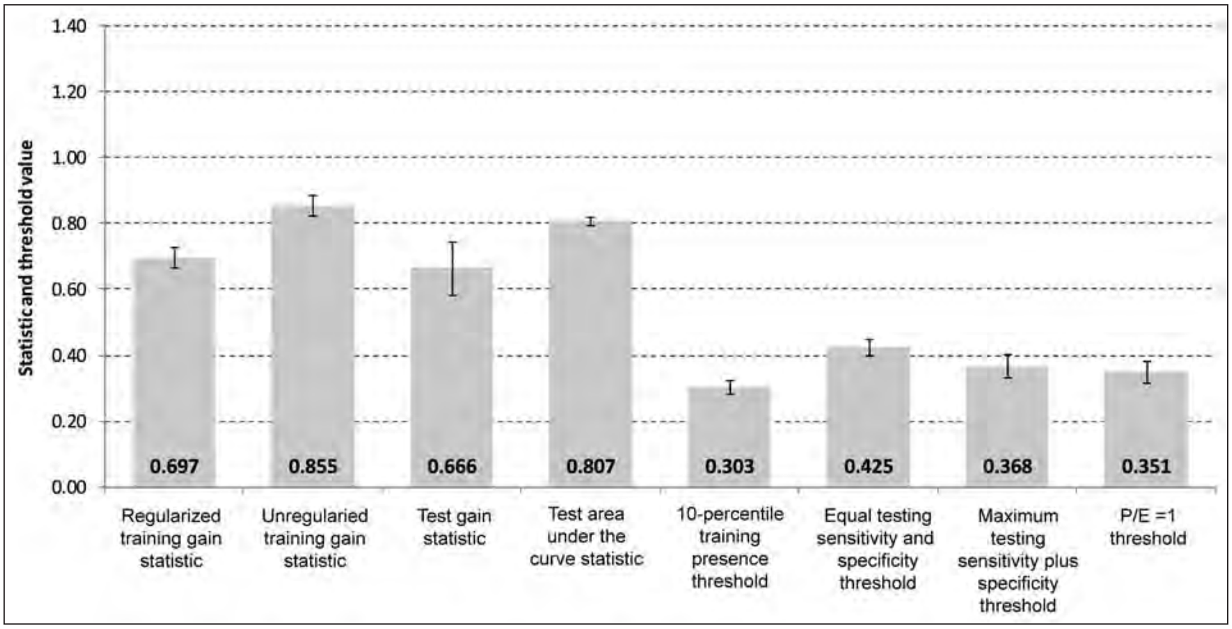


Figure C-17–Habitat modeling statistics produced during the MaxEnt model bootstrapped replicates for the California Coast modeling region. Bars represent the mean statistic value, and error bars show the 95-percent confidence intervals. The first four bars represent model fit and discrimination statistics; the last four bars are common "thresholds" used to classify continuous habitat suitability models into binary maps of "not-suitable" and "suitable" habitat.

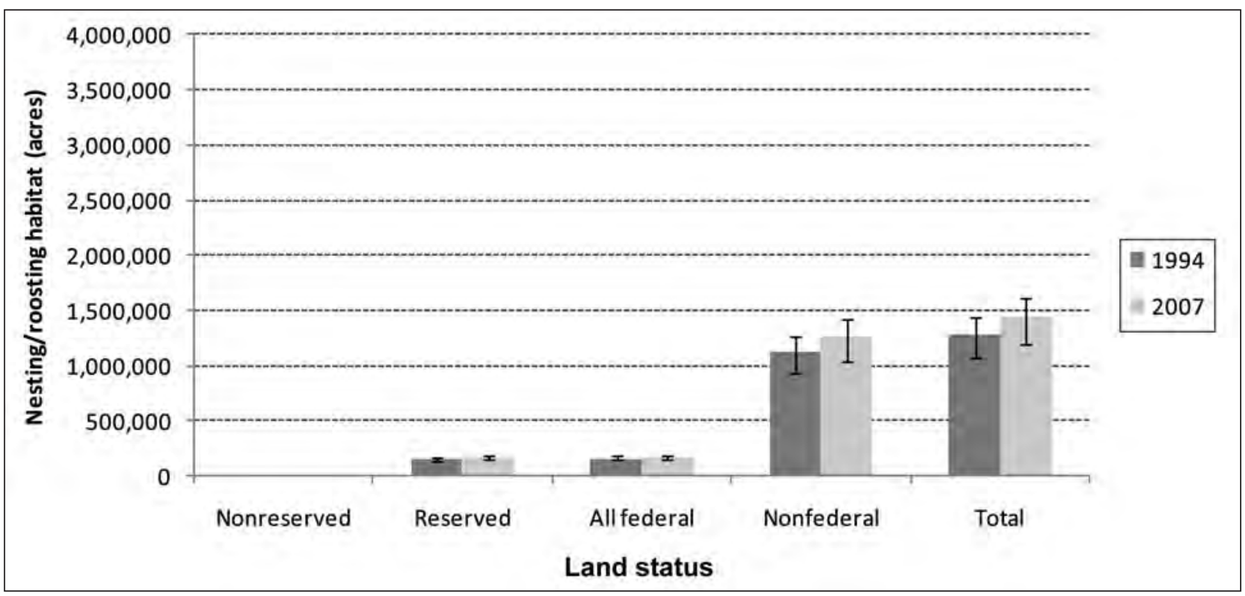


Figure C-18–Bookend habitat model area of suitable nesting/roosting habitat for northern spotted owls for the California Coast modeling region. The bars represent the mean estimate of suitable habitat, and error bars show the 95-percent confidence intervals. This histogram shows net change (losses and gains) between 1994 and 2007.

References

Hirzel, A.H.; Le Lay, G.; Helfer, V.; Randin, C.; Guisan, A. 2006. Evaluating the ability of habitat suitability models to predict species presences. Ecological Modelling. 199: 142–152.

Jason Mowdy

Table D-1–Estimates of nesting/roosting habitat and loss on federal reserved lands using LandTrendr change-detection data

Physiographic province	1994/96	Harvest	Insects and disease	Wildfire	Gross loss	2006/07	Change
	Acres						*Percent*
Washington:							
Olympic Peninsula	729,500	-300	0	-200	-500	729,000	-0.1
Western Lowlands	24,700	-400	0	0	-400	24,300	-1.6
Western Cascades	1,035,100	-2,400	-400	-700	-3,500	1,031,600	-0.3
Eastern Cascades	484,900	-4,800	-1,800	-15,900	-22,500	462,400	-4.6
State total	2,274,200	-7,900	-2,200	-16,800	-26,900	2,247,300	-1.2
Oregon:							
Coast Range	495,700	-1,300	0	0	-1,300	494,400	-0.3
Willamette Valley	700	0	0	0	0	700	0.0
Western Cascades	1,302,200	-1,900	-600	-24,500	-27,000	1,275,200	-2.1
Klamath	636,200	-1,600	-200	-85,000	-86,800	549,400	-13.6
Eastern Cascades	264,800	-1,300	-1,700	-13,300	-16,300	248,500	-6.2
State total	2,699,600	-6,100	-2,500	-122,800	-131,400	2,568,200	-4.9
California:							
Coast Range	135,200	-300	-100	-1,900	-2,300	132,900	-1.7
Klamath	975,500	-1,400	-1,500	-61,700	-64,600	910,900	-6.6
Cascades	103,300	-800	0	-800	-1,600	101,700	-1.5
State total	1,214,000	-2,500	-1,600	-64,400	-68,500	1,145,500	-5.6
Range total	6,187,800	-16,500	-6,300	-204,000	-226,800	5,961,000	-3.7

Note: Acres are rounded to the nearest 100 acres.

Table D-2–Estimates of nesting/roosting habitat and loss on federal nonreserved lands using LandTrendr change-detection data

Physiographic province	1994/96	Harvest	Insects and disease	Wildfire	Gross loss	2006/07	Change
	Acres						*Percent*
Washington:							
Olympic Peninsula	33,600	-200	0	0	-200	33,400	-0.6
Western Lowlands	0	0	0	0	0	0	0.0
Western Cascades	247,900	-1,300	0	0	-1,300	246,600	-0.5
Eastern Cascades	188,700	-3,300	-200	-4,100	-7,600	181,100	-4.0
State total	470,200	-4,800	-200	-4,100	-9,100	461,100	-1.9
Oregon:							
Coast Range	115,400	-2,000	0	0	-2,000	113,400	-1.7
Willamette Valley	2,700	-100	0	0	-100	2,600	-3.7
Western Cascades	956,500	-12,000	-500	-4,400	-16,900	939,600	-1.8
Klamath	348,800	-5,200	-100	-8,600	-13,900	334,900	-4.0
Eastern Cascades	138,000	-4,500	-600	-4,500	-9,600	128,400	-7.0
State total	1,561,400	-23,800	-1,200	-17,500	-42,500	1,518,900	-2.7
California:							
Coast Range	10,300	0	0	-200	-200	10,100	-1.9
Klamath	514,200	-3,000	-100	-9,900	-13,000	501,200	-2.5
Cascades	109,900	-5,700	-300	-1,000	-7,000	102,900	-6.4
State total	634,400	-8,700	-400	-11,100	-20,200	614,200	-3.2
Range total	2,666,000	-37,300	-1,800	-32,700	-71,800	2,594,200	-2.7

Note: Acres are rounded to the nearest 100 acres.

Table D-3—Estimates of nesting/roosting habitat and loss on all federal lands using LandTrendr change-detection data

Physiographic province	1994/96	Harvest	Insects and disease	Wildfire	Gross loss	2006/07	Change
	Acres						*Percent*
Washington:							
Olympic Peninsula	763,100	-500	0	-200	-700	762,400	-0.1
Western Lowlands	24,700	-400	0	0	-400	24,300	-1.6
Western Cascades	1,283,000	-3,700	-400	-700	-4,800	1,278,200	-0.4
Eastern Cascades	673,600	-8,100	-2,000	-20,000	-30,100	643,500	-4.5
State total	2,744,400	-12,700	-2,400	-20,900	-36,000	2,708,400	-1.3
Oregon:							
Coast Range	611,200	-3,300	0	0	-3,300	607,900	-0.5
Willamette Valley	3,400	-100	0	0	-100	3,300	-2.9
Western Cascades	2,258,700	-13,900	-1,100	-28,900	-43,900	2,214,800	-1.9
Klamath	985,000	-6,800	-300	-93,600	-100,700	884,300	-10.2
Eastern Cascades	402,900	-5,800	-2,300	-17,800	-25,900	377,000	-6.4
State total	4,261,200	-29,900	-3,700	-140,300	-173,900	4,087,300	-4.1
California:							
Coast Range	145,400	-300	-100	-2,100	-2,500	142,900	-1.7
Klamath	1,489,800	-4,400	-1,600	-71,600	-77,600	1,412,200	-5.2
Cascades	213,200	-6,500	-300	-1,800	-8,600	204,600	-4.0
State total	1,848,400	-11,200	-2,000	-75,500	-88,700	1,759,700	-4.8
Range total	8,854,000	-53,800	-8,100	-236,700	-298,600	8,555,400	-3.4

Note: Acres are rounded to the nearest 100 acres.

Table D-4–Estimates of nesting/roosting habitat and loss on all habitat-capable lands within the owl's range using LandTrendr change-detection data

Land class	1994/96	Harvest	Insects and disease	Wildfire	Gross loss	2006/07	Change
	Acres						*Percent*
Federal reserved:							
Washington	2,274,200	-7,900	-2,200	-16,800	-26,900	2,247,300	-1.2
Oregon	2,699,600	-6,100	-2,500	-122,800	-131,400	2,568,200	-4.9
California	1,214,000	-2,500	-1,600	-64,400	-68,500	1,145,500	-5.6
Range total	6,187,800	-16,500	-6,300	-204,000	-226,800	5,961,000	-3.7
Federal nonreserved:							
Washington	470,200	-4,800	-200	-4,100	-9,100	461,100	-1.9
Oregon	1,561,400	-23,800	-1,200	-17,500	-42,500	1,518,900	-2.7
California	634,400	-8,700	-400	-11,100	-20,200	614,200	-3.2
Range total	2,666,000	-37,300	-1,800	-32,700	-71,800	2,594,200	-2.7
All federal:							
Washington	2,744,400	-12,700	-2,400	-20,900	-36,000	2,708,400	-1.3
Oregon	4,261,200	-29,900	-3,700	-140,300	-173,900	4,087,300	-4.1
California	1,848,400	-11,200	-2,000	-75,500	-88,700	1,759,700	-4.8
Range total	8,854,000	-53,800	-8,100	-236,700	-298,600	8,555,400	-3.4
Nonfederal:							
Washington	1,258,900	-234,200	-6,000	-2,400	-242,600	1,016,300	-19.3
Oregon	1,382,400	-301,200	-2,700	-5,100	-309,000	1,073,400	-22.4
California	1,556,700	-90,200	-1,900	-5,600	-97,700	1,459,000	-6.3
Range total	4,198,000	-625,600	-10,600	-13,100	-649,300	3,548,700	-15.5
All lands:							
Washington	4,003,300	-246,900	-8,400	-23,300	-278,600	3,724,700	-7.0
Oregon	5,643,600	-331,100	-6,400	-145,400	-482,900	5,160,700	-8.6
California	3,405,100	-101,400	-3,900	-81,100	-186,400	3,218,700	-5.5
Range total	13,052,000	-679,400	-18,700	-249,800	-947,900	12,104,100	-7.3

Note: Acres are rounded to the nearest 100 acres.

Table E-1–Estimates of gross loss, gross gain, and net change of dispersal habitat on federal reserved lands

Physiographic province	1994/96	Harvest	Insects and disease	Wildfire	Gain	Net change	2006/07	Change
	Acres							*Percent*
Washington:								
Olympic Peninsula	1,052,600	-300	0	-400	46,100	45,400	1,098,000	4.3
Western Lowlands	61,800	-500	0	0	5,100	4,600	66,400	7.4
Western Cascades	1,889,300	-3,200	-400	-600	87,700	83,500	1,972,800	4.4
Eastern Cascades	1,428,400	-3,700	-1,300	-41,600	71,400	24,800	1,453,200	1.7
State total	4,432,100	-7,700	-1,700	-42,600	210,300	158,300	4,590,400	3.6
Oregon:								
Coast Range	742,200	-1,700	0	-100	90,200	88,400	830,600	11.9
Willamette Valley	2,300	0	0	0	200	200	2,500	8.7
Western Cascades	1,963,800	-2,000	-600	-29,600	93,400	61,200	2,025,000	3.1
Klamath	903,700	-1,700	-400	-121,400	43,900	-79,600	824,100	-8.8
Eastern Cascades	661,500	-3,400	-3,100	-22,100	44,300	15,700	677,200	2.4
State total	4,273,500	-8,800	-4,100	-173,200	272,000	85,900	4,359,400	2.0
California:								
Coast Range	169,300	-300	-100	-2,300	14,600	11,900	181,200	7.0
Klamath	1,939,600	-2,500	-2,000	-67,600	127,000	54,900	1,994,500	2.8
Cascades	244,400	-700	0	-700	18,600	17,200	261,600	7.0
State total	2,353,300	-3,500	-2,100	-70,600	160,200	84,000	2,437,300	3.6
Range total	11,058,900	-20,000	-7,900	-286,400	642,500	328,200	11,387,100	3.0

Note: Acres are rounded to the nearest 100 acres.

Table E-2–Estimates of gross loss, gross gain, and net change of dispersal habitat on federal nonreserved lands

Physiographic province	1994/96	Harvest	Insects and disease	Wildfire	Gain	Net change	2006/07	Change
	Acres							*Percent*
Washington:								
Olympic Peninsula	73,400	-200	0	0	15,700	15,500	88,900	21.1
Western Lowlands	200	0	0	0	100	100	300	50.0
Western Cascades	443,900	-1,500	0	0	48,900	47,400	491,300	10.7
Eastern Cascades	393,900	-3,500	-300	-9,200	45,100	32,100	426,000	8.1
State total	911,400	-5,200	-300	-9,200	109,800	95,100	1,006,500	10.4
Oregon:								
Coast Range	260,800	-2,400	0	0	45,800	43,400	304,200	16.6
Willamette Valley	10,200	-100	0	0	1,300	1,200	11,400	11.8
Western Cascades	1,495,100	-11,000	-700	-4,200	167,100	151,200	1,646,300	10.1
Klamath	605,100	-5,800	-300	-16,100	62,200	40,000	645,100	6.6
Eastern Cascades	347,000	-6,500	-700	-6,800	57,600	43,600	390,600	12.6
State total	2,718,200	-25,800	-1,700	-27,100	334,000	279,400	2,997,600	10.3
California:								
Coast Range	20,600	-100	0	-800	4,100	3,200	23,800	15.5
Klamath	996,000	-4,600	-300	-16,200	124,200	103,100	1,099,100	10.4
Cascades	333,800	-8,200	-4,000	-2,000	43,600	29,400	363,200	8.8
State total	1,350,400	-12,900	-4,300	-19,000	171,900	135,700	1,486,100	10.0
Range total	4,980,000	-43,900	-6,300	-55,300	615,700	510,200	5,490,200	10.2

Note: Acres are rounded to the nearest 100 acres.

Table E-3–Estimates of gross loss, gross gain, and net change of dispersal habitat on all federal lands

Physiographic province	1994/96	Harvest	Insects and disease	Wildfire	Gain	Net change	2006/07	Change
	Acres							*Percent*
Washington:								
Olympic Peninsula	1,126,000	-500	0	-400	61,800	60,900	1,186,900	5.4
Western Lowlands	62,000	-500	0	0	5,200	4,700	66,700	7.6
Western Cascades	2,333,200	-4,700	-400	-600	136,600	130,900	2,464,100	5.6
Eastern Cascades	1,822,300	-7,200	-1,600	-50,800	116,500	56,900	1,879,200	3.1
State total	5,343,500	-12,900	-2,000	-51,800	320,100	253,400	5,596,900	4.7
Oregon:								
Coast Range	1,003,000	-4,100	0	-100	136,000	131,800	1,134,800	13.1
Willamette Valley	12,500	-100	0	0	1,500	1,400	13,900	11.2
Western Cascades	3,458,900	-13,000	-1,300	-33,800	260,500	212,400	3,671,300	6.1
Klamath	1,508,800	-7,500	-700	-137,500	106,100	-39,600	1,469,200	-2.6
Eastern Cascades	1,008,500	-9,900	-3,800	-28,900	101,900	59,300	1,067,800	5.9
State total	6,991,700	-34,600	-5,800	-200,300	606,000	365,300	7,357,000	5.2
California:								
Coast Range	189,900	-400	-100	-3,100	18,700	15,100	205,000	8.0
Klamath	2,935,600	-7,100	-2,300	-83,800	251,200	158,000	3,093,600	5.4
Cascades	578,200	-8,900	-4,000	-2,700	62,200	46,600	624,800	8.1
State total	3,703,700	-16,400	-6,400	-89,600	332,100	219,700	3,923,400	5.9
Range total	16,038,900	-63,900	-14,200	-341,700	1,258,200	838,400	16,877,300	5.2

Note: Acres are rounded to the nearest 100 acres.

Table E-4—Estimates of gross loss, gross gain, and net change of dispersal habitat on all habitat-capable lands within the owl's range

Land class	1994/96	Harvest	Insects and disease	Wildfire	Gross loss	Gross gain	2006/07	Net change
	Acres							*Percent*
Federal reserved:								
Washington	4,432,100	-7,700	-1,700	-42,600	-52,000	210,300	4,590,400	3.6
Oregon	4,273,500	-8,800	-4,100	-173,200	-186,100	272,000	4,359,400	2.0
California	2,353,300	-3,500	-2,100	-70,600	-76,200	160,200	2,437,300	3.6
Range total	11,058,900	-20,000	-7,900	-286,400	-314,300	642,500	11,387,100	3.0
Federal nonreserved:								
Washington	911,400	-5,200	-300	-9,200	-14,700	109,800	1,006,500	10.4
Oregon	2,718,200	-25,800	-1,700	-27,100	-54,600	334,000	2,997,600	10.3
California	1,350,400	-12,900	-4,300	-19,000	-36,200	171,900	1,486,100	10.0
Range total	4,980,000	-43,900	-6,300	-55,300	-105,500	615,700	5,490,200	10.2
All federal:								
Washington	5,343,500	-12,900	-2,000	-51,800	-66,700	320,100	5,596,900	4.7
Oregon	6,991,700	-34,600	-5,800	-200,300	-240,700	606,000	7,357,000	5.2
California	3,703,700	-16,400	-6,400	-89,600	-112,400	332,100	3,923,400	5.9
Range total	16,038,900	-63,900	-14,200	-341,700	-419,800	1,258,200	16,877,300	5.2
Nonfederal:								
Washington	4,359,100	-689,300	-14,700	-7,000	-711,000	993,000	4,641,100	6.5
Oregon	4,129,400	-760,700	-7,200	-10,000	-777,900	971,200	4,322,700	4.7
California	2,858,900	108,000	2,900	9,900	120,800	443,900	3,423,600	19.8
Range total	11,347,400	-1,342,000	-19,000	-7,100	-1,368,100	2,408,100	12,387,400	9.2
All lands:								
Washington	9,702,600	-702,200	-16,700	-58,800	-777,700	1,313,100	10,238,000	5.5
Oregon	11,121,100	-795,300	-13,000	-210,300	-1,018,600	1,577,200	11,679,700	5.0
California	6,562,600	91,600	-3,500	-79,700	8,400	776,000	7,347,000	12.0
Range total	27,386,300	-1,405,900	-33,200	-348,800	-1,787,900	3,666,300	29,264,700	6.9

Note: Acres are rounded to the nearest 100 acres.

Appendix F: Crosswalk for Modifying Bookend 2 (2006/07) Map for Making Habitat Suitability Histograms

As discussed in chapter 3, we chose to not report on the highly suspect suitable habitat gains in nesting/roosting habitat for this monitoring cycle given the short timespan of our analysis and because of uncertainties with model transferability, bookend 2 (2006/07) map reviews with 1-m color aerial imagery Natonal Agricultural Imagery Program, geographic information system (GIS) analysis of model variable changes, and an inventory plot analysis (app. H). However, we anticipate that our ability to measure these gains will improve with the passing of more time to separate the bookend maps, and with improved remote sensing technologies. This appendix presents the following table to describe the crosswalk we used for creating a modified bookend 2 map for the purpose of making "habitat suitability histograms" to help visualize shifts in habitat classes between bookend 1 (1994/96) and bookend 2. This approach is similar to what was done in the 10-year report, where we had only a baseline map and change-detection data to estimate habitat changes. The habitat suitability histograms on the following pages are formatted to be similar to the histograms in appendix G of the 10-year report. The modified bookend 2 map (as described below) is our best estimate of habitat classes as of 2006/07. It is conservative in nature, as it maintains suitable habitat classes (3 and 4) from bookend 1, and only shows loss in these suitable classes **if** verified by LandTrendr (LT) data. We allow for minor shifts within habitat classes that may represent subtle changes but do not result in a change between the broader categories of "unsuitable/marginal" (i.e., classes 1 and 2) and the "suitable" classes (i.e., classes 3 and 4).

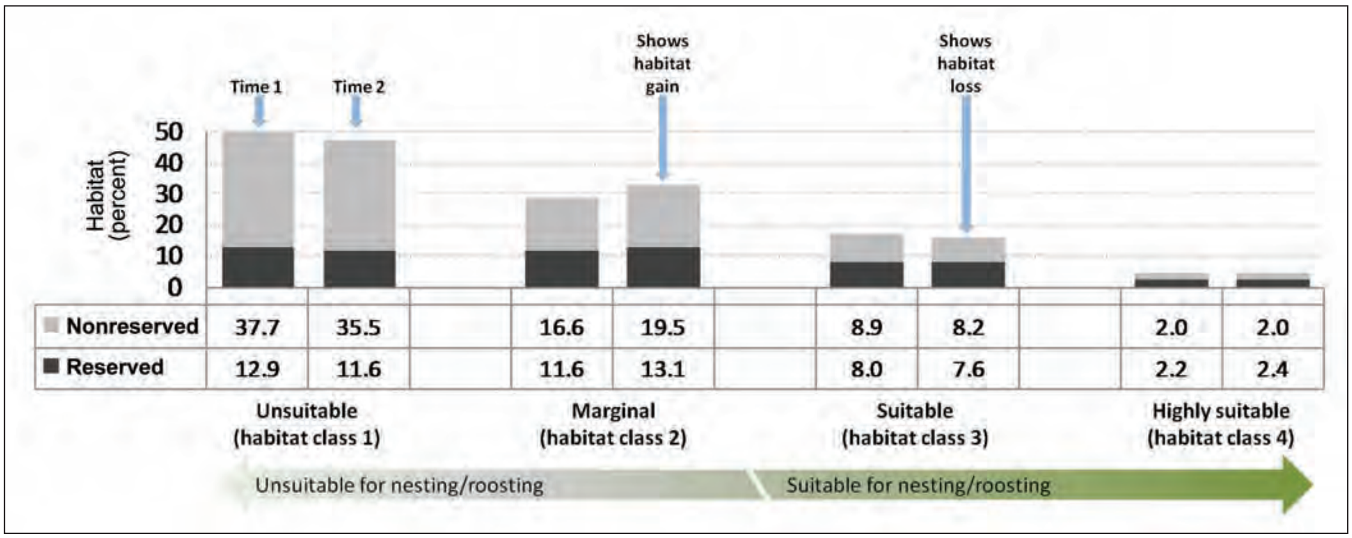
Table F-1–Crosswalk table for modified bookend 2 map

Bookend model habitat classes 1994/6	Bookend model habitat classes 2006/7	Assumptions (based on aerial image review and GIS analysis of environmental variables)	Modified 2006/07 habitat class (modified bookend 2)
1	1	Not suitable either period; no change	1
1	2	Not suitable either period; accept shift from unsuitable to marginal	2
1	3	Trend toward suitable, but highly uncertain gain; limit shift to marginal class	2
1	4	Trend toward suitable, but highly uncertain gain; limit shift to marginal class	2
2	1	Not suitable either period; accept shift from marginal to unsuitable	1
2	2	Not suitable either period; no change	2
2	3	Trend toward suitable, but highly uncertain gain; keep in marginal class	2
2	4	Trend toward suitable, but highly uncertain gain; keep in marginal class	2
3	1	If LT[a] verified habitat loss, moved to unsuitable; otherwise no change	1 if LT verified, otherwise 3
3	2	If LT verified habitat loss, moved to marginal; otherwise no change	2 if LT verified, otherwise 3
3	3	Suitable habitat both periods; no change	3
3	4	Suitable habitat both periods; accept shift to highly suitable	4
4	1	If LT verified habitat loss, moved to unsuitable; otherwise no change	1 if LT verified, otherwise 4
4	2	If LT verified habitat loss, moved to marginal; otherwise no change	2 if LT verified, otherwise 4
4	3	Suitable habitat both periods; accept shift to suitable (degraded)	3
4	4	Suitable habitat both periods; no change	4

[a] LT = LandTrendr.

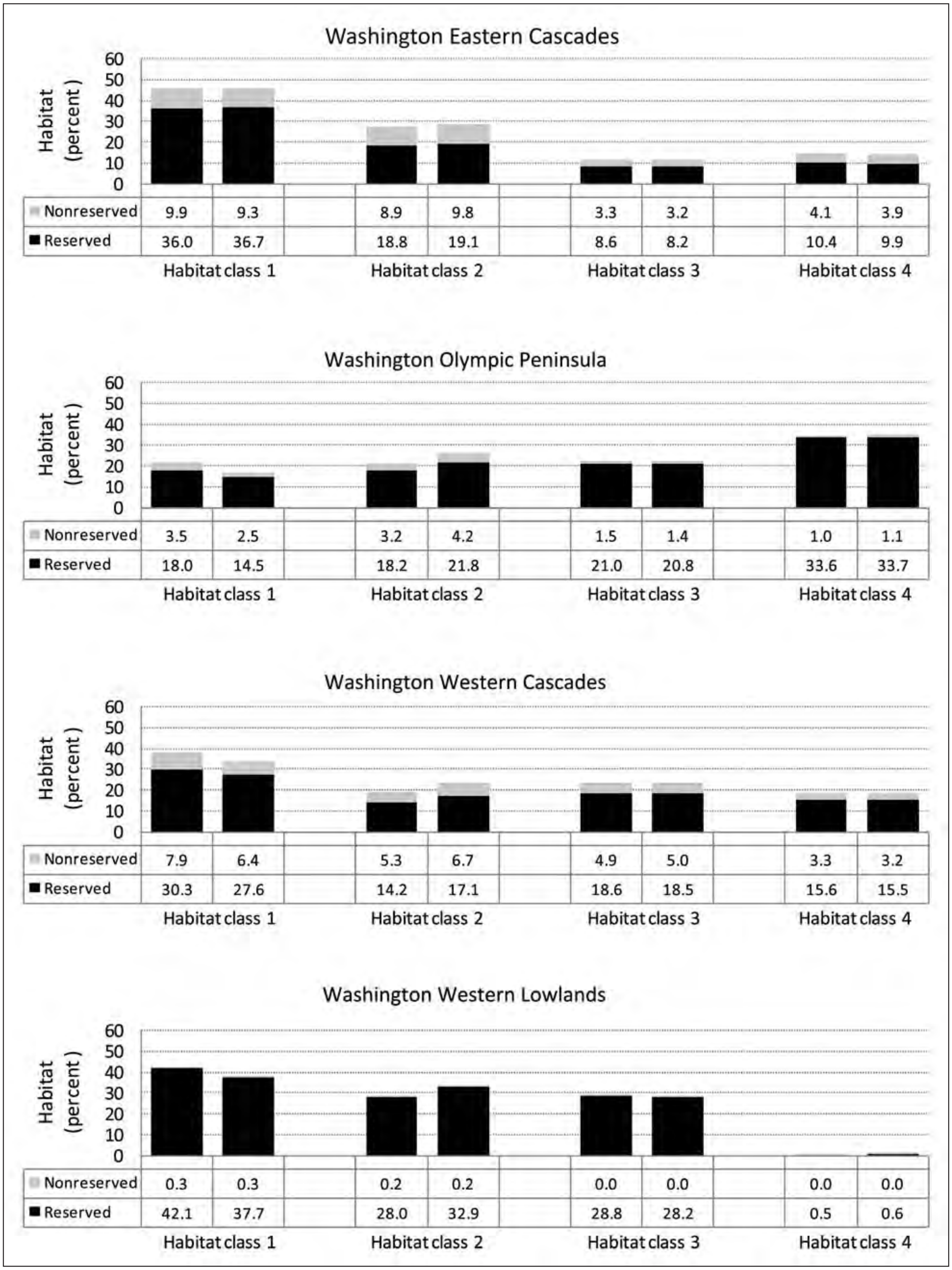
GIS = geographic information system.

The histograms on the following pages establish the format we propose for visually representing status and trends in habitat classes for future monitoring efforts. They are based on habitat conditions at roughly the time of the Northwest Forest Plan (the Plan) implementation (1994/96) to the end of our analysis data set in 2006/07. There are four pairs of histogram bars, one pair per habitat suitability class as described in chapter 3. The first bar in the pair shows conditions at time 1 (1994/96); the second bar shows conditions at time 2 (2006/07), based on our modified bookend 2 map. They also provide a visual on how owl habitat is distributed across reserved and nonreserved federal lands. The example histogram below is provided to help interpret the histograms provided for each physiographic province in the following pages.

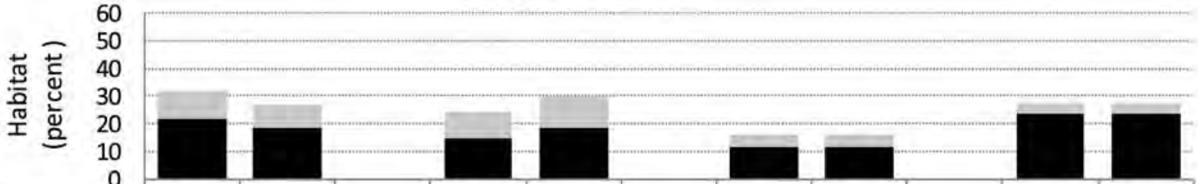


In the example above, we observe a slight decrease (3.5 percent) in unsuitable habitat class 1 between time 1 and time 2. We also observe a slightly larger (4.4 percent) increase in marginal habitat class (but still unsuitable for nesting/roosting). There has been a slight decrease in the suitable habitat class 3 (1.1 percent) with a very slight (0.2 percent) increase in the highly suitable habitat class. We can conclude that forest succession in habitat class 1 accounted for most of the increase in habitat class 2, but some of the loss in habitat class 3 may have also accounted for some of the changes in habitat class 2, or perhaps offset some of the decrease in habitat class 1. The slight increase in habitat class 4 may be a result of changes in habitat class 3, as seen in the plot analysis (app. H) where there may have been some subtle changes. However, this does not result in a change in the broader "suitable" class. The simplest interpretation indicates that the increase in the marginal habitat class (class 2) will continue to progress to the suitable classes with time. This province has very little suitable nesting/roosting habitat.

The table under the graphs shows the estimates of percentage of forest-capable land changes between habitat maps for both periods. The percentages are split into nonreserved and reserved land use allocations. The following graphs illustrate our best estimate of how habitat is changing (trending) at this early stage of the Plan. These graphs are primarily for interpretive purposes. The observed change between the bookends is small, with the largest changes being increases in the marginal classes. We observed similar changes in dispersal habitat (see chapter 3) and consider this an indication of noticeable future recruitment from marginal to suitable habitat within the next two to three decades.


Washington Eastern Cascades
Habitat (percent)
60
50
40
30
20
10
0
Nonreserved 9.9 9.3 8.9 9.8 3.3 3.2 4.1 3.9
Reserved 36.0 36.7 18.8 19.1 8.6 8.2 10.4 9.9
Habitat class 1
Habitat class 2
Habitat class 3
Habitat class 4
Washington Olympic Peninsula
Habitat (percent)
60
50
40
30
20
10
0
Nonreserved 3.5 2.5 3.2 4.2 1.5 1.4 1.0 1.1
Reserved 18.0 14.5 18.2 21.8 21.0 20.8 33.6 33.7
Habitat class 1
Habitat class 2
Habitat class 3
Habitat class 4
Washington Western Cascades
Habitat (percent)
60
50
40
30
20
10
0
Nonreserved 7.9 6.4 5.3 6.7 4.9 5.0 3.3 3.2
Reserved 30.3 27.6 14.2 17.1 18.6 18.5 15.6 15.5
Habitat class 1
Habitat class 2
Habitat class 3
Habitat class 4
Washington Western Lowlands
Habitat (percent)
60
50
40
30
20
10
0
Nonreserved 0.3 0.3 0.2 0.2 0.0 0.0 0.0 0.0
Reserved 42.1 37.7 28.0 32.9 28.8 28.2 0.5 0.6
Habitat class 1
Habitat class 2
Habitat class 3
Habitat class 4

Oregon Coast Range



Nonreserved	9.9	8.1		9.6	11.5		4.4	4.2		3.9	4.0
Reserved	22.0	18.4		14.7	18.4		11.9	11.8		23.6	23.7
	Habitat class 1			Habitat class 2			Habitat class 3			Habitat class 4	

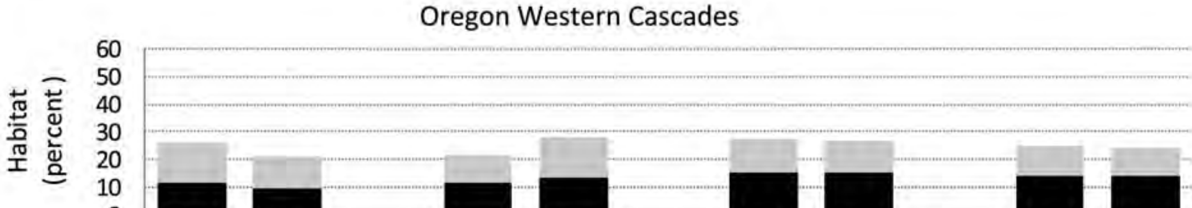
Oregon Eastern Cascades

Nonreserved	19.5	17.5		10.4	13.2		6.9	6.2		2.8	2.7
Reserved	22.4	22.3		19.5	20.8		13.0	12.2		5.4	5.1
	Habitat class 1			Habitat class 2			Habitat class 3			Habitat class 4	

Oregon Klamath

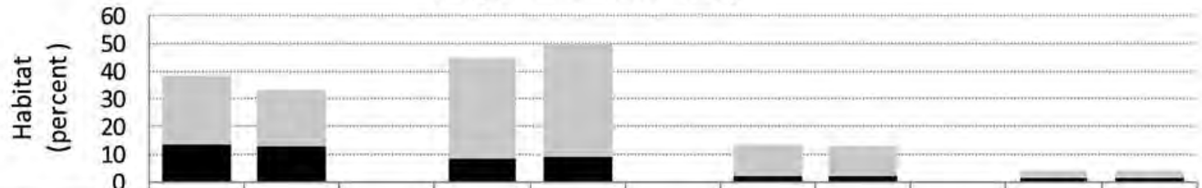
Nonreserved	12.2	10.8		14.2	16.4		9.3	8.6		7.3	7.4
Reserved	10.5	14.1		16.1	16.5		16.2	13.7		14.2	12.5
	Habitat class 1			Habitat class 2			Habitat class 3			Habitat class 4	

Oregon Western Cascades



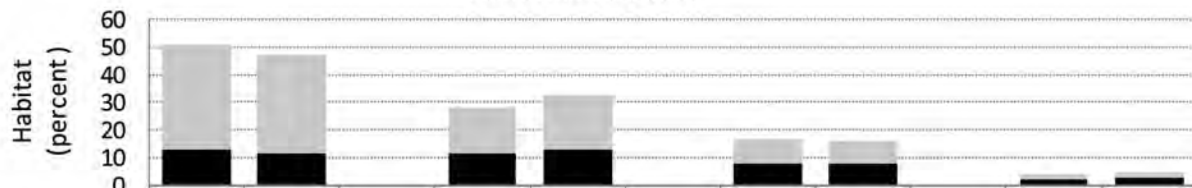
Nonreserved	14.5	10.9		10.1	14.1		11.5	11.3		10.6	10.4
Reserved	11.5	10.0		11.7	13.8		15.7	15.5		14.4	14.0
	Habitat class 1			Habitat class 2			Habitat class 3			Habitat class 4	

Oregon Willamette Valley



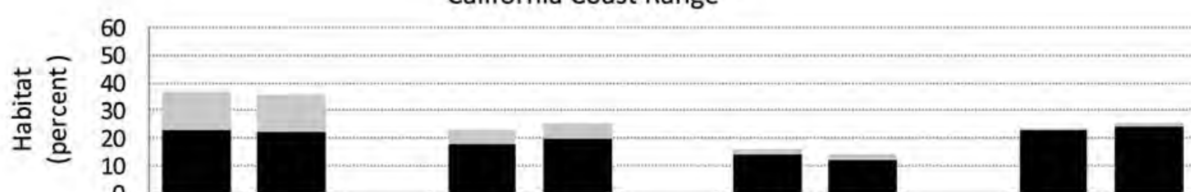
	Habitat class 1		Habitat class 2		Habitat class 3		Habitat class 4	
Nonreserved	24.4	19.8	35.8	40.6	11.8	11.1	2.2	2.6
Reserved	13.7	13.1	8.6	9.2	2.0	2.0	1.6	1.6

California Cascades



	Habitat class 1		Habitat class 2		Habitat class 3		Habitat class 4	
Nonreserved	37.7	35.5	16.6	19.5	8.9	8.2	2.0	2.0
Reserved	12.9	11.6	11.6	13.1	8.0	7.6	2.2	2.4

California Coast Range



	Habitat class 1		Habitat class 2		Habitat class 3		Habitat class 4	
Nonreserved	13.8	13.4	5.1	5.6	1.7	1.5	1.2	1.2
Reserved	23.3	22.2	17.9	19.7	14.3	12.3	22.8	24.1

California Klamath

	Habitat class 1		Habitat class 2		Habitat class 3		Habitat class 4	
Nonreserved	13.6	11.7	11.7	13.8	6.3	6.1	5.8	5.8
Reserved	19.3	18.8	20.2	22.3	12.4	11.4	10.6	10.2

Ray Davis

Appendix G: Wildfire Suitability Modeling, MaxEnt Replicate Data

Table G-1–Wildfire suitabilty modeling environmental variables and their model contributions

Environmental variable	Description	Value range	Units	Contribution to model
				Percent
August maximum temperature	PRISM (1971–2000)—mean maximum temperature for month of August	1,456–3,635	°C (x 100)	27.8
Lightning ignition density	Kernel density map of all lightning-caused fire ignitions 1970–2002, from Brown et al. (2002)[a]	0–992	Ignitions/km^2 (x100)	24.1
Slope	Percentage of slope based on analysis of Digital Elevation Model	0–125	Percent	23.7
Distance from road	Linear distance to nearest road, based on road layer in Gallo et al. (2011)[b]	0–28,300	Meters	14.6
Summer precipitation	PRISM (1971–2000)—mean rainfall between May and September, log transformed	3,243–6,884	ln mm (x1,000)	4.4
Elevation	U.S. Geological Survey Digital Elevation Model	0–2477	Meters	4.2
Solar radiation	Potential relative solar radiation as derived by Pierce et al. (2005)[c]	5,619–20,546	Index	1.1

[a] Brown, T.J.; Hall, B.L.; Mohrle, C.R.; Reinbold, H.J. 2002.
[b] Gallo, K.; Lanigan, S.H.; Eldred, P.; Gordon, S.N.; Moyer, C. 2005.
[c] Pierce, K.B.; Lookingbill, T.R.; Urban, D.L. 2005.

	August max temp	Slope	Solar radiation	Lightning density	Distance from road	Elevation	Summer precip
August max temp	1.000	-0.182	0.238	0.018	-0.336	-0.441	-0.428
Slope	-0.182	1.000	-0.426	-0.254	0.190	0.052	0.265
Solar radiation	0.238	-0.426	1.000	0.238	-0.234	-0.271	-0.124
Lightning density	0.018	-0.254	0.238	1.000	-0.232	0.340	-0.100
Distance from road	-0.336	0.190	-0.234	-0.232	1.000	0.263	0.166
Elevation	-0.441	0.052	-0.271	0.340	0.263	1.000	-0.118
Summer precip	-0.428	0.265	-0.124	-0.100	0.166	-0.118	1.000

Figure G-1–Correlation matrix (Pearson correlations) for environmental variables used in the model.

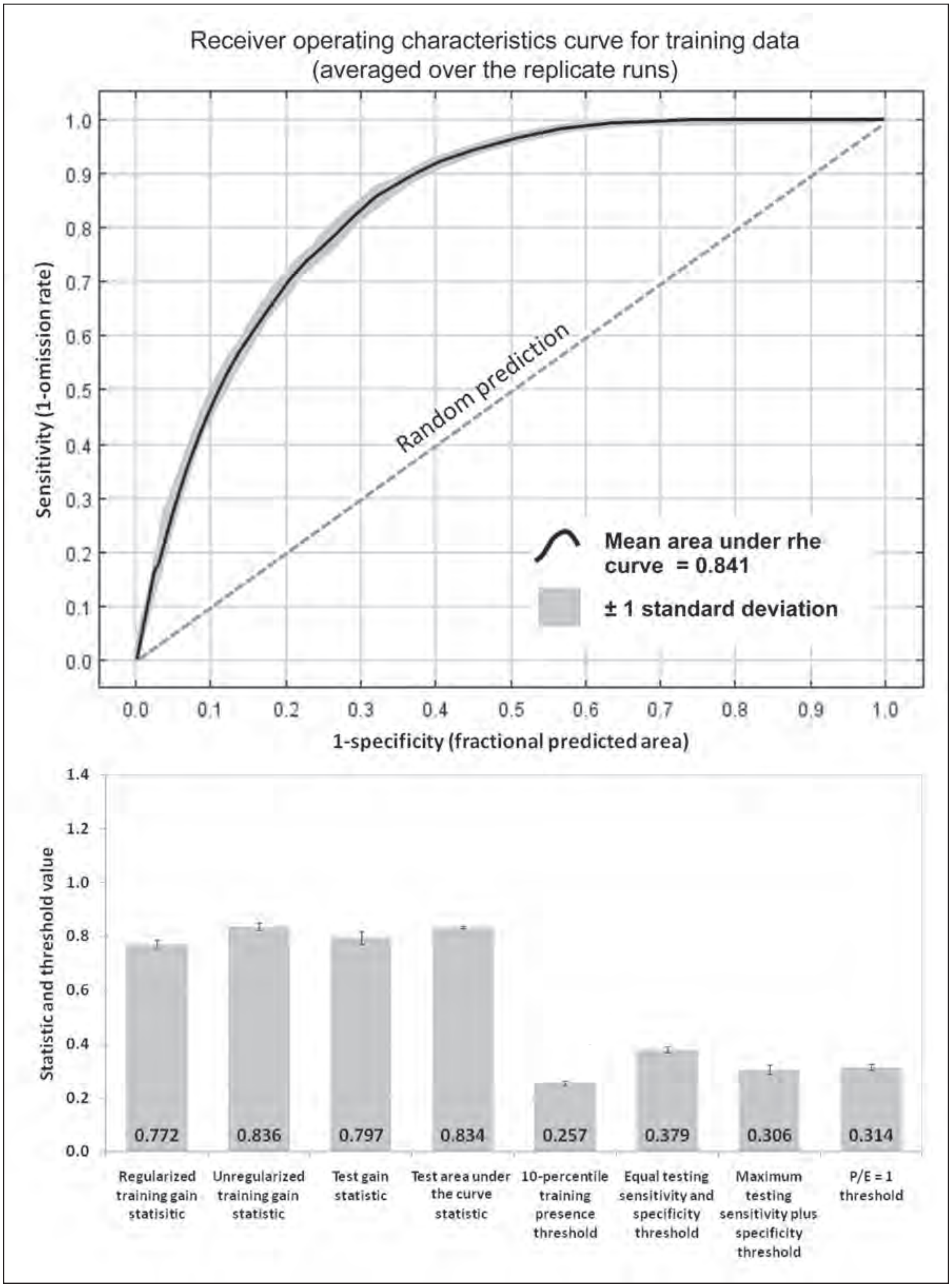


Figure G-2–Averaged model fit, accuracy, and threshold statistics (with 95-percent confidence intervals) from the 10 bootstrapped model replicates. Note that the predicted vs expected (P/E) = 1 threshold is similar to the maximum testing sensitivity plus specificity threshold, which minimizes model omission and commission errors.

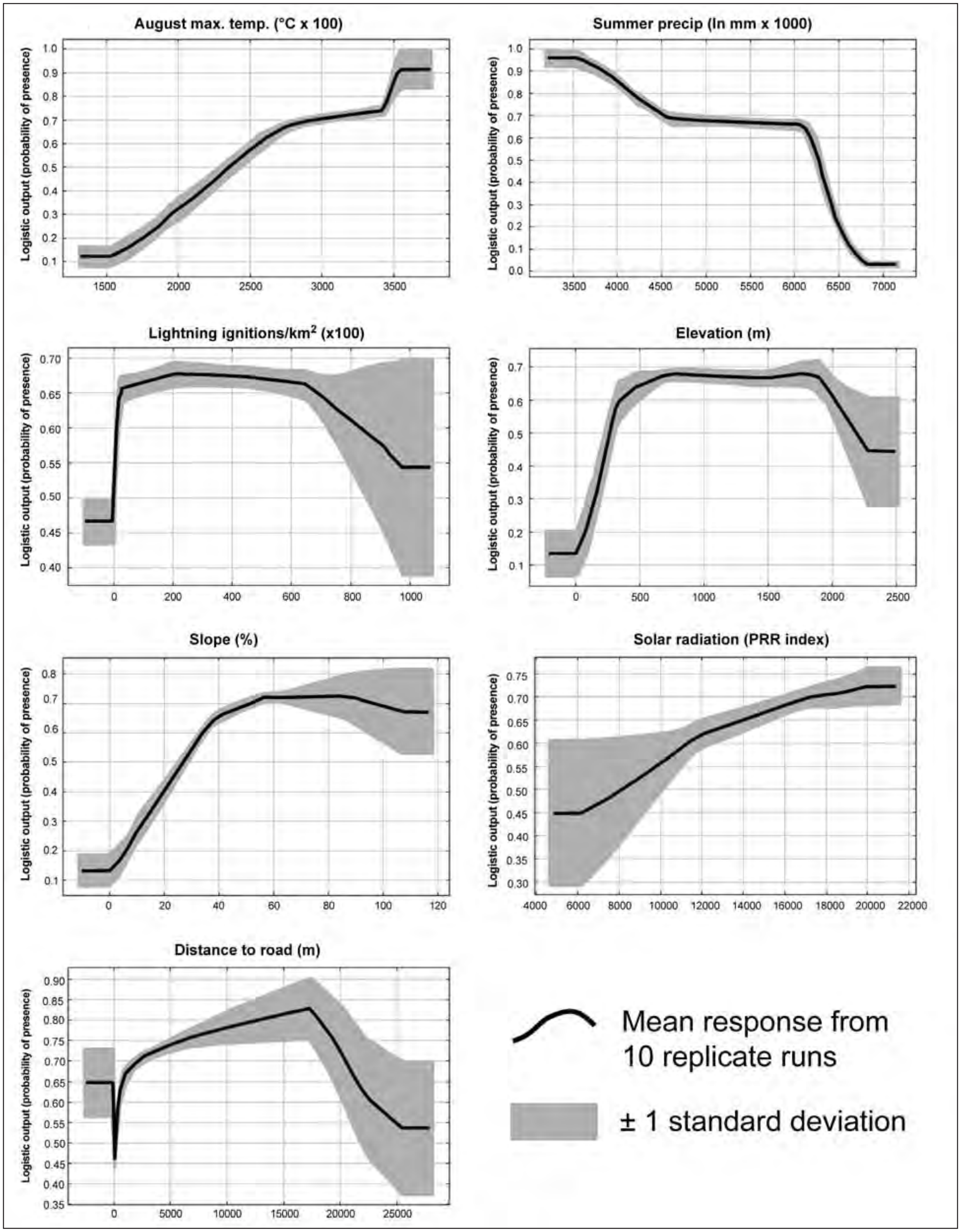


Figure G-3–Model response curves showing logistic probability of large wildfire occurrence (y-axis) for each environmental variable, as it is varied in jackknifed models, keeping all other environmental variables at their average sample values. PRP = potential relative radiation.

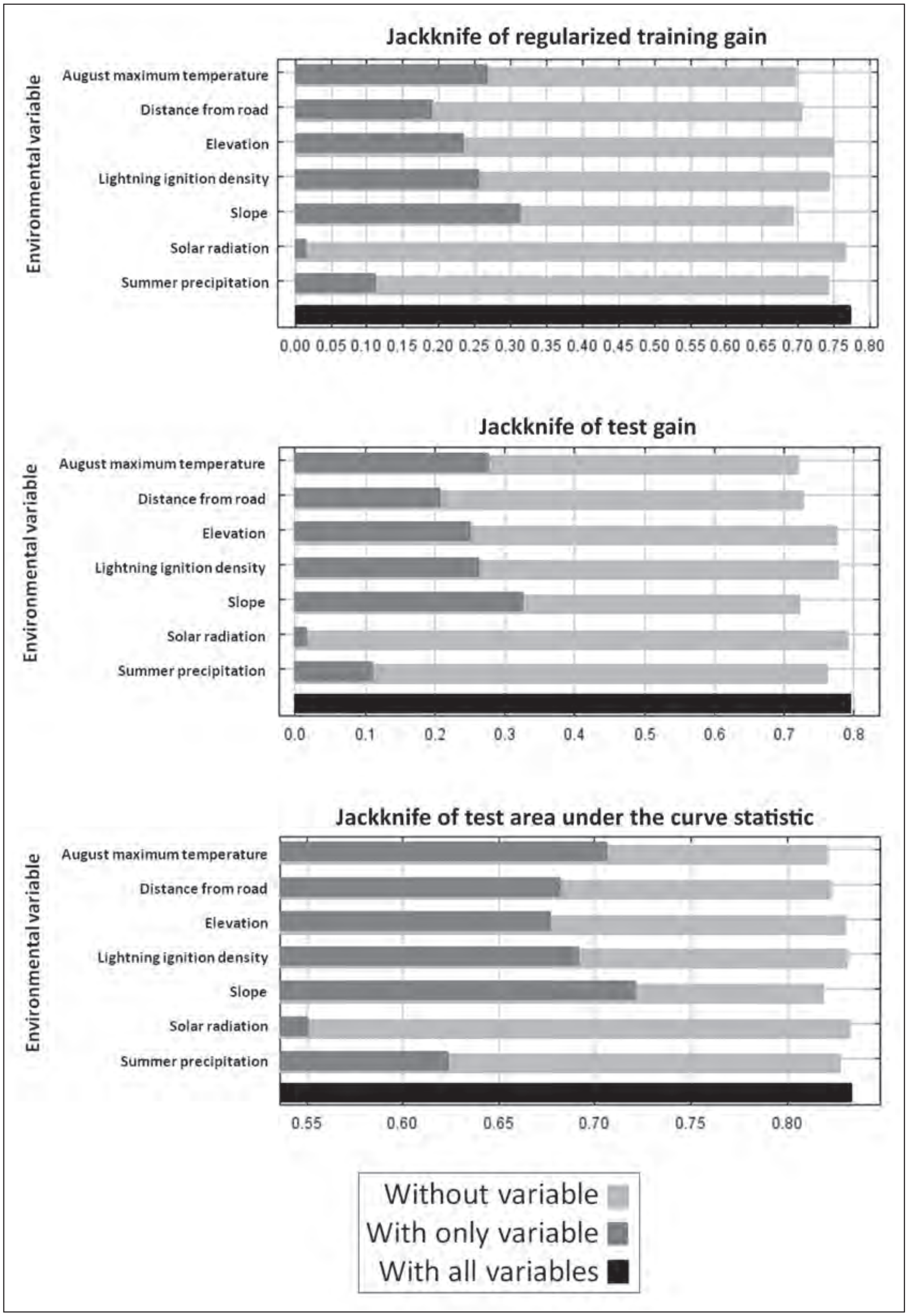


Figure G-4—Jackknife modeling results for variable importance. Note the similarities between the regularized training gain (top) and test gain (middle) graphs. The high level of similarity between them indicates that the model is not over-fit.

Literature Cited

Brown, T.J.; Hall, B.L.; Mohrle, C.R.; Reinbold, H.J. 2002. Coarse assessment of federal wildland fire occurrence data: report for the National Wildfire Coordinating Group. Reno, NV: CEFA Report 02-04. Program for Climate, Ecosystem and Fire Applications, Desert Research Institute, Division of Atmospheric Sciences. 31 p.

Gallo, K.; Lanigan, S.H.; Eldred, P.; Gordon, S.N.; Moyer, C. 2005. Northwest Forest Plan—the first 10 years (1994–2003): preliminary assessment of the condition of watersheds. Gen. Tech. Rep. PNW-GTR-647. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 133 p.

Pierce, K.B.; Lookingbill, T.R.; Urban, D.L. 2005. A simple method for estimating potential relative radiation (PRR) for landscape-scale vegetation analysis. Landscape Ecology. 20: 137–147

Ray Davis

Ray Davis

Appendix H: Regional Inventory Plot Analysis

Carol A. Apple[a] and Raymond J. Davis[b]

PLOT ANALYSIS

An analysis of regional vegetation inventory plots was performed to determine if there have been significant gains in northern spotted owl (*Strix occidentalis caurina*) nesting/roosting habitat since monitoring was implemented. We used plot data from the Current Vegetation Survey (CVS) inventory program on USDA Forest Service (FS) and USDI Bureau of Land Management (BLM) lands in Oregon and Washington. Forest Inventory and Analysis (FIA) program data were used for FS lands in California. Data were not available for USDI National Park Service lands or BLM lands in Washington or California.

The CVS inventory provides comprehensive information on vegetative resources on FS lands in Oregon and Washington and BLM lands in the Northwest Forest Plan area in Oregon. The CVS plots consist of four grids of field plots that are separated by 3.4 mi on a north-south, east-west direction. These four inventory grids are offset from one another to produce one single 1.7-mi grid of plots across BLM lands and FS lands, except in wilderness areas where the grid density is 3.4 mi. The FIA plots for FS lands in California are also distributed geographically on a 3.4-mi grid. For specific information on the attributes that are collected on FS lands, refer to the Web sites: http://www.fs.fed.us/r6/survey/ and http://www.fs.fed.us/r5/rsl/projects/inventory/InvInfo.shtml. Refer to pages 31–36 in Moeur et al. (2005) for additional discussion of the CVS and FIA.

A spotted owl nesting/roosting habitat query was developed (table H-1) that is similar to what was used in the 10-year report (Davis and Lint 2005). There were differences that included:

- Use of a slightly different set of plots
- Summarized data at the plot level vs. subplot level
- Top story quadratic mean diameter for only conifer and not all species
- Use of a different strata attribute

These differences were made to adjust to the new gradient nearest neighbor variables used for the spatial habitat modeling (see chapter 3, this report). The intent of this analysis was to explore for differences in "query group" acres between the initial measurement and remeasurement period, and not for differences between the 10-year report map results and this report's map results. In addition, the results of this analysis should not be compared to the results of the 10-year report plot analysis.

On Pacific Northwest Region FS lands, nearly all CVS plots have had two samples, but on Oregon BLM lands, only one-quarter of the original CVS plots had been remeasured at the time of this analysis. Based on the numbers of plots for each year of measurement, the weighted average year for initial plot measurements in Oregon and Washington was 1995 for initial plot measurements and 2002 for remeasurements. For California, the plot measurement period spans 1997 to 2005. The first inventory in California was conducted under the older FIA "periodic" sample design. This protocol was replaced by FIA's "annual" sample design, which was used for the plot remeasurments. This change in inventory protocol confounds inferences on habitat changes in California, as "real" change cannot be separated from effects related to changing sampling protocols (see Moeur et al. 2011) for more discussion.

As in the 10-year report, the "query groups" in table H-1 represent a progression of stand conditions, based on conifer diameter, total canopy cover, and stand structure complexity (strata) that represent habitat similarity to conditions used by spotted owls for nesting and roosting. A query was applied to both the initial measurement and remeasurement plot data in each physiographic province that occurred within the "habitat capable" areas described in Davis and Lint (2005) to assign a group code to each plot. In addition to the six groups in table H-1, two combined groups of EF and DEF were also assigned.

[a] Carol A. Apple, Mathematical statistician, Regional Vegetation Inventory Program, U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, 333 SW First Ave., Portland, OR 97204.

[b] Raymond J. Davis, Northern Spotted Owl Monitoring Module Leader, Northwest Forest Plan Interagency Monitoring Program, U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, 2900 NW Stewart Parkway, Roseburg, OR 97471.

Table H-1—Forest stand condition query for Current Vegetation Survey plot data

	Low <------- Spotted owl nesting/roosting habitat similarity -------> High					
	Query group					
Query attributes	**A**	**B**	**C**	**D**	**E**	**F**
Query part 1:						
Quadratic mean diameter (inches)	<10.5	≥10.5	10.5–20.5	10.5–20.5	≥20.5	≥20.5
Canopy cover (percent)	All	≤40	>40	>40	41–70	>70
Strata	All	All	1	≥2	≥2	≥2
Query part 2:						
Quadratic mean diameter (inches)	NA	NA	NA	≥20.5	NA	NA
Canopy cover (percent)				>40		
Strata				1		

An analysis was then done using the jackknife method to estimate the variance of mean acres for each query group by measurement period and province. The variance was used in performing a t-test to look at the differences in the means between the two periods. This test assumes independence between the two samples, but in reality many of the plots were remeasured. Taking that into consideration, this test provided conservative results for significance: if it is significant, it is very significant.

The results of this analysis did not show any evidence of significant habitat recruitment into classes EF or the broader class DEF. There were some significant decreases in class E, but these were concurrent with significant increases in class F; therefore, these changes “cancelled” each other out, resulting in no significant change in the EF group. Significant, decreases in EF and DEF were observed in the California Cascades and Klamath Mountain provinces (table H-4); however, as stated above, the change in protocol used to collect plot information in California confounds this inference. The histograms on the following page display the results of the plot analysis for each physiographic province with significant amounts of federal lands. The results of the t-test are shown in tables H-2 thru H-4.

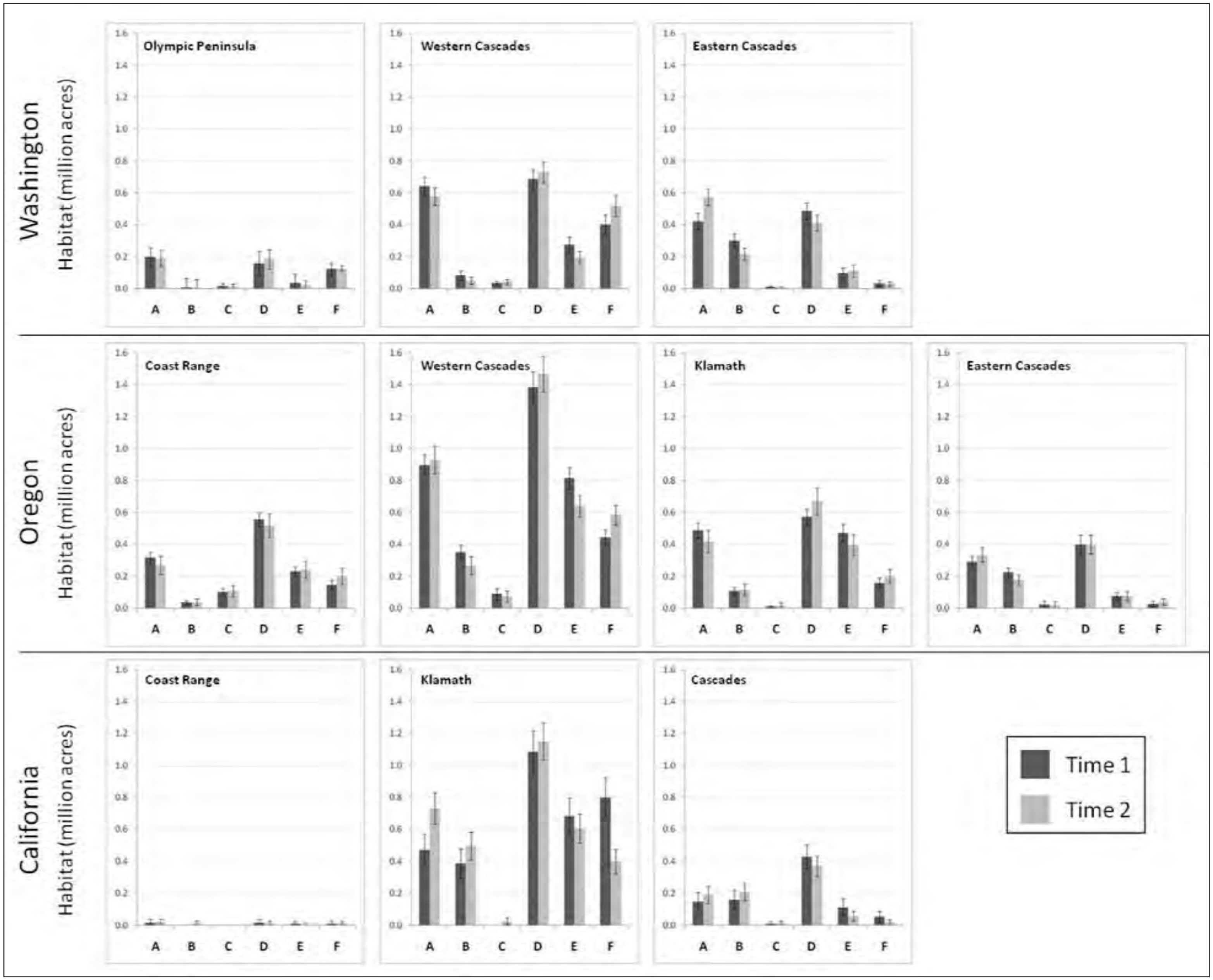


Figure H-1—Habitat changes between plot measurement periods (Time 1 = 1995 to 1997 and Time 2 = 2002 to 2005). Histrograms represent estimate of mean acres with 90-percent confidence intervals for each period.

Table H-2–Test for significant difference (bold-faced) of mean acres between measurement periods by physiographic province by query group at the 0.1 significance level (t = 1.6448), Washington

Physiographic province	Query group	t-value	Net change
			Acres
Olympic Peninsula	A	0.386	-9,300
	B	0.379	-1,900
	C	0.197	-1,500
	D	1.016	24,000
	E	1.455	-15,100
	F	0.157	3,900
	DEF	0.442	12,700
	EF	0.438	-11,200
Western Cascades	A	1.346	-65,000
	B	1.427	-31,200
	C	0.559	6,700
	D	0.824	44,800
	E	**2.057**	**-80,000**
	F	**2.134**	**115,600**
	DEF	1.143	80,400
	EF	0.562	35,600
Eastern Cascades	**A**	**3.584**	**151,200**
	B	**2.367**	**-85,000**
	C	0.337	-1,900
	D	**1.738**	**-75,400**
	E	0.477	14,100
	F	0.114	-1,600
	DEF	1.254	-63,000
	EF	0.384	12,400

Table H-3–Test for significant difference (bold-faced) of mean acres between measurement periods by physiographic province by query group at the 0.1 significance level (t = 1.6448), Oregon

Physiographic province	Query group	t-value	Net change
			Acres
Coast Range	A	1.206	-46,500
	B	0.061	900
	C	0.295	6,800
	D	0.770	-37,600
	E	0.318	11,200
	F	1.527	52,400
	DEF	0.479	26,000
	EF	1.374	63,600
Western Cascades	A	0.480	30,500
	B	**1.981**	**-85,000**
	C	0.472	-14,500
	D	0.945	85,400
	E	**2.988**	**-175,300**
	F	**2.993**	**140,500**
	DEF	0.526	50,500
	EF	0.499	-34,800
Klamath	A	1.400	-70,500
	B	0.287	7,600
	C	0.854	8,400
	D	**1.758**	**98,000**
	E	1.478	-77,700
	F	1.281	40,800
	DEF	0.924	61,000
	EF	0.638	-36,900
Eastern Cascades	A	1.290	44,500
	B	**1.743**	**-45,700**
	C	0.272	-5,200
	D	0.055	2,900
	E	0.034	700
	F	0.740	11,300
	DEF	0.272	14,900
	EF	0.464	12,000

Table H-4—Test for significant difference (bold-faced) of mean acres between measurement periods by physiographic province by query group at the 0.1 significance level (t = 1.6448), California

Physiographic province	Query group	t-value	Net change
			Acres
Coast Range	A	0.128	1,900
	B	1.145	12,300
	C	—	—
	D	0.309	-4,200
	E	0.229	-2,300
	F	0.213	2,400
	DEF	0.269	-4,100
	EF	0.008	100
Klamath	**A**	**2.988**	**259,400**
	B	1.404	108,700
	C	**1.722**	**25,200**
	D	0.597	63,700
	E	**0.901**	**-78,800**
	F	**4.835**	**-402,400**
	DEF	**3.887**	**-417,500**
	EF	**4.496**	**-481,200**
Cascades	A	0.929	43,400
	B	0.968	46,000
	C	0.271	3,500
	D	0.994	-57,600
	E	**1.660**	**-57,000**
	F	**1.681**	**-36,400**
	DEF	**2.628**	**-151,000**
	EF	**2.380**	**-93,500**

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In Reply Refer To:

08YRE00-2013-TA-0007

March 29, 2013

Mr. Michael Bacca
CAL FIRE
Northern Interior Region
6105 Airport Road
Redding, California 96002

Subject: Technical Assistance for Sierra Pacific Industries 2013 Proposed Survey Modification Request

Dear Mr. Bacca:

This is in response to your request for U.S. Fish and Wildlife Service (Service) technical assistance, dated and received in this office on February 20, 2013. Jan Johnson, of my staff, discussed preliminary information pertaining to this request with you, other CAL FIRE staff, and Sierra Pacific Industries' (SPI) staff on February 6, 2013. Subsequent to that meeting, drafts of this request were reviewed by the Service; your February 20, 2013, request incorporates our comments. At issue is the potential for incidental take of the federally listed northern spotted owl *(Strix occidentalis caurina)* (NSO) as a result of modifying NSO survey requirements in 2013 in specified areas of SPI ownership. Our review is based upon information provided with this request, along with outcomes of your recent reyiews of SPI survey data. After reviewing this information, the Service offers the following technical assistance.

Background

SPI's proposal pertains to minor modifications to NSO survey methodology and a request for clarification of pre-operation "Spot Check Surveys", as defined by the 2011 NSO Survey Protocol, revised January, 2012 (2012 Protocol, USDI 2012). This technical assistance applies to the lands managed by the SPI Weaverville District, excepting twelve legal sections, as identified in your request (Attachment 1).

Habitat Conditions

Existing landscape conditions is an important consideration when evaluating requests for survey modifications. Numerous prior technical assistance requests, field reviews by Service staff, and SPI's NSO habitat classification system, using the parameters as described by the Service (USDI

'J.&1

2009), have determined that SPI's landscape is dominated by habitats considered to provide foraging and 10\quality foraging habitat. Suitable nesting/roosting (Nhabitat on SPI managed lands is much more limited. As described in your request, SPI will continue to evaluate NSO habitat suitability in a 1.3 mile area around each Timber Harvest Plan (THP) proposing to affect suitable NSO habitat and will continue to survey all suitable habitat within 1.3 miles of SPI ownership.

Survey History

The survey history of a landscape is also an important consideration when evaluating alternative approaches to survey strategies. Project-level NSO surveys have been conducted on SPI lands since the early 1990's. Landscape-level surveys on SPI's Weaverville district were conducted from 2003-2007. Starting in 2010, through the present SPI has been surveying suitable habitat 1.3 miles from their ownership boundaries. Additionally, SPI has recently obtained a Recovery Permit (USDI Permit #TE80705A-O) for an ownership wide NSO banding program. During these same time periods adjacent federal and non-federal landowners have also conducted surveys and these available data will be reviewed by SPI as part of development of new THPs. The combination of surveys between SPI and other adjacent landowners and their review and analysis will maximize the knowledge ofNSO locations relative to proposed THPs.

Proposed Survey Modification for the 2013 Survey Season

When operations are within 1.3 miles of current or historical (known) NSO activity centers or barred owl responses, the Service concurs that operations proposed within unsuitable or LOW QUALITY foraging (LQF) habitat (USFWS 2009) may occur between February 1 and March 15 or concurrent with, landscape level surveys in 2013 provided:

a) No operations will occur within 0.5 mile of known NSO Activity Centers, during the breeding season, until location and reproductive success is determined or complete reproductive survey efforts following Section 17.0 of the 2012 protocol have yielded negative results.

b) If operations are within LQF or unsuitable habitat between 0.5 and 1.3 miles of known NSO Activity Centers *have not* commenced prior to February 1, and occur within 0.25 mile of high quality foraging or nesting/roosting habitat, operations *shall be* delayed. SPI Weaverville District must complete one of the three visits of all survey stations within 0.25 mile of the subject unit(s) prior to operations. The survey stations are those that have been previously reviewed and accepted by CAL FIRE. All NSO responses must be followed with survey methodology described in Section 10.3 of the 2012 protocol.

Spot Check Clarification

The Service and CAL FIRE have determined that the current landscape level surveys meet the intent of the 3rd and 4th year "spot check" surveys provided SPI:

- Maintains complete annual survey coverage of all suitable habitat out to 1.3 miles of SPI boundaries,

- Maintains annual Activity Center Searches (ACS) (2012 protocol) on known NSO out to 1.3 miles from SPI boundaries or ACS·will be coordinated with adjacent landowners.

Based on the above information on habitat conditions, survey history, known NSO locations and barred owls within and adjacent to the survey areas, the Service concurs that the above methodology is consistent with the intent of the 2012 Protocol, and that the likelihood of take of NSO is not likely to occur.

All data used to provide this technical assistance are on file at this office. If you have questions please contact Jan Johnson, Fish and Wildlife Biologist, at (530)841-3102 or janjohnson@fws.gov.

Sincerely,

EJ Willi
Field Supervisor

Regulatory and Scientific Basis for U.S. Fish and Wildlife Service Guidance for Evaluation of Take for Northern Spotted Owls on Private Timberlands in California's Northern Interior Region

Introduction

In 1999, the California Department of Forestry and Fire Protection (CALFIRE) requested that the U.S. Fish and Wildlife Service (FWS) review timber harvest plans (THP) and Non-industrial Timber Management Plans to ensure that such plans would not result in incidental take of northern spotted owls (NSO). For nearly a decade, the FWS provided this technical assistance. At first, the criteria and thresholds employed by the FWS to make our take evaluations were based on habitat retention regulations in the California Forest Practice Rules (Title 14, California Code of Regulations) (FPRs), which were originally developed collaboratively by the FWS, California Department of Fish and Game (CDFG), CALFIRE, and the California Board of Forestry. However, as knowledge of the habitat relationships of this species increased after 1992, the FWS increasingly made use of new scientific information to guide our evaluations of the potential for incidental take. The accumulation of published research results, combined with direct field experience with management of NSO and their habitat, resulted in substantial changes in the quantity and quality of habitat the FWS considered necessary to maintain continued occupancy and reproduction at NSO territories.

In 2008, the FWS returned responsibility for THP review to CALFIRE, the authorized agency under the California Environmental Quality Act. As a part of this transfer, the FWS provided CALFIRE with documentation of the criteria and thresholds currently used by the FWS in making take evaluations. This documentation, hereafter called the FWS guidelines, represents the best scientific information available to the FWS upon which to base evaluations of the likelihood of incidental take resulting from timber harvest operations in the Northern Interior Region. The FWS guidelines are not regulations and are not intended to substitute for regulations; they do, however, provide the scientific and biological foundation for reviewing proposed projects and determining the likelihood of incidental take of NSO. In this report, we provide the scientific basis for the FWS guidelines.

The habitat descriptions within the FWS guidelines were developed to enable CALFIRE personnel (who may not have extensive experience with NSO biology and habitat associations) to evaluate the likelihood of take posed by a proposed THP. This process contrasts with the technical assistance process formerly conducted by the FWS, wherein NSO experts conducted detailed evaluations of stand structure, habitat quantities, and NSO survey results to support a determination of the likelihood of take. While the FWS believes that expert review should play a central role in these evaluations, it is also true that robust habitat retention guidelines may be used to avoid take. Application of habitat retention guidelines in the absence of expert review, however, may limit managers' flexibility to classify habitat based on specific local conditions and to design harvest proposals based on these conditions.

Evaluation of the scientific bases of the FWS guidelines for NSO in the Interior Region of California (Klamath Province) is dependant on understanding the concept and regulatory definition of take, the practical and operational considerations of determining the likelihood of take, and the information supporting our conclusion that existing habitat guidelines in the FPRs are not sufficient for avoiding take. It is also important to recognize the difference between the use of habitat guidelines in the determination of take versus descriptions of desired habitat conditions for conservation of NSO.

Section I: Regulatory and operational aspects of take evaluation guidelines

A. Regulation and definition of take under Endangered Species Act

Regulatory Authority

Section 9(a)(B) of the Endangered Species Act of 1973 (ESA) prohibits the take of listed species within the United States, except as provided in section 10 of the ESA, which allows for permitted incidental take on private lands. Section 9 is intended to protect individual members of listed species.

Regulatory definition of take

The ESA defines "take" as "…to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct." The term "harm" is further defined in 50 CFR 17.3:

> "Harm" in the definition of "take" in the Act means an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Process for estimating the likelihood of incidental take and establishing habitat retention guidelines

Although the regulatory definition of take clearly expresses the intent of the ESA's Section 9, it does not provide any metrics or criteria upon which a determination of take should be made. Because our reviews of proposed projects under section 9 are typically conducted prior to project implementation, our determination is an estimate of the likelihood of take, based on the predicted effects of the project. Habitat retention guidelines such as those in the FPRs are intended to provide guidance as to the amount and quality of habitat that must be retained in order to avoid incidental take of NSO at sites where the species is known to occur. When the FPR guidelines were adopted in 1992, data relating habitat variables to occupancy, reproduction, and survival of NSO were limited. The FPR guidelines for avoiding incidental take of NSO were therefore based on comparison of proposed post-harvest habitat conditions with the amount and quality of habitat observed at occupied NSO sites described in various studies. Under this standard, habitat modification potentially could result in substantial reduction of reproduction, survival, and occupancy at NSO activity centers without the appearance of take, because habitat conditions still resemble other lower-quality NSO territories. NSO are known to occupy low-quality sites where their reproduction and survival are substantially reduced (Franklin *et al*. 2000, Dugger *et al.* 2005); the existence of these low-quality sites suggests that reliance on habitat conditions corresponding to the presence or absence of owls at historic territories represents a low bar for determining habitat thresholds and take.

Recent results from demographic studies of NSO in the Klamath Province provide new insights into the relationships between habitat and NSO population rates (e.g., occupancy, reproduction, and survival). By developing predictive models of these relationships, Franklin *et al*. (2000) and Dugger *et al*. (2005) introduce the concept of habitat fitness potential (HFP); "the fitness conferred on an individual occupying a territory of certain habitat characteristics" (Franklin *et al.* 2000:558). Habitat fitness potential is a function of both the survival and reproduction of individuals within a given territory. Evaluation of habitat parameters influencing these rates provides a more rigorous measure of "significant impairment of essential behavioral patterns such as breeding, feeding, or sheltering" that is readily incorporated into review of timber harvest plans. By incorporating the concept of HFP, the FWS can evaluate the predicted effects of habitat modification on fitness of NSO potentially affected by a project. Evaluation of incidental take based on habitat modification that measurably and significantly reduces the fitness of NSO within the project area (as estimated by HFP models) provides a quantitative element to our estimation of "significant impairment of breeding, feeding and sheltering" in Section 9 of the ESA. Furthermore, HFP models also provide information allowing determination of significant thresholds that may occur, such as average habitat conditions corresponding to HFP < 1.0 (territorial pair not replacing themselves).

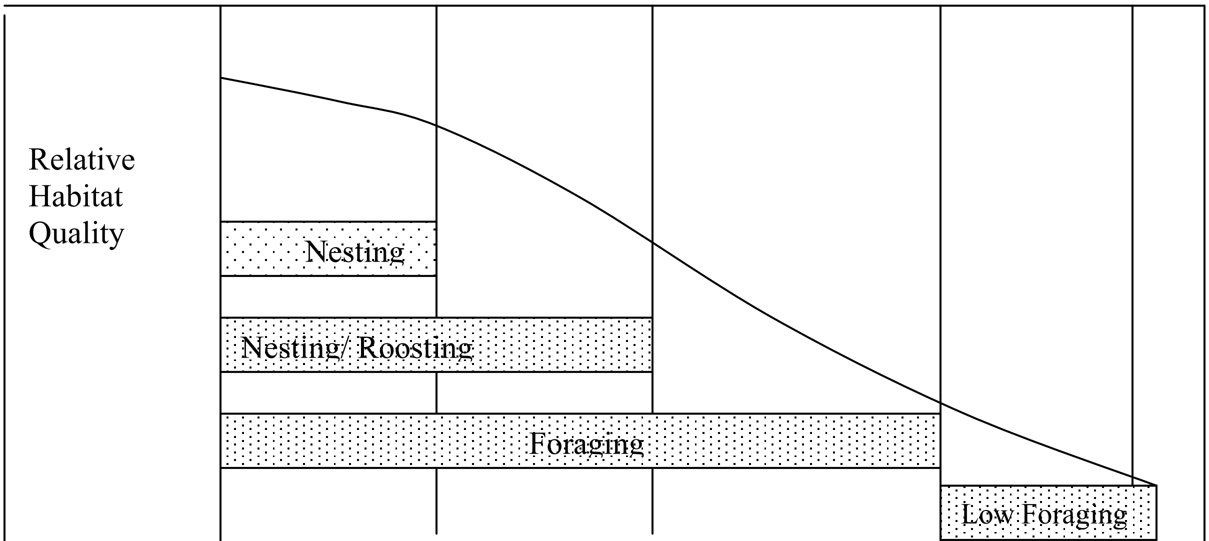
Description of the structural characteristics of NSO habitat and delineation of the range of habitat conditions corresponding to essential activities such as nesting, roosting, and foraging is a critical element of developing guidelines for evaluating the likelihood of incidental take. Determination of the amount of suitable habitat that must be retained in order to avoid incidental take of NSO is strongly influenced by the range of forest conditions that are classified as suitable habitat. The HFP models of Franklin *et al.* (2000), Olson *et al.* (2004), and Dugger *et al.* (2005) contain a limited number of habitat variables and relatively coarse definitions of NSO habitat, and therefore must be supplemented with additional information on forest structural parameters that support classification of forest habitat as suitable for nesting and foraging. Because the structural attributes of habitat immediately surrounding nests are easily quantified, data supporting classification of nesting habitat are readily available (see section III.C). Foraging habitat, on the other hand, is more variable and spatially extensive, requiring intensive radio-telemetry studies to measure use of various habitat conditions by NSO. In recent studies by the National Council for Air and Stream Improvement (NCASI), correlations between habitat data from detailed forest inventories and nocturnal locations of radio-tagged NSO and California spotted owls were used to estimate resource selection function (RSF) models (Irwin et al. 2007a,b) that quantify complex relationships between the owls and their environment. These models allow evaluation of the relative use of specific forest structural variables, such as tree size class distribution and stand density, by foraging NSO. The studies of Irwin *et al.* (2007), combined with other telemetry studies (Solis and Gutierrez 1990), provide the basis of our definitions of suitable foraging habitat for NSO in the Northern Interior Region.

Criticism of the THP review process is frequently focused on the use of "thresholds" that simplify complex gradients of habitat quality into a single value (e.g., 40% suitable habitat within 1.3 mile radius, or 185 ft^2 of basal area). The FWS has long recognized that many different combinations of habitat structure and amount may support a viable NSO territory; evaluation of these combinations by technical experts has been our primary role in technical assistance. However, to maintain consistency and incorporate new information it is necessary to implement unambiguous habitat standards and criteria (i.e., thresholds) that delineate conditions under which take is deemed unlikely. Thresholds do not represent arbitrary lines through consistent data sets; rather, they represent the preponderance of evidence derived from careful evaluation of the results and conclusions of many published studies, supplemented by data sets from credible sources.

Derivation of habitat thresholds from published studies consists of two consecutive steps. First, we consider the relationship or trend between habitat features and spotted owls. For example, most studies show that habitat use by foraging NSO is positively correlated with increasing tree size. These consistent, statistically significant relationships then serve as the foundation for subsequent choice of habitat values that correspond with viable NSO territories. We emphasize habitat parameters that receive disproportionate use by NSO, or are correlated with fitness. In this second step, we evaluate the pattern and distribution of data from a wide range of sources and attempt to identify ranges of values that correspond to consistent use. Deriving the central tendencies within complex, inconsistent data is a difficult task, and often requires input from the researchers responsible for published studies.

Despite consistent patterns of habitat selection by NSO, structural conditions of forest habitats occupied by NSO are highly variable, particularly in the diverse conifer-hardwood forests of the Klamath Province. We recognize that habitat retention guidelines must incorporate the range of habitat conditions used by NSO for nesting, roosting, and foraging, while at the same time ensuring that habitat conditions are not degraded to the point where significant impairment of breeding, feeding, and sheltering occurs. The FWS guidelines achieve this balance and provide a robust method for evaluating the likelihood of take because they describe a range of habitat conditions representing the central tendency for high-quality nesting habitat, nesting roosting habitat, foraging habitat, and low-quality foraging habitat that may provide prey resources (Fig. I.A.1).

Figure I.A.1: Conceptual model of spotted owl habitat functions, relative habitat quality, and associated forest structural conditions.



Basal Area[1]	300	200	150	120	80
QMD[2]		20”	15”	13”	11”
TPA > 26”[3]	50		8	5	
Canopy	100%	80%		60%	40%
WHR size[4]	← 4 →				
WHR density	← D →			← M →	

[1] Square feet per acre, [2]Quadratic Mean Diameter of trees >5”dbh, [3] Trees per acre greater than 26” diameter at breast height, [4] California Wildlife Habitat Relationships System

This process must be distinguished from the simple application of “minimum habitat standards” that correspond to the lowest denominator of observed habitat use. To illustrate this, Figure I.A.1 depicts the relationship between California Wildlife Habitat Relationships system (WHR) class 4M and relative use of habitat by NSO. The FPRs classify 4M stands as suitable for nesting, roosting, and foraging by NSO. Although 4M encompasses a wide range of stand conditions, some of which may be suitable as foraging habitat, it largely consists of stand conditions rarely used by NSO. For this reason, the use of existing minimum habitat standards such as those currently in the FPRs may result in take of NSO and are insufficient for programmatic use in take avoidance reviews of THPs.

B. Evidence indicating that regulatory guidance in the current Forest Practice Rules is not adequate to avoid incidental take of NSO

New information available

The current FPRs governing habitat retention for NSOs were developed in 1992 and predate much of the published research used in the FWS guidelines. In particular, studies correlating habitat and NSO fitness measures, and radio-telemetry studies of habitat use by foraging NSO (Irwin *et al*. 2007b) provide information directly applicable to evaluation of timber harvest-related impacts to NSO. During the past decade, the FWS has incorporated the results of new research into Technical Assistance on a plan by plan basis. However, with the February 2008 return of THP review to CALFIRE, the large number of recently published studies requires that a full synthesis of current knowledge be conducted and incorporated into updated take evaluation guidelines. This synthesis, and the habitat retention guidelines that it supports, are presented in section III of this report.

FWS experience in technical assistance process

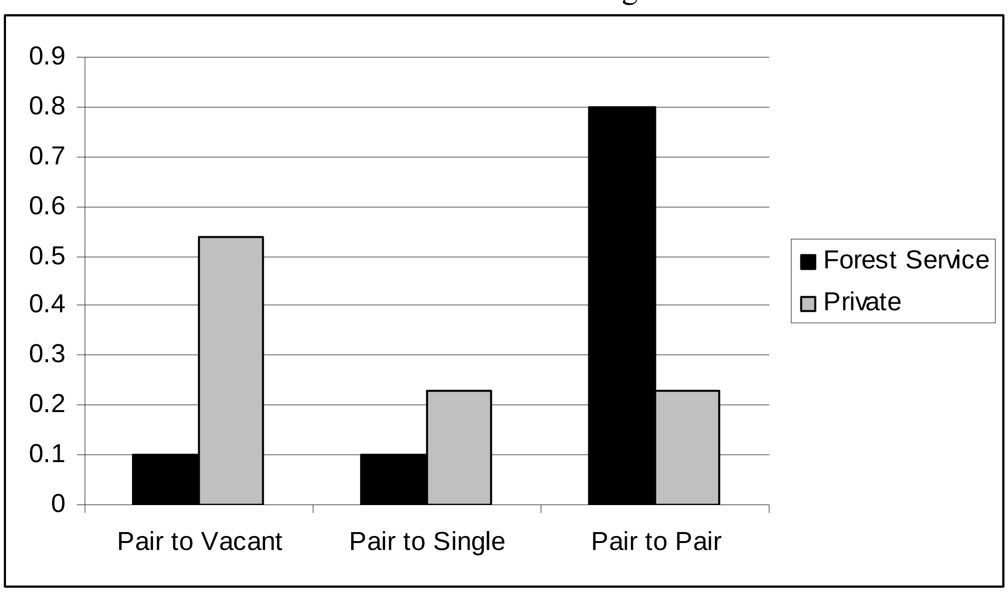
The FWS' primary source of information regarding habitat conditions and NSO status on industrial timberlands in the Northern Interior Region has been our review of

THPs. In the THP review process, FWS staff carefully evaluated historical NSO records and results of current surveys conducted in the plan area, as well as the habitat data provided in support of the THP. In cases where timber harvest was proposed in close proximity to an NSO activity center, the FWS evaluated habitat conditions in the field. The THP review process was conducted on a plan-by-plan basis, which does not permit systematic assessment of habitat conditions and NSO status across an entire ownership. However, our combined experience with hundreds of THPs indicates that the cumulative effects of repeated entries within many NSO home ranges has reduced habitat quality to a degree causing reduced occupancy rates and frequent site abandonment. In a large proportion of technical assistance letters to CALFIRE and industrial timberland owners during the past five years, we noted the lack of NSO responses at historic territories, and described habitat conditions considered inadequate to support continued occupancy and reproduction. This highlights the need for refined, objective criteria to determine the likelihood of NSO take when assessing THPs.

Analysis indicating loss of territories under Forest Practice Rules

To quantify the pattern of territory loss identified during the technical assistance process, we compared results of protocol surveys conducted at verified NSO territories supporting at least one year of occupancy by paired owls on Forest Service lands (N=196) with similar data from private timberlands (N=75) in Shasta and Trinity counties. The data set consisted of activity center status records in the California Department of Fish and Game's Spotted Owl Database (CDFG-NSO database), supplemented with territory locations and recent survey records received during technical assistance. We first evaluated the validity of activity center records in the CDFG-NSO database, and eliminated 18 sites on private lands due to lack of verification of status. The remaining 57 private-land activity centers had verified NSO status in at least one year between 1989 and 2007; 44 of these sites had supported pairs during at least one year. Of these verified pair sites, 54% declined from pair status to no response, and an additional 23% declined from pair status to a territorial single owl during subsequent protocol surveys (Figure I.B.1). On Forest Service-administered lands, 80% of pair sites did not change status during the same time periods. While we recognize that annual variation in survey effort and results at this relatively coarse scale of resolution may influence this type of analysis, the strong differences in trends observed on private versus federal lands supports the contention that management on private timberlands is creating habitat conditions that do not support sustained occupancy by NSO.

Figure I.B.1. Status of valid historical northern spotted owl activity centers (pair sites only) when resurveyed after 5-10 years. Data are from U.S. Fish and Wildlife Service technical assistance records and USFS monitoring records



Section II: Summary of the FWS NSO Take Evaluation Guidelines

The FWS guidelines provide a step-by-step process for evaluation of the likelihood of incidental take posed by proposed THPs (Appendix A). The steps include: (1) verifying the accuracy of NSO activity center location and status; (2) reviewing survey coverage and results to determine whether protocol has been met; and (3) evaluating the quantities and quality of habitat to be retained at each NSO home range potentially affected by the proposed THP. To assist the reader, this section briefly summarizes the analysis areas, habitat quantities, and habitat definitions used in step (3) of the FWS guidelines. See Appendix A for the full take avoidance analysis guidance provided to CALFIRE.

The FWS guidelines specify three spatial scales that form appropriate analysis areas for evaluation of habitat at NSO home ranges. The fourth analysis area, the 'outer core' represents the area between the core area and the total home range area (Table II.1). Within each analysis area, the FWS guidelines describe the quantities of habitat that must be retained in each of four functional habitat categories to avoid incidental take of NSO. These categories are: (1) high-quality nesting/roosting habitat; (2) nesting/roosting habitat; (3) foraging habitat; and (4) low-quality foraging habitat (Table II.2). Descriptions of the stand structural attributes corresponding to each functional habitat category are given in Table II.3. Table II.4 provides additional considerations for use in prioritizing habitat areas for retention.

Table II.1: Spatial scales used to evaluate habitat conditions at northern spotted owl activity centers in the Northern Interior Region

Analysis Area	Radius	Area
Nest Site	1000 feet	70 acres
Core Area	0.5 mile	502 acres
Outer Ring	0.5 – 1.3 mile	2,908 acres
Home Range	1.3 miles	3,410 acres

Table II.2: Minimum quantities of habitat to be retained within four functional habitat types to avoid incidental take of northern spotted owls on private timberlands in the Northern Interior Region

Analysis Area	Functional Habitat Type				
	High-quality NR	Nesting/ Roosting	Foraging	Low-quality Foraging	Total Suitable
Core area	100 acres	150 acres	100 acres	50 acres	300 acres
Outer 'ring'			655 acres	280 acres	935 acres
Home range (total)	100 acres	150 acres	755 acres	330 acres	1335 acres

Table II.3: Values for selected stand structural parameters used to classify nesting/roosting and foraging habitat for northern spotted owls in the Northern Interior Region

Parameter	Functional Habitat Type			
	High-quality NR	Nesting/Roosting	Foraging	Low-quality Foraging
Basal area	≥ 210 ft^2 /acre	Mix ranging from 150 to ≥180 ft^2 /acre	Mix ranging from 120 to ≥180ft^2 /acre	Mix ranging from 80 to ≥120ft^2 /acre
Quadratic mean diameter	≥ 15 inches	≥ 15 inches	≥ 13 inches	≥ 11 inches
Large trees per acre	≥ 8	≥ 8	≥ 5	NA
Canopy closure	≥ 60%	≥ 60%	≥ Mix ranging from 40 to 100%	≥ 40%

Table II.4: Guidelines for prioritizing habitat to be retained to avoid incidental take of northern spotted owls on private timberlands in the Northern Interior Region

Tree Species composition	Mixed conifer stands should be selected over pine-dominated stands
Abiotic considerations	
Distance to nest	Nesting/roosting and foraging habitat closest to identified nest trees, or roosting trees if nest unknown
Contiguity	Nesting/roosting and foraging habitat within the 0.5 mile radius must be as contiguous as possible
	Minimize fragmentation of foraging habitat as much as possible
Slope position	Habitats located on the lower 1/3 of slopes provide optimal microclimate conditions and increased potential for intermittent or perennial water sources
Aspect	Habitats located on northerly aspects provide optimal vegetation composition and cooler microclimates
Elevation	Habitat should be at elevations < 6000 feet, lower elevations are preferred

Section III: Scientific Basis for NSO Take Evaluation Guidelines

A. Fundamentals of spotted owl habitat relationships

Northern spotted owls exhibit clear, consistent patterns of habitat association, and these associations must provide the foundation of habitat management guidelines. In the 1990 *Conservation Strategy for the Northern Spotted Owl,* the Interagency Scientific Committee (Thomas *et al.* 1990) stated that:

"With the exception of recent studies in the coastal redwoods of California, all studies of habitat use suggest that old-growth forests are superior habitat for northern spotted owls. Throughout their range and across all seasons, spotted owls consistently concentrated their foraging and roosting in old-growth or mixed-age stands of mature and old-growth trees....Structural components that distinguish superior spotted owl habitat in Washington, Oregon, and northwestern California include: a multilayered, multispecies canopy dominated by large (>30 inches dbh) conifer overstory trees, and an understory of shade-tolerant conifers or hardwoods; a moderate to high (60-80 percent) canopy closure; substantial decadence in the form of large, live coniferous trees with deformities- such as cavities, broken tops, and dwarf mistletoe infections; numerous large snags; ground cover characterized by large accumulations of logs and other woody debris; and a canopy that is open enough to allow owls to fly within and beneath it."

Fifteen years later, the conclusions of the Interagency Scientific Committee were echoed in the *Scientific Evaluation of the Status of the Northern Spotted Owl* (Courtney *et al.* 2004), who found that the habitat attributes identified by Thomas *et al.* (1990) remain important components of NSO habitat. Notably, positive relationships were found with the aforementioned attributes whether the samples of owl and random locations were within old-growth forest, non-old growth forest, National Parks, public land, private land, or an Indian Reservation. In 2008, the *Recovery Plan for the Northern Spotted Owl* (USFWS 2008) again reiterated the association of NSO with older forest conditions, stating; "Spotted owls generally rely on older forested habitats (Carroll and Johnson 2008) because such forests contain the structures and characteristics required for nesting, roosting, and foraging." A major advance in our understanding of NSO habitat relationships from Thomas et al. (1990) to the present is that we now have a much better understanding of the spatial scale of habitat selection (Hunter et al. 1995), Meyer et al. 1998, Zabel et al. 2003) and relationships of habitat to owl fitness (Franklin et al. 2000, Dugger et al. 2005).

III.B: Analysis Areas

Management guidelines for territorial organisms are typically spatially explicit; that is, they apply to an area corresponding to the movements and activity patterns of the individuals occupying a territory. Spotted owls are territorial raptors that range widely in search of prey but are 'anchored' during the breeding season to a nest site (central-place forager). Evaluations of NSO habitat are usually conducted at two spatial scales; the home range and core areas. The home range is the "area traversed by the individual in its normal activities of food gathering, mating, and caring for young" (Burt 1943:351). Within home ranges, areas receiving concentrated use, typically surrounding the nest site and favored foraging areas, are called core areas. Because the size and pattern of NSO space use are typically unknown, estimates of use areas are derived from radio-telemetry studies. The analysis areas employed in the FWS guidelines are based on a subset of estimates that describe the outer perimeter of NSO activity areas, thus incorporating the areal extent most likely to contain important resources. In this section we review and summarize information related to home range size and patterns of space use within home ranges by NSO.

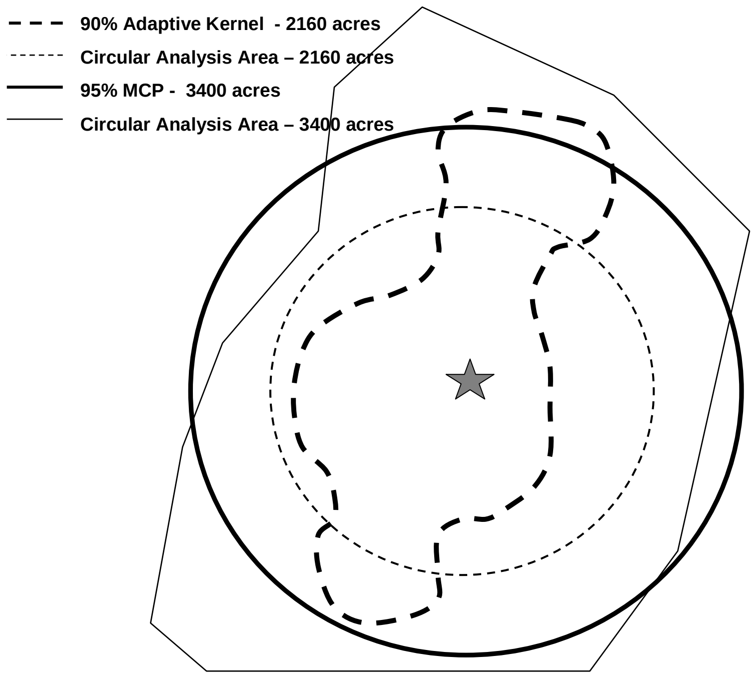
Home Range (1.3-Mile-Radius, 3,410-Acre) Analysis Area

The FPR guidelines for avoiding take of NSOs during timber operations in the Klamath Province indicate the amount of habitat to be retained within 1.3 miles of activity centers. The size of this area was originally based on estimated median annual home range sizes for NSO pairs in northern California, Oregon, and Washington (Thomas *et al.* 1990, USFWS 1992). There are numerous analytical techniques for estimating home range sizes based on animal locations (reviewed in Powell 2000). One of the most commonly used classes of home range estimators is the minimum convex polygon (MCP). Because MCP consists of a single polygon encompassing all or the majority of telemetry locations, this method may be viewed as providing a representation of the area *containing* the home range, including unused and infrequently used areas (Powell 2000, Laver and Kelly 2008). Generally biased large, MCP home range estimates provide relatively conservative values on which to base the size of habitat-analysis areas. Other home range estimators such as utilization distributions (e.g., kernel density estimates: see Powell 2000) de-emphasize areas less frequently used and typically yield smaller home range estimates that, when converted into circular analysis areas, may exclude distant, but potentially important, patches of habitat (see Figure 2.b.1). At the upper end of utilization distributions (e.g.; 90-100%), however, kernel estimates may resemble MCP polygons and circular analysis areas (Anthony and Wagner 1999).

Estimates of home range size are also important for developing management prescriptions and evaluating impacts of human activities on NSO. For the purpose of quantifying habitat and the impact of proposed modification of habitat, median home range estimates from radio telemetry studies are transformed into circular 'analysis areas' that are used as surrogates for actual home ranges (Fig. 2.b.1). Based on the median MCP home range estimate for NSO pairs in the Klamath Province, the FWS currently uses a circular analysis area of 1.3 mile radius (3,398 acres; Thomas *et al.* 1990, USFWS 1992). While this practice provides a practical and uniform method for quantifying NSO habitat, circular analysis areas will generally not correspond directly with areas actually used by NSO. Landscape pattern, both in terms of topographic features and vegetation pattern; prey distribution, abundance and availability; as well as distribution and/or abundance of competitors and predators are all likely to influence NSO territory and home range shape (Anthony and Wagner 1999).

Our understanding of space use by NSO is limited by lack of comparability among published studies due to variation in estimation methods, duration and seasonality of data collection, and whether estimates are for individuals or pairs. By looking for commonalities among studies and using a "strength of evidence" approach, however, we can evaluate whether the available information provides broadly modal values that are useful for conservation planning. Because the primary purpose of this review is to evaluate appropriate spatial scales for evaluation of effects to territorial paired NSO, we have focused on conservative estimates of year-round (annual) space use by NSO pairs.

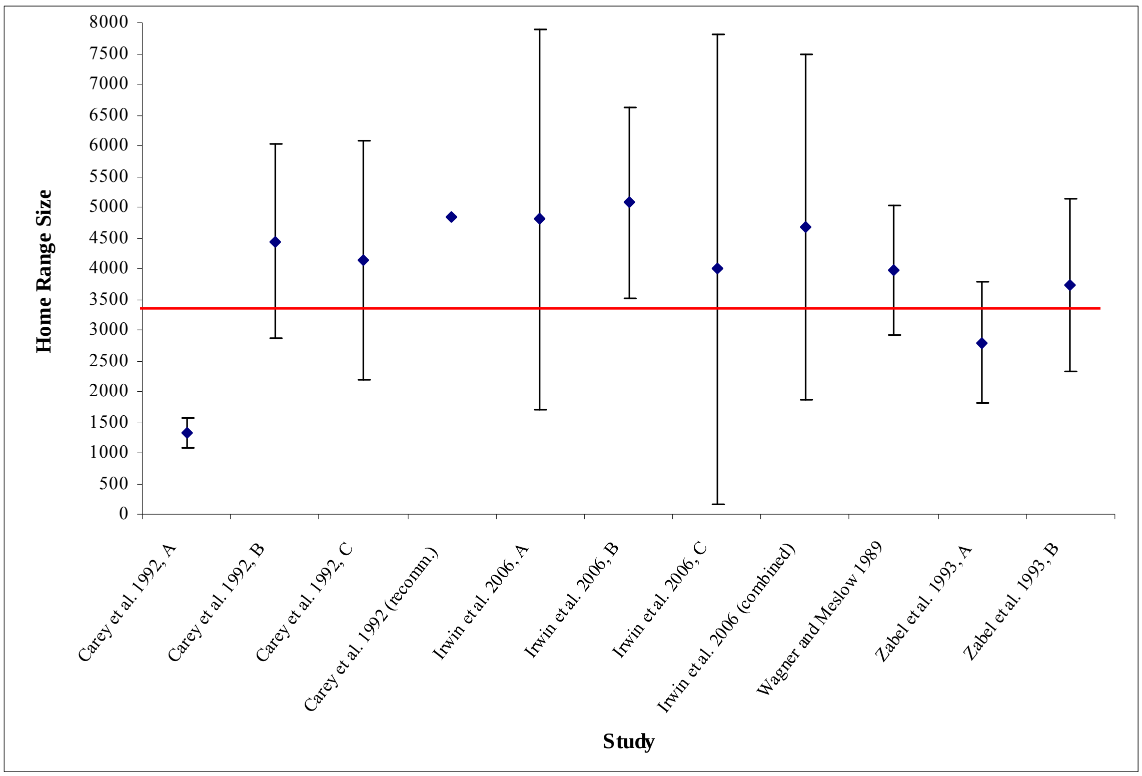
Figure III.B.1: Comparison of MCP and adaptive kernel home range estimates with corresponding circular analysis areas at an actual northern spotted owl home range.



The sizes of NSO home ranges are influenced by a variety of factors, including geographic differences in diets and habitat characteristics (Carey *et al.* 1992, Zabel *et al.* 1995). Therefore, we restricted our assessment of the validity of the 1.3-mile-radius analysis area to home range studies conducted within the Klamath Province. Because the outer analysis area should be large enough to include habitat needed to meet all major life history requirements and should accommodate areas important to both members of most pairs, we largely restricted our evaluation to studies that provided MCP estimates of the sizes of home ranges used year-round by pairs or paired individuals.

Home range studies conducted in the Klamath Province after the FPR guidelines were formulated support the use of a 1.3 mile radius analysis area, as this distance is encompassed by the confidence intervals of nearly all the home range studies we compiled. (see Figure III.B.2). Carey *et al.* (1992) found that the sizes of NSO pairs' home ranges were related to the type of forest and the degree of forest fragmentation (Table III.B.1). Pairs' home ranges in clumped, old forest were substantially smaller than the 1.3-mile-radius analysis area, whereas those in fragmented forest were somewhat larger than the analysis area. The authors suggested that management areas should be slightly larger than 1.3 miles, however, to encompass oblong-shaped home ranges. Zabel *et al.* (1993) provided estimates of 21 pairs' home ranges in two different study areas in the region (see Table III.B.2). They did not report the sizes of pairs' annual home ranges, but the average sizes of pairs' nonbreeding season home ranges were similar to the size of the FWS guidelines' outer analysis area. Pairs' annual home ranges would likely be larger than these values because their breeding- and nonbreeding-season home ranges probably do not completely overlap. In a different study, the mean cumulative pair MCP home range size for 9 pairs in the Medford, Oregon area was 3,971 acres (SD=1,063 acres), which is also similar to the 1.3-mile radius analysis area (Wagner and Meslow 1989). A fourth study by Irwin et al. (2006) showed greater mean home range sizes for 3 study areas in the region than the 1.3-mile radius analysis area used in the existing FWS guidelines (see Table III.B.3). The FWS recognizes that because of differences in methodology between these studies and those originally used to support the 1.3-mile radius analysis area (see Thomas *et al.* 1990, USFWS 1992), the results cannot be rigorously compared (see Powell 2000, Laver and Kelly 2008). Nonetheless, mean MCP values for home range area from more recent studies suggests that the outer analysis area should be somewhat larger than the 1.3-mile (3,410-acre) guideline (Figure III.B.2). We elected to retain the current guideline because, 1) the high degree of variability in MCP estimates in Figure III.B.2 does not compel us to reject the home range estimate in our existing guidelines in exchange for any particular alternative size, and 2) disproportionately high use of habitats closer to nest sites by NSO (see core areas, below) leads us to emphasize habitat conditions closer to nests, rather than expanding home range area.

Figure III.B.2: Mean Minimum Convex Polygon home range sizes (acres) for northern spotted owls in the Klamath Province, CA and OR. Error bars represent ±1 standard deviation. Horizontal line shows the size of the Fish and Wildlife Service guidelines' outer analysis area (3,410 acres).



Carey et al. 1992 = pairs' annual home ranges, A = Klamath Mountains, clumped forest, B = Klamath Mountains, fragmented forest, C = Umpqua, fragmented forest; Irwin et al. 2006 = paired-individuals' annual home ranges, A = Hilt, B = Medford, C = Yreka; Zabel et al. 1993 = pairs' nonbreeding-season home ranges, A = Mad River, B = Ukonom.

Table III.B.1: Minimum Convex Polygon estimates of annual home range sizes (acres) for northern spotted owl pairs within different types of forest in the Klamath Province, Oregon (Carey *et al.* 1992)

Area*	No. Pairs	Mean	SE
MCC	3	1317	143
MCF1	5	4139	870
MCF2	6	4438	645
Recommended	-	4843	-

*MCC = mixed-conifer, clumped, Klamath Mountains old forest; MCF1 = mixed-conifer, fragmented, Umpqua River Valley, old forest; MCF2 = mixed-conifer, fragmented, Klamath Mountains old forest.

Table III.B.2: Minimum Convex Polygon (100%) estimates of home range sizes (acres) for northern spotted owls in the Klamath Province, California (Zabel *et al.* 1993)

Study Area	Mad River		Ukonom	
	Mean	**SD**	**Mean**	**SD**
Individuals				
NB*	1989	890	2572	857
B*	1043	447	1460	578
A*	2456	1124	2847	1374
Pairs				
NB*	**2787**	986	**3721**	1409
B*	1436	368	1900	756

*NB = nonbreeding season home range; B = breeding season home range; A = annual home range.

Table III.B.3: Estimated cumulative (100%Minimum Convex Polygon) home range sizes (acres) for selected* territorial individual northern spotted owls in the Klamath Province, California (Irwin *et al.* 2006)

Study Area	Yreka	Medford	Hilt	Combined
No. Individuals	7	9	10	26
Mean	3987	5073	4805	4678
SD	3819	1557	3098	2816

*Excludes owls that did not exhibit normal ranging behavior (i.e., moved to new territory, or influenced by active timber harvest).

Core Area (0.5-Mile-Radius, 500-Acre) Analysis Area

The FPR guidelines for avoiding take of NSO during timber operations specified the amounts of habitat to be retained within 0.7 mile (986 acres) of activity centers. The 0.7-mile-radius scale was adopted in the FPR guidelines based on a study by Thomas *et al.* (1990), who found that circles of this size surrounding NSO nest sites contained significantly more suitable habitat compared with random circles. This study, however, only illustrated the importance of suitable habitat, rather than the amount of habitat required by NSO or the appropriate scales for evaluating and managing habitat (Bart 1995). The results of studies conducted after the FPR guidelines were formulated (see below) have indicated that a 0.5-mile-radius (500-acre) area around activity centers is a more appropriate scale at which to evaluate the amounts of habitat required by breeding NSO in the Klamath Province. These studies provide three primary lines of support for the core area size used in the FWS guidelines; distribution of locations of radio-telemetered NSO, territorial spacing of NSO, and studies comparing relative habitat selection at different scales.

Resources such as food and breeding and resting sites are patchily distributed in heterogeneous landscapes, such as those prevalent within the Klamath Province. In such landscapes, animals are likely to disproportionately use areas that contain relatively high densities of important resources (Powell 2000). These disproportionately used areas are referred to as core areas. One of the most influential studies of wildlife core areas was focused on NSOs in northern California (Bingham and Noon 1997). Although this study's sample size was small, it used an unusually rigorous method for determining the sizes of core areas (Powell 2000). Bingham and Noon (1997) noted that the combined size of NSO pair members' core areas is probably more meaningful than the sizes of individuals' core areas. Bingham and Noon (1997) estimated core areas by evaluating the ratio of total home range area to the area encompassing different adaptive kernel utilization distributions (UD), and found that individual NSO in northern California spent 60 to 75% of their time in their core areas, which comprised only 21 to 22% of their home ranges. The mean core area size for NSO pairs in the Klamath Province was 411 acres (166 ha; SE=26 ha; range=168-455 acres [68-184 ha]; n=7 pairs). Bingham and Noon (1997) also recommended that management guidelines attempt to meet the area requirements of most individuals in a population by accounting for variability in core area size; for example, by using the mean core area size plus one standard error. The addition of one standard error to the mean size of pairs' core areas totaled 475 acres (192 ha) for the Klamath Province data set. NSO core areas had diverse shapes due to variation in the distribution of foraging and roosting locations (Bingham and Noon 1997). However, assuming a circular shape for the purposes of evaluating and managing habitat, an area this size would have a radius of 0.49 mile. Carey and Peeler (1995) found remarkably similar results outside the Klamath Province, in southern Oregon.

We evaluated home range estimates from other studies in the Klamath Province in light of these patterns. By approximating Bingham and Noon's (1997) methodology, we evaluated kernel estimates in Irwin et al. (2004; Table 2) to estimate core area size (only 50%, 75% and 95% UD estimates were available). The 75 percent fixed kernel estimate accounted for 21 to 27 percent of the total (95%) home range, and the 75 percent adaptive kernel accounted for 23 to 30 percent, suggesting that a UD somewhat lower than 75 percent would yield core area estimates very similar to those obtained by Bingham and

Noon (1997). The addition of one standard error to individuals' mean 50 percent and 75 percent kernel density home range estimates from three different study areas in the province suggested that 500-acre analysis areas would include much of the important habitat for most breeding NSOs (Irwin *et al.* 2004, Table 2.b.4). Application of the same criteria to the results of a telemetry study in southwestern Oregon suggested that pairs used somewhat larger core areas than in other parts of the Klamath Province (Anthony and Wagner 1999, Table 2.b.5). Much of this study area is comprised of a checkerboard of public lands and industrial timberlands (Anthony and Wagner 1999, Dugger *et al.* 2005). To the extent that the amounts, quality, or contiguity of habitat have been reduced on these timberlands due to timber harvesting, NSO in this area may have larger area requirements than in parts of the province with less harvesting (Carey *et al.* 1990, 1992, Zabel et al. 1992, 1995).

Table III.B.4: Fixed kernel and adaptive kernel cumulative home range estimates (acres) for individual NSOs in the Klamath Province (Irwin *et al.* 2004).

Study Area	**Yreka**	**Medford**	**Hilt**	**Combined**
No. Individuals	9	10	11	30
No. Telemetry Points	3151	5041	2414	10606
50% Fixed Kernel				
Mean	128	210	147	162
SE	18	26	22	14
Mean + 1 SE	146	236	169	**176**
75% Fixed Kernel				
Mean	364	510	435	439
SE	38	47	54	29
Mean + 1 SE	402	557	489	**468**
50% Adaptive Kernel				
Mean	239	303	262	269
SE	47	39	42	24
Mean + 1 SE	286	342	304	**293**
75% Adaptive Kernel				
Mean	584	706	673	657
SE	124	68	91	54
Mean + 1 SE	708	774	764	**711**

Table III.B.5: Adaptive kernel home range estimates (acres) for NSO pairs in southwestern Oregon (Anthony and Wagner 1999).

Utilization Distribution	**50%**	**75%**
Mean	413	1443
SE	67	259
Mean + 1 SE	**480**	**1702**

The territorial spacing of NSO provides additional support for using a 0.5-mile-radius core area to evaluate and manage habitat for NSO in the Klamath Province. An individual's territory is thought to be the portion of the home range that both contains important resources and is economically defensible (Meyer *et al.* 1998). Therefore, average territory size provides a useful scale at which to evaluate core area habitat.

Wildlife biologists frequently use half the mean or median nearest neighbor distance to estimate the size of the defended portions of home ranges, or the portions of home ranges that are used exclusively by resident pairs (e.g., Reynolds and Joy 1998). Half the mean and median nearest neighbor distances for nesting NSO near Willow Creek were 0.49 mile (0.79 km: Hunter *et al.* 1995) and 0.44 mile (0.71 km: Franklin *et al.* 2000), respectively.

A third line of support for using a 0.5-mile-radius area for evaluating and managing habitat is provided by studies that modeled the habitat relationships of NSOs in the Klamath Province. Two studies in the region found that habitat within a 0.5-mile radius of nests differed more strongly from the general landscape compared with larger areas around nests (Hunter *et al.* 1995, Meyer *et al.* 1998, Zabel et al. 2003). While these results do not necessarily indicate that NSO are most selective of habitat at the 0.5-mile-radius scale, they do show that evidence of habitat selection by NSO is weaker at scales larger than this. Stronger support for the validity of assessing and managing habitat at the 0.5-mile-radius scale is provided by studies that modeled habitat-based fitness (Franklin *et al.* 2000, Dugger *et al.* 2005) and presence (Zabel *et al.* 2003) for NSO in the region. These studies found that important NSO-habitat relationships were well-captured at scales of 0.44 to 0.50 mile around activity centers.

III.C: Quantity, Distribution, and Configuration of Habitat

The FPR take-avoidance guidelines required that 40% of the 1.3-mile-radius analysis area and 50% of the 0.7-mile-radius analysis area be retained as suitable habitat. The FWS guidelines kept the 40% requirement because it is consistent with the results of research in the Klamath Province. However, the FWS guidelines require greater concentration of habitat near the nest or activity center than did the FPR guidelines. This concentration occurs through: (1) a decrease in the size of the inner analysis area (from 0.7- to 0.5-mile radius; see *Analysis Areas*) and (2) requirement that part of the total amount of foraging habitat (see *Habitat Definitions*) in the home range be retained within the inner analysis area. These changes are supported by studies conducted in the Klamath Province after the FPR guidelines were formulated.

Several types of information are available for evaluating the quantities, distribution, and configuration of habitat that must be retained in order to avoid take of NSO. The strongest type of information relevant to evaluation of take relates the fitness of NSO to characteristics of their habitat (Franklin *et al.* 2000, Olson *et al.* 2004, Dugger *et al.* 2005). Habitat-based fitness, or habitat fitness potential (HFP), is "the fitness conferred on an individual occupying a territory of certain habitat characteristics" (Franklin *et al.* 2000:558). HFP is a function of both the survival and reproduction of individuals within a given territory. Habitat-based modeling that accurately predicts the presence ("occupancy") of breeding NSO (Zabel *et al.* 2003) is another important tool for evaluating the species' habitat relationships. This modeling assumes that NSO gravitate toward areas likely to confer high fitness but does not directly relate habitat characteristics to the survival and reproduction of owls. Descriptions of areas around nests, and comparisons between them and random areas, are additional sources of information for investigating NSO-habitat relationships. This approach provides information about the habitat associations and preferences of NSO but must be cautiously considered because it does not relate habitat descriptions to the fitness of owls. For example, the average quantity of habitat around a sample of NSO nests could be higher than what is available around random locations, but still be lower than what is required for persistence of individuals or the population.

Comparisons among habitat studies can be problematic because researchers often define habitat differently and use different source data to classify vegetation (see Table III.C.1). Nonetheless, all studies in the Klamath Province have found that NSO exhibit strong relationships with older, more structurally complex, conifer-dominated forest classes. The concordance of these findings enabled the FWS to evaluate the guidelines relative to the quantities, distributions, and configurations of older forest within analysis areas. Spotted owls also forage within intermediate (younger and/or more open) forest classes (see *Habitat Definitions*, below). One study (Zabel *et al.* 2003; see below) found a positive association between NSO in the Klamath Province and moderate amounts of intermediate forest (see Table III.C.1) at the core area scale. This habitat class was based on conditions known to be used by foraging NSO. Other studies in the region have described the proportions of analysis areas comprised of intermediate forest classes but have not found positive associations between them and NSO. These forest classes often included conditions that receive little or no use by NSO, however, and are therefore not directly comparable with foraging habitat as defined by Zabel *et al.* (2003) and the FWS guidelines (see *Habitat Definitions*, below). There is currently no information for evaluating the proportion of intermediate forest that should be retained at the home range scale in order to avoid take of NSO in the Klamath Province.

Table III.C.1: Descriptions of suitable or selected habitat from studies of northern spotted owl-habitat relationships in the Klamath Province

Study	Location	Classification Method	Description of Selected or Suitable Habitat
USFWS 1992, Bart 1995	Washington, Oregon, northern California	research synthesis (various methods)	conifer-dominated forest with a multi-layered canopy, average DBH[1] >30 inches, ≥60% canopy cover, decadence (snags, logs, deformed trees)
Anthony and Wagner 1999	southwestern Oregon	aerial photographs, ground reconnaissance	conifer-dominated forest with a multi-layered canopy, ≥40% canopy cover, decadence, large snags and logs; characterized by trees ≥30 inches DBH and ≥200 yrs
Carey *et al.* 1992	southwestern Oregon	aerial photographs, forest inventory data, ground reconnaissance	multi-layered canopy, average DBH of dominant trees >39.4 inches, large snags and logs
Dugger *et al.* 2005	southwestern Oregon	aerial photographs, ground reconnaissance	conifer or mixed forest, ≥100 yrs; characterized by trees ≥13.8 inches DBH
Franklin *et al.* 2000	northwestern California	satellite imagery	forest comprised of ≥40% conifers, conifer QMD[2] ≥21 inches, hardwood QMD ≥6 inches, canopy cover ≥70%
Gutiérrez *et al.* 1998	northwestern California	satellite imagery	≥30% canopy cover, >50% of conifer basal area comprised of trees ≥21 inches DBH
Hunter *et al.* 1995	northwestern California	satellite imagery	≥30% canopy cover, >50% of conifer basal area comprised of trees ≥21 inches DBH
Meyer *et al.* 1998	western Oregon	aerial photographs	conifer-dominated forest, trees ≥80 yrs and/or multi-layered canopy
Ripple *et al.* 1997	southwestern Oregon	aerial photographs	conifer-dominated forest, average DBH ≥19.7 inches, canopy cover ≥60%
Solis and Gutiérrez 1990	northwestern California	timber type classification	average DBH >20.7 inches
Zabel *et al.* 1993	northwestern California	topographic maps, aerial photographs, and orthophotoquads	stands dominated (in terms of basal area) by trees >20.9 inches DBH; >20% canopy cover of dominant trees and >70% canopy cover of trees >5.1 inches DBH
Zabel *et al.* 2003	northwestern California	modified timber type classification, varied geographically	nesting-roosting habitat: for most locations average DBH ≥17 inches and average conifer canopy cover ≥60%; foraging habitat: in all locations average DBH ≥9.8 inches and average conifer canopy cover ≥40%, additional criteria in some locations

[1] DBH: Diameter at breast height

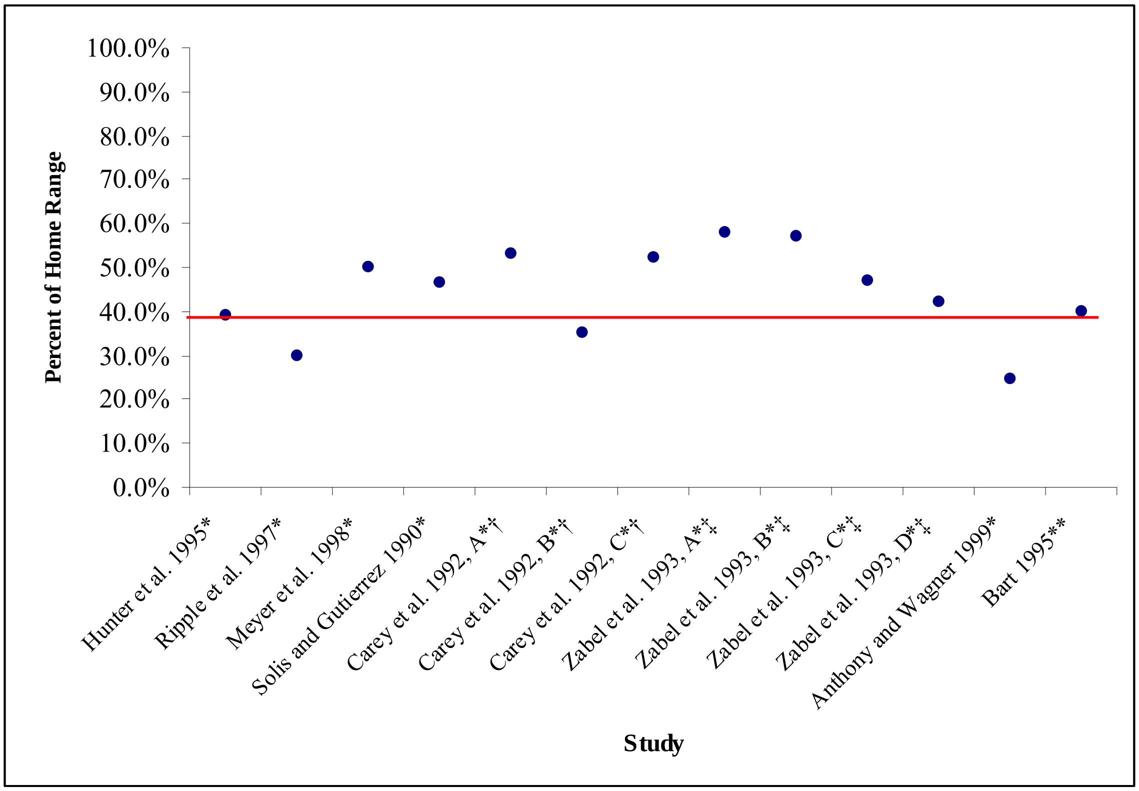
[2] QMD: Quadratic mean diameter

H*ome Range (1.3-Mile Radius)*

Bart (1995) evaluated the 1992 draft recovery plan's (USFWS 1992) requirement that at least 40 percent of the estimated home range be retained as suitable habitat. Using demographic data from throughout the NSOs' range, including the Klamath Province, he calculated that populations are stable when the average proportion of suitable habitat in home ranges is 30 to 50 percent. In a related comment on the FPR take-avoidance guidelines, Bart (1992:3) noted that "…lambda probably reaches 1.0 (stable population) when suitable habitat declines to somewhere between 40 and 55 percent. Since the Service must have good evidence that take did occur, not just that it might have occurred, using a value of 40 percent seems reasonable." Bart's (1992) conclusions continue to be supported by the results of recent research.

Studies have reported a wide range of mean proportions of older forest (ca. 24 - 58 percent; see Figure III.C.1) in home range-sized areas around NSO nests or roosts in the Klamath Province and adjacent areas (Solis and Gutiérrez 1990, Carey *et al.* 1992, Zabel *et al.* 1993, Hunter *et al.* 1995, Ripple *et al.* 1997, Meyer *et al.* 1998, Anthony and Wagner 1999). Variation in proportions of habitat was likely due to multiple factors, particularly differences in habitat classification (see Table III.C.1), but also including sizes of analysis areas and study season (i.e., breeding versus non-breeding), as well as geographic differences in the abundance and quality of habitat. Regardless, the central tendency of these means is about 45 percent; a somewhat higher percentage than the FWS guidelines. We retained the 40 percent threshold, however, because; 1) the FWS guidelines specify amounts of high-quality habitat, rather than a single 'suitable habitat' category, and; 2) FWS guidelines incorporate a higher standard for classifying forest habitat as ‘suitable’ than was used in many of the studies in Figure III.C.1, and; 3).

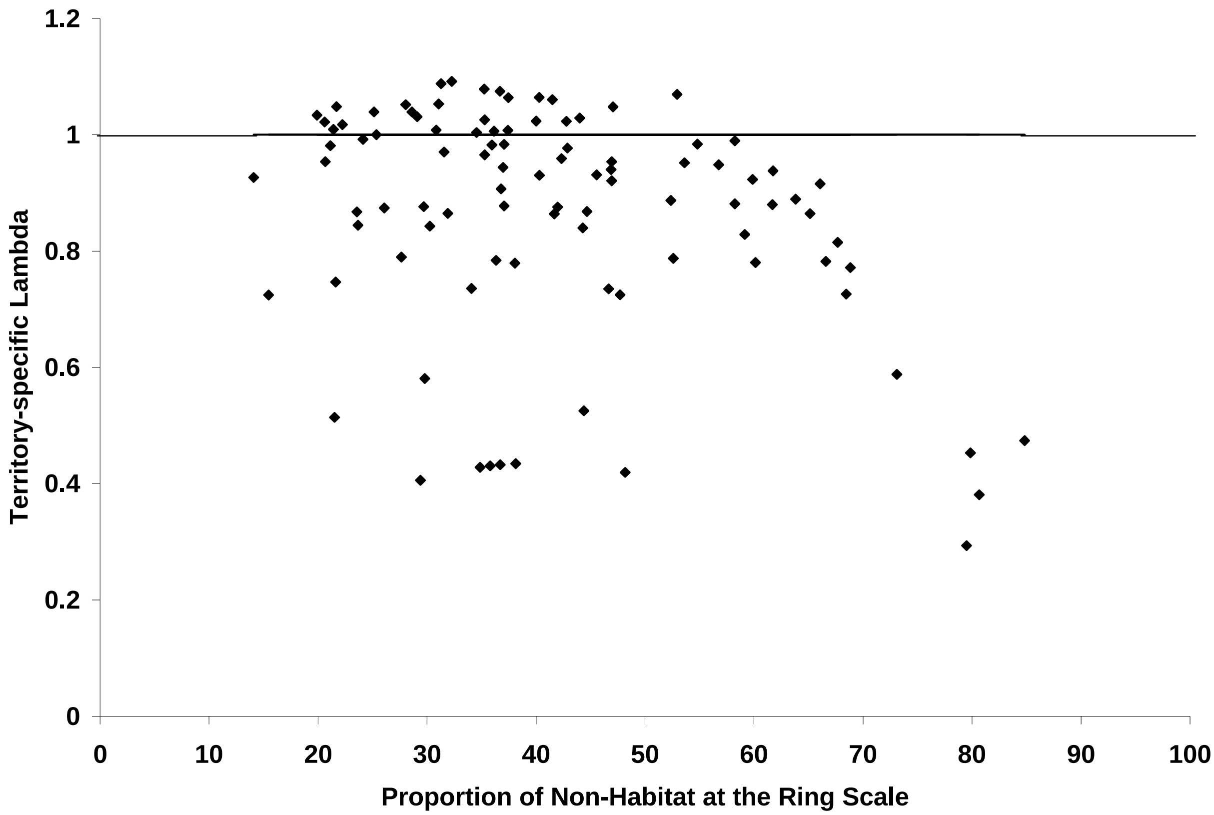
Figure III.C.1: Proportions of older forest (see Table III.C.1) at home range scales around northern spotted owl territory centers in the Klamath Province, CA and OR. Horizontal line shows the proportion of older forest required by the Fish and Wildlife Service guidelines (40 percent).



*Mean proportion. **Recommendation for take-avoidance guidelines. †Carey et al. 1992: A = Klamath Mountains, clumped forest, B = Klamath Mountains, fragmented forest, C = Umpqua, fragmented forest. ‡Zabel et al. 1993: A = Ukonom, breeding season, B = Ukonom, nonbreeding season, C = Mad River, breeding season, D = Mad River, nonbreeding season.

Research in the Klamath Province and adjacent areas indicates that NSO habitat should be concentrated at the core area scale around nests and interspersed with other land cover classes in the rest of the home range. For this reason, the FWS guidelines require retention of a higher proportion of the home range’s total suitable habitat (particularly nesting/roosting habitat) to be within the core area, and allow a wider range of forest conditions in the outer ring. A study in southwestern Oregon showed that HFP was optimal for NSO when the estimated home range beyond the core area (3,430-acre ring) was comprised of large amounts of forest (young, mature, and old classes) and an intermediate amount (ca. 38%) of "nonhabitat" (nonforest, early seral forest, heavily harvested forest) (Dugger *et al.* 2005; see Figure III.C.2). At this scale, HFP was below 1.0 at all territories with >50 percent nonhabitat. A similar study just outside the Klamath Province in southern Oregon found that high survival of NSO usually occurred with large proportions (ca. 70 percent was optimal) of conifer forest (average DBH >9.5 inches) in estimated home ranges (1,747 acres), whereas high reproduction was associated with large amounts of edge between "nonforest" (average diameter at breast height (DBH) <9.5 inches) and other vegetation classes (Olson *et al.* 2004). These findings suggest that HFP is highest when home ranges consist of large amounts of both forest and forest-edge. Zabel *et al.* (2003) found that the best large-scale (2,224-acre) model for probability of occupancy by NSO in northwestern California was an intermediate amount of old forest (≥24 inches DBH and ≥70 percent canopy cover) edge. Thus, both the demography and presence of NSO in the Klamath Province appear to be positively associated with an intermediate amount of horizontal heterogeneity at the home range scale.

Figure III.C.2: Association between habitat fitness potential (territory-specific lambda) and proportion of "nonhabitat" (nonforest, early seral stages, older forest receiving timber harvest entries removing >40 percent basal area in the portion of the estimated home range outside the estimated core area (3,430-acre ring) in southwestern Oregon (Dugger *et al.* 2005).



Core Area (0.5-Mile Radius)

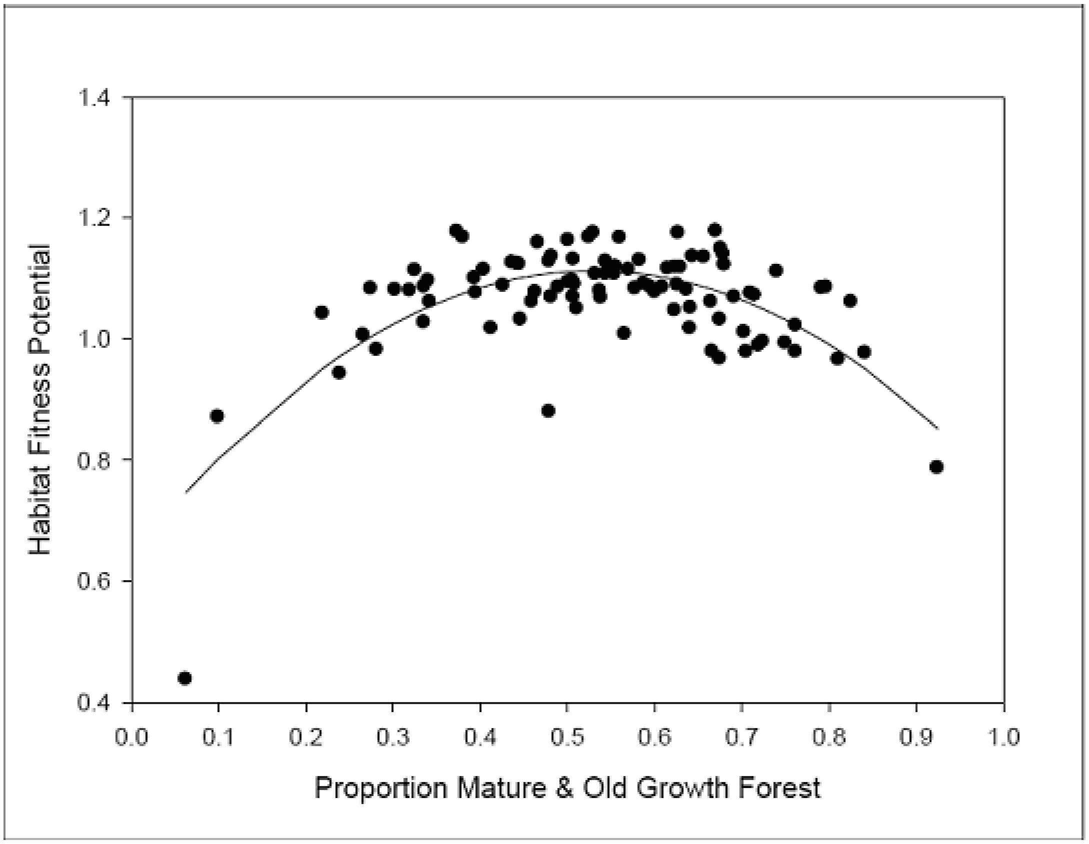
The disproportionate importance of habitat conditions within NSO core areas is indicated by the species' concentrated use of areas close to the territory center (see *Analysis Areas* and *Habitat Definitions*). The core area's relevance has also been demonstrated by strong associations between habitat patterns and the demography (Franklin *et al.* 2000, Dugger *et al.* 2005) and occurrence (Zabel *et al.* 2003) of NSO.

The results of two rigorous demographic studies of NSO in the Klamath Province (Franklin *et al.* 2000, Dugger *et al.* 2005) provide strong, consistent inferences regarding the relationship between habitat conditions and measures of NSO fitness such as adult survival and HFP at the core area scale. Although the habitat-based fitness models of Franklin *et al.* (2000) and Dugger *et al.* (2005) differ somewhat, both studies indicated that HFP for NSO in the Klamath Province was most likely to be ≥1 when at least 50% of the estimated core area was comprised of older forest (see Table III.C.1 for habitat criteria). An HFP of ≥1 indicates that a territory has the characteristics required for breeding females to replace themselves or contribute a surplus to the population (Franklin *et al.* 2000).

Franklin *et al.* (2000) found that territory-specific adult survival was strongly associated with the amounts of interior older forest in addition to the amount of edge between older forest and other vegetation types (see Table 7 in Franklin *et al*. 2000) at the core area scale (390 acres, 158 ha). Interior older forest was the amount of older forest 328 feet (100 m) from an edge and is not equivalent to the simple amount of older forest within a core. Interestingly, HFP declined overall when the core area contained more interior old forest. This was apparently due to a tradeoff between habitat characteristics associated with survival (amount of interior habitat and length of habitat edge) and reproduction (amount of habitat edge). High quality territories typically had core areas comprised of large patches of older forest with convoluted edges. Estimates of the amount of interior older forest that correlated with HFP >1 were provided to the FWS by Dr. Franklin (personal communication, September 19, 2005). The minimum proportion of interior older forest corresponding to HFP >1 was 41 percent; addition of the older forest area within the 328-foot "edge buffer" yielded a proportion of 62 percent ("total core": Franklin 1997). Based on this evaluation, Dr. Franklin recommended that 60 percent of the core area be comprised of older forest (Franklin, personal communication, September 19, 2005). The FWS guidelines incorporate the apparent positive influence of moderate amounts of edge by 1) requiring that retention of high-quality habitat be concentrated at the core scale and 2) specifying amounts of older forest and foraging habitat in the core.

Data sets used in Franklin *et al.* (2000) were recently re-analyzed to evaluate the relationship between HFP and the simple proportion of older forest within NSO core areas (Franklin 2006). The results of this analysis, proposed in Appendix D of the 2007 Draft Recovery Plan for the Northern Spotted Owl (USFWS 2007), indicated a quadratic relationship between HFP and older forest, with optimum HFP occurring when 53 percent of the estimated core area consisted of older forest (Franklin *et al.* 2000; Figure III.C.3). More than half (55 percent) of the high-quality (HFP $\geq$1) territories had core areas comprised of 50 to 65% older forest. This pattern is consistent with the previously described recommendations of Dr. Franklin and the habitat retention guidelines developed by the FWS.

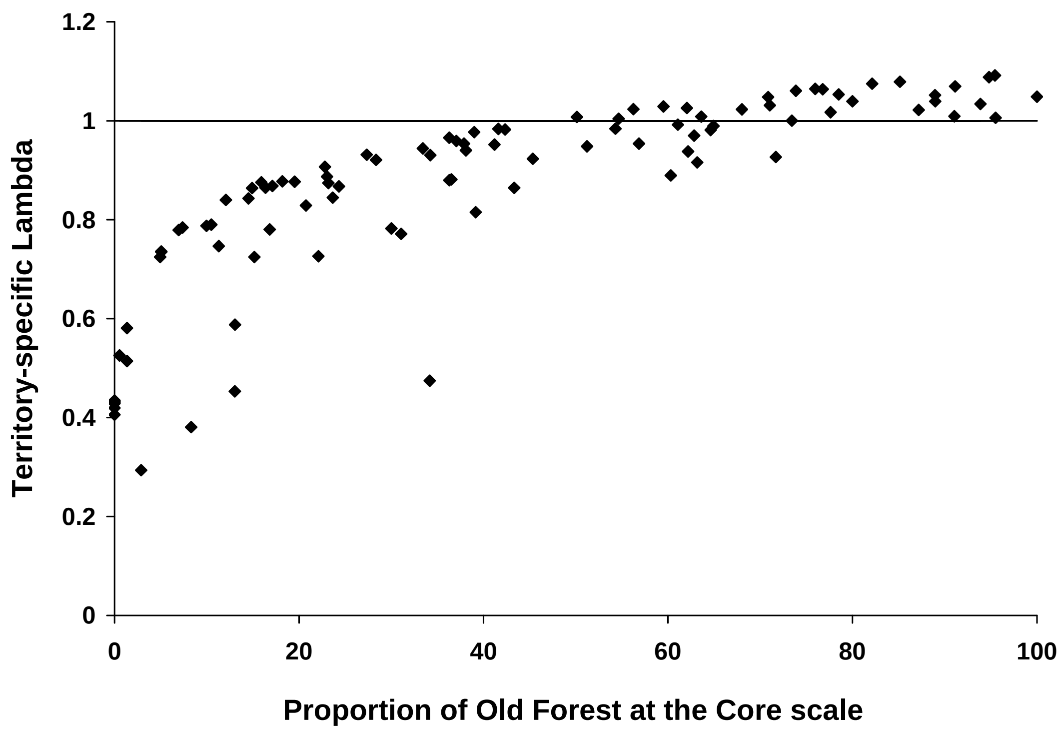
Figure III.C.3: Relationship between habitat fitness potential for northern spotted owls and proportion of older forest (see Table III.C.1) within 0.44 mile of territory centers in northwestern California (courtesy A. Franklin)



Because roughly 29 percent of high-quality territories (HFP ≥1) (Figure III.C.3) contained less than 50 percent old forest, some have suggested that a substantially lower habitat retention guideline would be adequate to avoid incidental take in timber harvest operations. Use of Franklin (2006) as the sole means of support for habitat retention guidelines is inappropriate (Franklin 2007) however, because the model estimating survival based on simple amounts of older forest was not well-supported and had only 3 percent of the weight in the model set (as opposed to 42.7 percent for the best-supported model which included interior old forest and amount of edge; see Table 7 in Franklin *et* *al.* 2000). Use of the simple amount of older forest for evaluating take of NSO is inappropriate because it ignores the model selection process used in Franklin *et al.* (2000), which found that simple amounts of older forest alone did not explain variation in survival nearly as well as amounts of interior older forest and edges (Franklin 2007). Nichols and Pollock (2008) reviewed the use of HFP in the draft NSO Recovery Plan and concurred with Franklin (2007), stating that plots based on a single variable (percent old forest) instead of multiple covariates in the model of Franklin *et al.* (2000) are potentially misleading. Consequently, the analysis using solely percent old forest was deleted from the final 2008 NSO Recovery Plan, and was not used by the FWS to develop recent NSO habitat retention guidelines.

In a similar study in southern Oregon, Dugger *et al.* (2005) found that HFP was positively related to the proportion of older forest in the estimated core area (413 acres, 167 ha), although it became decreasingly sensitive to increased proportions (see Figure III.C.4; Dugger, unpub. data). Roughly 72 percent of core areas with HFP greater than 1.0 had more than 50 percent older forest; whereas cores with HFP less than 1.0 never contained more than 50 percent older forest. In contrast to the conclusions of Franklin *et al.* (2000), the correlation of HFP with proportion of older forest in the estimated core area was roughly linear; HFP did not decline at high levels of older forest. It is unclear why these studies found differences in the nature of the NSOs' relationships with quantities of older forest in the core area. Possible reasons for this dissimilarity include differences in the availability and quality of habitat in the study areas and in the studies' classifications of habitat (see Table III.C.1). For example, the area studied by Dugger *et al.* (2005) was strongly fragmented by industrial timberlands in a checkerboard pattern, whereas the area studied by Franklin *et al.* (2000) was dominated by less-intensively managed federal lands. Regardless, both studies found that high quality territories typically had core areas comprised of at least 50 percent older forest.

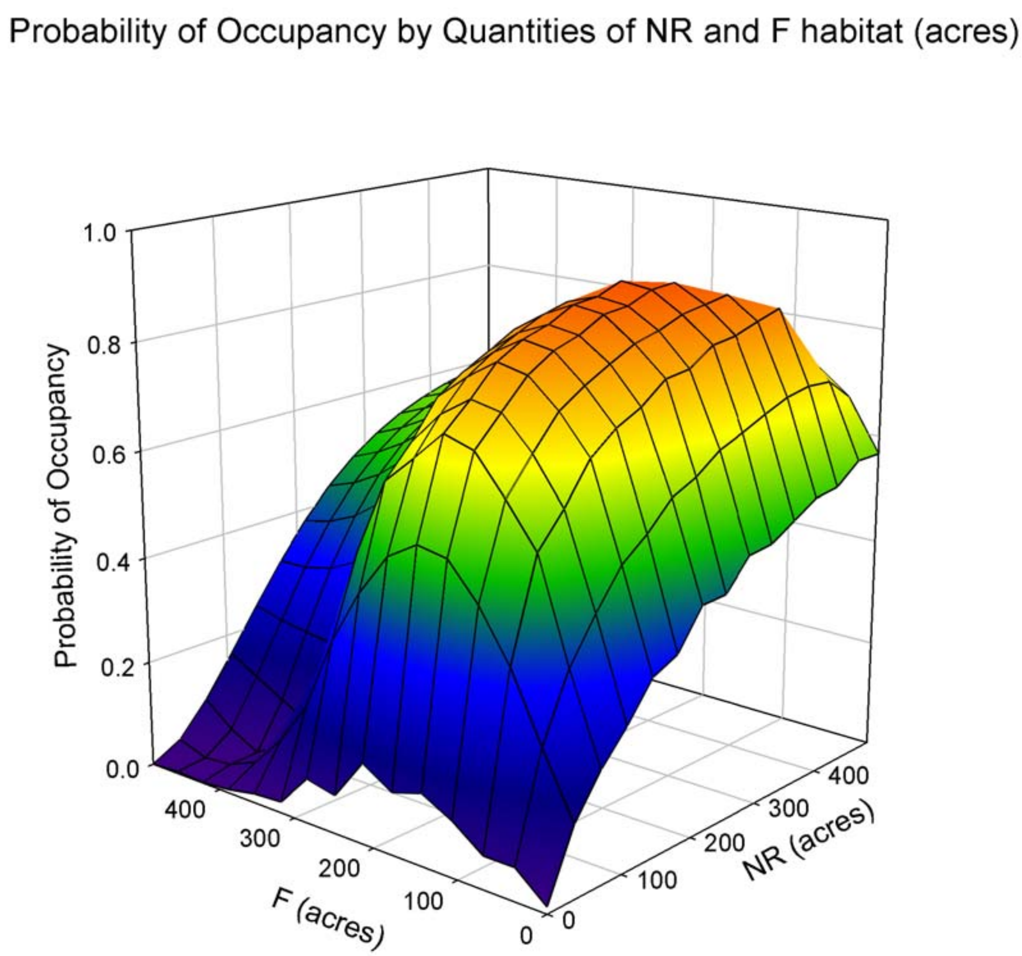
Figure III.C.4: Relationship between habitat fitness potential (territory-specific lambda) for northern spotted owls and proportion of older forest (see Table III.C.1) within 413 acres around territory centers in southwestern Oregon (courtesy K. Dugger)



Zabel *et al.* (2003) modeled the probability of occupancy for NSO in the Klamath Province based on habitat conditions at the core area scale (500 acres). The overall best model in this study indicated that the probability of NSO occurring in a given location was positively, albeit diminishingly, influenced by increased amounts of nesting-roosting habitat and by intermediate amounts of foraging habitat at the core area scale (see Table

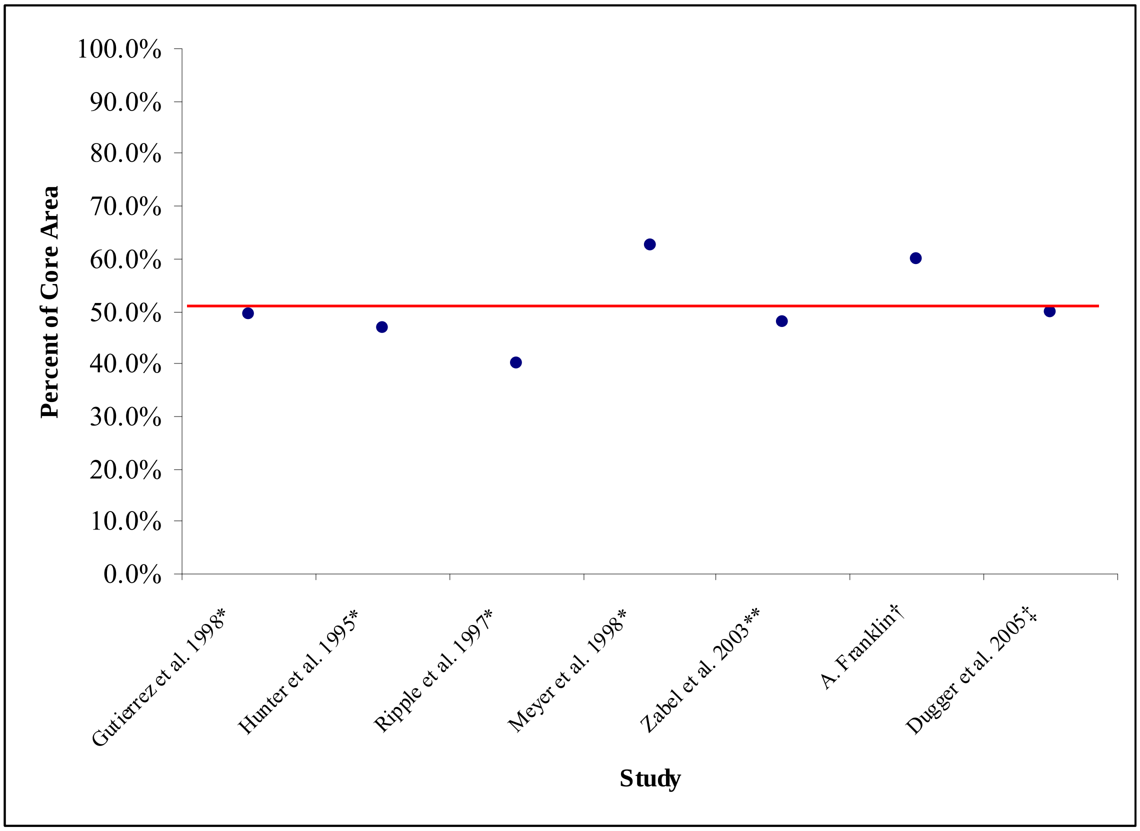
III.C.1 for habitat definitions). The highest probability of occupancy occurred when the core area scale consisted of 60 to 70 percent nesting-roosting habitat and 30 to 40 percent foraging habitat (see Figure III.C.5). The averages for all combinations of habitat associated with a high probability (≥0.70) of occupancy were 48 percent nesting-roosting habitat and 28 percent foraging habitat.

Figure III.C.5: Probability of northern spotted owl occupancy in the Klamath Province associated with amounts of nesting-roosting (NR) and foraging (F) habitats (see Table III.C.1) at the 500-acre (200 ha) scale (Zabel *et al.* 2003)



Researchers have reported a wide range of mean proportions of older forest (ca. 35-60 percent; see Figure III.C.6) at the core area scale around NSO nests in the Klamath Province and adjacent areas (Hunter *et al.* 1995, Ripple *et al.* 1997, Gutiérrez *et al.* 1998, Meyer *et al.* 1998). It is difficult to assess how much of this variation was due to differences in ecological setting, spatial scale, habitat classification, and individual variation among owls. Nonetheless, the central tendency of these results was roughly 50-60 percent, which is consistent with the FWS guidelines' requirement for proportion of nesting and roosting habitat (see *Habitat Definitions*) in the core area (see Figure III.C.6). The mean proportions of older forest at core area scales were higher than those around locations chosen for comparison (random or "unused" locations). Thus, NSO in the Klamath Province appear to select home ranges with large amounts of older forest concentrated around suitable nest locations.

Figure III.C.6: Proportions of older forest (see Table III.C.1) at core area scales around northern spotted owl territory centers in the Klamath Province, CA and OR. Horizontal line shows the proportion of older forest required by the FWS guidelines (50 percent)



*Mean proportion. **Mean proportion associated with ≥70% probability of occupancy. †Recommendation based on the combined proportions of interior and edge-buffer older forest associated with a habitat fitness potential greater than 1 (Franklin et al. 2000). ‡Approximate proportion of older forest associated with a habitat fitness potential of at least 1.

Taken together, the results of studies conducted in the Klamath Province support the conclusion that at least 50 percent of the core area should consist of older forest. Older forest is more likely than other vegetation classes to provide NSO with suitable structures for perching and nesting, a stable, moderate microclimate at nest and roost sites, and visual screening from both predators and prey (see *Habitat Definitions*).

Franklin *et al.* (2000) found that survival and HFP were highest when older forest occurred as large patches in the core area. Larger patches of forest likely buffer NSO from wind and heat associated with forest-opening edges (Chen *et al.* 1995) and predators and competitors associated with open or fragmented forest (e.g., great horned owls [*Bubo virginianus*]: Johnson 1993). Modeling by Franklin *et al.* (2000) also indicated that a balance of interior older forest and edge habitat in the core area is important to NSO in the region. The value of habitat edges for NSO might be related to the availability of woodrats and other prey species associated with more open, early-seral vegetation. The positive influence of large-bodied prey species such as woodrats on NSO reproductive success has been described in northwestern California (White 1996). However, habitat edges in the Franklin *et al.* study occurred wherever habitat was juxtaposed with other land cover classes, and was not necessarily related to the presence of woodrat habitat. In fact, the survival and reproduction of NSO did not appear to be influenced by woodrat habitat in the core area. Zabel *et al.* (2003) found that probability of occupancy by NSO was highest when the core area scale contained some foraging habitat, as well as nesting-roosting habitat. This result suggests that horizontal heterogeneity in the core area should be partially provided by a range of forest conditions suitable for use by NSO, dominated by older forest conditions, (see *Habitat Definitions*, below), not simply the juxtaposition of suitable and unsuitable habitat.

III.D: Habitat Definitions:

Determination of the amount of suitable habitat that must be retained in order to avoid incidental take of NSO is strongly influenced by the range of forest conditions that are classified as suitable habitat. The HFP models of Franklin *et al.* (2000), Olson *et al.* (2004), and Dugger *et al.* (2005) contain a limited number of habitat variables and relatively coarse definitions of NSO habitat, and therefore must be supplemented with additional information on forest structural parameters that support classification of forest habitat as suitable for nesting and foraging. Description of the structural characteristics of NSO habitat and delineation of the range of habitat conditions corresponding to essential activities such as nesting, roosting, and foraging is a critical element of developing guidelines for evaluating the likelihood of incidental take. Because the structural attributes of habitat immediately surrounding nests are easily quantified, data supporting classification of nesting habitat are readily available (see section III.C).

Foraging habitat, on the other hand, is more variable and spatially extensive, requiring intensive radio-telemetry studies to measure use of various habitat conditions by NSO. In recent studies by the National Council for Air and Stream Improvement (NCASI), correlations between habitat data from detailed forest inventories and nocturnal locations of radio-tagged NSO and California spotted owls were used to estimate resource selection function (RSF) models (Irwin *et al.* 2007a,b) that quantify complex relationships between the owls and their environment. These models allow evaluation of the relative use of specific forest structural variables such as tree size class distribution and stand density by foraging NSO. The studies of Irwin *et al.* (2007a, b), combined with other telemetry studies (Solis and Gutiérrez 1990), provide the basis of our definitions of suitable foraging habitat for NSO.

NSO are generally associated with structurally complex conifer or mixed-conifer forests containing dense, multilayered canopies and significant components of large-diameter trees and decadence in the form of deformed trees, snags, and down wood (Thomas *et al.* 1990, Gutiérrez 1996, Courtney *et al.* 2004, USFWS 2008). Variation in seral stage association has been reported for individuals within study areas and for populations in different study areas (Gutiérrez 1996). However, extensive use of younger forests by spotted owls tends to be reported in unusually productive forest types in coastal areas (Folliard *et al.* 1993, Thome *et al.* 1999) or in stands containing structural complexity retained from previous stands (Blakesley *et al.* 1992, Zabel *et al.* 1993, Carey and Peeler 1995, Irwin *et al.* 2000). In particular, NSO have been shown to nest and forage successfully in young redwood forests; in such areas their densities are among the highest on record (Diller and Thome 1999). Young redwood forests have also been associated with high reproduction in spotted owls (Thome et al. 1999). The ability of NSO to successfully occupy young redwood forests has been attributed to resource availability; young forests have been found to produce the highest abundance of woodrats in Douglas-fir/tanoak forests (Sakai and Noon 1993), and in the redwood/Douglas-fir zone, woodrats were most abundant in stands 5 to 20 years of age (Hamm et al. 2007: USDA Forest Service Gen. Tech. Rep. PSW-GTR-194). Ward et al. (1998) described the benefit of an energy rich woodrat diet; and White (1996) describes the positive influence of woodrat consumption on nesting success. The value of younger forest to NSO in the drier portions of the Klamath Province is poorly understood, whereas numerous studies in the Klamath Province and adjacent regions have demonstrated that NSO selectively use older, denser forest at a variety of spatial scales (e.g., Solis and Gutiérrez 1990, Bart and Forsman 1992, Blakesley *et al.* 1992, Carey *et al.* 1992, Hunter *et al.* 1995, Ripple *et al.* 1997, LaHaye and Gutiérrez 1999, Zabel *et al.* 2003) and that such forest is positively associated with measures of reproduction and survival (e.g., Ripple *et al.* 1997, Meyer *et al.* 1998, Franklin *et al.* 2000, Olson *et al.* 2004, Dugger *et al.* 2005).

Although spotted owls are generally associated with and preferentially select older, denser forest, suitable habitat for the species can be viewed as a continuum of structural conditions. Owls tend to use parts of this continuum more frequently than others, and to focus their activities within certain parts of it for meeting particular life history needs. The FWS has classified this continuum into habitat categories based on the conditions' primary function and apparent quality for NSO (nesting/roosting or foraging habitat, high or low quality habitat; see Table III.D.1 and Figure III.D.1). The FWS recognizes that conditions within a habitat category may be used by NSO to meet multiple life history needs; for example, NSO may forage in nesting/roosting habitat or roost in foraging habitat. We also acknowledge that rigorous classification of habitat quality requires an understanding of the relationships between habitat conditions and the demography of NSO. However, because NSO are mobile animals with large home ranges, most studies have used low-resolution vegetation data and broad habitat categories to explore their habitat relationships (see Table III.C.1). These studies have greatly improved our understanding of NSO-habitat relationships but provide limited insight into the specific structural conditions used by owls.

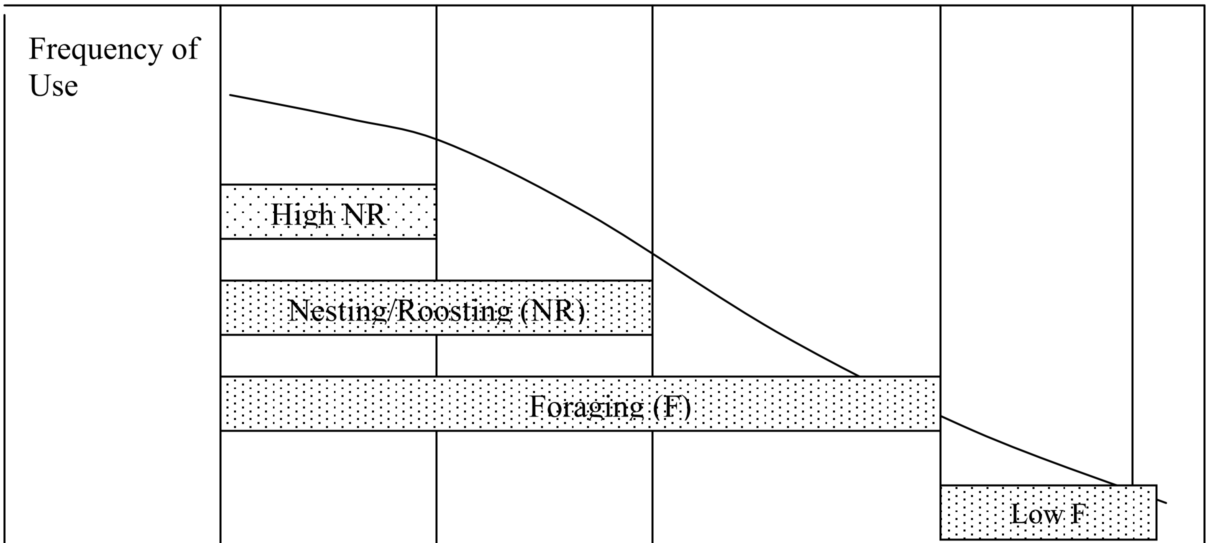
Table III.D.1: Values for selected structural parameters used in the Fish and Wildlife Service guidelines to classify nesting/roosting and foraging habitat for northern spotted owls.

Habitat category	Tree Size (QMD)[1]	Basal Area[2]	Trees > 26"dbh	Canopy closure
High nesting/roosting	≥ 15"	≥ 210 ft^2	8 per acre	≥60%
Nesting/roosting	≥ 15"	150–180+ ft^2	8 per acre	≥ 60%
Foraging	≥ 13"	120-180+ ft^2	5 per acre	≥ 60%
Low foraging	≥ 11"	80-120+ ft^2		≥ 40%

1: Quadratic Mean Diameter (inches) of trees > 5" diameter
2: Square feet per acre, trees > 5"

A few studies have provided plot-level descriptions of areas used by NSO. Habitat definitions in the FWS guidelines are primarily based on the statistical distributions of habitat parameters correlated with use by owls in these studies. Yet, the average conditions in small study plots around owl locations may poorly represent the inherent variability of stands and landscapes in owl territories. Therefore, the FWS guidelines distribute habitat categories in terms of ranges of values within analysis areas, rather than as stand averages. This approach ensures that a range of suitable habitat conditions is well-distributed at appropriate spatial scales, without being unrealistically or unreasonably prescriptive.

Figure III.D.1: Conceptual model of northern spotted owl habitat functions and associated forest structural conditions.



Basal Area	300+	200	150	120	80
QMD[1]	20”		15”	13”	11”
TPA > 26”[2]	50		8	5	
Canopy[3]	100%		60%		40%
Structure	Large tree/dense	Large/open to medium/dense		small/dense to open/brushy	

1: QMD= quadratic mean diameter of trees > 5 inches dbh
2: TPA>26”= trees per acres of trees >26 inches dbh
3: Canopy= percent cover of overstory trees

The FWS guidelines use a suite of structural metrics to classify NSO habitat (basal area, quadratic mean diameter, large-diameter [>26 inches DBH] trees per acre, and canopy cover) (Table III.D.1). We chose these metrics because they describe different aspects of stand structure that appear to be important to NSO and because they are commonly used by silviculturists to evaluate forest conditions. The FWS discourages the use of broad vegetation classification categories for defining habitat for NSO in the Klamath Province. These classification schemes are inappropriate for defining habitat in take-avoidance guidelines because they encompass broad ranges of vegetation parameters that often do not correspond to habitat used by NSO. For example, habitat class 4M in the CWHR system (average DBH 11 - 24 inches and average canopy cover 40-59 percent) might describe anything from infrequently-used foraging habitat to nesting and roosting habitat. Furthermore, use of broad habitat classification schemes can mask the effects of habitat modification. For example, timber harvests could remove important habitat elements (e.g., snags, deformed trees, dense groups of large trees) while maintaining the minimum average canopy cover and tree diameter values in a given habitat category and masking the loss of habitat quantity and quality.

Habitats Used for Nesting and Roosting

The 2008 NSO Recovery Plan (USFWS 2008:50) stated that: "Features that support nesting and roosting typically include a moderate to high canopy closure (60 to 90 percent); a multi-layered, multi-species canopy with large overstory trees (with diameter at breast height [dbh] of greater than 30 inches); a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for spotted owls to fly." The validity of applying this rangewide habitat definition to the Klamath Province has been supported by numerous studies in and adjacent to the region (e.g., Solis and Gutiérrez 1990, Blakesley *et al.* 1992, Carey *et al.* 1992, Hershey *et al.* 1998, LaHaye and Gutiérrez 1999), including on private timberlands (Self *et al.* 1991, SPI 1992, Farber and Crans 2000).

The characteristic structure of nesting/roosting habitat probably serves a variety of functions for NSO. NSO may partly favor older, more decadent forest for nesting because it frequently contains suitable nest structures. Nests are usually located in older, larger-diameter, deformed, decadent, or diseased trees containing cavities or platforms (Forsman *et al.* 1984, Hershey *et al.* 1998, LaHaye and Gutiérrez 1999, North *et al.* 2000). Northern spotted owls may also nest and roost in older, denser forest because it tends to provide a more moderate, stable microclimate compared with other kinds of forest. NSO are less able to dissipate body heat than other owls and appear to compensate by nesting and roosting in relatively cool, humid sites (Barrows 1981, Ganey *et al.* 1993, Ting 1998, Weathers *et al.* 2001). NSO also appear to use dense, multilayered canopies for protection from cold, wet weather (Forsman *et al.* 1984, North *et al.* 2000). Northern spotted owls may also prefer nesting and roosting in denser forest because it provides visual screening from predators (Carey 1985, Buchanan *et al.* 1995).

High-quality nesting/roosting habitat

As defined by the FWS guidelines, high-quality nesting/roosting habitat occurs where structural conditions resemble or exceed those of most observed NSO nest sites in northern California (see Table III.D.2). To date, no Klamath Province study has directly compared plot-level vegetation data for nest and roost sites to the demography of NSO, so it is unknown if the average structural conditions used by owls in the region are associated with high reproduction and survival. Therefore, a definition of high-quality nesting/roosting habitat must account for variability in habitat-use patterns among individuals by ensuring that the range of habitat values associated with owl use are well-represented, rather than prescribing a single criterion based on mean values.

Nesting/roosting habitat

The FWS' definition of nesting/roosting habitat is similar to high-quality nesting/roosting habitat, but is intended to reflect both variability in the structure of sites used by nesting and roosting owls and the variability typical of forest stands or patches encompassing denser nest and roost sites (see Table III.D.1and III.D.2). The FWS guidelines' requirement for a mix of basal areas in nesting/roosting habitat allows land managers some operational flexibility but also discourages homogenization of stands during harvesting. Although it is more stringent than that used in the FPR guidelines, the FWS guidelines provide definitions of habitats used for nesting and roosting that consistent with the range of conditions found at many spotted owl nest cores on private timberlands.

Table III.D.2: Mean structural characteristics of areas used by spotted owls for nesting, roosting, and foraging (rounded to the nearest whole number). The habitat variables are basal area (BA), quadratic mean diameter (QMD), large trees per acre (TPA), and canopy cover (CC)

Source	**FWS Guidelines**	**White 1996**	**Self et al.****	**Farber and Crans 2000**	**Irwin et al. 2007**	**L. Irwin, unpubl.**
Location	Klamath Province	Klamath National Forest*	Klamath Province and So. Cascades	Klamath Province and So. Cascades	Northern Sierra Nevada (CSOs)	Medford, Klamath Province
Habitat Type	High-Quality Nesting/ Roosting	Nest & Roost Sites	Nest Sites	Nest Sites	Roost Sites	
Plot Size	-	0.2-0.3 ac	1 ac	0.1 ac, 2.5 ac		
BA (ft2/ac)	≥210	246†	212‡	210, 166†	216†	
QMD (in)	≥15		16‡	14, 12†	16†	
TPA >26"	≥8				8	
TPA >35"	-	8				
CC%	≥60	73		70, 67	75	
Habitat Type	Nesting/ Roosting (High-Quality Foraging)		Nest Patches	Nest Stands	Foraging Locations	Foraging Locations
BA (ft2/ac)	mix >150		173‡	124†	190	180†
QMD (in)	≥15			13†	14	20†
TPA >22"	-		16			
TPA >26"	≥8				7	8
TPA >32"	-		4			
CC%	≥60				69	
Habitat Type	Foraging					Foraging Locations (Lower 25%)
BA (ft2/ac)	mix >120					120
QMD (in)	≥13					14
TPA >26"	≥5					0
CC%	mix ≥40					
Habitat Type	Low-Quality Foraging					Foraging Locations (Lower Values)
BA (ft2/ac)	mix >80					See Figure III.D.2
QMD (in)	≥11					See Figure III.D.3
CC%	≥40					

*Excludes data from the Goosenest Ranger District in the southern Cascade Range. **SPI = Self *et al.* 1991, SPI 1992, and Table III.D.2. †All trees >5" DBH (lower cutoff reported for QMD, assumed for BA). ‡All trees >6" DBH (lower cutoff reported for QMD, assumed for BA).

Foraging Habitat

Foraging habitat encompasses nesting and roosting habitat but includes a broader range of structure and might not support successful nesting by NSO (Gutiérrez 1996, USFWS 2008). Foraging NSO generally use older, denser, and more complex forest than expected based on its availability, but they also use younger forest (Solis and Gutiérrez 1990, Carey *et al.* 1992, Zabel *et al.* 1993, Carey and Peeler 1995, Anthony and Wagner 1999, Irwin *et al.* 2007b). The FWS guidelines incorporate this structural variability by specifying retention of habitat in four functional categories of habitat suitable for NSO. High-quality nesting/roosting and nesting/roosting habitat provide the upper range of stand structure selected by foraging NSO; foraging habitat encompasses a broad range of structure, and low-quality foraging habitat includes younger and more open habitats that may be important for prey production (Tables III.D.1 and III.D.2; Figure III.D.1). Northern spotted owls may prefer older, denser forest for foraging because it often contains both abundant prey and suitable structural characteristics for hunting. Several important prey species, including flying squirrels (*Glaucomys sabrinus*) and western red-backed voles (*Clethreionomys californicus*) tend to be most abundant in older, denser forest (Carey *et al.* 1992; Waters and Zabel 1995, 1998). Other important prey species, such as woodrats, have been found to be most abundant in young sapling stands (Sakai and Noon 1993), but can also reach high abundances in dense, old forest (Carey *et al.* 1992, Sakai and Noon 1993). Spotted owls usually hunt by listening and scanning for prey from elevated perches (Forsman *et al.* 1984). Dense, multilayered forest might provide owls with hunting perches at a variety of canopy levels (North *et al.* 1999). Dense vegetation might also visually screen foraging NSO from predators and prey

(Carey 1985, Buchanan *et al.* 1995). Conversely, spotted owls require space for flying, which could place an upper limit on the understory density of suitable habitat (Irwin *et al.* 2007b).

Descriptions of habitat structure used by foraging NSO are typically based on studies employing radio telemetry to monitor owl movements. While the habitats associated with nocturnal telemetry locations are commonly termed 'foraging locations', some researchers point out that the owl locations simply indicate the distribution of movements, and may not correspond to sites and habitats actually used by actively foraging NSO. During radio telemetry studies in northwestern California, Diller (unpub. data), found that owls moved frequently during monitoring periods (7.5 minutes/perch for 6 males; 17.0 minutes/perch for 4 females), suggesting that the process of triangulating azimuths for each location was unlikely to detect a specific site used for foraging. Conversely, owls in this study also were stationary for long periods of time, possibly resting, preening, or other activities not associated with active foraging. For these reasons, the FWS recognizes that our descriptions of NSO foraging habitat likely represent the range of habitat conditions used by owls at night, and may not represent the specific habitat qualities of sites where NSO successfully obtain prey.

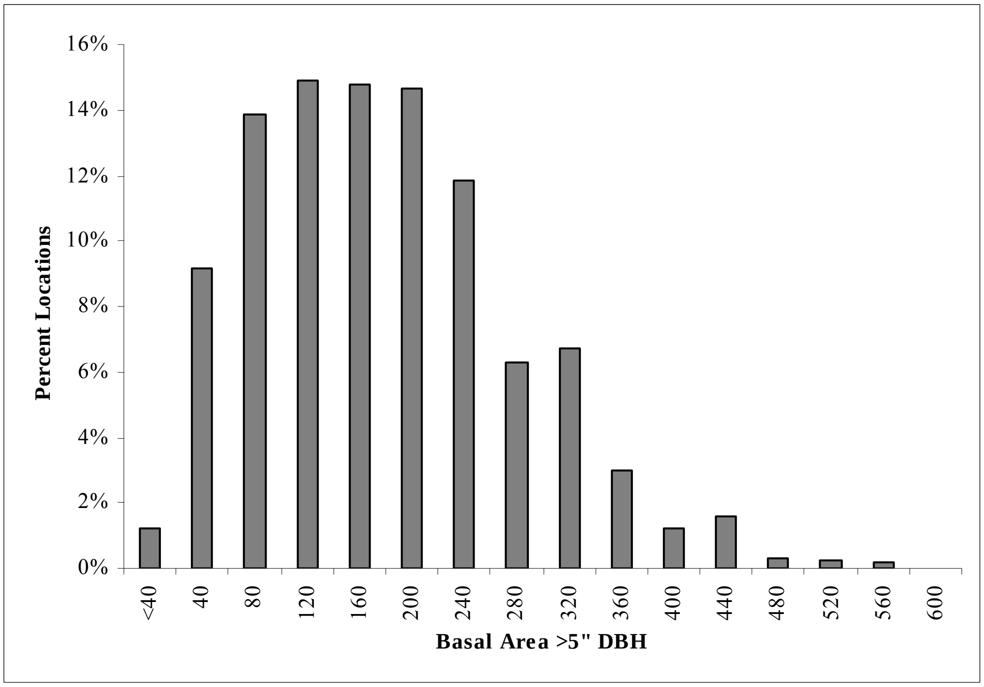
There are currently no published plot-based descriptions of NSO foraging habitat in the Klamath Province. We therefore strongly considered the results of both unpublished studies of NSO and a published study of California spotted owls (*Strix occidentalis occidentalis*, CSOs) in the northern Sierra Nevada (Irwin *et al.* 2007b) while formulating these habitat definitions. Much of the CSO study was conducted in a mixed-conifer/hardwood forest similar to forest types used by NSO in the Klamath Province.

Although spotted owls often selectively foraged in older forest, these telemetry studies show that they also use a relatively wide range of forest structure (Irwin *et al*. 2004, 2007).

The range of forest structure specified in the FWS guidelines is also based on the distribution of habitat use by foraging NSO in the Klamath Province. Analysis of radio-telemetry data from NSO in southern Oregon (L. Irwin, unpublished data) indicates that roughly 46 percent of nocturnal (foraging) locations occurred in nesting/roosting habitat (basal area ≥210 ft^2/acre), and 76 percent occurred in stands classified as foraging, nesting, and roosting habitat (Figure III.D.2). Only 14% of locations were in stands classified as low-quality foraging habitat. Thus, the functional habitat categories specified in the FWS guidelines capture about 90 percent of the observed distribution of actual use by NSO, but also require retention of the full range of structural conditions corresponding to nesting, roosting, and foraging.

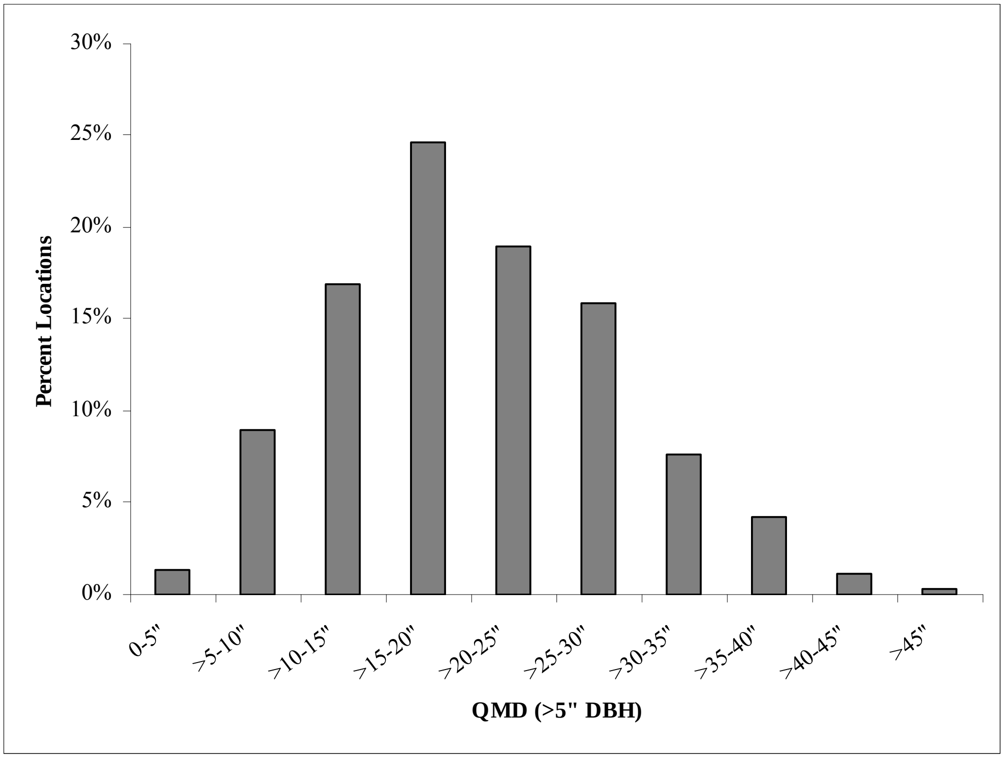
In addition to the structural characteristics addressed in the FWS guidelines, studies have indicated that certain conifer species such as Douglas-fir, as well as hardwoods and dead woody materials are important features of spotted owl foraging habitat (North *et al.* 1999, Irwin *et al.* 2000, Glenn *et al.* 2004, Irwin *et al.* 2007).

Figure III.D.2: Distribution of basal area at inventory plots near nocturnal telemetry locations for northern spotted owls in the Medford area of the Klamath Province (L. Irwin, unpublished data). This figure shows some of the range of basal area values used for foraging; it is does not show selection or avoidance of particular values since available conditions were not described.



DBH: diameter at breast height, in inches

Figure III.D.3: Distribution of quadratic mean diameter (QMD) at inventory plots near nocturnal telemetry locations for northern spotted owls in the Medford area of the Klamath Province (L. Irwin, unpublished data). This figure shows some of the range of QMD values used for foraging; it is does not show selection or avoidance of particular values since available conditions were not described.



DBH: diameter at breast height, in inches

Abiotic Habitat Characteristics

Habitat selection by breeding NSO is strongly influenced by spatial and topographic features such as proximity to nest, distance to water, slope position, and elevation. Termed 'abiotic considerations' in the FWS guidelines, these factors act to influence the habitat value of forest stands, and subsequently the importance of retaining habitat based on landscape position as well as stand structure. Abiotic considerations are explicitly incorporated into the FWS guidelines through a prioritization system that ranks habitat retention areas based on distance to nest, contiguity, slope position, aspect, and elevation.

Because the guidelines for abiotic considerations are less prescriptive than the guidelines for stand structure, they are more easily applied during habitat evaluations on a case by case basis.

Habitat selection by breeding NSO is strongly associated with proximity to the nest, as well as with vegetation characteristics (Carey and Peeler 1995, Rosenberg and McKelvey 1999, Glenn *et al.* 2004, Irwin *et al.* 2007b). Spotted owls appear to be central-place foragers, disproportionately using areas near the nest in order to minimize travel costs and maximize their energetic return from foraging (Carey and Peeler 1995, Rosenberg and McKelvey 1999). Home range studies have also indicated the importance of the territory center to spotted owls (see *Analysis Areas*). Combined, spatial patterns of habitat selection and habitat use suggest that NSO may be more sensitive to reductions of habitat in their core areas than in other parts of their home ranges. The FWS guidelines therefore emphasize retention of habitat at the core area scale.

Topography also appears to influence habitat use by NSO; which use lower slope positions more frequently than higher ones (Forsman *et al.* 1984, Blakesley *et al.* 1992, Hershey *et al.* 1998, LaHaye and Gutiérrez 1999, Irwin *et al.* 2007b). Lower slopes likely provide cooler, more humid microclimates for nesting and roosting and favor growth of the denser forest structure preferred by spotted owls. Furthermore, lower slope positions tend to have less frequent and severe fire regimes, potentially allowing trees to attain greater density, sizes and ages than on higher slopes (Beaty and Taylor 2001, Skinner *et al.* 2006). Spotted owls also appear to prefer areas close to streams, which often occur at the bottoms of slopes (Solis and Gutiérrez 1990, LaHaye and Gutiérrez 1999, Irwin *et al.* 2007b). Areas near streams likely tend to be more productive and have cooler, more humid microclimates than upland areas. Additionally, prey abundance can be high in riparian areas (Carey *et al.* 1992, Anthony *et al.* 2003) and NSO may use streams for drinking and bathing (Forsman *et al.* 1984). Some studies have found that NSO in the Klamath Province selectively use northerly aspects, but others found different patterns or no pattern at all (Solis and Gutiérrez 1990, Blakesley *et al.* 1992, Carey *et al.* 1992, Zabel *et al.* 1993, Farber and Crans 2000). Suitable microclimates for nesting and roosting, and for the vegetation structure preferred by NSO, may occur more frequently on north-facing slopes than on other aspects. However, aspect does not appear to influence vegetation distribution as strongly in some areas as in others (e.g., Zabel *et al.* 1993). Elevation also seems to influence habitat-use by spotted owls (Solis and Gutiérrez 1990, Blakesley *et al.* 1992, Hershey *et al.* 1998, LaHaye and Gutiérrez 1999, Irwin *et al.* 2007b). This might be related both to spotted owls' disproportionate use of lower slope positions and to the influence of elevation on vegetation distribution. The productive vegetation types favored by NSO, such as mixed-evergreen forest, primarily occur at lower elevations in the Klamath Province (Sawyer 2007).

III. E. Conclusions:

The FWS has conducted a thorough review and synthesis of published literature, unpublished data sets, and direct communication with NSO researchers in support of a rigorous process for evaluating the effects of habitat management on NSO. It is important to recognize that the habitat conditions described in the document are intended for use in estimating the likelihood of take of individual NSO under the ESA; they do not represent habitat conditions required for population growth or recovery. The FWS guidelines focus solely on individual NSO territories and do not incorporate larger-scale issues such as connectivity and dispersal habitat, wintering habitat, or longer-term habitat disturbance patterns. The FWS habitat evaluation guidelines that this science review document supports are complex; reflecting the complex nature of forest environments in the Klamath Province and the forest products industry's requirement to retain maximum flexibility to conduct timber harvests in the vicinity of occupied NSO territories.

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Appendix A: Full text of U.S. Fish and Wildlife Service Guidance for Evaluation of Take for Northern Spotted Owls on Private Timberlands in California's Northern Interior Region

I. Accuracy of NSO activity center location and status

1) Location
    a. Confirm plotted activity center location accuracy
        i. CDFG Reports 2 and 3
        ii. Data from adjacent landowners
        iii. Recent surveys
    b. Document deviations from CDFG locations
    c. Update habitat analysis maps as necessary

2) Status
    a. Valid site
        i. Review page 11 of protocol to determine
        ii. If not valid, report to CDFG for inclusion in next database update
    b. Current occupancy status
    c. Current reproductive status, if determined

II. Survey Effort

1) Coverage
    a. Surveys of nesting/roosting habitat out to 0.7 miles from THP boundary
        i. Use THP habitat map(s) to verify

2) Protocol survey
    a. Time of day
    b. Spacing between visits
    c. Number of surveys
    d. Survey dates
    e. Time spent at each call point

3) Follow up visit(s)
    a. Confirm that the area searched covers suitable habitat within response location/last known location within a logical distance.
    b. Time of follow up and duration of follow up
    c. Additional night surveys
        i. Review page 10 of protocol

III. Habitat

1) Typing
    a. Verify habitat typing with aerial photos, equivalent imagery, or field visits

b. Changes to typing need to be reflected in the NSO habitat acres table and habitat analysis maps
c. Post harvest typing
    i. Post-harvest habitat typing must agree with the silviculture prescription

2) Definitions
    a. Nesting/roosting
        i. High Quality Nesting/roosting Habitat
            1. Basal Area = 210+ square feet, **and**
            2. ≥ 15" quadratic mean diameter (QMD) , **and**
            3. ≥ 8 trees per acre (TPA) of trees ≥ 26" in diameter at breast height (DBH) , **and**
            4. ≥ 60% canopy closure
        ii. Nesting/roosting Habitat
            1. A mix of basal areas ranging from 150-180+ square feet, **and**
            2. ≥ 15" QMD, **and**
            3. ≥ 8 TPA of trees ≥ 26" DBH, **and**
            4. ≥ 60% canopy closure
    b. Foraging
        i. Foraging Habitat
            1. A mix of basal areas ranging from 120-180+ square feet, **and**
            2. ≥ 13" QMD, **and**
            3. ≥ 5 TPA of trees ≥ 26" DBH, **and**
            4. A mix of ≥ 40%-100% canopy closure
        ii. Low Quality Foraging Habitat
            1. A mix of basal areas ranging from 80-120+ square feet, **and**
            2. ≥ 11" QMD, **and**
            3. ≥ 40% canopy closure

3) Quantities
    a. Within 1000 feet of activity center
        i. Outside breeding season (September 1 through January 31): no timber operations other than use of existing roads
        ii. During the breeding season (February 1 through August 31): no timber operations other than the use of existing, permanent, year-round roads

    b. Within 0.5 mile radius (502 acres) centered on activity center
        i. Retention of habitat should follow Section III. 4 of this document
        ii. At least 250 acres nesting/roosting habitat present, as follows:
            1. 100 acres High Quality Nesting/roosting Habitat, **and**
            2. 150 acres Nesting/roosting Habitat

        –AND–

        iii. At least 150 acres foraging habitat must be present, as follows:
            1. 100 acres Foraging Habitat, **and**
            2. 50 acres Low Quality Foraging Habitat
        iv. No more than 1/3 of the remaining suitable habitat may be harvested during the life of the THP

c. Between 0.5 mile radius and 1.3 miles radius circles centered on activity center
    i. Retention of habitat should follow Section III. 4 of this document
    ii. ≥935 acres suitable habitat must be present, as follows:
        1. At least 655 acres Foraging Habitat, **and**
        2. At least 280 acres Low Quality Foraging, **and**
        3. No more than 1/3 of the remaining suitable habitat may be harvested during the life of the THP

4) Priority Ranking of Habitat Retention Acres
    a. Tree species composition
        i. Mixed conifer stands should be selected over pine dominated stands
    b. Abiotic considerations
        i. Distance to nest
            1. Nesting/roosting and foraging habitat closest to identified nest trees, or roosting trees if no nest trees identified
        ii. Contiguous
            1. Nesting/roosting habitat within the 0.5 mile radius must be as contiguous as possible
            2. Minimize fragmentation of foraging habitat as much as possible
        iii. Slope position
            1. Habitats located on the lower 1/3 of slopes provide optimal micro-climate conditions and an increased potential for intermittent or year-round water sources
        iv. Aspect
            1. Habitats located on northerly aspects provide optimal vegetation composition and cooler site conditions
        v. Elevation
            1. Habitat should be at elevations of less than 6000 feet, though the elevation of some activity centers (primarily east of Interstate 5) may necessitate inclusion of habitat at elevations greater than 6000 feet.

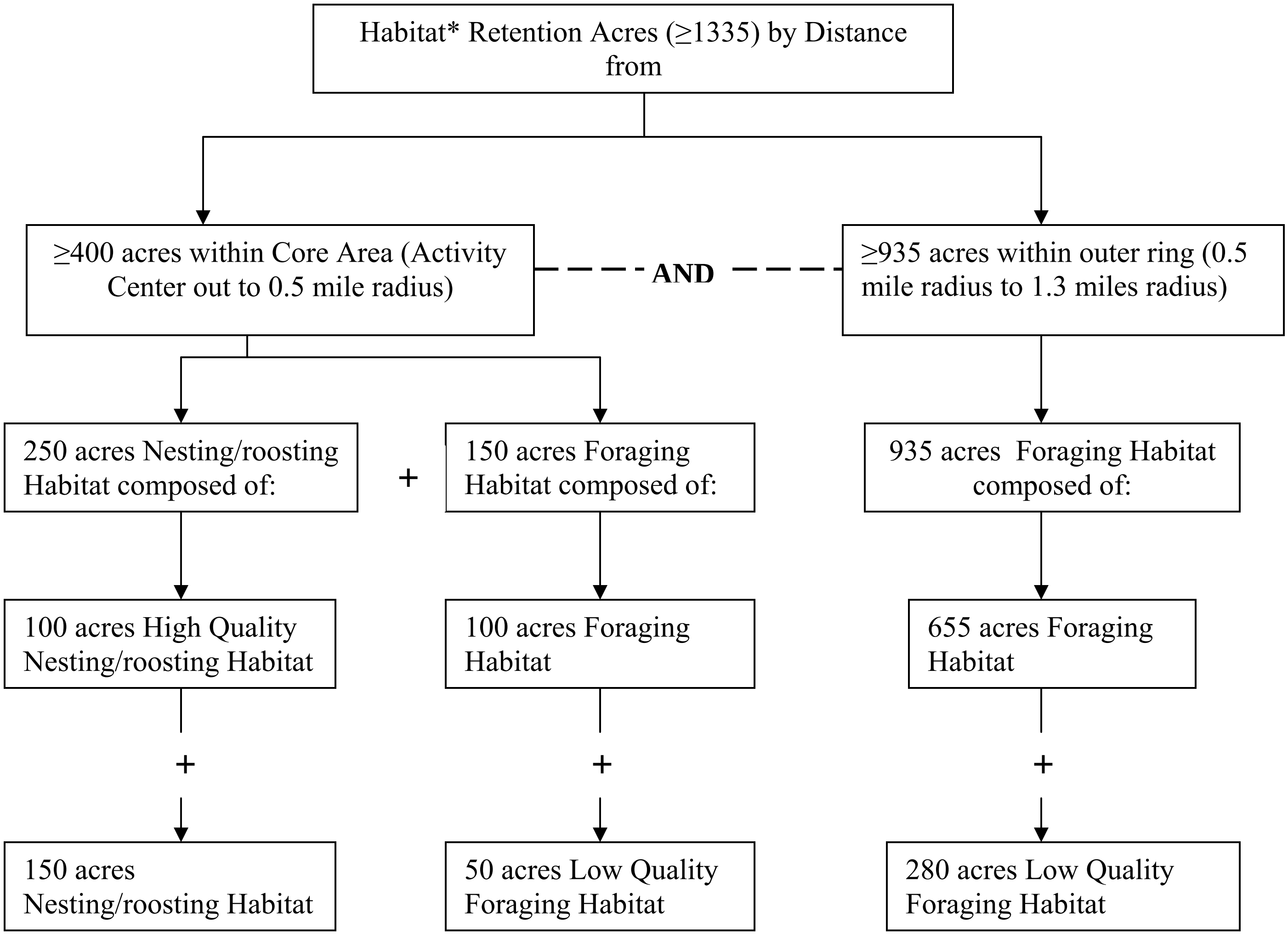
IV. Determination

1) If surveys are inadequate or do not meet the intent of protocol, take determination may not be possible.
2) If habitat typing is inadequate, take determination may not be possible.
3) If NSO home range habitat acres are below desired conditions (Section III. 2, 3, and 4), additional loss of suitable habitat can lead to take.
4) If NSOs are nesting, utilize seasonal restriction within 0.25 mile of nest (February 1 through August 31).
5) If effects are limited to noise disturbance, a modified seasonal restriction may be used from February 1 through July 9

    a. Harvest of unsuitable habitat, with unsurveyed suitable within 0.25 of unit boundary
6) Multiple THPs located within a given NSO territory need to be considered collectively or a take determination may not be possible.

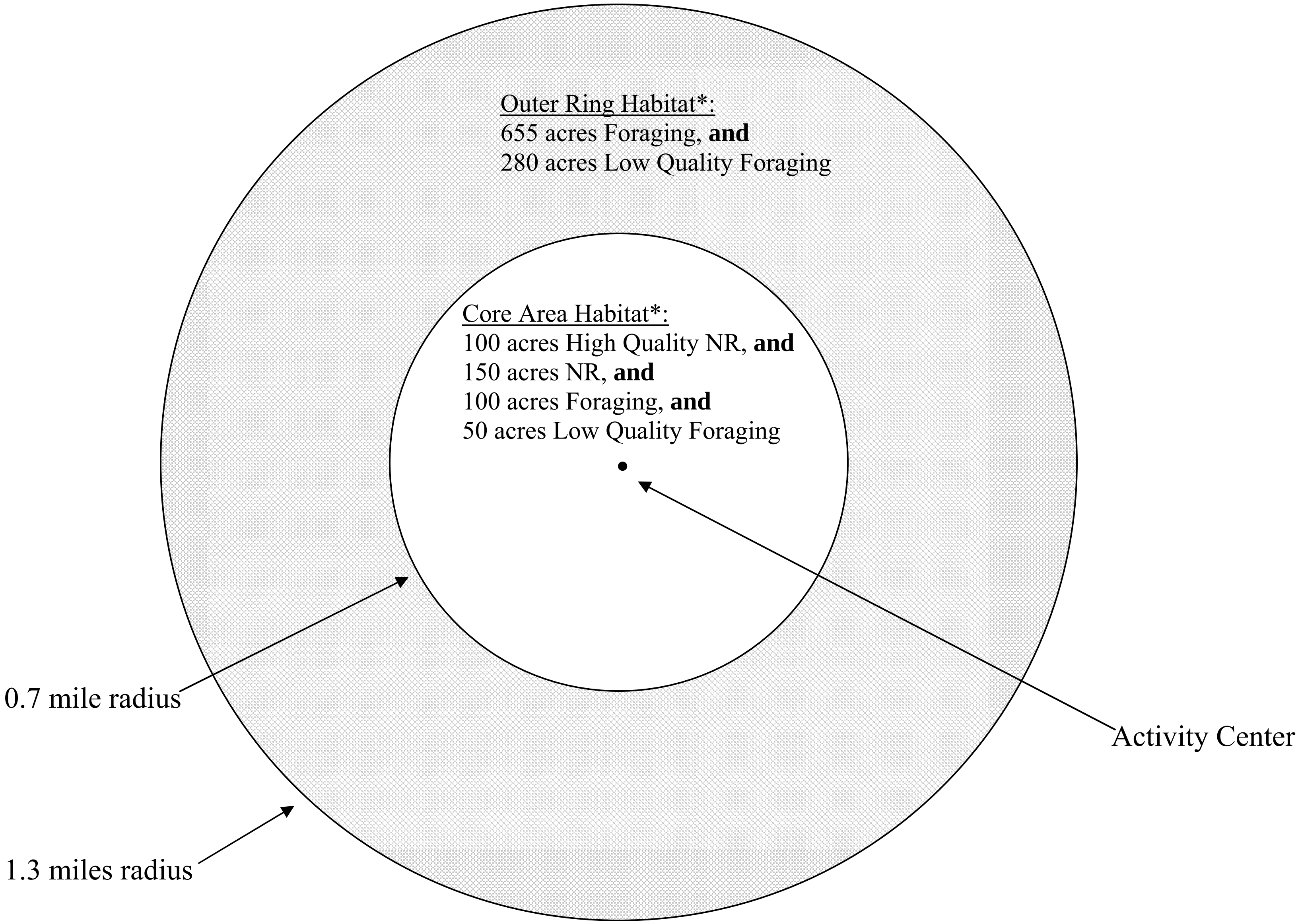
V. TA Letter Contents

1) Date of written TA request
2) Date request received
3) Note if previous TA(s) provided in past
4) Number of acres within THP units
5) Amounts and types of silviculture prescriptions
6) Location of THP
    a. Township, Range, and Section
    b. Meridian
    c. County
7) Identify NSO activity centers returned by CDFG reports
8) Surveys conducted and activity center status
9) Logic behind take determination
    a. Habitat considerations
        i. Acres, quality, and location of suitable habitat pre- and post-harvest
        ii. Effects of timber operations on suitable habitat
            1. Degrade: suitable habitat is harvested but still functions in the capacity it did pre-harvest (i.e. Foraging habitat before harvest functions as foraging habitat post-harvest, nesting/roosting habitat pre-harvest functions as nesting/roosting habitat post-harvest)
            2. Downgrade: pre-harvest nesting/roosting habitat becomes foraging habitat post-harvest
            3. Remove: nesting/roosting or foraging habitat is harvested such that it no longer functions as habitat post-harvest
    b. Proximity of activity center to operations
    c. Survey data
10) Sunset date and seasonal restrictions
    a. If 2 year protocol and surveys are current and negative, additional TA needed if operations not completed by February 1, *YEAR* (review protocol page 3).
    b. If 1 year protocol and surveys are current and negative, additional TA needed if operations not completed by February 1, *YEAR* (review protocol page 3).
    c. If NSOs detected in previous surveys and operations are not complete before February 1, surveys are required to determine location and status of NSOs prior to operations during each breeding season that operations are ongoing.
    d. If no owls within 1.3 miles of THP (CDFG reports) and no suitable habitat within units or 1.3 miles of units, additional technical assistance may not be required.
11) Name of agency person to contact if there questions regarding TA



*See Section III.2 for habitat definitions

Habitat Retention within Core Area and 1.3 mile Home Range–Interior



*See Section III.2 for habitat definitions

From: Rob DiPerna <rob@wildcalifornia.org>
Sent: Thursday, May 01, 2014 4:06 PM
To: Wildlife Management
Subject: Attn: Neil Clipperton--Northern Spotted Owl CESA status review comments
Attachments: dfw_statusreviewcomments_epic_5_1_14_final.pdf

Dear Mr. Clipperton and Department Officials:

Please find attached EPIC's comments regarding the Department's Northern Spotted Owl status review.

Please do not hesitate to contact me as necessary.

Thank you.

Rob DiPerna
California Forest and Wildlife Advocate
Environmental Protection Information Center
145 G Street, Suite A
Arcata, CA 95521
(707) 822-7711 Office
(707) 845-9528 Cell
www.wildcalifornia.org

Sent via e-mail to: wildlifemgt@wildlife.ca.gov on date shown below

May 1, 2014

California Department of Fish and Wildlife
Nongame Wildlife Program
Attn: Neil Clipperton
1812 9th Street
Sacramento, CA 95811

Re: EPIC Comments on Department of Fish and Wildlife California Endangered Species Act Status Review for the Northern Spotted Owl (*Strix occidentalis caurina*)

Dear Mr. Clipperton and Department Officials:

The Environmental Protection Information Center (EPIC) presents the following comments on the California Department of Fish and Wildlife (CDFW or Department) status review for the Northern Spotted Owl (*Strix occidentalis caurina*) (NSO) pursuant to the California Endangered Species Act (CESA). EPIC appreciates the opportunity to provide the Department with comments and direction as it conducts its review of the status of the NSO in California.

These comments demonstrate the plight of the Northern Spotted Owl in California through the lens of an appropriate review and analysis approach that considers bio-regional differences in NSO behavior, habitat needs, prey base, and forest types. We hope that this information and approach assist the Department in developing its review which recommends listing of the NSO under CESA.

Summary

The Northern Spotted Owl warrants listing under CESA because it meets several of the criteria for listing a species as specified under the Act. Specifically, the NSO warrants listing due to the following factors: 1) past, present, and threatened habitat destruction, modification or curtailment; 2) competition from invasive species; 3) inadequate regulatory mechanisms; and 4) climate change. The preponderance of the best available evidence suggests that these and other factors are contributing to the decline of the NSO throughout all provinces in California.

I. Introduction and Background

Petition History

EPIC submitted a petition to the California Fish and Game Commission (Commission) to list the Northern Spotted Owl as either "threatened" or "endangered" under CESA on September 4th, 2012. At its August 7th, 2013 meeting, the Commission voted to accept EPIC's petition, finding that the petitioned action "may be warranted." At its December 11th, 2013 hearing the Commission adopted findings for its decision, thus initiating a one-year "candidacy" period for the NSO.

CDFW Obligations during "Candidacy" Period

Fish and Game Code section 2074.6(a) requires that within 12 months of the Commission's "candidate" designation, the Department must produce and make publicly available a final written peer-reviewed status report. This report is to be based upon the best scientific information available to the Department. The Department must evaluate whether the petitioned action is warranted, includes a preliminary identification of the habitat that may be essential to the continued existence of the species, and recommends management activities and other recommendations for recovery of the species. "Prior to releasing the final written report, the Department shall have a draft status review report prepared and independently peer reviewed, and upon receiving the peer reviewers' input, shall evaluate and respond in writing to the independent peer review and shall amend the draft status review report as appropriate." *Id*. The revised report shall be posted on the Department's Internet Web site for a minimum of 30 days for public review prior to the Commission's hearing scheduled for final consideration of the petition and listing.

Standard of Evidence

CESA is modeled on the federal ESA (FESA), and the two statutes contain very similar substantive and procedural provisions. For instance, both statutes provide for the listing and protection of threatened and endangered species in a process initiated by a citizen petition. CFGC § 2071 *et seq*., 16 U.S.C. § 1533 *et seq*. At the first step in each process, the decision makers decide whether listing "may be warranted," CFGC § 2074.2, 16 U.S.C. § 1533(b)(3)(A), and at the second step in each process, the decision makers decide whether listing "is warranted." CFGC § 2075.5, 16 U.S.C. § 1533(b)(3)(B). Under CESA, as under FESA, listing decisions must be based on the best available science. CFGC §§ 2072.3, 2074.6; 16 U.S.C. § 1533(b)(1)(A).

California courts have explained that "it is a basic premise of statutory construction that when a state law is patterned after a federal law, the two are construed together." *NRDC v. California Fish & Game Comm.,* 28 Cal.App.4th 1102, 1118 (1994), citing *Moreland v. Department of Corporations*, 194 Cal.App.3d 506, 512-13 (1987). Thus, interpretation of the federal ESA guides CESA. This is particularly applicable here, as case law has determined that scientific certainty is not required for a species to qualify for protected status through listing.

> The [FESA] contains no requirement that the evidence be conclusive in order for a species to be listed. Application of such a stringent standard violates the plain terms of the statute . . . Congress repeatedly explained that it intended to require the FWS to take preventive measures before a species is 'conclusively' headed for extinction. The purpose of creating a separate designation for species which are 'threatened', in addition to species which are 'endangered', was to try to 'regulate these animals before the danger becomes imminent while long-range action is begun.'
>
> The FWS itself has taken the position that it need not, and must not wait for conclusive evidence in order to list a species. For example, in its decision to list the northern spotted owl, it explained that because the agency had 'used the best data available to prepare the proposed rule, it was 'not obligated to have data on all aspects of a species biology prior to reaching a determination on listing'. Moreover, the agency concluded that 'to withdraw the proposal and conduct additional research would not improve the status of the [species] and would not be in keeping with the mandates of the Endangered Species Act.' More recently, the FWS decided to list the California red-legged frog, even though many aspects of the species' status were 'not completely understood', because 'a significant delay in listing a species due to large, long-term biological or ecological research efforts could compromise the survival of the [species].'
>
> Furthermore, Defendants have gone to great lengths to argue that there is a lack of 'scientific certainty' as to various aspects of the [species'] status. The ESA does not, however, require such 'certainty' to justify the listing of a species. To the contrary, the clear intent and purpose of Congress in enacting the ESA was to provide preventive protection for species before there is 'conclusive' evidence that they have become extinct.

Defenders of Wildlife v. Babbitt, 958 F.Supp. 670, 679-81 (D.D.C. 1997) (internal citations omitted).

Accordingly, the Department cannot dismiss the need for listing of the NSO based on a claim of lack of "scientific certainty." Rather, following the U.S. Fish and Wildlife Service's (FWS) lead, the Department should determine whether or not listing is warranted based on the preponderance of available evidence. Like any topic of scientific research, there is scientific uncertainty regarding the status and ecology of NSOs. Nonetheless, the NSO is one of the most thoroughly studied vertebrates in North America and a substantial and compelling body of scientific information about the species is currently available.

Recommended Review Approach

EPIC strongly believes that any approach to conducting a status review for the NSO must be firmly rooted in the species' ecology. As noted by the FWS and leading researchers, the NSO's ecology, status, and threats vary among regions, forest types, and elevation zones (USFWS 2011, 2012; Forsman et al. 2011; Courtney et al. 2004). Any robust status review must also consider the available information on NSO populations, trends, and threats across ownership classes, and indeed down to the individual ownership level. Finally, care must be taken in how the Department weighs the various types and sources of information it receives for consideration. For example, the Department clearly must give greater weight and consideration to long-term peer-reviewed studies related to the NSO in California over unpublished, non-peer-reviewed monitoring reports or raw data from project-level surveys.

II. <u>Status of the Northern Spotted Owl</u>

<u>Range-wide Trends</u>

Forsman et al. (2011) identifies three categories of study to determine NSO trends range-wide. These are fecundity, apparent survival, and population trends. Below is a summary of the findings of Forsman et al. (2011) with respect to study areas range-wide.

TABLE 1: Summary of trends in demographic parameters for northern spotted owls, from 11 study areas 1985-2008, adapted from Forsman et al. (2011).

Study Area	Fecundity	Apparent survival	Population trend
Washington			
Cle Elum	Declining	Declining	Declining
Rainier	Increasing	Declining	Declining
Olympic	Stable	Declining	Declining
Oregon			
Coast Range	Increasing	Declining since 1998	Declining
H.J. Andrews	Increasing	Declining since 1997	Declining
Tyee	Stable	Declining since 2000	Stationary
Klamath	Declining	Stable	Stationary
Southern Cascades	Declining	Declining since 2000	Stationary
California			
Northwestern California	Declining	Declining	Declining
Hoopa	Stable	Declining since 2004	Stationary
Green Diamond	Declining	Declining	Declining

<u>California Trends</u>

A primary purpose of the status review is to determine trends in Northern Spotted Owl abundance, population, distribution, and demographic rates for California. EPIC recommends that the Department conduct its review on a bio-regional level, and at landscape and individual ownership scales. We address some of these factors below.

<u>Range and Distribution</u>

As noted in the petition, historically, the Northern Spotted Owl was found from British Columbia through western Washington, western Oregon, and northwestern California from Siskiyou County south to Marin County (American Ornithological Union 1957, Forsman 1976, Forsman et al. 1984, Gutiérrez et al. 1995). The ranges of the Northern and California subspecies of spotted owls meet at the southern end of the Cascade Range, near the Pit River area in northern California. In California, populations are declining in two of three long-term monitoring sites while numerous historic territories have been lost from interior forests in California. The Revised Recovery Plan for the Northern Spotted Owl states: “Many historical spotted owl site-centers are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or fires” (U.S. Fish and Wildlife Service 2011) (Petition, at page 7).

Despite this, the Department’s initial petition evaluation (CDFW 2013) states that,

> “Based on information in the Petition and other data that is readily available to the Department for California, there is not evidence to indicate that the distribution of northern spotted owl has changed during the time period of years for which surveying/monitoring of the species distribution has occurred” (CDFW Petition Evaluation, at 6).

While further study is needed to determine the range and distribution of the NSO range-wide and within California, the Department cannot reject listing based on an erroneous standard of “certainty” in the evidence; it must consider the best evidence available at the time of its status review, which instructs that the NSO population is declining in California.

NSO Abundance

With respect to NSO abundance, the Fish and Game Commission’s finding, citing the Department’s petition evaluation determined the following:

> “The petition (pages 12-15) does not include direct information about the population size or abundance of NSO populations in California, nor does it discuss abundance range-wide. The Department deemed the relevant information found in the literature cited in the petition and other scientific documents consulted for its evaluation report to be inconclusive to determine the abundance of NSO range-wide or in California, and concluded that further research and analysis is required to determine the abundance for NSO populations in California. (Evaluation Report, page 6).”

Further study is needed to answer the question of NSO abundance in California. In its initial petition evaluation the Department referenced the NSO database maintained as part of the California Native Diversity Database (CNDDB), and acknowledged that until recently this database has not been regularly maintained (CDFW Petition Evaluation, at page 3). The NSO CNDDB may be a useful tool for estimating owl abundance in California, but its utility is clearly limited. Not only is the database limited by infrequent maintenance, but it is also limited in use due to inadequate survey coverage in many areas.

While the evidence available to the Department regarding the abundance of NSO is inconclusive, there is clear evidence of negative demographic trends in California and rangewide (Forsman et al. 2011). Occupancy rates from Timber Company monitoring reports (e.g., CDFW 2013 errata sheet, page 1) should be considered as part of the body of information available concerning the

NSO's status in California (see below). However, they do not represent an equally rigorous or valid counterweight to peer-reviewed, long-term demographic research.

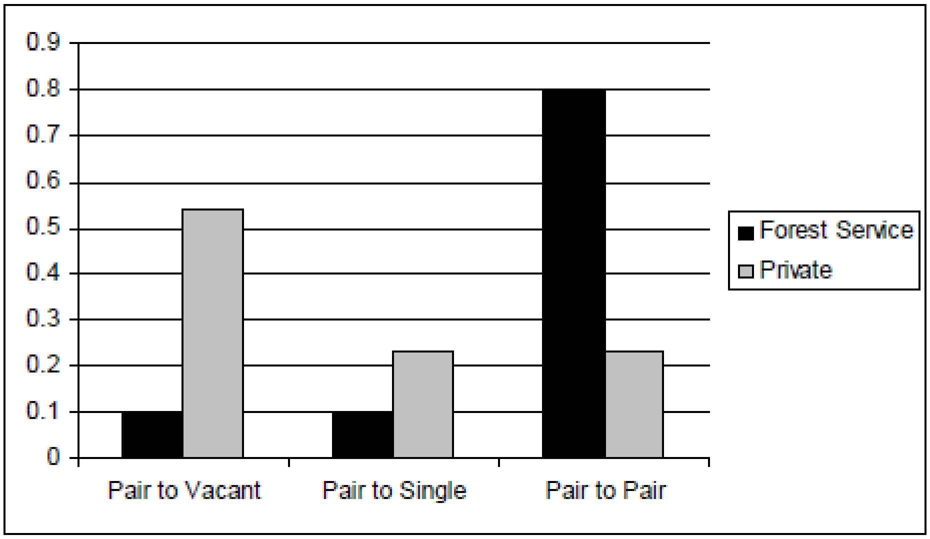
Occupancy trends

The Yreka office of the FWS has completed an extensive analysis of the status of historical spotted owl activity centers on federal and private lands in interior northern California (U.S. Fish and Wildlife Service 2009). The FWS found that extensive losses of owl pairs occurred on private lands, which sharply contrasted with the persistence of owl pairs on federal lands. (U.S. Fish and Wildlife Service 2009: 11-12) stated:

> To quantify the pattern of territory loss identified during the technical assistance process, we compared results of protocol surveys conducted at verified NSO territories supporting at least one year of occupancy by paired owls on Forest Service lands (N=196) with similar data from private timberlands (N=75) in Shasta and Trinity counties. The data set consisted of activity center status records in the California Department of Fish and Game's Spotted Owl Database (CDFG-NSO database), supplemented with territory locations and recent survey records received during technical assistance. We first evaluated the validity of activity center records in the CDFG-NSO database, and eliminated 18 sites on private lands due to lack of verification of status. The remaining 57 private-land activity centers had verified NSO status in at least one year between 1989 and 2007; 44 of these sites had supported pairs during at least one year. Of these verified pair sites, 54% declined from pair status to no response, and an additional 23% declined from pair status to a territorial single owl during subsequent protocol surveys (Figure I.B.1). On Forest Service-administered lands, 80% of pair sites did not change status during the same time periods. While we recognize that annual variation in survey effort and results at this relatively coarse scale of resolution may influence this type of analysis, the strong differences in trends observed on private versus federal lands supports the contention that management on private timberlands is creating habitat conditions that do not support sustained occupancy by NSO" (U.S. Fish and Wildlife Service 2009: 11-12).

The FWS created the figure below to illustrate the results of their analysis.

Figure I.B.1. Status of valid historical northern spotted owl activity centers (pair sites only) when resurveyed after 5-10 years. Data are from U.S. Fish and Wildlife Service technical assistance records and USFS monitoring records



This and other available evidence suggests that NSO site occupancy on private forestlands in interior California is declining.

III. Immediacy of Threats to the Northern Spotted Owl

Past, Present, and Threatened Habitat Destruction, Modification, or Curtailment

The topic of habitat loss must be broken into several categories to address the myriad of factors influencing past, present, and threatened habitat destruction, modification, or curtailment within the species range and in California specifically. We address the following factors affecting NSO habitat loss, modification, and curtailment: 1) timber harvest on public and private lands; 2) stand-replacing fire; and 3) habitat conversion.

Timber Harvest

The 2011 Revised Recovery Plan for the Northern Spotted Owl (U.S. Fish and Wildlife Service 2011) identifies past and present habitat loss due to timber harvest as a primary threat to the species range-wide. After a status review (U.S. Fish and Wildlife Service 1990a), the spotted owl was listed under the Endangered Species Act (ESA) as threatened on June 26, 1990 (U.S. Fish and Wildlife Service 1990b) because of widespread loss of the species' habitat across the spotted owl's range and the inadequacy of existing regulatory mechanisms to conserve the spotted owl. Past habitat loss and current habitat loss are also threats to the spotted owl, even though loss of habitat due to timber harvest has been greatly reduced on Federal lands over the past two decades (U.S. Fish and Wildlife Service 2011). The impacts of ongoing and threatened habitat loss, disturbance, and modification are significant and constitute a fundamental reason for listing.

The 2011 Revised Recovery Plan identified the impacts of timber harvest as a main threat to the NSO.

> "Currently, the most important range-wide threats to the spotted owl are competition with barred owls, ongoing loss of spotted owl habitat as a result of timber harvest, habitat loss or degradation from stand replacing wildfire and other disturbances, and loss of amount and distribution of spotted owl habitat as a result of past activities and disturbances" (U.S. Fish and Wildlife Service 2011).

Data presented in the 2011 Revised NSO Recovery Plan clearly shows substantially higher levels of NSO habitat loss on non-federal versus federal lands since the advent of the Northwest Forest Plan. Table 2-B taken from the Recovery Plan (below) indicates that non federal lands logging in California accounted for 5.8 percent of total habitat lost in California. Range-wide, 14.9% of NSO habitat on private lands within the range of the owl has been lost between 1994/96-2006/2007 to logging. Table B-2 demonstrates that habitat loss, modification, and curtailment continue to occur on both public and private lands in California and range-wide.

Table B-2. Estimated amount of spotted owl nesting and roosting habitat1 at the start of the Northwest Forest Plan (baseline 1994/96[2]) and losses owing to harvest through 2006/7[2], by State and ownership (adapted from Davis and Dugger in press).

Land class	Baseline (1994/96[2])	Harvest	Total Percent loss[3]
Federal reserved			
Washington	2,274,200	7,900	0.3%
Oregon	2,699,600	6,100	0.2%
California	1,214,000	2,500	0.2%
Range-wide total	6,187,800	16,500	0.3%
Federal non-reserved			
Washington	470,200	4,800	1.0%
Oregon	1,561,400	23,800	1.5%
California	634,400	8,700	1.4%
Range-wide total	2,666,000	37,300	1.4%
Non-federal			
Washington	1,258,900	234,200	18.6%
Oregon	1,382,400	301,200	21.8%
California	1,556,700	90,200	5.8%
Range-wide total	4,198,000	625,600	14.9%
Range-wide total	13,052,000	679,400	5.2%

[1] See Davis and Dugger (in press) for description of habitat.
[2] 1996 and 2006 for Oregon and Washington, 1994 and 2007 for California.
[3] Loss is the term used in Davis and Dugger (in press) to describe their data, which is summarized here.

On public lands, federal land management poses many problems for spotted owls. All federal lands within the range of the NSO are currently managed under the provisions of the Northwest Forest Plan (NWFP). The NWFP was adopted in 1994, and it amended land management planning documents for 19 National Forests and seven Bureau of Land Management districts throughout Washington, Oregon and California. The NWFP established a late-successional reserve (LSR) network and specified management standards and guidelines to further the recovery of the NSO.

The 15-year report on the NWFP performance for spotted owls was recently released. It shows that the NWFP is simply not adequate to ensure recovery of the species (Davis et al. 2011). The NWFP was based on overly optimistic assessments of spotted owl demographic performance (Franklin et al. 1999, Anthony et al. 2006). Demographic studies (Franklin et al. 1999, Anthony et al. 2006, Forsman et al. 2011, Davis et al. 2011) have demonstrated that the population declines are at a much greater rate than was anticipated across their range and particularly in Washington. In light of this decline, Forsman et al. (2011) stressed the importance of retaining high quality owl habitat: “[i]n view of the continued decline of Spotted Owls in most study areas, it would be wise to preserve as much high quality habitat (i.e., late-successional forests) for Spotted Owls as possible, distributed over as large an area as possible.”

It is much more difficult to quantify habitat loss, modification, and/or curtailment resulting from timber harvest on private lands than it is on public lands. Currently, there are no entity tracking habitat loss and modification, and there is no data, studies, or other information that addresses the impacts of timber harvest and other forest management practices on the NSO on private lands in California.

In our petition to the Fish and Game Commission, EPIC attempted to quantify habitat loss across some ownerships in California to illustrate that current and threatened habitat loss, modification and/or curtailment was continuing on private lands. In its initial petition evaluation, the Department was critical of our approach, citing inconsistencies in the numbers of acres of habitat removed versus the total acres of specified Timber Harvest Plans (THPs) (CDFW Petition Evaluation, at pages 10-11).

Because there is currently no entity in the State of California tracking the amount of NSO habitat lost, modified, or curtailed as a result of timber harvest activities on private lands, the best available source of information regarding these factors is contained may be individual THPs. We understand and appreciate the limitations of quantifying NSO habitat loss, modification, and/or curtailment by simply analyzing individual THPs. Indeed, information pertaining to the true impacts of timber operations on the NSO provided in THPs is often insufficient to allow for meaningful review of potentially significant impacts. The lack of accountability for habitat loss as a result of timber harvest is another reason why existing regulatory mechanisms are inadequate, and are another reason why listing under CESA is warranted. (See below).

What information is available documents that timber harvest activities in California are in fact destroying, modifying, or curtailing NSO habitat on private lands, and that the cumulative effect of over 150 years of such activities has left the NSO with a landscape that is largely either unsuitable or of very low quality to support stable or increasing rates of NSO occupancy, reproduction and survival.

The FWS's 2009 NSO "take" avoidance guidelines document (U.S. Fish and Wildlife Service 2009) provides the following conclusion regarding the impacts of persistent timber harvest on NSO habitat conditions on private lands:

> "…the strong differences in trends observed on private versus federal lands supports the contention that management on private timberlands is creating habitat conditions that do not support sustained occupancy by NSO." (p 12).

Indeed, in its March 29, 2013 letter of Technical Assistance to CAL FIRE and Sierra Pacific Industries (SPI) (TA 08YRE00-2013-007) the FWS made the following observation about habitat conditions on SPI lands:

> "[The U.S. Fish and Wildlife Service] have determined that SPI's landscape is dominated by habitats considered to provide foraging and quality foraging habitat. Suitable nesting/roosting habitat on SPI managed lands is much more limited." (U.S. Fish and Wildlife Service 2013).

SPI further acknowledges that its lands do not contain any high-quality nesting/roosting habitat in its own THPs, stating:

> "The absence of high quality nesting roosting habitat is largely a result of the USFWS's robust definition of this habitat type that exceeds the habitat conditions of most stands, except those that would traditionally be called "old growth" or primary older forest where no management footprint exists. These stands are not common in areas where historic or past management has been engaged either by Government or private land managers." (SPI THP 2-14-022TRI "Boomer" THP, Section V, page 293).

There are little, if any "primary older forests," or "old growth" forest habitat types available on SPI lands. SPI acknowledges that past management has resulted in the near extirpation of "primary older forests" or "old growth forests" on its property. *Id*. These forest types are clearly identified as preferable habitats for the NSO. As identified in the petition, the best available science shows that relatively large areas of structurally complex, older forests provide the habitat necessary to support viable populations of Northern Spotted Owls (Forsman et al. 2011). Spotted owls generally rely on older forested habitats because such forests contain the structures and characteristics required for nesting, roosting, and foraging, and dispersal.

Past, present and threatened habitat loss due to timber harvest remains a substantial threat to the Northern Spotted Owl in California. Habitat loss is ongoing on both public and private lands, and inadequate regulatory mechanisms exist to curtail this threat. (Please refer to section on inadequacy of regulatory mechanisms below).

Wildfire and Post-Fire Salvage Logging

Two major lines of evidence are available for evaluating effects of wildfire on NSOs: estimated loss of suitable habitat on federal lands (Davis and Dugger 2011) and studies of direct effects of fire on NSO demography, occupancy, and behavior (Bond et al. 2002, Clark et al. 2011, 2013).

Davis and Dugger (2011) estimated losses of suitable nesting-roosting habitat to wildfires and other disturbances on federal lands during 1994/1996 to 2006/2007 (evaluation periods varied among physiographic provinces). During that period some provinces experienced substantial (up to 10.2%) losses of suitable nesting-roosting habitat (Table B-1 [from the 2011 Recovery Plan, Figure 3-12 from Davis and Dugger 2011). These losses were primarily due to large wildfires in dry forests; largely within the Oregon and California Klamath provinces. Wildfires also fragmented suitable nesting-roosting habitat during this period (Figure 3-18 from Davis and Dugger 2011). Loss of 'core' (non-edge) nesting-roosting habitat could negatively affect NSO populations, due to the relationship between NSO fitness and amounts of core old-forest centered on nest trees or activity centers (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005).

Table B-1. Spotted owl habitat loss on Federal lands resulting from harvest and natural disturbances from 1994/96[1] to 2006-7[1] (acres) (adapted from Davis and Dugger in press).

Physiographic Provinces	1994/96 acres	Harvest *(%)*[2]	Natural Disturbance			Total Habitat Loss	Total Percent loss[2,3]
			Wildfire	Insects and disease	Total *(%)*[2]		
Olympic Peninsula	763,100	**500** *(0.06%)*	200	0	**200** *(0.03%)*	700	**0.1%**
Eastern WA Cascades	673,600	**8,100** *(1.2%)*	20,000	2,000	**22,000** *(3.3%)*	30,100	**4.5%**
Western WA Cascades	1,283,000	**3,700** (0.3%)	700	400	**1,100** (0.09%)	4,800	**0.4%**
Western WA Lowlands	24,700	**400** *(1.6%)*	0	0	**0**	400	**1.6%**
OR Coast Range	611,200	**3,300** *(0.5%)*	0	0	**0**	3,300	**0.5%**
OR Klamath	985,000	**6,800** *(0.7%)*	93,600	300	**93,900** *(9.5%)*	100,700	**10.2%**
Eastern OR Cascades	402,900	**5,800** *(1.4%)*	17,800	2,300	**20,100** *(5.0%)*	25,900	**6.4%**
Western OR Cascades	2,258,700	**13,900** *(0.6%)*	28,900	1,100	**30,000** *(1.3%)*	43,900	**1.9%**
Willamette Valley	3,400	**100** *(2.9%)*	0	0	**0**	100	**2.9%**
CA Coast	145,400	**300** *(0.2%)*	2,100	100	**2,200** *(1.5%)*	2,500	**1.7%**
CA Cascades	213,200	**6,500** *(3.0%)*	1,800	300	**2,100** *(1.0%)*	8,600	**4.0%**
CA Klamath	1,489,800	**4,400** *(0.3%)*	71,600	1,600	**73,200** *(4.9%)*	77,600	**5.2%**
Range-wide total	8,853,000	**53,800** *(0.6%)*	236,700	8,100	**244,800** *(2.8%)*	298,600	**3.4%**

[1] 1996 and 2006 for Oregon and Washington, 1994 and 2007 for California.
[2] Percent of 1994/96 habitat.
[3] Loss is the term used in Davis and Dugger (in press) to describe their data, which is summarized here.

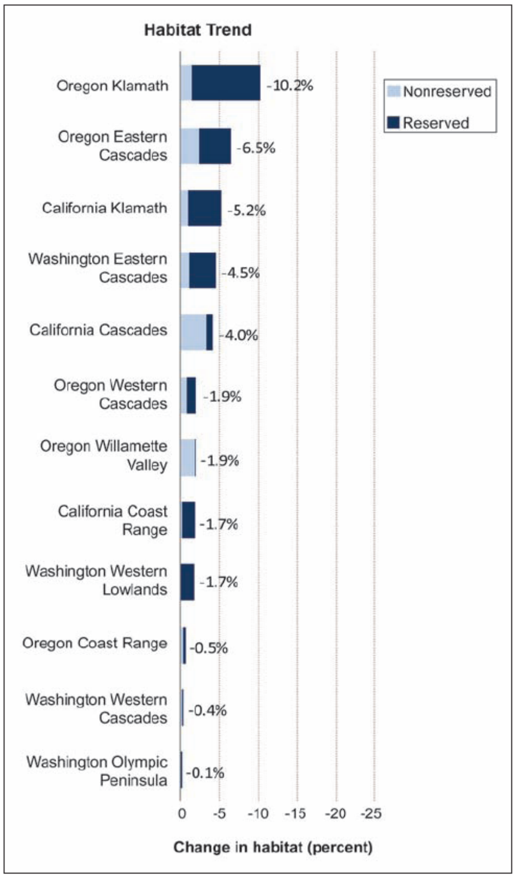


Figure 3-12—Nesting/roosting habitat trends (based on the LandTredr analysis) from 1994/96 to 2006/07 by physiographic province for reserved and nonreserved federal lands.

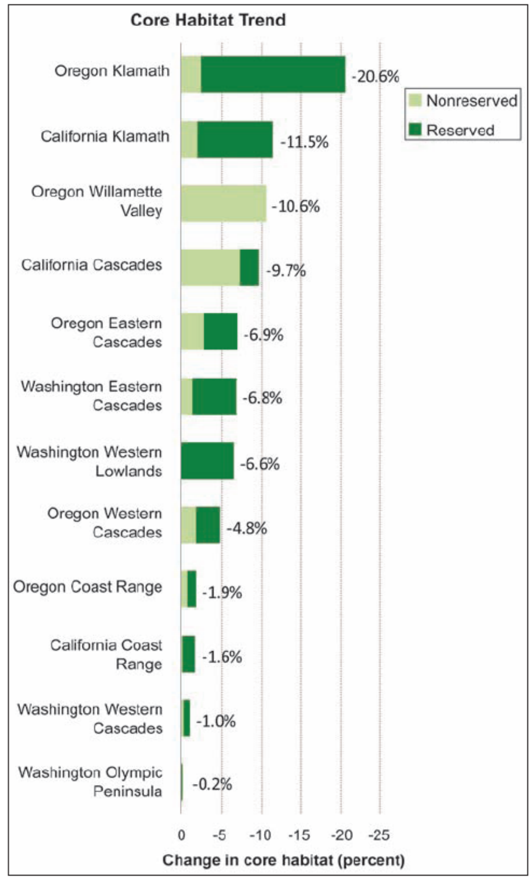


Figure 3-18—Nesting/roosting "core" habitat trends from 1994/96 to 2006/07 by physiographic province for reserved and nonreserved federal lands.

Bond et al. (2002) measured short-term (1 year) survival of 21 spotted owls and productivity of 7 pairs in 11 recently burned territories (4 NSO, 3 California spotted owl, and 4 Mexican spotted owl). Fire burned 83-100% of the area within estimated territories, including known nest and roost areas. Fire severity was mapped for 8 of 11 territories: 6 of these primarily experienced low- to moderate-severity fire and two experience extensive severe fire. The authors re-sighted 18 of 21 (86%) individual owls after the fires and 16 of these (89%) were in their pre-fire territories. These estimate survival and territory fidelity rates are similar to those found in other, longer-term studies of the three spotted owl subspecies. Bond et al. (2002) found 7 pairs in burned areas 1-year post-fire and an average of 1 offspring produced per pair. This level of productivity was higher than those found in other studies. While based on very small sample sizes, this study suggests that, in the very short-term (1-year post-fire) spotted owls may often continue to occupy and breed within territories that have experienced fire; particularly low-to-moderate severity fire.

Clark et al. (2013) examined how fire and subsequent salvage logging affected occupancy dynamics of NSOs in two wildfire areas in southwestern Oregon. First, the authors compared occupancy dynamics before and after the Timbered Rock Fire to those in another area not recently burned by wildfire (South Cascades study area). The burned study area (Timbered Rock) experienced a 64% reduction in site occupancy post-fire, compared with a 25% reduction in the unburned study area (South Cascades) during the same period. These results suggest that wildfire and/or post-fire salvage logging negatively affected site occupancy by NSOs. In the study's second analysis, the authors examined possible relationships between NSO occupancy dynamics and wildfire, post-fire salvage logging, and other habitat conditions in three burned areas (Biscuit, Timbered Rock, and Quartz). They were unable to determine relationships between pre-fire occupancy dynamics and habitat variables but they did find that site occupancy declined in the short-term post-fire. Declines in occupancy did not appear to have been due to salvage logging alone since post-fire site extinction probabilities were highest in the Biscuit Fire study area, in which 13.6% and 17.1% of intermediate-age and older forests experienced moderate and high severity fire, respectively, compared with only 1.6% being salvage logged. Past timber harvesting, high-severity fire, and post-fire salvage logging likely cumulatively contributed to declines in site occupancy in all three burned areas.

In the same study, Clark et al. (2011) estimated annual survival rates for 23 territorial NSOs in three burned study areas (Quartz, Timbered Rock, Biscuit). The remains of 4 of the 5 dead NSOs recovered during the study were severely emaciated, suggesting that the owls died of starvation; possibly due to wildfire and/or salvage logging effects on foraging habitat or prey populations. Estimated annual survival rates for owls located inside the fire perimeters or displaced by the fires and/or post-fire salvage logging were lower than those both in areas just outside the fire perimeters and in an unburned reference study area (South Cascades).

Apparently contradictory results found by these studies may be due to several factors, in addition to the occurrence of salvage logging in one study and not the other. For example, spotted owl populations in the areas studied by Clark et al. (2011) may have been more sensitive to habitat changes than those studied by Bond et al. (2002) because suitable nesting-roosting habitat was more limited due to past intensive timber harvesting and a checkerboard ownership pattern. It is also possible that the study by Bond et al. (2002) was too short to detect a negative effect of wildfire on spotted owls. For example, mortality of trees due to insect attack can take more than a year to occur (Gaines et al. 1997). Furthermore, spotted owls may not immediately respond to habitat changes due to strong fidelity to territories and mates. It is also likely that the studies' discrepant findings were strongly influenced by differences in fire severity. Much of the area studied by Clark et al. (2011) was severely burned and/or salvage logged (approximately 30-40%), while the majority of territories studied by Bond et al. (2002) primarily experienced low- to moderate-severity fire and none were salvage logged. Studies of California and Mexican spotted owls generally support conclusions that large, severe fires can have strong negative effects on spotted owls, whereas the species appears to be resilient to low- to moderate-severity fires (e.g., Keane et al. 2010, 2012).

Land use and Habitat Conversion

Conversion of Northern Spotted Owl habitat to other land uses was not identified as a significant threat to the species in the Revised Recovery Plan. There is, however an emerging and as yet little-understood threat in California—land conversion for cannabis agriculture, both legal and illegal. While there is little actual quantifiable evidence to demonstrate the extent or severity of this threat, it is clear that conversion of forests to agricultural cannabis use, both legal and illegal can fragment and degrade habitat for the NSO. NSO may also be affected when riparian areas are altered due to water diversion for cannabis agriculture.

<u>Competition from Invasive Species</u>

Competition from non-native invasive species has emerged as one of the greatest threats to NSO conservation. The larger and more aggressive barred owl (*Strix varina*) has made its way from eastern North America to the Pacific Northwest, and now into California. According to the Executive Summary for the Final EIS for experimental barred owl removal, the range of the barred owl now completely overlaps with that of the Northern Spotted Owl (U.S. Fish and Wildlife Service 2013).

The FEIS Executive Summary notes that:

> "Although northern spotted owl populations have been declining for many years, the presence of barred owls exacerbates the decline. Recent studies (Olson *et al*. 2005, p. 918; Forsman *et al*. 2011a, pp. 69-70, 75-76) have established negative relationships between barred owl presence and declines in spotted owl population performance across the range of the subspecies. This could result in the extirpation (local extinction) or near extirpation of the northern spotted owl from a substantial portion of their historical range, even if other known threats, such as habitat loss, continue to be addressed." (U.S. Fish and Wildlife Service 2013).

The 2011Revised Recovery Plan summarizes the general findings of the latest science regarding the effects of barred owls on Northern Spotted Owls.

> "Barred owls reportedly have reduced spotted owl site occupancy, reproduction, and survival. Limited experimental evidence, correlational studies, and copious anecdotal information all strongly suggest barred owls compete with spotted owls for nesting sites, roosting sites, and food, and possibly predate spotted owls…. Because the abundance of barred owls continues to increase, the effectiveness in addressing this threat depends on action as soon as possible." (U.S. Fish and Wildlife Service 2011, p. III-62).

Dugger et al. 2011 further summarizes the affects of barred owls on NSO and provides clear recommendations to protect as much habitat as possible to mitigate these effects:

> "We observed increased extinction rates in response to decreased amounts of old forest at the territory core and higher colonization rates when old-forest habitat was less fragmented. Annual site occupancy for pairs reflected the strong effects of Barred Owls on occupancy dynamics with much lower occupancy rates predicted for territories where Barred Owls were detected. The strong Barred Owl and habitat effects on occupancy dynamics of Spotted Owls provided evidence of interference competition between the species. These effects increase the importance of conserving large amounts of contiguous, old-forest habitat to maintain Northern Spotted Owls in the landscape." (Dugger et al. 2011).

The implications for this invasive competition on the Northern Spotted Owl are clear and enormous. Listing of the Northern Spotted Owl under CESA is warranted for this reason alone, not withstanding all the other well-documented threats to the species.

<u>Inadequate Regulatory Mechanisms</u>

The petition at Section D-pages 19-23 describes the inadequacy of regulatory mechanisms range-wide and in California, on both public and private lands. We further discuss the inadequacy of regulatory mechanisms on public and private lands in California.

<u>Public Lands</u>

Federal land management poses many problems for Northern Spotted Owls. All federal lands within the range of the Northern Spotted Owl are currently managed under the provisions of the NWFP. As noted above, the NWFP alone is inadequate to provide recovery for the NSO, and populations are still in decline. (Davis et al. 2011, Franklin et al. 1999, Anthony et all 2006, Forsman et al. 2011).

According to Appendix A of the U.S. Fish and Wildlife Service's consultation for the U.S. Forest Service's Gemmill Thin project, the FWS has provided consultation on U.S. Forest Service Timber Sales within the range of the Northern Spotted Owl since 1994. Between 1994 and October 24, 2013, the FWS has consulted on the proposed removal/downgrade of approximately 708,155 acres (Table A1), or eight percent of the 8.854 million acres of Northern Spotted Owl nesting/roosting habitat estimated by Davis et al. (2011) to have occurred on Federal lands (Table A1). While these changes in suitable Northern Spotted Owl habitat may be consistent with the expectations for implementation of the NWFP, which anticipated a rate of habitat harvested at 2.5 percent per decade on public lands (USFS and BLM 1994a) (U.S. Fish and Wildlife Service 2013), they nonetheless document that habitat loss, modification, and/or curtailment are occurring on public lands, and that the NWFP has not adequately curtailed such habitat modification.

In all, the available evidence suggests that while the NWFP has reduced logging of suitable habitat on public lands, habitat loss and degradation is still occurring, including within the so-called "late-successional reserves." The inadequacies of the NWFP to protect spotted owls and preserve the species habitat constitute a substantial threat to the NSO.

<u>Private Lands</u>

The California Forest Practices Rules (FPRs) are the primary state regulations affecting the management of the Northern Spotted Owl on private lands in California. These regulations implement the Z'berg Nejedley Forest Practices Act of 1973 (Pub. Res. Code § 4511 et seq.).

The FPRs provide a suite of options for landowners to achieve the goal of "take" avoidance (14 CCR 919.9[939.9]). These options (a-g) were adopted by the California Board of Forestry and Fire Protection (Board of Forestry) in the early 1990's in response to the federal listing of the NSO as a "threatened" species under the federal ESA.

In addition to 14 CCR 919.9 [939.9] the FPRs also contain specific criteria to guide CAL FIRE in making a determination that "take" has been avoided (14 CCR 919.10 [939.10]). The FPRs provide that if CAL FIRE determines that "take" will not be avoided, then the Director must disapprove the plan (14 CCR 989.2 (f)).

When the NSO was originally listed, the then-California Department of Fish and Game provided consultation services to landowners and the California Department of Forestry and Fire Protection (CAL FIRE) on individual Timber Harvest Plans (THPs) in hopes of ensuring that "take" would be avoided. The Department of Fish and Game turned the biological review of individual projects to the FWS in 1999. Since that time the CDFW has been largely absent from the review and approval process for individual projects that may impact the NSO. The FWS conducted a process known as "technical assistance" whereby it reviewed individual THPs to ensure "take" avoidance through the lens of the existing FPRs, while augmenting its review with independent agency biological expertise. Although the process of seeking technical assistance falls under 14 CCR 919.9(e) [939.9(e)], the actual criteria for habitat protection and retention standards are contained in 14 CCR 919.9(g) [939.9(g)]. The FWS provided technical assistance through the lens of 14 CCR 919.9(g) [939.9(g)].

In 2009, the FWS ceased providing technical assistance to landowners and CAL FIRE. CAL FIRE thus became solely responsible for ensuring "take" avoidance. In doing so, the Service provided CAL FIRE with a review of the effectiveness of the FPRs to avoid "take" of NSO as defined under the federal Act. The FWS also provided CAL FIRE with a set of alternative "take" avoidance guidelines it believes would be more effective at protecting the NSO than current Rules.

The FWS's guidance document specifically called out the ineffectiveness of existing FPRs. The FWS's overall conclusion was:

> "…our combined experience with hundreds of THPs indicates that **the cumulative effects of repeated entries within many NSO home ranges has reduced habitat quality to a degree causing reduced occupancy rates and frequent site abandonment**. In a large proportion of technical assistance letters to CAL FIRE and industrial timberland owners during the past five years, we noted the lack of NSO responses at historic territories, and described habitat conditions considered inadequate to support continued occupancy and reproduction." (Emphasis added) (p 11).

14 CCR 919.9(g)[939.9(g)] otherwise known as "option "g"" contains prescriptive rules that delineate how much total NSO habitat must be retained following a given timber harvest in order to ensure that "take" is avoided. Habitat has traditionally been described using the definitions found in the FPRs at 14 CCR 895.1. Option "g" does not specify quantities of individual habitat types to be retained and in what configuration. Option "g" also contains disturbance minimization measures that are primarily employed during the breeding season for the NSO.

CAL FIRE advised the Board of Forestry at its March 2013 hearing that option "g"" is out-of-date, and no longer reflects the best available science.

> "…the Department recognizes that frankly Ken [Hoffman] knows we have been working with him prior to retirement in the Service and we have recognized the problems with option "g" for quite some time and even before we were handed the full brunt of the responsibility back in 2008 we had heard from the Service that option "g" was really not adequate." (Shintaku 2013).

Mr. Shintaku agreed with points made at the hearing by EPIC that option "g" is obsolete and inadequate:

> "…so first of all CAL FIRE agrees with EPIC in terms of the obsolete nature of option "g".... so really where we are today is what we are calling "g-plus".... what that means is we recognize "g" is not going to get it done, but the rules specifically say an RPF only has the choices "a"-"g" in order to address a spotted owl in a THP, so because the RPF has to say I am using option "g," coupled with the fact that we know option "g" is obsolete that forces the Department into what I would consider a full-blown CEQA analysis; we have to make sure that significant impacts, cumulative impacts and take are all addressed in the plan, and we just use the "g" vehicle to get that done." (Shintaku 2013).

The U.S. Fish and Wildlife Service (2009) identified several failings in the standard provisions and application of option "g." These include inadequate habitat retention standards and out dated habitat definitions. Regarding the existing FPR Northern Spotted Owl habitat definitions contained at 14 CCR 895.1 the Service stated:

> "...use of [California] W[ildlife] H[abitat] Relationship[s] habitat definitions in the FPRs is unlikely to avoid take. This is because the WHR types considered to be NSO habitat (4M & 4D) are widely variable, and at the lowest end of size class/density are typically poor habitat or non-habitat." (1-24-08 e-mail from Brian Woodbridge to CAL FIRE's Chris Browder).

The FWS expounded on the inadequacies of the FPR definitions:

> "Service staff in the Yreka Fish and Wildlife Office believe that application of the FPRs **typically does not avoid or reduce the likelihood of take of NSO**. This is because the habitat definitions and retention standards in the FPRs represent minimum values that are below the habitat parameters associated with reasonable levels of territory occupancy, survival, and reproduction by NSO."(ibid)(Emphasis added).

The following tables summarize the differences between the FPR NSO habitat definitions and the definitions recommended by the FWS:

FWS Interior				
	Basal Area	**TPA 26"+**	**Canopy closure**	**QMD (DBH)**
HQNR	210	> 8	>60%	>15"
N/R	150-180	>8	>60%	>15"
F	Mix ranging 120-180	>5	Mix 40-100%	>13"
LQF	Mix ranging 80-120		>40%	>11"

Forest Practice Rules		
	Canopy closure	**DBH**
N	>60% total (40% dominant and co-dominant)	>11"
R	>40% with high degree of variability	>11"
F	>40% but if more than 80% must be "fly space"	>11" conifer >6" hardwoods

As noted by CAL FIRE's Duane Shintaku, CAL FIRE has recognized the ineffectiveness of option-"g" and has begun to undertake a heretofore undefined review and approval process for THPs utilizing option "g" known only as "g-plus." CAL FIRE is implementing a review and approval process for THPs utilizing option "g" or "g-plus" that has not been vetted by a rulemaking process and that is not specified in regulation. This is contrary to the requirements of the FPRs themselves. 14 CCR 898.1 provides that the provisions of the Forest Practice Act and the FPRs shall be the only criteria employed by the Director when reviewing plans, consistent with Public Resources Code section 4582.7. CAL FIRE is left in the precarious position of recommending that landowners comply with the FWS Guidelines while not being able to require their implementation due to the lack of codified regulations to address the inadequacies of the existing Rules.

The existing evidence provided by the FWS indicates that existing regulatory mechanisms, particularly on private lands, are inadequate and have failed to curtail the downward trend of NSO fecundity, apparent survival, and populations in California. Listing of the NSO under CESA is necessary because the existing regulatory mechanisms are inadequate and because the lack of independent agency biological expertise of the CDFW and the FWS has resulted in CAL FIRE in the precarious position of determining that "take" has been avoided without consultation with the listing agency.

Climate Change

The Revised Recovery Plan acknowledged that climate change has been and will continue to affect forest ecosystems in the range of the Northern Spotted Owl. In preparing the recovery plan, the experts identified disease and the effect of climate change on vegetation as potential and more uncertain future threats. (U.S. Fish and Wildlife Service 2011, at I-8)

Franklin et al. 2000 found that changes in climate alone can affect Northern Spotted Owl life-history traits. Franklin et al. 2000 found:

> "Climate explained most of the temporal variation in life history traits. Annual survival varied the least over time, whereas recruitment rate varied the most, suggesting a ''bet-hedging'' life history strategy for the owl. A forecast of annual rates of population change (l), estimated from life history traits, suggested that Northern Spotted Owl populations may change solely due to climate influences, even with unchanging habitat conditions." (Franklin et al. 2000, Abstract).

According to Franklin et al. 2000, climatic variation is one structured source of temporal variation that may affect avian populations through its influence on life history traits, largely in a density-independent manner (Boyce 1984). Extremes in climatic variation also can function as catastrophic events and have been associated with sudden large scale mortality in avian populations (Tompa 1971, Johnson et al. 1991, Rogers et al. 1991, Smith et al. 1991).(Franklin et al. 2000).

The U.S. Fish and Wildlife Service's Biological and Conference Opinions for the issuance of the Fruit Growers Supply Company Habitat Conservation Plan and Incidental Take Permit briefly summarize the potential impacts of climate change:

> Loarie et al. (2008) projected that up to 66 percent of California's endemic flora would experience >80 percent reductions in range size as a result of anticipated climate changes. While this is a worst-case scenario based on high levels of CO2 emissions in the future, a global climate model with high sensitivity to atmospheric greenhouse gas levels, and no dispersal component, the models ignore several factors that would exacerbate the projected impacts of climate change, including specialization to restricted soil types and the spread of invasive species…
>
> Despite variability in climate change simulations, consistent projections for warmer summers, reduced spring snowpacks, and earlier and more rapid snowmelt suggest that forests in California and the Pacific Northwest will experience longer fire seasons and more frequent, extensive, and severe fires in the future (Flannigan et al. 2000, Lenihan et al. 2003a, Whitlock et al. 2003, McKenzie et al. 2004). (U.S. Fish and Wildlife Service 2012).

The FWS specifically discussed the potential impacts of climate change on NSO in this same document:

> Climate change, a potential additional threat to northern spotted owl populations, is not explicitly addressed in the NWFP. Climate change could have direct and indirect effects on northern spotted owls and their prey. Based upon a global meta-analysis, Parmesan and Yohe (2003) discussed several potential implications of global climate change to biological systems, including terrestrial flora and fauna. Results indicated that 62 percent of species exhibited trends indicative of advancement of spring conditions. In bird species, trends were manifested in earlier nesting activities. Because the northern spotted owl exhibits a limited tolerance to heat relative to other bird species (Weathers et al. 2001), subtle changes in climate have the potential for significant negative effects. However, the direct effects of climate change to the species are unknown. *Id.*

The Department must critically evaluate the potential threats to the Northern Spotted Owl that may result from climate change. Changes in climate are significant factors affecting the survival and enhancement of the Northern Spotted Owl now and into the future. The Department must give serious consideration to the best available evidence related to changes in climate.

IV. Conclusion

The best available information clearly establishes the necessity to list the Northern Spotted Owl under CESA. The best quality information identifies NSO declines in fecundity, apparent survival, population trends throughout the state and throughout the species' range, and the realities of ongoing habitat loss and the incursion of barred owls. The Northern Spotted Owl warrants listing as either a "threatened" or "endangered" species.

We appreciate the opportunity to provide comments to the Department to inform its status review. EPIC will follow this process closely and provide additional comments when the status review is available for public comment. Please do not hesitate to contact me at the number provided below if additional information is required or if there are questions about anything we present here.

Sincerely,

Rob DiPerna
California Forest and Wildlife Advocate

Environmental Protection Information Center
145 G Street, Suite A
Arcata, California 95521
Office: (707) 822-7711
Email: rob@wildcalifornia.org

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From: Rob DiPerna <rob@wildcalifornia.org>
Sent: Thursday, May 01, 2014 12:10 PM
To: Wildlife Management
Subject: Attn: Neil Clipperton--Northern Spotted Owl CESA staus review comments--group
Attachments: nso_cesa_statusreview_signon_epic_final.pdf

Dear Mr. Clipperton and Department Officials:

Please find attached a short summary comment letter that has been endorsed by numerous conservation groups.

We will be providing more extensive comments as well as supporting material later in the day today.

Thank you for your attention and consideration. Please do not hesitate to contact me at either of the numbers provided below as necessary.

Thank you.

Rob DiPerna
California Forest and Wildlife Advocate
Environmental Protection Information Center
145 G Street, Suite A
Arcata, CA 95521
(707) 822-7711 Office
(707) 845-9528 Cell
www.wildcalifornia.org

Sent to wildlifemgt@wildlife.ca.gov on date shown below

May 1st, 2014

California Department of Fish and Wildlife
Nongame Wildlife Program
Attn: Neil Clipperton
1812 9th Street
Sacramento, California 95811

Re: Comments Regarding CDFW Status Review for the Northern Spotted Owl (*Strix occidentalis caurina*)

Dear Mr. Clipperton and Department Officials:

The undersigned conservation organizations submit the following comments on the California Department of Fish and Wildlife Status Review for the Northern Spotted Owl (*Strix occidentalis caurina*) (NSO) pursuant to the California Endangered Species Act (CESA). Please consider these comments as part of the Department's review.

The available evidence supports the conclusion that the Northern Spotted Owl warrants listing as either "threatened" or "endangered" under CESA. The Northern Spotted Owl warrants listing under CESA because it meets several of the criteria for listing a species as specified under the Act. Specifically, the NSO warrants listing due to the following factors: 1) past, present, and threatened habitat destruction, modification or curtailment; 2) competition from invasive species; 3) inadequate regulatory mechanisms; 4) climate change.

The status and trends of NSO in California on both public and private lands show continued declines in NSO fecundity, apparent survival, and population trends (e.g. Forsman et al. 2011). The best available evidence clearly points to habitat loss and the incursion of the invasive and aggressive barred owl among the primary reasons for declines in NSO across the species' range, and in California specifically.

There is ample evidence available to the Department via long-term, independent, and peer-reviewed literature to show that the NSO warrants listing as either "threatened" or "endangered."

Long-term demographic studies such as Forsman et al. 2011 demonstrate that both public and private lands study areas show declines in key indicating factors. It is critical that the Department conduct its review with scientific rigor, and that it appropriately weighs available evidence based on the strengths of said evidence. We encourage the Department to seek and consider evidence of the highest quality and that represents the best available science.

CESA requires the Department to consider the best available information, but does not require certainty in the science or evidence. The Department must, therefore, conduct its evaluation through the lens of the best, most rigorous and most credible evidence.

The Northern Spotted Owl is clearly in decline in California and throughout its range, and is faced with a myriad of threats, and therefore warranting listing as either "threatened" or "endangered" under CESA. We appreciate the opportunity to provide comments to the Department and are happy to answer any questions that the Department may have.

Sincerely,

Susan Jane Brown
Western Environmental Law Center

George Sexton
Klamath-Siskiyou Wildlands Center

Kimberly Baker
Klamath Forest Alliance

Justin Augustine
Center for Biological Diversity

Steve Holmer
American Bird Conservancy

Jodi Frediani
Central Coast Forest Watch

Larry Glass
Safe Alternatives for our Forest Environment

Daniel Ehresman
Northcoast Environmental Center

Paul Hughes
Forests Forever

Marily Woodhouse
Battle Creek Alliance

Susan Robinson
Ebbetts Pass Forest Watch

From: Rob DiPerna <rob@wildcalifornia.org>
Sent: Thursday, May 01, 2014 1:32 PM
To: Wildlife Management
Subject: Attn: Neil Clipperton--Northern Spotted Owl EPIC comments--supporting documentation
Attachments: 20140409_2-14-022TRI_Sec5 131.pdf

Please see attached. Reference from Section V of SPI "Boomer" THP re: habitat conditions on SPI.

Thank you.

Rob DiPerna
California Forest and Wildlife Advocate
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The THP includes enforceable statements of compliance with 14 CCR 939.9(g)(3)&(4).

Table 1 Demonstration of compliance with 14 CCR 939.9(g)(3)&(4)

Habitat within 0.7 mile radius, using USFWS habitat definitions	Pre-harvest acres	Post-harvest acres	Net change	Compliance Requirement 500 acres 14 CCR 939.9(g)(3)
High Quality Nesting habitat*	0	0	0	
Nesting-roosting Habitat	186	186	0	
Foraging habitat	22	22	0	
Low Quality foraging habitat	406	369	-37	
Unsuitable	371	408	37	
Total Owl Habitat	614	577	37	577
Habitat within 1.3 mile radius, using USFWS habitat definitions	**Pre-harvest acres**	**Post-harvest acres**	**Net change**	**Compliance Requirement 1336 acres 14 CCR 939.9(g)(4)**
High Quality Nesting habitat*	0	0	0	
Nesting-roosting Habitat	280	280	0	
Foraging habitat	487	487	0	
Low Quality foraging habitat	1452	1260	-192	
Unsuitable	1176	1368	192	
Total Owl Habitat	2219	2027	192	2027

The following table has been developed using the methodology suggested to CAL FIRE by the USFWS in the document "<u>Important Information for Timber Operations Proposed within the Range of the Northern Spotted Owl"</u> (CAL FIRE, 2008). It is provided to further support the avoidance of "*take*" via *harm*.

Table 2 Demonstration of deficiency with USFWS Guidance

Habitat within 0.5 mile radius	Pre-harvest acres	Post-harvest acres	Net change	Recommend Retention 400 acres
High Quality Nesting habitat*	0	0	0	At least 100
Nesting-roosting Habitat	132	132	0	150
Foraging habitat	8	8	0	100
Low Quality foraging habitat	166	164	-2	50
Unsuitable	196	198	2	
Total Owl Habitat	306	304	2	304
Habitat within 0.5-1.3 mile radius	**Pre-harvest acres**	**Post-harvest acres**	**Net change**	**Compliance Requirement 935 acres**
High Quality Nesting habitat*	0	0	0	
Nesting-roosting Habitat	148	148	0	
Foraging habitat	479	479	0	655
Low Quality foraging habitat	1286	1096	-190	280
Unsuitable	973	1163	190	
Total Owl Habitat	1913	1723	190	1723

* The absence of high quality nesting Roosting habitat is largely a result of the USFWS's robust definition of this habitat type that exceeds the habitat conditions of most stands, except those that would traditionally be called "old growth" or primary older forest where no management footprint exists. These stands are not common in areas where historic or past management has been engaged by either Government or private land managers.

From: Rob DiPerna <rob@wildcalifornia.org>
Sent: Thursday, May 01, 2014 1:33 PM
To: Wildlife Management
Subject: Attn: Neil Clipperton--Northern Spotted Owl supporting documentation
Attachments: 2012-28714.pdf; RevisedNSORecPlan2011.pdf

Please see attached.

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Part II

Department of the Interior

Fish and Wildlife Service

50 CFR Part 17

Endangered and Threatened Wildlife and Plants; Designation of Revised Critical Habitat for the Northern Spotted Owl; Final Rule

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

[FWS–R1–ES–2011–0112; 4500030114]

RIN 1018–AX69

Endangered and Threatened Wildlife and Plants; Designation of Revised Critical Habitat for the Northern Spotted Owl

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Final rule.

SUMMARY: We, the U.S. Fish and Wildlife Service, designate revised critical habitat for the northern spotted owl (*Strix occidentalis caurina*) under the Endangered Species Act. In total, approximately 9,577,969 acres (ac) (3,876,064 hectares (ha)) in 11 units and 60 subunits in California, Oregon, and Washington fall within the boundaries of the critical habitat designation.

DATES: The rule becomes effective on January 3, 2013.

ADDRESSES: The final rule and the associated economic analysis and environmental assessment are available on the Internet at *http://www.regulations.gov* at Docket No. FWS–R1–ES–2011–0112. Comments and materials received, as well as supporting documentation used in preparing this final rule, are available for public inspection, by appointment, during normal business hours, at the U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office, 2600 SE. 98th Ave., Suite 100, Portland, OR 97266; telephone 503–231–6179; facsimile 503–231–6195.

The coordinates or plot points or both from which the maps are generated are included in the administrative record for this critical habitat designation and are available at *http://www.fws.gov/oregonfwo,* at *http://www.regulations.gov* at Docket No. FWS–R1–ES–2011–0112, and at the Oregon Fish and Wildlife Office (see **FOR FURTHER INFORMATION CONTACT**). The additional tools and supporting information that we developed for this critical habitat designation are available at the Fish and Wildlife Service Web site and Field Office set out above and at *http://www.regulations.gov.*

FOR FURTHER INFORMATION CONTACT: Paul Henson, Field Supervisor, U.S. Fish and Wildlife Service, Oregon Fish and Wildlife Office, 2600 SE. 98th Ave., Suite 100, Portland, OR 97266; telephone 503–231–6179; facsimile 503–231–6195. If you use a telecommunications device for the deaf (TDD), call the Federal Information Relay Service (FIRS) at 800–877–8339.

SUPPLEMENTARY INFORMATION:

Organization of the Final Rule

This final rule describes the revised critical habitat designation for the northern spotted owl under the Endangered Species Act of 1973, as amended (Act) (16 U.S.C. 1531 *et seq.*). The pages that follow summarize the comments and information received in response to the proposed designation published on March 8, 2012 (77 FR 14062), and in response to the notice of availability of the draft economic analysis and draft environmental assessment of the proposed revised designation published on June 1, 2012 (77 FR 32483), describe any changes from the proposed rule, and detail the final designation for the northern spotted owl. To assist the reader, the content of the document is organized as follows:

I. Executive Summary

Why we need to publish a rule. This is a final rule to designate revised critical habitat for the northern spotted owl. Under the Endangered Species Act of 1973, as amended (Act), designations and revisions of critical habitat can only be completed through rulemaking.

We, the U.S. Fish and Wildlife Service (Service), listed the northern spotted owl as threatened on June 26, 1990 (55 FR 26114), because of widespread loss of habitat across its range and the inadequacy of existing regulatory mechanisms to conserve it. We previously designated critical habitat for the northern spotted owl in 1992 and 2008. The 2008 designation (73 FR 47326, August 13, 2008) was subsequently challenged in court. In July 2009, the Federal Government requested voluntary remand of the 2008 revised critical habitat designation. On March 8, 2012, we published in the **Federal Register** a revised proposed critical habitat designation for the northern spotted owl (77 FR 14062). This rule complies with the court-ordered deadline to submit a final revised critical habitat rule for the northern spotted owl to the **Federal Register** by November 21, 2012.

Section 4(b)(2) of the Act states that the Secretary shall designate critical habitat on the basis of the best available scientific data after taking into consideration the economic impact, national security impact, and any other relevant impact of specifying any particular area as critical habitat. The critical habitat areas we are designating in this rule constitute our current best assessment of the areas that meet the definition of critical habitat for the northern spotted owl.

The rule revises our designation of critical habitat in Washington, Oregon, and California. Consistent with the best scientific data available, the standards of the Act and our regulations, we are designating 9,577,969 ac (3,876,064 ha) in 11 units and 60 subunits in California, Oregon, and Washington that meet the definition of critical habitat. The approximate totals by State and comparison to previous designations are outlined below, as follows (note some units and subunits overlap State boundaries; therefore, totals do not add up to 11 units and 60 subunits):

- Approximately 2,918,067 ac (1,180,898 ha) in 4 units and 26 subunits in Washington.
- Approximately 4,557,852 ac (1,844,496 ha) in 8 units and 58 subunits in Oregon.
- Approximately 2,102,050 ac (850,669 ha) in 5 units and 36 subunits in California.
- This designation increases previously designated critical habitat, including the addition of 272,026 ac (110,085 ha) ac of State lands. However, this final critical habitat designation is a decrease from the 13,962,449 ac (5,649,660 ha) identified as meeting the definition of critical habitat in the March 8, 2012 (77 FR 14062) proposed rule.
- We have also excluded areas of State and private land from this designation of critical habitat under section 4(b)(2) of the Act, as explained in the Exclusions section of this rule.

The Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011; hereafter ''Revised Recovery Plan'') recommends that land managers: (1) conserve older forest, high-value habitat, and areas occupied by northern spotted owls; and (2) actively manage forests to restore ecosystem health in many parts of the species' range. In developing this critical habitat designation, we also recognize the importance of the Northwest Forest Plan (NWFP) and its land management strategy for conservation of native species associated with old-growth and late-successional forest, including the northern spotted owl. The designation of areas as critical habitat does not change land use allocations or Standards and Guidelines for management under the NWFP, nor does this rule establish any management plan or prescriptions for the management of critical habitat. However, we encourage land managers to consider implementation of forest management practices recommended in the Revised Recovery Plan to restore natural ecological processes where they have been disrupted or suppressed (*e.g.,* natural fire regimes), and application of ''ecological forestry'' management practices (e.g., Gustafsson *et al.* 2012, entire; Franklin *et al.* 2007, entire; Kuuluvian and Grenfell *et al.* 2012 entire) within critical habitat to reduce the potential for adverse impacts associated with commercial timber harvest when such harvest is planned within or adjacent to critical habitat. In sum, the Service encourages land managers to consider the conservation of existing high-quality northern spotted owl habitat, the restoration of forest ecosystem health, and the ecological forestry management practices recommended in the Revised Recovery Plan that are compatible with both the goals of northern spotted owl recovery and Standards and Guidelines of the NWFP.

The basis for our action. This final critical habitat designation is based on the current status and recent scientific research on northern spotted owl populations. We used the best scientific information available to identify those specific areas within the geographical area occupied by the species at the time it was listed on which are found those physical or biological features essential to the conservation of the species, and which may require special management considerations or protection. For the northern spotted owl, these features include particular forest types that are used or likely to be used by northern spotted owls for nesting, roosting, foraging, or dispersing habitat. In addition, we used the best available information to identify those areas that are otherwise determined to be essential to the conservation of the species.

We relied on the recovery criteria set forth in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) to determine what is essential to the conservation of the species; therefore we have identified a habitat network that meets the following criteria:

- Ensures sufficient habitat to support stable, healthy populations across the range, and also within each of the 11 recovery units;
- Ensures distribution of northern spotted owl populations across the range of habitat conditions used by the species;
- Incorporates uncertainty, including potential effects of barred owls, climate change, and wildfire disturbance risk; and
- Recognizes that these protections are meant to work in concert with other recovery actions, such as barred owl management.

To assist us in determining critical habitat, we integrated habitat and demographic information (relating to occupancy, survival, reproduction, and movement) to develop a modeling tool that assesses the distribution of habitat quality and population dynamics across the range, and provides a more accurate picture of where high-quality northern spotted owl habitat exists. This model synthesized more than 20 years of data from on-the-ground demographic surveys, and allowed for analysis of how northern spotted owl populations would fare under different habitat conservation scenarios. We determined what is essential to recovery of the northern spotted owl by evaluating the performance of each potential critical habitat scenario considered against the recovery needs of the owl.

Peer reviewers support our methods. We solicited expert opinions from knowledgeable individuals with scientific expertise that included familiarity with the species, the geographic region in which the species occurs, and conservation biology principles. These peer reviewers generally concurred with our methods and conclusions and provided additional information, clarifications, and suggestions to improve this final rule.

Consistency with Presidential Directive. On February 28, 2012, the President issued a memorandum to the Secretary of the Interior regarding the proposed revised critical habitat for the northern spotted owl, specifically on minimizing regulatory burdens. The Service has fully addressed each of the directives in this memo and has taken steps to comply with this directive, including:

- We conducted and completed, as is the Service's normal practice, an economic analysis on the probable impacts of the proposed revised critical habitat.
- We provided a description of ecological forestry management actions that may be compatible with both northern spotted owl recovery and timber harvest, as recommended in the Revised Recovery Plan for the Northern Spotted Owl. This discussion appears in the following sections of this rule:
    - An Ecosystem-based Approach to the Conservation of the Northern Spotted Owl and Managing Its Critical Habitat
    - Special Management Considerations or Protection
    - Determination of Adverse Effects and Application of the ''Adverse

Modification'' Standard.

We note, however, that this discussion of ecological forestry is provided to Federal, State, local and private land managers, as well as the public, for their consideration as they make decisions on the management of forest land under their jurisdictions and through their normal processes. This critical habitat rule itself does not take any action or adopt any policy, plan, or program in relation to active forest management.

• As per the Service's normal practice, we solicited public review and comment on this rulemaking action, using information thus gained to correct and refine our designation.

• We fully considered exclusion of private lands and State lands from the final revised critical habitat, consistent with the best available scientific and commercial information.

The Service appreciates, and is sensitive to, the potential for regulatory burden that may result from our designation of critical habitat for the northern spotted owl under the Act. Our analysis indicated that the revision of critical habitat could have relatively little incremental effect above and beyond the conservation measures already required as a result of its threatened species status under the Act, and thus is not expected to impose substantial additional regulatory burdens. The Service appreciates, and relies on the many partners we have in conservation, including private landowners, Tribes, States, and local governments, and strongly desires to promote conservation partnerships to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people.

Costs and benefits. In order to identify and analyze the potential economic impacts of the designation of critical habitat for the northern spotted owl, we worked with a contractor to draft an economic analysis report, which was released in May of 2012 and finalized following consideration and incorporation of public comment. The report looked at a variety of economic activities including timber harvest, wildlife management, road construction, and other forest management activities, but focused primarily on timber management. It concludes that only a relatively small portion of the overall proposed revised designation may result in more than minor incremental administrative costs. It found that potential incremental changes in timber harvests on Bureau of Land Management and U.S. Forest Service lands may occur on approximately 1,449,534 ac (585,612 ha) proposed for designation, or 10 percent of the total lands included in the proposed designation and that there is the potential for 307,308 ac (123,364 ha) of private land to experience incremental changes in harvests, or approximately 2 percent of total lands proposed. No incremental changes in harvests are expected on State lands.

II. Background

It is our intent to discuss only those topics directly relevant to the revised designation of critical habitat in this rule. For further details regarding northern spotted owl biology and habitat, population abundance and trend, distribution, demographic features, habitat use and conditions, threats, and conservation measures, please see the Northern Spotted Owl 5-year Review Summary and Evaluation, completed October 26, 2011, and the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), completed July 1, 2011. Both of these documents are available on the U.S. Fish and Wildlife Service's Endangered Species Web site at *http://ecos.fws.gov/;* under ''Species Search,'' enter ''northern spotted owl.'' As detailed below, Appendix C of the Revised Recovery Plan is particularly informative, as we used the habitat modeling process it describes as a tool to help identify areas containing the essential physical and biological features or areas that were otherwise essential to the conservation of the northern spotted owl in this revised designation of critical habitat. Furthermore, the recovery criteria for the northern spotted owl, as described in the Revised Recovery Plan (USFWS 2011, pp. I–1 to I–2), helped to discriminate between the various scenarios considered in the modeling process in terms of assessing which of the habitat networks evaluated included what is essential to the conservation of the northern spotted owl in the most efficient configuration possible.

Introduction

The northern spotted owl inhabits structurally complex forests from southwestern British Columbia through Washington and Oregon to northern California. The northern spotted owl was listed under the Act as a threatened species in 1990 because of widespread loss of habitat across its range and the inadequacy of existing regulatory mechanisms to conserve it (55 FR 26114; June 26, 1990). Although the rate of loss of habitat due to timber harvest has been reduced on Federal lands over the past two decades, both past and current habitat loss remain a threat to the northern spotted owl. Despite implementation of habitat conservation measures in the early 1990s, Thomas *et al.* (1990, p. 5) and USDI (1992, Appendix C) foresaw that owl populations would continue to decline for several decades, even with habitat conservation, as the consequence of lag effects at both individual and population levels. However, many populations of northern spotted owls have declined at a faster rate than anticipated, especially in the northern parts of the subspecies' range (Anthony *et al.* 2006, pp. 31–32; Forsman *et al.* 2011, pp. 65, 76). We now know that the suite of threats (detailed below) facing the northern spotted owl differs from those at the time it was listed; in addition to the effects of historical and ongoing habitat loss, the northern spotted owl faces a new significant and complex threat in the form of competition from the congeneric (referring to a member of the same genus) barred owl (USFWS 2011, pp. I–7 to I–8).

During the second half of the 20th century, barred owls expanded their range from eastern to western North America, and the range of the barred owl now completely overlaps that of the northern spotted owl (Gutiérrez *et al.* 1995, p. 3; Crozier *et al.* 2006, p. 761). Barred owls compete with northern spotted owls for habitat and resources for breeding, feeding, and sheltering, and the presence of barred owls has significant negative effects on northern spotted owl reproduction, survivorship, and successful occupation of territories (see Population Status and Trends, below). The loss of habitat has the potential to intensify competition with barred owls by reducing the total amount of resources available to the northern spotted owl and by increasing the likelihood and frequency of competitive interactions. While there are important differences in the ecology between barred owls and northern spotted owls, barred owls select very similar habitat for breeding, feeding, and sheltering, and loss of habitat has the potential to intensify competition between species. While conserving habitat will not completely alleviate the barred owl threat, Dugger *et al.* (2011, pp. 2464–2465) found that northern spotted owl occupancy and colonization rates decreased as both barred owl presence increased and available habitat decreased. Similar to another case in which increased suitable habitat was required to support two potentially competing raptors, these authors concluded that increased habitat protection for northern spotted owls may be necessary to provide for sustainable populations in the presence of barred owls in some areas (Dugger *et al.* 2011, p. 2467). Maintaining high-quality habitat has been important since the northern spotted owl was initially listed as a threatened species in 1990, and this competitive pressure from barred owls has intensified the need to conserve and restore large areas of contiguous, high-quality habitat across the range of the northern spotted owl (Dugger *et al.* 2011, p. 2464; Forsman *et al.* 2011, p. 76; USFWS 2011, Recovery Action 32 [RA32], p. III–67).

It is becoming increasingly evident that solely securing habitat will not be effective in achieving the recovery of the northern spotted owl when barred owls are present (USFWS 2011, p. vi). While conservation of high-quality habitat is essential for the recovery and conservation of the owl, habitat conservation alone is not sufficient to achieve recovery objectives. As stated in the Revised Recovery Plan, ''* * * addressing the threats associated with past and current habitat loss must be conducted simultaneously with addressing the threats from barred owls. Addressing the threat from habitat loss is relatively straightforward with predictable results. However, addressing a large-scale threat of one raptor on another, closely related raptor has many uncertainties'' (USFWS 2011, p. I–8). A designation of critical habitat is intended to ameliorate habitat-based threats to an endangered or threatened species; critical habitat cannot reasonably be expected to fully address other, non-habitat-related threats to the species. In the case of the northern spotted owl, the recovery goal of supporting population viability and demographically stable populations of northern spotted owls will likely require habitat conservation in concert with the implementation of recovery actions that address other, non-habitat-based threats to the species, including the barred owl. In addition, recovery actions include scientific evaluation of potential management options to reduce the impact of barred owls on northern spotted owls (USFWS 2011, Recovery Action 29 [RA29], p. III–65), and implementation of management actions determined to be effective (USFWS 2011, Recovery Action 30 [RA30], p. III–65).

When developing a critical habitat rule, the Service must use the best scientific information available to identify critical habitat as defined in section (3)(5)(A) of the Act, which are (i) the specific areas within the geographical area occupied by the species at the time it was listed that provide the physical or biological features essential for the conservation of the species, and which may require special management considerations or protection, and (ii) specific areas outside the geographical area occupied by the species at the time it was listed that are otherwise determined to be essential to the conservation of the species. However, like most critical habitat designations, this rule addresses elements of risk management, because we must make recommendations and decisions in the face of incomplete information and uncertainty about factors influencing northern spotted owl populations. This uncertainty exists even though the northern spotted owl is among the most thoroughly studied of listed species. We understand a great deal about the habitats the subspecies prefers and the factors that influence its demographic trends. Nonetheless, considerable uncertainty remains, particularly about interactions among different factors that threaten the owl.

In the face of such uncertainty, the Revised Recovery Plan proposes strategies to address the primary threats to the northern spotted owl from habitat loss and barred owls (USFWS 2011, p. I–7). The effects of climate change and of past management practices are changing forest ecosystem processes and dynamics, including patterns of wildfires, insect outbreaks, and disease, to a degree greater than anticipated in the Northwest Forest Plan (NWFP) (Hessburg *et al.* 2005, pp. 134–135; Carroll *et al.* 2010, p. 899; Spies *et al.* 2010, entire; USFWS 2011, p. I–8). At the same time, the expansion of barred owl populations is altering the capacity of intact habitat to support northern spotted owls. Projecting the effects of these factors and their interactions into the future leads to even higher levels of uncertainty, especially considering how the influences of different threats may vary across the owl's large geographical range. It is clear that ecosystem-level changes are occurring within the northern spotted owl's forest habitat.

The development of a critical habitat network for the northern spotted owl must take into account current uncertainties, such as those associated with barred owl impacts and climate change predictions (USFWS 2011, p. III–10). These uncertainties require that we make some assumptions about likely future conditions in developing, modeling, and evaluating potential critical habitat for the northern spotted owl; those assumptions are identified clearly in this rule (see Criteria Used to Identify Critical Habitat, below) and in our supporting documentation (Dunk *et al.* 2012b, entire).

Given the continued decline of northern spotted owl populations, the apparent increase in severity of the threat from barred owls, and information indicating a recent loss of genetic diversity for the subspecies, retaining both occupied northern spotted owl sites and unoccupied, high-value northern spotted owl habitat across the subspecies' range are key components for recovery (USFWS 2011, p. I–9). High-value habitat is defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as habitat that is important for maintaining northern spotted owls on landscapes, including areas with current and historic use by northern spotted owls. We refer readers to the glossary (Appendix G) of the Revised Recovery Plan for definitions of forest stand conditions and habitat types discussed in this rule.

Accordingly, in this rule, we have identified areas of habitat occupied at the time of listing that provide the physical or biological features essential to the conservation of the northern spotted owl, and that may require special management considerations or protection. When occupied areas were not adequate to achieve essential recovery goals, we also identified some unoccupied areas as critical habitat for the northern spotted owl only upon a determination that such areas are essential to the conservation of the species (see the second part of the definition of critical habitat in section (3)(5)(a)(ii), which states that critical habitat also includes ''specific areas outside the geographical area occupied by the species at the time of listing in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.'') However, it is important to note that this revised designation of critical habitat does not include all sites where northern spotted owls are presently known to occur. The habitat modeling that we used, in part, to assist us in developing this revised designation was based primarily on present habitat suitability. While we did also consider the present known locations of northern spotted owls in refining the identified habitat network, not all such sites were included in the revised designation if those areas did not make a significant contribution to population viability (for example, if known sites were too small or isolated to play a meaningful role in the conservation of the species; see Criteria Used to Identify Critical Habitat). This is in accordance with section 3(5)(C) of the Act, which specifies that ''critical habitat shall not include the entire geographical area which can be occupied by the threatened or endangered species.''

Because of the uncertainties associated with the effects of barred owl interactions with the northern spotted owl and habitat changes that may occur as a result of climate change, active adaptive forest management strategies will be needed to achieve results in certain landscapes. Active adaptive forest management is a systematic approach for improving resource management by learning from the results of explicit management policies and practices and applying that learning to future management decisions (USFWS 2011, p. G–1). This critical habitat rule identifies key sources of uncertainty, and the need to learn from our management of forests that provide habitat for northern spotted owls. We have designated a critical habitat network that was developed based on what we determined to be the areas containing the physical and biological features essential for the conservation of the northern spotted owl or are otherwise essential to owl conservation, after taking into consideration information on essential habitats, the current distribution of those habitats, and the best available scientific knowledge about northern spotted owl population dynamics, while acknowledging uncertainty about future conditions in Pacific Northwest forests.

An Ecosystem-Based Approach to the Conservation of the Northern Spotted Owl and Managing Its Critical Habitat

Section 2 of the Act states, ''The purposes of this Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved.'' Although the conservation of the listed species is the specific objective of a critical habitat designation, the essential physical or biological features that serve as the basis of critical habitat are often essential components of the ecosystem upon which the species depends. In such cases, a fundamental goal of critical habitat management is not only to conserve the listed species, but also to conserve the ecosystem upon which that species depends. This is the case with the northern spotted owl.

An ecosystem is defined as a biological community of interacting organisms and their physical environment, or as the complex of a community of organisms and its environment functioning as an ecological unit (Krebs 1972, pp. 10–11; Ricklefs 1979, pp. 31–32, 869). These ecosystem interactions and functions are often referred to as ecological relationships or processes. Thus, to conserve the northern spotted owl as directed by the Act, one must also conserve the ecological processes that occur within the ecological landscape inhabited by the species. These processes—such as vegetation succession, forest fire regimes, and nutrient cycling—create and shape the physical or biological features that form the foundation of critical habitat. The northern spotted owl was initially listed as a threatened species largely due to the loss or degradation of the late-successional forest ecosystems upon which it depends. A complex interaction of physical or biological factors contribute to the development and maintenance of these ecosystems, which in turn provide the northern spotted owl with the environmental conditions required for its conservation and survival, such as large areas of suitable habitat, nest structures, and sufficient prey to sustain interconnected populations of owls across the landscape. A fundamental goal of critical habitat management should thus be to understand, describe, and conserve these processes, which in turn will maintain the physical or biological features essential to the conservation of the species. This ''ecosystem approach'' will ultimately have the highest likelihood of conserving listed species such as the northern spotted owl in the long term (Knight 1998, p. 43).

The U.S. Forest Service, which manages the great majority of areas being designated as revised northern spotted owl critical habitat, has prioritized restoring and maintaining natural ecological function and resiliency to its forest lands (Blate *et al.* 2009, entire; USDA 2010, entire; Tidwell 2011, entire). Active adaptive forest management within critical habitat, as discussed herein for the consideration of land managers, may be fully compatible and consistent with these landscape-level ecosystems. Most importantly, this approach is compatible with the ecosystem-based approach of the Northwest Forest Plan.

Revised critical habitat for the northern spotted owl includes a diverse forest landscape that covers millions of acres and contains several different forest ecosystems and thousands of plant and animal species. It ranges from moist old-growth conifer forest in the western portion, to a mix of conifers and hardwood trees in the Klamath region, to dry, fire-prone forests in the eastern Cascades. Thousands of species occur in these forest ecosystems, including other listed and sensitive species with very specific biological needs. In areas where prescribed management is needed to maintain ecosystem function, such management is often expensive, logistically difficult, and contentious (Thompson *et al.* 2009, p. 29). Many scientists believe a single-species approach to forest management is limited and that land managers need to focus on broader landscape goals that address ecosystem process and future habitat conditions (see, e.g., Thomas *et al.* 2006, p. 286; Boyd *et al.* 2008, p. 42; Hobbs *et al.* 2010, p. 487; Mori 2011, pp. 289–290). The Revised Recovery Plan (USFWS 2011) encourages the application of ecosystem management principles to ensure the long-term conservation of the northern spotted owl and its habitat, as well as other species dependent on these shared ecosystems.

We reference here the recommendations for habitat management as made in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011). This discussion is provided primarily for consideration by Federal, State, local, and private land managers, as they make decisions on the management of forest land under their jurisdictions and through their normal processes. This critical habitat rule does not take any action or adopt any policy, plan or program in relation to active forest management.

Critical Habitat and the Northwest Forest Plan

It is important to understand the relationship between northern spotted owl critical habitat and the Northwest Forest Plan (NWFP). In brief, the designation of areas as critical habitat does not change land use allocations or Standards and Guidelines for management under the NWFP. Critical habitat for the northern spotted owl was first designated in 1992 (January 15, 1992; 57 FR 1796). Since 1994, the NWFP has also served as an important landscape-level plan that has contributed to the conservation of the northern spotted owl and late-successional forest habitat on Federal lands across the range of the species (Thomas *et al.* 2006, pp. 278–284). The NWFP introduced a system of reserves where conservation of late-successional forest, riparian habitats, northern spotted owls, and other species dependent on older forest would be the priority, and matrix areas where timber harvest would be the goal. The Standards and Guidelines for the NWFP (USDA and USDI 1994) prescribe an ecosystem-based approach to management for the Federal action agencies that manage these lands, and provide guidance for activities conducted on different land use allocations. All Bureau of Land Management and U.S. Forest Service lands identified as northern spotted owl critical habitat in this rule fall under the NWFP, and should be managed consistent with its standards. Here we briefly provide a summary of how our designation of critical habitat has been informed by and relates to forest management under the NWFP.

In developing this critical habitat designation, the Service recognizes the importance of the NWFP as the overarching land management strategy for conservation of the northern spotted owl and other native species associated with old-growth and late-successional forest. The system of reserves within the NWFP is essential for the conservation and development of large areas of late-successional forest across the landscape; however, because the NWFP was designed to benefit multiple species not every acre of the late-successional reserves (LSRs) provide high-quality habitat for northern spotted owls. In addition, barred owls have become increasingly abundant in the Pacific Northwest and likely have a large effect on the continued decline of northern spotted owl populations. With barred owls now sharing the range of the northern spotted owl, conservation of northern spotted owls outside NWFP reserved areas is increasingly important for species recovery.

In our designation of critical habitat on Federal lands, we identified lands that contain the features essential to the conservation of the species including lands both within NWFP reserves and matrix that function as highly valuable northern spotted owl habitat. As noted above, designation as critical habitat does not change these land use allocations or Standards and Guidelines for management under the NWFP, and we fully recognize the ecological functions and land management goals of the different land use allocations as outlined under the NWFP. While the NWFP has been successful in conserving large blocks of late-successional forest (Thomas *et al.* 2006, p. 283, Davis *et al.* 2011, p. 38), concerns have been expressed that it provides less than the anticipated level of commercial timber harvest on matrix lands, does not promote active restoration in areas that may contain uncharacteristically high risk of severe fire (Spies *et al.* 2006, pg. 359; Thomas *et al.* 2006, p. 277), and does not promote development of complex early-seral forest in areas where regeneration harvest has been conducted (Betts *et al.* 2010, p. 2117; Hagar 2007, p. 109; Swanson *et al.* 2011, p. 124) (''seral'' refers to developmental or successional stages of the forest community that influences species composition, i.e., early, mid, late seral stages).

Thomas *et al.* (2006, pp. 284–287) provided three recommendations to improve the NWFP. These recommendations are highly relevant to northern spotted owl critical habitat conservation and management:

1. Conserve old-growth trees and forests on Federal lands *wherever they are found* (emphasis added), and undertake appropriate restoration treatment in the threatened forest types.

2. Manage NWFP forests as dynamic ecosystems that conserve all stages of forest development (e.g., encompassing the range of conditions between early-seral and old-growth), and where tradeoffs between short-term and long-term risks are better balanced.

3. Recognize the NWFP as an integrated conservation strategy that contributes to all components of sustainability across Federal lands.

It is our hope that management of critical habitat for the northern spotted owl will be compatible with these broader landscape management goals articulated by Thomas *et al.* (2006, pp. 284–287). Furthermore, the Standards and Guidelines for the NWFP encourage an ecosystem-based approach to land management (*e.g.,* USDA and USDI 1994, p. A–1, Standards and Guidelines, pp. C–12, C–13). As discussed in the Revised Recovery Plan, recovery of the northern spotted owl will likely require that an ecosystem management approach that includes both passive and active management, to meet a variety of conservation goals that support long-term northern spotted owl conservation, be implemented. We fully support the land use allocation goals and the Standards and Guidelines for management under the NWFP (USDA and USDI 1994) as informed by the recommendations of the Revised Recovery Plan. Some general considerations for managing the threats to the essential physical or biological features for the northern spotted owl are discussed in the *Special Management Considerations or Protections* and *Determinations of Adverse Effects and Application of the ''Adverse Modification'' Standard* sections of this document, below, as well as in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, pp. III–11 to III–39).

Forest Management Activities in Northern Spotted Owl Critical Habitat

As stated above, many areas of critical habitat do not require active management, and active forest management within such areas could negatively impact northern spotted owls. We are not encouraging land managers to consider active management in areas of high-quality owl habitat or occupied owl sites; rather, we encourage management actions that will maintain and restore ecological function where appropriate. In some areas, forest stands are not on a trajectory to develop into high-value habitat, ecological processes have been disrupted by human actions, or projected climate change is expected to further disrupt or degrade desired forest conditions. In these areas, land managers may choose to implement active management, as recommended in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), to improve ecological health and development of forest conditions more favorable to northern spotted owls and other biodiversity. For example, LSRs are to be managed to protect and enhance old-growth forest conditions (defined in the Revised Recovery Plan as forests that have accumulated specific characteristics related to tree size, canopy structure, snags, and woody debris and plant associations). According to the NWFP Standards and Guidelines (USDA and USDI 1994), no programmed timber harvest is allowed inside the reserves. However, thinning or other silvicultural treatments inside these reserves may occur in younger stands if the treatments are beneficial to the creation and maintenance of late-successional forest conditions. On the east of the Cascades and in Oregon and California Klamath Provinces, additional management activities may be considered both within and outside reserves to reduce risks of large-scale disturbance (NWFP Standards and Guidelines, p. C–12—C–13).

We also recognize that ecological restoration is not the management goal on all NWFP land use allocations (*e.g.,* matrix) within designated critical habitat, and we provide a discussion of options land managers could consider to tailor traditional forest management activities on these lands to consistent with conservation of current and future northern spotted owl habitat (see, *e.g.,* Gustafsson *et al.* 2012, entire; Franklin *et al.* 2007, entire; Kuuluvainen and Grenfell 2012, entire; North and Keeton 2008; Long 2009, entire; Lindenmayer *et al.* 2012; entire). Our discussion of potential management considerations for the northern spotted owl are intended to be fully compatible with the objectives and Standards and Guidelines of the NWFP as informed by the conservation guidelines presented in the 2011 Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) to provide a means whereby the ecosystems on which northern spotted owls depend will be conserved.

Mimicking natural disturbance regimes, such as fire, is an important strategy in North American forest management (Seymour and Hunter 1999, p. 56; Long 2009, p. 1868; Gustafsson *et al.* 2012, p. 635; Kuuluvainen and Grenfell 2012, entire). This change is occurring in response to: (1) The simplification of forests in terms of structure, age-class diversity, and species composition as a result of management for timber production, and (2) a recognition of fundamental changes in ecosystem function and processes due to land management practices, especially fire and successional patterns (Franklin *et al.* 2002, pp. 402–408; Hessburg *et al.* 2005, pp. 134–135; Drever *et al.* 2006, p. 2291). Although human disturbance is unlikely to precisely mimic natural forest disturbance, it can be used to better maintain the resilience of landscapes and wildlife populations to respond to natural disturbance and climate change (Lindenmayer *et al.* 2008, p. 87). In general, prescriptions (e.g., vegetation management, prescribed fire, etc.) that apply ecological forestry principles to address the restoration and conservation of broader ecological processes in areas where this is needed, while minimizing impacts to structurally diverse or mature and old forest that does not require such management can be compatible with maintaining the critical habitat's essential features in the long term at the landscape scale (USFWS 2011, p. III–14). The Service has recently consulted on these types of management actions in occupied northern spotted owl habitat on Bureau of Land Management (BLM) and U.S. Forest Service (USFS) lands.

Specifically prescribing such management is beyond the scope or purpose of this document, and should instead be developed by the appropriate land management agency at the appropriate land management scale (e.g., National Forest or Bureau of Land Management District) (USDA 2010, entire; Fontaine and Kennedy 2012, p. 1559; Gustafsson *et al.* 2012, pp. 639–641, Davis *et al.* 2012, entire) through the land managing agencies' planning processes and with technical assistance from the Service, as appropriate. Furthermore, we encourage an active adaptive forest management approach, should agencies choose to implement ecological forestry practices, as we continue to learn from continuing research on these methods (see *Research and Adaptive Management,* below).

Some general considerations for managing for the conservation of essential physical or biological features within northern spotted owl critical habitat are discussed in more detail in the *Special Management Considerations or Protections* and *Determinations of Adverse Effects and Application of the ''Adverse Modification'' Standard* sections of this document, below. In sum, vegetation and fuels management in dry and mixed-dry forests may be appropriate both within and outside designated critical habitat where the goal of such treatment is to conserve natural ecological processes or restore them (including fire) where they have been modified or suppressed (Allen *et al.* 2002, pp. 1429–1430; Spies *et al.* 2006, pp. 358–361; Fielder *et al.* 2007, entire; Prather *et al.* 2008, entire; Lindenmayer *et al.* 2009, p. 274; Tidwell 2011, entire; Stephens *et al.* 2009, pp. 316–318; Stephens *et al.* 2012a, p. 13; Stephens *et al.* 2012b, pp. 557–558; Franklin *et al.* 2008, p. 46; Miller *et al.* 2009, pp. 28–30; Fule *et al.* 2012, pp. 75–76). These types of management are encouraged in the NWFP (USDA and USDI 1994, p. C–13). Likewise, in some moist and mixed forests, management of northern spotted owl critical habitat should be compatible with broader ecological goals, such as the retention of high-quality older forest, the continued treatment of young or homogenous forest plantations to enhance structural diversity, heterogeneity and late-successional forest conditions, and the conservation or restoration of complex early-seral forest habitat, where appropriate (Spies *et al.* 2007b, pp. 57–63; Betts *et al.* 2010, pp. 2117, 2126–2127; Swanson *et al.* 2011, entire).

In general, actions that promote ecological restoration and those that apply ecological forestry principles at appropriate scales as described above and in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, pp. III–11 to III–41) may be, in the right circumstances, consistent with the conservation of the northern spotted owl and the management of its critical habitat. However, we emphasize that this rule does not take any action or adopt any policy, plan or program in relation to active forest management. The discussion is provided only for consideration by Federal, State, local and private land managers, as well as the public, as they make decisions on the management of forest land under their jurisdictions and through their normal processes.

Research and Adaptive Management

The Service supports the goals of maintaining and restoring ecological function and development of future northern spotted owl habitat. We encourage land managers to consider a stronger focus on ecological forestry in areas where commercial harvest and restoration are planned. We recognize the need to balance both the conservation of current owl sites and the development of future owl habitat. However, a better understanding of how ecological forestry approaches affect owls and their prey is needed. Studies have shown negative effects of commercial thinning and other conventional forestry practices on both northern spotted owls (Forsman *et al.* 1984, pp. 16–17; Meiman *et al.* 2003, p. 1261) and their prey (Waters *et al.* 1994, p. 1516; Luoma *et al.* 2003, pp. 343–373; Wilson 2010, entire).This need was recognized in Recovery Action 11 of the Revised Recovery Plan, which states ''When vegetation management treatments are proposed to restore or enhance habitat for northern spotted owls (e.g., thinnings, restoration projects, prescribed fire, etc.), consider designing and conducting experiments to better understand how these different actions influence the development of northern spotted owl habitat, northern spotted owl prey abundance and distribution, and northern spotted owl demographic performance at local and regional scales.'' Furthermore, the recovery strategy outlined in the Revised Recovery Plan (USFWS 2011) identifies monitoring and research, as well as active adaptive forest management, as important steps in achieving recovery goals.

Given these concerns, and recognizing that appropriate management actions will vary depending upon site-specific conditions, we provide the following suggestions regarding active forest management for consideration by land managers within critical habitat as consistent with the recommendations of the Revised Recovery Plan for the Northern Spotted Owl:

1. Focus active management in younger forest, lower quality owl habitat, or where ecological conditions are most departed from the natural or desired range of variability.

2. In moist forests on Federal lands, follow NWFP guidelines as informed by the Revised Recovery Plan and focus on areas outside of LSRs (i.e., matrix). In dry forests, follow NWFP guidelines and focus on lands in or outside of reserves

that are most ''at-risk'' of experiencing uncharacteristic disturbance and where the landscape management goal is to restore more natural or resilient forest ecosystems (see, *e.g.,* Davis *et al.* 2012, entire; Franklin *et al.* 2008, p. 46).

3. Avoid or minimize activities in active northern spotted owl territories (or the high-quality habitat within these territories).

4. Ensure transparency of process so the public can see what is being done, where it is done, what the goal of the action is, and how well the action leads to the desired goal.

5. Practice active adaptive forest management by incorporating new information and learning into future actions to make them more effective, focusing on how these actions affect northern spotted owls and their prey.

Towards this objective of learning critical new scientific insights from research and adaptive management, we especially encourage research and active adaptive forest management on the seven Forest Service Experimental Forests (H.J. Andrews Experimental Forest, Pringle Falls Experimental Forest, South Umpqua Experimental Forest, and Cascades Head Experimental Forest in Oregon; Wind River Experimental Forest and Entiat Experimental Forest in Washington; and Yurok Redwood Experimental Forest in California) within designated northern spotted owl critical habitat. We acknowledge the specific value and contributions of research done within experimental forests in furtherance of the research and active adaptive forest management objectives in the Revised Recovery Plan. These Experimental Forests have four principal scientific advantages that support the specific kinds of research needed to better understand how management affects and potentially enhances northern spotted owl habitat:

(1) These sites are intended for and enabled to conduct manipulative research to test forest management strategies in a rigorous scientific manner;

(2) They have long-term baseline datasets that enable detailed climate/environmental change assessments;

(3) The sites represent a diversity of forest types within the range of northern spotted owl; and

(4) Experimental forests have been the subject of intensive, long-term study that can serve as a backdrop for new research.

Essential research and active adaptive forest management questions, detailed in the Revised Recovery Plan, that could be conducted on Experimental Forests include (but are not limited to):

(a) What vegetation management treatments best accelerate the development of forest structure associated with northern spotted owl habitat functions while maintaining or restoring natural disturbance and provide greater ecosystem resiliency?

(b) What are the effects of wildland and prescribed fire on the structural elements of northern spotted owl habitat?

(c) Can strategically-placed restoration treatments be used to reduce the risk of northern spotted owl habitat being burned by high severity fire within dry forest ecosystems?

(d) What are the effects of epidemic forest insect outbreaks on northern spotted owl occupancy and habitat use immediately following the event and at specified time periods after treatment?

Sound scientific information represents a vital component of our path to recovery for the northern spotted owl (and almost all threatened or endangered species). We believe it would be counterproductive to inhibit or curtail research that is designed to benefit the northern spotted owl and the ecosystem in which it is found, and therefore support research activities within experimental forests.

The Biology and Ecology of the Northern Spotted Owl

Physical Description and Taxonomy

The northern spotted owl is a medium-sized owl and the largest of the three subspecies of northern spotted owls currently recognized by the American Ornithologists' Union (Gutiérrez *et al.* 1995, p. 2). It is dark brown with a barred tail and white spots on the head and breast, and has dark brown eyes that are surrounded by prominent facial disks. The taxonomic separation of these three subspecies is supported by numerous factors (reviewed in Courtney *et al.* 2004, pp. 3–3 to 3–31), including genetic (Barrowclough and Gutiérrez 1990, p. 739; Barrowclough *et al.* 1999, p. 922; Haig *et al.* 2004, p. 1353; Barrowclough *et al.* 2005, p. 1113), morphological (Gutiérrez *et al.* 1995, pp. 2 to 3), behavioral (Van Gelder 2003, p. 30), and biogeographical characteristics (Barrowclough *et al.* 1999, p. 928).

Distribution and Habitat

The current range of the northern spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County, California. The subspecies is listed as a threatened species under the Act throughout its range (55 FR 26114; June 26, 1990). Within the United States, the northern spotted owl ranges across 12 ecological regions, based on recognized landscape subdivisions exhibiting different physical and environmental features, often referred to as ''physiographic provinces'' (Franklin and Dyrness 1988, pp. 5–26; Thomas *et al.* 1990, p. 61; USDA and USDI 1994, p. A–3). These include the Olympic Peninsula, Western Washington Lowlands, Western Washington Cascades, Eastern Washington Cascades, Oregon Coast Ranges, Western Oregon Cascades, Willamette Valley, Eastern Oregon Cascades, Oregon Klamath, California Klamath, California Coast Ranges, and California Cascades Provinces (based on USDA and USDI 1994, p. A–3). Very few northern spotted owls are found in British Columbia, in the Western Washington Lowlands or Willamette Valley; therefore, the subspecies is restricted primarily to 10 of the 12 provinces within its range.

For the purposes of developing this rule, and based on Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, pp. C–7 to C–13), we have divided the range of the northern spotted owl into 11 different regions. We used these 11 regions in the habitat modeling that informed this revised designation of critical habitat. The regions used here are more ''owl specific'' than the physiographic provinces used in the past. In addition to regional patterns of climate, topography, and forest communities, which the physiographic provinces also considered, the 11 regions are based on specific patterns of northern spotted owl habitat relationships and prey base relationships across the range of the species. The 11 regions include the North Coast Olympics; West Cascades North; West Cascades Central; West Cascades South; East Cascades North; East Cascades South; Oregon Coast; Klamath West; Klamath East; Redwood Coast; and Inner California Coast Ranges. We additionally grouped these 11 regions into 4 broad ecological zones (West Cascades/Coast Ranges of Oregon and Washington; East Cascades; Redwood; and Klamath and Northern California Interior Coast Ranges). A map of the 11 regions used for the purposes of habitat modeling, as well as the 4 ecological zones, is provided in Figure 1 of this document. We used these 11 regions as the organizing units for our designation of critical habitat, and the 4 ecological zones for the identification of region-specific primary constituent elements (PCEs) for the northern spotted owl.

Northern spotted owls generally rely on older forested habitats because such forests contain the structures and characteristics required for nesting, roosting, and foraging, and dispersal. Forest characteristics associated with northern spotted owls usually develop with increasing forest age, but their occurrence may vary by location, past forest practices, and stand type, history, and condition. Although northern spotted owl habitat is variable over its range, some general attributes are common to the owl's life-history requirements throughout its range. To support northern spotted owl reproduction, a home range requires appropriate amounts of nesting, roosting, and foraging habitat arrayed so that nesting pairs can survive, obtain resources, and breed successfully. In northern parts of the range where nesting, roosting, and foraging habitat have similar attributes, nesting is generally associated with late-seral or old-growth forest in the core area (Swindle *et al.* 1999, p. 1216). In some southern portions of the range, northern spotted owl survival is positively associated with the area of old forest habitat in the core, but reproductive output is positively associated with amount of edge between older forest and other habitat types in the home range (Franklin *et al.* 2000, pp. 573, 579). This pattern suggests that where dusky-footed woodrats (*Neotoma fuscipes*) are the primary prey species, core areas that have nesting habitat stands interspersed with varied types of foraging habitat may be optimal for northern spotted owl survival and reproduction. Both the amount and spatial distribution of nesting, roosting, foraging, and dispersal habitat influence reproductive success and long-term population viability of northern spotted owls.

Population growth can occur only if there is adequate habitat in an appropriate configuration to allow for the dispersal of owls across the landscape. This includes support of dispersing juveniles, as well as nonresident subadults and adults that have not yet recruited into the breeding population. The survivorship of northern spotted owls is likely greatest when dispersal habitat most closely resembles nesting, roosting, and foraging habitat, but owls may use other types of habitat for dispersal on a short-term basis. Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy cover to provide protection from avian predators and at least minimal foraging opportunities (57 FR 1805, January 15, 1992). In this rule, we consider canopy cover as a vertical measurement of the amount of canopy that would cover the ground.

The three essential functions served by habitat within the home range of a northern spotted owl are:

(1) *Nesting.* Nesting habitat is essential to provide structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks. Habitat requirements for nesting and roosting are nearly identical. However, nesting habitat is specifically associated with a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe (*Arceuthobium* spp.) infections, and other evidence of decadence) or large snags suitable for nest placement. Additional features that support nesting and roosting typically include a moderate to high canopy cover; a multilayered, multispecies canopy with large overstory trees; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for northern spotted owls to fly (Thomas *et al.* 1990, p. 164). Forested stands with high canopy cover also provide thermal cover (Weathers *et al.* 2001, p. 686) and protection from predators. Patches of nesting habitat, in combination with roosting habitat, must be sufficiently large and contiguous to maintain northern spotted owl core areas and home ranges, and must be proximate to foraging habitat. Ideally, nesting habitat also functions as roosting, foraging, and dispersal habitat.

(2) *Roosting.* Roosting habitat is essential to provide for thermoregulation, shelter, and cover to reduce predation risk while resting or foraging. As noted above, the same habitat generally serves for both nesting and roosting functions; technically ''roosting habitat'' differs from nesting habitat only in that it need not contain those specific structural features used for nesting (cavities, broken tops, and mistletoe platforms), but does contain moderate to high canopy cover; a multilayered, multispecies canopy; large accumulations of fallen trees and other woody debris on the ground; and open space below the canopy for northern spotted owls to fly. In practice, however, roosting habitat is not segregated from nesting habitat. Nesting and roosting habitat will also function as foraging and dispersal habitat.

(3) *Foraging.* Foraging habitat is essential to provide a food supply for survival and reproduction. Foraging habitat is the most variable of all habitats used by territorial northern spotted owls, and is closely tied to the prey base, as described below. Nesting and roosting habitat always provides for foraging, but in some cases owls also use more open and fragmented forests, especially in the southern portion of the range where some younger stands may have high prey abundance and structural attributes similar to those of older forests, such as moderate tree density, subcanopy perches at multiple levels, multilayered vegetation, or residual older trees. Foraging habitat generally has attributes similar to those of nesting and roosting habitat, but foraging habitat may not always support successfully nesting pairs (USDI 1992, pp. 22–25). Foraging habitat can also function as dispersal habitat. The primary function of foraging habitat is to provide a food supply for survival and reproduction.

Because northern spotted owls show a clear geographical pattern in diet, and different prey species prefer different habitat types, prey distribution contributes to differences in northern spotted owl foraging habitat selection across the range. In the northern portion of their range, northern spotted owls forage heavily in older forests or forests with similar complex structure that support northern flying squirrels (*Glaucomys sabrinus*) (Carey *et al.* 1992, p. 233; Rosenberg and Anthony 1992, p. 165). In the southern portion of their range, where woodrats are a major component of their diet, northern spotted owls are more likely to use a variety of stands, including younger stands, brushy openings in older stands, and edges between forest types in response to higher prey density in some of these areas (Solis 1983, pp. 89–90; Sakai and Noon 1993, pp. 376–378; Sakai and Noon 1997, p. 347; Carey *et al.* 1999, p. 73; Franklin *et al.* 2000, p. 579). Both the amount and distribution of foraging habitat within the home range influence the survival and reproduction of northern spotted owls.

Dispersal Habitat and Habitat for Nonresident Owls

Successful dispersal of northern spotted owls is essential to maintaining genetic and demographic connections among populations across the range of the species. Habitats that support movements between larger habitat patches that provide nesting, roosting, and foraging habitats for northern spotted owls act to limit the adverse genetic effects of inbreeding and genetic drift and provide demographic support to declining populations (Thomas *et al.* 1990, pp. 271–272). Dispersing juvenile northern spotted owls experience high mortality rates (more than 70 percent in some studies (Miller 1989, pp. 32–41;

Franklin *et al.* 1999, pp. 25, 28; 55 FR 26115; June 26, 1990)) from starvation, predation, and accidents (Miller 1989, pp. 41–44; Forsman *et al.* 2002, pp. 18–19). Juvenile dispersal is thus a highly vulnerable life stage for northern spotted owls, and enhancing the survivorship of juveniles during this period could play an important role in maintaining stable populations of northern spotted owls.

Successful juvenile dispersal may depend on locating unoccupied suitable habitat in close proximity to other occupied sites (LaHaye *et al.* 2001, pp. 697–698). Dispersing juveniles are likely attracted to conspecific calls, and may look for suitable sites preferentially in the vicinity of occupied territories. When all suitable territories are occupied, dispersers may temporarily pursue a nonresident (nonbreeding) strategy; such individuals are sometimes referred to as ''floaters'' (Forsman *et al.* 2002, pp. 15, 26). Floaters prospect for territorial vacancies created when residents die or leave their territories. Floaters contribute to stable or increasing populations of northern spotted owls by quickly filling territorial vacancies. Where large blocks of habitat with multiple breeding pairs occur, the opportunities for successful recruitment of dispersers and floaters are enhanced due to the within-block production of potential replacement birds (Thomas *et al.* 1990, pp. 295, 307).

Juvenile dispersal occurs in steps (Forsman *et al.* 2002, pp. 13–14), between which dispersing juveniles settle into temporary home ranges for up to several months (Forsman *et al.* 2002, p. 13). Natal dispersal distances, measured from natal areas to eventual home range, tend to be larger for females (about 15 mi (24 km)) than males (about 8.5 mi (13.7 km)) (Courtney *et al.* 2004, p. 8–5). Forsman *et al.* (2002, pp. 15–16) reported dispersal distances of 1,475 northern spotted owls in Oregon and Washington for the period from 1985 to 1996. Median maximum dispersal distance (the straight-line distance between the natal site and the farthest location) for radio-marked juvenile male northern spotted owls was 12.7 mi (20.3 km), and that of female northern spotted owls was 17.2 mi (27.5 km) (Forsman *et al.* 2002, Table 2).

Northern spotted owls can utilize forests with the characteristics needed for nesting, roosting, foraging, and dispersal, and likely experience greater survivorship under such conditions. However, dispersing or nonresident individuals may also make use of other forested areas that do not meet the requirements of nesting or roosting habitat on a short-term basis. Such short-term dispersal habitats must, at minimum, consist of stands with adequate tree size and canopy cover to provide protection from avian predators and at least minimal foraging opportunities.

Population Status and Trends

Demographic data from studies initiated as early as 1985 have been analyzed every 5 years to estimate northern spotted owl demographic rates and population trends (Anderson and Burnham 1992, entire; Burnham *et al.* 1994, entire; Franklin *et al.* 1999, entire; Anthony *et al.* 2006, entire; Forsman *et al.* 2011, entire). The most current evaluation of population status and trends is based on data through 2008 (Forsman *et al.* 2011, p. 1). Based on this analysis, populations on 7 of 11 study areas (Cle Elum, Rainier, Olympic Peninsula, Oregon Coast Ranges, H.J. Andrews, Northwest California, and Green Diamond) were declining (Forsman *et al.* 2011, p. 64, Table 22).

Estimates of realized population change (cumulative population change across all study years) indicated that, in the more rapidly declining populations (Cle Elum, Rainier, and Olympic Peninsula), the 2006 populations were 40 to 60 percent of the population sizes observed in 1994 or 1995 (Forsman *et al.* 2011, pp. 47–49). Populations at the remaining areas (Tyee, Klamath, Southern Oregon Cascades, and Hoopa) showed declining population growth rates as well, although the estimated rates were not significantly different from stable populations (Forsman *et al.* 2011, p 64). A meta-analysis combining data from all 11 study areas indicates that rangewide the population declined at a rate of about 2.9 percent per year for the period from 1985 to 2006. Northern spotted owl populations on Federal lands had better demographic rates than elsewhere, but still declined at a mean annual rate of about 2.8 percent per year for 1985–2006 (Forsman *et al.* 2011, p. 67).

In addition to declines in population growth rates, declines in annual survival were reported for 10 of the 11 study areas (Forsman *et al.* 2011, p. 64, Table 22). Number of young produced each year showed declines at 5 areas (Cle Elum, Klamath, Southern Oregon Cascades, Northwest California, and Green Diamond), was relatively stable at 3 areas (Olympic Peninsula, Tyee, Hoopa), and was increasing at 2 areas (Oregon Coast Ranges, H. J. Andrews) (Forsman *et al.* 2011, p. 64 Table 22).

As noted above, the barred owl has emerged as a greater threat to the northern spotted owl than was previously recognized. The range of the barred owl has expanded in recent years and now completely overlaps that of the northern spotted owl (Crozier *et al.* 2006, p. 761). The presence of barred owls has significant negative effects on northern spotted owl reproduction (Olson *et al.* 2004, p. 1048), survival (Anthony *et al.* 2006, p. 32), and number of territories occupied (Kelly *et al.* 2003, p. 51; Olson *et al.* 2005, p. 928). The determination of population trends for the northern spotted owl has become complicated by the finding that northern spotted owls are less likely to call when barred owls are also present; therefore, they are more likely to be undetected by standard survey methods (Olson *et al.* 2005, pp. 919–929; Crozier *et al.* 2006, pp. 766–767). As a result, it is difficult to determine whether northern spotted owls no longer occupy a site, or whether they may still be present but are not detected. The 2011 Revised Recovery Plan for the Northern Spotted Owl concludes that ''barred owls are contributing to the population decline of northern spotted owls, especially in Washington, portions of Oregon, and the northern coast of California.'' (USFWS 2011, p. B–12).

British Columbia has a small population of northern spotted owls. This population has declined at least 49 percent since 1992 (Courtney *et al.* 2004, p. 8–14), and by as much as 90 percent since European settlement (Chutter *et al.* 2004, p. 6) to a 2004 breeding population estimated at about 23 birds (Sierra Legal Defence [sic] Fund and Western Canada Wilderness Committee 2005, p. 16) on 15 sites (Chutter *et al.* 2004, p. 26). Chutter *et al.* (2004, p. 30) suggested immediate action was required to improve the likelihood of recovering the northern spotted owl population in British Columbia. In 2007, the Northern Spotted Owl Population Enhancement Team recommended to remove northern spotted owls from the wild in British Columbia. Personnel in British Columbia captured and brought into captivity the remaining 16 known wild northern spotted owls. Prior to initiating the captive-breeding program, the population of northern spotted owls in Canada was declining by as much as 35 percent per year (Chutter *et al.* 2004, p. 6). The amount of previous interaction between northern spotted owls in Canada and the United States is unknown (Chutter *et al.* 2004, p. 24). Although the status of the northern spotted owl in Canada is informative in terms of the overall declining trend of the northern spotted owl throughout its range, and consequently the increased need for conservation in those areas where it persists, the Service does not designate critical habitat in foreign countries (50 CFR 424.12(h)).

Life History

Northern spotted owls are a long-lived species with relatively stable and high rates of adult survival, lower rates of juvenile survival, and highly variable reproduction. Franklin *et al.* (2000, p. 576) suggested that northern spotted owls follow a ''bet-hedging'' life-history strategy, where natural selection favors individuals that reproduce only during favorable conditions. For such species, population growth rate is more susceptible to changes in adult survival than to recruitment of new individuals into the population. For northern spotted owls, recent demographic analyses have indicated declining trends in both adult survival and recruitment across much of the species range (Forsman *et al.* 2011, p. 64, Table 22).

Northern spotted owls are highly territorial (Courtney *et al.* 2004, p. 2–7). They maintain large home ranges; however, they actively defend a smaller area, and overlap between the outer portions of the home ranges of adjacent pairs is common (Forsman *et al.* 1984, pp. 5, 17, 22–24; Solis and Gutiérrez 1990, p. 742; Forsman *et al.* 2005, p. 374). Pairs are nonmigratory and remain on their home range throughout the year, although they often increase the area used for foraging during fall and winter (Forsman *et al.* 1984, p. 21; Sisco 1990, p. 9), likely in response to potential depletion of prey in the core of their home range (Carey *et al.* 1992, p. 245; Carey 1995, p. 649; but see Rosenberg *et al.* 1994, entire). The northern spotted owl shows strong year-round fidelity to its territory, even when not nesting (Solis 1983, pp. 23–28; Forsman *et al.* 1984, pp. 52–53) or after natural disturbance alters habitat characteristics within the home range (Bond *et al.* 2002, pp. 1024–1026). A discussion of northern spotted owl home range size and use is included in the Primary Constituent Elements section of this rule.

Prey

Northern spotted owl diets vary across owl territories, years, seasons, and geographical regions (Forsman *et al.* 2001, pp. 146–148; 2004, pp. 217–220). However, four to six species of nocturnal mammals typically dominate their diets (Forsman *et al.* 2004, p. 218), with northern flying squirrels being a primary prey species in all areas. In Washington, diets are dominated by northern flying squirrels, snowshoe hare (*Lepus americanus*), bushy-tailed woodrats (*Neotoma cinerea*), and boreal red-backed voles (*Clethrionomys gapperi*) (Forsman *et al.* 2001, p. 144). In Oregon and northern California, northern flying squirrels in combination with dusky-footed woodrats, bushy-tailed woodrats, red tree voles (*Arborimus longicaudus*), and deer mice (*Peromyscus maniculatus*) comprise the majority of diets (Courtney *et al.* 2004, pp. 41–31 to 4–32; Forsman *et al.* 2004, p. 221). Northern spotted owls are also known to prey on insects, other terrestrial mammals, birds, and juveniles of larger mammals (e.g., mountain beaver (*Aplodontia rufa*) (Forsman *et al.* 2001, p. 146; 2004, p. 223).

Northern flying squirrels are positively associated with late-successional forests with high densities of large trees and snags (Holloway and Smith 2011, p. 671). Northern flying squirrels typically use cavities in large snags as den and natal sites, but may also use cavities in live trees, hollow branches of fallen trees, crevices in large stumps, stick nests of other species, and lichen and twig nests they construct (Carey 1995, p. 658), as well as mistletoe brooms when snags are not abundant (Lehmkuhl *et al.* 2006, p. 593). Fungi (mychorrhizal and epigeous types) are prominent in their diet; however, seeds, fruits, nuts, vegetation matter, insects, and lichens may also represent a significant proportion of their diet (summarized in Courtney *et al.* 2004, App. 4 p. 3–12). Northern flying squirrel densities tend to be higher in older forest stands with ericaceous shrubs (e.g., Pacific rhododendron (*Rhododendron macrophyllum*)) and an abundance of large snags (Carey 1995, p. 654), and higher tree canopy cover (Lehmkuhl *et al.* 2006, p. 591) likely because these forests produce a higher forage biomass. Wilson (2012, pp. i–ii) reported that dense mid-story canopy conditions can also be a limiting factor for flying squirrel abundance. Flying squirrel density tends to increase with stand age (Carey 1995, pp. 653–654; Carey 2000, p. 252), although managed and second-growth stands sometimes also show high densities of squirrels, especially when canopy cover is high (e.g., Rosenberg and Anthony 1992, p. 163; Lehmkuhl *et al.* 2006, pp. 589–591). The main factors that may limit northern flying squirrel densities are the availability of den structures and food, especially hypogeous (below ground) fungi or truffles (Gomez *et al.* 2005, pp. 1677–1678), as well as protective cover from predators (Wilson 2010, p. 115).

For northern spotted owls in Oregon, both dusky-footed and bushy-tailed woodrats are important prey items (Forsman *et al.* 2004, pp. 226–227), whereas in Washington owls rely primarily on the bushy-tailed woodrat (Forsman *et al.* 2001, p. 144). Habitats that support bushy-tailed woodrats usually include early-seral mixed-conifer/mixed-evergreen forests close to water (Carey *et al.* 1999, p. 77). Bushy-tailed woodrats reach high densities in both old forests with openings and closed-canopy young forests (Sakai and Noon 1993, pp. 376–378; Carey *et al.* 1999, p. 73), and use hardwood stands in mixed-evergreen forests (Carey *et al.* 1999, p. 73). Bushy-tailed woodrats are important prey species south of the Columbia River and may be more limited by abiotic features, such as the availability of suitable rocky areas for den sites (Smith 1997, p. 4) or the presence of streams (Carey *et al.* 1992, p. 234; 1999, p. 72). Dense woodrat populations in shrubby areas are likely a source of colonists to surrounding forested areas (Sakai and Noon 1997, p. 347); therefore, forested areas with nearby open, shrubby vegetation generally support high numbers of woodrats. The main factors that may limit woodrats are access to stable, brushy environments that provide food, cover from predation, materials for nest construction, dispersal ability, and appropriate climatic conditions (Carey *et al.* 1999, p. 78), and arboreal and terrestrial cover in the form of large snags, mistletoe, and soft logs (Lehmkuhl *et al.* 2006, p. 376).

Home Range and Habitat Use

Territorial northern spotted owls remain resident on their home range throughout the year; therefore, these homes ranges must provide all the habitat components needed for the survival and successful reproduction of a pair of owls. Northern spotted owls exhibit central-place foraging behavior (Rosenberg and McKelvey 1999, p. 1036), with much activity centered within a core area surrounding the nest tree during the breeding season. During fall and winter as well as in nonbreeding years, owls often roost and forage in areas of their home range more distant from the core. In nearly all studies of northern spotted owl habitat use, the amount of mature and old-growth forest was greater in core areas and home ranges than at random sites on the landscape (Courtney *et al.* 2004, pp. 5–6, 5–13; also see USFWS 2011, Appendix G for definitions of mature and old-growth forest), and forests were less fragmented within northern spotted owl home ranges (Hunter *et al.* 1995, p. 688). The amount of habitat at the core area scale shows the strongest relationships with home range occupancy (Meyer *et al.* 1998, p. 34; Zabel *et al.* 2003, p. 1036), survival (Franklin *et al.* 2000, p. 567; Dugger *et al.* 2005, p. 873), and reproductive success (Ripple *et al.* 1997, pp. 155–156; Dugger *et al.* 2005, p. 871). A more complete description of the home range is presented in Population Spatial Requirements, below.

The size, configuration, and characteristics of vegetation patches within home ranges affect northern spotted owl survival and reproduction, a concept referred to as habitat fitness potential (Franklin *et al.* 2000, p. 542). Among studies that have estimated habitat fitness potential, the effects of forest fragmentation and heterogeneity vary geographically. In the California Klamath Province, locations for nesting and roosting tend to be centered in larger patches of old forest, but edges between forest types may provide increased prey abundance and availability (Franklin *et al.* 2000, p. 579). In the central Oregon Coast Range, northern spotted owls appear to benefit from a mixture of older forests with younger forest and nonforested areas in their home range (Olson *et al.* 2004, pp. 1049–1050), a pattern similar to that found in the California Klamath Province. Courtney *et al.* (2004, p. 5–23) suggest that although in general large patches of older forest appear to be necessary to maintain stable populations of northern spotted owls, home ranges composed predominantly of old forest may not be optimal for northern spotted owls in the California Klamath Province and Oregon Coast Ranges Province.

The northern spotted owl inhabits most of the major types of coniferous forests across its geographical range, including Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), mixed conifer and mixed evergreen, grand fir (*Abies grandis*), Pacific silver fir (*A. amabilis*), Douglas-fir (*Pseudotsuga menziesii*), redwood (*Sequoia sempervirens*)/Douglas-fir (in coastal California and southwestern Oregon), white fir (*A. concolor*), Shasta red fir (*A. magnifica* var. *shastensis*), and the moist end of the ponderosa pine (*Pinus ponderosa*) zone (Forsman *et al.* 1984, pp. 15–16; Thomas *et al.* 1990, p. 145). Habitat for northern spotted owls has traditionally been described as consisting of four functional types: Nesting, roosting, foraging, and dispersal habitats. Recent studies continue to support the practical value of discussing northern spotted owl habitat usage by classifying it into these functional habitat types (Irwin *et al.* 2000, p. 183; Zabel *et al.* 2003, p. 1028; Buchanan 2004, p. 1334; Davis and Lint 2005, p. 21; Forsman *et al.* 2005, p. 372), and data from studies are available to describe areas used for these types of activities, so we retain it here to structure our discussion of the physical or biological features of habitat essential to the conservation of the northern spotted owl.

Recent habitat modeling efforts have also accounted for differences in habitat associations across regions, which have often been attributed to regional differences in forest environments and factors including available prey species (USFWS 2011, p. C–7). These recent advances allowed for modeling of northern spotted owl habitat by regions to account for: (1) The degree of similarity between nesting/roosting and foraging habitats based on prey availability; (2) latitudinal patterns of topology and climate; (3) regional patterns of topography, climate, and forest communities; and (4) geographical distribution of habitat elements that influence the range of conditions occupied by northern spotted owls (USFWS 2011, p. C–8). Detailed characterizations of each of these functional habitat types and their relative distribution are described in Physical or Biological Features, below.

Climate Change

There is growing evidence that recent climate change has impacted a wide range of ecological systems (Stenseth *et al.* 2002, entire; Walther *et al.* 2002, entire; Adahl *et al.* 2006, entire; Karl *et al.* 2009, entire; Moritz *et al.* 2012, entire; Westerling *et al.* 2011, p. S459; Marlon *et al.* 2012, p. E541). Climate change, combined with effects from past management practices, is exacerbating changes in forest ecosystem processes and dynamics to a greater degree than originally anticipated under the NWFP. Environmental variation affects all wildlife populations; however, climate change presents new challenges as systems may change beyond historical ranges of variability. In some areas, changes in weather and climate may result in major shifts in vegetation communities that can persist in particular regions.

Climate change will present unique challenges to the future of northern spotted owl populations and their habitats. Northern spotted owl distributions (Carroll 2010, entire) and population dynamics (Franklin *et al.* 2000, entire; Glenn *et al.* 2010, entire; *et al.* 2011a, entire; Glenn *et al.* 2011b, entire) may be directly influenced by changes in temperature and precipitation. In addition, changes in forest composition and structure as well as prey species distributions and abundance resulting from climate change may impact availability of habitat across the historical range of the subspecies. The Revised Recovery Plan for the Northern Spotted Owl provides a detailed discussion of the possible environmental impacts to the habitat of the northern spotted owl from the projected effects of climate change (USFWS 2011, pp. III–5 to III–11).

Because both northern spotted owl population dynamics and forest conditions are likely to be influenced by large-scale changes in climate in the future, we have attempted to account for these influences in our designation of critical habitat by recognizing that forest composition may change beyond the range of historical variation, and that climate changes may have unpredictable consequences for both Pacific Northwest forests and northern spotted owls. This critical habitat designation recognizes that forest management practices that promote ecosystem health under changing climate conditions will be important for northern spotted owl conservation.

III. Previous Federal Actions

The northern spotted owl was listed as a threatened species on June 26, 1990 (55 FR 26114); a description of the relevant previous Federal actions up to the time of listing can be found in that final rule. On January 15, 1992, we published a final rule designating 6,887,000 ac (2,787,000 ha) of Federal lands in Washington, Oregon, and California as critical habitat for the northern spotted owl (57 FR 1796). On January 13, 2003, we entered into a settlement agreement with the American Forest Resources Council, Western Council of Industrial Workers, Swanson Group Inc., and Rough & Ready Lumber Company, to conduct a 5-year status review of the northern spotted owl and consider potential revisions to its critical habitat (*Western Council of Industrial Workers (WCIW) v. Secretary of the Interior, Civ. No. 02–6100–AA (D. Or*). On April 21, 2003, we published a notice initiating the 5-year review of the northern spotted owl (68 FR 19569), and published a second information request for the 5-year review on July 25, 2003 (68 FR 44093). We completed the 5-year review on November 15, 2004, concluding that the northern spotted owl should remain listed as a threatened species under the Act (USFWS 2004, entire). On November 24, 2010, we published in the **Federal Register** a notice initiating a new 5-year review for the northern spotted owl (75 FR 71726); the information solicitation period for this review was reopened from April 20, 2011, through May 20, 2011 (76 FR

22139), and the completed review was signed on September 29, 2011, concluding that the northern spotted owl was appropriately listed as a threatened species.

In compliance with the settlement agreement in the *WCIW* case, as amended, we published a proposed revised critical habitat rule in the **Federal Register** on June 12, 2007 (72 FR 32450). On May 21, 2008, we published a notice announcing the availability of a Recovery Plan for the Northern Spotted Owl (73 FR 29471; May 21, 2008). We also announced the availability of a draft economic analysis on the proposed critical habitat designation and the reopening of the public comment period on the proposed revised critical habitat designation. The 2008 recovery plan formed the basis for the current designation of northern spotted owl critical habitat. We published a final rule revising the critical habitat designation in the **Federal Register** on August 13, 2008 (73 FR 47325).

Both the 2008 critical habitat designation and the 2008 recovery plan were challenged in court in *Carpenters' Industrial Council v. Salazar,* Case No. 1:08–cv–01409–EGS (D.DC). In addition, on December 15, 2008, the Inspector General of the Department of the Interior issued a report entitled ''Investigative Report of The Endangered Species Act and the Conflict between Science and Policy,'' which concluded that the integrity of the agency decision-making process for the northern spotted owl recovery plan was potentially jeopardized by improper political influence. As a result, the Federal Government filed a motion in the lawsuit for remand of the 2008 recovery plan and the critical habitat designation which was based on it. On September 1, 2010, the Court issued an opinion remanding the 2008 recovery plan to us for issuance of a revised plan within 9 months.

On September 15, 2010, we published a **Federal Register** notice (75 FR 56131) announcing the availability of the Draft Revised Recovery Plan for the Northern Spotted Owl, and opened a 60-day comment period through November 15, 2010. On November 12, 2010, we announced by way of press release an extension of the comment period until December 15, 2010. On November 30, 2010, we announced in the **Federal Register** the reopening of the public comment period until December 15, 2010 (75 FR 74073). At that time we also announced the availability of a synopsis of the population response modeling results for public review and comment. The supporting information regarding the modeling process was posted on our Web site (*http://www.fws.gov/oregonfwo/*). Of the approximately 11,700 comments received on the Draft Revised Recovery Plan, many requested the opportunity to review and comment on more detailed information on the habitat modeling process in Appendix C. On April 22, 2011, we reopened the comment period on Appendix C of the Draft Revised Recovery Plan (76 FR 22720); this comment period closed on May 23, 2011. On May 6, 2011, the Court granted our request for an extension of the due date for issuance of the final revised recovery plan until July 1, 2011. We published the notice of availability of the final Revised Recovery Plan for the Northern Spotted Owl in the **Federal Register** on July 1, 2011 (76 FR 38575).

On October 12, 2010, the Court remanded the 2008 critical habitat designation, which had been based on the 2008 Recovery Plan for the Northern Spotted Owl, and adopted the Service's proposed schedule to issue a new proposed revised critical habitat rule for public comment by November 15, 2011, and a final rule by November 15, 2012. The Court subsequently extended the date for delivery of the proposed rule to the **Federal Register** to February 28, 2012. A proposed revision to the designated critical habitat for the northern spotted owl was signed on February 28, 2012 and published in the **Federal Register** on March 8, 2012 (77 FR 14062), with a 3-month public comment period. On May 8, 2012, we announced an extension of the comment period through July 6, 2012 (77 FR 27010). A June 1, 2012 **Federal Register** notice announced the availability of the associated draft economic analysis and draft environmental assessment (conducted under NEPA), and invited the public to comment on these documents through July 6, 2012 (77 FR 32483). We held seven public information meetings and one public hearing. Two public information meetings were held each night in Redding, California, on June 4, 2012; in Tacoma, Washington, on June 12, 2012; and in Roseburg, Oregon, on June 27, 2012. One public information meeting was held in Portland, Oregon on June 20, 2012 and the public hearing was held in Portland, Oregon, on June 20, 2012. On July 20, 2012, the Service sent letters to all potentially affected Counties and State fish and wildlife agencies in Washington, Oregon and California advising them of the additional opportunity to comment until August 20, 2012, to ensure that they were able to thoroughly review and comment on the proposed rule as provided by Section 4(b)(5)(A)(ii) of the Act. In order to allow sufficient time for interagency review, the Court extended the time for delivery of the final rule to the **Federal Register** to November 21, 2012.

IV. Changes From the Proposed Rule

In preparing this final revised critical habitat designation for the northern spotted owl, we reviewed and considered comments from the public, peer reviewers, and other interested parties on the proposed revised designation of critical habitat published on March 8, 2012 (77 FR 14062). We also reviewed and considered comments on the draft environmental assessment and draft economic analysis. As a result of these comments and a reevaluation of the revised proposed critical habitat boundaries, we have made changes in this final designation, as follows:

(1) We responded to peer-review, public, stakeholder, and internal comments on a wide variety of topics to clarify and strengthen the supporting rationale of this final designation, clarify our meanings and descriptions, and to refine specific aspects of the rule to include emerging research or provide additional explanation. Included in these types of changes from the proposed to final rule are the following:

- Clarifications to the language to specify that northern spotted owl occupancy data are not needed or appropriate for an analysis of the effects of an action on northern spotted owl critical habitat.
- Clarifications to the language to more clearly describe the potential management of hazard trees in critical habitat along roadways.
- In the Special Management Considerations section, we reference Recovery Action 10 from the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), which focuses on retaining existing northern spotted owls on the landscape. We have edited those references to clarify that management of critical habitat and the section 7 evaluation under the Act that management should focus on the habitat's ability to support nesting northern spotted owls instead of focusing on individual northern spotted owls.
- To determine how to conduct those evaluations under section 7 of the Act, the proposed revised critical habitat recommended assessing the impacts of a timber management project in the context of 500 ac (200 ha) around where the impacts would occur. After numerous discussions with section 7 practitioners in different parts of the

range of the species, we are recommending that the effects determination for a section 7 consultation be conducted at a scale consistent with ''the localized biology of the life-history needs of the northern spotted owl (such as the stand scale, a 500-acre (200-ha) circle, or other appropriate, localized scale).'' Please see detailed discussion of the distinction between effects determination and the adverse modification standard in the section *Determinations of Adverse Effects and Application of the ''Adverse Modification'' Standard.*

- We have clarified that our discussion of ecological forestry and active management is intended for land managers to consider when developing management plans or planning projects, as in many areas this approach may be consistent with critical habitat for the northern spotted owl, but that such management is not mandated by the Service and is not required as the result of this rulemaking. We have also clarified this issue in the final rule language by stating that we have made the 16 U.S.C. 1532(5)(A)(i) determination that essential biological and physical features in occupied areas may require special management considerations or protection, but that the rule does not require land managers to implement, or preclude land managers from implementing, such measures.
- We have provided land managers with a discussion of relevant emerging science and greater detail regarding the appropriate application of active management and ecological forestry to benefit forest ecosystem restoration, as recommended in the Revised Recovery Plan for the Northern Spotted Owl. In addition, we received extensive comments regarding the appropriateness of developing diverse early-seral forest at the expense of older forest stands. We have clarified language regarding development of diverse, early-seral forest to indicate that: (1) We do not recommend these actions in older forest stands or areas that currently function as owl habitat; and (2) this type of management is most appropriate where more traditional forestry methods have typically been conducted on matrix lands. As stated in both the proposed rule and in this final rule, our first recommendation for northern spotted owl critical habitat is the conservation of old growth trees and forests on Federal lands wherever they are found, and to undertake appropriate restoration treatment in the threatened forest types.
- We have clarified the relationship between this revised designation of critical habitat for the northern spotted owl and the Northwest Forest Plan. Numerous commenters were concerned that this critical habitat would undermine the Standards and Guidelines of the Northwest Forest Plan, or enable timber harvest activities in Late-Successional Reserves that would not otherwise be permissible. We have added language to the preamble to clarify that the revised designation of critical habitat does not supersede the Standards and Guidelines of the Northwest Forest Plan. Our discussion of potential active management within critical habitat is intended to encourage land managers to consider the range of management flexibility already contained in the Northwest Forest Plan.

(2) In the proposed rule we requested specific information regarding the amount and distribution of northern spotted owl habitat that should be included in the designation. We refined the designation based on input from peer-review, public comment, and comments from Federal land management agencies, combined with further evaluation of modeled population response to the potential revisions of the critical habitat network, and including the following.

(A) Formal comments from the Forest Service requested that we consider large numbers of specific areas to be removed from, or added to, critical habitat, submitted to us in the form of GIS data. This proposal would have greatly reduced matrix lands in moist forest areas (Western Cascades, Oregon Coast Range, and North Coast Olympics) and eliminated Adaptive Management Areas and Experimental Forests from critical habitat. In addition, BLM requested removal of approximately 300,000 acres of selected BLM lands in western Oregon. We evaluated a new map of relative habitat suitability (Composite 8, as described in our Modeling Supplement, Dunk *et al.* 2012b) that incorporated all of these requested changes. Population modeling results for Composite 8 indicated that many of the lands proposed for removal were essential to conservation of the northern spotted owl because the rangewide population declined by 39 percent and population risk increased by 44 percent. To bring the spotted owl population results back up to levels comparable to proposed critical habitat, the final critical habitat designation includes areas recommended by those agencies for elimination (and that had been removed in our test of Composite 8) because we determined they are essential to the conservation of the species. To increase efficiency and ensure that the designation included only occupied habitat containing the features essential to conservation or habitat that is otherwise essential to the species' conservation, we further refined the boundaries of some subunits by moving the boundaries to include more high-value habitat while simultaneously and less lower-value habitat in the network. To the greatest degree possible, wherever possible we removed matrix lands and incorporated habitat in LSRs in this process.

(B) In response to peer review comments about connectivity and population issues we identified specific areas providing high-suitability habitat that were required to better achieve population objectives in specific lower-performing modeling regions. The additional areas consisted solely of Federal lands, primarily USFS LSR lands, that were essential to provide connectivity between populations in the Oregon Coast Ranges and adjacent regions with larger spotted owl populations, as pointed out in peer review and public comments, and supported by results of population modeling. In many cases, areas added were specifically identified by the USFS or BLM as lands that should be added to compensate for removal of other, lower value lands. To the degree possible, we attempted to situate additions within LSRs and balanced additions by removing lower-quality areas in matrix land allocations. In some cases, additions were made to balance areas removed in (A) above. No additional State or private lands were designated in this process, and all areas are within the critical habitat units as described in the proposed rule.

The changes described in (A) and (B) above had the desired effect of bringing population results back up to levels similar to proposed critical habitat, while simultaneously reducing the area of matrix and lower-quality habitat in the designation thus ensuring that only essential habitat is designated. Overall, about 318,296 acres of BLM and USFS lands were removed from critical habitat, 74 percent (236,887 acres) of which were matrix lands of relatively lower value to northern spotted owls.

(C) We identified and removed lands based on information we received during the public comment period indicating that they did not meet the definition of critical habitat. In general, lands removed had recently lost their ability to function as northern spotted owl habitat either through stand-replacing wildfire or through timber harvest conducted after 2006 (the date of our most recent comprehensive vegetation layer). When such lands were identified, we removed them from critical habitat because they were unlikely to support northern spotted owls, and did not contain the PCEs or could not be otherwise considered essential.

(D) We further refined the critical habitat boundaries to better conform to identifiable landscape features or administrative boundaries, and to improve consistency with our goal of prioritizing high value Federal lands to include in critical habitat while removing relatively lower value lands in all ownerships. The USFS provided a number of specific suggestions in their public comment for this type of refinement. Overall, these refinements resulted in a small net reduction of critical habitat area.

(E) Correcting ownership boundary errors identified in peer-review and public comment. When the underlying land ownership was corrected, we determined that some lands originally labeled as private lands were in fact Federal or State lands.

In the State of Washington, in response to public comment and upon further review using the underlying aerial photo imagery from the 2011 National Agricultural Imagery Program (NAIP) and Ruraltech's 2007 forestland parcel data, we determined that the vast majority of Small Forest Landowner parcels we examined had either highly fragmented, little, or no northern spotted owl habitat currently present. Based on the combination of parcel size, current habitat conditions, and spatial distribution, we concluded that private lands identified as Small Forest Landowner parcels in the State of Washington do not provide the PCEs for northern spotted owls, nor are they essential to the conservation of the species; thus, these areas do not meet the definition of critical habitat, and we have removed them from the final designation of critical habitat.

Also in the State of Washington, we corrected ownership of Washington Department of Fish and Wildlife (WDFW) lands. In the proposed rule, we identified 1,752 ac (709 ha) as under the ownership of WDFW. In this rule, we have corrected this acreage to 8,328 ac (3,370 ha). This correction reflects a land transfer between WDFW and the Washington Department of Natural Resources, as well as a mistaken usage of a mineral rights GIS layer instead of a landownership layer.

Additional changes that were made were minor and included corrections of mapping errors, removing lower value areas that were inadvertently included, or correctly identifying administrative boundaries. Changes in total area are detailed in Table 1, below, and are shown by land ownership.

TABLE 1—LANDS IN THE PROPOSED REVISED CRITICAL HABITAT DETERMINED NOT TO CONTAIN THE PHYSICAL AND BIOLOGICAL FEATURES ESSENTIAL TO CONSERVATION OF THE NORTHERN SPOTTED OWL OR NOT OTHERWISE ESSENTIAL TO ITS CONSERVATION AND THEREFORE NOT INCLUDED IN FINAL CRITICAL HABITAT

State	Ownership	Acres	Hectares
Washington	USFS	11,864	4,793
Oregon	USFS	55,788	22,538
	BLM	62,862	25,396
	STATE	14,114	5,702
California	USFS	64,114	25,902
	BLM	17,152	6,929
Total		225,894	91,261

(3) We have exempted 14,313 ac (5,782 ha) of Department of Defense lands at Joint Base Lewis-McChord in Washington from critical habitat for the northern spotted owl, in accordance with section 4(a)(3) of the Act (see Exemptions). These lands comprised subunit NCO–3 in the proposed revision of critical habitat, and represented the only entirely unoccupied unit of critical habitat proposed for the northern spotted owl.

(4) In the proposed revised rule (77 FR 14062; March 8, 2012), we identified numerous areas under consideration for exclusion from the final designation, and solicited public comment on whether the benefits of exclusion of these lands would outweigh the benefits of inclusion, for example, based on active conservation agreements or conservation plans. We did a thorough evaluation of all the areas identified in the proposed rule, as well as others identified through our review and through information received from the public, and found that the benefits of exclusion for many of these areas outweighed the benefits of inclusion in critical habitat and that excluding these areas will not lead to the extinction of the species. Therefore, the Secretary is exercising his discretion to exclude specific areas covered under conservation agreements, programs, and partnerships under section 4(b)(2) of the Act (see Exclusions section of this document). The total area excluded from the final critical habitat designation under section 4(b)(2) of the Act are given in Table 2, below, again shown by land ownership.

TABLE 2—AREAS EXCLUDED FROM FINAL CRITICAL HABITAT UNDER SECTION 4(b)(2) OR EXEMPTED UNDER SECTION 4(a)(3) OF THE ACT

State (Ownership)	Proposed area (ac)	Proposed area (ha)	Final area (ac)	Final area (ha)	Excluded or exempted (ac)	Excluded or exempted (ha)
Washington:						
USFS	3,601,564	1,455,032	2,909,739	1,177,528	680,197	274,800
NPS	835,510	337,546	0	0	835,510	337,546
Other Federal (Joint Base Lewis-McChord; 4(a)(3) exemption)	14,313	5,782	0	0	14,313	5,782
STATE	226,708	91,590	8,328	3,370	218,380	88,225
PRIVATE	178,310	72,037	0	0	178,310	72,037
Oregon: *						
USFS	3,555,630	1,436,475	3,114,637	1,260,448	458,965	185,422
BLM	1,297,529	524,202	1,230,417	497,932	25,785	10,417
NPS	35,161	14,205	0	0	35,161	14,205
STATE	228,733	92,408	212,798	86,116	0	0
California:						
USFS	2,367,916	956,638	1,933,411	782,423	389,387	157,312
BLM	186,082	75,177	98,195	39,738	70,735	28,577
NPS	127,913	51,677	0	0	127,913	51,677
STATE	215,333	86,995	70,444	28,508	144,889	58,487

TABLE 2—AREAS EXCLUDED FROM FINAL CRITICAL HABITAT UNDER SECTION 4(b)(2) OR EXEMPTED UNDER SECTION 4(a)(3) OF THE ACT—Continued

State (Ownership)	Proposed area (ac)	Proposed area (ha)	Final area (ac)	Final area (ha)	Excluded or exempted (ac)	Excluded or exempted (ha)
PRIVATE	1,091,747	441,066	0	0	1,091,747	441,066
Grand Totals	13,962,449	5,640,829	9,577,969	3,876,064	4,271,291	1,725,553

(* Please note that no private lands in Oregon were proposed or included in this final designation.)

Note the difference in area between the proposed and final rules will not align exactly with the sum total of areas removed because they did not meet the definition of critical habitat and areas excluded or exempted from the final designation. Some minor discrepancies in area are due to mapping errors in the proposed designation have been corrected here, and may not be readily apparent through simple addition or subtraction of the total areas identified under various land categories. For example, the proposed rule mistakenly identified 16,031 ac (6,487 ha) of lands under the ownership of SDS and Broughton Lumber Companies in Washington as under consideration for exclusion. The accurate area included within the proposed critical habitat was, in fact, 2,035 ac (824 ha), and it is that area, which was excluded from this final designation, reflected in this final rule. The difference of nearly 14,000 ac (5,655 ha) will not be reflected in the difference between areas proposed and areas excluded in the final rule, as it was not really in the proposed critical habitat to begin with (and thus, was not excluded).

The number of subunits in the final critical habitat designation have changed as a result of exclusions under section 4(b)(2) or exemptions under section 4(a)(3). There were 11 critical habitat units and 63 subunits in the proposed rule. Eleven critical habitat units and 60 subunits comprise the final designation. In the North Coast Olympics, subunit NCO–3, composed entirely of Department of Defense lands at Joint-Base Lewis McChord, was exempted from the final designation under section 4(a)(3) of the Act (see Exemptions). In the Redwood Coast Region, subunits RDC–3 and RDC–4 were made up of private lands excluded under section 4(b)(2) of the Act (see Exclusions).

(5) Not all areas identified for potential exclusion in the proposed revised rule were excluded from the final designation. Based on the best available scientific information, we have found that the benefits of excluding other areas proposed or considered for exclusion do not outweigh the benefits of including them in the designation for the reasons discussed below. Therefore, the Secretary has determined not to exercise his discretion to exclude these lands. These areas are identified in Table 3 and are discussed further, below.

TABLE 3—LANDS THAT WERE PROPOSED FOR EXCLUSION, OR OTHERWISE CONSIDERED FOR EXCLUSION, WHICH ARE RETAINED IN THE FINAL CRITICAL HABITAT DESIGNATION FOR THE NORTHERN SPOTTED OWL

Type	State	Landowner	Acres	Hectares
State Lands	WA	Washington Department of Fish and Wildlife Lands [1]	8,328	3,370
State Lands	OR	Oregon Department of Forestry	212,798	86,116
State Lands	CA	California State Forests	49,760	20,137
	CA	Local Government Lands [2]	20,684	8,371
Total			291,570	117,994

(a) State, County, and Municipal Lands Not Excluded.

California

We retained a relatively limited area of State, County, and municipally owned or managed lands in California. Retained areas include lands managed as State Forests, County Parks, and a Municipal Water District. No habitat conservation plans (HCPs) or sage harbor agreements (SHAs) are currently in place on these lands. Most of these lands are in areas that have repeatedly been identified as critical to maintaining linkages among northern spotted owl populations in California. These State and County lands play an essential conservation role in this area of limited Federal ownership. Retaining these lands in the critical habitat designation promotes movement of northern spotted owls, and maintains the potential for genetic interchange. Including these lands would increase the awareness of State, County and local agencies about the status of and threats to spotted owls, the conservation actions needed for recovery, and the essential conservation role this habitat plays. It also increases the potential for educating visitors to State Forests and County Parks and Open Space areas about northern spotted owl conservation needs. Excluding these lands would have little impact on regulatory burdens because (a) current management of these lands is generally consistent with maintenance of habitat values, limiting the potential for adverse effects to critical habitat, and (b) management activities typically do not involve a Federal nexus. Therefore, the Secretary has chosen not to exclude the following California State, County, or municipal lands from the final designation of critical habitat for the northern spotted owl:

California Demonstration State Forests—Two California State Forests are included in the final critical habitat designation: (1) Jackson Demonstration State Forest (DSF), within subunit 2 in the Redwood Coast CHU in Mendocino County, California; and (2) Las Posadas DSF within subunit 6 of the Interior Coastal California CHU in Napa County, California. The California Department of Forestry and Fire Protection (CALFIRE) requested that the Jackson DSF be excluded from the final critical habitat designation for the northern spotted owl.

CALFIRE developed the Las Posadas DSF Management Plan (California Department of Forestry and Fire Protection, 1992) for the Las Posadas DSF and characterizes current management on the forest as ''custodial.'' Goals for fish and wildlife under the plan include maintenance of the ''* * * Forest's status as one of the last relatively undisturbed fish and wildlife habitats in Napa County.'' However, the management plan is quite dated, having been approved in 1992. There is acknowledgment of the presence of northern spotted owl activity sites in the management plan, but no specific provisions for owl management or conservation actions in the plan. There have been no publicly-available amendments or updates to the plan since its enactment in 1992 and the timeframe in which any revisions to the plan may take place is uncertain. The designation of critical habitat on these lands would perform an important educational function in highlighting their essential role in owl conservation as the State updates its plan and conducts management activities. Habitat within the plan area is not typical forested habitat often associated with the northern spotted owl but includes oak woodlands and grasslands in this southern part of the species range and represents a unique ecological setting for the species; the educational benefit of including this area in critical habitat is therefore high, as landowners may not be aware that the northern spotted owl inhabits this atypical habitat type. After reviewing the information available, we find that the benefits of including these areas as critical habitat will assist in maintaining linkages and movement among and between northern spotted owl populations, and heightening the awareness and educating visitors of the conservation role this habitat plays for recovery of the northern spotted owl. As a result we are not excluding the areas designated as critical habitat within the Las Posadas DSF.

CALFIRE has also developed a management plan for the Jackson DSF (Jackson Demonstration State Forest Management Plan (dated January 2008) and CALFIRE has requested that the area be excluded from the final designation. In their request for exclusion CALFIRE stated that the designation of the Jackson DSF as critical habitat was unnecessary given: (1) Extensive conservation planning and environmental assessment has already been completed for the area; (2) the designation would potentially have negative impacts on the mission of the Jackson DSF on implementing restoration and research projects; (3) that the draft economic analysis for the proposed critical habitat concluded that the designation would not affect timber harvest on State lands; and (4) designation does not provide meaningful wildlife benefits any different from those already in place.

The Service responds, as follows, to the four elements in CALFIRE'S request for exclusion. (1) While there are efforts by CALFIRE in the development of a forest management plan and environmental assessment for the Jackson DSF, the plan does not specifically provide for northern spotted owl conservation. We believe that the Jackson DSF Management Plan (CALFIRE, 2008) could provide potential benefits to the northern spotted owl, in that there is a high likelihood that land allocations stated in the plan, along with the long-term desired conditions for forest composition will improve habitat over time. However, we find that: (a) Existing management direction in the Plan relating to the northern spotted owl is vague; (b) the stated conservation policy for the owl is limited to a take-avoidance strategy; and (c) while CALFIRE collects monitoring data on northern spotted owl activity sites on a continuous basis, there is no apparent strategy for evaluating that information or applying it to the benefit of the species. The only overt policy statement in the 2008 Plan regarding the northern spotted owl states that ''* * * forest management objectives * * * are to maintain or increase the number and productivity of nesting owl pairs through forest management practices that enhance nesting/roosting opportunities and availability of a suitable prey base.'' The terms ''maintain'' and ''increase'' are not supported with measurable standards or targets; and there are no remedial measures or mechanisms in the 2008 Plan that are triggered by a decrease in activity sites or demographic productivity. The northern spotted owl conservation strategy in the 2008 Plan is predicated on take-avoidance (CALFIRE 2008, pp. 109 and 267). Take avoidance alone is not a sufficient conservation strategy and it will not necessarily satisfy CALFIRE's direction to maintain or increase owl activity sites or demographic performance. If there are local variations in the ''true'' optimal forest conditions that support owl occupancy, strict adherence to the take-avoidance provisions may not be satisfactory and occupancy rates may decrease, and there are no corrective mechanisms in the 2008 Plan to account for this possibility. This dual problem of the suitability and occupancy of activity sites is further complicated by barred owl intrusion, and likewise is not addressed by total reliance on a take-avoidance strategy. In addition, in the monitoring chapter for the 2008 Plan we find that there is continuous monitoring of northern spotted owl activity sites (CALFIRE 2008, p. 149), but it is not spelled out in detail. (For example, it does not include the detail and adaptability (i.e., adaptive management provisions) as are specified for instream conditions and fisheries (CALFIRE 2008, pp. 153–154). In addition, the 2008 Plan does not appear to contain guidance on how to process, evaluate, and interpret the continuous data that is currently being collected on northern spotted owl activity sites, or on how to apply that information to agency decision-making in the event that activity sites and demographic performance are not maintained or increased under the existing management direction. In summary, although the 2008 Jackson DSF Management Plan can potentially produce positive long-term outcomes for the northern spotted owl, it contains an incomplete conservation plan for the species.

(2) We do not agree with CALFIRE's contention that the designation would potentially have negative impacts on its ability to implement restoration and research projects. The fact that a Federal agency (i.e., U.S. Forest Service) is a research cooperator does not, by itself, create a section 7 nexus. The Service contacted the senior Forest Service scientist connected with the research program at Jackson DSF who described the Forest Service research activities as simply a scientific examination of the State's proposed actions. At this time, we see no Federal regulatory mechanism in connection with the Jackson DSF's existing cooperative research program that would trigger consultation under section 7 of the Act. Therefore, we believe any regulatory burden from designation would be minimal.

(3) The Service agrees with CALFIRE's observation, in their July 6, 2012 correspondence, that the economic analysis rightly concluded that critical habitat designation would have no effect on Jackson DSF harvest levels. The only potential effect on harvest schedules would occur if Federal permits or grants-of-funds were connected to the harvest activity.

(4) We disagree with CALFIRE's position that ''designation would

provide no meaningful wildlife benefits from those already in place.'' Our response to item 1, above, indicates that there are potentially meaningful informational benefits that may assist implementation of the existing Jackson DSF Management Plan. We believe designating these lands as critical habitat would serve a very important informational function as the management plan is implemented; it would highlight the fact that this habitat is essential to the conservation of the northern spotted owl.

While acknowledging that the 2008 Management Plan contains many features that have the potential to benefit the northern spotted owl over the long term, and also recognizing that there several remediable omissions in that Plan, the Secretary has elected not to exclude Jackson Demonstration State Forest from critical habitat designation under section 4(b)(2) of the Act because we believe that the educational and informational benefits of inclusion outweigh the benefits of exclusion.

Mount Tamalpais Municipal Watershed of the Marin Municipal Water District—We are not excluding the Mount Tamalpais Watershed (Watershed) from critical habitat designation. The Watershed (18,500 ac (7,487 ha)) is administered by the Marin Municipal Water District (MMWD) in Marin County, California. The Watershed is flanked on all sides by public parks, county-administered open space areas, grazing land, and residential areas within the triangle formed by U.S. Highway 101, California State Route 1 and Sir Francis Drake Boulevard. The MMWD currently does not operate under a conservation plan such as an HCP or SHA.

A key management consideration for the MMWD is the practical need to limit sediment delivery thereby extending the service life of the five reservoirs within the Watershed (Kent, Alpine, Bon Tempe, Lagunitas, and Phoenix Lakes). To that end, the policy of the MMWD is to maintain land in a natural condition and limit human activities to those that have the least impact on the Watershed. Within specified constraints, permitted public activities include hiking, bicycling, horseback riding, fishing and picnicking. Camping, swimming and boating are prohibited. There is limited public motor vehicle access into the Watershed on Panoramic Highway, Ridgecrest Boulevard and the Fairfax-Bolinas Road. These roads mostly access scenic vistas and day use areas around the reservoirs. The remainder of the road network in the Watershed is dedicated for firefighter access and administrative use, and is closed to public motor vehicles. The MMWD has produced several current management plans addressing specific subject areas, including public access, vegetation management, road and trail management, and long term fire and fuels management. Several elements in those plans are compatible with long-term northern spotted owl conservation. However, there is no explicit discussion about long-term owl management in any of the MMWD's planning documents. The upcoming Vegetation Management Plan (projected in 2013) may provide additional information that is relevant to northern spotted owl habitat management. We are not aware of any substantial benefits to excluding these areas from critical habitat and find that there would be significant educational benefits to including them in the designation in that it would highlight the significance this area has for northern spotted owl conservation in future planning efforts.

Marin County Parks and Open Space Department—We have included in the designation six Open Space Preserves (OSPs) totaling 3,626 ac (1,467 ha) administered by the Marin County (California) Parks and Open Space Department (Department). We have designated three contiguous OSPs adjacent to the Mount Tamalpais Watershed and south of the communities of Lagunitas and Fairfax including Gary Giacomini (1,476 ac (597 ha)), White Hill (390 ac (158 ha)), and Cascade Falls (498 ac (202 ha)). We have also designated three contiguous OSPs adjacent the Watershed and west of the community of Corte Madera including Baltimore Canyon (193 ac (78 ha)), Blithedale Summit (899 ac (364 ha), and Camino Alto (170 ac (69 ha). The Parks Department currently does not operate under a conservation plan such as an HCP or SHA.

Park management emphasizes non-motorized public use. Five of the six OSPs are served only by fire roads that are closed to public motor vehicle access. The exception is the Camino Alto OSP which is flanked on the east by a public street. Several land management elements in the park system strategic plan (Marin County Parks and Open Space Department, 2008) are compatible with northern spotted owl. However, there is no explicit discussion about long term owl management in this planning document. We are not aware of any substantial benefits to excluding these areas from critical habitat and find that there would be significant educational benefits to including them in the designation.

Sonoma County Regional Parks Department—Lands within Hood Mountain Regional Park, administered by the Sonoma County (California) Regional Parks Department (SCRPD), are included in the designation in subunit 6 of the Interior California Coast CHU. The proposed critical habitat designation includes all, or portions of, four assessor's parcels totaling 460 ac (186 ha) within the park boundary. The SCRPD does not operate under an HCP or SHA.

Hood Mountain Regional Park is minimally roaded; the Sonoma County General Plan of 2008 indicates a modest program of trail construction and management within the countywide regional parks system. Public information materials, along with maps showing the local road network, and the types and locations of facilities within Hood Mountain Regional Park, indicate that the SCRPD is emphasizing non-motorized recreation and protection of undeveloped land. Through public information sources in Sonoma County, we located a mission statement for the SCRPD but were unable to find any planning or guidance documents to indicate how the regional parks system would be managed over the long term. The absence of planning direction and the reasons for inclusion are similar to those for the Marin Municipal Water District and for the Marin County Parks and Open Space Department. We are not aware of any substantial benefits to excluding these areas from critical habitat and find that there would be significant educational benefits to including them in the designation.

Oregon

In Oregon, we considered excluding 228,733 ac (92,565 ha) of State lands managed by the Oregon Department of Forestry (ODF). These lands contain both demographically productive sites for northern spotted owls and provide connectivity linkages among northern spotted owl populations in the Oregon Coast and North Coast-Olympic Modeling Regions. These lands are not currently managed under any sort of conservation plan or agreement with the Service, but are managed by ODF for multiple benefits including commodity production.

The State of Oregon has indicated that the designation of their lands as critical habitat would have ''virtually no impact—positive or negative * * *'' on either the management of their lands or their ability to pursue HCPs, SHAs or other conservation agreements (ODF *in litt.*). This is because there is rarely a Federal nexus that would trigger Service regulatory authority, such as the section

7 consultation process and the adverse modification analysis. Thus, there would be little negative impact of including State lands in the critical habitat designation.

Inclusion of these lands in the critical habitat designation highlights their essential conservation role and provides opportunities for educating visitors to these areas, nearby landowners, and ODF about the potential conservation contribution of these lands to northern spotted owls. If ODF were to pursue some sort of conservation agreement, this critical habitat designation would provide a blueprint not only for the lands that would be essential to include in such an effort but also the types of management that would be appropriate there. If ODF does not pursue such an effort this designation clearly indicates the value of these lands for the conservation of the northern spotted owl. We believe the value of the information included in the designation would provide an opportunity for management direction that focuses on benefits to the species.

Because we are unaware of any negative impacts of including these ODF lands, the benefits of exclusion do not outweigh the benefits of inclusion for these lands, and the Secretary has chosen not to exercise his discretion to exclude these State of Oregon lands from the final designation.

Washington

In Washington we proposed or considered excluding 226,869 ac (91,811 ha) of State lands managed by the Washington Department of Natural Resources (225,013 ac; 91,059 ha), Washington State Parks (104 ac; 42 ha), and Washington Department of Fish and Wildlife (8,328 ac; 3,370 ha). We excluded the lands managed by the Washington Department of Natural Resources from the final designation based on their HCP, and excluded 104 ac (42 ha) of State Parks and Department of Fish and Wildlife Lands (see Exclusions). We retained 8,328 ac (3,370 ha) of State-owned lands managed by the State Department of Fish and Wildlife for wildlife habitat in the final designation. No conservation agreements are currently in place on these lands, but some could be covered by an HCP which is currently under development. Most of these lands are located in the central Cascades in an area that has repeatedly been identified as critical to maintaining linkages among spotted owl populations in Washington. These State lands play an essential conservation role in this area of limited or checkerboard Federal ownership. Retaining these lands in the critical habitat designation promotes movement of northern spotted owls between the northern and southern Cascades Range, as well as between the western and eastern slopes of the Cascades. Including these State lands would increase the awareness of State agencies about the essential conservation role these lands play and the conservation actions needed for recovery. Excluding these lands would impose little regulatory burden because (a) management of these lands is consistent with maintenance of habitat values, limiting the potential for adverse effects to critical habitat, and (b) management activities typically do not involve a Federal nexus. Therefore, the Secretary has chosen not to exercise his discretion to exclude lands managed by the Washington Department of Fish and Wildlife from the final designation of critical habitat for the northern spotted owl.

Summary of Changes From the Proposed Rule

The areas identified in this final rule constitute a revision from the areas we designated as critical habitat for the northern spotted owl in 2008 (August 13, 2008; 73 FR 47326), which was a revision of the areas we initially designated as critical habitat for the northern spotted owl in 1992 (January 15, 1992; 57 FR 1796; see Changes from Previously Designated Critical Habitat, below). This final rule supersedes and replaces both of these earlier designations. The changes to the proposed revised critical habitat designation identified above result in a final designation of 9,577,969 ac (3,876,064 ha), a decrease of 4,197,484 ac (1,689,072 ha) from the 13,962,449 ac (5,649,660 ha) identified as meeting the definition of critical habitat in the March 8, 2012 (77 FR 14062) proposed rule (Table 4, below).

TABLE 4—DIFFERENCES BETWEEN PROPOSED AND FINAL REVISED CRITICAL HABITAT. TOTALS MANY NOT SUM DUE TO ROUNDING (ROUNDED TO NEAREST 100 UNITS). SMALL DIFFERENCES BETWEEN THE PROPOSED AND FINAL REVISED CRITICAL HABITAT THAT ARE NOT NOTED AS ADDITIONS OR DELETIONS ARE THE RESULT OF CORRECTIONS OF THE GIS MAP AND ROUNDING ERROR

Critical habitat unit	Proposed acres	Proposed hectares	Final acres	Final hectares
East Cascades North	1,919,469	775,465	1,345,523	544,514
East Cascades South	526,810	212,831	368,381	149,078
Inner California Coast Ranges	1,276,450	515,686	941,568	381,039
Klamath East	1,111,679	449,118	1,052,731	426,025
Klamath West	1,291,606	521,809	1,197,389	484,565
North Coast Olympic	1,595,821	644,712	824,500	333,663
Oregon Coast Ranges	891,154	360,026	859,864	347,975
Redwood Coast	1,550,747	626,502	180,855	73,189
West Cascades Central	1,353,045	546,630	909,687	368,136
West Cascades North	820,832	331,616	542,274	219,450
West Cascades South	1,624,836	656,434	1,355,198	548,429
Total	13,962,449	5,640,829	9,577,969	3,876,064

V. Changes From Previously Designated Critical Habitat

In 2008, we designated 5,312,300 ac (2,149,800 ha) of Federal lands in California, Oregon, and Washington as critical habitat for the northern spotted owl (73 FR 47326; August 13, 2008). In this revision, we are designating 9,577,969 ac (3,876,064 ha) as critical habitat for the northern spotted owl. We have revised the designation of critical habitat for the northern spotted owl to be consistent with the most current assessment of the conservation needs of the species, as described in the 2011 Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, Appendix B). In this final designation, 4,085,808 ac (1,653,468 ha) are the same as in the 2008 designation. Of the current designation, 5,679,162 ac (2,298,275 ha) are lands not formerly designated in 2008, and 1,229,119 ac (497,405 ha) of lands that were included in the former designation are not included here, for reasons detailed below.

This revision of critical habitat represents an increase in the total land area identified from previous designations in 1992 and 2008. This increase in area is due, in part, to: (a) The unanticipated steep decline of the northern spotted owl and the impact of the barred owl, requiring larger areas of habitat to maintain sustainable spotted owl populations in the face of competition with the barred owl (e.g., Dugger *et al.* 2011, p. 2467); (b) the recommendation from the scientific community that the conservation of more occupied and high-quality habitat is essential to the conservation of the species (Forsman *et al.* 2011, p. 77); (c) the need to provide for redundancy in northern spotted owl populations, by maintaining sufficient suitable habitat for northern spotted owls on a landscape level in areas prone to frequent natural disturbances, such as the drier, fire-prone regions of its range (in other words, ''back-up'' areas of habitat so that owls have someplace to go if their habitat burns or trees die due to insect infestation, etc.) (Noss *et al.* 2006, p. 484; Thomas *et al.* 2006, p. 285; Kennedy and Wimberly 2009, p. 565); and (d) in contrast to the previous critical habitat designation, the inclusion of some State lands in areas where Federal lands are not sufficient to meet the conservation needs of the northern spotted owl.

The new delineation of areas determined to provide the physical or biological features essential for the conservation of the northern spotted owl, or otherwise determined to be essential for the conservation of the species, was based, in part, on an improved understanding of the forest characteristics and spatial patterns that influence habitat usage by northern spotted owls which were incorporated into the latest population evaluation and mapping technology. The modeling process we used to evaluate alternative critical habitat scenarios differed fundamentally from the conservation planning approach used to inform the 1992 and 2008 designations of critical habitat for the northern spotted owl. These past designations relied on *a priori* (predefined) rule sets derived from the best scientific information and expert judgment available at that time regarding the size of reserves or habitat conservation blocks, target number of spotted owl pairs per reserve or block, and targeted spacing between reserves or blocks (USFWS 2011, p. C–4), which we then assessed and refined based on local conditions. This revised designation reflects our use of a series of spatially explicit modeling processes to determine those specific areas where biological features are essential to the conservation of the northern spotted owl, and in the case of unoccupied habitat, to determine the areas that are otherwise essential to the conservation of the owl, as described in Criteria Used to Identify Critical Habitat. These models enabled us to compare potential critical habitat scenarios in a repeatable and scientifically accepted manner (USFWS 2011, p. C–4), using current tools that capitalize on new spatial information and algorithms (rule sets to solve problems) for identifying the most efficient habitat network containing what is essential for conservation.

The areas designated are lands that were occupied at the time of listing and that currently provide suitable nesting, roosting, foraging, or dispersal habitat for northern spotted owls, or that are otherwise essential to the conservation of the species. However, as noted above, not every site of known owl occupancy, either at present or at the time of listing, is included in the designation. We did not include owl sites if they were isolated from other known occurrences or in areas of marginal habitat quality such that they were unlikely to make a significant contribution to the conservation of the species, and therefore were not considered to provide the essential features.

The critical habitat network development and evaluation strategy we used attempted to maximize the efficiency of the network by prioritizing Federal lands. Utilization of new scientific information and advanced modeling techniques accounts for many of the changes in the revised critical habitat; in particular, the location of areas essential to northern spotted owls may have shifted from previous designations based on the best information available regarding the spatial distribution of high-value habitat. These advances include improvements in remotely-sensed vegetation data, use of models that better identify spatial configurations of habitat features important to owls, and assessment of relative population performance of northern spotted owls under different critical habitat designations. In addition, negative effects of barred owls on northern spotted owl populations were incorporated into the modeling process.

Late-successional reserves (LSRs) were not prioritized in this approach based solely on their status as a reserved land allocation, but were included in the 2012 designation only where the habitat quality was high enough to meet the selection criteria. In contrast, the 2008 critical habitat identified lands in part based on status as LSRs. However, LSRs were not originally designed under the NWFP solely to meet the needs of the northern spotted owl, but may include areas designated for other late-successional forest species. Therefore, not all LSRs contain habitat of sufficient quality to be included in the critical habitat network for the northern spotted owl. Connected to the decision to designate lands in part because of their status as LSRs, we did not include NWFP matrix on Forest Service lands in 2008. In this designation we have included NWFP matrix lands where they contain high quality habitat essential to the species' conservation. As described in the section Changes from the Proposed Rule, we tested a habitat network that did not include many of these high-value matrix lands; doing so led to a significant increase in the risk of extinction for the species, therefore these lands are retained in this final designation.

Table 5 shows a comparison of areas included in the 2008 designation and those included in this revision to critical habitat. The process we used to determine occupied areas containing essential features and unoccupied areas essential to the conservation of the species is described in Criteria Used to Identify Critical Habitat.

TABLE 5—COMPARISON OF AREA INCLUDED IN 2008 CRITICAL HABITAT AND 2012 CRITICAL HABITAT BY REGION. THE 11 REGIONS ARE DESCRIBED IN DETAIL IN THE PROPOSED REVISED CRITICAL HABITAT DESIGNATION SECTION

Modeling region	2012 Critical habitat		2008 Final critical habitat	
	acres	hectares	acres	hectares
North Coast Olympics	824,500	333,663	485,039	196,289

TABLE 5—COMPARISON OF AREA INCLUDED IN 2008 CRITICAL HABITAT AND 2012 CRITICAL HABITAT BY REGION. THE 11 REGIONS ARE DESCRIBED IN DETAIL IN THE PROPOSED REVISED CRITICAL HABITAT DESIGNATION SECTION—Continued

Modeling region	2012 Critical habitat		2008 Final critical habitat	
	acres	hectares	acres	hectares
Oregon Coast	859,864	347,975	507,082	205,209
Redwood Coast	180,855	73,189	70,153	28,390
West Cascades North	542,274	219,450	390,232	157,921
West Cascades Central	909,687	368,136	546,333	221,093
West Cascades South	1,355,198	548,429	700,421	283,450
East Cascades North	1,345,523	544,514	687,702	278,303
East Cascades South	368,381	149,078	207,291	83,888
Klamath East	1,052,731	426,025	667,795	270,247
Klamath West	1,197,389	484,565	667,795	270,247
Inner California Coast Ranges	941,568	381,039	535,863	216,856
Grand total	9,577,969	3,876,064	5,312,327	2,149,823

The reduction in the number of critical habitat units from 33 in 2008 to 11 in 2012 is a reflection, in part, of our decision to aggregate habitat by regions. The 2008 designation included 33 critical habitat units; the 2012 revision includes 11 critical habitat units with 60 subunits.

Our determination of PCEs in this revised designation incorporates new information resulting from research conducted since the last revision in 2008. This new information, along with relevant older studies, allowed us to include a higher level of specificity in the PCEs in this revision. This final rule also includes two changes in overall organization. The 2008 revised designation considered nesting and roosting habitat as separate PCEs. In this designation, we have combined these habitat types, because northern spotted owls generally use the same habitat for both nesting and roosting; they are not separate habitat types, and function differs only based on whether a nest structure is present. At the scale of a rangewide designation of critical habitat, nesting and roosting habitats cannot be systematically distinguished, and, therefore, we combined them in our analysis and resulting rulemaking. For project planning and management of northern spotted owls at the local scale, the distinction between nesting and roosting habitat remains useful, especially in portions of the subspecies' range where nesting structures are conspicuous (e.g., mistletoe brooms). The second organizational change was to subdivide the range of the northern spotted owl into four separate regions, and to describe PCEs for foraging habitat separately for each of these to provide more appropriate region-specific information.

VI. Critical Habitat

Background

Critical habitat is defined in section 3 of the Act as:

(1) The specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the Act, on which are found those physical or biological features;

(a) Essential to the conservation of the species; and

(b) Which may require special management considerations or protection; and

(2) Specific areas outside the geographical area occupied by the species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.

Conservation, as defined under section 3 of the Act, means to use and the use of all methods and procedures that are necessary to bring an endangered or threatened species to the point at which the measures provided pursuant to the Act are no longer necessary. Such methods and procedures include, but are not limited to, all activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation, and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking.

Critical habitat receives protection under section 7 of the Act through the requirement that Federal agencies ensure, in consultation with the Service, that any action they authorize, fund, or carry out is not likely to result in the destruction or adverse modification of critical habitat. The designation of critical habitat does not affect land ownership or establish a refuge, wilderness, reserve, preserve, or other conservation area. Such designation does not allow the government or public to access private lands. Such designation does not require implementation of restoration, recovery, or enhancement measures by non-Federal landowners. Where a landowner requests Federal agency funding or authorization for an action that may affect a listed species or critical habitat, the consultation requirements of section 7(a)(2) of the Act would apply, but even in the event of a destruction or adverse modification finding, the obligation of the Federal action agency and the landowner is not to restore or recover the species, but to implement reasonable and prudent alternatives to avoid destruction or adverse modification of critical habitat.

Under the first prong of the Act's definition of critical habitat, areas within the geographical area occupied by the species at the time it was listed are included in a critical habitat designation if they contain physical or biological features: (1) Which are essential to the conservation of the species, and (2) which may require special management considerations or protection. For these areas, critical habitat designations identify, to the extent known using the best scientific and commercial data available, those physical or biological features that are essential to the conservation of the species (such as space, food, cover, and protected habitat). In identifying those physical or biological features within an area, we focus on the principal biological or physical constituent elements (PCEs—primary constituent elements such as roost sites, nesting grounds, rainfall, canopy cover, soil type) that are essential to the conservation of the species.

Under the second prong of the Act's definition of critical habitat, we can designate critical habitat in areas outside the geographical area occupied by the species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. For example, an area that was not occupied at the time of listing but is essential to the conservation of the species may be included in the critical habitat designation. We designate critical habitat in areas outside the geographical area occupied by a species only when a designation limited to its range would be inadequate to ensure the conservation of the species (50 CFR 424.12(e)).

Section 4 of the Act requires that we designate critical habitat on the basis of the best scientific and commercial data available. Further, our Policy on Information Standards Under the Endangered Species Act (published in the **Federal Register** on July 1, 1994 (59 FR 34271)), the Information Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Pub. L. 106–554; H.R. 5658)), and our associated Information Quality Guidelines, provide criteria, establish procedures, and provide guidance to ensure that our decisions are based on the best scientific data available. They require our biologists, to the extent consistent with the Act and with the use of the best scientific data available, to use primary and original sources of information as the basis for recommendations to designate critical habitat.

When we are determining which areas should be designated as critical habitat, our primary source of information is generally the information developed during the listing process for the species. Additional information sources may include the recovery plan for the species, articles in peer-reviewed journals, conservation plans developed by States and counties, scientific status surveys and studies, biological assessments, other unpublished materials, or experts' opinions or personal knowledge.

Habitat is dynamic, and northern spotted owls may move from one area to another over time. We recognize that critical habitat designated at a particular point in time may not include all of the habitat areas that we may later determine are necessary for the recovery of the species. For these reasons, a critical habitat designation does not signal that habitat outside the designated area is unimportant or may not be needed for recovery of the species. Areas that are important to the conservation of the species, both inside and outside the critical habitat designation, will continue to be subject to: (1) Conservation actions implemented under section 7(a)(1) of the Act, (2) regulatory protections afforded by the requirement in section 7(a)(2) of the Act for Federal agencies to insure their actions are not likely to jeopardize the continued existence of any endangered or threatened species, and (3) the prohibitions of section 9 of the Act on taking any individual of the species, including taking caused by actions that affect habitat. Federally funded or permitted projects affecting listed species outside their designated critical habitat areas may still result in jeopardy findings in some cases. These protections and conservation tools will continue to contribute to recovery of this species. Similarly, critical habitat designations made on the basis of the best available information at the time of designation will not control the direction and substance of future recovery plans, habitat conservation plans (HCPs), or other species conservation planning efforts if new information available at the time of these planning efforts calls for a different outcome.

Physical or Biological Features

In accordance with section 3(5)(A)(i) and 4(b)(1)(A) of the Act and regulations at 50 CFR 424.12, in determining which areas within the geographical area occupied by the species at the time of listing to designate as critical habitat, we consider the physical or biological features essential to the conservation of the species and which may require special management considerations or protection. These include, but are not limited to:

(1) Space for individual and population growth and for normal behavior;

(2) Food, water, air, light, minerals, or other nutritional or physiological requirements;

(3) Cover or shelter;

(4) Sites for breeding, reproduction, or rearing (or development) of offspring; and

(5) Habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species.

For the northern spotted owl, the physical or biological features essential to the conservation of the species are forested areas that are used or likely to be used for nesting, roosting, foraging, or dispersing. The specific characteristics or components that comprise these features include, for example, specific ranges of forest stand density and tree size distribution; coarse woody debris; and specific resources, such as food (prey and suitable prey habitat), nest sites, cover, and other physiological requirements of northern spotted owls and considered essential for the conservation of the species. Below, we describe the life-history needs of the species and the broader physical or biological features essential to the conservation of the northern spotted owl, which informed our identification of the primary constituent elements (PCEs). The following information is based on studies of the habitat, ecology, and life history of the species, as described in the final listing rule for the northern spotted owl, published in the **Federal Register** on June 26, 1990 (55 FR 26114); the Revised Recovery Plan for the Northern Spotted Owl released on June 30, 2011 (USFWS 2011); the Background section of this document; and the following information.

Although the northern spotted owl is typically considered a habitat and prey specialist, it uses a relatively broad array of forest types for nesting, roosting, foraging, and dispersal. The diversity of forest types used is a reflection of the large geographical range of this subspecies, and the strong gradation in annual precipitation and temperature associated with both coastal mountain ranges and the Cascade Range. While the northern spotted owl is unquestionably associated with old-growth forests, habitat selection and population performance involves many additional features (Loehle *et al.* 2011, p. 20). This description of physical or biological features summarizes both variation in habitat use and particular features or portions of the overall gradient of variation that northern spotted owls preferentially select, and that we, therefore, consider essential to their conservation. We begin by considering the broad-scale patterns of climate, elevation, topography, and forest community type that act to influence northern spotted owl distributions and space for population growth and dispersal. We then discuss the abundance and pattern of habitats used for nesting, roosting, and foraging at the landscape scale that influence the availability and occupancy of breeding sites and the survival and fecundity of northern spotted owls. Thus, we begin by considering factors that operate at broader spatial scales and proceed to factors that influence habitat quality at the forest stand scale. When we discuss the physical or biological features, we focus on features that are common range wide, but also summarize specific features or patterns of habitat selection that characterize particular regions.

Physical Influences Related to Features Essential to the Northern Spotted Owl

Climate, elevation, and topography are features of the physical environment that influence the capacity of a landscape to support habitat with high value for northern spotted owls and the type of habitat needed by the species. The distribution and amount of habitat on the landscape reflects interactions among these physical elements. Several studies have found that physical aspects of the environment, such as topographic position, aspect, and elevation, influence the northern spotted owl's selection of habitat (e.g., Clark 2007, pp. 97–111; Stalberg *et al.* 2009, p. 80). These features are also factors in determining the type of habitats essential to northern spotted owl conservation.

Climate—Population processes for northern spotted owls are affected by both large-scale fluctuations in climate conditions and by local weather variation (Glenn 2009, pp. 246–248). The influence of weather and climate on northern spotted owl populations has been documented in northern California (Franklin *et al.* 2000, pp. 559–583), Oregon (Olson *et al.* 2004, pp. 1047–1052; Dugger *et al.* 2005, pp. 871–877; Glenn *et al.* 2010, pp. 2546–2551), and Washington (Glenn *et al.* 2010, pp. 2546–2551). Climate and weather effects on northern spotted owls are mediated by vegetation conditions, and the combination of climate and vegetation variables improves models designed to predict the distribution of northern spotted owls (e.g., Carroll 2010, pp. 1434–1437).

Climate niche models for the northern spotted owl identified winter precipitation as the most important climate variable influencing ability to predict the distribution of northern spotted owl habitat (Carroll 2010, p. 1434). This finding is consistent with previous demographic studies that suggest there are negative effects of winter and spring precipitation on survival, recruitment, and dispersal (Franklin *et al.* 2000; pp. 559–583). Niche modeling suggested that precipitation variables, both in winter and in summer, were more influential than winter and summer temperatures (Carroll 2010, p. 1434–1436).

Wet, cold weather during the winter or nesting season, particularly the early nesting season, has been shown to negatively affect northern spotted owl reproduction (Olson *et al.* 2004, p. 1039; Dugger *et al.* 2005, p. 863; Glenn *et al.* 2011b, p. 1279), survival (Franklin *et al.* 2000, p. 539; Olson *et al.* 2004, p. 1039; Glenn *et al.* 2011a, p. 159), and recruitment (Franklin *et al.* 2000, p. 559; Glenn *et al.* 2010, p. 2546). Cold, wet weather may reduce reproduction or survival during the breeding season, due to declines or decreased activity in small mammal populations, so that less food is available during this period when metabolic demands are high (Glenn *et al.* 2011b, pp. 1290–1294). Wet, cold springs or intense storms during this time may increase the risk of starvation in adult birds (Franklin *et al.* 2000, pp. 559–590). Cold, wet weather may also limit abundance of prey (Lehmkuhl *et al.* 2006, pp. 589–595), and reduce the male northern spotted owl's ability to bring food to incubating females or nestlings (Franklin *et al.* 2000, pp. 559–590). Cold, wet nesting seasons have been shown to increase the mortality of nestlings due to chilling (Franklin *et al.* 2000, pp. 559–590), and reduce the number of young fledged per pair per year (Franklin *et al.* 2000, p. 559, Olson *et al.* 2004, p. 1047; Glenn *et al.* 2011b, p. 1279). Wet, cold weather may decrease survival of dispersing juveniles during their first winter, thereby reducing recruitment (Franklin *et al.* 2000, pp. 559–590).

Habitat quality may offset the negative effects of climate extremes. Franklin *et al.* (2000, pp. 582–583) argued that northern spotted owl populations are regulated or limited by both habitat quality and environmental factors, such as weather. Abundance and availability of prey may ultimately limit northern spotted owl populations, and abundance of prey is strongly associated with habitat conditions. As habitat quality decreases, other factors, such as weather, have a stronger influence on demographic performance. In essence, the presence of high-quality habitat appears to buffer the negative effects of cold, wet springs and winters on survival of northern spotted owls, as well as ameliorate the effects of heat. High-quality northern spotted owl habitat was defined in a northern California study area as a mature or old-growth core within a mosaic of old and younger forest (Franklin *et al.* 2000, p. 559). The high-quality habitat can help maintain a stable prey base, thereby reducing the cost of foraging during the early breeding season, when energetic needs are high (Carey *et al.* 1992, pp. 223–250; Franklin *et al.* 2000, p. 559). In addition, mature and old forest with high canopy cover typically remains cooler during summer months than younger stands.

Drought or hot temperatures during the previous summer have also been associated with reduced northern spotted owl recruitment and survival (Glenn *et al.* 2010, p. 2546). Drier, warmer summers and drought conditions during the growing season strongly influence primary production in forests, food availability, and the population sizes of small mammals (Glenn *et al.* 2010, p. 2546). Northern flying squirrels (one of the northern spotted owl's primary prey), for example, forage primarily on ectomycorrhizal fungi (truffles), many of which grow better under moist conditions (Lehmkuhl *et al.* 2004, pp. 58–60). Drier, warmer summers, or the high-intensity fires, which such conditions support, may change the range or availability of these fungi, affecting northern flying squirrels and the northern spotted owls that prey on them. Periods of drought are associated with declines in annual survival rates for other raptors, due to a presumed decrease in prey availability (Glenn *et al.* 2010, pp. 2546–2551).

Mexican northern spotted owls (*Strix occidentalis lucida*) and California northern spotted owls (*S. o. occidentalis*) have a narrow temperature range in which body temperature can be maintained without additional metabolic energy expenditure (Ganey *et al.* 1993, pp. 653–654; Weathers *et al.* 2001, pp. 682–686). Others (e.g., Franklin *et al.* 2000, entire) have assumed the northern spotted owl to be similar in this regard. While winter temperatures are relatively mild across much of the northern spotted owl's range, heat stress has been identified as a potential stressor at temperatures exceeding 30 °C (86 °F; Weathers *et al.* 2001, p. 678). The northern spotted owl's selection for areas with older-forest characteristics has been hypothesized to be related, in part, to its needing cooler areas in summer to avoid heat stress (Barrows and Barrows 1978, entire).

Elevation and Topography—Elevation and corresponding changes in temperature or moisture regimes constrain the development of vegetation communities selected by northern spotted owls, and may exceed the bounds of physiological tolerance of northern spotted owls or their prey as well. Several studies have noted the avoidance or absence of northern spotted owls above location-specific elevational limits (Blakesley *et al.* 1992, pp. 390–391; Hershey *et al.* 1998, p. 1406; LaHaye and Gutiérrez 1999, pp. 326, 328). In some locations, elevational limits occur despite the presence of forests that appear to have the structural characteristics typically associated with northern spotted owl habitat. Where forest structure is not the apparent cause of elevational limits, the mechanistic bases of these limits are unknown, but they could be related to prey availability, presence of competitors, or extremes of temperature or precipitation. Habitat for northern spotted owls can occur from sea level to the lower elevation limit of subalpine vegetation types. This upper elevation limit varies with latitude from about 3,000 feet (ft) (900 meters (m)) above sea level in coastal Washington and Oregon (Davis and Lint 2005, p. 32) to about 6,000 ft (1,800 m) above sea level near the southern edge of the range (derived from Davis and Lint 2005, p. 32).

Topography also influences the distribution of northern spotted owl habitat and patterns of habitat selection. The effects of topography are strongest in drier forests, where aspect and insolation (amount of solar radiation received in an area) contribute to moisture stress that can limit forest density and tree growth. In drier forests east of the Cascades and in the Klamath region, suitable habitat can be concentrated at intermediate topographic positions, on north-facing aspects, and in concave landforms that retain moisture. This leads to a distribution of suitable habitat characterized by ribbon-like bands and discrete patches. Ribbons occur along drainages and valley bottoms, along the north faces of ridges that trend from east to west, and at intermediate topographic positions between drier pine-dominated forests at lower elevations, and subalpine forest types at higher elevations. Discrete patches also occur on top of higher plateaus. Northern spotted owl populations inhabiting drier forests have higher fecundity and lower survival rates than owls in other regions (Hicks *et al.* 2003, pp. 61–62; Anthony *et al.* 2006, pp. 28, 30). The naturally fragmented distribution of suitable habitat in drier forests, and increased predation risk associated with traversing this landscape, may be one of many features that contributed to the evolution of these life-history characteristics.

Slope may also influence the distribution of suitable habitat. Intermediate slopes have been associated with northern spotted owl sites in some studies (e.g., Gremel 2005, p. 37; Gaines *et al.* 2010, pp. 2048–2050; USFWS 2011, Appendix C), but the mechanisms underlying this association are unclear, potentially including a variety of features from soil depth to competition with barred owls.

Disturbance Regimes—Natural disturbances and anthropogenic (human-caused) activities continuously shape the amount and distribution of northern spotted owl habitat on the landscape. In moist forests west of the Cascades in Washington and Oregon, and in the Redwood region in California, anthropogenic activities have a dominant influence on distribution patterns of remaining habitat, with natural disturbances typically playing a secondary role. In contrast, drier forests east of the Cascades and in the Klamath region have dynamic disturbance regimes that continue to exert a strong influence on northern spotted owl habitat. Climate change may modify disturbance regimes across the range of the northern spotted owl, resulting in substantial changes to the frequency and extent of habitat disruption by natural events.

In drier forests, low- and mixed-severity fires historically contributed to a high level of spatial and temporal variability in landscape patterns of disturbed and recovering vegetation. However, anthropogenic activities have so altered these historical patterns and composition of vegetation, fuels, and associated disturbance regimes, that contemporary landscapes no longer function as they did historically (Hessburg *et al.* 2000a, pp. 77–78; Hessburg and Agee 2003, pp. 44–51; Hessburg *et al.* 2005, pp. 122–127, 134–136; Skinner *et al.* 2006, pp. 176–179; Skinner and Taylor 2006, pp. 201–203).

Fire exclusion, combined with the removal of fire-tolerant structures (e.g., large, fire-tolerant tree species such as ponderosa pine, western larch (*Larix occidentalis*), and Douglas-fir), have reduced the resiliency of the landscape to fire and other disturbances, (Agee 1993, pp. 280–319; Hessburg *et al.* 2000a, pp. 71–80; Hessburg and Agee 2003, pp. 44–46). Understory vegetation in these forests has shifted in response to fire exclusion from grasses and shrubs to shade-tolerant conifers, reducing fire tolerance of these forests, and increasing drought stress on dominant tree species.

Anthropogenic activities have also fundamentally changed the spatial distribution of fire-intolerant stands among the fire-tolerant stands, changing the pattern of fire activity across the landscape. Past management has altered the natural disturbance regime, homogenized the formerly patchy vegetative network, and reduced the complexity that was more prevalent during the presettlement era (Skinner 1995, pp. 224–226; Hessburg and Agee 2003, pp. 44–45; Hessburg *et al.* 2007, p. 21; Kennedy and Wimberly 2009, pp. 564–565). This alteration in the disturbance regime further affects forest structure and composition. Patches of fire-intolerant vegetation that had been spatially separated have become more contiguous and are more prone to conducting fire, insects, and diseases across larger swaths of the landscape (Hessburg *et al.* 2005, pp. 71–74, 77–78). This homogenized landscape may be altering the size and intensity of current disturbances and further altering landscape functionality (e.g., Everett *et al.* 2000, pp. 221–222).

The intensity and spatial extent of natural disturbances that affect the amount, distribution, and quality of northern spotted owl habitat in dry forests are also influenced by local topographic features, elevation, and climate (Swanson *et al.* 1988, entire). At local scales, these factors can be used to identify areas that are insulated from recent or existing disturbance, and consequently tend to persist without disturbance for longer periods (Camp *et al.* 1997, entire). These disturbance refugia are locations where northern spotted owl habitat has a higher likelihood of developing and persisting in drier forests. As a result of these unevenly distributed disturbance regimes, especially in the drier forests within its range, habitat for the northern spotted owl naturally occurs in a patchy mosaic in various stages of suitability in these regions. Sufficient area to provide for these habitat dynamics and to allow for the maintenance of adequate quantities of suitable habitat on the landscape at any one point in time is, therefore, essential to the conservation of the northern spotted owl in the dry forest regions.

Pattern and Distribution of Habitat—Historically, forest types occupied by the northern spotted owl were fairly continuous, particularly in the wetter parts of its range in coastal northern California and most of western Oregon and Washington. Suitable forest types in the drier parts of the range (interior northern California, Klamath region, interior southern Oregon, and east of the Cascade crest in Oregon and Washington) occur in a mosaic pattern interspersed with infrequently used vegetation types, such as open forests, shrubby areas, and grasslands. As described above, natural disturbance processes in these drier regions likely contributed to a pattern in which patches of habitat in various stages of suitability shift positions on the landscape through time. In the Klamath Mountains Provinces of Oregon and California, and to a lesser extent in the Coast and Cascade Provinces of California, large areas of serpentine soils exist that are typically not capable of supporting northern spotted owl habitat (Davis and Lint 2005, pp. 31–33).

Biological Influences Related to Features Essential to the Northern Spotted Owl

Forest Community Type (Composition)—Across their geographical range, northern spotted owl use of habitat spans several scales, with increasing levels of habitat selection specificity at each scale. We refer to these scales as the ''landscape,'' ''home range,'' and ''core area'' scales. Nest stands within core areas are even more narrowly selected (see Functional Categories of Northern Spotted Owl Habitat, in the Background section, above).

Landscapes supporting populations of northern spotted owls are the broadest scale we considered, encompassing areas sufficient to support numerous reproductive pairs (roughly 20,000 to 200,000 ac (8,100 to 81,000 ha). At the landscape scale, the northern spotted owl inhabits most of the major types of coniferous forests across its geographical range, including Sitka spruce, western hemlock, mixed conifer and mixed evergreen, grand fir, Pacific silver fir, Douglas-fir, redwood/Douglas-fir (in coastal California and southwestern Oregon), white fir, Shasta red fir, and the moist end of the ponderosa pine zone (Forsman *et al.* 1984, pp. 8–9; Franklin and Dyrness 1988, entire; Thomas *et al.* 1990, p. 145). These forest types may be in early-, mid-, or late-seral stages, and must occur in concert with at least one of the physical or biological features characteristic of breeding and nonbreeding (dispersal) habitat, described below.

Landscape-level patterns in tree species composition and topography can influence the distribution and density of northern spotted owls. These differences in northern spotted owl distribution occur even when different forest types have similar structural attributes, suggesting that northern spotted owls may prefer specific plant associations or tree species. Some forest types, such as pine-dominated and subalpine forests, are infrequently used, regardless of their structural attributes. In areas east of the Cascade Crest, northern spotted owls select forests with high proportions of Douglas-fir trees. The effects of tree species composition on habitat selection also extend to hardwoods within conifer-dominated forests (e.g., Meyer *et al.* 1998, p. 35). For example, our habitat modeling indicated that habitat value in the central Western Cascades was negatively related to proportion of hardwoods present. At the home range and core area scales, locations occupied by northern spotted owls consistently have greater amounts of mature and old-growth forest compared to random locations or unused areas. The proportion of older or structurally complex forest within the home range varies greatly by geographical region, but typically falls between 30 and 78 percent (Courtney *et al.* 2004, p. 5–6). In studies where circles of different sizes were compared, differences between northern spotted owl sites and random locations diminished as circles of increasing size were evaluated (Courtney *et al.* 2004, p. 5–7), suggesting habitat selection is stronger at the core area scale than at the home range and landscape scales.

Population Spatial Requirements—We have described a range of climatic, elevational, topographic, and compositional factors, and associated disturbance dynamics typical of different regions, that constrain the amount and distribution of northern spotted owl habitat across landscapes. Within this context, areas that contain the physical or biological features described below must provide habitat in an amount and distribution sufficient to support persistent populations, including metapopulations of reproductive pairs, and opportunities for nonbreeding and dispersing owls to move among populations to be considered essential to the conservation of the northern spotted owl.

Northern spotted owls maintain large home ranges that vary in size across nearly an order of magnitude across the species' range, from about 1,400 to 14,000 ac (570 to 5,700 ha), depending on geographic latitude and prey resources (see *Home Range Requirements,* below). Overlap occurs among adjoining territories, but the large size of territories nonetheless means that populations of northern spotted owls require landscapes with large areas of habitat suitable for nesting, roosting, and foraging. For example, in the northern parts of the subspecies' range where territories are largest, a population of 20 resident pairs would require at least 100,000 ac (about 40,500 ha) of habitat that is relatively densely distributed and of high quality.

As described in the Background section above, several studies have examined patterns of northern spotted owl habitat selection at the territory scale and the consequences on fitness of habitat configuration within a territory. We do not know if the features that contribute to enhancing northern spotted owl occupancy and reproductive success at the territory scale can be scaled up to predict what landscape-scale patterns of habitat are most conducive to stable or increasing northern spotted owl populations. Studies that use populations as units of analysis in order to investigate the effects of the landscape-scale configuration of habitat on the performance of northern spotted owl populations have only begun recently. Past models of northern spotted owl population dynamics have included predictions about the effects of habitat configuration on population performance, but these predictions have not been tested or validated by empirical studies (Franklin and Gutiérrez 2002; p. 215). Recent demographic analyses suggested that recruitment was positively related to the proportion of study areas covered by suitable habitat (see Forsman *et al.* 2011, pp. 59–62), but this covariate was not associated with other aspects of demographic performance, and few other covariates were investigated.

When the northern spotted owl was listed as threatened in 1990 (55 FR 26114; June 26, 1990), habitat loss and fragmentation of old-growth forest were identified as major factors contributing to declines in northern spotted owl populations. As older forests were reduced to smaller and more isolated patches, the ability of northern spotted owls to successfully disperse and establish territories was likely reduced (Lamberson *et al.* 1992, pp. 506, 508, 510–511). Lamberson *et al.* (1992, pp. 509–511) identified an apparent sharp threshold in the amount of habitat below which northern spotted owl population viability plummeted. Lamberson *et al.* (1994, pp. 185–186, 192–194) concluded that size, spacing, and shape of reserved areas all had strong influence on population persistence, and reserves that could support a minimum of 20 northern spotted owl territories were more likely to maintain northern spotted owl populations than smaller reserves. They also found that juvenile dispersal was facilitated in areas large enough to support at least 20 northern spotted owl territories.

In addition to area size, spacing between reserves had a strong influence on successful dispersal (Lamberson *et al.* 1992, pp. 508, 510–511). Forsman *et al.* (2002, pp. 15–16) reported dispersal distances of 1,475 northern spotted owls in Oregon and Washington for 1985 to 1996. Median maximum dispersal distance (the straight-line distance between the natal site and the farthest location) for radio-marked juvenile male northern spotted owls was 12.7 miles (mi) (20.3 kilometers (km)), and that of female northern spotted owls was 17.2 mi (27.5 km) (Forsman *et al.* 2002: Table

2). Dispersal data and other studies on the amount and configuration of habitat necessary to sustain northern spotted owls provided the foundation for developing previous northern spotted owl habitat reserve systems. Given the range-wide declining trends in northern spotted owl populations, as well as declining trends in the recruitment of new individuals into territorial populations (Forsman *et al.* 2011, pp. 59–66, Table 22), we have determined that, to be essential, physical or biological features must be positioned on the landscape to enable populations to persist and to allow individual owls to disperse among populations.

In contrast to earlier designations of critical habitat, we did not develop an *a priori* rule set to identify those areas that provide the physical or biological features essential to the conservation of the owl, using factors such as minimum size of habitat blocks, targeted numbers of owl pairs, or maximum distance between blocks of habitat. Instead, we determined the spatial extent and placement of the areas providing the physical or biological features that are essential to the conservation of the owl based on the relative demographic performance of the habitat models tested. This process is summarized in the section Criteria Used to Identify Critical Habitat, presented later in this document, and is presented in detail in our supporting documentation (Dunk *et al.* 2012b, entire). This supporting documentation, which describes in detail the modeling process we used, is available at our Web site. We refer to this document in the Summary of Comments and Recommendations section, below, as our ''Modeling Supplement'' (Dunk *et al.* 2012b).

Home Range Requirements—Most adult northern spotted owls remain on their home range throughout the year; therefore, their home range must provide all the habitat components, including prey, needed for the survival and successful reproduction of a territorial pair. The home range of a northern spotted owl is relatively large, but varies in size across the range of the subspecies (Courtney *et al.* 2004, p. 5–24; 55 FR 26117; June 26, 1990). Home range sizes are largest in Washington (Olympic Peninsula: 9,231 ac (3,736 ha) (Forsman *et al.* 2005, pp. 371–372), and generally decrease along a north-south gradient to approximately 1,430 ac (580 ha) in the Klamath region of northwestern California and southern Oregon (Zabel *et al.* 1995, p. 436). Northern spotted owl home ranges are generally larger where northern flying squirrels are the predominant prey and smaller where woodrats are the predominant prey (Zabel *et al.* 1995, p. 436). Home range size also increases with increasing forest fragmentation (Carey *et al.* 1992, p. 235; Franklin and Gutiérrez 2002, p. 212; Glenn *et al.* 2004, p. 45) and decreasing proportions of nesting habitat on the landscape (Carey *et al.* 1992, p. 235; Forsman *et al.* 2005, p. 374), suggesting that northern spotted owls increase the size of their home ranges to encompass adequate amounts of suitable forest types (Forsman *et al.* 2005, p. 374).

Meta-analysis of features associated with occupancy at the territory-scale indicated that northern spotted owls consistently occupy areas having larger patches of older forests that were more numerous and closer together than random sites (Franklin and Gutiérrez 2002; p. 212). In the Klamath and Redwood regions owls also consistently occupy sites with higher forest heterogeneity than random sites. Occupied sites in the Klamath region, in particular, show a high degree of vegetative heterogeneity, with more variable patch sizes and more perimeter edge than in other regions (Franklin and Gutiérrez 2002; p. 212). In the Klamath region, ecotones, or edges between older forests and other seral stages, may contribute to improved access to prey (Franklin and Gutiérrez 2002, p. 215). Several studies in the Klamath region and the Redwood region have found that variables describing the relationship between habitat core area and edge length improve the ability of models to predict northern spotted owl occupancy (e.g., Folliard *et al.* 2000, pp. 79–81; Zabel *et al* 2003, pp. 1936–1938). In contrast, northern spotted owl sites in the Oregon Coast Range had a more even distribution of cover types than random locations, and nest stands had a higher ratio of core to edge and more complex stand shapes than non-nest stands (Courtney *et al.* 2004, p. 5–9).

A home range provides the habitat components essential for the survival and successful reproduction of a resident breeding pair of northern spotted owls. The exact amount, quality, and configuration of these habitat types required for survival and successful reproduction varies according to local conditions and factors, such as the degree of habitat fragmentation, proportion of available nesting habitat, and primary prey species (Courtney *et al.* 2004, p. 5–2).

Core Area Requirements—Northern spotted owls often use habitat within their home ranges disproportionally, and exhibit central-place foraging behavior (Rosenberg and McKelvey 1999, p. 1028), with much activity centered within a core area surrounding the nest tree during the breeding season. During fall and winter, as well as in nonbreeding years, owls often roost and forage in areas of their home range more distant from the core. The size of core areas varies considerably across the subspecies' geographical range following a pattern similar to that of home range size (Bingham and Noon 1997, p. 133), varying from over 4,057 ac (1,642 ha) in the northernmost (flying squirrel prey) provinces (Forsman *et al.* 2005, pp. 370, 375) to less than 500 ac (202 ha) in the southernmost (dusky-footed woodrat prey) provinces (Pious 1995, pp. 9–10, Table 2; Zabel *et al.* 2003, pp. 1036–1038). Owls often switch nest trees and use multiple core areas over time, possibly in response to local prey depletion or loss of a particular nest tree.

Core areas contain greater proportions of mature or old forest than random or nonuse areas (Courtney *et al.* 2004, p. 5–13), and the amount of high-quality habitat at the core area scale shows the strongest relationships with occupancy (Meyer *et al.* 1998, p. 34; Zabel *et al.* 2003, pp. 1027, 1036), survival (Franklin *et al.* 2000, p. 567; Dugger *et al.* 2005, p. 873), and reproductive success (Ripple *et al.* 1997, pp. 155 to 156; Dugger *et al.* 2005, p. 871). In some areas, edges between forest types within northern spotted owl home ranges may provide increased prey abundance and availability (Franklin *et al.* 2000, p. 579). For successful reproduction, core areas need to contain one or more forest stands that have both the structural attributes and the location relative to other features in the home range that allow them to fulfill essential nesting, roosting, and foraging functions (Carey and Peeler 1995, pp. 233–236; Rosenberg and McKelvey 1999, pp. 1035–1037).

Areas to Support Dispersal and Nonbreeding Owls—Northern spotted owls regularly disperse through highly fragmented forested landscapes that are typical of the mountain ranges in western Washington and Oregon, and have dispersed from the Coastal Mountains to the Cascades Mountains in the broad forested regions between the Willamette, Umpqua, and Rogue Valleys of Oregon (Forsman *et al.* 2002, p. 22). Corridors of forest through fragmented landscapes serve primarily to support relatively rapid movement through such areas, rather than colonization or residency of nonbreeding owls.

During the transience (movement) phase, dispersers used mature and old-growth forest slightly more than its availability; during the colonization phase, mature and old-growth forest was used at nearly twice its availability (Miller *et al.* 1997, p. 144). Closed pole-sapling-sawtimber habitat was used roughly in proportion to availability in both phases and may represent the minimum condition for movement. Open sapling and clearcuts were used less than expected based on availability during colonization (Miller *et al.* 1997, p. 145). In comparison, nondispersing subadults or nonbreeding adults that are residents require habitats that are more similar to the nesting, roosting, and foraging habitats utilized by breeding pairs. This suggests that juveniles and transient dispersers either have a less developed ability to avoid areas where starvation or predation are more likely, or they can use a greater variety of forested habitats than nondispersing adults, or both.

We currently do not have sufficient information to permit formal modeling of dispersal habitat and the influence of dispersal habitat condition on dispersal success (USFWS 2011, p. C–15). We expect, based on the studies discussed above, that dispersal success is highest when dispersers move through forests that have the characteristics of nesting-roosting and foraging habitats. Northern spotted owls can also disperse successfully through forests with less complex structure, but risk of starvation and predation likely increase with increasing divergence from the characteristics of suitable (nesting, roosting, foraging) habitat. The suitability of habitat to contribute to successful dispersal of northern spotted owls is likely related to the degree to which it ameliorates heat stress, provides abundant and accessible prey, limits predation risk, and resembles habitat in natal territories (Carey 1985, pp. 105–107; Buchanan 2004, pp. 1335–1341).

Dispersal habitat is habitat that both juvenile and adult northern spotted owls must use when looking to establish a new territory. Although optimal dispersal habitat would be the same as suitable nesting, roosting, or foraging habitat (mature and old-growth stands), dispersing owls will use younger forest for dispersal, and the Interagency Scientific Committee (Thomas *et al.* 1990) suggested the 50–11–40 rule for maintaining baseline forest conditions between blocks of old forest to enhance dispersal. Forests composed of at least 50 percent of trees with 11 inches (in) (28 centimeters (cm)) diameter at breast height (dbh) or greater, and with roughly a minimum 40 percent canopy cover, were considered to meet this baseline condition for northern spotted owl dispersal. Dispersal habitat can occur between larger blocks of nesting, foraging, and roosting habitat or within blocks of nesting, roosting, and foraging habitat. Dispersal habitat is essential to maintaining stable populations by promoting rapid filling of territorial vacancies when resident northern spotted owls die or leave their territories, and to providing adequate gene flow across the range of the species.

Regional Variation in Habitat Use—Differences in patterns of habitat associations across the range of the northern spotted owl suggest four different broad zones of habitat use, which we characterize as the (1) West Cascades/Coast Ranges of Oregon and Washington, (2) East Cascades, (3) Klamath and Northern California Interior Coast Ranges, and (4) Redwood Coast (Figure 1. We configured these zones based on a qualitative assessment of similarity among ecological conditions and habitat associations within the 11 different regions analyzed, as these 4 zones efficiently capture the range in variation of some of the physical or biological features essential to the conservation of the northern spotted owl. We summarize the physical or biological features for each of these four zones, emphasizing zone-specific features that are distinctive within the context of general patterns that apply across the entire range of the northern spotted owl.

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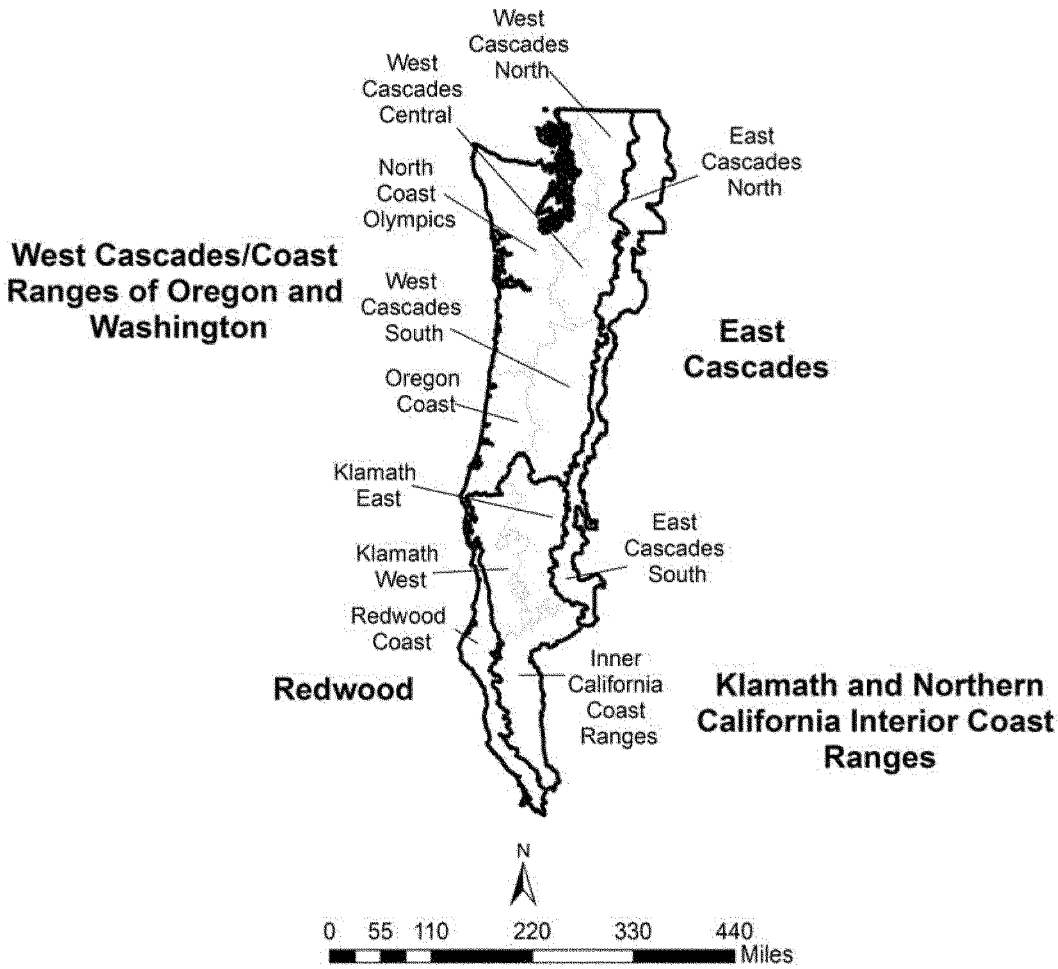
Figure 1. Eleven regions and four zones of habitat associations of northern spotted owls in Washington, Oregon, and California.



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West Cascades/Coast Ranges of Oregon and Washington

This zone includes five regions west of the Cascade crest in Washington and Oregon (Western Cascades North, Central and South; North Coast Ranges and Olympic Peninsula; and Oregon Coast Ranges; USFWS 2011, p. C–13). Climate in this zone is characterized by high rainfall and cool to moderate temperatures. Variation in elevation between valley bottoms and ridges is relatively low in the Coast Ranges, creating conditions favorable for development of contiguous forests. In contrast, the Olympic and Cascade ranges have greater topographic variation with many high-elevation areas supporting permanent snowfields and glaciers. Douglas-fir and western hemlock dominate forests used by northern spotted owls in this zone. Root diseases and wind-throw are important natural disturbance mechanisms that form gaps in forested areas. Flying squirrels are the dominant prey, with voles and mice also representing important items in the northern spotted owl's diet.

Our habitat modeling indicated that vegetation structure had a dominant influence on owl population performance, with habitat pattern and topography also contributing. High canopy cover, high density of large trees, high numbers of subcanopy vegetation layers, and low to moderate slope positions were all important features.

Nesting habitat in this zone is mostly limited to areas with large trees with defects such as mistletoe brooms, cavities, or broken tops. The subset of foraging habitat that is not nesting/roosting habitat generally had slightly lower values than nesting habitat for canopy cover, tree size and density, and canopy layering. Prey species (primarily northern flying squirrel) in this zone are associated with mature to late-successional forests, resulting in small differences between nesting, roosting, and foraging habitat.

East Cascades

This zone includes the Eastern Cascades North and Eastern Cascades South regions (USFWS 2011, p. C–13). This zone is characterized by a continental climate (cold, snowy winters and dry summers) and a high frequency of natural disturbances due to fires and outbreaks of forest insects and pathogens. Flying squirrels are the dominant prey species, but the diet of northern spotted owls in this zone also includes relatively large proportions of bushy-tailed woodrats, snowshoe hare, pika, and mice (Forsman *et al.* 2001, pp. 144–145).

Our modeling indicates that habitat associations in this zone do not show a pattern of dominant influence by one or a few variables (USFWS 2011, Appendix C). Instead, habitat association models for this zone included a large number of variables, each making a relatively modest contribution (20 percent or less) to the predictive ability of the model. The features that were most useful in predicting habitat quality were vegetation structure and composition, and topography, especially slope position in the north. Other efforts to model habitat associations in this zone have yielded similar results (e.g., Gaines *et al.* 2010, pp. 2048–2050; Loehle *et al.* 2011, pp. 25–28).

Relative to other portions of the subspecies' range, nesting and roosting habitat in this zone includes relatively younger and smaller trees, likely reflecting the common usage of dwarf mistletoe brooms (dense growths) as nesting platforms (especially in the north). Forest composition that includes high proportions of Douglas-fir is also associated with this nesting structure. Additional foraging habitat in this zone generally resembles nesting and roosting habitat, with reduced canopy cover and tree size, and reduced canopy layering. High prey diversity suggests relatively diverse foraging habitats are used. Topographic position was an important variable, particularly in the north, possibly reflecting competition from barred owls (Singleton *et al.* 2010, pp. 289, 292). Barred owls, which have been present for over 30 years in northern portions of this zone, preferentially occupy valley-bottom habitats, possibly compelling northern spotted owls to establish territories on less productive, mid-slope locations (Singleton *et al.* 2010, pp. 289, 292).

Klamath and Northern California Interior Coast Ranges

This zone includes the Klamath West, Klamath East, and Interior California Coast regions (USFWS 2011, p. C–13). This region in southwestern Oregon and northwestern California is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and large differences in moisture from west to east. Summer temperatures are high, and northern spotted owls occur at elevations up to 5,800 ft (1,768 m). Western portions of this zone support a diverse mix of mesic forest communities interspersed with drier forest types. Forests of mixed conifers and evergreen hardwoods are typical of the zone. Eastern portions of this zone have a Mediterranean climate with increased occurrence of ponderosa pine. Douglas-fir dwarf mistletoe (*Arceuthobium douglasii*) is rarely used for nesting platforms in the western part of the northern spotted owl's range, but is commonly used in the east. The prey base for northern spotted owls in this zone is correspondingly diverse, but dominated by dusky-footed woodrats, bushy-tailed woodrats, and flying squirrels. Northern spotted owls have been well studied in the western Klamath portion of this zone (Forsman *et al.* 2004, p. 217), but relatively little is known about northern spotted owl habitat use in the eastern portion and the California Interior Coast Range portion of the zone. Our habitat association models for this zone suggest that vegetation structure and topographic features are nearly equally important in influencing owl population performance, particularly in the Klamath. High canopy cover, high levels of canopy layering, and the presence of very large dominant trees were all important features of nesting and roosting habitat. Compared to other zones, additional foraging habitat for this zone showed greater divergence from nesting habitat, with much lower canopy cover and tree size. Low to intermediate slope positions were strongly favored. In the eastern Klamath, presence of Douglas-fir was an important compositional variable in our habitat model (USFWS 2011, Appendix C).

Redwood Coast

This zone is confined to the northern California coast, and is represented by the Redwood Coast region (USFWS 2011, p. C–13). It is characterized by a maritime climate with moderate temperatures and generally mesic conditions. Near the coast, frequent fog delivers consistent moisture during the summer. Terrain is typically low-lying (0 to 3,000 ft (0 to 900 m)). Forest communities are dominated by redwood, Douglas-fir–tanoak (*Lithocarpus densiflorus*) forest, coast live oak (*Quercus agrifolia*), and tanoak series. Dusky footed woodrats are the dominant prey items for northern spotted owls in this zone.

Habitat association models for this zone diverged strongly from models for other zones. Topographic variables (slope position and curvature) had a dominant influence with vegetation structure having a secondary role. Low position on slopes was strongly favored, along with concave landforms.

Several studies of northern spotted owl habitat relationships suggest that stump-sprouting and rapid growth of redwood trees, combined with high availability of woodrats in patchy, intensively managed forests, enables northern spotted owls to occupy a wide range of vegetation conditions within the redwood zone. Rapid growth rates enable young stands to develop structural characteristics typical of older stands in other regions. Thus, relatively small patches of large remnant trees can also provide nesting habitat structure in this zone.

Physical or Biological Features and Primary Constituent Elements

Under the Act and its implementing regulations, we are required to identify the physical or biological features essential to the conservation of the northern spotted owl in areas occupied at the time of listing, focusing on the features' primary constituent elements. Primary constituent elements are those specific elements of the physical or biological features that provide for a species' life-history processes and are essential to the conservation of the species. The physical or biological features essential to the conservation of the northern spotted owl are forested lands that can be used for nesting, roosting, foraging, or dispersing. We have further determined that these physical or biological features may require special management considerations or protection, as described in the section *Special Management Considerations or Protection,* below. For the northern spotted owl, the primary constituent elements are the specific characteristics that make areas suitable for nesting, roosting, foraging and dispersal habitat. To be essential to the conservation of the northern spotted owl, these features need to be distributed in a spatial configuration that is conducive to persistence of populations, survival and reproductive success of resident pairs, and survival of dispersing individuals until they can recruit into a breeding population.

Models developed for the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, Appendix C) to assess habitat suitability for the northern spotted owl across the range of the species and applied here to help identify potential critical habitat were based on habitat conditions within 500-acre (200-ha) core areas. Because core areas support a mix of nesting, roosting, and foraging habitats, their characteristics provide a basis for identification and quantification of PCEs.

Physical or Biological Features by Life-History Function

Each of the essential features—in this case, forested lands that provide the functional categories of northern spotted owl habitat—comprises a complex interplay of structural elements, such as tree size and species, stand density, canopy diversity, and decadence.

Northern spotted owls have been shown to exhibit strong associations with specific PCEs; however, the range of combinations of PCEs that may constitute habitat (particularly foraging habitat) is broad. In addition, the relative importance of specific habitat elements (and subsequently their relevance as PCEs) is strongly influenced by physical factors, such as elevation and slope position, and the degree to which physical factors influence the role of individual PCEs varies geographically. In addition to forest type, the key elements of habitats with the physical or biological features essential for the conservation of the northern spotted owl may be organized as follows:

Nesting and Roosting Habitat

Nesting and roosting habitat provides structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks for adults and young. Because nesting habitat provides resources critical for nest site selection and breeding, its characteristics tend to be conservative; stand structures at nest sites tend to vary little across the northern spotted owl's range. Nesting stands typically include a moderate to high canopy cover (60 to over 80 percent); a multilayered, multispecies canopy with large (greater than 30 in (76 cm) dbh) overstory trees; a high incidence of large trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for northern spotted owls to fly (Thomas *et al.* 1990, p. 164; 57 FR 1798, January 15, 1992). These findings were recently reinforced in rangewide models developed by Davis and Dugger (2011, Table 3–1, p. 39), who found that stands used for nesting (moderate to high suitability) exhibited high canopy cover of conifers (65 to 89 percent), large trees (mean diameter from 20 to 36 in (51 to 91 cm)), with a forest density of 6 to 19 large trees (greater than 30 in dbh) per acre (15 to 47 large trees (greater than 76 cm dbh) per hectare), and high diameter diversity.

Recent studies have found that northern spotted owl nest stands tend to have greater tree basal area, number of canopy layers, density of broken-top trees, number or basal area of snags, and volume of logs (Courtney *et al.* 2004, pp. 5–16 to 5–19, 5–23) than non-nest stands. In some forest types, northern spotted owls nest in younger forest stands that contain structural characteristics of older forests (legacy features from previous stands before disturbance). In the portions of the northern spotted owl's range where Douglas-fir dwarf mistletoe occurs, infected trees provide an important source of nesting platforms (Buchanan *et al.* 1993, pp. 4–5). Nesting northern spotted owls consistently occupy stands having a high degree of canopy cover that may provide thermoregulatory benefits (Weathers *et al.* 2001, p. 686), allowing northern spotted owls a wider range of choices for locating thermally neutral roosts near the nest site. A high degree of canopy cover may also conceal northern spotted owls, reducing potential predation. Studies of roosting locations found that northern spotted owls tended to use stands with greater vertical canopy layering (Mills *et al.* 1993, pp. 318–319), canopy cover (King 1993, p. 45), snag diameter (Mills *et al.* 1993, pp. 318–319), diameter of large trees (Herter *et al.* 2002, pp. 437, 441), and amounts of large woody debris (Chow 2001, p. 24; reviewed in Courtney *et al.* 2004, pp. 5–14 to 5–16, 5–23). Northern spotted owls use the same habitat for both nesting and roosting; the characteristics of roosting habitat differ from those of nesting habitat only in that roosting habitat need not contain the specific structural features used for nesting (Thomas *et al.* 1990, p. 62). Aside from the presence of the nest structure, nesting and roosting habitat are generally inseparable.

Habitat modeling developed for the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, Appendix C) and used as one means of helping us identify potential critical habitat for the northern spotted owl supports previous descriptions of nesting habitat (57 FR 1796, January 15, 1992; 73 FR 47326, August 13, 2008), and suggests a high degree of similarity among the 11 ecological regions across the range of the species. Across regions, moderate to high suitability nesting habitat was characterized as having high canopy cover (65 to over 80 percent) and high basal area (240 ft²/ac; (55 m²/ha), mean dbh of conifers at least 16.5 to 24 in (42 to 60 cm), and a significant component of larger trees (greater than 30 in (75 cm)).

Foraging Habitat

Habitats used for foraging by northern spotted owls vary widely across the northern spotted owl's range, in accordance with ecological conditions and disturbance regimes that influence vegetation structure and prey species distributions. In general, northern spotted owls select old forests for foraging in greater proportion than their availability at the landscape scale (Carey *et al.* 1992, pp. 236–237; Carey and Peeler 1995, p. 235; Forsman *et al.* 2005, pp. 372–373), but will forage in younger stands and brushy openings with high prey densities and access to prey (Carey *et al.* 1992, p. 247; Rosenberg and Anthony 1992, p. 165; Thome *et al.* 1999, pp. 56–57; Irwin *et al.* 2012, pp. 208–210). Throughout much of the owl's range, the same habitat that provides for nesting and roosting also provides for foraging, although northern spotted owls have greater flexibility in utilizing a variety of habitats for foraging than they do for nesting and roosting. That is, habitats that meet the species' needs for nesting and roosting generally also provide for foraging (and dispersal) requirements of the owl. However, in some areas owls may use other types of habitats for foraging, in addition to those used for nesting and roosting; thus, habitat that supports foraging (or dispersal) does not always support the other PCEs, and does not necessarily provide for nesting or roosting. Variation in the potential use of various foraging habitats throughout the range of the northern spotted owl is described here.

West Cascades/Coast Ranges of Oregon and Washington

In the West Cascades/Coast Ranges of Oregon and Washington, high-quality foraging habitat is also nesting/roosting habitat. Foraging activity is positively associated with tree height diversity (North *et al.* 1999, p. 524), canopy cover (Irwin *et al.* 2000, p. 180; Courtney *et al.* 2004, p. 5–15), snag volume, density of snags greater than 20 in (50 cm) dbh (North *et al.* 1999, p. 524; Irwin *et al.* 2000, pp. 179–180; Courtney *et al.* 2004, p. 5–15), density of trees greater than or equal to 31 in (80 cm) dbh (North *et al.* 1999, p. 524) density of trees 20 to 31 in (51 to 80 cm) dbh (Irwin *et al.* 2000, pp. 179–180), and volume of woody debris (Irwin *et al.* 2000, pp. 179–180).

While the majority of studies reported strong associations with old-forest characteristics, younger forests with some structural characteristics (legacy features) of old forests (Carey *et al.* 1992, pp. 245 to 247; Irwin *et al.* 2000, pp. 178 to 179), hardwood forest patches, and edges between old forest and hardwoods (Glenn *et al.* 2004, pp. 47–48) are also used by foraging northern spotted owls.

East Cascades

Foraging habitats used by northern spotted owls in the East Cascades of Oregon, Washington, and California were similar to those used in the Western Cascades, but can also encompass forest stands that exhibit somewhat lower mean tree sizes (quadratic mean diameter 16 to 22 in (40 to 55 cm) (Irwin *et al.* 2012, p. 207). However, foraging activity was still positively associated with densities of large trees (greater than 26 in (66 cm)) and increasing basal area (Irwin *et al.* 2012, p. 206). Stands dominated by Douglas-fir and white fir/Douglas-fir, or grand fir/Douglas-fir were preferred in some regions, whereas stands dominated by ponderosa pine were generally avoided (Irwin *et al.* 2012, p. 207).

Klamath and Northern California Interior Coast Ranges

Because diets of northern spotted owls in the Klamath and Northern California Interior Coast Ranges consist predominantly of both northern flying squirrels and dusky-footed woodrats, habitats used for foraging northern spotted owls are much more variable than in northern portions of the species' range. As in other regions, foraging northern spotted owls select stands with mature and old-forest characteristics such as increasing mean stand diameter and densities of trees greater than 26 in (66 cm) dbh (Irwin *et al.* 2012, p. 206) and a dominant canopy of large conifer trees greater than 21 in (52.5 cm) dbh (Solis and Gutierrez 1990, p. 747), high canopy cover (87 percent at frequently used sites; Solis and Gutierrez 1990, p. 747, Table 3), and multiple canopy layers (Solis and Gutierrez 1990, pp. 744–747; Anthony and Wagner 1999, pp. 14, 17). However, other habitat elements are disproportionately used, particularly forest patches within riparian zones of low-order streams (Solis and Gutierrez 1990, p. 747; Irwin *et al.* 2012, p. 208) and edges between conifer and hardwood forest stands (Zabel *et al.* 1995, pp. 436–437; Ward *et al.* 1998, pp. 86, 88–89). Foraging use is positively influenced by conifer species, including incense-cedar (*Calocedrus decurrens*), sugar pine (*P. lambertiana*), Douglas-fir, and hardwoods such as bigleaf maple (*Acer macrophyllum*), California black oak (*Q. kelloggii*), live oaks, and Pacific madrone (*Arbutus menziesii*) as well as shrubs (Sisco 1990, p. 20; Irwin *et al.* 2012, pp. 206–207, 209–210), presumably because they produce mast important for prey species. Within a mosaic of mature and older forest habitat, brushy openings and dense young stands or low-density forest patches also receive some use (Sisco 1990, pp. 9, 12, 14, 16; Zabel *et al.* 1993, p. 19; Irwin *et al.* 2012, pp. 209–210).

Redwood Coast

The preponderance of information regarding habitats used for foraging by northern spotted owls in the Redwood Coast zone comes from intensively managed industrial forests. In these environments, which comprise the majority of the redwood region, interspersion of foraging habitat and prey-producing habitat appears to be an important element of habitat suitability. Foraging habitat is used by owls to access prey and is characterized by a wide range of tree sizes and ages. Foraging activity by owls is positively associated with density of small to medium sized trees (10 to 22 in (25 to 56 cm)) and trees greater than 26 in (66 cm) in diameter (Irwin *et al.* 2007b, p. 19) or greater than 41 years of age (MacDonald *et al.* 2006, p. 381). Foraging was also positively associated with hardwood species, particularly tanoak (MacDonald *et al.* 2006, pp. 380–382; Irwin *et al.* 2007a, pp. 1188–1189). Prey-producing habitats occur within early-seral habitats 6 to 20 years old (Hamm and Diller 2009, p. 100, Table 2), typically resulting from clearcuts or other intensive harvest methods. Habitat elements within these openings include dense shrub and hardwood cover, and woody debris.

Nonbreeding and Dispersal Habitat

Although the term ''dispersal'' frequently refers to post-fledgling movements of juveniles, for the purposes of this rule we are using the term to include all movement during both the transience and colonization phase, and to encompass important concepts of linkage and connectivity among owl subpopulations. Population growth can only occur if there is adequate habitat in an appropriate configuration to allow for the dispersal of owls across the landscape. Although habitat that allows for dispersal may currently be marginal or unsuitable for nesting, roosting, or foraging, it provides an important linkage function among blocks of nesting habitat both locally and over the owl's range that is essential to its conservation. However, as noted above, we expect dispersal success is highest when dispersers move through forests that have the characteristics of nesting-roosting and foraging habitats. Although northern spotted owls may be able to move through forests with less complex structure, survivorship is likely decreased. Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy cover to provide protection from avian predators and at least minimal foraging opportunities; there may be variations over the owl's range (e.g., drier site in the east Cascades or northern California). This may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the transience phase.

Habitat supporting nonbreeding northern spotted owls, or the colonization phase of dispersal, is generally equivalent to nesting, roosting, and foraging habitat and is described above, although it may be in smaller amounts than that needed to support nesting pairs.

Primary Constituent Elements for the Northern Spotted Owl

Based on our current knowledge of the physical or biological features and habitat characteristics required to sustain the species' life-history processes, we determine that the primary constituent elements specific to the northern spotted owl are as follows; note that PCE 1 must occur in concert with PCE 2, 3, or 4:

(1) Forest types that may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographical range; these forest types are primarily:

(a) Sitka spruce,
(b) Western hemlock,
(c) Mixed conifer and mixed evergreen,
(d) Grand fir,
(e) Pacific silver fir,
(f) Douglas-fir,
(g) White fir,
(h) Shasta red fir,
(i) Redwood/Douglas-fir (in coastal California and southwestern Oregon), and
(j) The moist end of the ponderosa pine coniferous forests zones at elevations up to approximately 3,000 ft (900 m) near the northern edge of the range and up to approximately 6,000 ft (1,800 m) at the southern edge.

(2) Habitat that provides for nesting and roosting. In many cases the same habitat also provides for foraging (PCE (3)). Nesting and roosting habitat provides structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks for adults and young. This PCE is found throughout the geographical range of the northern spotted owl, because stand structures at nest sites tend to vary little across the northern spotted owl's range. These habitats must provide:

(a) Sufficient foraging habitat to meet the home range needs of territorial pairs of northern spotted owls throughout the year.

(b) Stands for nesting and roosting that are generally characterized by:

(i) Moderate to high canopy cover (60 to over 80 percent);

(ii) Multilayered, multispecies canopies with large (20–30 in (51–76 cm) or greater dbh) overstory trees;

(iii) High basal area (greater than 240 ft^2/ac (55 m^2/ha));

(iv) High diversity of different diameters of trees;

(v) High incidence of large live trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and other evidence of decadence);

(vi) Large snags and large accumulations of fallen trees and other woody debris on the ground; and

(vii) Sufficient open space below the canopy for northern spotted owls to fly.

(3) Habitat that provides for foraging, which varies widely across the northern spotted owl's range, in accordance with ecological conditions and disturbance regimes that influence vegetation structure and prey species distributions. Across most of the owl's range, nesting and roosting habitat is also foraging habitat, but in some regions northern spotted owls may additionally use other habitat types for foraging as well. The foraging habitat PCEs for the four ecological zones within the geographical range of the northern spotted owl are generally the following:

(a) West Cascades/Coast Ranges of Oregon and Washington

(i) Stands of nesting and roosting habitat; additionally, owls may use younger forests with some structural characteristics (legacy features) of old forests, hardwood forest patches, and edges between old forest and hardwoods;

(ii) Moderate to high canopy cover (60 to over 80 percent);

(iii) A diversity of tree diameters and heights;

(iv) Increasing density of trees greater than or equal to 31 in (80 cm) dbh increases foraging habitat quality (especially above 12 trees per ac (30 trees per ha));

(v) Increasing density of trees 20 to 31 in (51 to 80 cm) dbh increases foraging habitat quality (especially above 24 trees per ac (60 trees per ha));

(vi) Increasing snag basal area, snag volume (the product of snag diameter, height, estimated top diameter, and including a taper function (North *et al.* 1999, p. 523)), and density of snags greater than 20 in (50 cm) dbh all contribute to increasing foraging habitat quality, especially above 4 snags per ac (10 snags per ha);

(vii) Large accumulations of fallen trees and other woody debris on the ground; and

(viii) Sufficient open space below the canopy for northern spotted owls to fly.

(b) East Cascades

(i) Stands of nesting and roosting habitat;

(ii) Stands composed of Douglas-fir and white fir/Douglas-fir mix;

(iii) Mean tree size greater than 16.5 in (42 cm) quadratic mean diameter;

(iv) Increasing density of large trees (greater than 26 in (66 cm)) and increasing basal area (the total area covered by trees measured at breast height) increases foraging habitat quality;

(v) Large accumulations of fallen trees and other woody debris on the ground; and

(vi) Sufficient open space below the canopy for northern spotted owls to fly.

(c) Klamath and Northern California Interior Coast Ranges

(i) Stands of nesting and roosting habitat; in addition, other forest types with mature and old-forest characteristics;

(ii) Presence of the conifer species, incense-cedar, sugar pine, Douglas-fir, and hardwood species such as bigleaf maple, black oak, live oaks, and madrone, as well as shrubs;

(iii) Forest patches within riparian zones of low-order streams and edges between conifer and hardwood forest stands;

(iv) Brushy openings and dense young stands or low-density forest patches within a mosaic of mature and older forest habitat;

(v) High canopy cover (87 percent at frequently used sites);

(vi) Multiple canopy layers;

(vii) Mean stand diameter greater than 21 in (52.5 cm);

(viii) Increasing mean stand diameter and densities of trees greater than 26 in (66 cm) increases foraging habitat quality;

(ix) Large accumulations of fallen trees and other woody debris on the ground; and

(x) Sufficient open space below the canopy for northern spotted owls to fly.

(d) Redwood Coast

(i) Nesting and roosting habitat; in addition, stands composed of hardwood tree species, particularly tanoak;

(ii) Early-seral habitats 6 to 20 years old with dense shrub and hardwood cover and abundant woody debris; these habitats produce prey, and must occur in conjunction with nesting, roosting, or foraging habitat;

(iii) Increasing density of small-to-medium sized trees (10 to 22 in (25 to 56 cm)) increases foraging habitat quality;

(iv) Trees greater than 26 in (66 cm) in diameter or greater than 41 years of age; and

(v) Sufficient open space below the canopy for northern spotted owls to fly.

(4) Habitat to support the transience and colonization phases of dispersal, which in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCEs (2) or (3)), but which may also be composed of other forest types that occur between larger blocks of nesting, roosting, and foraging habitat. In cases where nesting, roosting, or foraging habitats are insufficient to provide for dispersing or nonbreeding owls, the specific dispersal habitat PCEs for the northern spotted owl may be provided by the following:

(a) Habitat supporting the transience phase of dispersal, which includes:

(i) Stands with adequate tree size and canopy cover to provide protection from avian predators and minimal foraging opportunities; in general this may include, but is not limited to, trees with at least 11 in (28 cm) dbh and a minimum 40 percent canopy cover; and

(ii) Younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, if such stands contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the transience phase.

(b) Habitat supporting the colonization phase of dispersal, which is generally equivalent to nesting, roosting, and foraging habitat as described in PCEs (2) and (3), but may be smaller in area than that needed to support nesting pairs.

This revised designation describes the physical or biological features and their primary constituent elements essential to support the life-history functions of the northern spotted owl. We have determined that all of the units and subunits designated in this rule were occupied by the northern spotted owl at the time of listing, and that (depending on the scale at which occupancy is considered) some smaller areas within the subunits may have been unoccupied at the time of listing. To address any uncertainty regarding occupancy, we have also evaluated all of the areas identified here as critical habitat under the standard of section 3(5)(a)(ii) of the Act, and determined that they are essential to the conservation of the species, as described in Criteria Used to Identify Critical Habitat, below. The criteria section also describes our evaluation of the configuration of the physical or biological features on the landscape to determine where those features are essential to the conservation of the northern spotted owl. We have further determined that the physical or biological features essential to the conservation of the northern spotted owl require special management considerations or protection, as described below.

In areas occupied at the time of listing, not all of the revised critical habitat will contain all of the PCEs, because not all life-history functions require all of the PCEs. Some subunits contain all PCEs and support multiple life processes, while some subunits may contain only those PCEs necessary to support the species' particular use of that habitat. However, all of the areas occupied at the time of listing and designated as critical habitat support at least the first PCE described (forest-type), in conjunction with at least one other PCE. Thus PCE (1) must always occur in concert with at least one additional PCE (PCE 2, 3, or 4).

Special Management Considerations or Protection

When designating critical habitat, we assess whether the specific areas within the geographical area occupied by the species at the time of listing contain features that are essential to the conservation of the species and which may require special management considerations or protection. The term critical habitat is defined in section 3(5)(A) of the Act, in part, as the specific areas within the geographical areas occupied by the species, at the time it is listed, on which are found those physical or biological features essential to the conservation of the species and ''which may require special management considerations or protection.'' Accordingly, in identifying critical habitat in areas occupied at the time of listing, we determine whether the features essential to the conservation of the species on those areas may require any special management actions or protection. Here we present a discussion of the special management considerations or protections that may be required throughout the critical habitat for the northern spotted owl. In addition, for the benefit of land managers, we provide management suggestions consistent with the recommendations of the Revised Recovery Plan for consideration.

An effective critical habitat strategy needs to conserve extant, high-quality northern spotted owl habitat in order to reverse declining population trends and address the threat from barred owls. The northern spotted owl was initially listed as a threatened species due largely to both historical and ongoing habitat loss and degradation. The recovery of the northern spotted owl therefore requires both protection of habitat and management where necessary to provide sufficient high-quality habitat to allow for population growth and to provide a buffer against threats such as competition with the barred owl. Recovery Criterion 3 in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) is the ''Continued Maintenance and Recruitment of Northern Spotted Owl Habitat,'' which is further described as the achievement of a stable or increasing trend in northern spotted owl nesting, roosting, and foraging habitat throughout the range of the species. Meeting this recovery criterion will require special management considerations or protection of the physical or biological features essential to the conservation of the northern spotted owl in all of the critical habitat units and subunits, as described here. Special management includes both passive and active management.

The 2011 Revised Recovery Plan for the Northern Spotted Owl describes the three main threats to the northern spotted owl as competition from barred owls, past habitat loss, and current habitat loss (USFWS 2011, p. III–42). As the barred owl is present throughout the range of the northern spotted owl, special management considerations or protections may be required in all of the critical habitat units and subunits to ensure the northern spotted owl has sufficient habitat available to withstand competitive pressure from the barred owl (Dugger *et al.* 2011, pp. 2459, 2467). In particular, studies by Dugger *et al.* (2011, p. 2459) and Wiens (2012, entire) indicated that northern spotted owl demographic performance is better when additional high-quality habitat is available in areas where barred owls are present.

Scientific peer reviewers of the 2011 Revised Recovery Plan for the Northern Spotted Owl (USFSW 2011, entire) and Forsman *et al.* (2011, p. 77) recommended that we address currently observed downward demographic trends in northern spotted owl populations by protecting currently occupied sites, as well as historically occupied sites, and by maintaining and restoring older and more structurally complex multilayered conifer forests on all lands (USFWS 2011, pp. III–42 to III–43). The types of management or protections that may be required to achieve these goals and maintain the physical or biological features essential to the conservation of the owl in occupied areas vary across the range of the species. Some areas of northern spotted owl habitat, particularly in wetter forest types, are unlikely to be enhanced by active management activities, but instead need protection of the essential features; whereas other forest areas would likely benefit from more proactive forestry management. For example, in drier, more fire-prone regions of the owl's range, habitat conditions will likely be more dynamic, and more active management may be required to reduce the risk to the essential physical or biological features from fire, insects, disease, and climate change, as well as to promote regeneration following disturbance.

While we recommend conservation of high-quality and occupied northern spotted owl habitat, long-term northern spotted owl recovery could benefit from forest management where the basic goals are to restore or maintain ecological processes and resilience, as discussed in detail in the Revised Recovery Plan (USFWS 2011, pp. III–11 to III–39). Special management considerations or protections may be required throughout the critical habitat to achieve these goals and benefit the conservation of the owl. The natural ecological processes and landscape that once provided large areas of relatively contiguous northern spotted owl habitat (especially on the west side of the Cascade Range) have been altered by a history of anthropogenic activities, such as timber harvest, road construction, development, agricultural conversion, and fire suppression. The resilience of these systems is now additionally challenged by the effects of climate change. As recommended in the Revised Recovery Plan for the Northern Spotted Owl, active forest management may be required throughout the range of the owl with the goal of maintaining or restoring forest ecosystem structure, composition, and processes so they are sustainable and resilient under current and future climate conditions, to provide for the long-term conservation of the species (USFWS 2011, p. III–13). For example, in some areas, past management practices have decreased age-class diversity and altered the structure of forest patches; in these areas, management, such as targeted vegetation treatments, could simultaneously reduce fuel loads and increase canopy and age-class diversity (Miller *et al.* 2009, p. 30; Stephens *et al.* 2009, p. 316–318; Stephens *et al.* 2012b, p. 554; Fontaine and Kennedy 2012, p. 1559; Chmura *et al.* 2011, p. 1134; USFWS 2011, p. III–18).

In moist forests that are currently providing mature and late-successional forest that functions as habitat for northern spotted owls, active management is generally unnecessary to conserve older growth forests (Johnson and Franklin 2009, p. 3). Within younger, homogeneous stands, active management that retains larger and older trees but reduces density of smaller trees may be useful to accelerate development of within-stand structural diversity. Management insights, such as those provided by Aubry *et al.* (2009, entire), Johnson and Franklin (2009, entire), Johnson and Franklin (2012 entire), Kerr 2012, entire), and Spies *et al.* (2010, entire), provide examples of how such actions could occur in a manner consistent with northern spotted owl conservation in moist forests.

In dry forest regions, where natural disturbance regimes and vegetation structure, composition, and distribution have been substantially altered since Euro-American settlement, vegetation and fuels management (through influencing fire behavior, severity, and distribution) may be required to retain and recruit northern spotted owl habitat on the landscape (Buchanan 2009, pp. 114–115; Healey *et al.* 2008, pp. 1117–1118; Roloff *et al.* 2012, pp. 8–9; Ager *et al.* 2007, pp. 53–55; Ager *et al.* 2012, pp. 279–282; Franklin *et al.* 2009, p. 46; Kennedy and Wimberly 2009, pp. 564–565), to conserve other biodiversity (Perry *et al.* 2011, p. 715), and to restore more natural vegetation and disturbance regimes and heterogeneity (e.g., Stephens *et al.* 2012b, pp. 557–558). Special management considerations may be required to maintain adequate northern spotted owl habitat in the near term, not only to allow northern spotted owls to persist in the face of threats from barred owl expansion and habitat modifications from fire and other disturbances, but also to restore landscapes to a more resilient state in the face of alterations projected to occur with ongoing climate change (USFWS 2011, p. III–32).

If land managers are actively managing forests, we recommend that these activities be focused on lower quality owl habitat (lower relative habitat sustainability (RHS)); that these activities focus on ecological restoration, or apply principles of ecological forestry; and, where possible, evaluate the effects of these treatments on northern spotted owls and other species of concern using an active adaptive forest management framework.

We recognize that the only regulatory effect of the designation of critical habitat is that section 7(a)(2) of the Act applies, and that it does not require active management or mandate any specific type of management; it only requires that Federal agencies ensure that their actions are not likely to destroy or adversely modify critical habitat, as those terms are used in section 7. However, because the Act requires us to make a determination that the physical and biological features essential to conservation of the species may also need special management considerations or protection, we are taking this opportunity to describe, for consideration by land managers, specific management approaches and types of forest where land managers should consider applying them in order to maintain sufficient suitable habitat across the range of the owl. We have determined that the physical and biological features in habitat occupied by the species at the time it was listed, as represented by the primary constituent elements, may require special management considerations or protection as required by 16 U.S.C. 1532(5)(A). However, nothing in this rule requires land managers to implement, or precludes land managers from implementing, special management or protection measures.

Because these will vary geographically, here we provide a more detailed discussion of the types of management considerations or protections that may be required to preserve or enhance the essential physical or biological features for the northern spotted owl in the West Cascades/Coast Ranges of Oregon and Washington, East Cascades, Klamath and Northern California Interior Coast Ranges, and the Redwood Coast.

West Cascades/Coast Ranges of Oregon and Washington

Special management considerations or protection may be required in areas of moist forests to conserve or protect older stands that contain the conditions to support northern spotted owl occupancy (RA10: USFWS 2011, p. 43) or contain high-value northern spotted owl habitat (RA32: USFWS 2011, p. 67). Silvicultural treatments are generally not needed to maintain existing old-growth forests and high-quality habitat on moist sites (Wimberly *et al.* 2004, p. 155; Johnson and Franklin 2009, pp. 3, 39). In contrast to dry forests, short-term fire risk is generally lower in the moist forests that not only dominate on the west side of the Cascade Range, but also occur east of the Cascades as a higher-elevation band or as peninsulas or inclusions in mesic forests. Disturbance-based management for forests and northern spotted owls in moist forest areas should be different from that applied in dry forests. Efforts to alter either fuel loading or potential fire behavior in these sites could have undesirable ecological consequences as well (Johnson and Franklin 2009, p. 39; Mitchell *et al.* 2009, pp. 653–654; USFWS 2011, p. III–17). Furthermore, commercial thinning has been shown to have negative consequences for northern spotted owls (Forsman *et al.* 1984, Meiman *et al.* 2003) and their prey (Waters *et al.* 1994, Luoma *et al.* 2003, Wilson 2010). Active management may be more appropriate in younger plantations that are not currently on a trajectory to develop old-growth structure. These stands typically do not provide high-quality northern spotted owl habitat, although they may occasionally be used for foraging and dispersal.

In general, to advance long-term northern spotted owl recovery and ecosystem restoration in moist forests in the face of climate change and past management practices, special management considerations or protections may be required that follow these principles as recommended in the 2011 Revised Recovery Plan (USFWS 2011, p. III–18):

(1) Conserve older stands that contain the conditions to support northern spotted owl occupancy or high-value northern spotted owl habitat as described in Recovery Actions 10 and 32 (USFWS 2011, pp. III–43, III–67). On Federal lands this recommendation applies to all land-use allocations (see also Thomas *et al.* 2006, pp. 284–285).

(2) Management emphasis needs to be placed on meeting northern spotted owl recovery goals and long-term ecosystem restoration and conservation. When there is a conflict between these goals, actions that would disturb or remove the essential physical or biological features of northern spotted owl critical habitat need to be minimized and reconciled with long-term ecosystem restoration goals.

(3) Continue to manage for large, continuous blocks of late-successional forest.

(4) In areas that are not currently late-seral forest or high-value habitat and where more traditional forest management might be conducted (e.g. matrix), these activities should consider applying ecological forestry prescriptions. Some examples that could be utilized include Franklin *et al.* (2002, pp. 417–421; 2007, entire), Kerr (2012), Drever *et al.* (2006, entire), Johnson and Franklin (2009, pp. 39–41), Swanson *et al.* (2010, entire), and others cited in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, pp. III–14, III–17 to III–19).

These special management considerations or protections apply to Units 1, 2, 4, 5 and 6 of the revised critical habitat.

East Cascades

Special management considerations or protection may be required in the East Cascades to address the effects of past activities associated with Euro-American settlement, such as timber harvest, livestock grazing, fire suppression, and fire exclusion, that have substantially altered the inland northwest, modifying the patterns of vegetation and fuels, and subsequent disturbance regimes to the degree that contemporary landscapes no longer function as they did historically (Hessburg *et al.* 2000a, pp. 74–81; Hessburg and Agee 2003, pp. 44–46; Hessburg *et al.* 2005, pp. 134–135; Skinner *et al.* 2006, pp. 178–179; Skinner and Taylor 2006, pp. 201–203; Miller *et al.* 2009, p. 30; Stephens *et al.* 2009, pp. 316–318; Stephens *et al.* 2012b, p. 554; Fontaine and Kennedy 2012, p. 1559; Chmura *et al.* 2011, p. 1134). This has affected not only the existing forest and disturbance regimes, but the quality, amount, and distribution of northern spotted owl habitat on the landscape (Buchanan 2009, pp. 114–115; Healey *et al.* 2008, pp. 1117–1118; Roloff *et al.* 2012, pp. 8–9; Ager *et al.* 2007, pp. 53–55; Ager *et al.* 2012, pp. 279–282; Franklin *et al.* 2009, p. 46; Kennedy and Wimberly 2009, pp. 564–565). In order to preserve the essential physical or biological features, these dynamic, disturbance-prone forests should be managed in a way that promotes northern spotted owl conservation, responds to climate change, and restores dry forest ecological structure, composition and processes, including wildfire and other disturbances (USFWS 2011, p. III–20). The following restoration principles apply to the management that may be required in this dry forest region (USFWS 2011, pp. III–34 to III–35):

(1) Conserve older stands that contain the conditions to support northern spotted owl occupancy or high-value northern spotted owl habitat as described in Recovery Actions 10 and 32 (USFWS 2011, pp. III–43, III–67). On Federal lands this recommendation applies to all land-use allocations (see also Thomas *et al.* 2006, pp. 284–285).

(2) Emphasize vegetation management treatments outside of northern spotted owl territories or highly suitable habitat;

(3) Design and implement restoration treatments at the landscape level;

(4) Retain and restore key structural components, including large and old trees, large snags, and downed logs;

(5) Retain and restore heterogeneity within stands;

(6) Retain and restore heterogeneity among stands;

(7) Manage roads to address fire risk; and

(8) Consider vegetation management objectives when managing wildfires, where appropriate.

The above principles will result in treatments that have a variety of effects on northern spotted owl habitat in the short and long term. For example, some restoration treatments may have an immediate neutral or beneficial effect on existing northern spotted owl habitat (e.g., roads management, some prescribed fire prescriptions). Other treatments, however, may involve reductions in stand densities, canopy cover, or ladder fuels (understory vegetation that has the potential to carry up into a crown fire)—and thus affect the physical or biological features needed by the species. At the stand scale, this can result in a level of conflict between conserving existing northern spotted owl habitat and restoring dry-forest ecosystems. Resolution of such conflicts can be enhanced by considering the range of forest conditions that comprise suitable owl habitat and tailoring management accordingly.

Land managers should change from the practice of implementing many small, uncoordinated and independent fuel-reduction and restoration treatments. Instead, coordinated and strategic efforts that link individual projects to the larger objectives of restoring landscapes while conserving and recovering northern spotted owl habitat are needed (sensu Sisk *et al.* 2005, entire; Prather *et al.* 2008, entire; Gaines *et al.* 2010, entire). Some examples of this type of planning in the east Cascades that may be emulated or referenced include the Okanagon-Wenatchee National Forest (USDA 2010, entire), The Nature Conservancy (Davis *et al.* 2012, entire), and the Deschutes National Forest (Smith *et al.* 2011, entire).

The special management considerations or protections identified here apply to Units 7 and 8 of the revised critical habitat.

Klamath and Northern California Interior Coast Ranges

The special management considerations or protections that may be required in the Klamath and Northern California Interior Coast Ranges represent a mix of the requirements needed to maintain or enhance the essential physical or biological features in mesic and dry forest types. This region in southwestern Oregon and northwestern California is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and large differences in moisture from west to east. Summer temperatures are high, and northern spotted owls occur at elevations up to 1,768 m (5,800 ft). Western portions of this zone support a diverse mix of mesic forest communities interspersed with drier forest types. Forests of mixed conifers and evergreen hardwoods are typical of the zone. Eastern portions of this zone have a Mediterranean climate with increased occurrence of ponderosa pine. Douglas-fir dwarf mistletoe is rarely used for nesting platforms in the west, but commonly used in the east. The prey base for northern spotted owls in this zone is correspondingly diverse, but is dominated by dusky-footed woodrats, bushy-tailed woodrats, and flying squirrels. Northern spotted owls have been well studied in the western portion of this zone (Forsman *et al.* 2005, p. 219), but relatively little is known about northern spotted owl habitat use in the eastern portion and the California Interior Coast Range portion of the zone.

High canopy cover, high levels of canopy layering, and the presence of very large dominant trees were all important features of nesting and roosting habitat. Compared to other zones, models of foraging habitat for this zone showed greater divergence from nesting habitat. Low to intermediate slope positions were strongly favored. In the eastern Klamath, presence of Douglas-fir was an important compositional variable. Habitat associations in the Klamath zone are diverse and unique, reflecting the climate, topography, and vegetation of this area. Nesting and roosting habitat somewhat resembles that of other zones, with a greater emphasis on topography that provides some relief from high temperatures while foraging habitat in this zone includes more open forests. Consequently, management actions consistent with maintaining and developing northern spotted owl habitat need to consider local conditions. In some areas, appropriate management will be more consistent with dry forest management strategies, while in other areas wet forest management strategies will be more appropriate.

This region contains habitat characteristics of both moist and dry forests interspersed across a highly diverse landscape (Halofsky *et al.* 2011, p. 1). The special management recommendations from the moist and dry forest sections, above, apply to the management actions or protections that may be required in the Klamath and Northern California Interior Coast Ranges. Similar to the discussion in moist forests concerning conservation of small patches of early-seral habitat, Perry *et al.* (2011, p. 715) noted that replacement of early successional shrub-hardwood communities by closed forests in the absence of fire significantly impacts landscape diversity. Restoration of appropriate fire regimes and use of targeted silvicultural intervention may be effective where the goal is to restore or maintain this diversity (Halofsky *et al.* 2011, p. 15). An example of this type of planning in this area that may be emulated or referenced is the Ashland Forest Resiliency Project (USDA 2009, entire).

The special management considerations or protections identified here apply to Units 9, 10, and 11 of the revised critical habitat.

Redwood Coast

Special management considerations or protection may be needed in the Redwood Coast Zone to maintain or enhance the essential physical or biological features for the owl. Although the Redwood Coast zone of coastal northern California is considered part of the wet/moist forest region within the range of the northern spotted owl, there are distinct differences in northern spotted owl habitat use and diet within this zone. The long growing season in this region, combined with redwood's ability to resprout from stumps, allows redwood stands to attain suitable stand structure for nesting in a relatively short period of time (40–60 years) if legacy structures are present. Late-successional forest is an important component of nesting and roosting habitat in the Redwood Zone, and demographic productivity on northern spotted owl breeding sites has been positively correlated with the density of legacy trees in proximity to owl nest sites (Thome *et al.* 1999, p. 57). Forest management in this region should conserve older stands that contain the conditions to support northern spotted owl occupancy or high-value northern spotted owl habitat as described in Recovery Actions 10 and 32 (USFWS 2011, pp. III–43, III–67). On Federal lands this recommendation applies to all land-use allocations (see also Thomas *et al.* 2006, pp. 284–285). In this region, some degree of fine-scale fragmentation in redwood forests appears to benefit northern spotted owls. Forest openings aged 5 to 20 years (e.g., harvest units or burns), with dense shrub and hardwood cover, and abundant food sources, can provide high-quality habitat for the northern spotted owl's primary prey, the dusky-footed woodrat. Woodrat populations within recent openings probably peak by about stand age 10. Food sources and understory cover decline steadily through about stand age 20, when the woodrat population-source diminishes. In northern spotted owl territories within the Redwood Zone, active management that creates small openings in proximity to nesting, roosting, or foraging habitat may enhance northern spotted owl foraging opportunities.

The special management considerations or protections identified here apply to Unit 3 of the revised critical habitat.

Summary of Special Management Considerations or Protection

We find that each of the areas occupied at the time of listing that we are designating as critical habitat contains features essential to the conservation of the species that may require special management considerations or protection to ensure the conservation of the northern spotted owl. These special management considerations or protection may be required to preserve and enhance the essential features needed to achieve the conservation of the northern spotted owl. Additional information on management activities compatible with northern spotted owl conservation can be found within the Section 7 Consultation section of this preamble.

VII. Criteria Used To Identify Critical Habitat

As required by section 4(b)(1)(A) of the Act, we use the best scientific and commercial data available to designate critical habitat. We have reviewed the available information pertaining to the habitat requirements of the species. In accordance with the Act and its implementing regulations at 50 CFR 424.12(e), based on this review, we have identified the specific areas within the geographical area occupied by the species at the time it was listed on which are found those physical or biological features essential to the conservation of the species, and which may require special management considerations or protection. In addition, we considered whether any additional areas outside those occupied at the time of listing are essential for the conservation of the species.

Occupied Areas

For the purpose of developing and evaluating this revised critical habitat designation for the northern spotted owl, we identified ''geographical area occupied by the species'' at the time it was listed consistent with the species' distribution, population ecology, and use of space. We based our identification of occupied geographical areas on: (1) The distribution of verified northern spotted owl locations at the time of listing and (2) scientific information regarding northern spotted owl population structure and habitat associations.

We determined the geographical area occupied by the species at the time of listing based in part on a habitat suitability model incorporating the distribution of approximately 4,000 known northern spotted owl territories across the geographical range of the species (USFWS 2011, Appendix C). We used this model rather than just relying on surveyed sites at that time because large areas within the species' geographical range had not been surveyed; therefore the distribution of northern spotted owl populations was incompletely known at the time the species was listed, and remains so today. For this reason, designating critical habitat based solely on the locations of territories identified through surveys would exclude a substantial proportion of the area that would have been occupied by the species at the time of listing, and that provides the physical or biological features essential to the conservation of the species. To address this, we used our descriptions of the physical and biological features to develop a habitat suitability model that enabled us to map the distribution of relative habitat suitability and reliably identify areas that would have supported northern spotted owl territories at the time of listing, based on habitat value (USFWS 2011, Appendix C). Our habitat suitability model was based on GNN (Gradient Nearest Neighbor) vegetation data from 1996, and the locations of approximately 4,000 known owl pairs documented within 3 years of the date of the GNN vegetation data (USFWS 2011, p. C–20). Because our evaluations of model performance demonstrated that the models had good predictive ability (USFWS 2011, Appendix C, p. C–38–42) we used the relative habitat suitability models to predict the distribution of areas that would have supported occupancy by spotted owls at the time of listing.

Because the best available habitat and owl location data and information corresponded to 1996, we made an explicit assumption that the 1996-based habitat suitability model would reliably predict the distribution of spotted owls at the time of listing (1990). This assumption was based on: (1) Our expectation that patterns of habitat selection by spotted owls would not change over a 6-year period; (2) the high degree of site fidelity exhibited by territorial spotted owls over many years; and (3) the fact that the amount and distribution of older forest habitat, which takes many decades to develop and is a primary component of northern spotted owl habitat, would not have increased significantly in the period between listing and 1996. Therefore, we concluded that the 1996 GNN layer is a reasonable representation of the habitat that would have been occupied by northern spotted owls at the time of listing.

We tested this assumption by analyzing the relationship between our 1996 habitat suitability map and the distribution of 3,723 spotted owl sites known to be occupied at the time of listing (1987–1996). This time period reasonably represents the time of listing because northern spotted owls are relatively long-lived and exhibit a high degree of fidelity to territory core areas; their territory locations are, therefore, relatively stable through time, unless substantial changes occur to territory habitat. For this reason, we consider it highly likely that locations occupied between 1987 and 1990, and 1990 and 1996 were also occupied at the time of listing in 1990. We found that over 85 percent of the proposed critical habitat area was within the estimated home ranges of known spotted owl sites, strongly supporting our assumption that the model reliably predicted areas were occupied at the time of listing.

However, restricting a definition of occupancy to areas known to be used by resident territorial owls overlooks a large segment of the owl population that is not generally reflected in standard survey methodologies, as described below. Northern spotted owl populations consist of the territorial, resident owls, for which we have documentation of occupancy throughout much of the owl's range, described above, but also include nonterritorial adult ''floaters'' and dispersing subadult owls. Both dispersing subadults and nonterritorial floaters are consistently present on the landscape and require suitable habitat to support dispersal and survival until they recruit into the breeding population; this habitat requirement is in addition to that already utilized by resident territorial owls. Nonterritorial owls are difficult to detect in surveys because most surveys rely on territorial defense behavior of resident owls (responding to artificial owl calls) to determine their presence. Because they are difficult to detect, the number and distribution of nonterritorial and dispersing owls is poorly known for any given northern spotted owl population. However, they constitute essential elements of northern spotted owl populations, and can reliably be assumed to occur in suitable habitat within the same landscapes occupied by territorial owls. As stated, the great majority (85 percent) of the area within the identified critical habitat is covered by the home ranges of known owl territories at the time of listing. Because it is well established that dispersing subadults and non-territorial northern spotted owls regularly occupy high-quality habitat in the vicinity of other territorial northern spotted owls, and because our relative habitat suitability models exhibited high accuracy at predicting the probability of presence by owls, we conclude that these areas of high-quality habitat were occupied by the species at the time of listing.

Therefore, based on the best available scientific information regarding population structure of northern spotted owls, ''occupied at the time of listing'' encompasses (1) home ranges of resident, territorial northern spotted owls known from surveys to be present at the time of listing, (2) home ranges of territorial owls that would have been present at the time of listing based on a model developed specifically to predict owl presence based on relative habitat suitability, and (3) areas used by nonterritorial and dispersing owls that were likely to be present within the matrix of territories in a given landscape known to be occupied by resident owl pairs.

Having determined our working definition of the term ''occupied,'' in this instance, we then characterized ''specific areas'' as used in the definition of critical habitat in section 3(5)(A) of the Act, to conform with known patterns of space-use and distribution exhibited by northern spotted owls. Northern spotted owls are wide-ranging organisms that maintain large home ranges and disperse relatively long distances. Home ranges are used regularly by territorial owls for foraging, raising young, and other activities, and are actively defended by the resident pair year-round; as such, we consider these home ranges to be continually occupied by the species. Although much activity is centered on core areas within the home ranges, northern spotted owls are dependent upon the entirety of the home range for prey resources and use it on a regular basis throughout the year. As described earlier, territorial northern spotted owls cover home ranges from roughly 1,400 ac (570 ha) at the southern end of their range (Zabel *et al.* 1995, p. 436) up to over 14,000 ac (5,700 ha) (USDI 1992, p. 23; USFWS 1994 in litt., p. 1) in the northern portion of the species' range. These large home ranges may overlap with those of neighboring northern spotted owls, such that large landscapes may be fully occupied by population clusters in areas where suitable habitat is well distributed. Some demographic study areas still exhibit this pattern over large landscapes today, although overlapping home ranges were more the case when the northern spotted owl was first listed, prior to extensive colonization of the species' range by the barred owl.

To conservatively evaluate the proportion of each subunit that was composed of areas known to be occupied by northern spotted owls at the time of listing, we calculated the area within estimated home ranges (USFWS 2011, p. C–63 Table C–24) for all verified northern spotted owl locations known at the time of listing, as described above. Overall, 85 percent of the area designated is within estimated home ranges of verified territorial northern spotted owls located through surveys at the time of listing; this area is entirely representative of verified owl locations, and does not include habitat occupied based on habitat suitability or nonresident owls. Twenty-two (37 percent) of the 60 subunits have at least 90 percent of their area within verified known home ranges; 41 (68 percent) have at least 70 percent. As explained above, given that these areas represent occupancy by verified resident owls only, and considering the suitable habitat available at the time of listing in these same landscapes, we conclude that the remainder of these areas was occupied by other resident owls that simply were not within surveyed areas, nonterritorial adult owls (floaters), or dispersing subadults.

To help us identify and map potential critical habitat for the owl, we used a three-step modeling framework developed as part of the Revised Recovery Plan that integrates a northern spotted owl habitat model, a habitat conservation planning model, and a population simulation model. The details of this modeling framework are presented in Appendix C of the Revised Recovery Plan (USFWS 2011), and a detailed technical description of the modeling and habitat network evaluation process we used in this revised designation of critical habitat is provided in Dunk *et al.* (2012b, entire). Both of these supporting documents are available at *http://www.regulations.gov* (see **ADDRESSES**), or by contacting the

Oregon Fish and Wildlife Office (see **FOR FURTHER INFORMATION CONTACT**).

The overall approach for critical habitat modeling consisted of three main steps (USFWS 2011, Appendix C, p. C–3) to help refine, select, and evaluate a series of alternative critical habitat networks for the northern spotted owl. Each of these steps helped us to identify a critical habitat network that meets the statutory definition of critical habitat, namely, the distribution of the physical or biological features needed by the species across its geographical range occupied at the time of listing, and the identification of a landscape configuration where these features, as well as any necessary unoccupied areas, are essential to the conservation of the species. These steps are summarized here, and then each is described in further detail.

Step 1: At the outset, the attributes of forest composition and structure and characteristics of the physical environment associated with nesting, roosting, and foraging habitat—physical or biological features used by the species—were identified based on published research, input from individual experts, and analysis of northern spotted owl location and habitat data from nearly 4,000 known owl pairs (USFWS 2011, pp. C–20 to C–28). We then used these physical or biological features of nesting, roosting, and foraging habitats to create a rangewide map of relative habitat suitability using the model MaxEnt (Phillips *et al.* 2006, entire; Phillips and Dudik 2008, entire), based on the habitat selection exhibited by these known owl pairs. In addition to providing a map of relative habitat suitability, this process allowed us to evaluate an area's suitability and determine whether the presence of the species was likely based on an assessment of known species-habitat relationships.

Step 2: We developed northern spotted owl habitat networks based on the relative habitat suitability map using the Zonation conservation planning model (Moilanen and Kujala 2008, entire). The Zonation model used a hierarchical prioritization of the landscape based on relative habitat suitability and other user-specified criteria (e.g., land ownership) to develop the most efficient solutions for incorporating high-value habitat. Zonation analyses were conducted separately for each region to ensure that reserves would be well-distributed across the range of the owl. Zonation also allowed for consideration of land ownership in development of reserve designs.

Step 3: In the last step, we determined where the physical or biological features, as well as unoccupied areas, are essential to the conservation of the species. To do this we used a spatially explicit northern spotted owl population model (HexSim) (Schumaker 2008, entire) to predict relative responses of northern spotted owl populations to different habitat network designs, and evaluated these responses against the recovery objectives and criteria for the northern spotted owl using a rule set based on those criteria. Simulations from these models are not meant to be estimates of what will occur in the future, but rather provide information on trends predicted to occur under different network designs; this allowed us to compare the relative performance of various critical habitat scenarios.

In Step 1 of the modeling framework, we used published research, input from individual experts, and analysis of northern spotted owl location and habitat data to develop models of relative habitat suitability for northern spotted owls. These relative habitat suitability models identify areas with habitat that provides the combination of variables (forest composition and structure, and abiotic factors such as elevation, precipitation, and temperature) with a high predictive probability of supporting northern spotted owls, based on data gathered from known owl sites. Based on the physical or biological features of nesting, roosting, and foraging habitats known to be utilized by resident owls, we used these models to identify areas containing those physical or biological features required by the owl, and to map their distribution across the range of the owl (USFWS 2011, pp. C–27 to C–42, C–62). Because the models are based in large part on data from nearly 4,000 owl sites (USFWS 2011, p. C–62), model outputs highlight surveyed and verified owl home ranges. However, they also identify areas with habitat that supported territorial and non-territorial owls at the time of listing, based on habitat suitability, and areas that may have been unoccupied at the time of listing, but that may be essential for the conservation of the species based on their relative habitat suitability as well as the habitat characteristics needed for population growth or dispersal (see below). To ensure that the variety of physical or biological features used by northern spotted owls across their range is represented in the models, we applied separate habitat models for each of 11 ecological regions, based on differences in forest environments, northern spotted owl habitat use and prey distribution, and variation in ecological conditions (USFWS 2011, C–7 to C–13).

In Step 2 of the modeling framework, we used a habitat conservation planning model (Zonation) (Moilanen *et al.* 2005, entire; Moilanen and Kujala 2008, entire) to develop a northern spotted owl conservation planning model. We used this in the critical habitat process to aggregate areas of greatest relative habitat suitability (areas occupied at the time of listing that provide the physical or biological features, or areas of habitat that may have been unoccupied at the time of listing, but have the potential to play an essential conservation role, for example, in providing connectivity between isolated populations) from Step 1 into discrete units. This process provided a series of maps representing a range of alternative critical habitat networks, each containing a different amount and distribution of northern spotted owl habitat quality (representing differing amounts and configurations of the primary constituent elements). The Zonation model seeks to provide the most efficient design (most habitat value on smallest land area) and allowed us to maximize reliance on public lands to provide what is essential to northern spotted owl conservation.

In Step 3 of the modeling framework, we developed a northern spotted owl population simulation model that allowed us to simulate the relative population responses of northern spotted owls to various habitat conservation network scenarios (HexSim) (Schumaker 2011, entire). In developing this rule, we used this northern spotted owl population simulation model to compare alternative critical habitat networks and evaluate each design's ability to meet the recovery goals and criteria for the northern spotted owl (described further below, and in detail in Dunk *et al.* 2012b). This step of the process enabled us to determine the amount and configuration of physical or biological features on the landscape that are essential to the conservation of the owl, as well as to determine those unoccupied areas essential for the conservation of the species. By evaluating northern spotted owl population metrics, such as relative population size, population trend, and extinction risk that resulted from each scenario evaluated, we are designating the most efficient habitat network necessary to conserve the northern spotted owl (efficient, as noted above, in terms of balancing greatest conservation value for the owl in proportion to acres designated). This network has the potential to support an increasing or stable population trend of northern spotted owls, exhibits relatively low extinction risk, both rangewide and at the recovery unit scale (recovery units, as identified in the Revised Recovery Plan for the Northern Spotted Owl, are defined by physiographic provinces (USFWS 2011, pp. III–1 to III–2)), and achieves adequate connectivity among recovery units, while prioritizing reliance on public lands.

We determined what is essential to recovery of the northern spotted owl by evaluating the performance of each potential critical habitat scenario considered against the recovery needs of the owl. In contrast with earlier conservation modeling efforts for the northern spotted owl, the modeling framework we utilized does not rely on *a priori* (predefined) rule sets for features such as size of habitat blocks, number of owl pairs per block, or distance between blocks (USFWS 2011, p. C–4) to determine what is essential for the conservation of the species. Instead, we evaluated northern spotted owl population metrics such as relative population size and trend to determine what is essential to owl conservation, both in terms of where and how much of the physical or biological features are essential and how much unoccupied habitat is essential to meet the recovery objectives for the owl, as defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, p. ix) and detailed in our supporting documentation (Dunk *et al.* 2012b, entire).

To accomplish this, we developed a rule set for the identification of critical habitat based on the ability of that habitat to meet the recovery objectives and criteria set forth in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, p. ix). The recovery objectives for the northern spotted owl are:

(1) Northern spotted owl populations are sufficiently large and distributed such that the species no longer requires listing under the Act;

(2) Adequate habitat is available for northern spotted owls and will continue to exist to allow the species to persist without the protection of the Act; and

(3) The effects of threats have been reduced or eliminated such that northern spotted owl populations are stable or increasing and northern spotted owls are unlikely to become threatened again in the foreseeable future.

The recovery criteria for the northern spotted owl (aside from the requirement for post-delisting monitoring) are:

Recovery Criterion 1—Stable Population Trend: The overall population trend of northern spotted owls throughout the range is stable or increasing over 10 years, as measured by a statistically reliable monitoring effort.

Recovery Criterion 2—Adequate Population Distribution: Northern spotted owl subpopulations within each province (i.e., recovery unit), excluding the Willamette Valley Province, achieve viability, as informed by the HexSim population model or some other appropriate quantitative measure.

Recovery Criterion 3—Continued Maintenance and Recruitment of Northern Spotted Owl Habitat: The future range-wide trend in northern spotted owl nesting/roosting and foraging habitat is stable or increasing throughout the range, from the date of Revised Recovery Plan approval, as measured by effectiveness monitoring efforts or other reliable habitat monitoring programs.

We used the following rule set to compare and evaluate the potential of various habitat scenarios to meet these recovery objectives and criteria, and thus determine what is essential to the conservation of the northern spotted owl:

(1) Ensure sufficient habitat to support population viability across the range of the species.

(a) Habitat can support an increasing or stable population trend, as measured by a population growth rate of 1.0 or greater.

(b) Habitat will be sufficient to insure a low risk of extinction.

(2) Support demographically stable populations in each recovery unit.

(a) Habitat can support an increasing or stable population trend in each recovery unit.

(b) Habitat will be sufficient to insure a low risk of extinction in each recovery unit.

(c) Conserve or enhance connectivity within and among recovery units.

(d) Conserve genetic diversity.

(e) Ensure sufficient spatial redundancy in critical habitat within each recovery unit.

(i) Accommodate habitat disturbance due to fire, insects, disease, and catastrophic events.

(3) Ensure distribution of northern spotted owl populations across representative habitats.

(a) Maintain distribution across the full ecological gradient of the historical range.

(4) Acknowledge uncertainty associated with both future habitat conditions and northern spotted owl population performance—including influence of barred owls, climate change, fire/disturbance risk, and demographic stochasticity—in assessment of critical habitat design.

These critical habitat objectives of supporting population viability and demographically stable populations are intended to be met in concert with the implementation of recovery actions to address other nonhabitat-based threats to the owl.

We applied this rule set to the outcome of HexSim modeling simulations on the various habitat scenarios considered (see Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) and Dunk *et al.* 2012b, entire, for all details). Each HexSim simulation began with a population of 10,000 females (all population metrics are in numbers of females), consisted of 100 replicates and 350 time steps for each habitat scenario considered, and included the introduction of environmental stochasticity. We then evaluated the relative performance of each habitat scenario using numerous metrics to assess the ability of that scenario to meet the specified recovery goals for the northern spotted owl, as laid out in our rule set for identifying critical habitat; these metrics were evaluated at the scale of each region, as well as collectively rangewide. Our metrics of population performance resulting from each habitat scenario considered included:

- The percentage of simulations during which the rangewide population fell below 1,250 individuals.
- The percentage of simulations during which the rangewide population fell below 1,000 individuals.
- The percentage of simulations during which the rangewide population fell below 750 individuals.
- The percentage of simulations during which the population fell below 250 in each region (using 250 as a quasi-extinction threshold).
- The percentage of simulations during which the population fell below 100 in each region (using 100 as a quasi-extinction threshold).
- The percentage of simulations that went to extinction (population = 0) in each region.
- The mean population size from time step 150 to time step 350 in each region.
- The mean population size at the last time step in each region.
- The mean population size at the last time step rangewide.

Measures of extinction risk are used as an indirect measure of sufficient population abundance, as well as viability.

These metrics were used to comparatively evaluate the ability of each scenario under consideration to determine what is essential for the conservation of the species as informed by our rule set. We selected habitat scenarios for further evaluation if they outperformed the other scenarios under consideration in terms of being better able to meet the population abundance, viability, and trend criteria both across regions and rangewide. In all cases, we attempted to identify the most efficient (smallest) total area that would meet the population goals essential to recovery. Our final critical habitat designation is based on the habitat network that best met all of these criteria, and then was further refined, as described below.

We also focused on public lands to the maximum extent possible (see Dunk *et al.* 2012b, entire, for specific details). In this step, we compared scenarios that did not discriminate between various land ownerships, and those that prioritized publicly owned lands. As Federal agencies have a mandate under section 7(a)(1) of the Act to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of listed species, we looked first to Federal lands for critical habitat. However, in some areas of limited Federal ownership, State and private lands may provide areas determined to be essential to the northern spotted owl by contributing to demographic support and connectivity to facilitate dispersal and colonization. In all cases, if the scenarios under consideration provided equal contribution to recovery, as measured by the population metrics described above, we chose the scenario that prioritized inclusion of federally owned lands. State and private lands were included only if they were necessary to achieve conservation of the species, and were determined to provide either occupied areas that support the PCEs or unoccupied areas essential for the conservation of the owl. We also considered Indian lands in our evaluations; if habitat scenarios performed equally well with or without Indian lands, we did not include them (see Indian Lands, below).

To determine which of the numerous potential arrays of habitat we considered contained only those areas that are essential to the conservation of the northern spotted owl, we evaluated each of them according to the rule set and criteria detailed above. Briefly summarizing, all of the habitat networks we assessed contained varying amounts of the physical or biological features needed by the northern spotted owl in varying amounts and spatial arrangements across the range of the species. Our first consideration in determining which of these scenarios contained the physical or biological features in the quantity and configuration essential to the conservation of the species (i.e., the physical and biological features essential to the conservation of the species) was our evaluation of how well the network performed in terms of contributing toward the recovery criteria for the northern spotted owl; we used the recovery criteria as our standard for the conservation of the species.

To ensure that we designated only what is essential to the species' conservation, our secondary consideration was efficiency. For our purposes, we evaluated efficiency both in terms of number of acres and landownership. Some of the networks we evaluated were smaller than this final designation, or did not include any State or private lands; however, such networks failed to meet the recovery criteria required to achieve the conservation of the species, and therefore could not be considered to provide the quantity and configuration of the physical or biological features essential to the conservation of the species. Other potential designations were significantly larger than this final designation and while they were also capable of meeting the recovery criteria, they did not provide proportionately greater conservation value relative to the additional area (as measured, for example, in relative projected numbers of owls). We concluded that such networks therefore included large areas of habitat that may contribute to recovery, but that are not necessary to achieve the recovery criteria for the northern spotted owl, therefore these superfluous areas could not be considered essential to the conservation of the species.

Finally, our assessment of potential habitat networks, based not only on the population models but additionally refined by expert opinion, as described below, indicated that critical habitat limited to areas presently occupied by the northern spotted owl would not be sufficient to achieve the recovery criteria for the species, as such a designation would lead to inadequate population distribution and inadequate population connectivity (50 CFR 424.12(e)). Modeling led us to a similar conclusion regarding areas that were occupied at the time of listing; networks limited to such areas were not capable of meeting the recovery criteria for the species, and the models assisted us in identifying those additional specific areas of habitat unoccupied at the time of listing that are essential in terms of achieving the conservation of the species. Another element of an essential network was therefore the identification of sufficient areas of suitable habitat or potentially suitable habitat not presently occupied by the northern spotted owl, or that was not occupied at the time of listing, to achieve the conservation of the species, in conjunction with occupied habitat.

Our final designation is the critical habitat network that includes the quantity and spatial configuration of habitat that meets the requirement that it contain occupied areas with the essential physical and biological features or unoccupied areas that are themselves essential for conservation of the species by achieving the recovery criteria for the northern spotted owl while avoiding the designation of areas of habitat that do not make an essential contribution to the conservation of the species. This essential habitat network is composed predominantly of areas occupied at the time of listing and that contain the essential physical or biological features, in conjunction with some areas that may have been unoccupied at the time of listing, to collectively comprise the habitat configuration and quantity that most efficiently meets the recovery criteria for the species. All areas in this final critical habitat designation, whether considered occupied at the time of listing or unoccupied at the time of listing, are therefore considered essential to the conservation of the species. The specific modeling outcomes and our evaluation of each potential critical habitat network are presented in detail in Dunk *et al.* 2012b.

It is important to recognize that although the application of this modeling framework provided the foundation for identifying those areas that meet the definition of critical habitat for the northern spotted owl, the models do not simply produce a map of critical habitat. Working from the model results, we then further refined the model-based map units, after considering land ownership patterns, interagency coordination, and best professional judgment, with the objective of increasing the efficiency and effectiveness of the critical habitat designation, as well as making corrections based on ground truthing and local knowledge. The process generally consisted of modifying boundaries to better conform to existing administrative and landscape features, removing small areas of relatively lower-suitability habitat, and incorporating additional areas that may have been unoccupied at the time of listing, but were determined to be essential for population connectivity, for population growth, or to accommodate maintenance of suitable habitat on the landscape for owls in the face of natural disturbance regimes (e.g., fire) or competition with the barred owl, while retaining the overall configuration of the model-based maps. In addition, as part of this refinement process, expert knowledge helped us to identify essential areas such as the unique oak woodland ecotype used by northern spotted owls at the southernmost extent of the species' range in Napa, Sonoma, and Marin Counties, California. We used the population simulation model to evaluate whether this revised critical habitat network continued to provide what is essential to the conservation of the northern spotted owl, and used this same process to evaluate changes made between the proposed and final rule (see Changes from Proposed Rule for details).

Summary of How We Determined Where Physical and Biological Features and Unoccupied Areas Are Essential to Conservation of the Species

The decision of where the requisite physical and biological features and unoccupied areas are essential to the northern spotted owl was made by identifying those areas in the range of the owl that are necessary to achieving a relatively high likelihood of meeting the recovery objectives described in the Revised Recovery Plan (USFWS 2011, p. ix), while at the same time minimizing the inclusion of areas that are relatively less important or not necessary to spotted owl recovery. Striking this balance required by the Act—designating only those areas that contain the essential features or are themselves essential for conservation of the species and not unnecessarily designating the entire geographical area that is or can be occupied by the species—was accomplished using the best available information: a combination of scientific modeling, expert scientific opinion of agency biologists and peer reviewers, and careful consideration of public comment.

We made sure that this final critical habitat designation includes only what is essential to the species' conservation by evaluating a variety of potential critical habitat networks and assessing their relative probability of meeting recovery objectives and, secondarily, their relative ''efficiency'' in meeting these objectives. The various scenarios were designed to bracket a variety of conditions and included different aggregations of total habitat area, landscape juxtaposition, and forest conditions. Some were smaller or larger in total size than this final designation, and some did or did not include Federal matrix lands, State lands, or private lands. The process of comparing alternative networks and population results is described in detail in the Modeling Supplement (Dunk *et al.* 2012b). When compared to other possible network scenarios, we conclude the final identification of critical habitat either contains essential physical and biological features or is otherwise essential because it has the highest likelihood of meeting recovery objectives in the most efficient manner for the following reasons.

(1) It ensures that northern spotted owl populations are sufficiently large to exhibit low extinction risk at the rangewide scale. Under the final designation, modeled rangewide populations have less than a 10 percent probability of declining to fewer than 1,000 females, and a 3 percent probability of declining to fewer than 750 females. Modeled population size and extinction risk results for the designation are within the top 10 percent of all alternative networks, yet the designation is much smaller than other top-ranking alternatives.

(2) It ensures that northern spotted owl populations are well-distributed across the geographic range of the species by selecting a habitat network that supports population sizes with low extinction risk within each of 11 modeling regions. Modeling region-specific population sizes in the final designation are in the top 10 percent of all alternative networks.

(3) It ensures that adequate amounts of current and future habitat is available for spotted owls to persist and recover by designating a habitat network consisting of approximately 50 percent of the available high-suitability spotted owl habitat rangewide. An additional 21 percent of high-quality habitat is encompassed within Congressionally Reserved lands that are not designated, but will retain their value for spotted owls. This high-quality habitat, in addition to areas required for population connectivity, is necessary to support rangewide populations with low extinction risk at both rangewide and regional scales.

(4) Compared to previous spotted owl conservation strategies, it provides increased redundancy in habitat to help buffer potential adverse impacts due to climate change and other stochastic (i.e., unpredictable) events by enlarging the total area of the final designation within the fire-prone portions of the northern spotted owl's range. This means that the final designation supports larger populations in some modeling regions than would be minimally required to achieve low extinction risk. Although it is impossible to predict with precision how much redundancy may be required to deal with future changes in forest conditions, this is essential to ameliorating the potential impacts of fire, insects, and forest disease on spotted owls.

(5) The balancing of population objectives and parsimony resulted in a final designation that encompasses 50 percent of the total available high-suitability habitat rangewide and less than nine percent of low-quality habitat, and supported population size and extinction risk within the top 10 percent of all alternatives. Other larger alternatives had similar or slightly better population characteristics, but contained much larger proportions of lower-suitability habitat. The small amount of low-quality habitat contained in the final designation is essential because it provides for population growth and connectivity both within regional populations and between populations; however, we determined that additional lower-suitability habitat was not necessary to the conservation of the species.

We considered but rejected potential critical habitat networks that provided less total area, that did not include Federal matrix lands, or that did not include some State or private lands where Federal lands were lacking, because these networks had a significantly lower likelihood of meeting recovery objectives as measured by demographic modeling results and expert scientific opinion. For example, modeled rangewide population sizes in this final designation were 1.7 times larger than under the proposed rule's Possible Outcome 4, which did not include any State or private lands, and nearly twice the size of populations under 2008 critical habitat. This larger population size is essential because it results in low extinction risk. Likewise, we considered but rejected several potential networks that included significantly more total area than the final designation. These potential networks had a high probability of meeting recovery objectives as measured by model results and expert opinion, but they did not confer much of a net increase in the likelihood of meeting recovery objectives beyond what is provided by the final designation. This lack of parsimony, combined with a lack of a proportional increase in measurable demographic performance, justified the rejection of these larger potential networks when compared to the final designation.

This methodological approach was generally supported by the scientific peer reviewers. One peer reviewer felt the proposed critical habitat identified too much total area, and another peer reviewer felt that more land area should be included, but most peer reviewers felt the total area and the juxtaposition of land areas seemed reasonable and scientifically justified given the current status of the owl and the recovery objectives. Most of these experts also concluded that the use of the modeling process was justified for informing the final decision.

In sum, we believe this final designation of critical habitat for the northern spotted owl meets the intent of the Act by identifying those areas containing essential features or are otherwise essential in a way that has a very high probability of providing for the conservation of the species, while minimizing the potential for unnecessarily including areas of low conservation value to the species.

Unoccupied Areas

Based on the northern spotted owl's wide-ranging use of the landscape, and the distribution of known owl sites at the time of listing across the units and subunits designated as critical habitat in this rule, we find that all units and all subunits meet the Act's definition of being within the geographical area occupied by the species at the time of listing.

As noted above in *Occupied Areas,* within the units and subunits designated as critical habitat, each consists predominantly of habitat occupied by the species at the time of listing. However, parts of most units and subunits contain a forested mosaic that includes younger forests that may not have been occupied at the time of listing; we evaluated such areas of younger forest as unoccupied at the time of listing. Unoccupied areas must meet the standard of section 3(5)(a)(ii) of the Act: They must be determined to be essential for the conservation of the species. In addition, there are some areas we have concluded were highly likely occupied at the time of listing, based on the presence of suitable habitat and our predictive models, but acknowledge there is some element of uncertainty to recognizing these areas as occupied under the statutory definition due to the lack of survey information. Therefore, we also evaluated all areas that we concluded were likely occupied but which lack survey information applying the standard of section 3(5)(A)(ii) of the Act, and have determined that all such areas included in this designation are essential for the conservation of the species. Finally, as noted earlier, as a result of our application of the modeling framework and refinement process described above, in which we evaluated various habitat scenarios to identify the network that is essential to the conservation of the species by providing the quantity and configuration of habitat essential for the conservation of the species, we have additionally determined that all areas identified here as critical habitat, whether occupied at the time of listing or unoccupied at the time of listing, are essential for the conservation of the species and therefore meet the definition of critical habitat under section 3(5)(A)(ii) of the Act.

Thus, even if not occupied at the time of listing, all units and subunits designated as critical habitat are essential for the conservation of the species because, in addition to nesting, roosting, foraging, and dispersal habitat, they provide connectivity between occupied areas, room for population growth, and the ability to provide sufficient suitable habitat on the landscape for owls in the face of natural disturbance regimes (e.g., fire).

In general, northern spotted owls require large areas of habitat due to their expansive home range requirements and the need for connectivity between subpopulations to maintain genetic diversity and support stable, viable populations over the long term. The northern spotted owl was initially listed in large part due to past habitat loss and degradation. In addition, recent work has confirmed that northern spotted owls require additional areas of habitat to persist in the face of competition with barred owls (Dugger *et al.* 2011, p. 2467). Given the effects of past habitat loss and the increased habitat area needed to offset competition from the barred owl, our assessment indicates that large areas of contiguous areas of nesting, roosting, and foraging habitat are essential to sustaining viable northern spotted owl populations and meeting recovery goals.

In addition, because past habitat loss and degradation was identified as a major threat to the northern spotted owl at the time of listing and because this threat currently continues, conservation and recovery of the species is dependent in part on development of additional habitat to allow for population growth and recovery. Therefore, portions of the habitat mosaic in some subunits designated as critical habitat within the geographical area occupied by the species at the time of listing consist of younger or partially harvested forest. These are essential for the conservation of the species because they are capable of developing the PCEs that support nesting, roosting, or foraging by northern spotted owls that will be necessary for population growth. Typically the result of past timber harvest or wildfire, these areas of younger forest contain the elements conducive to fully developing the physical or biological features essential to the conservation of the owl (they are of suitable elevation, climate, and forest community type). They may, however, be lacking some element of the physical or biological features, such as large trees or dense canopies that are associated with nesting habitat. In particular, of 60 subunits designated, 4 (NCO–4, NCO–5, and ORC–1) contain proportionally greater areas of younger forests that are essential for the conservation of the species, because they can develop additional habitat necessary to support viable northern spotted owl populations in the future. These subunits are located within Southwestern Washington and Oregon Coast Ranges Areas of Special Concern (Thomas *et al.* 1990, pp. 66–69), areas described as exhibiting a scarcity of suitable habitat due to extensive timber harvest. The recovery goal of achieving viable populations distributed across the range of the owl cannot be achieved without these areas; therefore, we have determined them to be essential for the conservation of the species.

Finally, there are portions of two subunits that function primarily for connectivity between populations. Although portions of these subunits may not have been occupied at the time of listing, these areas contain the dispersal and foraging habitat to support movement between adjacent subunits and are therefore essential to provide population connectivity. Many of these areas are also anticipated to develop into habitat capable of supporting nesting pairs in the future. In 1990, the Interagency Scientific Committee (ISC) (Thomas *et al.* 1990, entire) identified ''Areas of Special Concern'' in the Draft Strategy for the Conservation of the Northern Spotted Owl. The ISC defined Areas of Special Concern as lands where past natural occurrences and human actions had adversely affected habitat more than in the remainder of the physiographic province under consideration (Thomas *et al.* 1990, p. 66). Within the Areas of Special Concern described by the ISC (Thomas *et al.* 1990, pp. 66–69), we identified areas that were strategically located between subunits that would otherwise be demographically isolated. Of 60 subunits designated, two (ORC–4 and ECS–3) are identified as functioning primarily for population connectivity with less than 70 percent of the subunit covered by survey-located owl sites.

Our evaluation of the various habitat scenarios considered in the modeling process described above enabled us to determine the amount and configuration of habitat essential for the conservation of the owl, based on the relative ability of that habitat network to meet the recovery criteria of stable or increasing populations and adequate distribution of viable populations. Although this evaluation was primarily based on areas we know to have been occupied at the time of listing, our evaluation of the distribution and configuration of the physical and biological features essential to the conservation of the owl additionally identified areas that may not have been occupied at the time of listing, if those areas were essential to meeting the recovery goals for the species. We have determined these areas to be essential for the conservation of the species, to provide for dispersal and connectivity between currently occupied areas, allow space for population growth, and provide habitat replacement in the event of disturbances, such as wildfires and competition with barred owls. Our evaluation of alternative habitat networks, described above, indicates that the specific areas identified in this designation are necessary to achieve the amount and configuration of habitat that meets the recovery criteria for the species. Because these areas do so efficiently (without designating more areas than are needed, or designating areas that would not make a significant contribution to conservation value), we have determined that these areas are essential for the conservation of the species. As described above, we have determined that a critical habitat designation that does not include these areas, even if they may not be occupied, would be inadequate to ensure the conservation of the species. The resulting revised critical habitat represents the amount and spatial distribution of habitats that we have determined to be essential for the conservation of the northern spotted owl.

This designation is an improvement over the previous designation in that it anticipates that in geographical regions with drier forests and more dynamic natural disturbance regimes, land managers will consider taking a landscape approach to managing critical habitat. This landscape approach would recognize that large areas are essential in these regions to accommodate disturbance-driven shifts in the physical or biological features essential for the conservation of the northern spotted owl, and that restorative management actions may be needed across these landscapes to help manage for resilience in such a dynamic ecosystem. These large landscapes, although essential to provide for the conservation of the northern spotted owl, do include within their boundaries several particular types of areas that are not included in critical habitat, because they cannot support northern spotted owl habitat. The following types of areas are not critical habitat for the northern spotted owl, and are not included in the revised designation:

- Meadows and grasslands. These include dry, upland prairies and savannas found in the valleys and foothills of western Washington, Oregon, and northwest California; subalpine meadows; and grass and forb dominated cliffs, bluffs and grass balds found throughout these same areas. Dominated by native grasses and diverse forbs, they may include a minor savanna component of Oregon white oak, Douglas-fir, or Ponderosa pine.
- Oak and aspen (*Populus* spp.) woodlands. Oak woodlands are characterized by an open canopy dominated by Oregon white oak but may also include ponderosa pine, California black oak, Douglas-fir, or canyon live oak. The understory is relatively open with shrubs, grasses and wildflowers. Oak woodlands are typically found in drier landscapes and on south-facing slopes. Note this exception for oak woodlands does not include tanoak (*Notholithocarpus densiflorus*) stands, closed-canopy live oak (*Quercus agrifolia*) woodlands and open-canopied valley oak (*Quercus lobata*) and mixed-oak woodlands in subunits ICC–6 and RDC–5 in Napa, Sonoma, and Marin Counties, California. Aspen woodlands are dominated by aspen trees with a forb, grass or shrub understory and are typically found on mountain slopes, rock outcrops and talus slopes, canyon walls, and some seeps and stream corridors. This forest type also can occur in riparian areas or in moist microsites within drier landscapes.
- Manmade structures (such as buildings, aqueducts, runways, roads, and other paved areas) and the land on which they are located.

When determining critical habitat boundaries, we made every effort to avoid including these areas because they lack physical or biological features for the northern spotted owl. Due to the limitations of mapping at such fine scales, however, we were often not able to segregate these areas from areas shown as critical habitat on critical habitat maps suitable in scale for publication within the Code of Federal Regulations. Thus, we have included regulatory text clarifying that these areas are not included in the designation even if within the mapped boundaries of critical habitat, as a Federal action involving these lands would not trigger section 7 consultation with respect to effects to critical habitat unless the specific action would affect the physical or biological features in the adjacent critical habitat.

VIII. Final Critical Habitat Designation

Consistent with the standards of the Act and our regulations we have identified 9,577,969 ac (3,876,064ha) in 11 units and 60 subunits as meeting the definition of critical habitat for the northern spotted owl. The 11 units we have identified as critical habitat are: (1) North Coast Olympics, (2) Oregon Coast Ranges, (3) Redwood Coast, (4) West Cascades North, (5) West Cascades Central, (6) West Cascades South, (7) East Cascades North, (8) East Cascades South, (9) Klamath West, (10) Klamath East, and (11) Interior California Coast Ranges. All of the critical habitat units and subunits identified were occupied at the time of listing; however, some units may include some smaller areas that were not known to be occupied at the time of listing but have been determined to be essential to the conservation of the species. In addition, as described above, we have determined that all areas being designated are essential to the conservation of the species. Land ownership of the designated critical habitat includes Federal and State lands. No tribal lands are included in the critical habitat designation. The approximate area of each critical habitat unit is shown in Table 6. Table 7 gives totals by land ownership.

TABLE 6—REVISED CRITICAL HABITAT UNITS FOR THE NORTHERN SPOTTED OWL

[Area estimates reflect all land within critical habitat unit boundaries.]

Critical habitat unit	Land ownership	Acres	Hectares
Unit 1—North Coast Olympics	Federal	696,230	281,754
	State	128,270	51,909
	Total	824,500	333,663
Unit 2—Oregon Coast Ranges	Federal	788,919	319,264
	State	70,945	28,711
	Total	859,864	347,975
Unit 3—Redwood Coast	Federal	111,258	45,025
	State	48,912	19,794
	Local government	20,684	8,371
	Total	180,855	73,189
Unit 4—West Cascades North	Federal	541,476	219,127
	State	798	323
	Total	542,274	219,450
Unit 5—West Cascades Central	Federal	908,861	367,802
	State	825	334
	Total	909,687	368,136
Unit 6—West Cascades South	Federal	1,354,989	548,345
	State	209	85
	Total	1,355,198	548,429
Unit 7—East Cascades North	Federal	1,338,988	541,869
	State	6,534	2,644
	Total	1,345,523	544,514
Unit 8—East Cascades South	Federal	368,380	149,078
Unit 9—Klamath West	Federal	1,186,750	480,260
	State	10,639	4,305
	Total	1,197,389	484,565
Unit 10—Klamath East	Federal	1,049,826	424,850
	State	2,905	1,175
	Total	1,052,731	426,025
Unit 11—Inner California Coast Ranges	Federal	940,721	380,696
	State	848	343
	Total	941,568	381,039
Grand Total		9,577,969	3,876,064

Note: Area sizes may not sum due to rounding.

TABLE 7—REVISED CRITICAL HABITAT UNITS FOR THE NORTHERN SPOTTED OWL, DESCRIBING AREA INCLUDED UNDER DIFFERENT LANDOWNERSHIPS

	Acres	Hectares
USFS	7,957,787	3,220,399
BLM	1,328,612	537,670
NPS	0	0
State	270,886	109,624
Local Government	20,684	8,371
Private	0	0
Other Federal (DOD)	0	0
Tribal	0	0
Total	9,577,969	3,876,064

We present brief descriptions of all units and their subunits below. For each subunit, we describe the proportion of the area that is covered by verified northern spotted owl home ranges at the time of listing. As described above in the section Criteria Used to Identify Critical Habitat, all areas being designated that were occupied at the time of listing contain the physical or biological features essential to the conservation of the northern spotted owl, and which may require special management considerations or protection. In addition, there are smaller areas of suitable habitat within subunits that we considered likely occupied by nonterritorial owls and dispersing subadults, at the time of listing, as well as some smaller areas of younger forest within the larger habitat mosaic that may have been unoccupied at the time of listing. Due to some potential for uncertainty in these latter two categories of areas in terms of occupancy at the time of listing, we evaluated all such areas applying the standard under section 3(5)(A)(ii) of the Act, and have determined that all such areas included in this designation are essential to the conservation of the species. In addition, as a result of our application of the modeling framework described earlier, we have determined that all areas identified here as critical habitat, whether occupied at the time of listing or unoccupied at the time of listing, are essential to the conservation of the species and therefore meet the definition of critical habitat under section 3(5)(A)(ii) of the Act. This applies to all units and subunits described below.

Unit 1: North Coast Ranges and Olympic Peninsula (NCO)

Unit 1 consists of 824,500 ac (333,623 ha) and contains five subunits. This unit consists of the Oregon and Washington Coast Ranges Section M242A, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994a, Section M242A). This region is characterized by high rainfall, cool to moderate temperatures, and generally low topography (1,470 to 2,460 ft (448 to 750 m)). High elevations and cold temperatures occur in the interior portions of the Olympic Peninsula, but northern spotted owls in this area are limited to the lower elevations (less than 2,950 ft (900 m)). Forests in the NCO are dominated by western hemlock, Sitka spruce, Douglas-fir, and western red cedar (*Thuja plicata*). Hardwoods are limited in species diversity (consist mostly of bigleaf maple and red alder (*Alnus rubra*)) and distribution within this region, and typically occur in riparian zones. Root pathogens like laminated root rot (*Phellinus weirii*) are important gap formers, and vine maple (*Acer circinatum*), among others, fills these gaps. Because Douglas-fir dwarf mistletoe is unusual in this region, northern spotted owl nesting habitat consists of stands providing very large trees with cavities or deformities. A few nests are associated with western hemlock dwarf mistletoe (*Arceuthobium tsugense* subsp. *tsugense*). Northern spotted owl diets are dominated by species associated with mature to late-successional forests (flying squirrels, red tree voles), resulting in similar definitions of habitats used for nesting/roosting and foraging by northern spotted owls.

Subunit Descriptions: Unit 1

NCO–1. The NCO–1 subunit consists of approximately 293,539 ac (118,791 ha) in Clallam, Jefferson, Grays Harbor, and Mason Counties, Washington, and comprises lands managed by U.S. Forest Service (USFS) and State of Washington. The USFS manages 230,966 ac (93,309 ha) as Late-successional Reserves to maintain functional, interactive, late-successional and old-growth forest ecosystems and 62,966 ac (25,481 ha) under the adaptive management area land use allocation. Threats in this subunit include current and past timber harvest, competition with barred owls, and isolation on a peninsula (along with subunit NCO–2). This subunit is expected to function primarily for demographic support of the overall population. NCO–1 is located primarily in the watersheds of Lyre, Hoko, Soleduck, Hoh, Quinault, Queets, and Clearwater Rivers, and includes the northern part of the Lower Chehalis River watershed.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 94 percent of the area of NCO–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

NCO–2. The NCO–2 subunit consists of approximately 213,633 ac (86,454 ha) in Kitsap, Clallam, Jefferson, Grays Harbor, and Mason Counties, Washington, and comprises lands managed by the USFS. The USFS manages 173,682 ac (70,287 ha) as Late-successional Reserves to maintain functional, interactive, late-successional and old-growth forest ecosystems and 39,083 ac (15,816 ha) under the adaptive management area land use allocation. Threats in this subunit include current and past timber harvest, competition with barred owls, and isolation on a peninsula (along with subunit NCO–1). This subunit is expected to function primarily for demographic support of the overall population. NCO–2 is located primarily in the watersheds of the Elwha, Dungeness, Quilcene, Snow, Skokomish, and Dosewallips rivers.

Our evaluation of sites known to be occupied at the time of listing indicate that approximately 95 percent of the area of this subunit was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

NCO–3. We exempted subunit NCO–3 from the final designation of critical habitat under Section 4(a)(3) of the Act (See Exemptions section below). This subunit is comprised approximately 14,313 ac (5,792 ha) of lands managed by the Department of Defense as part of Joint Base Lewis-McChord under their integrated natural resource management plan (INRMP).

NCO–4. The NCO–4 subunit consists of approximately 179,745 ac (72,740 ha) in Clatsop, Columbia, Tillamook, and Washington Counties, Oregon, and comprises Federal lands and lands managed by the State of Oregon. Of this subunit, 117,033 ac (47,361 ha) are managed as part of the Tillamook and Clatsop State Forests for multiple uses including timber revenue production, recreation, and wildlife habitat according to the Northwest Oregon State Forest Management Plan (ODF 2010a, entire). Federal lands encompass 62,712 ac (25,379 ha) of this subunit and are managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population. This subunit is isolated from the nearest subunit to the north but is adjacent to subunit NCO–5 to the south.

Our evaluation of sites known to be occupied at the time of listing indicate that approximately 63 percent of the area of NCO–4 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider a large part of this subunit to have been occupied at the time of listing. There are some areas of younger forest in this subunit that may have been unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat in this subunit is especially important for providing for population growth and additional demographic support in this region. The development of additional suitable habitat in this subunit is needed to support viable northern spotted owl populations over the long term. The recruitment of additional suitable habitat will also contribute to the successful dispersal of northern spotted owls, and serve to buffer northern spotted owls from competition with the barred owl.

NCO–5. The NCO–5 subunit consists of approximately 142,937 ac (57,845 ha) in Yamhill, Lincoln, Tillamook, and Polk Counties, Oregon, and comprises lands managed by the State of Oregon, the BLM, and the USFS. Of this subunit 11,067 ac (4,479 ha) are managed by the State of Oregon for multiple uses including timber revenue production, recreation, and wildlife habitat according to the Northwest Oregon State Forest Management Plan (ODF 2010a, entire), and may be considered for exclusion from the final critical habitat designation. Federal lands comprise 131,870 ac (53,666 ha) and are managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population and north-south connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicate that approximately 63 percent of the area of NCO–5 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider a large part of this subunit to have been occupied at the time of listing. There are some areas of younger forest in this subunit that may have been unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat in this subunit is especially important for providing for population growth and additional demographic support in this region. The development of additional suitable habitat in this subunit is needed to support viable northern spotted owl populations over the long term. The recruitment of additional suitable habitat will also contribute to the successful dispersal of northern spotted owls, and serve to buffer northern spotted owls from competition with the barred owl.

Unit 2: Oregon Coast Ranges (OCR)

Unit 2 consists of 859,864 ac (347,975 ha) and contains six subunits. This unit consists of the southern third of the Oregon and Washington Coast Ranges Section M242A, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994a, Section M242A). We split the section in the vicinity of Otter Rock, OR, based on gradients of increased temperature and decreased moisture that result in different patterns of vegetation to the south. Generally this region is characterized by high rainfall, cool to moderate temperatures, and generally low topography (980 to 2,460 ft (300 to 750 m)). Forests in this region are dominated by western hemlock, Sitka spruce, and Douglas-fir; hardwoods are limited in species diversity (largely bigleaf maple and red alder) and distribution, and are typically limited to riparian zones. Douglas-fir and hardwood species associated with the California Floristic Province (tanoak, Pacific madrone, black oak, giant chinquapin (*Castanopsis chrysophylla*)) increase toward the southern end of the OCR. On the eastern side of the Coast Ranges crest, habitats tend to be drier and dominated by Douglas-fir. Root pathogens like laminated root rot are important gap formers, and vine maple among others fills these gaps. Because Douglas-fir dwarf mistletoe is unusual in this region, northern spotted owl nesting habitat tends to be limited to stands providing very large trees with cavities or deformities. A few nests are associated with western hemlock dwarf mistletoe. Northern spotted owl diets are dominated by species associated with mature to late-successional forests (flying squirrels, red tree voles), resulting in similar definitions of habitats used for nesting/roosting and foraging by northern spotted owls. One significant difference between OCR and NCO is that woodrats comprise an increasing proportion of the diet in the southern portion of the modeling region.

Subunit Descriptions—Unit 2

OCR–1. The OCR–1 subunit consists of approximately 110,657 ac (44,781 ha) in Polk, Benton and Lincoln Counties, Oregon, and comprises lands managed by the State of Oregon, the BLM, and the USFS. Of this subunit 6,612 ac (2,676 ha) are managed by the State of Oregon for multiple uses including timber revenue production, recreation, and wildlife habitat according to the Northwest Oregon State Forest Management Plan (ODF 2010a, entire). Federal lands comprise 104,045 ac (42,105 ha) and are managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population and north-south connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 55 percent of the area of OCR–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider a large part of this subunit to have been occupied at the time of listing. There are some areas of younger forest in this subunit that may have been unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat in this subunit is especially important for providing for population growth and additional demographic support in this region. The development of additional suitable habitat in this subunit is needed to support viable northern spotted owl populations over the long term. The recruitment of additional suitable habitat will also contribute to the successful dispersal of northern spotted owls, and serve to buffer northern spotted owls from competition with the barred owl.

OCR–2. The OCR–2 subunit consists of approximately 261,405 ac (105,787 ha) in Lane, Benton, and Lincoln Counties, Oregon, and comprises lands managed by the State of Oregon, the BLM, and the USFS. Of this subunit 18,504 ac (7,448 ha) are managed by the State of Oregon for multiple uses including timber revenue production, recreation, and wildlife habitat according to the Northwest Oregon State Forest Management Plan (ODF 2010a, entire). Federal lands comprise 242,901 ac (98,298 ha) and are managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population and north-south connectivity between subunits.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 77 percent of the area of OCR–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

OCR–3. The OCR–3 subunit consists of approximately 203,681 ac (82,427 ha) in Lane and Douglas Counties, Oregon, and comprises lands managed by the State of Oregon, the BLM, and the USFS. Of this subunit 5,082 ac (2,07 ha) are managed by the State of Oregon for multiple uses including timber revenue production, recreation, and wildlife habitat according to the Northwest Oregon State Forest Management Plan (ODF 2010a, entire). Federal lands comprise 198,599 ac (80,369 ha) and are managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population and for both north-south and east-west connectivity between subunits.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 97 percent of the area of OCR–3 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

OCR–4. The OCR–4 subunit consists of approximately 8,263 ac (3,344 ha) in Lane and Douglas Counties, Oregon, and comprises lands managed by the BLM as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for east-west connectivity between subunits and critical habitat units, and between the Oregon coast and the western Cascades.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 43 percent of the area of OCR–4 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider a large part of this subunit to have been occupied at the time of listing. There are some areas of younger forest in this subunit that may have been unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat in this subunit is especially important for providing essential connectivity between currently occupied areas to support the successful dispersal of northern spotted owls, and may also help to buffer northern spotted owls from competition with the barred owl.

OCR–5. The OCR–5 subunit consists of approximately 176,905 ac (71,591ha) in Coos and Douglas Counties, Oregon, and comprises lands managed by the State of Oregon, the BLM, and the USFS. Of this subunit 40,747 ac (16,490 ha) are managed by the State of Oregon for multiple uses including sustained economic benefit through timber harvest and management, recreation, and wildlife habitat according to the Elliot State Forest Management Plan (ODF 2011, entire). Federal lands comprise 136,158 ac (55,101 ha) and are managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population and for north-south, and potentially east-west, connectivity between subunits.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 94 percent of the area of OCR–5 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

OCR–6. The OCR–6 subunit consists of approximately 81,900 ac (33,144 ha) in Coos and Douglas Counties, Oregon, and comprises lands managed by the BLM as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population and for north-south connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 97 percent of the area of OCR–6 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Unit 3: Redwood Coast (RWC)

Unit 3 contains 180,855ac (73,189ha) and three subunits. This unit consists of the Northern California Coast Ecological Section 263, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994b, entire). This region is characterized by low-lying terrain (0 to 2,950 ft (0 to 900 m)) with a maritime climate, generally mesic conditions, and moderate temperatures. Climatic conditions are rarely limiting to northern spotted owls at all elevations. Forest communities are dominated by redwood, Douglas-fir-tanoak forest, coast live oak, and tanoak series. The vast majority of the region is in private ownership, dominated by a few large industrial timberland holdings. The results of numerous studies of northern spotted owl habitat relationships suggest stump-sprouting and rapid growth rates of redwoods, combined with high availability of woodrats in patchy, intensively managed forests, enables northern spotted owls to maintain high densities in a wide range of habitat conditions within the Redwood zone.

Subunit Descriptions—Unit 3

RDC–1. This subunit contains 63,127 ac (25,547 ha) of lands managed by the USFS and BLM in Curry County, Oregon and in Del Norte, Humboldt, and Trinity Counties, California. Special management considerations or protection are required in this subunit to address threats from the barred owl. Suitable habitat within the subunit is relatively contiguous north-to-south, and is capable of supporting a sustainable subpopulation of owls. We expect that this subunit will provide strong connectivity among the adjacent critical habitat units to the north (OCR) and east (KLW, ICC). The subunit is weakly connected to the adjacent subunit to the south (RDC–2).

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 78 percent of the area of RDC–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

RDC–2. This subunit contains 65,391 ac (26,463 ha) in Mendocino and southwestern Humboldt Counties, California. There are 16,479 ac (6,669 ha) of Federal lands in the subunit, managed by the Bureau of Land Management. The California Department of Forestry and Fire Protection operates the Jackson Demonstration State Forest (48,912 ac (19,794 ha)) for multiple uses including timber production, water quality, wildlife habitat, and research.

Special management considerations or protection are required in this subunit to address threats from the barred owl. Suitable habitat within the subunit is relatively contiguous north-to-south, and is capable of supporting a sustainable subpopulation of owls. The subunit is weakly connected to the adjacent CHU to the east (ICC) and to the coastal subunit to the north (RDC–1); it is relatively well connected to the coastal subunit to the south (RDC–3).

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 85 percent of the area of RDC–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

RDC–3. This subunit was comprised entirely of private lands, which have been excluded from the final rule.

RDC–4. This subunit was comprised entirely of private lands, which have been excluded from the final rule.

RDC–5. This subunit contains 20,684 ac (8,371 ha) in southern Marin County, California and represents the southern range limit of the subspecies. No private lands are contained in this subunit. The Mount Tamalpais Watershed (18,900 ac (7,649 ha)) of the Marin Municipal Water District is included in the final critical habitat designation. Six Open Space Preserves (OSPs) in the Marin County Parks and Open Space System, totaling 3,627 ac (1,468 ha), are included in the final critical habitat designation, including Gary Giacomini, White Hill, Cascade Canyon, Baltimore Canyon, Camino Alto, and Blithedale Summit OSPs. Special management considerations or protection are required in this subunit to address incipient threats from the barred owl. Suitable habitat within the subunit is continuous from east to west. It is unknown whether this subunit is capable of supporting a self-sustaining subpopulation of owls without support from the subunit to the north (RDC–4). The lands between this subunit and the nearest subunit to the east (ICC–6) are dominated by agricultural and urban land use, and are very weakly connected.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 82 percent of the area of RDC–5 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Unit 4: West Cascades North (WCN)

This unit contains 542,274 ac (219,450 ha) and two subunits. This unit coincides with the northern Western Cascades Section M242B, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994a, Section M242B), combined with the western portion of M242D (Northern Cascades Section), extending from the U.S.-Canadian border south to Snoqualmie Pass in central Washington. It is similar to the Northern Cascades Province of Franklin and Dyrness (1988, pp. 17–20). This region is characterized by high mountainous terrain with extensive areas of glaciers and snowfields at higher elevation. The marine climate brings high precipitation (both annual and summer) but is modified by high elevations and low temperatures over much of this modeling region. The resulting distribution of forest vegetation is dominated by subalpine species, mountain hemlock and silver fir; the western hemlock and Douglas-fir forests typically used by northern spotted owls are more limited to lower elevations and river valleys (northern spotted owls are rarely found at elevations greater than 4,200 ft (1,280 m) in this region) grading into the mesic Puget lowland to the west.

Subunit Descriptions—Unit 4

WCN–1. The WCN–1 subunit consists of approximately 438,255 ac (177,355 ha) in Whatcom, Skagit, and Snohomish Counties, Washington, and comprises lands managed by the USFS and the State of Washington. The USFS manages 320,146 ac (129,559 ha) as Late-successional Reserves to maintain functional, interactive, late-successional, and old-growth forest ecosystems and 6,147 ac (2,487 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest, competition with barred owls, steep topography with high-elevation ridges that separate relatively small, linear strips of suitable habitat in valley bottoms, and location at the northern limit of the subspecies range. This subunit is expected to function primarily for demographic support of the overall population and to maintain the subspecies distribution in the northernmost portion of its range. WCN–1 is located in the watersheds of the Stillaguamish, Skagit, and Nooksack rivers, and is bounded on the north by the international boundary with British Columbia, Canada. In this subunit, we have excluded lands covered under the Washington Department of Natural Resources State Lands HCP.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 92 percent of the area of WCN–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

WCN–2. The WCN–2 subunit consists of approximately 103,988 ac (42,083 ha) in King and Snohomish Counties, Washington, and comprises lands managed by the USFS, State of Washington, and private landowners. The USFS manages 82,316 ac (33,312 ha) as Late-successional Reserves to maintain functional, interactive, late-successional, and old-growth forest ecosystems and 834 ac (338 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest, competition with barred owls, and steep topography with high-elevation ridges that separate relatively small, linear strips of suitable habitat in valley bottoms. This subunit has a key role in maintaining connectivity between northern spotted owl populations, both north to south in the West Cascades and west to east between the West and East Cascades units. This role is shared with the WCC–1 subunit to the south and the ECN–4 subunit to the east. This subunit is also expected to provide demographic support of the overall population. WCN–2 is located in the watersheds of the Snohomish and Cedar/Sammamish Rivers. In this subunit, we have excluded lands covered under the Washington Department of Natural Resources State Lands HCP in the final designation.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 79 percent of the area of WCN–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Unit 5: West Cascades Central (WCC)

This unit contains 909,687 ac (368,136 ha) and three subunits. This region consists of the midsection of the Western Cascades Section M242B, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994a, Section M242B), extending from Snoqualmie Pass in central Washington south to the Columbia River. It is similar to the Southern Washington Cascades Province of Franklin and Dyrness (1988, pp. 21–23). We separated this region from the northern section based on differences in northern spotted owl habitat due to relatively milder temperatures, lower elevations, and greater proportion of western hemlock/Douglas-fir forest and occurrence of noble fir (*A. procera*) to the south of Snoqualmie Pass. Because Douglas-fir dwarf mistletoe occurs rarely in this region, northern spotted owl nest sites are largely limited to defects in large trees, and occasionally nests of other raptors.

Subunit Descriptions—Unit 5

WCC–1. The WCC–1 subunit consists of approximately 225,847 ac (91,397 ha) in King, Pierce, Thurston, Lewis, Kittitas, and Yakima Counties, Washington, and comprises lands managed by USFS and State of Washington. The USFS manages 183,884 ac (76,843 ha) as Late-successional Reserves to maintain functional, interactive, late-successional, and old-growth forest ecosystems and 35,145 ac (14,222 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest, competition with barred owls, and stand conversion. This subunit is expected to provide demographic support of the overall population and to maintain demographic connectivity between the Cascade Range and the Olympic Peninsula in conjunction with subunit NCO–3. WCC–1 is located primarily in the watersheds of the Nisqually, Puyallup, White, Duwamish, and Green Rivers. In this subunit, we have excluded lands from our final critical habitat designation that are covered under the Washington Department of Natural Resources State Lands HCP, the Cedar River Watershed HCP, the Plum Creek Timber Central Cascades HCP, the West Fork Timber HCP, the Tacoma Water Green River Water Supply Operations and Watershed Protection HCP as well as other private lands from the final designation.

Our evaluation of sites known to be occupied at the time of listing indicate that approximately 96 percent of the area of WCC–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

WCC–2. The WCC–2 subunit consists of approximately 279,445 ac (113,087 ha) in Pierce, Lewis, Cowlitz, Skamania, and Yakima Counties, Washington, and comprises lands managed by USFS, State of Washington, and private landowners. The USFS manages 92,835 ac (37,569 ha) as Late-successional Reserves to maintain functional, interactive, late-successional, and old-growth forest ecosystems and 88,655 ac (35,878 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest and competition with barred owls. This subunit is expected to provide demographic support of the overall population. WCC–2 is located primarily in the Cowlitz River watersheds west of the Cascade Crest and the headwaters of the Naches River watershed east of the Crest. In this subunit, we have excluded lands covered under the Washington Department of Natural Resources State Lands HCP, the West Fork Timber HCP, and the Port Blakely Tree Farms L.P. (Morton Block) SHA, Landowner Option Plan, and Cooperative Habitat Enhancement Agreement in the final critical habitat designation.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 96 percent of the area of WCC–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

WCC–3. The WCC–3 subunit consists of approximately 394,501 ac (159,649 ha) in Clark, Skamania, and Yakima Counties, Washington, and comprises lands managed by the USFS, the State of Washington, and private landowners. The USFS manages 242,929 ac (98,310 ha) as Late-successional Reserves to maintain functional, interactive, late-successional, and old-growth forest ecosystems and 122,641 ac (49,631 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest, competition with barred owls, and the Columbia River as an impediment to northern spotted owl dispersal. This subunit is expected to provide demographic support of the overall population and an opportunity for demographic exchange between the WCC Unit and the WCS Unit. WCC–3 is located primarily in the watersheds of the Lewis, Wind, and White Salmon Rivers, and is bounded on the south by the Columbia River. In this subunit, we have excluded lands covered under the Washington Department of Natural Resources State Lands HCP from critical habitat designation.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 96 percent of the area of WCC–3 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Unit 6: West Cascades South (WCS)

Unit 6 contains 1,355,198ac (548,429 ha) and contains six subunits. This unit consists of the southern portion of the Western Cascades Section M242B, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994a, Section M242B), and extends from the Columbia River south to the North Umpqua River. We separated this region from the northern section due to its relatively milder temperatures, reduced summer precipitation due to the influence of the Willamette Valley to the west, lower elevations, and greater proportion of western hemlock/Douglas-fir forest. The southern portion of this region exhibits a gradient between Douglas-fir/western hemlock and increasing Klamath-like vegetation (mixed conifer/evergreen hardwoods), which continues across the Umpqua divide area. The southern boundary of this region is novel and reflects a transition to mixed-conifer forest (Franklin and Dyrness 1988, pp. 23–24, 137–143). The importance of Douglas-fir dwarf mistletoe increases to the south in this region, but most northern spotted owl nest sites are found in defective large trees, and occasionally nests of other raptors.

Subunit Descriptions—Unit 6

WCS–1. The WCS–1 subunit consists of approximately 92,586 ac (37,468 ha) in Multnomah, Hood River, and Clackamas Counties, Oregon, and comprises only Federal lands managed by the BLM and the USFS under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south and east-west connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 88 percent of the area of WCS–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

WCS–2. The WCS–2 subunit consists of approximately 150,105 ac (60,745 ha) in Clackamas, Marion, and Wasco Counties, Oregon, and comprises only Federal lands managed by the BLM and the USFS under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south connectivity between subunits.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 82 percent of the area of WCS–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011 p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

WCS–3. The WCS–3 subunit consists of approximately 319,736 ac (129,393 ha) in Clackamas, Marion, Linn, and Lane Counties, Oregon, and comprises lands managed by the State of Oregon, the BLM, and the USFS. Of this subunit, 184 ac (75 ha) are managed by the State of Oregon primarily for recreation (Oregon Administrative Rules, Chapter 736, entire). The remaining 319,552 ac (129,318 ha) are Federal lands managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south connectivity between subunits.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 85 percent of the area of WCS–3 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

WCS–4. The WCS–4 subunit consists of approximately 379,130 ac (153,429 ha) in Lane and Douglas Counties, Oregon, and comprises only Federal lands managed by the BLM and the USFS under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south connectivity between subunits.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 86 percent of the area of WCS–4 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

WCS–5. The WCS–5 subunit consists of approximately 356,415 ac (144,236 ha) in Lane and Douglas Counties, Oregon, and comprises only Federal lands managed by the USFS under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south and east-west connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 83 percent of the area of WCS–5 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

WCS–6. The WCS–6 subunit consists of approximately 99,558 ac (40,290 ha) in Lane, Klamath, and Douglas Counties, Oregon, and is managed by the BLM and the USFS as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest and competition with barred owls. This subunit is expected to function primarily for east-west connectivity between subunits and critical habitat units, and between the Oregon coast and the western Cascades.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 97 percent of the area of WCS–6 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Unit 7: East Cascades North (ECN)

Unit 7 contains 1,345,523ac (557,002 ha) and nine subunits. This unit consists of the eastern slopes of the Cascade range, extending from the Canadian border south to the Deschutes National Forest near Bend, OR. Terrain in portions of this region is glaciated and steeply dissected. This region is characterized by a continental climate (cold, snowy winters and dry summers). High-frequency, low-intensity fire regimes occur at lower elevations, mid elevations have mixed-severity regimes, and high elevations have high-severity regimes. Increased precipitation from marine air passing east through Snoqualmie Pass and the Columbia River has resulted in an increase of moist forest conditions in this region (Hessburg *et al.* 2000b, p. 165). In Washington, ponderosa pine and Douglas-fir forest are dominant at low elevations, Douglas-fir/grand fir mixed-conifer forest are characteristic of mid-elevations, and higher elevations support forests of silver fir, hemlock, and subalpine fir. The terrain is highly dissected and mountainous. The terrain and ecology are different on the southern portion of the unit, where ponderosa pine predominates on flat terrain at low elevations, and owl habitat is restricted to buttes and the slopes of the Cascade Range in forests of Douglas-fir, grand/white fir, and true firs. There is substantially less habitat in the Deschutes area of Oregon compared to the area north of Sisters, Oregon, and into Washington. The bulk of owls in this Unit are in Washington.

Forest composition, particularly the presence of grand fir and western larch, distinguishes this modeling region from the southern section of the eastern Cascades. While ponderosa pine forest dominates lower and middle elevations in both this and the southern section, the northern section supports grand fir and Douglas-fir habitat at middle elevations. Dwarf mistletoe provides an important component of nesting habitat, enabling northern spotted owls to nest within stands of relatively younger and smaller trees.

Subunit Descriptions—Unit 7

ECN–1. The ECN–1 subunit consists of approximately 101,661 ac (41,141 ha) in Whatcom, Skagit, and Okanogan Counties, Washington, and comprises lands managed by USFS. The USFS manages 60,173 ac (24,351 ha) as Late-successional Reserves to maintain functional, interactive, late-successional and old-growth forest ecosystems and 22,802 ac (9,228 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest; competition with barred owls; removal or modification of habitat by forest fires, insects, and diseases; steep topography with high-elevation ridges that separate relatively small, linear strips of suitable habitat in valley bottoms; and location at the northeastern limit of the range of the subspecies. This subunit is expected to provide demographic support of the overall population and maintain the subspecies distribution in the northeastern portion of its range. ECN–1 is located primarily in the watershed of the Methow River and includes a small portion of the upper Skagit River watershed. It is bounded on the north by the international boundary with British Columbia, Canada.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 41 percent of the area of ECN–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECN–2. The ECN–2 subunit consists of approximately 60,128 ac (24,333 ha) in Chelan County, Washington, and comprises lands managed by USFS. The USFS manages 35,835 ac (14,502 ha) as Late-successional Reserves to maintain functional, interactive, late-successional and old-growth forest ecosystems and 17,545 ac (7,100 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest; competition with barred owls; steep topography with high-elevation ridges that separate relatively small, linear strips of suitable habitat in valley bottoms; the combination of Lake Chelan and the Sawtooth Mountains acting as a barrier to dispersal; and removal or modification of habitat by forest fires, insects, and diseases. This subunit is expected to provide demographic support of the overall population. ECN–2 is located primarily in the watersheds of the Chelan and Entiat Rivers.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 34 percent of the area of ECN–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECN–3. The ECN–3 subunit consists of approximately 301,219 ac (121,899 ha) in Chelan County, Washington, and comprises lands managed by the USFS and private landowners. The USFS manages 187,103 ac (75,718 ha) as Late-successional Reserves to maintain functional, interactive, late-successional and old-growth forest ecosystems and 114,117 ac (46,181 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest, competition with barred owls, and removal or modification of habitat by forest fires, insects, and diseases. This subunit is expected to provide demographic support of the overall population. ECN–3 is located primarily in the watershed of the Wenatchee River. In this subunit, we have excluded private lands and lands covered under the Washington Department of Natural Resources State Lands HCP.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 71 percent of the area of ECN–3 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECN–4. The ECN–4 subunit consists of approximately 222,818 ac (90,171 ha) in Kittitas County, Washington, and comprises lands managed by the USFS and the State of Washington. The USFS manages 99,641 ac (40,323 ha) as Late-successional Reserves to maintain functional, interactive, late-successional, and old-growth forest ecosystems and 118,676 ac (48,027 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. The Washington Department of Fish and Wildlife manages 4,498 ac (1,820 ha). Threats in this subunit include current and past timber harvest, competition with barred owls, and removal or modification of habitat by forest fires, insects, and diseases. This subunit is expected to provide demographic support of the overall population. This subunit also has a key role in maintaining connectivity between northern spotted owl populations, both north to south in the East Cascades North Unit and west to east between the West and East Cascades units. This role is shared with the WCN–2 subunit and the WCC–1 subunit to the west. ECN–4 is located primarily in the Upper Yakima River watershed. In this subunit, we have excluded private lands and lands covered under the Washington Department of Natural Resources State Lands HCP and the Plum Creek Timber Central Cascades HCP.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 78 percent of the area of ECN–4 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECN–5. The ECN–5 subunit consists of approximately 201,108 ac (81,415 ha) in Kittitas and Yakima Counties, Washington, and comprises lands managed by the USFS and the State of Washington. The USFS manages 115,289 ac (46,656 ha) as Late-successional Reserves to maintain functional, interactive, late-successional, and old-growth forest ecosystems and 83,849 ac (33,933 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest, competition with barred owls, and removal or modification of habitat by forest fires, insects, and diseases. This subunit is expected to provide demographic support of the overall population. ECN–5 is located primarily in the watershed of the Naches River. In this subunit, we have excluded from final critical habitat designation lands covered under the Washington Department of Natural Resources State Lands HCP, the Plum Creek Timber Central Cascades HCP, and private lands.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 85 percent of the area of ECN–5 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECN–6. The ECN–6 subunit consists of approximately 81,852 ac (33,124 ha) in Skamania, Yakima, and Klickitat Counties, Washington, and comprises lands managed by the USFS and the State of Washington. The USFS manages 32,400 ac (13,112 ha) as Late-successional Reserves to maintain functional, interactive, late-successional, and old-growth forest ecosystems; and 49,452 ac (20,012 ha) under the matrix land use allocation where multiple uses occur, including most timber harvest and other silvicultural activities. Threats in this subunit include current and past timber harvest, competition with barred owls, and the Columbia River as an impediment to northern spotted owl dispersal. This subunit is expected to provide demographic support of the overall population. ECN–6 is located primarily in the watersheds of the Klickitat and White Salmon Rivers, and is bounded on the south by the Columbia River. In this subunit, we have excluded lands covered under the Washington Department of Natural Resources State Lands HCP as well as private lands from the final designation.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 88 percent of the area of ECN–6 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECN–7. The ECN–7 subunit consists of approximately 139,983 ac (56,649 ha) in Hood River and Wasco Counties, Oregon, and comprises only Federal lands managed by the USFS under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest, removal or modification of habitat by forest fires and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south and east-west connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that nearly 100 percent of the area of ECN–7 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECN–8. The ECN–8 subunit consists of approximately 94,622 ac (38,292 ha) in Jefferson and Deschutes Counties, Oregon, of Federal lands managed by the USFS under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south connectivity between subunits.

Our evaluation of sites known to be occupied at the time of listing indicate that approximately 61 percent of the area of ECN–8 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECN–9. The ECN–9 subunit consists of approximately 155,434 ac (62,902 ha) in Deschutes and Klamath Counties, Oregon, and comprises only Federal lands managed by the USFS under the NWFP (USDA and USDI 1994). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 45 percent of the area of ECN–9 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Unit 8: East Cascades South (ECS)

Unit 8 contains 368,381 ac (149,078 ha) and three subunits. This unit incorporates the Southern Cascades Ecological Section M261D, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994c, Section M261D) and the eastern slopes of the Cascades from the Crescent Ranger District of the Deschutes National Forest south to the Shasta area. Topography is gentler and less dissected than the glaciated northern section of the eastern Cascades. A large expanse of recent volcanic soils (pumice region) (Franklin and Dyrness 1988, pp. 25–26), large areas of lodgepole pine, and increasing presence of red fir (*Abies magnifica*) and white fir (and decreasing grand fir) along a south-trending gradient further supported separation of this region from the northern portion of the eastern Cascades. This region is characterized by a continental climate (cold, snowy winters and dry summers) and a high-frequency/low-mixed severity fire regime. Ponderosa pine is a dominant forest type at mid-to-lower elevations, with a narrow band of Douglas-fir and white fir at middle elevations providing the majority of northern spotted owl habitat. Dwarf mistletoe provides an important component of nesting habitat, enabling northern spotted owls to nest within stands of relatively younger, smaller trees.

Subunit Descriptions—Unit 8

ECS–1. The ECS–1 subunit consists of approximately 127,801 ac (51,719 ha) in Klamath, Jackson, and Douglas Counties, Oregon, and comprises lands managed by the BLM and the USFS. Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south and east-west connectivity between subunits and critical habitat units. This subunit is adjacent to ECS–2 to the south.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 78 percent of the area of ECS–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECS–2. The ECS–2 subunit consists of approximately 66,086 ac (26,744 ha) in Klamath and Jackson Counties, Oregon, and Siskiyou County, California, all of which are Federal lands managed by the BLM and USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for north-south connectivity between subunits, but also for demographic support in this area of sparse Federal land and sparse high-quality nesting habitat.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 77 percent of the area of ECS–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ECS–3. The ECS–3 subunit consists of approximately 112,179 ac (45,397 ha) in Siskiyou County, California, all of which are Federal lands managed by the USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. The function of this subunit is to provide demographic support in this area of sparsely distributed high-quality habitat and Federal land, and to provide for population connectivity between subunits to the north and south.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 69 percent of the area of ECS–3 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider a large part of this subunit to have been occupied at the time of listing. There are some areas of younger forest in this subunit that may have been unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat in this subunit is especially important for providing essential connectivity between currently occupied areas to support the successful dispersal of northern spotted owls, and may also help to buffer northern spotted owls from competition with the barred owl.

Unit 9: Klamath West (KLW)

Unit 9 contains 1,197,389 ac (484,565 ha) and nine subunits. This unit consists of the western portion of the Klamath Mountains Ecological Section M261A, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994c, Section M261A). A long north-south trending system of mountains (particularly South Fork Mountain) creates a rainshadow effect that separates this region from more mesic conditions to the west. This region is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and the influence of marine air (relatively high potential precipitation). These conditions support a highly diverse mix of mesic forest communities such as Pacific Douglas-fir, Douglas-fir tanoak, and mixed evergreen forest interspersed with more xeric forest types. Overall, the distribution of tanoak is a dominant factor distinguishing the Western Klamath Region. Douglas-fir dwarf mistletoe is uncommon and seldom used for nesting platforms by northern spotted owls. The prey base of northern spotted owls within the Western Klamath is diverse, but dominated by woodrats and flying squirrels.

Subunit Descriptions—Unit 9

KLW–1. The KLW–1 subunit consists of approximately 147,326 ac (59,621 ha) in Douglas, Josephine, Curry, and Coos Counties, Oregon, and comprises lands managed by the State of Oregon and the BLM. Of this subunit 7,682 ac (3,109 ha) are managed by the State of Oregon for multiple uses including timber revenue production, recreation, and wildlife habitat according to the Southwest Oregon State Forests Management Plan (ODF 2010b, entire). Federal lands comprise 139,644 ac (56,512 ha) and are managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support to the overall population and for north-south and east-west connectivity between subunits and critical habitat units. This subunit sits at the western edge of an important connectivity corridor between coastal Oregon and the western Cascades.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 96 percent of the area of KLW–1was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLW–2. The KLW–2 subunit consists of approximately 148,929 ac (60,674 ha) in Josephine, Curry, and Coos Counties, Oregon, and comprises lands managed by the USFS and the BLM as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support to the overall population and for north-south and east-west connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 71 percent of the area of KLW–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLW–3. The KLW–3 subunit consists of approximately 143,862 ac (58,219 ha) in Josephine, Curry, and Coos Counties, Oregon, and comprises lands managed by the USFS, the BLM and the State of Oregon. There are 142,982 ac (57,863 ha) of Federal lands managed as directed by the NWFP (USDA and USDI 1994, entire). The 880 ac (356 ha) of State of Oregon lands are managed according to the Southwest Oregon State Forests Management Plan (ODF 2010b, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support to the overall population and for north-south connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 88 percent of the area of KLW–3 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLW–4. The KLW–4 subunit consists of approximately 158,299 ac (64,061 ha) in Josephine and Jackson Counties, Oregon, and Del Norte and Siskiyou Counties, California, and comprises lands managed by the USFS and the BLM that are managed as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support to the overall population and for north-south and east-west connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 95 percent of the area of KLW–4 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLW–5. The KLW–5 subunit consists of approximately 31,085 ac (12,580 ha) in Josephine County, Oregon, and Del Norte and Siskiyou Counties, California, all of which are Federal lands managed by the BLM and USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 98 percent of the area of KLW–5 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLW–6. The KLW–6 subunit consists of approximately 117,545 ac (47,569 ha) in Del Norte, Humboldt, and Siskiyou Counties, California, all of which are Federal lands managed by the USFS as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 91 percent of the area of KLW–6 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLW–7. The KLW–7 subunit consists of approximately 255,779 ac (103,510 ha) in Del Norte, Humboldt, and Siskiyou Counties, California, all of which are Federal lands managed by the BLM and USFS as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential or physical features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 91 percent of the area of KLW–7 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLW–8. The KLW–8 subunit consists of approximately 114,287 ac (46,250 ha) in Siskiyou and Trinity Counties, California, all of which are Federal lands managed by the BLM and USFS as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 85 percent of the area of KLW–8 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLW–9. The KLW–9 subunit consists of approximately 149,656 ac (60,564 ha) in Humboldt and Trinity Counties, California, all of which are Federal lands managed by the USFS as directed by the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 89 percent of the area of KLW–9 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Unit 10: Klamath East (KLE)

Unit 10 contains 1,052,731ac (426,025ha) and seven subunits. This unit consists of the eastern portion of the Klamath Mountains Ecological Section M261A, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994c, Section M261A), and portions of the Southern Cascades Ecological Section M261D in Oregon. This region is characterized by a Mediterranean climate, greatly reduced influence of marine air, and steep, dissected terrain. Franklin and Dyrness (1988, pp. 137–149) differentiate the mixed-conifer forest occurring on the ‘‘Cascade side of the Klamath from the more mesic mixed evergreen forests on the western portion (Siskiyou Mountains),’’ and Kuchler (1977) separates out the eastern Klamath based on increased occurrence of ponderosa pine. The mixed-conifer/evergreen hardwood forest types typical of the Klamath region extend into the southern Cascades in the vicinity of Roseburg and the North Umpqua River, where they grade into the western hemlock forest typical of the Cascades. High summer temperatures and a mosaic of open forest conditions and Oregon white oak (*Quercus garryana*) woodlands act to influence northern spotted owl distribution in this region. Northern spotted owls occur at elevations up to 1,768 m. Dwarf mistletoe provides an important component of nesting habitat, providing additional structure and enabling northern spotted owls to occasionally nest within stands of relatively younger, small trees.

Subunit Descriptions—Unit 10

KLE–1. The KLE–1 subunit consists of approximately 242,338 ac (98,071 ha) in Jackson and Douglas Counties, Oregon, and comprises Federal lands managed by the USFS and the BLM under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support to the overall population, as well as north-south and east-west connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 84 percent of the area of KLE–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLE–2. The KLE–2 subunit consists of approximately 101,942 ac (41,255 ha) in Josephine and Douglas Counties, Oregon, and comprises Federal lands managed by the USFS and the BLM under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for east-west connectivity between subunits and critical habitat units, but also for demographic support. This subunit facilitates northern spotted owl movements between the western Cascades and coastal Oregon and the Klamath Mountains.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 92 percent of the area of KLE–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLE–3. The KLE–3 subunit consists of approximately 111,410 ac (45,086 ha) in Jackson, Josephine, and Douglas Counties, Oregon, and comprises Federal lands managed by the USFS and the BLM under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for east-west connectivity between subunits and critical habitat units, but also for demographic support. This subunit facilitates northern spotted owl movements between the western Cascades and coastal Oregon and the Klamath Mountains.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 97 percent of the area of KLE–3 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLE–4. The KLE–4 subunit consists of approximately 254,442 ac (102,969 ha) in Jackson, Klamath, and Douglas Counties, Oregon, and comprises Federal lands managed by the USFS and the BLM under the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for east-west connectivity between subunits and critical habitat units, but also for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 81 percent of the area of KLE–4 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLE–5. The KLE–5 subunit consists of approximately 38,283 ac (15,493 ha) in Jackson County, Oregon, and comprises lands managed by the BLM and USFS. The BLM and USFS lands are managed per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for north-south connectivity between subunits, but also for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 86 percent of the area of KLE–5 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLE–6. The KLE–6 subunit consists of approximately 167,849 ac (67,926 ha) in Jackson County, Oregon, and Siskiyou County, California, all of which are Federal lands managed by the BLM and USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for north-south connectivity between subunits, but also for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 97 percent of the area of KLE–6 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

KLE–7. The KLE–7 subunit consists of approximately 66,078 ac (26,741 ha) in Siskiyou County, California, all of which are Federal lands managed by the BLM and USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function for demographic support and also for connectivity across the landscape.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 96 percent of the area of KLE–7 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

Unit 11: Interior California Coast (ICC)

Unit 11 contains 941,568 ac (381,039 ha) and eight subunits. This unit consists of the Northern California Coast Ranges ecological Section M261B, based on section descriptions of forest types from Ecological Subregions of the United States (McNab and Avers 1994c, Section M261B), and differs markedly from the adjacent redwood coast region. Marine air moderates winter climate, but precipitation is limited by rainshadow effects from steep elevational gradients (328 to 7,847 ft (100 to 2,400 m)) along a series of north-south trending mountain ridges. Due to the influence of the adjacent Central Valley, summer temperatures in the interior portions of this region are among the highest within the northern spotted owl's range. Forest communities tend to be relatively dry mixed-conifer, blue and Oregon white oak, and the Douglas-fir tanoak series. Northern spotted owl habitat within this region is poorly known; there are no Demographic Study Areas (DSAs—areas within forested habitats specifically surveyed to determine northern spotted owl occupation and density), and few studies have been conducted here. Northern spotted owl habitat and occupancy data obtained during this project suggests that some northern spotted owls occupy steep canyons dominated by live oak and Douglas-fir. The distribution of dense conifer habitats most suitable for the northern spotted owl is limited to higher elevations on the Mendocino National Forest.

Subunit Descriptions—Unit 11

ICC–1. The ICC–1 subunit consists of approximately 332,042 ac (134,372 ha) in Humboldt, Trinity, Shasta, and Tehama Counties, California, all of which are Federal lands managed by the BLM and the USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support, but also for connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 97 percent of the area of ICC–1 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ICC–2. The ICC–2 subunit consists of approximately 204,400 ac (82,718 ha) in Humboldt and Trinity Counties, California, all of which are Federal lands managed by the BLM and the USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support, but also for connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 98 percent of the area of ICC–2 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ICC–3. The ICC–3 subunit consists of approximately 103,971 ac (42,035 ha) in Trinity, Tehama, and Mendocino Counties, California, all of which are Federal lands managed by the BLM and the USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support, but also for north-south connectivity between subunits.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 89 percent of the area of ICC–3 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ICC–4. The ICC–4 subunit consists of approximately 120,997 ac (48,966 ha) in Mendocino, Glenn, and Colusa Counties, California, all of which are Federal lands managed by the BLM and USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 93 percent of the area of ICC–4 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ICC–5. The ICC–5 subunit consists of approximately 34,957 ac (14,147 ha) in Lake and Mendocino Counties, California, all of which are Federal lands managed by the USFS and BLM per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function primarily for demographic support, but also for connectivity between subunits and critical habitat units.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 78 percent of the area of ICC–5 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ICC–6. The ICC–6 subunit consists of approximately 2,072 ac (839 ha) of State and Federal lands in Napa and Sonoma Counties, California.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 90 percent of the area of ICC–6 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ICC–7. The ICC–7 subunit consists of approximately 119,742 ac (48,458 ha) in Trinity and Shasta Counties, California, all of which are Federal lands managed by the BLM and USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats to the essential physical or biological features from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function both for demographic support and for east-west connectivity between subunits in an area of sparse Federal ownership.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 73 percent of the area of ICC–7 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

ICC–8. The ICC–8 subunit consists of approximately 83,376 ac (33,742 ha) in Siskiyou and Shasta Counties, California, all of which are Federal lands managed by the BLM and the USFS per the NWFP (USDA and USDI 1994, entire). Special management considerations or protection are required in this subunit to address threats from current and past timber harvest, losses due to wildfire and the effects on vegetation from fire exclusion, and competition with barred owls. This subunit is expected to function both for demographic support and for connectivity between subunits in an area of sparse Federal ownership.

Our evaluation of sites known to be occupied at the time of listing indicates that approximately 84 percent of the area of ICC–8 was covered by verified northern spotted owl home ranges at the time of listing. When combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for the continued maintenance and recruitment of northern spotted owl habitat (USFWS 2011, p. ix). The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.

IX. Effects of Critical Habitat Designation

Section 7 Consultation

Section 7(a)(2) of the Act requires Federal agencies, including the Service, to ensure that any action they fund, authorize, or carry out is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or determinations of designated critical habitat of such species. Decisions by the Fifth and Ninth Circuit Courts of Appeals have invalidated our regulatory definition of ''destruction or adverse modification'' (50 CFR 402.02) (*Gifford Pinchot Task Force* v. *U.S. Fish and Wildlife Service,* 378 F. 3d 1059 (9th Cir. 2004); *Sierra Club* v. *U.S. Fish and Wildlife Service.,* 245 F.3d 434, 442 (5th Cir. 2001)), and we do not rely on this regulatory definition when analyzing whether an action is likely to destroy or adversely modify critical habitat. Under the statutory provisions of the Act, we determine destruction or adverse modification on the basis of whether, with implementation of the proposed Federal action, the affected critical habitat would continue to serve its intended conservation function or purpose for the species.

If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency (action agency) must enter into consultation with the Service. Examples of actions that are subject to the section 7 consultation process are actions on State, Indian, local, or private lands that require a Federal permit (such as a permit from the U.S. Army Corps of Engineers under section 404 of the Clean Water Act (33 U.S.C. 1251 *et seq.*) or a permit from the Service under section 10 of the Act) or that involve some other Federal action (such as funding from the Federal Highway Administration, Federal Aviation Administration, or the Federal Emergency Management Agency). Federal actions not affecting listed species or critical habitat, and actions on State, Indian, local, or private lands that are not federally funded or federally authorized do not require section 7 consultation.

Section 7 consultation results in issuance of:

(1) A concurrence letter for Federal actions that may affect, but are not likely to adversely affect, listed species or critical habitat; or

(2) A biological opinion for Federal actions that may affect, and are likely to adversely affect, listed species or critical habitat.

When we issue a biological opinion concluding that a project is likely to jeopardize the continued existence of a listed species and/or destroy or adversely modify critical habitat, we provide reasonable and prudent alternatives to the project, if any are identifiable, that would avoid the likelihood of jeopardy and/or destruction or adverse modification of critical habitat. We define ''reasonable and prudent alternatives'' (at 50 CFR 402.02) as alternative actions identified during consultation that:

(1) Can be implemented in a manner consistent with the intended purpose of the action,

(2) Can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction,

(3) Are economically and technologically feasible, and

(4) Would, in the Director's opinion, avoid the likelihood of jeopardizing the continued existence of the listed species and/or avoid the likelihood of destroying or adversely modifying critical habitat.

Reasonable and prudent alternatives can vary from slight project modifications to extensive redesign or relocation of the project. Costs associated with implementing a reasonable and prudent alternative are similarly variable.

Regulations at 50 CFR 402.16 require Federal agencies to reinitiate consultation on previously reviewed actions in instances where we have listed a new species or subsequently designated critical habitat that may be affected, and the Federal agency has retained discretionary involvement or control over the action, or the agency's discretionary involvement or control is authorized by law. Consequently, Federal agencies sometimes may need to request reinitiation of consultation with us on actions for which formal consultation has been completed, if those actions with discretionary involvement or control may affect subsequently listed species or designated critical habitat.

Determinations of Adverse Effects and Application of the ''Adverse Modification'' Standard

The key factor involved in the destruction/adverse modification determination for a proposed Federal agency action is whether the affected critical habitat would continue to serve its intended conservation function or purpose for the species with implementation of the proposed action after taking into account any anticipated cumulative effects (USFWS 2004, *in litt.* entire). Activities that may destroy or adversely modify critical habitat are those that alter the physical or biological features to an extent that appreciably reduces the conservation value of critical habitat for the northern spotted owl. As discussed above, the role of critical habitat is to support life-history needs of the species and provide for the conservation of the species.

Section 4(b)(8) of the Act requires us to briefly evaluate and describe, in any proposed or final regulation that designates critical habitat, activities involving a Federal action that may destroy or adversely modify such habitat, or that may be affected by such designation.

Activities that may affect critical habitat, when carried out, funded, or authorized by a Federal agency, should result in consultation for the northern spotted owl under section 7(a)(2) of the Act. In general, there are five possible outcomes in terms of how proposed Federal actions may affect the PCEs or physical or biological features of northern spotted owl critical habitat or essential habitat qualities associated with that critical habitat area: (1) No effect; (2) wholly beneficial effects (e.g., improve habitat condition); (3) both short-term adverse effects and long-term beneficial effects; (4) insignificant or discountable adverse effects; or (5) wholly adverse effects. Actions with no effect on the PCEs and physical or biological features of occupied areas or the essential habitat qualities in unoccupied areas do not require section 7 consultation, although such actions may still require consultation if they have effects on the species itself as a result of its status as a threatened species under the Act. Actions with effects to the PCEs, physical or biological features, or other essential habitat qualities of northern spotted owl critical habitat that are discountable, insignificant, or wholly beneficial would be considered not likely to adversely affect critical habitat, and do not require formal consultation if the Service concurs in writing with that Federal action agency determination. Actions that are likely to adversely affect the physical or biological features or other essential habitat qualities of northern spotted owl critical habitat require formal consultation and the preparation of a Biological Opinion by the Service. The Biological Opinion sets forth the basis for our section 7(a)(2) determination as to whether the proposed Federal action is likely to destroy or adversely modify northern spotted owl critical habitat.

Activities that may destroy or adversely modify critical habitat are those that alter the essential physical or biological features or other essential habitat qualities of the critical habitat to an extent that appreciably reduces the conservation value of the critical habitat for the listed species. As discussed above, the conservation role or value of northern spotted owl critical habitat is to adequately support the life-history needs of the species to the extent that well-distributed and interconnected northern spotted owl nesting populations are likely to persist within properly functioning ecosystems at the critical habitat unit and range-wide scales.

Proposed Federal actions that may affect northern spotted owl critical habitat will trigger the consultation requirements under section 7 of the Act and compliance with the section 7(a)(2) standard described above. The consultation process evaluates the effects of a proposed action to designated critical habitat regardless of the species' presence or absence. For an action that may affect critical habitat, the next step is to determine whether it is likely to adversely affect critical habitat. For example, where a project is designed to reduce fuels such that the effect of wildfires will be reduced, but will also reduce foraging opportunities within treatment areas, established interagency consultation teams should determine whether the proposed project has more than an insignificant impact on the foraging PCEs for northern spotted owls. A localized reduction in foraging habitat within a stand may have such an insignificant impact on foraging PCEs within the stand that a not likely to adversely affect determination is appropriate. Similarly, a hazard tree removal project in a stand with many suitable nest trees may have such a minimal reduction in nesting PCEs of that stand that the effect to nesting habitat is insignificant. In such a case, a ''not likely to adversely affect'' determination would be appropriate.

For actions that are likely to adversely affect critical habitat, the agencies will enter into formal consultation. At this stage of consultation, scale and context are especially important in evaluating the potential effects of forest management on northern spotted owl habitat. The degree to which various forest management activities are likely to affect the capability of the critical habitat to support northern spotted owl nesting, roosting, foraging, or dispersal will vary depending on factors such as the scope and location of the action, and the quantity of the critical habitat affected. In addition, in analyzing whether an action will likely destroy or adversely modify critical habitat, the effects of the action on the factors that were the basis for determining the area to meet the definition of critical habitat should be considered.

In general, we would anticipate that management actions that are consistent with the overall purpose for which a critical habitat unit was designated would not likely destroy or adversely modify critical habitat as those terms are used in the context of section 7(a)(2) of the Act. Such actions include activities whose intent is to restore ecological processes or long-term forest health to forested landscapes that contain northern spotted owl habitat, such as those actions described in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) and elsewhere in this document. However, each proposed action will be considered on a case-by-case basis.

Section 7 Process Under This Critical Habitat Rule

The Presidential Memo, dated February 28, 2012 (77 FR 12985; March 5, 2012), directed the Service to address six action items in the final revised critical habitat rule for the northern spotted owl. One item in the Memo called for the Service to develop clear direction ''for evaluating logging activity in areas of critical habitat, in accordance with the scientific principles of active forestry management and to the extent permitted by law.'' The following summarizes the evaluation process for logging activities in areas of northern spotted owl critical habitat under section 7 of the Act and its implementing regulations, and our plans for close coordination with the land management agencies to best meet the dual goals of recovering the northern spotted owl and managing our public forest lands for multiple use.

Coordination With Land Management Agencies

The Service is committed to working closely with the U.S. Forest Service and BLM to implement the active management and ecological forestry concepts discussed in the Revised Recovery Plan and this critical habitat rule. Both recommend that land managers use the best science to maintain and restore forest health and resilience in the face of climate change and other challenges.

To meet this goal, we have prioritized the timely review of forestry projects that will be proposed in critical habitat. We have already completed section 7 conference opinions on the proposed rule with the agencies, and have recently held interagency coordination meetings with the section 7 Level 1 staff in Oregon, Washington, and California. In these meetings, we identified ways to streamline the section 7 process to ensure that potential projects can be implemented in a timely manner consistent with northern spotted owl conservation. We are also closely involved in and supportive of the respective Forest Service and BLM landscape-level planning efforts currently underway, and will work with the agencies to incorporate the conservation planning recommended in the Revised Recovery Plan and discussed in this final critical habitat designation.

Finally, appropriate Service staff have been directed that all levels of management and field teams stay fully engaged in this process to ensure these commitments are met.

Determining Whether an Action Is Likely to Adversely Affect Critical Habitat

The 1992 northern spotted owl critical habitat rule (57 FR 1796; January 15, 1992) identified the primary constituent element (PCE) as the fundamental scale of analysis at which the ''evaluation of actions that may affect critical habitat for the northern spotted owl'' should occur. Those elements included nesting, roosting, foraging and dispersal habitats. In the 2008 northern spotted owl critical habitat rule (73 FR 47326; August 13, 2008), the forested stand is identified as the appropriate scale for determining whether an action was likely to adversely affect northern spotted owl critical habitat. The 2012 proposed revised critical habitat rule identified a 500-ac (200-ha) circle as a logical scale for determining the effects of a timber sale to critical habitat because research shows northern spotted owls respond more favorably to an area larger than a single tree when choosing where to live.

However, there are many variables to be considered when determining whether the effects to critical habitat are adverse or not. When making a determination as to whether an action is likely to adversely affect critical habitat, and thus require formal consultation, it is not possible to design a ''one size fits all'' set of rules due to differences in project types, habitat types, and habitat needs across the range of the species (Fontaine and Kennedy 2012, p. 1559). This determination should be conducted at a scale that is relevant to the northern spotted owl life-history functions supplied by the PCEs and affected by the project. We note that this more localized scale differs from that used in determining whether an action will destroy or adversely modify critical habitat, which is made at the scale of the designated critical habitat, as described further below.

Northern spotted owl critical habitat PCE 4 (habitat to support the transience and colonization phases of dispersal) provides a life-history need that functions at a landscape-level scale and should be assessed at a larger scale than the other PCEs. Potential scales of analysis include the local watershed (e.g., fifth-field watershed) or subwatershed (e.g., sixth-field watershed), a dispersal corridor, or a relevant landform. Both PCE 2 (habitat that provides for nesting and roosting) and PCE 3 (habitat that provides for foraging) provide life-history needs that function at a more localized landscape, which should help inform the scale at which the determination of whether an action will likely adversely affect critical habitat should be conducted. We encourage the level one consultation teams to tailor this scale of the effects determination to the localized biology of the life-history needs of the northern spotted owl (such as the stand scale, a 500-ac (200-ha) circle, or other appropriate, localized scale).

If a project produces an effect on critical habitat that is wholly beneficial, insignificant, or discountable, then the project is not likely to adversely affect critical habitat, and consultation would be concluded with a letter of concurrence. Wholly beneficial effects include those that actively promote the development or improve the functionality of critical habitat for the northern spotted owl without causing adverse effects to the PCEs. Such actions might involve variable-density thinning in forest stands that do not currently support nesting, roosting, or foraging habitat for the northern spotted owl, which would speed the development of these types of habitats, while maintaining dispersal habitat function. Thinning or other treatments in young plantations that are specifically designed to accelerate the development of owl habitat, and either are in areas that do not provide dispersal habitat or where the effects to dispersal capability would be insignificant or discountable, would also fall into the ''not likely to adversely affect'' category. While these wholly beneficial actions may affect critical habitat and would, therefore, require consultation under section 7 of the Act, they most likely would be completed via an informal consultation with a determination that they are not likely to adversely affect critical habitat.

Likewise, if the adverse effects of a proposed Federal action on the life-history needs supported by physical or biological features of northern spotted owl critical habitat are expected to be discountable or insignificant, that action would also be considered not likely to adversely affect northern spotted owl critical habitat. In such cases, the section 7 consultation requirements can also be satisfied through the informal concurrence process. Examples of such actions may include: Pre-commercial or commercial thinning that does not delay the development of essential physical or biological features; fuel-reduction treatments that have a negligible effect on northern spotted owl foraging habitat within the stand; and the removal of hazard trees, where the removal has an insignificant effect on the capability of the stand to provide northern spotted owl nesting opportunities.

Some proposed Federal forest management activities may have short-term adverse effects and long-term beneficial effects on the physical or biological features of northern spotted owl critical habitat. The Revised Recovery Plan for the Northern Spotted Owl recommends that land managers actively manage portions of both moist and dry forests to improve stand conditions and forest resiliency, which should benefit the long-term recovery of the northern spotted owl (USFWS 2011, p. III–11). For example, variable thinning in single-story, uniform forest stands to promote the development of multistory structure and nest trees may result in short-term adverse impacts to the habitat's current capability to support owl dispersal and foraging, but have long-term benefits by creating higher quality habitat that will better support territorial pairs of northern spotted owls. Such activities would have less impact in areas where foraging and dispersal habitat is not limiting, and ideally can be conducted in a manner that minimizes short-term negative impacts. Even though they may have long-term beneficial effects, if they have short-term adverse effects, such actions may adversely affect critical habitat, and would require formal consultation under section 7 of the Act. For efficiency, such actions may be evaluated under section 7 programmatically at the landscape scale (e.g., USFS or BLM District).

Habitat conditions in moist/wet and dry/fire-prone forests within the range of the northern spotted owl vary widely, as do the types of management activities designed to accelerate or enhance the development of northern spotted owl habitat. ''Wet'' and ''dry'' are ends of a spectrum, not distinct categories that adequately describe the full range of forest types within the range of the northern spotted owl. Because these categories are broad, and conditions on the ground are more variable, land managers and cooperators should have the expectation that multiple forest types may be involved, and similar projects in different forest types may not always lead to the same effect determination for purposes of compliance with section 7 of the Act.

To make effects determinations, we recommend generating area-specific maps showing the current habitat condition (such as types of habitat, known nest trees, or other feature) and, using information on the proposed action (such as location, type and intensity of harvest, location of new roads and landings, or other proposed activity effects), produce a post-project habitat map such that the pre- and post-project comparison of the PCEs can be assessed. We also recommend the cooperative development of a spatial and temporal framework for evaluating the impact of both the short- and long-term effects of the proposed activities on the northern spotted owl. Framework examples include a landscape assessment or a checklist of key questions the answers to which will illustrate how the project will impact the northern spotted owl (see Spies *et al.* 2012, p. 11, for an example).

Determining Whether an Action Will Destroy or Adversely Modify Critical Habitat

If the effects of the project have more than an insignificant or discountable impact on the ability of the PCEs to provide life-history functions for the northern spotted owl, then the project is likely to adversely affect northern spotted owl critical habitat, and formal consultation is warranted. For projects that will adversely affect critical habitat, it is the Service's responsibility to conduct an analysis of whether the action is likely to ''destroy or adversely modify critical habitat'' during the formal consultation process. As discussed below, the determination of whether an action is likely to destroy or adversely modify critical habitat is made at the scale of the entire critical habitat network. However, a proposed action that compromises the capability of a subunit or unit to fulfill its intended conservation function or purpose could represent an appreciable reduction in the conservation value of the entire designated critical habitat. Therefore, the biological opinion should describe the relationship between the conservation role of the action area, affected subunits, units, and the entire designated critical habitat. This analysis must incorporate all direct and indirect effects and any cumulative effects from the project within the action area. If, after the formal consultation analysis, it is determined that the proposed project will not destroy or adversely modify critical habitat, then the action can be conducted.

Factors to consider in evaluating whether activities, including timber harvest, are likely to destroy or adversely modify critical habitat pursuant to section 7 include:

- The extent of the proposed action, both its temporal and spatial scale, relative to the critical habitat subunit and unit within which it occurs, and the entire critical habitat network.
- The specific purpose for which the affected subunit was identified and designated as critical habitat.
- The cumulative effects of all completed activities in the critical habitat unit.
- The impact of the proposed action on the ability of the affected critical habitat to continue to support the life-history functions supplied by the PCEs.
- The impact of the proposed action on the subunit's likelihood of serving its intended conservation function or purpose.
- The impact of the proposed action on the unit's likelihood of continuing to contribute to the conservation of the species.
- The overall consistency of the proposed action with the intent of the recovery plan or other landscape-level conservation plans.
- The special importance of project scale and context in evaluating the potential effects of timber harvest to northern spotted owl critical habitat.

The first step is to describe the impacts to critical habitat in the action area with respect to the subunit's intended functions as identified in this rule. For example, if a particular subunit was designated to support northern spotted owl connectivity between subunits, then the loss or impact to connectivity must be assessed. Subunits that are expected to provide demographic support should be assessed for their ability to continue to support northern spotted owl nesting territories in conditions suitable for occupancy by pairs of owls (e.g., amount and location of nesting habitat, proximity of foraging habitat, etc.). The analysis should describe the extent to which the project is expected to prevent, preclude, or significantly impair the ability of that subunit to meet its intended function. The analysis should not incorporate the effect of the proposed action on individual northern spotted owls but, instead, on the life-history functions supplied by the PCEs and the physical biological features. Effects to northern spotted owls should be included in the effects to the species section of a biological opinion, as appropriate.

The analysis in a biological assessment or a biological opinion should include an evaluation of the type, frequency, magnitude, and duration of impacts likely to be caused by the action on the PCEs of the action area, affected subunits and critical habitat units, and an assessment of how those impacts are likely to influence the capability of the affected critical habitat units to provide for a well-distributed and self-sustaining northern spotted owl population. The analysis in a biological assessment or a biological opinion of cumulative effects on critical habitat should include a similar assessment for any future, non-Federal actions reasonably certain to occur in the action area, and at the level of the affected subunits and critical habitat units.

Consideration of the effects of the action, together with any cumulative effects, will form the basis for the biological opinion's determination as to whether the action will destroy or adversely modify critical habitat. In accordance with Service policy, the adverse modification determination is made at the scale of the entire designated critical habitat, unless the critical habitat rule identifies another basis for the analysis (FWS and NMFS 1998). The adverse modification determination for the northern spotted owl will occur at the scale of the entire designated critical habitat, as described below, with consideration given to the need to conserve viable populations within each of the recovery units identified in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, Recovery Criterion 2).

It is important to note that although the adverse modification determination is made at the scale of the entire designated critical habitat, a proposed action that compromises the capability of a subunit or unit to fulfill its intended conservation function or purpose could represent an appreciable reduction in the conservation value of the entire designated critical habitat. Therefore, the biological opinion should describe the relationship between the conservation role of the action area, affected subunits, units, and the entire designated critical habitat. In this way, the biological opinion establishes a sensitive analytical framework for informing the determination of whether a proposed action is likely to appreciably reduce the conservation role of critical habitat overall.

The Service has assured the BLM and FS that it is committed to working closely with them to evaluate and implement active management and ecological forestry concepts of the recovery plan and critical habitat rule into potential timber management projects. Both documents recommend that land managers use the best science to maintain and restore forest health and resilience in the face of climate change and other challenges.

To meet this goal we have prioritized the timely review of forestry projects that will be proposed in critical habitat. We have already completed section 7 conference opinions on the proposed rule with several of your units, and we have recently held interagency coordination meetings with the section 7 Level 1 staff in Oregon, Washington, and California. In these meetings, we identified ways to streamline the section 7 process to ensure that potential projects can be implemented in a timely manner consistent with northern spotted owl conservation. We are also closely involved in and supportive of the respective FS and BLM landscape-level planning efforts currently underway and will work with you to incorporate the conservation planning reflected in the revised recovery plan and the final critical habitat designation.

Finally, appropriate Service staff have been directed that all levels of management and field teams—from Level 1 biologists up to the Assistant Regional Director—stay fully engaged in this process to ensure these commitments are met. Any problems or disagreement should be promptly elevated and resolved.

Within dry forests, the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) emphasizes active forest management that could meet overlapping goals of northern spotted owl conservation, climate change response, and restoration of dry forest ecological structure, composition, and process, including wildfire and other disturbances (USFWS 2011, pp. III–20). For the rest of the northern spotted owl's range that is not fire-prone, the Revised Recovery Plan emphasizes habitat management that accelerates the development of future habitat, restores larger habitat blocks, and reduces habitat fragmentation. The following discussion describes the type of management approaches that would be consistent with the Revised Recovery Plan in the West Cascades/Coast Ranges of Oregon and Washington, East Cascades, and the Redwood Coast zones, and in some cases includes consideration of possible corresponding effect determinations for activities implementing these approaches, for the purpose of analyzing effects to critical habitat under section 7 of the Act. The Klamath and Northern California Interior Coast Ranges regions contain conditions similar to the three regions discussed below, and similar management approaches would be consistent with the recovery needs of the owl.

West Cascades/Coast Ranges of Oregon and Washington

The primary goal of the Revised Recovery Plan for this portion of the northern spotted owl's range is to conserve stands that support northern spotted owl occupancy or contain high-value northern spotted owl habitat (USFWS 2011, p. III–17). Silvicultural treatments are generally not needed to accomplish this goal. However, there is a significant amount of younger forest that occurs between and around the older stands, where silvicultural treatments may accelerate the development of these stands into future northern spotted owl nesting habitat, even if doing so temporarily degrades existing dispersal habitat, as is recommended in Recovery Action 6 (USFWS 2011, p. III–19). The Revised Recovery Plan encourages silviculture designed to develop late-successional structural complexity and to promote resilience (USFWS 2011, pp. III–17 to III–19). Restoration or ecological prescriptions can help uniform stands of poor quality develop more quickly into more diverse, higher quality northern spotted owl habitat, and provide resiliency in the face of potential climate change impacts in the future. Targeted vegetation treatments could simultaneously increase canopy and age-class diversity, putting those stands on a more efficient trajectory towards nesting and roosting habitat, while reducing fuel loads. Introducing varying levels of spatial heterogeneity, both vertically and horizontally, into forest ecosystems can contribute to both of the goals stated above.

On matrix lands under the NWFP where land managers have a range of management goals, the Service anticipates that not all forest management projects in critical habitat will be focused on the development or conservation of northern spotted owl habitat. Ideally, proposed actions within critical habitat should occur on relatively small patches of younger, mid-seral forest stands that do not cause reductions in higher quality northern spotted owl habitat. They should also be planned in such a way that their net occurrence on the regional landscape is consistent with broader ecosystem-based planning targets (e.g., Spies *et al.* 2007a, entire) to provide the physical or biological features that are essential to the conservation of the northern spotted owl. Within that context, thinning and targeted variable-retention harvest in moist forests could be considered where the conservation of complex early-seral forest habitat is a management goal. This approach provides a contrast to traditional clearcutting that does not mimic natural disturbance or create viable early-seral communities that grow into high-quality habitat (Dodson *et al.* 2012, p. 353; Franklin *et al.* 2002,

p. 419; Swanson *et al.* 2011, p. 123; Kane *et al.* 2011, pp. 2289–2290; Betts *et al.* 2010, p. 2127, Hagar 2007, pp. 117–118). Swanson (2012, entire) provides a good overview and some management considerations.

In cases where these moist forest treatments in matrix are intended to meet management goals other than northern spotted owl conservation, they can be designed to enable the development of northern spotted owl habitat over time at the landscape scale. If planned well at this scale, these projects may have short-term adverse effects, but are not expected to adversely modify the role and function of critical habitat units. In other words, such treatments can be dispersed across the landscape and over time to both accommodate northern spotted owl habitat needs and conservation of diverse and complex early-seral habitat. Additional information about ecological forestry activities in moist forests can be found in the Revised Recovery Plan under *Northern Spotted Owls and Ecological Forestry* (USFWS 2011, p. III–11) and *Habitat Management in Moist Forests* (USFWS 2011, p. III–17).

East Cascades

The Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) recommends that the dynamic, fire-prone portion of the northern spotted owl's range be actively managed to conserve northern spotted owls, but also address climate change and restore dry forest ecological structure, composition, and processes (*e.g.,* wildfire) to provide for the long-term conservation of the species and its habitat in a dynamic ecosystem (USFWS 2011, pp. III–13, III–20). To do this, management actions should be considered to balance short-term adverse effects with long-term beneficial effects. In some cases, formal consultation on the effects of dry forest management activities on northern spotted owl critical habitat is likely to occur; in other cases, there may be no adverse effects and consultation can be concluded informally.

Management in dry forests should increase the likelihood that northern spotted owl habitat will remain on the landscape longer and develop as part of the dynamic fire- and disturbance-adapted community. Several management approaches can be described for these systems. The first is to maintain adequate northern spotted owl habitat in the near term to allow owls to persist on the landscape in the face of threats from barred owl expansion and habitat alterations from fire and other disturbances. The next is to restore landscapes that are resilient to fire and other disturbances, including those projected to occur with climate change. This will require more than reducing fuels and thinning trees to promote low-severity fires; management will need to develop ''more natural patterns and patch size distributions of forest structure, composition, fuels, and fire regime area'' (Hessburg *et al.* 2007, p. 21).

Our prime objective for vegetation management activities within northern spotted owl critical habitat is to maintain adequate amounts of nesting, roosting, foraging, or dispersal habitat where it currently exists, and to restore degraded habitat where it is essential to the owl and can be best sustained on the landscape, as recommended in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, Section III). Successfully accomplishing these objectives can be facilitated by spatially and temporally explicit landscape assessments that identify areas valuable for northern spotted owl conservation and recovery, as well as areas important for process restoration (*e.g.,* Prather *et al.* 2008, p. 149; Franklin *et al.* 2008, p. 46; Spies *et al.* 2012, entire). Such assessments could answer questions that are frequently asked about proposed forest management activities, namely ''why here?'' and ''why now?'' Providing well-reasoned responses to these questions becomes especially important when restoration activities degrade or remove existing northern spotted owl habitat. By scaling up conservation and restoration planning from the stand to the landscape level, many apparent conflicts may disappear because management actions can be prioritized and spatially partitioned (Prather *et al.* 2008, p. 149; Rieman *et al.* 2010, p. 464). For example, portions of the landscape can be identified where there may be no conflict between objectives, and where relatively aggressive approaches to ecosystem restoration can occur without placing listed species at substantial risk (Prather *et al.* 2008, pp. 147–149; Gaines *et al.* 2010, pp. 2049–2050). Conflicts between objectives will remain in some locations, such as in places where removing younger, shade-intolerant conifers to reduce competition with larger, legacy conifers may result in a substantial decrease in canopy cover that translates into a reduction in northern spotted owl habitat quality. However, when this sort of treatment is well designed, strategically located, and justified within a landscape approach to treatments, it is easier to assess its effectiveness in meeting both owl conservation and forest restoration needs.

Landscape assessments developed at the scale of entire National Forests, Ranger Districts, or BLM Districts have the broad perspective that can improve ability to estimate effects of management activities on the function of critical habitat and better identify and prioritize treatment areas and the actions that will restore landscapes while conserving northern spotted owl habitat. The Okanogan-Wenatchee National Forest has developed a landscape evaluation process as part of their forest restoration strategy (USDA 2010, pp. 36–52) that can serve as an example for other administrative units when developing their own assessment approaches. We suggest that the value of such assessments in guiding vegetation management within critical habitat can be enhanced by spatially identifying locations where restoration objectives and northern spotted owl habitat objectives converge, are in conflict, or simply are not an issue (see, *e.g.,* Davis *et al.* 2012, entire). We suggest the following approach for the East Cascades:

1. Spatially identify and map:

a. Existing northern spotted owl habitat and northern spotted owl nesting sites.

b. Places on the landscape where northern spotted owl habitat is expected to be retained longer on the landscape in the face of disturbance activities such as fire and insect outbreaks.

c. Places on the landscape where key ecosystem structures and processes are at risk and would benefit from restoration (e.g. legacy trees, unique habitats).

2. Overlay what is known about landscape patterns of vegetation and disturbance processes with items from step 1 above to determine:

a. Stands of high restoration value but low value as existing northern spotted owl habitat.

b. Stands of low restoration value but high value as existing northern spotted owl habitat.

c. Stands of low restoration value and low value as existing northern spotted owl habitat.

d. Stands of high restoration value and high value as existing northern spotted owl habitat.

In locations where there is high restoration value and high value as existing northern spotted owl habitat, a landscape assessment can help to build a strong rationale for impacting owl habitat functionality to achieve broader landscape goals. Conditions that may support management activities in these stands may include, but are not limited to the following:

1. The patch of habitat is located in an area where it is likely unsustainable and has the potential for conveying natural disturbances across the landscape in ways that jeopardize large patches of suitable northern spotted owl habitat.

2. There are nearby areas that are more likely to sustain suitable northern spotted owl habitat and are either currently habitat or will likely develop suitable conditions within the next 30 years.

3. The patch of habitat does not appear to be associated with a northern spotted owl home range or to promote successful dispersal between existing home ranges.

4. The area will still retain some habitat function after treatment, while still meeting the intended restoration objective. For example, stands that are suitable as foraging habitat may be degraded post treatment but remain foraging habitat after treatment. Or, stands may be downgraded to dispersal habitat as a result of treatment.

We do not expect the desired landscape conditions will be achieved within the next decade or two; a longer time will be required as younger forests develop into northern spotted owl nesting, roosting, and foraging habitat. In the interim, we recommend that land managers consider management actions to protect current habitat, especially where it occurs in larger blocks on areas of the landscape, where it is more likely to be resistant or resilient to fires and other disturbance agents. We also encourage land managers to consider actions to accelerate the restoration of habitat, especially where it is consistent with overall forest restoration and occurs in those portions of the landscape that are less fire prone or are resilient in the face of these disturbances. The careful application of these types of activities is expected to achieve a landscape that is more resilient to future disturbances. As such, we anticipate that projects designed to achieve this goal will need to be of a larger spatial scale as to have a meaningful effect on wildfire behavior, regimes, and extent. The effects of these projects will vary depending on existing condition, prescriptions, proximity of habitat, and other factors. It is likely that such projects may affect northern spotted owl critical habitat and require section 7 consultation.

Some situations also exist in the final critical habitat area where northern spotted owl habitat has been created through fire suppression activities (e.g., meadow conversion, white fir intrusion), but retention of those forested habitat elements is contrary to the overall goals of ecosystem restoration and long-term security for the owl. Restoration projects that modify these elements, while sometimes prudent and recommended (Franklin *et al.* 2008, p. 46), may adversely affect northern spotted owls or their critical habitat, and may need to be evaluated through the section 7 consultation process. Additional information about restoration activities in dry forests can be found in the Revised Recovery Plan for the Northern Spotted Owl under *Restoring Dry Forest Ecosystems* (USFWS 2011, p. III–32).

Redwood Coast

While the Redwood Coast region of coastal northern California is similar to the West Cascades/Coast region in many respects, there are some distinct differences in northern spotted owl habitat use and diet within this zone. The long growing season, combined with the redwood's ability to resprout from stumps, allows redwood stands to attain suitable stand structure for nesting in a relatively short period of time (40 to 60 years) if legacy structures are present. In contrast to the large, contiguous, older stands desired in other wet provinces, some degree of fine-scale fragmentation in redwood forests appears to benefit northern spotted owls. These openings provide habitat for the northern spotted owl's primary prey, the dusky-footed woodrat. High woodrat abundance is associated with dense shrub and hardwood cover that persists for up to 20 years in recent forest openings created by harvesting or burns. Under dense shrub and hardwood cover, woodrats can forage, build nests, and reproduce, relatively secure from owl predation. These sites quickly become overpopulated, and surplus individuals are displaced into adjacent older stands where they become available as owl prey. When developing stands reach an age of around 20 years, understory vegetation is increasingly shaded-out, cover and food sources become scarce, and woodrat abundance declines rapidly. By this time, the stand that once supported a dense woodrat population makes a structural transition into a stand where woodrats are subject to intense owl predation. In northern spotted owl territories within the Redwood Forest zone, active management that creates small openings within foraging habitat can enhance northern spotted owl foraging opportunities and produce or retain habitat suitability in the short term. Actions consistent with this type of land management are not expected to adversely modify critical habitat.

Summary of Section 7 Process

This discussion has covered projects that may or may not require formal section 7 consultation. It is important to distinguish between a finding that a project is likely to adversely affect critical habitat and a finding at the conclusion of formal consultation that a project is likely to destroy or adversely modify critical habitat; these are two very different outcomes. It is not uncommon for a proposed project to be considered likely to adversely affect critical habitat, and thus require formal consultation, but still warrant a conclusion that it will not destroy or adversely modify critical habitat. An action may destroy or adversely modify critical habitat if it adversely affects the essential physical or biological features to an extent that the intended conservation function or purpose of critical habitat for the northern spotted owl is appreciably reduced.

The adverse modification determination is made at the scale of the entire designated critical habitat, unless the final critical habitat rule identifies another basis for that determination, such as at the scale of discrete units and/or groups of units necessary for different life cycle phases, units representing distinctive habitat characteristics or gene pools, or units fulfilling essential geographical distribution requirements of the species (USFWS and NMFS 1998, p. 4–39). In the case of northern spotted owl critical habitat, the adverse modification determination will be made at the scale of the entire designated critical habitat. However, by describing the relationship between the conservation role of affected subunits, units, and the entire designated critical habitat in the biological opinion, a sensitive analytical framework is established for informing the determination of whether a proposed action is likely to appreciably reduce the conservation role of the critical habitat overall. In this way, a proposed action that compromises the capability of a subunit or unit to fulfill its intended conservation function or purpose (e.g., demographic, genetic, or distributional support for northern spotted owl recovery) could represent an appreciable reduction in the conservation value of the entire designated critical habitat. This approach should avoid false no-adverse-modification determinations, when the functionality of a unit or subunit would actually be impaired by a proposed action.

As described above, in general, we do not anticipate that activities consistent with the stated management goals or recommended recovery actions of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, Chapters II and III) would constitute adverse modification of critical habitat, even if those activities may have adverse effects in the short term, if the intended result over the long term is an improvement in the function of the habitat to provide for the essential life-history needs of the northern spotted owl. However, such activities will be evaluated under section 7, taking into account the specific proposed action, location, and other site-specific factors.

X. Exemptions

Application of Section 4(a)(3) of the Act

The Sikes Act Improvement Act of 1997 (Sikes Act) (16 U.S.C. 670a) required each military installation that includes land and water suitable for the conservation and management of natural resources to complete an integrated natural resources management plan (INRMP) by November 17, 2001. An INRMP integrates implementation of the military mission of the installation with stewardship of the natural resources found on the base. Each INRMP includes:

(1) An assessment of the ecological needs on the installation, including the need to provide for the conservation of listed species;

(2) A statement of goals and priorities;

(3) A detailed description of management actions to be implemented to provide for these ecological needs; and

(4) A monitoring and adaptive management plan.

Among other things, each INRMP must, to the extent appropriate and applicable, provide for fish and wildlife management; fish and wildlife habitat enhancement or modification; wetland protection, enhancement, and restoration where necessary to support fish and wildlife; and enforcement of applicable natural resource laws.

The National Defense Authorization Act for Fiscal Year 2004 (Pub. L. 108–136) amended the Act to limit areas eligible for designation as critical habitat. Specifically, section 4(a)(3)(B)(i) of the Act (16 U.S.C. 1533(a)(3)(B)(i)) now provides: ''The Secretary shall not designate as critical habitat any lands or other geographical areas owned or controlled by the Department of Defense, or designated for its use, that are subject to an integrated natural resources management plan prepared under section 101 of the Sikes Act (16 U.S.C. 670a), if the Secretary determines, in writing, that such plan provides a benefit to the species for which critical habitat is proposed for designation.''

We consult with the military on the development and implementation of INRMPs for installations with listed species. We analyzed INRMPs developed by military installations located within the range of the designated critical habitat designation for the northern spotted owl to determine if they are exempt under section 4(a)(3) of the Act. The following areas are Department of Defense lands with completed, Service-approved INRMPs that fell within the area we proposed as revised critical habitat (77 FR 14062; March 8, 2012).

Approved INRMPs

U.S. Army Joint Base Lewis-McChord

Joint Base Lewis-McChord (JBLM), formerly known as Fort Lewis, is an 86,500-ac (35,000-ha) U.S. Army military reservation in western Washington, south of Tacoma and the Puget Sound. JBLM contains one of the largest remaining intact forest areas in the Puget Sound basin, with approximately 54,400 ac (22,000 ha) of forests and woodlands, predominantly of the dry Douglas-fir forest type and including some moist forest types (Douglas-fir, red cedar, hemlock). The forested area of JBLM is managed by the Base's Forestry Program, and the primary mission for the JBLM Forest is to provide a variety of forested environments for military training. JBLM has a history of applying an ecosystem management strategy to their forests to provide for multiple conservation goals, which have included promoting native biological diversity, maintaining and restoring unique plant communities, and developing late-successional (older) forest structure. There are 14,997 ac (6,069 ha) of lands within the boundary of JBLM that were identified in the proposed critical habitat designation; these lands comprised subunit NCO–3 in the proposed rule (77 FR 14062; March 8, 2012).

JBLM has an INRMP in place that was approved in 2008; JBLM is in the process of updating that INRMP. To date, JBLM has managed their forest lands according to their Forest Management Strategy, first prepared for then-Fort Lewis in 1995 by the Public Forestry Foundation based in Eugene, Oregon, in collaboration with The Nature Conservancy. The Forest Management Strategy was last revised in May 2005, and is also in the process of being updated (Forest Management Strategy 2005, entire). However, in 2012, JBLM amended their existing INRMP with specific regard to the northern spotted owl by completing an Endangered Species Management Plan (ESMP) that includes guidelines for protecting, maintaining, and enhancing habitat essential to support the northern spotted owl on JBLM. The Service has found, in writing, that the amended INRMP provides a net conservation benefit to the species.

The ESMP identifies management objectives for the conservation of the northern spotted owl. Specifically, the ESMP includes three focus areas for management of northern spotted owl. The long-term objective for the first is development of all four types of owl habitat (nesting, roosting, foraging, and dispersal). The long-term objectives for Focus Areas 2 and 3 are development of owl foraging and dispersal habitat. The primary conservation goals for northern spotted owl habitat on JBLM are to protect and maintain existing northern spotted owl suitable habitat; manipulate unsuitable habitat to suitable habitat; and ensure long-term suitable habitat and monitor northern spotted owl habitat to assure that goals are met and actions are successful. Although northern spotted owls are not currently known to occupy JBLM, it is the only significant Federal ownership in this region of Washington, and it provides the largest contiguous block of forest in this area as well. The potential development of suitable owl habitat at JBLM provides one of the only feasible opportunities for establishing connectivity between owl populations in the Olympic Peninsula and the western Cascades Range. Connectivity allows gene flow between populations, and further maintains northern spotted owl distribution and metapopulation dynamics, which are important components of the recovery strategy for the northern spotted owl (USFWS 2011, p. III–1, III–44). The Forest Management Strategy (2005, p. 82) notes that the mosaic of dry forest, woodland, and prairie at JBLM is very different from typical forest landscapes that support northern spotted owls, and that while suitable habitat for dispersal of northern spotted owls can be achieved in the short term, at least 40 to 50 years may be needed to meet the desired condition for foraging, nesting, and roosting habitat.

Based on the above considerations and in accordance with section 4(a)(3)(B)(i) of the Act, we have determined that the identified lands are subject to the JBLM INRMP and that conservation efforts identified in the INRMP through its ESMP for the northern spotted owl will provide a benefit to the species occurring in habitats within or adjacent to JBLM, including the northern spotted owl. Therefore, lands within this installation are exempt from critical habitat designation under section 4(a)(3) of the Act. We are not including approximately 14,997 ac (6,069 ha) of habitat in this final critical habitat designation as a result of this exemption.

XI. Exclusions

Application of Section 4(b)(2) of the Act

Section 4(b)(2) of the Act states that the Secretary must designate or make revisions to critical habitat on the basis of the best available scientific data after taking into consideration the economic impact, national security impact, and any other relevant impacts of specifying any particular area as critical habitat. The Secretary may exclude an area from critical habitat if he determines that the benefits of such exclusion outweigh the benefits of specifying such area as part of the critical habitat, unless he determines, based on the best scientific data available, that the failure to designate such area as critical habitat will result in the extinction of the species. In making that determination, the statute on its face, as well as the legislative history, are clear that the Secretary has broad discretion regarding which factor(s) to use and how much weight to give to any factor.

When considering the benefits of inclusion for an area, we consider the additional regulatory benefits that area would receive from the protection from adverse modification or destruction as a result of actions with a Federal nexus; the educational benefits of mapping essential habitat for recovery of the listed species; and any benefits that may result from a designation due to State or Federal laws that may apply to critical habitat.

When considering the benefits of exclusion, we consider, among other things, whether exclusion of a specific area is likely to result in the overall conservation of the northern spotted owl through the continuation, strengthening, or encouragement of partnerships and the implementation of management plans or programs that provide equal or more conservation for the northern spotted owl than could be achieved through a designation of critical habitat. The Secretary can consider the existence of conservation agreements and other land management plans with Federal, State, private, and tribal entities when making decisions under section 4(b)(2) of the Act. The Secretary may also consider relationships with landowners, voluntary partnerships, and conservation plans, and weigh the implementation and effectiveness of these against that of designation to determine which provides the greatest conservation value to the listed species.

Consideration of relevant impacts of designation or exclusion under section 4(b)(2) may include, but is not limited to, any of the following factors: (1) Whether the plan provides specific information on how it protects the species and the physical or biological features, and whether the plan is at a geographical scope commensurate with the species; (2) whether the plan is complete and will be effective at conserving and protecting the physical or biological features; (3) whether a reasonable expectation exists that conservation management strategies and actions will be implemented, that those responsible for implementing the plan are capable of achieving the objectives, that an implementation schedule exists, and that adequate funding exists; (4) whether the plan provides assurances that the conservation strategies and measures will be effective (i.e., identifies biological goals, has provisions for reporting progress, and is of a duration sufficient to implement the plan); (5) whether the plan has a monitoring program or adaptive management to ensure that the conservation measures are effective; (6) the degree to which the record supports a conclusion that a critical habitat designation would impair the benefits of the plan; (7) the extent of public participation; (8) a demonstrated track record of implementation success; (9) the level of public benefits derived from encouraging collaborative efforts and encouraging private and local conservation efforts; and (10) the effect designation would have on partnerships.

After evaluating the benefits of inclusion and the benefits of exclusion, we carefully weigh the two sides to determine whether the benefits of excluding a particular area outweigh the benefits of its inclusion in critical habitat. If we determine that the benefits of excluding a particular area outweigh the benefits of its inclusion, then the Secretary can exercise his discretion to exclude the area, provided that the exclusion will not result in the extinction of the species.

Under section 4(b)(2) of the Act, we must consider all relevant impacts of the designation of critical habitat, including economic impacts. In addition to economic impacts (discussed in the Economics Analysis section, below), we considered a number of factors in a section 4(b)(2) analysis. We considered whether Federal or private landowners or other public agencies have developed management plans, habitat conservation plans (HCPs) or Safe Harbor Agreements (SHAs) for the area or whether there are conservation partnerships or other conservation benefits that would be encouraged or discouraged by designation of, or exclusion from, critical habitat in an area. We also considered other relevant impacts that might occur because of the designation. To ensure that our final determination is based on the best available information, we also considered comments received on foreseeable economic, national security, or other potential impacts resulting from this designation of critical habitat from governmental, business, or private interests and, in particular, any potential impacts on small businesses.

Based on the information provided by entities seeking exclusion, as well as any additional public comments received, we evaluated whether certain lands in the proposed revised critical habitat were appropriate for exclusion from this final designation pursuant to section 4(b)(2) of the Act. Based on our evaluation, we are excluding approximately 3,879,506 ac (1,567,875 ha) of lands that meet the definition of critical habitat under section 4(b)(2) of the Act from final critical habitat.

Final Economic Analysis

Under section 4(b)(2) of the Act, we consider the economic impacts of specifying any particular area as critical habitat. In order to consider economic impacts, we prepared a draft economic analysis (DEA) of the proposed critical habitat designation and related factors (IEC 2012a). The draft analysis was made available for public review from June 1, 2012, through July 6, 2012 (77 FR 32483). Following the close of the comment period, we developed a final economic analysis (FEA) (IEC 2012b) of the potential economic effects of the designation taking into consideration the public comments and any new information.

The intent of the FEA is to quantify economic impacts that may be directly attributable to the designation of critical habitat—that is, costs above and beyond what are considered ''baseline'' costs, as described below. The economic impact of the final critical habitat designation is analyzed by comparing scenarios both ''with critical habitat'' and ''without critical habitat.'' The ''without critical habitat'' scenario represents the baseline for the analysis, and considers the costs incurred as a result of protections already in place for the species (e.g., under the Federal listing and other Federal, State, and local regulations); these are costs that are incurred regardless of whether critical habitat is designated. The ''with critical habitat'' scenario describes the ''incremental'' economic impacts associated specifically with the designation of critical habitat for the species—these costs are those not expected to occur but for the designation of critical habitat for the species. In other words, the incremental costs are those attributable solely to the designation of critical habitat above and beyond the baseline costs; these are the costs we consider in the final designation of critical habitat.

The FEA also addresses how potential economic impacts are likely to be distributed, including an assessment of any local or regional impacts of habitat conservation and the potential effects of conservation activities on government agencies, private businesses, and individuals. Decisionmakers can use this information to assess whether the effects of the designation might unduly burden a particular group or economic sector. Finally, the FEA considers those costs that may occur in the 20 years following the revised designation of critical habitat, which was determined to be the appropriate period for analysis because limited planning information was available for most activities to forecast activity levels for projects beyond a 20-year timeframe. The FEA quantifies economic impacts of northern spotted owl conservation efforts associated with timber harvests, wildfire management, barred owl management, road construction, and linear projects (road and bridge construction and maintenance, installation of power transmission lines and utility pipelines), as these are the types of activities we determined were most likely to occur within northern spotted owl habitat.

The results of the FEA concludes that only a portion of the overall proposed revised designation will result in more than incremental, minor administrative costs. Specifically, of the 13,962,449 ac proposed for designation, potential incremental changes in timber harvest practices were anticipated on only 1,449,534 ac (585,612 ha) of USFS and BLM lands, or approximately 10 percent of the proposed designation. In addition, there was potential for the owners of 307,308 ac (123,364 ha) of private land to experience incremental changes in harvests (approximately 2 percent of the proposed designation). No incremental changes in harvests are expected on State lands.

In addition, to address the uncertainty in the types of management and activities that may or may not occur within the proposed critical habitat, the FEA evaluated three scenarios to capture the full range of potential economic impacts of the designation. The first scenario contemplates that minimal or no changes to current timber management practices will occur, thus the incremental costs of the designation would be predominantly administrative. The potential additional administrative costs due to critical habitat designation on Federal lands range from $185,000 to $316,000 on an annualized basis for timber harvest.

The second scenario posits that action agencies may choose to implement management practices that yield an increase in timber harvest relative to the baseline (current realized levels of timber harvest). For this scenario, baseline harvest projections were scaled upward by 10 percent, resulting in a positive impact on Federal lands ranging from $893,000 to $2,870,000 on an annualized basis for timber harvest.

The third scenario considers that actions agencies may choose to be more restrictive in response to critical habitat designation, resulting in a decline in harvest volumes relative to the baseline. To illustrate the potential for this effect, baseline harvest projections were scaled downward by 20 percent, resulting in a negative impact on timber harvest on Federal lands ranging from $2,650,000 to $6,480,000 on an annualized basis.

The USFS and BLM suggested certain alterations to the baseline timber harvest projections, based on differing assumptions regarding northern spotted owl occupancy in matrix lands and projected levels of timber harvest relative to historical yields. The FEA presents the results of a sensitivity analysis considering these alternative assumptions, which widen the range of annualized potential impacts to Federal timber harvest relative to the scenarios described above (IEC 2012b, pp. 4–37 to 4–39). This sensitivity analysis contemplated a situation in which 26.6 percent of northern spotted owl habitat on BLM matrix lands is unoccupied, and a 20 percent increase in baseline timber harvest in USFS Region 6 relative to historical yields. The range of incremental impacts under these alternative assumptions widens to a potential annualized increase of $0.7 million under Scenario 2, and an annualized decrease of $1.4 million under Scenario 3, relative to the results reported above.

Timber harvest was not anticipated to change on State lands in response to critical habitat designation. Timber harvest effects on private lands were highly uncertain, and were only identified qualitatively as potential negative impacts associated with regulatory uncertainty, and possibly (but speculative) new regulation in the State of Washington.

Under all three scenarios, linear projects reflected administrative costs only, ranging from $10,800 to $19,500 on an annualized basis.

Counties receive Federal lands payments from a subset of four programs: The U.S. Forest Service 25% Fund; the BLM O&C lands payments; Payment in Lieu of Taxes (PILT); and Secure Rural Schools and Community Self-determination Act (SRS) (please see FEA pp. 3–19 to 3–21 for a thorough discussion of these programs). Counties have the option of receiving either SRS of 25%/O&C payments, but not both. For reasons unrelated to proposed critical habitat, the future of the PILT and SRS programs is uncertain and depends on forces, including Congressional action, unrelated to critical habitat designation. If funding is not appropriated to PILT, or SRS is not reauthorized, payments from the USFS 25% Fund and the BLM O&C lands become relatively more important. Payments for these latter two programs are based on commercial receipts, main from timber generated on Federal lands; payments from PILT and SRS are not as closely linked to fluctuations in timber sales. In recent years, most counties have opted to receive SRS payments; for example, in FY 2009 all 18 counties in Oregon that contain BLM lands opted to receive SRS payments instead of the LBM O&C lands revenue-sharing payment. Therefore, it is difficult to quantify the effects that future changes in timber harvests from Federal lands resulting from critical habitat designation would have on counties if SRS and PILT payment programs ended and the counties were forced to rely on revenue-sharing payments only. Given the baseline uncertainty associated with the continuance of SRS and PILT payments, we were unable to quantify possible changes in county revenue payments that could result from the critical habitat designation. However, based on recent socioeconomic trends, we were able to identify those counties that may be more sensitive to future changes in timber harvests, industry employment, and Federal land payments. Potential timber harvest changes related to critical habitat designation, whether positive, negative, or neutral, are one potential aspect of this sensitivity. The counties identified as relatively more sensitive to future changes in timber harvests, employment, and payments were Del Norte and Trinity Counties, California; Douglas and Klamath Counties, Oregon; and Skamania County, Washington.

With regard to jobs, increases or decreases in timber harvests from Federal or private lands could result in positive or negative changes in jobs, respectively. The FEA notes that many factors affect timber industry employment (Chapter 6). The scope of our analysis was limited to the incremental effects of critical habitat within the area proposed for designation by the northern spotted owl. The FEA did not consider potential changes in timber activities outside the proposed critical habitat designation, and did not evaluate the potential effects related to the timber industry as a whole.

Based on our economic analysis of the potential effects of the proposed revised designation of critical habitat for the northern spotted owl, there is a range of potential outcomes, ranging from positive to negative impacts of the designation. Most potential economic impacts would occur, if at all, on Federal matrix lands managed by BLM and the Forest Service, although we note that the amount of Federal matrix lands has been reduced from the proposed rule, as described in Changes from the Proposed Rule, which would have the effect of reducing the range of potential economic impacts presented by the FEA. While there is uncertainty over whether such impacts will occur and to what extent, even assuming higher economic impacts suggested by some commenters, we would not exclude these lands from designation under section 4(b)(2) because a critical habitat designation on these lands will have benefits in conserving this essential habitat. In addition, our evaluation of these matrix lands clearly demonstrates their importance to the conservation of the northern spotted owl; as also discussed in the section Changes from the Proposed Rule, our evaluation of a habitat network with reduced areas of high value habitat on matrix lands indicated a significant increase in extinction risk to the species as a result.

A copy of the FEA with supporting documents may be obtained by contacting the Oregon Fish and Wildlife Office (see **ADDRESSES**) or by downloading from the Internet at *http://www.regulations.gov.*

National Security Impacts

Under section 4(b)(2) of the Act, we consider whether there are lands owned or managed by the Department of Defense (DOD) where a national security impact might exist. In preparing this final rule, we have determined that the only lands within the proposed revised designation of critical habitat for the northern spotted owl that are owned or managed by the Department of Defense have an active INRMP which provides a benefit to the species, and are thus exempt from critical habitat designation under section 4(a)(3) of the Act (see Exemptions, above). We therefore anticipate no impact on national security from this designation. Consequently, the Secretary is not exercising his discretion to exclude any additional areas from this final revised designation based on impacts to national security.

Relevant Impacts

Under section 4(b)(2) of the Act, we consider all relevant impacts, including but not limited to economic impacts and impacts on national security. We consider a number of factors including whether the landowners have developed any HCPs or other management plans for the area, or whether there are conservation partnerships that would be encouraged by designation of, or exclusion from, critical habitat. In addition, we look at any tribal issues, and consider the government-to-government relationship of the United States with tribal entities. We also consider any social impacts that might occur because of the designation.

Here we provide our analysis of areas that were proposed as revised designation of critical habitat for the northern spotted owl, for which there may be a greater conservation benefit to exclude rather than include in the designation. Our weighing of the benefits of inclusion versus exclusion considered all relevant factors in order to make our final determination as to what will result in the greatest conservation benefit to the owl. Depending on the specifics of each situation, there may be cases where the designation of critical habitat will not necessarily provide enhanced protection, and may actually lead to a net loss of conservation benefit.

Benefits of Designating Critical Habitat

The process of designating critical habitat as described in the Act requires that the Service identify those lands within the geographical area occupied by the species at the time of listing on which are found the physical or biological features essential to the conservation of the species that may require special management considerations or protection, and those areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of the species.

The identification of areas that contain the features essential to the conservation of the species, or are otherwise essential for the conservation of the species if outside the geographical area occupied by the species at the time of listing, is a benefit resulting from the designation. The critical habitat designation process includes peer review and public comment on the identified physical or biological features and areas, and provides a mechanism to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by clearly delineating areas of high conservation value for the species, and is valuable to land owners and managers in developing conservation management plans by describing the essential physical or biological features and special management actions or protections that are needed for identified areas. Including lands in critical habitat also informs State agencies and local governments about areas that could be conserved under State laws or local ordinances.

However, the prohibition on destruction or adverse modification under section 7(a)(2) of the Act constitutes the only Federal regulatory benefit of critical habitat designation. As discussed above, Federal agencies must consult with the Service on actions that may affect critical habitat and must avoid destroying or adversely modifying critical habitat. Federal agencies must also consult with us on actions that may affect a listed species and refrain from undertaking actions that are likely to jeopardize the continued existence of such species. The analysis of effects to critical habitat is a separate and different analysis from that of the effects to the species. Therefore, the difference in outcomes of these two analyses also represents the regulatory benefit of critical habitat. For some species, and in some locations, the outcome of these analyses will be similar because effects on habitat will often result in effects on the species. However, these two regulatory standards are different. The jeopardy analysis evaluates how a proposed action is likely to influence the likelihood of a species' survival and recovery. The adverse modification analysis evaluates how an action affects the capability of the critical habitat to serve its intended conservation function or purpose (USFWS, in litt. 2004). Although these standards are different, it has been the Service's experience that in many instances proposed actions that affect both a listed species and its critical habitat and that constitute jeopardy also constitute adverse modification. In some cases, however, application of these different standards results in different section 7(a)(2) determinations, especially in situations where the affected area is mostly or exclusively unoccupied critical habitat. Thus, critical habitat designations may provide greater benefits to the recovery of a species than would listing as endangered or threatened under the Act alone.

There are two limitations to the regulatory effect of critical habitat. First, a section 7(a)(2) consultation is required only where there is a Federal nexus (an action authorized, funded, or carried out by any Federal agency)—if there is no Federal nexus, the critical habitat designation of non-Federal lands itself does not restrict any actions that destroy or adversely modify critical habitat. Aside from the requirement that Federal agencies ensure that their actions are not likely to result in destruction or adverse modification of critical habitat under section 7, the Act does not provide any additional regulatory protection to lands designated as critical habitat.

Second, designating critical habitat does not create a management plan for the areas; does not establish numerical population goals or prescribe specific management actions (inside or outside of critical habitat); and does not have a direct effect on areas not designated as critical habitat. The designation only limits destruction or adverse modification of critical habitat, not all adverse effects. By its nature, the prohibition on adverse modification ensures that the conservation role and function of the critical habitat network is not appreciably reduced as a result of a Federal action.

Once an agency determines that consultation under section 7(a)(2) of the Act is necessary, the process may conclude informally when the Service concurs in writing that the proposed Federal action is not likely to adversely affect the species or critical habitat. However, if we determine through informal consultation that adverse impacts are likely to occur, then formal consultation is initiated. Formal consultation concludes with a biological opinion issued by the Service on whether the proposed Federal action is likely to jeopardize the continued existence of listed species or result in destruction or adverse modification of critical habitat.

For critical habitat, a biological opinion that concludes in a determination of no destruction or adverse modification may recommend additional conservation measures to minimize adverse effects to primary constituent elements, but such measures would be discretionary on the part of the Federal agency.

The designation of critical habitat does not require that any management or recovery actions take place on the lands included in the designation. Even in cases where consultation has been initiated under section 7(a)(2) of the Act because of effects to critical habitat, the end result of consultation is to avoid adverse modification, but not necessarily to manage critical habitat or institute recovery actions on critical habitat. On the other hand, voluntary conservation efforts by landowners can remove or reduce known threats to a species or its habitat by implementing recovery actions. We find that in many instances the regulatory benefit of critical habitat is minimal when compared to the conservation benefit that can be achieved through implementing HCPs under section 10 of the Act, or other voluntary conservation efforts or management plans. The conservation achieved through implementing HCPs, or other habitat management plans can be greater than what we achieve through multiple site-by-site, project-by-project section 7(a)(2) consultations involving project effects to critical habitat. Management plans can commit resources to implement long-term management and protection to particular habitat for at least one and possibly other listed or sensitive species. Section 7(a)(2) consultations commit Federal agencies to preventing adverse modification of critical habitat caused by the particular project; consultation does not require Federal agencies to provide for conservation or long-term benefits to areas not affected by the proposed project. Thus, implementation of any HCP, or management plan that incorporates enhancement or recovery as the management standard may often provide as much or more benefit than a consultation for critical habitat designation. After reviewing all current HCPs, SHAs, and any other active management plans or conservation agreements, and weighing the benefits of inclusion and exclusion (see below), we are excluding all State and private lands covered by such agreements from the final critical habitat designation.

We are also excluding under section 4(b)(2) congressionally-reserved natural areas such as national parks and wilderness areas, State parks, and other private lands that had been proposed for designation, for the reasons discussed below. These analyses are based in large part on the particular conservation requirements of the northern spotted owl or the State laws aimed at protecting this species, and are specific to this designation. Thus, our determination that the benefits of exclusion outweigh the benefits of inclusion in these cases, as well as the decision to exclude in these instances, do not necessarily have a bearing on any future critical habitat designations.

Table 8 identifies all lands excluded from the final rule.

TABLE 8—LANDS EXCLUDED FROM THE FINAL REVISED DESIGNATION OF CRITICAL HABITAT FOR THE NORTHERN SPOTTED OWL UNDER SECTION 4(B)(2) OF THE ACT

Type of agreement	Critical habitat unit	State	Land owner/agency	*Acres*	*Hectares*
Safe Harbor Agreement	WCC	WA	Port Blakely Tree Farms, L.P., Safe Harbor Agreement, Landowner Option Plan, Cooperative Habitat Enhancement.	195	79
	WCC/ECN	WA	SDS Co. & Broughton Lumber Co. Conservation Plan	2,035	824
	RWC	CA	Forster-Gill, Inc	238	96
	RWC	CA	Van Eck Forest Foundation, Safe Harbor Agreement	2,774	1,122
Habitat Conservation Plan	WCC	WA	Cedar River Watershed Habitat Conservation Plan	3,244	1,313
	WCC	WA	Green River Water Supply Operations and Watershed Protection Habitat Conservation Plan.	3,162	1,280
	WCC/ECN	WA	Plum Creek Timber Central Cascades I–90 Habitat Conservation Plan.	33,144	13,413

TABLE 8—LANDS EXCLUDED FROM THE FINAL REVISED DESIGNATION OF CRITICAL HABITAT FOR THE NORTHERN SPOTTED OWL UNDER SECTION 4(B)(2) OF THE ACT—Continued

Type of agreement	Critical habitat unit	State	Land owner/agency	Acres	Hectares
	WCC	WA	West Fork Timber Habitat Conservation Plan	5,105	2,066
	RWC	CA	Green Diamond Resource Company Habitat Conservation Plan.	369,384	149,484
	RWC	CA	Humboldt Redwood Company, Habitat Conservation Plan.	208,172	84,244
	RWC	CA	Regli Estate Habitat Conservation Plan	484	196
	ICC	CA	Terra Springs Habitat Conservation Plan	39	16
		WA	Washington Department of Natural Resources State Lands HCP.	225,751	91,358
Other Conservation Measures or Partnerships.	ECN	WA	Scofield Corporation	40	16
	RWC	CA	Mendocino Redwood Company	232,584	94,123
National Parks, State Parks, and Congressionally Reserved Lands.			National Parks	998,585	404,113
			State Parks and Natural Areas	180,894	73,267
			Congressionally Reserved USFS and BLM Lands	1,625,068	657,644
Other Private Lands		WA		42,513	17,204
		CA		123,348	49,917
Total lands excluded under section 4(b)(2) of the Act.				4,056,759	1,641,777

Benefits of Excluding Lands With Safe Harbor Agreements

A Safe Harbor Agreement (SHA) is a voluntary agreement involving private or other non-Federal property owners whose actions contribute to the recovery of listed species. The agreement is between cooperating non-Federal property owners and the Service. In exchange for actions that contribute to the recovery of listed species on non-Federal lands, participating property owners receive formal assurances from the Service that, if they fulfill the conditions of the SHA, the Service will not require any additional or different management activities by the participants without their consent. In addition, at the end of the agreement period, participants may return the enrolled property to the baseline conditions that existed at the beginning of the SHA.

Because many endangered and threatened species occur exclusively, or to a large extent, on privately owned property, the involvement of the private sector in the conservation and recovery of species is crucial. Property owners are often willing partners in efforts to recover listed species. However, some property owners may be reluctant to undertake activities that support or attract listed species on their properties, due to fear of future property-use restrictions related to the Act. To address this concern, an SHA provides that future property-use limitations will not occur without the landowner's consent if the landowner is in compliance with the permit and agreement and the activity is not likely to result in jeopardy to the listed species.

Central to this approach is that the actions taken under the SHA must provide a net conservation benefit that contributes to the recovery of the covered species. Examples of conservation benefits include:

• Reduced habitat fragmentation;
• Maintenance, restoration, or enhancement of existing habitats;
• Increases in habitat connectivity;
• Stabilized or increased numbers or distribution;
• The creation of buffers for protected areas; and
• Opportunities to test and develop new habitat management techniques.

By entering into a SHA, property owners receive assurances that land use restrictions will not be required even if the voluntary actions taken under the agreement attract particular listed species onto enrolled properties or increase the numbers of distribution of those listed species already present on those properties. The assurances are provided through an enhancement of survival permit issued to the property owner, under the authority of section 10(a)(1)(A) of the Act. To implement this provision of the Act, the Service and National Marine Fisheries Service (NMFS) issued a joint policy for developing SHAs for listed species on June 17, 1999 (64 FR 32717). The Service simultaneously issued regulations for implementing SHAs on June 17, 1999 (64 FR 32706). A correction to the final rule was announced on September 30, 1999 (64 FR 52676). The enhancement of survival permit issued in association with an SHA authorizes incidental take of species that may result from actions undertaken by the landowner under the SHA, which could include returning the property to the baseline conditions at the end of the agreement. The permit also specifies that the Service will not require any additional or different management activities by participants without their consent if the permittee is in compliance with the requirements of the permit and the SHA and the permittee's actions are not likely to result in jeopardy.

The benefits of excluding lands with approved SHAs from critical habitat designation may include relieving landowners, communities, and counties of any additional regulatory burden that might be imposed as a result of the critical habitat designation. Even if any additional regulatory burden would be unlikely due to a lack of a Federal nexus, the designation of critical habitat could nonetheless have an unintended negative effect on our relationship with non-Federal landowners, due to the perceived imposition of government regulation. An additional benefit of excluding lands covered by approved SHAs from critical habitat designation is that it may make it easier for us to seek new partnerships with future SHA participants, including States, counties, local jurisdictions, conservation organizations, and private landowners, in cases where potential partners may be reluctant to encourage the development of habitat that supports endangered or threatened species. In such cases, we may be able to implement conservation actions that we would be unable to accomplish otherwise. By excluding these lands, we may preserve our current partnerships and encourage additional future conservation actions.

In weighing the benefits of inclusion versus the benefits of exclusion for lands subject to approved SHAs, it is important to note that a fundamental requirement of an SHA is an advance determination by the Service that the provisions of the SHA will result in a net conservation benefit to the listed species. Approved SHAs have, therefore, already been determined to provide a net conservation benefit to the listed species; in addition, the management activities provided in an SHA often provide conservation benefits to unlisted sensitive species as well. As described earlier, the designation of critical habitat may not provide any substantial realized conservation benefit to the species on non-Federal lands absent a Federal nexus for an activity. Especially where further Federal action is unlikely, the net conservation benefit provided by the terms of the SHA itself, considered in conjunction with the benefit of excluding lands subject to an SHA by preserving our working relationships with landowners who have entered into SHAs with the Service, and the benefit of laying the positive groundwork for possible future agreements with other landowners, may collectively outweigh the potentially limited benefit that would be realized on these lands from the designation of critical habitat. However, as with all potential exclusions under consideration, lands subject to an SHA will only be excluded if we determine that the benefits of exclusion outweigh the benefits of inclusion following a rigorous examination of the record on a case-by-case basis.

We note that permit issuance in association with SHA applications requires consultation under section 7(a)(2) of the Act, which would include the review of the effects of all SHA-covered activities that might adversely impact the species under a jeopardy standard, including possibly significant habitat modification (see definition of ''harm'' at 50 CFR 17.3), even without the critical habitat designation. In addition, all other Federal actions that may affect the listed species would still require consultation under section 7(a)(2) of the Act, and we would review these actions for possible significant habitat modification in accordance with the definition of harm, described in the *Benefits of Excluding Lands with Habitat Conservation Plans,* below.

We further note that SHAs may include a provision that the landowner may return the area to baseline conditions upon expiration of the permit. The term of the permit is thus an important consideration in weighing the relative benefits of inclusion versus exclusion from the designation of critical habitat. However, the Service has the right to revise a critical habitat designation at any time. Furthermore, the potential benefit of acknowledging the positive conservation contributions of landowners willing to enter into voluntary conservation agreements with the Service for the recovery of endangered or threatened species may nonetheless outweigh the loss of benefit that may be incurred through a possible return to baseline following permit expiration. As stated above, such circumstances require careful consideration on a case-by-case basis in order to make a final determination of the benefits of exclusion or inclusion in a critical habitat designation.

Below is a description of each SHA and our analysis of the benefits of including and excluding it from the critical habitat designation under section 4(b)(2) of the Act.

State of California

Forster-Gill, Inc., Safe Harbor Agreement

In this final designation, the Secretary has exercised his authority to exclude 238 ac (96 ha) of lands from critical habitat, under section 4(b)(2) of the Act, that are covered by the Safe Harbor Agreement (SHA) of Forster-Gill, Inc., within subunit 1 of the Redwood Coast CHU in Humboldt County, California. The enhancement of survival permit associated with this SHA was noticed in the **Federal Register** on March 22, 2002 (67 FR 13357), and issued June 18, 2002. The term of the agreement is 80 years, and the term of the permit is 90 years. The SHA provides for the creation and enhancement of habitat for the northern spotted owl on 238 ac (96 ha) of lands in Humboldt County, California, and provides for continued timber harvest on those lands. There are two baseline conditions that will be maintained under the SHA: (1) Protection of an 11.2-ac (5-ha) no-harvest area that will buffer the most recent active northern spotted owl nest site, but will also be maintained in the absence of a nest site; and (2) maintenance of 216 ac (87 ha) on the property such that the trees will always average 12 to 24 in (30 to 60 cm) dbh with a canopy cover of 60 to 100 percent. At the time of the agreement, forest conditions were on the lower end of the diameter and canopy cover ranges. By the end of the agreement, the property will be at the upper end of the diameter and canopy cover ranges. Under the SHA, Forster-Gill, Inc., agrees to: (1) Annually, survey and monitor for the location and reproductive status of northern spotted owls on the property; (2) protect all active nest sites (locations where nesting behavior is observed during any of the previous 3 years) with a no-harvest area that buffers the nest site by no less than 300 ft (90 m) and limits timber harvest operations within 1,000 ft (305 m) of an active nest site during the breeding season, allowing only the use of existing haul roads; and (3) manage the second-growth redwood timber on the property in a manner that maintains suitable northern spotted owl habitat, while creating, over time, the multilayered canopy structure with an older, larger tree component associated with high-quality northern spotted owl habitat. The SHA is expected to provide, maintain, and enhance for the 80-year life of the agreement over 200 ac (80 ha) of northern spotted owl habitat within a matrix of private timberland. The cumulative impact of the agreement and the timber management activities it covers, which are facilitated by the allowable incidental take, is expected to provide a net benefit to the northern spotted owl.

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands that might trigger such consultation is limited (there is little likelihood of an action that will involve Federal funding, authorization, or implementation). In addition, since the lands under the SHA in question are occupied by the northern spotted owl, if a Federal nexus were to occur, section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species through a jeopardy analysis. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or functionality of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the additional conservation that could be attained through the supplemental adverse modification analysis for critical habitat under section 7 would likely not be significant, and would be triggered only in the event of a Federal action. Furthermore, any such potential benefit would be small in comparison to the benefits derived from the SHA, which already incorporates measures that specifically benefit the northern spotted owl and its habitat, as described above, and remains in place regardless of the designation of critical habitat.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. However, in this case the landowners are aware of the needs of the species through the development of their SHA, in which they have agreed to take measures to protect the northern spotted owl on their property and create and enhance suitable habitat for the species as well. Any additional educational and information benefits that might arise from critical habitat designation have been largely accomplished through the public review of and comment on the SHA and the associated permit. The release of the Revised Recovery Plan for the Northern Spotted Owl in 2011 was also preceded by outreach efforts and public comment opportunities. In addition, the rulemaking process associated with critical habitat designation included several opportunities for public comment, and we also held multiple public information meetings across the range of the species. Through these outreach opportunities, land owners, State agencies, and local governments have become aware of the current status of and threats to the northern spotted owl, and the conservation actions needed for recovery.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, CALFIRE has indicated to us that it is unlikely to impose any new requirements on project proponents if critical habitat is designated in areas already subject to California Forest Practice Rules. Therefore, we believe this potential benefit of critical will be limited.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 236 ac (96 ha) of lands currently managed under the SHA are substantial. We have created a close partnership with Forster-Gill through the development of the SHA, which incorporates protections and management objectives for the northern spotted owl and the habitat upon which it depends for breeding, sheltering, and foraging activities, as described above. The conservation approach identified in the Forster-Gill, Inc. SHA, along with our close coordination with the company, addresses the identified threats to northern spotted owl habitat on the covered lands that contain the physical or biological features essential to the conservation of the species.

The conservation measures identified within the SHA seek to achieve conservation goals for northern spotted owls and their habitat, and thus can be of greater conservation benefit than the designation of critical habitat, which does not require specific, proactive management actions. If there is a Federal nexus, consultation under critical habitat requires only that the action agency avoid actions that destroy or adversely modify critical habitat. In contrast, SHA conservation measures that provide a benefit to the northern spotted owl and its habitat have been, and will be, implemented continuously beginning with the enactment of the SHA in 2002 through the 80-year term of the ITP, through 2082, on all covered lands owned and managed by Forster-Gill, Inc. The key conservation measure is a provision that will lead to an approximate doubling of mean tree diameter from roughly 12 to 24 in (30 to 60 cm) on covered lands over the life of the permit, leading to enhancement of habitat suitability.

The designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the Forster-Gill SHA are designated as critical habitat, it would likely have a chilling effect on our continued ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement various conservation actions (such as SHAs, HCPs, and other conservation plans, particularly large, regional Conservation Plans that involve numerous participants and/or address landscape-level conservation of species and habitats) that we would be unable to accomplish otherwise.

Excluding the approximately 238 ac (96 ha) owned and managed by Forster-Gill, Inc. from critical habitat designation will sustain and enhance the working relationship between the Service and this private lands partner. The willingness of Forster-Gill to work with the Service to manage federally listed species will continue to reinforce those conservation efforts and our partnership, which contribute toward achieving recovery of the northern spotted owl. We consider this voluntary partnership in conservation vital to our understanding of the status of species on non-Federal lands and necessary to implement recovery actions such as habitat protection and restoration, and beneficial management actions for species. By excluding these lands, we preserve our current conservation partnership with Forster-Gill and encourage additional conservation actions by this partner, and potentially others as well, in the future. We consider the positive effect of excluding proven conservation partners from critical habitat to be a significant benefit of exclusion.

The Benefits of Exclusion Outweigh the Benefits of Inclusion—We reviewed and evaluated the exclusion of approximately 238 ac (96 ha) of land owned and managed by Forster-Gill, Inc. from our designation of critical habitat. The benefits of including these lands in the designation are relatively small. The habitat on the covered lands is already being monitored and managed under the SHA to improve the habitat elements that are equivalent to the physical or biological features that are outlined in this critical habitat rule. The additional designation of critical habitat would provide unnecessarily duplicative protections, and would in any case be unlikely to be triggered under section 7, since there is little probability of a Federal nexus for any activity on these lands. Even if triggered, since the lands in question are occupied by the species, section 7 consultation would already be required under the jeopardy standard, and as noted, the analysis under the adverse modification standard would be unlikely to provide additional protections beyond those already in place under the SHA. The regulatory benefit of additional Federal review on individual proposed actions is episodic and confined to the scope and scale of the specific actions, whereas implementation of the SHA is continuous and affects the entire property.

Educational benefits are also limited. The landowner is already aware of the conservation needs of the species through development of the SHA. Because there is no public access to the land, we are not aware of any public constituency connected with this ownership which would derive informational benefits from the designation of critical habitat. However, as noted, we have conducted extensive outreach efforts, both in relation to the SHA and its associated permit, as well as our proposed critical habitat, which have provided opportunity for public education and comment on critical habitat for the northern spotted owl. As such, much of the potential educational benefit of critical habitat on these lands has already been accomplished.

On the other hand, the SHA has provisions for protecting and maintaining northern spotted owl habitat that far exceed the conservation benefits that could be obtained through section 7 consultation. These measures will not only prevent the degradation of essential features of the northern spotted owl, but they will maintain or improve these features over time. Furthermore, landowners always have the option not to return to baseline after the term of the SHA is over. Exclusion of these lands from critical habitat will help foster the partnership we have developed with Forster-Gill through the development and continuing implementation of the SHA, and may encourage the landowner to continue these cooperative efforts even after the term of the SHA. In addition, this partnership may serve as a model and aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species. For these reasons, we have determined that the benefits of exclusion of lands covered by the Forster-Gill, Inc. SHA outweigh the benefits of critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that the exclusion of 238 ac (96 ha) from the designation of critical habitat for the northern spotted owl of lands owned and managed by Forster-Gill, Inc., as identified in their SHA will not result in extinction of the species because current conservation efforts under the plan adequately protect the geographical areas containing the physical or biological features essential to the conservation of the species. For projects having a Federal nexus and affecting northern spotted owls in occupied areas, as in this case, the jeopardy standard of section 7 of the Act, coupled with protection provided under the terms of the SHA, would provide assurances that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Forster-Gill, Inc. SHA boundary totaling 238 ac (96 ha).

Van Eck Forest Foundation Safe Harbor Agreement

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, that are covered by the SHA between the Fred M. Van Eck Forest Foundation and the Service within subunit 1 of the Redwood Coast CHU in California. These lands are also protected under a conservation easement held by the Pacific Forest Trust. The enhancement of survival permit associated with this SHA was noticed in the **Federal Register** on July 8, 2008 (73 FR 39026), and issued August 18, 2008. The term of the permit and the agreement is 90 years. The SHA provides for the creation and enhancement of habitat for the northern spotted owl on 2,774 ac (1,122 ha) of lands in Humboldt County, California, and provides for continued timber harvest on those lands. At the time of the agreement, the lands under consideration supported 1,730 ac (700 ha) of northern spotted owl nesting and roosting habitat and one northern spotted owl activity center (a location where owls are observed nesting or roosting). We anticipate that under the northern spotted owl habitat creation and enhancement timber management regime proposed in the SHA that approximately 1,947 ac (788 ha) of nesting and roosting habitat and potentially up to five northern spotted owl activity centers could exist on the property at the end of 90 years. The SHA does not provide for a return to baseline conditions at the end of the agreement term. Instead, the agreement provides that if more than five northern spotted owl activity centers should become established on the property during the 90-year term, the landowner would be allowed to remove such additional activity centers during the agreement period.

Under the SHA, the Fred M. van Eck Forest Foundation agrees to: (1) Conduct surveys annually to determine the locations and reproductive status of any northern spotted owls; (2) protect up to five activity centers with a no-harvest area that buffers the activity center by no less than 100 ft (30 m); (3) utilize selective timber harvest methods such that suitable nesting habitat is maintained within 300 ft (91 m) of each activity center; (4) limit noise disturbance from timber harvest operations within 1,000 ft (305 m) of an active nest during the breeding season; and (5) manage all second-growth redwood timber on the property in a manner that maintains or creates suitable nesting and roosting habitat over time. The term of the SHA and ITP is 90 years; there is no term limitation on the easement deed held by the Pacific Forest Trust. Specific long-term management targets for second-growth timber are enumerated in the easement deed. All are expressed as propertywide averages; for example, a stocking target of 100,000 board feet (bf) per acre, 75 percent minimum conifer occupancy, 25 percent of standing inventory made up of trees greater than 200 years of age, 15 dominant conifers per acre 36-inches DBH or greater, 4 standing snags per acre 30-inches DBH or greater, 1,600 cubic feet per acre of dead and down logs. The cumulative impact of the SHA and the easement, is expected to provide a substantial net benefit to the northern spotted owl.

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands is limited (there is little likelihood of an action that will involve Federal funding, authorization, or implementation). In addition, since the lands under the SHA in question are occupied by the northern spotted owl, if a Federal nexus were to occur, section

7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species through a jeopardy analysis. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the additional conservation that could be attained through the supplemental adverse modification analysis for critical habitat under section 7 would likely not be significant, and would be triggered only in the event of a Federal action. Furthermore, any such potential benefit would be small in comparison to the benefits already derived from the SHA, which already incorporates measures that specifically benefit the northern spotted owl and its habitat, as described above, and remains in place regardless of the designation of critical habitat.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. The landowners in this case are aware of the needs of the species through the development of their SHA, in which they have agreed to take measures to protect the northern spotted owl on their property and create and enhance suitable habitat for the species as well. Any additional educational and information benefits that might arise from critical habitat designation have been largely accomplished through the public review of and comment on the SHA and the associated permit. The release of the Revised Recovery Plan for the Northern Spotted Owl in 2011 was also preceded by outreach efforts and public comment opportunities. In addition, the rulemaking process associated with critical habitat designation included several opportunities for public comment, and we also held multiple public information meetings across the range of the species. Through these outreach opportunities, land owners, State agencies, and local governments have become aware of the current status of and threats to the northern spotted owl, and the conservation actions needed for recovery.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, CALFIRE has indicated to us that it is unlikely to impose any new requirements on project proponents if critical habitat is designated in areas already subject to California Forest Practice Rules. Therefore, we believe this potential benefit of critical will be limited.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 2,774 ac (1,122 ha) of lands currently managed under the SHA are substantial. We have created a close partnership with the Foundation through the development of the SHA, which incorporates protections and management objectives for the northern spotted owl and the habitat upon which it depends for breeding, sheltering, and foraging activities, as described above. The conservation approach identified in the Van Eck Forest Foundation SHA, along with our close coordination with the Foundation, addresses the identified threats to northern spotted owl on covered lands that contain the physical or biological features essential to the conservation of the species.

The SHA conservation measures that provide a benefit to the northern spotted owl and its habitat have been, and will be, implemented continuously beginning with the enactment of the SHA in 2008 through the 90-year term of the ITP, through 2088, on all covered lands owned and managed by the Van Eck Forest Foundation. Such measures include the examples we identified above: A volume-based mean stocking target, mean conifer occupancy, mean percentages of standing inventory in older age classes, mean size and density of dominant conifers, mean size and density of standing snags, and mean volume of dead and down logs. The measures provided in the SHA are aimed at the maintenance and enhancement of suitable nesting and roosting habitat over time to benefit the northern spotted owl.

The designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the Van Eck Forest Foundation SHA are designated as critical habitat, it would likely have a chilling effect on our continued ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement various conservation actions (such as SHAs, HCPs, and other conservation plans) that we would be unable to accomplish otherwise. Excluding the approximately 2,774 ac (1,122 ha) owned and managed by the Van Eck Forest Foundation from critical habitat designation will sustain and enhance this working relationship between the Service and the Foundation. The willingness of the Foundation to work with us to manage federally listed species will continue to reinforce those conservation efforts and our partnership, which contribute toward achieving recovery of the northern spotted owl. We consider this voluntary partnership in conservation vital to our understanding of the status of species on non-Federal lands and necessary for us to implement recovery actions, such as habitat protection and restoration, and beneficial management actions for species. Further, this partnership may aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species. We consider the positive effect of excluding proven conservation partners from critical habitat to be a significant benefit of exclusion.

The Benefits of Exclusion Outweigh the Benefits of Inclusion—We reviewed and evaluated the exclusion of approximately 2,774 ac (1,122 ha) of land owned and managed by the Van Eck Forest Foundation from our designation of critical habitat. The benefits of including these lands in the designation are relatively small, since the habitat on the covered lands is already being monitored and managed under the SHA to improve the habitat elements that are equivalent to the physical or biological features that are outlined in this critical habitat rule. The additional designation of critical habitat would provide unnecessarily duplicative protections, and would in any case be unlikely to be triggered under section 7, since there is little probability of a Federal nexus on these lands. Even if triggered, since the lands in question are occupied by the species, section 7 consultation would already be required under the jeopardy standard, and, as noted, the analysis under the adverse modification standard would be unlikely to provide additional protections beyond those already in place under the SHA.

Educational benefits are also limited. The landowner is already aware of the conservation needs of the species through development of the SHA. Because the Van Eck lands, for the most part, are not open to the general public, there is no public constituency that would derive informational benefits from the designation of critical habitat. However, as noted, we have conducted extensive outreach efforts, both in relation to the SHA and its associated permit, as well as our proposed revision of critical habitat, which have provided opportunity for public education and comment on critical habitat for the northern spotted owl. As such, much of the potential educational benefit of critical habitat on these lands has already been accomplished.

On the other hand, the conservation measures identified within the SHA seek to achieve conservation goals for northern spotted owls and their habitat, and thus can be of greater conservation benefit than the designation of critical habitat, which does not require specific, proactive actions. Thus, the implementation of the SHA provides a substantially greater benefit to the northern spotted owl than would be obtained through section 7 consultation. The measures provided in the SHA will not only prevent the degradation of essential features for the northern spotted owl, but they are designed to maintain or enhance these features over time. Furthermore, landowners always have the option not to return to baseline after the term of the SHA is over. Exclusion of these lands from critical habitat will help foster the partnership we have developed with the Van Eck Forest Foundation through the development and continuing implementation of the SHA and may encourage the landowner to continue these cooperative efforts even after the term of the SHA. In addition, this partnership may serve as a model and aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species. For these reasons we have determined that the benefits of exclusion of lands covered by the Van Eck Forest Foundation SHA outweigh the benefits of critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that the exclusion of 2,774 ac (1,122 ha) from the designation of critical habitat for the northern spotted owl of lands owned and managed by the Van Eck Forest Foundation, as identified in their SHA will not result in extinction of the species because current conservation efforts under the plan adequately protect the geographical areas containing the physical or biological features essential to the conservation of the species. For projects having a Federal nexus and affecting northern spotted owls in occupied areas, such as in this case, the jeopardy standard of section 7 of the Act, coupled with protection provided under the terms of the SHA and Conservation Easement Agreement, would provide assurances that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Van Eck Forest Foundation SHA boundary totaling 2,774 ac (1,122 ha).

State of Washington

Port Blakely Tree Farms L.P. (Morton Block) Safe Harbor Agreement, Landowner Option Plan, and Cooperative Habitat Enhancement Agreement

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, totaling approximately 195 ac (79 ha) that are covered under the Port Blakely Tree Farms (also known as Morton Block) SHA in the West Cascades Central CHU in Washington. The enhancement of survival permit associated with this SHA was noticed in the **Federal Register** on December 17, 2008 (73 FR 76680) and issued May 22, 2009. The SHA and permit include both the marbled murrelet (*Brachyramphus marmoratus*) and the northern spotted owl, and covers an area of 45,306 ac (18,335 ha) of managed forest lands known as the ''Morton Block,'' in Lewis and Skamania Counties. The term of the permit and SHA is 60 years.

The covered lands have been intensively managed for timber production and at the time the permit was issued were not known to be occupied by northern spotted owls. The environmental baseline was measured in terms of dispersal habitat. There are no known northern spotted owls nesting on Port Blakely lands. However, northern spotted owls have historically nested on adjacent Federal lands and the 1.82-mile (2.9-km) radius circles around those sites that are used for evaluating potential habitat availability for northern spotted owls extend onto Port Blakely lands. Because of this, Port Blakely Tree Farms conducted habitat evaluations of their properties to determine the amount of suitable northern spotted owl habitat present. The baseline estimate to be provided by the SHA is 8,360 ac (3,383 ha) of northern spotted owl dispersal habitat.

Under the SHA, Port Blakely is implementing conservation measures that are expected to provide net conservation benefits to the northern spotted owl and marbled murrelet. The SHA also provides that Port Blakely will manage their tree farm in a manner that contributes to the goals of the Mineral Block Northern Spotted Owl Special Emphasis Area (SOSEA) according to Washington Forest Practices Rules and Regulations (Washington Forest Practices Board 2002, WAC 222–16–080, WAC 222–16– 086). This area is intended to facilitate dispersal of juvenile northern spotted owls, as well as provide demographic support to core northern spotted owl populations.

Under the SHA, Port Blakely is implementing enhanced forest-management measures that would create potential habitat for the northern spotted owl and marbled murrelet, such as longer harvest rotations, additional thinning to accelerate forest growth, a snag-creation program, retention of more fallen wood than is required by Washington Forest Practices Rules, establishment of special management areas and special set-aside areas, and monitoring. The terms of the agreement are intended to produce conditions that will facilitate the dispersal of the northern spotted owl across the Port Blakely ownership.

At present, there are no known nesting sites for owls in the covered area. However, portions of the covered area are within owl management circles associated with site centers on adjacent ownerships. The majority of the stand-management units are composed of 20- to 60-year-old timber. There are no stands that would provide nesting opportunities for owls in the covered area, and very little young forest marginal habitat is present in the areas of the Morton Block with the potential for utilization by owls that may occur on adjacent ownerships. The young forest marginal habitat known to exist on Port Blakely's ownership is within circles that have greater than 40 percent suitable habitat and, thus, may be harvested under Washington State Forest Practices Rules.

The SHA landscape-management approach contributes to owl recovery by complementing the existing owl landscape-management strategies on adjacent Federal and State forestlands. The SHA goals and objectives for the northern spotted owl are to provide demographic interchange through dispersal and foraging habitat across their ownership on a dynamic basis, as well as higher-quality habitat in harvest set-asides. These habitats provide for both dispersal and demographic interchange. SOSEA goals are identified in the Washington State Forest Practices Rules and shown on the SOSEA maps (see WAC 222–16–086). SOSEA goals provide for demographic and dispersal support as necessary to complement the northern spotted owl protection strategies on Federal lands within or adjacent to the SOSEA (WAC 222–16–010).

Port Blakely will achieve these goals and objectives both in the near term and over the term of the SHA by immediately protecting special management areas and special set-aside areas of northern spotted owl habitat, and managing commercial forested lands in the plan area on an average rotation length of 60 years. In addition, the SHA provides silvicultural measures to benefit the northern spotted owl, including a thinning program and a snag-retention and creation program.

Port Blakely has agreed to collaborate with State and Federal biologists in research efforts to better understand how their management will influence dispersal habitat conditions in the plan area. Port Blakely is working cooperatively with the Service, WDFW, WDNR, and other entities that have expertise, in designing a statistically robust snag-monitoring study. Port Blakely will also map all leave tree areas, and mark a sample of snag and defective trees for use in snag-monitoring studies. The SHA acknowledges uncertainty in some aspects of anticipated results. Areas of uncertainty include the likelihood that green retention trees will become snags during the period between commercial thinning and future entries, as well as the recruitment success and persistence of snags. Port Blakely has committed to work collaboratively with agencies in these matters. The SHA also contains monitoring and reporting requirements.

Benefits of Inclusion—Critical habitat designation on private lands introduces a higher level of Federal scrutiny under the interagency consultation process in section 7 of the Act. This higher level of scrutiny can arise through two avenues. Under section 7(a)(2) of the Act, Federal agencies that grant funds or issue permits for proposed actions on private lands, whether or not those lands are designated critical habitat, are required to consult with the Service to ensure that the proposed action ''* * * is not likely to jeopardize the continued existence of any endangered species or threatened species * * *'' When lands are designated critical habitat, the section 7(a)(2) consultation requirement is expanded so that the granting or permitting Federal agencies and the Service are required to ensure that the proposed action will not ''* * * result in the destruction or adverse modification of critical habitat * * *'' of any endangered species or threatened species. Critical habitat designation adds a new element to the Federal consultation: The consideration and analysis of adverse effects to habitat that might potentially arise from the proposed action. In evaluating the effects of proposed actions on critical habitat, the Service must be satisfied that the essential physical or biological features of the critical habitat likely will not be altered or destroyed by proposed activities to the extent that the conservation function of the designated critical habitat would be appreciably diminished. Briefly, if the land potentially affected by the proposed action is not designated critical habitat, the scope of the consultation must include a consideration of ''jeopardy'' to threatened or endangered species; but if the same land is designated critical habitat, the consultation must include considerations of both ''jeopardy'' and ''adverse modification'' of critical habitat.

We find that the conservation achieved through implementing these types of agreements is typically greater than would be achieved through multiple site-by-site, project-by-project, section 7 consultations involving consideration of critical habitat. In addition, it is unlikely that Federal projects would be proposed on these relatively remote forest lands unless it was a linear project such as a powerline, pipeline, or transportation project. Due to the scope of such projects, they would likely already have a Federal nexus regardless whether these lands are designated as critical habitat. While the SHA lands may not have nesting sites on them at this time, degradation of the habitats on the SHA or adjacent lands could be considered an adverse effect to the species. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus likely would, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or functionality of the habitat for the species, regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on land designated as critical habitat. However, the amount of conservation that could be attained through the addition of a critical habitat analysis to the section 7 consultation would be relatively low in comparison to the conservation provided by the SHA. The additional benefits of inclusion on the section 7 process are therefore relatively small.

The benefits of inclusion are further minimized because, as mentioned above, the Port Blakely SHA provides for the needs of the northern spotted owl by protecting and preserving landscape levels of suitable northern spotted owl nesting, roosting, and foraging habitat, as well as foraging and dispersal habitat over the term of the SHA in strategic landscapes, and implementing species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. A fundamental requirement of an SHA is a determination by the Service that the provisions of the SHA will result in a net conservation benefit to the listed species. Approved SHAs have, therefore, already been determined to provide a net conservation benefit to the listed species. In addition, monitoring will track SHA progress over the term of the permit and provide feedback on management actions. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measureable protections.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Designation of critical habitat could inform State agencies and local governments about areas that could be conserved under State laws or local ordinances, such as the Washington State Growth Management Act, which encourage the protection of ''critical areas'' including fish and wildlife habitat conservation areas. However, not only has the public process for this rulemaking provided information to the landowner, State agencies and local governments and the public about the importance of this area, but the process for approving a SHA, which requires public notice and comment, has served this educational function as well. Through these opportunities, land owners, State agencies, and local governments have become more aware of the status of and threats to listed species, and the conservation actions needed for recovery particularly as it relates to this property. For this reason, we believe that the educational benefits that might accrue from critical habitat designation would be minimal.

Thus, we find that there is minimal benefit from designating critical habitat for the northern spotted owl within the Port Blakely SHA.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 195 ac (79 ha) of lands currently managed under the SHA are substantial and include maintaining our partnership with this landowner. This is important because it may encourage the company not to return to baseline immediately after expiration of the SHA.

Excluding lands with SHAs from critical habitat designation may also enhance our ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement conservation actions that we would be unable to accomplish otherwise. If lands within the plan area are designated as critical habitat, it could have a negative effect on our ability to work with various companies to accomplish our goals for the SHA program and recovery of the northern spotted owl. This SHA is located in a key landscape between the Mineral Block and other Federal lands, and represents a unique opportunity to maintain northern spotted owls at the western extreme of the Cascades, which may support dispersal between the Cascades and Olympics. This SHA contributes meaningfully to the recovery of the northern spotted owl and serves as an example to other industrial companies. This SHA was the first to combine a Federal SHA effort with similar planning processes under State jurisdiction and serves as a role model in combining SHA planning with State processes. By excluding these lands, we preserve our current private and local conservation partnerships and encourage additional conservation actions in the future.

Benefits of Exclusion Outweigh the Benefits of Inclusion—In summary, we determine that the benefits of excluding the Port Blakely SHA from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat. We find that including the Port Blakely SHA would result in minimal, if any, additional benefits to the northern spotted owl, as explained above. We also find that the benefits of including these lands are further minimized by the fact that the management strategies of the Port Blakely SHA are designed to maintain and enhance habitat for the northern spotted owl. The SHA includes species-specific avoidance and minimization measures, monitoring requirements to track success and ensure proper implementation, and forest-management practices and habitat conservation objectives that benefit the northern spotted owl and its habitat, which exceeds any conservation value provided as a result of a critical habitat designation. Furthermore, encouraging landowners to enter into voluntary conservation agreements with the Service for the recovery of endangered or threatened species which we believe would be one of the benefits of exclusion may outweigh the loss of benefit that may be incurred through a possible return to baseline following permit expiration.

Therefore, in consideration of the factors discussed above in the Benefits of Exclusion section, including the relevant impact to current and future partnerships, we have determined that the benefits of exclusion of lands covered by the Port Blakely SHA outweigh the benefits of critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of a net of approximately 195 ac (79 ha) of lands within the Port Blakely SHA will not result in extinction of the northern spotted owl because current and future conservation efforts under the agreement provide management to facilitate dispersal of juvenile northern spotted owls, as well as provide demographic support to core northern spotted owl populations. Further, should nesting populations of the owl become reestablished in this area (and projects subsequently planned that have a Federal nexus and would potentially affect northern spotted owls), the jeopardy standard of section 7 of the Act, coupled with protection provided by the Port Blakely SHA, would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Port Blakely SHA totaling about 195 ac (79 ha).

SDS Company LLC and Broughton Lumber Company Safe Harbor Agreement

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, lands totaling about 2,035 ac (824 ha) that are covered under the SDS Lumber Company LLC and its registered business name Stevenson Land Company (together SDS) and Broughton Lumber Company (in total are related companies and are herein known as ''the Companies'') SHA, in Washington and Oregon. (Note the proposed rule contained an error, in which we mistakenly identified approximately 16,031 ac (6,487 ha) of SDS and Broughton lands for potential exclusion). The enhancement of survival permits associated with this SHA were noticed in the **Federal Register** on August 21, 2012 (77 FR 50526) and issued to the Companies on October 26, 2012. The term of each of the permits is 60 years. The Companies collectively manage approximately 83,000 ac (33,589 ha) of forestland in Skamania and Klickitat Counties in Washington, and Hood River and Wasco Counties in Oregon. Much of this ownership is composed of potential habitat outside of any owl circles and, therefore, is currently available for harvest under Washington State Forest Practices Rules. However, 30 northern spotted owl home ranges overlap some portion of the Companies' land base. Most site centers are currently located on Federal or State ownership; only one site center is located on Companies' ownership. Because the Companies have committed to manage their commercial forest lands for a substantially longer rotation than the typical 45-year rotation, and to implement additional conservation measures, northern spotted owls could occupy the covered area in the future under the SHA.

The Companies' landscape management approach contributes to owl recovery by complementing the existing owl landscape-management strategies on adjacent Federal and State forestlands. The Companies' SHA goals and objectives for the northern spotted owl are to provide dispersal and young forest marginal habitat across their ownership on a dynamic basis, as well as submature and higher quality habitat in harvest set-asides. These habitats provide both dispersal and demographic support, an established goal for lands within the two northern spotted owl special emphasis areas (SOSEAs). SOSEA goals are identified in the Forest Practices Rules and shown on the SOSEA maps (see WAC 222–16–086). SOSEA goals provide for demographic and/or dispersal support as necessary to complement the northern spotted owl protection strategies on Federal lands within or adjacent to the SOSEA (WAC 222–16–010).

The Companies will achieve these goals and objectives both in the near term and over the term of the SHA by immediately protecting special set-aside areas of northern spotted owl habitat and managing commercial forested lands in the plan area on an average rotation length of 60 years. In addition, the SHA provides silvicultural measures to benefit the northern spotted owl, including a snag-retention and creation program.

The SHA includes an elevated baseline, provisions for a 240-acre nesting set-aside and a 411-acre reserve in the White Salmon SOSEA, a 10-year deferral of harvest of any habitat in the 0.7-mile circle of the four site centers in which the Companies' covered lands comprise greater than 15 percent, future nest site protection, and the support and enhancement of existing conservation agreements. The SHA will include a monitoring and reporting schedule to ensure that the anticipated benefits will accrue both in the near term and over the term of the SHA.

Benefits of Inclusion—We find that there is minimal benefit from designating critical habitat for the northern spotted owl within the SDS SHA. It is unlikely that Federal projects would be proposed on these relatively remote forest lands unless it was a linear project such as a powerline, pipeline, or transportation project. Due to the scope of such projects, they would likely already have a Federal nexus regardless whether these lands are designated as critical habitat. Even where the SHA lands may not have nesting sites on them at this time, degradation of the habitats on the SHA or adjacent lands could be considered an adverse effect to the species. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus likely would, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or functionality of the habitat for the species, regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on land designated as critical habitat. However, the amount of conservation that could be attained through the addition of a critical habitat analysis to the section 7 consultation would be relatively low in comparison to the conservation provided by the SHA, as discussed below. The additional benefits of inclusion on the section 7 process are therefore relatively small.

The benefits of inclusion are further minimized because this SHA provides for the needs of the northern spotted owl by protecting and preserving landscape levels of suitable northern spotted owl nesting, roosting, and foraging habitat, as well as foraging and dispersal habitat over the term of the SHA in strategic landscapes, and implementing species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. A fundamental requirement of an SHA is a determination by the Service that the provisions of the SHA will result in a net conservation benefit to the listed species. Approved SHAs have, therefore, already been determined to provide a net conservation benefit to the listed species. In addition, funding for management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which in contrast to SHAs, do not commit the project proponent to long-term, special management practices or protections. In addition, monitoring will track SHA progress over the term of the permit and provide feedback on management actions. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measureable protections.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Designation of critical habitat could inform State agencies and local governments about areas that could be conserved under State laws or local ordinances, such as the Washington State Growth Management Act, which encourage the protection of ''critical areas'' including fish and wildlife habitat conservation areas. However, not only has the public process for this rulemaking provided information to the landowner, State agencies and local governments and the public about the importance of this area, but the process for approving a SHA, which also requires public notice and comment, has served this educational function too. Through these opportunities, land owners, State agencies, and local governments have become more aware of the status of and threats to listed species, and the conservation actions needed for recovery particularly as it relates to this property. For these reasons, we believe that the educational benefits that might accrue from critical habitat designation would be minimal.

Therefore, we find that there is minimal benefit from designating critical habitat for the northern spotted owl within this SHA.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 2,035 ac (824 ha) of lands currently managed under the SHA are substantial and include maintaining our partnership with this landowner. This is important because it may encourage the company not to return to baseline immediately after expiration of the SHA.

Excluding lands with SHAs from critical habitat designation may also enhance our ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement conservation actions that we would be unable to accomplish otherwise. If lands within the plan area are designated as critical habitat, it could have a negative effect on our ability to work with various companies to accomplish our goals for the SHA program and recovery of the northern spotted owl. This SHA is located in key northern spotted owl landscapes and contributes meaningfully to the recovery of the northern spotted owl. Two SOSEAs, the White Salmon and Columbia Gorge SOSEAs, encompass approximately 54 percent of the Companies' lands in Skamania and Klickitat Counties. The Companies' landscape-management approach contributes to northern spotted owl recovery by complementing the existing northern spotted owl landscape-management strategies on adjacent Federal and State forestlands. With the Companies' participation in northern spotted owl conservation, it will be the first time in these SOSEAs, that a private landowner has joined State and Federal land managers to implement a landscape approach for northern spotted owl habitat. The Companies' lands provide a major link in the goal of managing both the Columbia River and White Salmon SOSEAs under a unified landscape-management regime rather than a competitive harvesting regime under owl-circle management.

The designation of critical habitat could nonetheless have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the SDS SHA plan area are designated as critical habitat, it would likely have a negative effect on our ability to establish new partnerships to develop SHAs, HCPs, and other conservation plans, particularly plans that address landscape-level conservation of species and habitats. This SHA is being observed by other land and timber companies in Washington and Oregon and may serve as a model for ongoing and future efforts. By excluding these lands, we preserve our current private and local conservation partnerships and encourage additional conservation actions in the future.

Benefits of Exclusion Outweigh the Benefits of Inclusion—In summary, we determine that the benefits of excluding the SDS SHA from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat. We find that including it would result in minimal, if any, additional benefits to the northern spotted owl, as explained above. We also find that the benefits of including these lands are further minimized by the fact that the management strategies of the SHA are designed to maintain and enhance habitat for the northern spotted owl. The SHA includes species-specific avoidance and minimization measures, monitoring requirements to track success and ensure proper implementation, and forest-management practices and habitat conservation objectives that benefit the northern spotted owl and its habitat, which exceeds any conservation value provided as a result of a critical habitat designation. Furthermore, encouraging landowners to enter into voluntary conservation agreements with the Service for the recovery of endangered or threatened species which we believe would be one of the benefits of exclusion may outweigh the loss of benefit that may be incurred through a possible return to baseline following permit expiration.

Therefore, in consideration of the factors discussed above in the Benefits of Exclusion section, including the relevant impact to current and future partnerships, we have determined that the benefits of exclusion of lands covered by the Port Blakely SHA outweigh the benefits of critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of a net of approximately 2,035 ac (824 ha) of lands within the SDS SHA will not result in extinction of the northern spotted owl because, under this agreement, the landscape management approach contributes to owl recovery by complementing the existing owl landscape-management strategies on adjacent Federal and State forestlands. The SDS SHA goals and objectives for the northern spotted owl are to provide dispersal and young forest marginal habitat across their ownership on a dynamic basis, as well as submature and higher quality habitat in harvest set-asides. These habitats provide both dispersal and demographic support, an established goal for lands within the two northern spotted owl special emphasis areas (SOSEAs). Further, for projects having a Federal nexus and affecting northern spotted owls in occupied areas, the jeopardy standard of section 7 of the Act, coupled with protection provided by the SDS SHA, would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. We find that exclusion of these lands within the SDS SHA will not result in extinction of the northern spotted owl. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the SDS SHA totaling about 2,035 ac (824 ha).

How We Evaluate Lands Protected Under HCPs for Exclusion

The consultation provisions under section 7(a)(2) of the Act constitute a regulatory benefit of critical habitat. Federal agencies must consult with us on actions that may affect critical habitat and must avoid destroying or adversely modifying critical habitat. In areas without designated critical habitat, Federal agencies consult with us on actions that may affect a listed species and must refrain from undertaking actions that are likely to jeopardize the continued existence of the species. Thus, the analysis of effects to critical habitat is a separate and different analysis from that of the effects to the species. The difference in outcomes of these two analyses represents the regulatory benefit of critical habitat. For some species, and in some locations, the outcome of these analyses will be similar, because effects on habitat will often result in effects on the species. However, the regulatory standard is different: The jeopardy analysis looks at the action's impact on survival and recovery of the species, while the adverse modification analysis looks at the action's effects on the designated habitat's contribution to the species' conservation. This will, in some instances, lead to different results or consultation where it might not have otherwise occurred (e.g. in habitat not currently occupied by the species).

Once an agency determines that consultation under section 7 of the Act is necessary, the process may conclude informally when we concur in writing that the proposed Federal action is not likely to adversely affect critical habitat. However, if the action agency determines through informal consultation that adverse effects are likely to occur, then it would initiate formal consultation, which would conclude when we issue a biological opinion on whether the proposed Federal action is likely to result in destruction or adverse modification of critical habitat. A biological opinion that concludes in a determination of no destruction or adverse modification may contain discretionary conservation recommendations to minimize adverse effects to critical habitat, but it would not contain any mandatory reasonable and prudent measures or terms and conditions because these do not apply to critical habitat. In addition, we suggest reasonable and prudent alternatives to the proposed Federal action only when our biological opinion finds that the action may destroy or adversely modify critical habitat.

The process of designating critical habitat as described in the Act requires, in part, that the Service identify those lands occupied at the time of listing on which are found the physical or biological features essential to the conservation of the species, which may require special management considerations or protection and any unoccupied lands that are essential to the conservation of the species. In identifying those lands, the Service must consider the recovery needs of the species. Once critical habitat has been designated, Federal agencies must consult with the Service under section 7(a)(2) of the Act on their actions that may adversely affect the species or critical habitat to ensure that their actions are not likely to adversely modify critical habitat or jeopardize the continued existence of the species.

We find that in some cases, the conservation benefits to a species and its habitat that may be achieved through the designation of critical habitat are less than those that could be achieved through the implementation of a habitat conservation management plan that includes specific provisions based on enhancement or recovery as the management standard. Consequently, the implementation of any HCP or management plan that considers enhancement or recovery as the management standard will often provide as much or more benefit than a section 7(a)(2) consultation under the Act. There may be some regulatory benefit that results from designating critical habitat in the areas covered by the HCPs because of section 7 consultation requirements; however, they are often minimal compared to the benefits of exclusion.

Non-Federal landowners are often motivated to work with the Service collaboratively to develop HCPs because of the regulatory certainty provided by an incidental take permit under section 10(a)(1)(B) of the Act, including assurances under the No Surprises Policy (63 FR 8859; February 23, 1998). The No Surprises Policy sets forth a clear commitment to incidental take permittees that, to the extent consistent with the Act and other Federal laws, the government will not seek additional mitigation under an approved HCP where the permittee is implementing the HCP's terms and conditions. Although the HCP process can be complex and time-consuming, the benefit to landowners in undertaking this extensive process is not only incidental take authorization but the resulting regulatory certainty, which translates into real savings for private landowners in terms of opportunity costs, as well as direct savings and avoided costs. Designation of critical habitat within the boundaries of already approved HCPs may be viewed as a disincentive by other entities currently developing HCPs or contemplating them in the future, because it may be perceived as imposing duplicative regulatory burdens. In discussions with the Service, HCP permittees have indicated they view critical habitat designation as an unnecessary additional intrusion on their property, and have expressed concern that the Service may request new conservation measures for the northern spotted owl, even though they have an existing HCP and associated incidental take permit that has already gone through NEPA and the section 7 consultation process already in place.

Although parties whose actions may take listed species may still desire incidental take permits to avoid liability under section 9 of the Act, failure to exclude HCP lands from critical habitat could reduce the conservation value of the HCP program in several ways. First, parties may be less willing to seek a section 10 (a)(2) permit and develop an HCP where they are not certain their actions will cause incidental take in order to avoid involving the Federal government when that involvement could lead to future section 7 consultations because of critical habitat designation. Second, in any given HCP, applicants may reduce the amount of protection to which they are willing to agree, in effect holding some additional protective measures ''in reserve'' for use in any future discussions to address critical habitat. The failure to exclude qualified HCP lands from critical habitat designations could decrease the program's efficacy and have profound effects on our ability to establish and maintain important conservation partnerships with stakeholders.

Excluding qualified HCP lands from critical habitat provides permittees with the greatest possible certainty, and thereby may help foster the cooperation necessary to allow the HCP program to achieve the greatest possible conservation benefit. Thus, excluding the lands covered by HCPs may improve the Service's ability to enter into new partnerships. In addition, permittees who trust and benefit from the HCP process may encourage future HCP participants, such as States, counties, local jurisdictions, conservation organizations, and private landowners, leading to new HCPs that may result in implementation of conservation actions we would be unable to accomplish otherwise.

Excluding lands covered under HCPs from the critical habitat designation may also relieve landowners from the possibility of any additional regulatory burden and costs associated with the preparation of section 7 documents related to critical habitat. While the costs of providing these additional documents to the Service is minor, there may be resulting delays that generate perceived or very real costs to private landowners in the form of opportunity costs, as well as direct costs.

HCPs can provide other important conservation benefits, including the development of important biological information needed to guide conservation efforts and assist in species conservation outside the HCP planning area. Each of the HCPs evaluated below have some component of adaptive forest management to address uncertainties in achieving their agreed-upon conservation objectives for the northern spotted owl. The adaptive management strategy helps to ensure management will continue to be consistent with agreed-upon northern spotted owl conservation objectives.

Below is a brief description of each HCP and the lands proposed as critical habitat covered by each plan that we have excluded from critical habitat designation under section 4(b)(2) of the Act.

State of California

Green Diamond Resource Company Habitat Conservation Plan

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, that are covered under the Green Diamond Resource Company Northern Spotted Owl Habitat Conservation Plan of 1992. The Green Diamond Resource Company (Green Diamond, formerly Simpson Timber Company) operates under a northern spotted owl HCP within the Redwood Coast Critical Habitat Unit in California. The Incidental Take Permit (ITP) issued in association with this HCP was initially noticed in the **Federal Register** on May 27, 1992 (57 FR 22254) and issued September 17, 1992. Both the HCP and the permit had a term of 30 years, with a comprehensive review scheduled after 10 years to review the efficacy of the plan. The permit allows incidental take of up to 50 pairs of northern spotted owls and their habitat during the course of timber harvest operations on 369,384 ac (149,484 ha) of forest lands in Del Norte and Humboldt Counties.

At the time the permit was issued, more than 100 northern spotted owl nest sites or activity centers were known or suspected on the property. The Service determined that the projected growth and harvest rates indicated more habitat of the age class primarily used by northern spotted owls would exist on the property at the end of the 30-year permit period. In addition, the HCP provided that nest sites would be protected during the breeding season, and no direct killing or injuring of owls was anticipated. Green Diamond also agreed to continue their monitoring programs, in which more than 250 adult owls and more than 100 juveniles were already banded, as well as analyses of timber stands used by owls. As required by the terms of the HCP, Green Diamond and the Service conducted a comprehensive review of the first 20 years of implementation, including a comparison of actual and estimated levels of owl displacement, a comparison of estimated and actual distribution of habitat, a reevaluation of the biological basis for the HCP's conservation strategy, an examination of the efficacy of and continued need for habitat set-asides, and an estimate of future owl displacements. During the comprehensive review, Green Diamond requested an amendment to the 1992 ITP to allow incidental take of up to eight additional northern spotted owl pairs. This request was noticed in the **Federal Register** on February 26, 2007 (72 FR 8393) and the modified permit was issued in October 2007.The original Green Diamond Northern Spotted Owl HCP relied on extensive monitoring and research to inform development of more comprehensive conservation strategies for their lands. The outcome of 20 years of implementation of Green Diamond's 1992 informed the Service and Green Diamond on how to develop new, or modify the original, conservation strategies to further benefit the northern spotted owl.

On April 16, 2010, we announced our intent to prepare an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) in response to an expected new HCP from Green Diamond, which would include provisions for the northern spotted owl and possibly the Pacific fisher (*Martes pennanti*), a species that may be considered for listing during the term of the HCP. This new HCP, if completed and approved, would replace the 1992 HCP, and would require the issuance of a new incidental take permit. The proposed new HCP is intended to address the retention of suitable northern spotted owl nesting habitat, the development of older forest habitat elements and habitat structures, and future establishment of northern spotted owl nest sites in streamside retention zones. In addition, the new plan will help cluster owl sites in favorable habitat areas, and initiate future research on other wildlife species such as fishers and barred owls. Since this new draft HCP has not yet been completed, the draft HCP does not serve as the basis for exclusion and we only provide this information in terms of demonstrating the progression of involvement and partnership between the Service and Green Diamond. The existing HCP, originally completed in 1992, is still in effect as of this date and serves, in part, as the basis for this exclusion.

Since approval of the 1992 HCP, personnel from Green Diamond, along with academic and research institutions, have been the largest single contributor of scientific information on the ecology of northern spotted owls and their habitats on managed forest lands in the redwood region, in the form of graduate theses and peer-reviewed papers. Since the initial listing of the northern spotted owl in 1990, Green Diamond has maintained on their lands 1 of the 11 demographic study areas within the range of the northern spotted owl that have been used for rangewide monitoring and evaluation of populations and population trends in the Pacific northwest. This important demographic information is reported in a continuing series of monographs, the most recent being Forsman *et al.* (2011).

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands that might trigger such consultation is limited; there is little likelihood of an action that will involve Federal funding, authorization, or implementation. In addition, since the lands under the HCP in question are occupied by the northern spotted owl, if a Federal nexus were to occur, section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species through a jeopardy analysis. While the jeopardy and adverse modification standards are different, the additional conservation that could be attained through the supplemental adverse modification analysis for critical habitat under section 7 would not be significant in light of the benefits of the HCP, which already incorporates protections and management objectives for the northern spotted owl and the habitat upon which it depends for breeding, sheltering, and foraging activities. The conservation approach identified in the Green Diamond HCP, along with our close coordination with the company, addresses the identified threats to northern spotted owl on lands covered by the HCP that contain the physical or biological features essential to the conservation of the species. The conservation measures identified within the HCP seek to achieve conservation goals for northern spotted owls and their habitat, and thus can be of greater conservation benefit than the designation of critical habitat, which does not require specific, proactive actions. HCPs typically provide for greater conservation benefits to a covered species than section 7 consultations because HCPs ensure the long-term protection and management of a covered species and its habitat. In addition, funding for such management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which in contrast to HCPs, often do not commit the project proponent to long-term, special management practices or protections. Thus, a section 7 consultation typically does not afford the lands it covers similar extensive benefits as an HCP. In addition, the protections of critical habitat come into play only in the event of a Federal action, whereas the protections of an HCP are in continuous force.

Another potential benefit of including lands in a critical habitat designation is that the designation can serve to educate landowners, State and local government agencies, and the public regarding the potential conservation value of an area, and may help focus conservation efforts on areas of high conservation value for certain species. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. However, in this case the educational value of critical habitat is limited. Green Diamond has already made substantial contributions to our knowledge of the species through research and monitoring without critical habitat designated on their lands. In addition, the educational and informational benefits that might arise from critical habitat designation have been largely accomplished through the public review and comment on the HCP and associated documents. The release of the Revised Recovery Plan for the Northern Spotted Owl in 2011 was also preceded by outreach efforts and public comment opportunities. Furthermore, we conducted extensive outreach efforts on the proposed revision of critical habitat, including multiple public information meetings and opportunities for public comment. Through these outreach opportunities, land owners, State agencies, and local governments have become aware of the status of and threats to the northern spotted owl, and the conservation actions needed for recovery.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, CALFIRE has indicated to us that it is unlikely to impose any new requirements on project proponents if critical habitat is designated in areas already subject to California Forest Practice Rules. Therefore, we believe this potential benefit of critical will be limited.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 369,864 ac (149,484 ha) of lands currently managed under the Green Diamond HCP are significant. We have created a close partnership with Green Diamond through development of the HCP, and they have proven to be an invaluable partner in the conservation of the northern spotted owl. Green Diamond has made a significant contribution to our knowledge of the northern spotted owl through their support of continuing research on their lands. Excluding the approximately 369,864 ac (149,484 ha) owned and managed by Green Diamond from critical habitat designation will sustain and enhance the working relationship between the Service and Green Diamond. The willingness of Green Diamond to work with the Service in innovative ways to conduct solid scientific research and manage federally listed species will continue to reinforce those conservation efforts and our partnership, which contribute toward achieving recovery of the northern spotted owl. Due to the important research they are facilitating, we consider this voluntary partnership in conservation vital to our understanding of the northern spotted owl status of species on non-Federal lands and necessary for us to implement recovery actions such as habitat protection and restoration, and beneficial management actions for species.

The designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the Green Diamond HCP are designated as critical habitat, it would likely have a negative effect on our continued ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement various conservation actions (such as SHAs, HCPs, and other conservation plans) that we would be unable to accomplish otherwise. In addition, our conservation partnership with Green Diamond may serve as a model and aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species. We consider the positive effect of excluding proven conservation partners from critical habitat to be a significant benefit of exclusion.

The Benefits of Exclusion Outweigh the Benefits of Inclusion—We reviewed and evaluated the exclusion of approximately 369,864 ac (149,484 ha) of land owned and managed by the Green Diamond Resource Company from our designation of critical habitat. The benefits of including these lands in the designation are comparatively small, since the habitat on the covered lands is already being monitored and managed under the current HCP to improve the habitat elements that are equivalent to the physical or biological features outlined in this critical habitat rule. Any potential regulatory benefits of critical habitat would be minimal, at best, as additional Federal review on individual proposed actions is episodic and confined to the scope and scale of the specific Federal actions that take the form of project review or granting of funds. In any case, any potential regulatory benefit that would be gained from a supplemental adverse modification analysis, should section 7 be triggered, would likely be minimal since the protections afforded by critical habitat would be duplicative with the protections provided through the HCP. Educational benefits to the company that might be attributed to critical habitat designation are limited because the company already has an active program of research and analysis that is embedded in company planning. In addition, extensive outreach efforts that have already occurred in conjunction with the HCP, Revised Recovery Plan, and the proposed revision of critical habitat have raised awareness of the current status of and threats to the northern spotted owl, and the conservation actions needed for recovery. Green Diamond has made a significant contribution to the body of scientific information about the northern spotted owl in the redwood region.

In this instance, the regulatory and educational benefits of inclusion in critical habitat are minimal compared to the significant benefits gained through our conservation partnership with Green Diamond. In addition, the conservation measures of their HCP serves not only an educational function for the company and local and State regulatory jurisdictions, but also provides for significant conservation and management of northern spotted owl habitat and contributes to the recovery of the species. The HCP provisions for protecting and maintaining northern spotted owl habitat far exceed the conservation benefits that would be obtainable through section 7 consultation. The company's current program of research on the northern spotted owl habitat and demographics could not be obtained through section 7 consultation.

Exclusion of these lands from critical habitat will help foster the partnership we have developed with Green Diamond, partly through the development and continuing implementation of the HCP, and partly through the encouragement of elective actions by the company that are unconnected to the HCP. For example, Green Diamond's elective role in maintaining a demographic study area, which is a key part of the network of demographic study areas essential to determining the rangewide population trends of the northern spotted owl, is integral to continuing research on the species. Our partnership with Green Diamond not only provides a benefit for the conservation of the northern spotted owl, but it may also serve as a model and aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species. For these reasons, we have determined that the benefits of exclusion of lands covered by the Green Diamond Resource Company HCP outweigh the benefits of critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that the exclusion of 369,864 ac (149,484 ha) from the designation of critical habitat for the northern spotted owl of lands owned and managed by the Green Diamond Resource Company, as identified in their HCP, will not result in extinction of the species because current conservation efforts under the plan adequately protect the geographical areas containing the physical or biological features essential to the conservation of the species. For those infrequent projects having a Federal nexus and affecting northern spotted owls on these lands, which are occupied by the species, the jeopardy standard of section 7 of the Act, coupled with protection provided by the current Green Diamond HCP, would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Green Diamond HCP boundary totaling 369,864 ac (149,484 ha).

Humboldt Redwood Company Habitat Conservation Plan

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, that are covered under the Humboldt Redwood Company (formerly Pacific Lumber) HCP in the Redwood Coast CHU in California. The permit under this HCP with a term of 50 years was noticed on July 14, 1998 (63 FR 37900) and issued on March 1, 1999. The HCP includes 208,172 ac (84,244 ha) of commercial timber lands in Humboldt County, essentially all of the formerly Pacific Lumber timberlands outside of the Headwaters Reserve, which is currently under Bureau of Land Management administration. The Humboldt Redwood Company HCP includes nine nonlisted species (including one candidate species) and three listed species, including the northern spotted owl. Activities covered by the HCP include forest management activities and mining or other extractive activities. With regard to the northern spotted owl in particular, the HCP addresses the harvest, retention, and recruitment of requisite habitat types and elements within watershed assessment areas and individual northern spotted owl activity sites. The management objectives of the HCP are to minimize disturbance to northern spotted owl activity sites, monitor to determine whether these efforts maintain a high-density and productive population of northern spotted owls, and apply adaptive forest management provisions as necessary to evaluate or modify existing conservation measures. In addition, there are specific habitat retention requirements to conserve habitat for foraging, roosting, and nesting at northern spotted owl activity sites. The other conservation elements of the HCP are also expected to aid in the retention and recruitment of potential foraging, roosting, and nesting habitat in watersheds across the ownership. For example, the HCP establishes a network of marbled murrelet conservation areas, outlines silvicultural requirements associated with riparian management zones and mass wasting avoidance areas, imposes cumulative effects/disturbance index restrictions, and contains a retention standard of 10 percent late seral habitat in each watershed assessment. Each of these measures is likely to provide additional suitable habitat for the northern spotted owl.

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands that might trigger such consultation is limited since there is little likelihood of an action that will involve Federal funding, authorization, or implementation. In addition, since the lands under the HCP in question are occupied by the northern spotted owl, if a Federal nexus were to occur, section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species through a jeopardy analysis. Although the jeopardy and adverse modification standards are different, the additional conservation that could be attained through the supplemental adverse modification analysis for critical habitat under section 7 would not be significant because the HCP incorporates protections and management objectives for the northern spotted owl and the habitat upon which it depends for breeding, sheltering, and foraging activities. The conservation approach identified in the HCP, along with our close coordination with the Humboldt Redwood Company, addresses the identified threats to northern spotted owl on lands covered by the HCP that contain the physical or biological features essential to the conservation of the species. The conservation measures identified within the HCP seek to achieve conservation goals for northern spotted owls and their habitat, and thus can be of greater conservation benefit than the designation of critical habitat, which does not require specific, proactive actions. HCPs typically provide for greater conservation benefits to a covered species than section 7 consultations because HCPs ensure the long-term protection and management of a covered species and its habitat. In addition, funding for such management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which in contrast to HCPs, often do not commit the project proponent to long-term, special management practices or protections. Thus, a section 7 consultation typically does not afford the lands it covers similar extensive benefits as an HCP. In addition, the protections of critical habitat come into play only in the event of a Federal action, whereas the protections of an HCP are in continuous force.

The HCP conservation measures that provide direct and indirect benefits to the northern spotted owl and its habitat have been implemented continuously since 1999 on all covered lands owned and managed by the Humboldt Redwood Company. Northern spotted owl conservation measures are subject to re-evaluation and modification through active adaptive forest management provisions in the Plan, which can be initiated by the Service or by the Company.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. The landowners in this case are aware of the needs of the species through the development of their HCP, in which they have agreed to take measures to protect the northern spotted owl and its habitat. Any additional educational and information benefits that might arise from critical habitat designation have been largely accomplished through the public review of and comment on the HCP and the associated permit. The release of the Revised Recovery Plan for the Northern Spotted Owl in 2011 was also preceded by outreach efforts and public comment opportunities. In addition, the rulemaking process associated with critical habitat designation included several opportunities for public comment, and we also held multiple public information meetings across the range of the species. Through these outreach opportunities, land owners, State agencies, and local governments have become aware of the current status of and threats to the northern spotted owl, and the conservation actions needed for recovery.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, CALFIRE has indicated to use that it is unlikely to impose any new requirements on project proponents if critical habitat is designated in areas already subject to California Forest Practice Rules. Therefore, we believe this potential benefit of critical will be limited.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 208,172 ac (84,244 ha) of lands currently managed under the Humboldt Redwood Company (formerly Pacific Lumber Company) HCP are significant. Although the HCP was originally negotiated with Pacific Lumber, we have developed a good working rapport with Humboldt Redwood Company, and expect this conservation partnership to continue through the implementation of the HCP. We consider conservation partnerships with private landowners to represent an integral component of recovery for listed species. However, the designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the Humboldt Redwood Company HCP are designated as critical habitat, it would likely have a chilling effect on our continued ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement various conservation actions (such as SHAs, HCPs, and other conservation plans) that we would be unable to accomplish otherwise.

Excluding the approximately 208,172 ac (84,244 ha) owned and managed by the Humboldt Redwood Company from critical habitat designation will sustain and enhance the working relationship between the Service and the Company, and will bolster our ability to pursue additional conservation partnerships for the benefit of listed species. The willingness of the Humboldt Redwood Company to work with us to manage their forest lands for the benefit of the northern spotted owl will continue to reinforce those conservation efforts and our partnership, which contributes to the recovery of the species. We consider this voluntary partnership in conservation important to our understanding of the status of northern spotted owls on non-Federal lands and necessary for us to implement recovery actions such as habitat protection and restoration, and beneficial management actions for species. In addition, as noted above, our conservation partnership with the Humboldt Redwood Company may serve as a model and aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species. We consider the positive effect of excluding proven conservation partners from critical habitat to be a significant benefit of exclusion.

The Benefits of Exclusion Outweigh the Benefits of Inclusion—We have reviewed and evaluated the exclusion, from critical habitat designation, of approximately 208,172 ac (84,244 ha) of land owned and managed by the Humboldt Redwood Company. The benefits of including these lands in the designation are comparatively small, since the habitat on the covered lands is already being monitored and managed under the current HCP to improve the habitat elements that are equivalent to the physical or biological features that are outlined in this critical habitat rule. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus in areas occupied by the species, such as is the case here, will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or function of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the HCP provides habitat conservation measures that apply for the benefit of northern spotted owl. In addition, educational benefits are limited, since outreach efforts associated with various conservation actions for this species have been extensive, and members of the public, as well as State and local agencies, are likely familiar with the species and its biological needs. Company personnel are knowledgeable in the ecology of the northern spotted owl and have contributed to the body of scientific information about the northern spotted owl in the redwood region. In this case, the regulatory and education benefits of inclusion are less than the continued benefit of this conservation partnership.

Humboldt Redwood Company has made important contributions to our understanding of the ecology of the northern spotted owl and its habitats in the redwood region, and continues to do so through HCP implementation and long-term monitoring. The Service recognizes the conservation value of partnerships with non-Federal landowners, such as the Humboldt Redwood Company, which allow us to achieve conservation measures that would not otherwise be attainable on these private lands. We have determined that our conservation partnership with the Humboldt Redwood Company HCP, in conjunction with the conservation measures provided in the HCP, provide a greater benefit than would the regulatory and educational benefits of critical habitat designation. Furthermore, we have determined that the additional regulatory benefits of designating critical habitat, afforded through the section 7(a)(2) consultation process, are minimal because of limited Federal nexus and because conservation measures specifically benefitting the northern spotted owl and its habitat are in place through the implementation of the HCP. Therefore, in consideration of the factors discussed above in the Benefits of Exclusion section, including the relevant impact to current and future partnerships, we have determined that the benefits of exclusion of lands covered by the Humboldt Redwood Company HCP outweigh the benefits of critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that the exclusion of 208,172 ac (84,244 ha) from the designation of critical habitat for the northern spotted owl of lands owned and managed by the Humboldt Redwood Company, as identified in their HCP, will not result in extinction of the species because current conservation efforts under the plan adequately protect the geographical areas containing the physical or biological features essential to the conservation of the species. For projects having a Federal nexus and affecting northern spotted owls in occupied areas, which is the case here, the jeopardy standard of section 7 of the Act, coupled with protection provided by the current Humboldt Redwood Company HCP, would provide a high level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Humboldt Redwood Company HCP boundary totaling 208,172 ac (84,244 ha).

Regli Estate Habitat Conservation Plan

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, that are covered under the Regli Estate HCP in the Redwood Coast CHU. The permit issued under this HCP in 1995 (noticed July 17, 1995 (60 FR 36432) and issued August 30, 1995) covers 484 ac (196 ha) in Humboldt County, California, to be used for forest management activities.

Two listed species, the marbled murrelet and northern spotted owl, as well as two nonlisted species, are covered under the incidental take permit. Provisions in the HCP for the northern spotted owl include the mitigation of impacts from forest management activities by using single-tree selection silviculture that would retain owl foraging habitat suitability in all harvested areas; protecting an 80-ac (32-ha) core nesting area for one of the two owl pairs known to exist in the HCP area; and planting conifer tree species on approximately 73 ac (30 ha) of currently nonforested habitat within the HCP area, which would result in a net increase in forested habitat over time. In addition, take of owls would be minimized using seasonal protection measures specified in the HCP.

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands that might trigger such consultation is limited since there is little likelihood of an action that will involve Federal funding, authorization, or implementation. In addition, since the lands under the HCP in question are occupied by the northern spotted owl, if a Federal nexus were to occur, section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species through a jeopardy analysis. The additional conservation that could be attained through the supplemental adverse modification analysis for critical habitat under section 7 would not be significant because this HCP incorporates measures that specifically benefit the northern spotted owl and its habitat. The HCP incorporates protections and management objectives for the northern spotted owl designed to produce a net increase in forested habitat for the species over time. The conservation measures identified within the HCP seek to achieve conservation goals for northern spotted owls and their habitat can be of greater conservation benefit than the designation of critical habitat, which does not require specific, proactive actions. HCPs typically provide for greater conservation benefits to a covered species than section 7 consultations because HCPs ensure the long-term protection and management of a covered species and its habitat. In addition, funding for such management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which in contrast to HCPs, often do not commit the project proponent to long-term, special management practices or protections. Thus, a section 7 consultation typically does not afford the lands it covers similar extensive benefits as an HCP. In addition, the protections of critical habitat come into play only in the event of a Federal action, whereas the protections of an HCP are in continuous force.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. The landowners in this case are aware of the needs of the species through the development of their HCP, in which they have agreed to take measures to protect the northern spotted owl and its habitat. Any additional educational and information benefits that might arise from critical habitat designation have been largely accomplished through the public review of and comment on the HCP and the associated permit. The release of the Revised Recovery Plan for the Northern Spotted Owl in 2011 was also preceded by outreach efforts and public comment opportunities. In addition, the rulemaking process associated with critical habitat designation included several opportunities for public comment, and we also held multiple public information meetings across the range of the species. Through these outreach opportunities, land owners, State agencies, and local governments have become aware of the current status of and threats to the northern spotted owl, and the conservation actions needed for recovery.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, CALFIRE has indicated to us that it is unlikely to impose any new requirements on project proponents if critical habitat is designated in areas already subject to California Forest Practice Rules. Therefore, we believe this potential benefit of critical will be limited.

Benefits of Exclusion—The benefits of excluding from critical habitat designation the approximately 484 ac (196 ha) of lands currently managed under the HCP are greater than those that would accrue from inclusion. We have developed a conservation partnership with Regli Estate through the development and implementation of the HCP. The conservation measures that provide a benefit to the northern spotted owl and its habitat have been, and will continue to be, implemented continuously beginning with the issuance of the Incidental Taking Permit in 1995 and continuing through the 20-year term of the permit, through 2015. These measures include use of single-tree selection silviculture to retain owl foraging habitat suitability, protection of an 80-ac (32-ha) core nesting area for one of the two known owl pairs, and reforestation of approximately 73 ac (30 ha) of ''old-field'' grasslands, the latter which has already been accomplished and will result in a net increase in forested habitat over time. A significant benefit of exclusion would be the increased likelihood of this landowner continuing with conservation actions for the northern spotted owl and its habitat, such as the development of a new HCP and application for a new incidental take permit upon the expiration of their current permit.

The HCP incorporates protections and management objectives for the northern spotted owl and the habitat upon which it depends for breeding, sheltering, and foraging activities. The approach used in the HCP, along with our close coordination with the landowner, addresses the identified threats to northern spotted owl on covered lands that contain the physical or biological features essential to the conservation of the species. The conservation measures identified within the HCP seek to maintain or surpass current habitat suitability for northern spotted owls, and thus can be of greater conservation benefit than the designation of critical habitat, which does not require specific, proactive actions.

Excluding the approximately 484 ac (196 ha) of this covered land from critical habitat designation will sustain and enhance the working relationship between the Service and the owner, and will increase the likelihood that the owner will update the HCP and apply for a new incidental take permit when the current permit expires in 2015. The willingness of the landowner to work with the Service to manage federally listed species will continue to reinforce those conservation efforts and our partnership, which contribute toward achieving recovery of the northern spotted owl. We consider this voluntary partnership in conservation important in maintaining our ability to implement recovery actions such as habitat protection and restoration, and beneficial management actions for species on non-Federal lands. The Service recognizes the importance of non-Federal landowners in contributing to the conservation and recovery of listed species, and seeks to maintain and promote these partnerships for the benefit of all threatened and endangered species.

We consider conservation partnerships with private landowners to represent an integral component of recovery for listed species. However, the designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the Regli Estate HCP are designated as critical habitat, it would likely have a chilling effect on our continued ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement various conservation actions (such as SHAs, HCPs, and other conservation plans) that we would be unable to accomplish otherwise. We therefore consider the positive effect of excluding proven conservation partners from critical habitat to be a significant benefit of exclusion.

The Benefits of Exclusion Outweigh the Benefits of Inclusion—We reviewed and evaluated the exclusion of approximately 484 ac (196 ha) of land owned and managed by Regli Estate from our designation of critical habitat. The benefits of including these lands in the designation are relatively small. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus in areas occupied by the species, such as is the case here, will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or function of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the HCP provides habitat conservation measures that apply for the benefit of northern spotted owl, and remains in place regardless of critical habitat. In addition, for the reasons described above, the educational benefits of designation in this instance are minimal.

Exclusion of these lands from critical habitat will help foster the partnership we have developed with the company, through the continuing implementation of the HCP. Furthermore, we believe exclusion of these lands from critical habitat will increase the likelihood that the owner will update the HCP and apply for a new incidental take permit when the current permit expires in 2015, thereby ensuring continuing benefits to the northern spotted owl and its habitat on these lands. The HCP has provisions for protecting and maintaining northern spotted owl habitat that exceed the conservation benefits that could be obtained through section 7 consultation. These measures will not only prevent the degradation of essential features of the northern spotted owl, but they will maintain or improve these features over time. Finally, this partnership may serve as a model and aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species.

In summary, we have determined that our conservation partnership with the Regli Estate, in conjunction with the conservation measures provided in the HCP, provide a greater benefit than would the regulatory and educational benefits of critical habitat designation. We have determined that the additional regulatory benefits of designating critical habitat, afforded through the section 7(a)(2) consultation process, are minimal because the probability of a Federal nexus for projects on this land is limited in scope and will occur episodically at most. On the other hand, the conservation measures specifically benefitting the northern spotted owl and its habitat are in continuous effect throughout the lands covered by this HCP. Finally, the Service acknowledges the importance of conservation partnerships with private landowners in achieving the recovery of listed species, such as the northern spotted owl, and recognizes the positive benefits that accrue to conservation through the exclusion of recognized conservation partners from critical habitat. Therefore, in consideration of the factors discussed above in the *Benefits of Exclusion* section, including the relevant impact to current and future partnerships, we have determined that the benefits of exclusion of lands covered by the Regli Estate Habitat Conservation Plan outweigh the benefits of critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that the exclusion of 484 ac (196 ha) of Regli Estate lands from the designation of critical habitat for the northern spotted owl, as identified in their HCP, will not result in extinction of the species because current conservation efforts under the plan adequately protect the geographical areas containing the physical or biological features essential to the conservation of the species. For projects having a Federal nexus and affecting northern spotted owls in occupied areas, as is the case here, the jeopardy standard of section 7 of the Act, coupled with protection provided under the terms of the HCP, would provide assurances that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Regli Estate Habitat Conservation Plan boundary totaling 484 ac (196 ha).

Terra Springs Habitat Conservation Plan

In this final designation, the Secretary has exercised his authority to exclude 39 ac (16 ha) of lands from critical habitat, under section 4(b)(2) of the Act, that are covered under the Terra Springs LLC HCP in subunit 6 of the Interior California Coast CHU. The permit issued in association with this HCP (noticed October 29, 2002 (67 FR 65998), and issued in 2004) has a term of 30 years and includes a total of 76 ac (31 ha) of covered land second-growth forest lands in Napa County, California. This HCP addresses the effects of timber harvest and conversion of forest lands to vineyard and subsequent maintenance, in perpetuity, of suitable northern spotted owl habitat characteristics on the remaining 39 ac (16 ha) of mature (80–120 years) Douglas-fir forest on covered lands. The HCP provides a conservation program to minimize and mitigate for the covered activities, including a deed restriction that requires management in perpetuity of 39 ac (16 ha) of the property as nesting and roosting quality habitat for the northern spotted owl. In addition to mitigation, the Plan also includes measures to minimize take of the northern spotted owl.

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands that might trigger such consultation is limited since there is little likelihood of an action that will involve Federal funding, authorization, or implementation. In addition, since the lands under the HCP in question are occupied by the northern spotted owl, if a Federal nexus were to occur, section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species through a jeopardy analysis. The additional conservation that could be attained through the supplemental adverse modification analysis for critical habitat under section 7 would not be significant because this HCP incorporates measures that specifically benefit the northern spotted owl and its habitat. The HCP incorporates protections and management objectives for the northern spotted owl designed to maintain suitable habitat on the property for the species in perpetuity. The conservation measures identified within the HCP seek to achieve conservation goals for northern spotted owls and their habitat that can be of greater conservation benefit than the designation of critical habitat, which does not require specific, proactive actions. HCPs typically provide for greater conservation benefits to a covered species than section 7 consultations because HCPs ensure the long-term protection and management of a covered species and its habitat. In addition, funding for such management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which in contrast to HCPs, often do not commit the project proponent to long-term, special management practices or protections. Thus, a section 7 consultation typically does not afford the lands it covers similar extensive benefits as an HCP. In addition, the protections of critical habitat come into play only in the event of a Federal action, whereas the protections of an HCP are in continuous force.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. The landowners in this case are aware of the needs of the species through the development of their HCP, in which they have agreed to take measures to protect the northern spotted owl and its habitat. Any additional educational and information benefits that might arise from critical habitat designation have been largely accomplished through the public review of and comment on the HCP and the associated permit. The release of the Revised Recovery Plan for the Northern Spotted Owl in 2011 was also preceded by outreach efforts and public comment opportunities. In addition, the rulemaking process associated with critical habitat designation included several opportunities for public comment, and we also held multiple public information meetings across the range of the species. Through these outreach opportunities, land owners, State agencies, and local governments have become aware of the current status of and threats to the northern spotted owl, and the conservation actions needed for recovery.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, CALFIRE has indicated to use that it is unlikely to impose any new requirements on project proponents if critical habitat is designated in areas already subject to California Forest Practice Rules. Therefore, we believe this potential benefit of critical will be limited.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 39 ac (16 ha) of lands currently managed under the HCP are substantial. We have developed a conservation partnership with Terra Springs through the development and implementation of the HCP.

Excluding the approximately 39 ac (16 ha) owned and managed by Terra Springs, LLC from critical habitat designation will sustain and enhance the working relationship between the Service and the company. The willingness of the company to work with the Service to manage federally listed species will continue to reinforce those conservation efforts and our partnership, which contribute toward achieving recovery of the northern spotted owl. We consider this voluntary partnership in conservation important in maintaining our ability to implement recovery actions, such as habitat protection and restoration, and beneficial management actions for species on non-Federal lands. The Service recognizes the importance of non-Federal landowners in contributing to the conservation and recovery of listed species, and seeks to maintain and promote these partnerships for the benefit of all threatened and endangered species.

We consider conservation partnerships with private landowners to represent an integral component of recovery for listed species. However, the designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the Terra Springs HCP are designated as critical habitat, it would likely have a chilling effect on our continued ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement various conservation actions (such as SHAs, HCPs, and other conservation plans) that we would be unable to accomplish otherwise. We therefore consider the positive effect of excluding proven conservation partners from critical habitat to be a significant benefit of exclusion.

The Benefits of Exclusion Outweigh the Benefits of Inclusion—We reviewed and evaluated the exclusion of approximately 39 ac (16 ha) of land owned and managed by Terra Springs, LLC from our designation of critical habitat. The benefits of including these lands in the designation are relatively small. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus in areas occupied by the species, such as is the case here, will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or function of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the HCP provides habitat conservation measures that apply for the benefit of northern spotted owl, and remains in place regardless of critical habitat. These measures will not only prevent the degradation of essential features of the northern spotted owl, but will preserve some suitable northern spotted owl habitat in perpetuity.

We have determined that the preservation of our conservation partnership with Terra Springs, in conjunction with the conservation measures provided by the HCP, provide a greater benefit than would the regulatory and educational benefits of critical habitat designation. The additional regulatory benefits of designating critical habitat, afforded through the section 7(a)(2) consultation process, are minimal because there is little probability of a Federal nexus on these private lands. On the other hand, the conservation measures specifically benefitting the northern spotted owl and its habitat are in continuous effect throughout the lands covered by this HCP. Finally, the Service acknowledges the importance of conservation partnerships with private landowners in achieving the recovery of listed species, such as the northern spotted owl, and recognizes the positive benefits that accrue to conservation through the exclusion of recognized conservation partners from critical habitat. Therefore, in consideration of the factors discussed above in the *Benefits of Exclusion* section, including the relevant impact to current and future partnerships, we have determined that the benefits of exclusion of lands covered by the Terra Springs Habitat Conservation Plan outweigh the benefits of critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that the exclusion of 39 ac (16 ha) from the designation of critical habitat for the northern spotted owl of lands owned and managed by Terra Springs, LLC, as identified in their HCP, will not result in extinction of the species because current conservation efforts under the plan adequately protect the geographical areas containing the physical or biological features essential to the conservation of the species. For projects having a Federal nexus and affecting northern spotted owls in occupied areas, as is the case here, the jeopardy standard of section 7 of the Act, coupled with protection provided under the terms of the HCP would provide assurances that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Terra Springs, LLC Habitat Conservation Plan boundary totaling 76 ac (31 ha).

State of Oregon

No lands covered under an HCP in the State of Oregon are designated as critical habitat.

State of Washington

Cedar River Watershed Habitat Conservation Plan in King County, Washington

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, totaling approximately 3,244 ac (1,313 ha) that are covered under the Cedar River Watershed HCP (Cedar River HCP) in King County, Washington. The permit associated with this HCP was noticed in the **Federal Register** on December 11, 1998 (63 FR 68469), and issued on April 21, 2000. The term of the permit and HCP is 50 years. The plan was prepared to address declining populations of salmon, steelhead, bull trout, northern spotted owl, marbled murrelet, and 76 unlisted species of fish and wildlife in the Cedar River watershed. The City of Seattle's HCP covers 90,535 ac (36,368 ha) of City-owned land in the upper Cedar River watershed and the City's water supply and hydroelectric operations on the Cedar River, which flows into Lake Washington. Participants involved in the development and implementation of the Cedar River HCP include the City of Seattle, Seattle City Light, Seattle Public Utilities, Washington Department of Fish and Wildlife, Washington Department of Ecology, Muckelshoot Indian Tribe, King County, and several conservation-oriented nongovernmental organizations.

At the time the HCP was approved, the 90,535 ac (36,638 ha) in upper Cedar River Watershed, owned and managed by the City of Seattle as a closed-watershed, consisted of approximately 13,889 ac (5,620 ha) of old growth forest (190–800 years old), 91 ac (37 ha) of late-successional (120–189 years old), 1,074 ac (435 ha) of mature forests (80–119 years old), and 70,223 ac (28,418 ha) of second growth forests (greater than 80 years old). Conservation strategies in the HCP for covered lands are centered around protecting and preserving the remaining old growth, late-successional, and mature forest habitats; accelerating the development of mature forest characteristics in the existing second growth forests though a combination of riparian, ecological, and restoration thinnings; and minimizing human disturbance through road closures and road abandonments, elimination of commercial harvest on covered lands, and continued management of the covered lands as a closed municipal watershed.

At the time the HCP was approved, only two northern spotted owl reproductive site centers and two single-resident site centers had been identified on covered lands. In addition, two reproductive site enters located outside the watershed boundary had owl circles that partially overlap the Cedar River watershed. The boundaries of all known reproductive site centers are protected by the City of Seattle's commitment to conservation strategies and species-specific measures in the Cedar River HCP. The objectives of the northern spotted owl conservation strategy are to avoid, minimize, and mitigate impacts of watershed activities to northern spotted owls, provide a long-term net benefit to the northern spotted owl, and contribute to the owl's recovery. These objectives are to be accomplished by protecting existing habitat; enhancing and recruiting significantly more nesting, roosting, foraging, and dispersal habitat in the Cedar River watershed; and protecting nest sites, reproductive pairs, and their offspring from disturbances. In addition, the City of Seattle committed to implementing a monitoring and research program that will be used to help determine if the conservation strategies for the northern spotted owl achieve their conservation objectives and support the adaptive management program designed to provide a means by which conservation measures could be altered to meet these conservation objectives. Elements of the monitoring and research program important to northern spotted owls include a project to improve the City's forest habitat inventory and data base, a project to track changes in forest habitat characteristics, a study to classify old-growth types in the Cedar River watershed, and projects to monitor all forest restoration efforts.

Benefits of Inclusion—We find that there is minimal benefit from designating critical habitat for the northern spotted owl within the Cedar River HCP because, as explained above, these covered lands are already managed for the conservation of the species over the term of the HCP. As discussed above, the inclusion of these covered lands as critical habitat could provide some additional Federal regulatory benefits for the species consistent with the conservation standard based on the Ninth Circuit Court's decision in Gifford Pinchot. A benefit of inclusion would be the requirement of a Federal agency to ensure that their actions on these non-Federal lands would not likely result in the destruction or adverse modification of critical habitat. However, this additional analysis to determine whether a Federal action is likely to result in destruction or adverse modification of critical habitat is not likely to be significant because these covered lands are not under Federal ownership making the application of section 7 less likely, and we are not aware of any other potential Federal nexus. In addition, any Federal agency proposing a Federal action on these covered lands would have to consider the conservation restrictions on these lands and incorporate measures necessary to ensure the conservation of these resources, thereby reducing any incremental benefit critical habitat may have.

The incremental benefit from designating critical habitat for the northern spotted owl within the Cedar River HCP is further minimized because, as explained above, these covered lands are already managed for the conservation of the species over the term of the HCP and the conservation measures provided by the HCP will provide greater protection to northern spotted owl habitat than the designation of critical habitat.

The Cedar River HCP provides for the needs of the northern spotted owl by protecting and preserving thousands of acres of existing suitable northern spotted owl habitat in the Cedar River watershed, committing to the enhancement and recruitment of approximately 70,000 ac (28,328 ha) of additional habitat over the term of the Cedar River HCP, and implementing species-specific conservation measures designed to avoid and minimize impacts to northern spotted owls. Monitoring and research and adaptive management programs were developed to track HCP progress over the term of the permit and provide critical feedback on management actions that allow for management changes in response to this feedback or to larger trends outside the HCP boundaries such as climate change. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measureable protections.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Designation of critical habitat would inform State agencies and local governments about areas that could be conserved under State laws or local ordinances, such as the Washington State Growth Management Act, which encourage the protection of ''critical areas'' including fish and wildlife habitat conservation areas. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. However, the additional educational and informational benefits that might arise from critical habitat designation here have been largely accomplished through the public review and comment of the HCP, Environmental Impact Statement, and Implementation Agreement. Through these processes, this HCP included intensive public involvement.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, in Washington, State forest practices regulations provide an exemption for review for lands managed under an HCP. Thus, even should the State respond to designation of critical habitat by instituting additional protections, the HCP will not be subject to those protections as the species is considered already addressed, and therefore no additional benefit would accrue through State regulations.

Benefits of Exclusion—Compared to the minimal benefits of inclusion of this area in critical habitat, the benefits of excluding from designated critical habitat the approximately 3,244 ac (1,313 ha) of lands currently managed under the HCP are more substantial.

HCP conservation measures that provide a benefit to the northern spotted owl and its habitat have been implemented continuously since 1998 on all covered lands owned and managed under the Cedar River HCP. Excluding the lands managed under the Cedar River HCP from critical habitat designation will sustain and enhance the working relationship between the Service and the permit holder.

Excluding lands within HCPs from critical habitat designation can also facilitate our ability to seek new partnerships with future HCP participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement conservation actions that we would be unable to accomplish otherwise. If lands within HCP plan areas are designated as critical habitat, it would likely have a negative effect on our ability to establish new partnerships to develop HCPs, particularly large, regional HCPs that involve numerous participants and/or address landscape-level conservation of species and habitats. By excluding these lands, we preserve our current partnerships and encourage additional conservation actions in the future.

Benefits of Exclusion Outweigh the Benefits of Inclusion—In summary, we determine that the benefits of excluding the Cedar River HCP from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat. The regulatory and informational benefits of inclusion will be minimal. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or functionality of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the additional benefits of inclusion on the section 7 process are relatively unlikely because a Federal nexus on these relatively remote forest lands would rarely occur. If one were to occur, it would most likely be a linear project such as a powerline, pipeline, or transportation. In the last 12 years of the permit, none have occurred.

In addition, the management strategies of the Cedar River HCP are designed to protect and enhance habitat for the northern spotted owl. The Cedar River HCP includes species-specific avoidance and minimization measures, monitoring requirements to track success and ensure proper implementation, and forest management practices and habitat conservation objectives that benefit the northern spotted owl and its habitat which further minimizes the benefits that would be provided as a result of a critical habitat designation.

On the other hand, the benefit of excluding these lands is that it will help us maintain an important and successful conservation partnership with a major city, and may encourage others to join in conservation partnerships as well. For these reasons, we have determined that the benefits of exclusion outweigh the benefits of inclusion in this case.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of approximately 3,244 ac (1,313 ha) of lands covered under the Cedar River HCP will not result in extinction of the northern spotted owl because the Cedar River HCP provides for the needs of the northern spotted owl by protecting and preserving thousands of acres of existing suitable northern spotted owl habitat in the Cedar River watershed, committing to the enhancement and recruitment of additional habitat over the term of the Cedar River HCP, and implementing species-specific conservation measures designed to avoid and minimize impacts to northern spotted owls. In addition, monitoring, research, and adaptive management programs were developed to track HCP progress and provide critical feedback on management actions that allow for management changes in response. Further, for projects having a Federal nexus and affecting northern spotted owls in occupied areas, the jeopardy standard of section 7 of the Act, coupled with protection provided by the Cedar River HCP, would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. The species is also protected from take under section 9 of the Act. For these reasons we find that exclusion of these lands within the Cedar River HCP will not result in extinction of the northern spotted owl. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Cedar River Watershed HCP boundary totaling about 3,244 ac (1,313 ha).

Green River Water Supply Operations and Watershed Protection Habitat Conservation Plan

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, totaling approximately 3,162 ac (1,280 ha) that are covered under Tacoma Water's Green River Water Supply Operations and Watershed Protection HCP (Green River HCP) in the State of Washington. The permit associated with this HCP was noticed in the **Federal Register** on August 21, 1998 (63 FR 44918), and issued on July 6, 2001. The term of the permit and HCP is 50 years. The Green River HCP addresses upstream and downstream fish passage issues, flows in the middle and lower Green River, and timber and watershed-management activities on 15,843 ac (6,411 ha) of Tacoma-owned land in the upper Green River Watershed. The Green River HCP covers 32 species of fish and wildlife, including the northern spotted owl and 10 other listed species, under an agreement designed to allow the continuation of water-supply operations on the Green River, forest management practice in the upper Green River watershed, and aquatic restoration and enhancement activities. The plan also provides for fish passage into and out of the upper Green River Watershed.

The City of Tacoma manages approximately 15,843 ac (6,411 ha) of covered lands in the upper Green River watershed for water quality benefits and timber harvest. The Green River HCP divides Tacoma-owned lands into three distinct management zones, and contains a series of conservation measures that address upland forest management, riparian buffers, and avoid or minimize impacts to covered species. Each management zone has specific goals and objectives that focus on water quality, fish and wildlife, and timber management. The Natural Zone contains 5,850 ac (2,370 ha). In this zone, Tacoma is committed to conduct no timber harvest management except for danger tree removal. The long-term goal is to allow these timber stands to develop into late-seral (greater than 155 years old) and mature timber (106–155 years old) conditions through natural succession. The Conservation Zone contains 5,180 ac (2,080 ha) of covered lands. In this zone, Tacoma will conduct no even-aged harvest in conifer stands and no harvest of any form in stands over 100 years old (except for danger tree removal). Tacoma may conduct uneven-aged harvest in stands less than 100 years old to improve stand condition. Once stands reach 100 years of age, no timber harvest will be conducted and stands will be allowed to develop through natural succession. The Commercial Zone contains 3,858 ac (1,561 ha) of covered lands. Stands in this zone will be managed sustainably for timber production on a 70-year rotation. A considerable area of late-seral and mature forest capable of supporting nesting, roosting, foraging, and dispersal of northern spotted owls is expected to develop over time in the Natural Zone, Conservation Zone, and to a lesser extent, riparian buffers. Over the term of the permit, the amount of late-seral forest is expect to increase from 41 ac (17 ha) to 292 ac (118 ha), and the amount of mature forest is expected to increase from 268 ac (108 ha) to 4,027 ac (1,630 ha).

At the time the permit was approved, there were 16 known northern spotted owl activity centers within 1.8 miles of covered lands. Fifteen were reproductive site centers and one was a single-resident site center. Only the single-resident site center was actually located on covered lands. Species-specific conservation measures are designed to protect habitat around known nest sites and minimize disturbance during the nesting season.

Benefits of Inclusion—We find that there is minimal benefit from designating critical habitat for the northern spotted owl within the Green River HCP because, as explained above, these covered lands are already managed for the conservation of the species over the term of the HCP. As discussed above the inclusion of these covered lands as critical habitat could provide some additional Federal regulatory benefits for the species consistent with the conservation standard based on the Ninth Circuit Court's decision in *Gifford Pinchot.* A benefit of inclusion would be the requirement of a Federal agency to ensure that their actions on these non-Federal lands would not likely result in the destruction or adverse modification of critical habitat. However, this additional analysis to determine whether a Federal action is likely to result in the destruction or adverse modification of critical habitat is not likely to be significant not only because a Federal nexus is unlikely (these covered lands are not under Federal ownership), any Federal agency proposing a Federal action on these covered lands would likely consider the conservation value of these lands and take the necessary steps to avoid adverse effects to northern spotted owl habitat. If a Federal nexus did occur, it would most likely be in the context of a linear project such as a powerline, pipeline, or transportation project. In the last 11 years of the permit, none have occurred.

Another factor that minimizes any regulatory benefits that might result from critical habitat designation is that the Green River HCP already provides for the needs of the northern spotted owl by protecting and preserving acres of existing suitable northern spotted owl habitat in the Green River watershed, committing to the enhancement and recruitment of additional area of suitable habitat over the term of the Green River HCP, and implementing species-specific conservation measures designed to avoid and minimize impacts to northern spotted owls. Monitoring was developed to track HCP progress over the term of the permit and provide critical feedback on management actions, which allow for management changes in response to this feedback or to larger trends outside the HCP boundaries such as climate change. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measurable protections.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Designation of critical habitat would inform State agencies and local governments about areas that could be conserved under State laws or local ordinances, such as the Washington State Growth Management Act, which encourage the protection of ''critical areas'' including fish and wildlife habitat conservation areas. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. However, the additional educational and informational benefits that might arise from critical habitat designation here have been largely accomplished through the public review and comment on the HCP, Environmental Impact Statement, and Implementation Agreement.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, in Washington, State forest practices regulations provide an exemption for review for lands managed under an HCP. Thus, even should the State respond to designation of critical habitat by instituting additional protections, the HCP will not be subject to those protections as the species is considered already addressed, and therefore no additional benefit would accrue through State regulations.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 3,162 ac (1,280 ha) of lands currently managed under the HCP are substantial. HCP conservation measures that provide a benefit to the northern spotted owl and its habitat have been implemented continuously since 2001 on all covered lands owned and managed under the Green River HCP. Excluding the lands managed under the Green River HCP from critical habitat designation will sustain and enhance the working relationship between the Service and the permit holder.

Excluding lands within HCPs from critical habitat designation may also support our continued ability to seek new partnerships with future HCP participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement conservation actions that we would be unable to accomplish otherwise. If lands within HCP plan areas are designated as critical habitat, it would likely have a negative effect on our ability to establish new partnerships to develop HCPs, particularly HCPs address landscape-level conservation of species and habitats. By excluding these lands, we preserve our current partnerships and encourage additional conservation actions in the future.

Benefits of Exclusion Outweigh the Benefits of Inclusion—In summary, we determine that the benefits of excluding the Green River HCP from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat. The regulatory and informational benefits of inclusion will be minimal. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or functionality of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, any benefits from the section 7 process are unlikely because Federal projects would be rare on these relatively remote forest lands. The regulatory benefits of inclusion are even more minimal in light of the fact that the Green River HCP includes species-specific avoidance and minimization measures, monitoring requirements to track success and ensure proper implementation, and forest management practices and habitat conservation objectives that benefit the northern spotted owl and its habitat, which exceeds any conservation value provided as a result of a critical habitat designation. On the other hand, the benefit of excluding these lands is that it will help us maintain an important and successful conservation partnership with a major city, and may encourage others to join in conservation partnerships as well. Therefore, we find that the benefits of exclusion of the lands covered by Green River HCP outweigh the benefits of inclusion.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of approximately 3,162 ac (1,280 ha) of lands covered under the Green River HCP will not result in extinction of the northern spotted owl because the Green River HCP provides for the needs of the northern spotted owl by protecting and preserving acres of existing suitable northern spotted owl habitat in the Green River watershed, committing to the enhancement and recruitment of additional area of suitable habitat over the term of the Green River HCP, and implementing species-specific conservation measures designed to avoid and minimize impacts to northern spotted owls. Monitoring was developed to track HCP progress over the term of the permit and provide critical feedback on management actions, which allow for management changes in response to this feedback or to larger trends outside the HCP boundaries such as climate change. The conservation measures provided by this HCP have been implemented continuously since 1998 on all covered lands owned and managed under the Green River HCP. Further, for projects having a Federal nexus and affecting northern spotted owls in occupied areas, the jeopardy standard of section 7 of the Act, coupled with protection provided by the Green River HCP, would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. The species is also protected by ESA section 9, which prohibits the take of listed species. For these reasons, we find that exclusion of these lands within the Green River HCP will not result in extinction of the northern spotted owl. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Green River HCP boundary totaling about 3,162 ac (1,280 ha).

Plum Creek Timber Central Cascades Habitat Conservation Plan

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, totaling about 33,144 ac (13,413 ha) that are covered under the Plum Creek Timber Central Cascades HCP (Plum Creek HCP) in the State of Washington. The permit associated with the Plum Creek HCP was first noticed in the **Federal Register** on November 17, 1995 (60 FR 57722), issued on June 27, 1996, and later modified in December of 1999 as noticed on February 10, 2000 (65 FR 6590). The permit has a term of 50 years (with an option to extend to 100 years if certain conditions are met) and currently covers 84,600 ac (34,236 ha) of lands in the Interstate-90 corridor in King and Kittitas Counties, Washington. The HCP includes over 315 species of fish and wildlife, including the northern spotted owl and 7 other listed species. The plan addresses forest-management activities across an area of industrial timberlands in Washington's central Cascade Mountains, and provides for management of the northern spotted owl based on landscape conditions tailored to the guidelines provided by the NWFP by providing additional protection to northern spotted owl sites near late-successional reserves. Wildlife trees are retained in buffers of natural features (e.g., caves, wetlands, springs, cliffs, talus slopes) and streams, as well as scattered and clumped within harvest units. The HCP also requires Plum Creek to maintain and grow nesting, roosting, and foraging habitat as well as habitat that can be used for foraging and dispersal. They are also required to provide forests of various structural stages across all of their HCP ownerships. This commitment of owl habitat and forest stages, in combination with wildlife trees retained within harvest units and stream and landscape-feature buffers will provide a matrix of habitat conditions that complements the owl habitat provided in the Plum Creek HCP and nearby LSRs. Stands containing scattered leave trees following harvest will be expected to become more valuable for northern spotted owls at earlier ages than those harvested using previous methods.

At the time the permit was approved, there were 107 known northern spotted owl activity centers within 1.82 miles of covered lands, which included reproductive site centers, single-resident site centers, and historic sites. A detailed description of each sites history is provided in the HCP and associated technical papers.

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands is small unless it is a larger project covering adjacent Federal lands as well, in which case section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species. In addition, although the standards of jeopardy and adverse modification are different, the margin of conservation that could be attained through section 7 would not be significant in light of the benefits already derived from the HCP.

HCPs typically provide for greater conservation benefits to a covered species than section 7 consultations because HCPs ensure the long-term protection and management of a covered species and its habitat. In addition, funding for such management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which in contrast to HCPs, often do not commit the project proponent to long-term, special management practices or protections. Thus, a section 7 consultation typically does not afford the lands it covers similar extensive benefits as a HCP. The development and implementation of HCPs provide other important conservation benefits, including the development of biological information to guide the conservation efforts and assist in species conservation, and the creation of innovative solutions to conserve species while meeting the needs of the applicant. In this case, substantial information has been developed from the research, monitoring, and surveys conducted under the Plum Creek HCP.

There is minimal incremental benefit from designating critical habitat for the northern spotted owl within the Plum Creek HCP because, as explained above, these covered lands are already managed for the conservation of the species over the term of the HCP and the conservation measures provided by the HCP will provide greater protection to northern spotted owl habitat than the designation of critical habitat, which provides regulatory protections only in the event of a Federal action. The Plum Creek HCP provides for the needs of the northern spotted owl by protecting and preserving landscape levels of suitable northern spotted owl nesting, roosting, and foraging habitat as well as foraging and dispersal habitat over the term of the HCP in strategic landscapes, and implementing species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. The HCP also provides for the ability to make ongoing adjustments in a number of forms including active adaptive forest management. The ability to change is crucial to meet new recovery challenges. The Service negotiated this plan with Plum Creek, which contains mandatory permit conditions in the form of HCP commitments, and continues to be involved in its ongoing implementation. The Service conducts compliance monitoring on the covered lands and routinely meets with Plum Creek to discuss ongoing implementation. The HCP contains provisions that address ownership changes and the outcomes expected by the Service. Monitoring was developed to track HCP progress over the term of the permit and provide feedback on management actions. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measureable protections.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Designation of critical habitat would inform State agencies and local governments about areas that could be conserved under State laws or local ordinances, such as the Washington State Growth Management Act, which encourage the protection of ''critical areas'' including fish and wildlife habitat conservation areas. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable.

However, Plum Creek is knowledgeable about the northern spotted owl and the company has made substantial contributions in research and science for the species. The additional educational and informational benefits that might arise from critical habitat designation here have been largely accomplished through the public review and comment of the HCP, Environmental Impact Statement, and Implementation Agreement, as well as the supplemental Environmental Impact Statements associated with the modification of the HCP and the I–90 Land Exchange. Through these processes, this HCP included intensive public involvement. This HCP continues to receive a high degree of scrutiny and study by academics, as well as informational releases to the general public and has resulted in improved understanding by the public. This level of exposure in local newspapers and television stations exceeds the level of education that would come from a designation that would be read by few people in the public. Moreover, the rulemaking process associated with critical habitat designation includes several opportunities for public comment, and thus also provides for public education. Through these outreach opportunities, land owners, State agencies, and local governments have become more aware of the status of and threats to the northern spotted owl and the conservation actions needed for recovery.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, in Washington, State forest practices regulations provide an exemption for review for lands managed under an HCP. Thus, even should the State respond to designation of critical habitat by instituting additional protections, the HCP will not be subject to those protections as the species is considered already addressed, and therefore no additional benefit would accrue through State regulations.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 33,144 ac (13,413 ha) of lands currently managed under the HCP are more substantial. The designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the Plum Creek HCP area are designated as critical habitat, it would likely have a negative effect on our continued ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement conservation actions (such as SHAs, HCPs, and other conservation plans, particularly those that address landscape-level conservation of species and habitats) that we would be unable to accomplish otherwise. This HCP is currently serving as a model for ongoing and future efforts. Due to the high level of visibility in the Interstate-90 corridor and the overlap with recreational lands used by many residents of the Seattle metropolitan area, this HCP received an unusual amount of scrutiny. Because it was one of the first HCPs to address species using a habitat-based approach, it set a high standard for application of the best available science. Plum Creek has been a long-standing partner and advocate for HCPs across the nation. They are viewed as leaders in their industry and as an example in the HCP community. By excluding these lands, we preserve our current private and local conservation partnerships and encourage additional conservation actions in the future.

In addition, exclusion may encourage Plum Creek to engage in further land exchanges or sales of their lands for conservation purposes. This HCP is located in a key landscape between the I–90 and other Federal lands and represents a unique opportunity in maintaining northern spotted owls at the western extreme of the Cascades, which may support dispersal between the Cascades. This HCP contributes meaningfully to the recovery of the northern spotted owl and serves as an example to other industrial companies. Since issuance of the Plum Creek HCP, Plum Creek's ownership has decreased from about 170,000 ac (68,797 ha) to about 81,000 ac (32,780 ha). This decrease is mostly due to land exchanges and sales by Plum Creek for conservation purposes. Conservation sales have been completed on a number of sensitive sites. Plum Creek has worked to find conservation buyers and has responded to requests from agencies and conservation groups. They have sold lands to a various parties using differing funding mechanisms, but sold lands have been transferred to public ownership, primarily the U.S. Forest Service. All of these lands have been placed in conservation status. If lands within the Plum Creek HCP plan areas are designated as critical habitat, it would likely have a negative effect on the willingness of various groups and funding sources to accomplish these conservation sales, and could also negatively affect Plum Creek's willingness to participate in these acquisition processes.

Benefits of Exclusion Outweigh the Benefits of Inclusion—The benefits of including these lands in the designation are small. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or functionality of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the HCP contains provisions for protecting and maintaining northern spotted owl habitat that far exceed the conservation benefits afforded through section 7 consultation. It provides for comprehensive measures applied across a large landscape that will benefit spotted owls. Plum Creek personnel are knowledgeable in the ecology of the northern spotted owl and have contributed to the body of scientific information about the northern spotted owl. In this instance, the regulatory and educational reasons for inclusion have much less benefit than the continued benefit of the HCP, including the educational benefits derived from the HCP.

On the other hand, the benefits of exclusion will continue the positive relationship we currently have with Plum Creek and encourage others to engage in conservation partnerships such as HCPs as well. For these reasons, we determine that the benefits of excluding the Plum Creek Cascades HCP from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of approximately 33,144 ac (13,413 ha) of lands covered under the Plum Creek HCP will not result in extinction of the northern spotted owl because the Plum Creek HCP provides for the needs of the northern spotted owl by protecting and preserving landscape levels of suitable northern spotted owl nesting, roosting, and foraging habitat as well as foraging and dispersal habitat over the term of the HCP in strategic landscapes, and implementing species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. Monitoring was developed to track HCP progress over the term of the permit and provide feedback on management actions. The Plum Creek HCP provides for the ability to make ongoing adjustments in a number of forms, including active adaptive forest management. The ability to change is crucial to meet new recovery challenges. The HCP contains provisions that address ownership changes and the outcomes expected by the Service. Further, for projects having a Federal nexus and affecting northern spotted owls in occupied areas, the jeopardy standard of section 7 of the Act, coupled with protection provided by the Plum Creek HCP, would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. We find that exclusion of these lands within the Plum Creek HCP will not result in extinction of the northern spotted owl. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Plum Creek HCP boundary totaling about 33,144 ac (13,413 ha).

Washington State Department of Natural Resources State Lands Habitat Conservation Plan

Washington State lands totaling approximately 225,751 ac (91,358 ha) that are covered and managed under the Washington State Department of Natural Resources State Lands Habitat Conservation Plan (WDNR HCP), are excluded from this critical habitat designation under section 4(b)(2) of the Act. The WDNR HCP covers approximately 1.7 million ac (730,000 ha) of State forest lands within the range of the northern spotted owl in the State of Washington. The majority of the area covered by the HCP is west of the Cascade Crest and includes the Olympic Experimental State Forest. The HCP area on the east side of the Cascade Range includes lands within the range of the northern spotted owl. The permit associated with this HCP, issued January 30, 1997, was noticed in the **Federal Register** on April 5, 1996 (61 FR 15297), has a term of 70 to 100 years, and covers activities primarily associated with commercial forest management, but also includes limited nontimber activities such as some recreational activities. The HCP covers all species, including the northern spotted owl and other listed species.

The HCP addressed multiple species through a combination of strategies. The HCP includes a series of Natural Area Preserves and Natural Resource Conservation Areas. The marbled murrelet is addressed through a combination of steps culminating in the development of a long-term plan to retain and protect important old-forest habitat, which will also benefit the northern spotted owl. Riparian conservation includes buffers on fish-bearing streams as well as substantial buffers on streams and wetlands without fish, and deferring harvest on unstable slopes. Wildlife trees are retained in buffers of natural features (e.g., caves, wetlands, springs, cliffs, talus slopes) and streams, as well as scattered and clumped within harvest units. The HCP also requires WDNR to maintain and grow forests of various structural stages across all of their HCP ownerships. Specifically for northern spotted owls, they have identified portions of the landscape upon which they will manage for nesting, roosting, and foraging (NRF) habitat for northern spotted owls. These areas are known as NRF Management Areas (NRFMAs) and were located to provide demographic support that would strategically complement the NWFP's Late-Successional Reserves as well as those Adaptive Management Areas that have late-successional objectives. The NRFMAs also were situated to help maintain species distribution. Generally, these NRFMAs will be managed so that approximately 50 percent of those lands will develop into NRF habitat for the northern spotted owl over time. Within this 50 percent, certain nest patches containing high-quality nesting habitat are to be retained and grown. Since the HCP was implemented, within the NRFMAs, WDNR has carried out 5,100 ac (2,064 ha) of pre-commercial thinning and 7,800 ac (3,156 ha) of timber harvest specifically configured to enhance northern spotted owl habitat. WDNR's habitat-enhancement activities will continue under the HCP.

Some areas outside of the NRFMAs are managed to provide for dispersal and foraging conditions in 50 percent of the forests in those areas; these were strategically located in landscapes important for connectivity. The Olympic Experimental State Forest is managed to provide for northern spotted owl conservation across all of its lands. Even in areas not specifically managed for northern spotted owls, WDNR has committed to providing a range of forest stages across the landscape to address multiple species. This commitment of forest stages, in combination with wildlife trees retained within harvest units and stream and landscape-feature buffers, will provide a matrix of habitat conditions that will also provide some assistance in conserving northern spotted owls. Stands containing scattered leave trees following harvest will become more valuable for northern spotted owls at earlier ages than those stands harvested using previous methods. Northern Spotted owls across the WDNR HCP are expected to benefit from the combination of these strategies.

At the time the permit was approved, there were approximately 292 northern spotted owl site centers overlapping on WDNR covered lands, including 76 known site centers (excluding historic sites and non-territorial singles). There were approximately 484,717 ac (196,158 ha) of suitable habitat on covered lands, which comprised over 10 percent of all suitable habitat in Washington State at that time.

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands is small unless it is a larger project covering adjacent Federal lands as well, in which case section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species. In addition, although the standards of jeopardy and adverse modification are different, in this case, the benefits of applying the latter standard would be minimal in light of the benefits already derived from the HCP.

HCPs typically provide for greater conservation benefits to a covered species than section 7 consultations because HCPs ensure the long-term protection and management of a covered species and its habitat. Funding for such management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which in contrast to HCPs, often do not commit the project proponent to long-term, special management practices or protections. Thus, a section 7 consultation typically does not afford the lands the same benefits as a HCP.

The development and implementation of HCPs provide other important conservation benefits, including the development of biological information to guide the conservation efforts and assist in species conservation, and the creation of innovative solutions to conserve species while meeting the needs of the applicant. In this case, substantial information has been developed from the research, monitoring, and surveys conducted under the WDNR HCP.

There is minimal incremental benefit from designating critical habitat for the northern spotted owl within the WDNR HCP because, as explained above, these covered lands are already managed for the conservation of the species over the term of the HCP and the conservation measures provided by the HCP will provide greater protection to northern spotted owl habitat than the designation of critical habitat, which provides regulatory protections only in the event of a Federal action. The WDNR HCP provides for the needs of the northern spotted owl by protecting and preserving landscape levels of suitable northern spotted owl nesting, roosting, and foraging habitat as well as foraging and dispersal habitat over the term of the HCP in strategic landscapes, and implementing species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. The HCP also provides for the ability to make ongoing adjustments in a number of forms, including active adaptive forest management. The ability to change is crucial to meet new recovery challenges. The Service continues to be involved in the implementation of this HCP. The Service conducts compliance monitoring on the covered lands and routinely meets with WDNR to discuss ongoing implementation. The HCP contains provisions that address ownership changes and the outcomes expected by the Service. Monitoring was developed to track HCP progress over the term of the permit and provide feedback on management actions. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measureable protections.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Designation of critical habitat would inform State agencies and local governments about areas that could be conserved under State laws or local ordinances, such as the Washington State Growth Management Act, which encourage the protection of ''critical areas'' including fish and wildlife habitat conservation areas. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. However, WDNR, as the State's natural resource agency, is knowledgeable about the species and has made substantial contributions to our knowledge of the species. In addition the additional educational and informational benefits that might arise from critical habitat designation here have been largely accomplished through the public review and comment of the HCP, Environmental Impact Statement, and Implementation Agreement, as well as the supplemental Environmental Impact Statements associated with the modification of the HCP. This HCP included intensive public involvement and continues to be an example used when discussing HCPs. The HCP is frequently a topic of open and public discussion during meetings of the Washington State Board of Natural Resources, whose meetings are open to the public and frequently televised. This level of exposure in local newspapers and television stations exceeds the level of education that would come from a designation that would be read by few people in the public. Moreover, the rulemaking process associated with critical habitat designation includes several opportunities for public comment, and thus also provides for public education.

Benefits of Exclusion—A benefit of excluding lands within this HCP from critical habitat designation is that it would encourage the State and other parties to continue to work for owl conservation. Since issuance of this HCP, a number of land transactions and land exchanges with the HCP area have occurred. These transactions have included creation of additional Natural Resource Conservation Areas and Natural Area Preserves (both land designations with high degree of protection) and have also included large land exchanges and purchases that have changed the footprint of the HCP. These land-based adjustments have facilitated better management on many important parcels and across larger landscapes than would otherwise have been possible. If lands within HCP plan areas are designated as critical habitat, it would likely have a negative effect on the willingness of various groups and funding sources to accomplish these land-ownership adjustments because of a reluctance to acquire lands designated as critical habitat as well as a reduced willingness on the part of WDNR to accommodate the Services goals. This HCP is located in key landscapes across the State and contributes meaningfully to the recovery of the northern spotted owl.

If lands within the WDNR HCP plan area are designated as critical habitat, it would also likely have a negative effect on our ability to establish new partnerships to develop HCPs, particularly large, regional HCPs that involve numerous participants and/or address landscape-level conservation of species and habitats. This HCP has served as a model for several completed and ongoing HCP efforts, including the Washington State Forest Practices HCP. By excluding these lands, we preserve our current private and local conservation partnerships and encourage additional conservation actions in the future because other parties see our exclusion as a sign that the Service will not impose duplicative regulatory burdens on landowners who have developed an HCP.

HCPs typically provide for greater conservation benefits to a covered species than section 7 consultations because HCPs ensure the long-term protection and management of a covered species and its habitat. In addition, funding for such management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which in contrast to HCPs often do not commit the project proponent to long-term, special management practices or protections. Thus, a section 7 consultation typically does not afford the lands it covers similar extensive benefits as an HCP. The development and implementation of HCPs provide other important conservation benefits, including the development of biological information to guide the conservation efforts and assist in species conservation, and the creation of innovative solutions to conserve species while meeting the needs of the applicant. In this case, substantial information has been developed from the research, monitoring, and surveys conducted under the WDNR HCP. Therefore, exclusion is a benefit because it maintains and fosters development of biological information and innovative solutions.

Benefits of Exclusion Outweigh the Benefits of Inclusion—The benefits of including these lands in the designation are small. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or functionality of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the HCP contains provisions for protecting and maintaining northern spotted owl habitat that far exceed the conservation benefits afforded through section 7 consultation. It provides for comprehensive measures applied across a large landscape that will benefit spotted owls. Washington State DNR personnel are extremely knowledgeable regarding the ecology of the northern spotted owl and have contributed to the body of scientific information about the northern spotted owl. In this instance, the regulatory and educational benefits of inclusion have much less benefit than the continued benefit of the HCP including the educational benefits derived from the HCP.

The WDNR HCP provides for significant conservation and management within geographical areas that contain the physical or biological features essential to the conservation of the northern spotted owl and help achieve recovery of this species through the conservation measures of the HCP. Exclusion of these lands from critical habitat will help foster the partnership we have developed with WDNR, through the development and continuing implementation of the HCP. Furthermore, this partnership may aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species.

For these reasons, we determine that the benefits of excluding the WDNR HCP from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of approximately 225,751 ac (91,358 ha) of lands covered under the WDNR HCP will not result in extinction of the northern spotted owl. The WDNR HCP protects and preserves landscape levels of suitable northern spotted owl nesting, roosting, and foraging habitat as well as foraging and dispersal habitat over the term of the HCP in strategic landscapes, and implements species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. Monitoring was developed to track HCP progress over the term of the permit and provide critical feedback on management actions. Adaptive management provides for responses to this feedback. Further, for projects having a Federal nexus and affecting northern spotted owls in occupied areas, the jeopardy standard of section 7 of the Act, coupled with protection provided by the WDNR HCP, would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. We find that exclusion of these lands within the WDNR HCP will not result in extinction of the northern spotted owl. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the WDNR HCP totaling about 225,751 ac (91,358 ha).

West Fork Timber Habitat Conservation Plan

The Service has excluded approximately 5,105 ac (2,066 ha) of lands from final critical habitat designation, under section 4(b)(2) of the Act, that are covered under the West Fork Timber HCP (West Fork HCP) (formerly known as Murray Pacific Corporation) in the West Cascades Central CHU in Washington. The West Fork HCP was the first multispecies HCP on forested lands in the Nation. The permit associated with the West Fork HCP has a term of 100 years and was first issued on September 24, 1993; amended on June 26, 1995; and amended again on October 16, 2001 (66 FR 52638). The HCP includes 53,558 ac (21,674 ha) of commercial timber lands managed as a tree farm in Lewis County, Washington. The HCP is situated between an area of Federal land known as the Mineral Block and the larger block of Federal lands in the Cascades. The HCP was first developed to allow for forest-management activities and provide for the conservation of the northern spotted owl; the amended HCP provides for all species, including six listed species. The HCP is designed to develop and maintain northern spotted owl dispersal habitat across 43 percent of the tree farm, and must also meet quantitative measures of amount and distribution. As a result, total dispersal habitat will more than double in amount, and wide gaps between stands of dispersal habitat will be decreased.

In addition, the West Fork HCP provides for leaving at least 10 percent of the tree farm in reserves for the next 100 years. These reserves will primarily take the form of riparian buffers averaging at least 100 feet (30 m) on each side of all fish-bearing streams, as well as other buffers and set-a-side areas. Other provisions of the HCP are designed to ensure that all forest habitat types and age classes currently on the tree farm, as well as special habitat types such as talus slopes, caves, nest trees, and den sites, are protected or enhanced. Seasonal protection is provided within ¼ mile of an active northern spotted owl nest site.

At the time the permit was approved, there were approximately 4,678 ac (1,893 ha) of suitable habitat in small stands sporadically located, comprising about 8 percent of the ownership. The HCP included 3 resident northern spotted owls and included about 20 percent of the ownership in dispersal habitat.

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands is small unless it was a larger project covering adjacent Federal lands as well, in which case section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species. In addition, although the standards for jeopardy and adverse modification are not the same, the benefits of the section 7 prohibition on adverse modification would be minimal in light of the benefits already derived from the HCP.

HCPs typically provide for greater conservation benefits to a covered species than section 7 consultations because HCPs ensure the long-term protection and management of a covered species and its habitat. In addition, funding for such management is ensured through the Implementation Agreement. Such assurances are typically not provided by section 7 consultations, which, in contrast to HCPs, usually do not commit the project proponent to long-term, special management practices or protections. Thus, a section 7 consultation typically does not afford the lands it covers benefits similar to those provided by an HCP. The development and implementation of HCPs provide other important conservation benefits, including the development of biological information to guide the conservation efforts and assist in species conservation, and the creation of innovative solutions to conserve species while meeting the needs of the applicant.

There is minimal incremental benefit from designating critical habitat for the northern spotted owl within the West Fork HCP because, as explained above, these covered lands are already managed for the conservation of the species over the term of the HCP and the conservation measures provided by the HCP will provide greater protection to northern spotted owl habitat than the designation of critical habitat, which provides regulatory protections only in the event of a Federal action. The West Fork HCP provides for the needs of the northern spotted owl by protecting and preserving landscape levels of suitable northern spotted owl dispersal habitat over the term of the HCP in strategic landscapes, and implementing species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. The HCP also provides for the ability to make ongoing adjustments in a number of forms, including active adaptive forest management. The ability to change is crucial to meet new recovery challenges. The Service continues to be involved in implementation of the HCP. It contains provisions that address ownership changes and the outcomes expected by the Service. Monitoring was developed to track HCP progress over the term of the permit and provide feedback on management actions. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measureable protections.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Designation of critical habitat would inform State agencies and local governments about areas that could be conserved under State laws or local ordinances, such as the Washington State Growth Management Act, which encourage the protection of ''critical areas'' including fish and wildlife habitat conservation areas. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. However, this landowner is knowledgeable about the species through its implementation of the HCP. In addition the additional educational and informational benefits that might arise from critical habitat designation here have been largely accomplished through the public review and comment of the HCP, Environmental Impact Statement, and Implementation Agreement. Through these processes, this HCP included intensive public involvement. Moreover, the rulemaking process associated with critical habitat designation includes several opportunities for public comment, and thus also provides for public education. Through these outreach opportunities, land owners, State agencies, and local governments have become more aware of the status of and threats to the northern spotted owl and the conservation actions needed for recovery.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, in Washington, State forest practices regulations provide an exemption for review for lands managed under an HCP. Thus, even should the State respond to designation of critical habitat by instituting additional protections, the HCP will not be subject to those protections as the species is considered already addressed, and therefore no additional benefit would accrue through State regulations.

Benefits of Exclusion—Compared to the minimal benefits of inclusion of this area in critical habitat, the benefits of excluding it from designated critical habitat are more substantial.

HCP conservation measures that provide a benefit to the northern spotted owl and its habitat have been implemented continuously since 1993 on all covered lands owned and managed under the HCP. Excluding these lands from critical habitat designation will sustain and enhance the working relationship between the Service and the permit holder.

A related benefit of excluding lands within HCPs from critical habitat designation is the unhindered, continued ability to seek new partnerships with future HCP participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement conservation actions that we would be unable to accomplish otherwise. If lands within the West Fork HCP plan area are designated as critical habitat, it would likely have a negative effect on our ability to establish new partnerships to develop HCPs, particularly large, regional HCPs that involve numerous participants and/or address landscape-level conservation of species and habitats. If excluded, the willingness of the landowner to work with the Service to manage federally listed species will continue to reinforce those conservation efforts and our partnership, which contribute toward achieving recovery of the northern spotted owl. We consider this voluntary partnership in conservation important in maintaining our ability to implement recovery actions such as habitat protection and restoration, and beneficial management actions for species on non-Federal lands.

In summary, the designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of redundant government regulation. If lands within the West Fork HCP area are designated as critical habitat, it would likely have a negative effect on our continued ability to seek new partnerships with future participants can implement conservation actions (such as SHAs, and HCPs) that we would be unable to accomplish otherwise. By excluding these lands, we preserve our current private and local conservation partnerships and encourage additional conservation actions in the future.

Benefits of Exclusion Outweigh the Benefits of Inclusion—The benefits of including these lands in the designation are comparatively small. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or functionality of the habitat for the species regardless of whether critical habitat is designated for these lands. The analytical requirements to support a jeopardy determination on excluded land are similar, but not identical, to the requirements in an analysis for an adverse modification determination on included land. However, the HCP contains provisions for protecting and maintaining northern spotted owl habitat that far exceed the conservation benefits afforded through section 7 consultation. It provides for comprehensive measures applied across a large landscape that will benefit spotted owls. In this instance, the regulatory and educational benefits of inclusion have much less benefit than the continued benefit of the HCP including the educational benefits derived from the HCP.

The West Fork HCP provides for significant conservation and management within geographical areas that contain the physical or biological features essential to the conservation of the northern spotted owl and help achieve recovery of this species through the conservation measures of the HCP. Exclusion of these lands from critical habitat will help foster the partnership we have developed with West Fork, through the development and continuing implementation of the HCP. Furthermore, this partnership may aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species.

In summary, we determine that the benefits of excluding the West Fork HCP from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of approximately 5,105 ac (2,066 ha) of lands covered under the West Fork HCP will not result in extinction of the northern spotted owl because the conservation measures identified within the HCP seek to maintain or surpass current habitat suitability for northern spotted owls. The HCP is designed to develop and maintain northern spotted owl dispersal habitat; as a result, total dispersal habitat will more than double in amount and wide gaps between stands of dispersal habitat will be decreased. In addition, the West Fork HCP provides for reserves for the next 100 years, ensuring that all forest habitat types and age classes currently on the tree farm, as well as special habitat types such as talus slopes, caves, nest trees, and den sites, are protected or enhanced. Seasonal protection is provided for active northern spotted owl nest sites. Further, for projects having a Federal nexus and affecting northern spotted owls in occupied areas, the jeopardy standard of section 7 of the Act, coupled with protection provided by the West Fork HCP, would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. We find that exclusion of these lands within the West Fork HCP will not result in extinction of the northern spotted owl. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the West Fork HCP boundary totaling about 5,105 ac (2,066 ha).

Other Conservation Measures or Partnerships

State of California

Mendocino Redwood Company

In this final designation, the Secretary has exercised his authority to exclude lands from critical habitat, under section 4(b)(2) of the Act, owned by The Mendocino Redwood Company (MRC, the company) and totaling approximately 232,584 total ac (94,123 ha) in Unit 3—Redwood Coast, in Mendocino and Sonoma Counties, California. This land is distributed among three critical habitat subunits as described in the following. In subunit RDC–2, we proposed approximately 209,550 ac (84,802 ha) for critical habitat designation. In subunit RDC–3, we proposed approximately 22,733 ac (9,200 ha) for critical habitat designation. In subunit RDC–4, we proposed 301 ac (121 ha) for critical habitat designation. All company lands proposed for designation within these three subunits have been excluded from critical habitat designation under section 4(b)(2) of the Act.

MRC has a long-standing voluntary partnership with the Service to protect the northern spotted owl on MRC lands. MRC initially approached the Service in 1998 to develop a combined habitat conservation plan and a State-level counterpart draft natural communities conservation plan (HCP/NCCP). Knowing that the completion of an HCP/NCCP would take an extended period of time, MRC and the Service worked together to develop a set of interim standards and measures to conserve and protect the northern spotted owl and its habitat, pending the completion of the HCP/NCCP. These written interim standards and measures are detailed and specific and have been incorporated into each of MRC's timber harvest plans since their development. These interim standards and measures are detailed in MRC's January 15, 2010, Northern Spotted Owl Resource Plan/Management Plan (SORP) (MRC 2010, pp. 1–30). The SORP was intended to serve as a bridge document to reduce resource impacts to both the northern spotted owl and its habitat until the completion of the HCP/NCCP. The SORP includes monitoring and survey requirements and northern spotted owl habitat protection measures that are implemented across the landscape. The SORP describes methodologies to locate owls, assess reproductive status, and provide a framework that includes habitat definitions and protections associated with northern spotted owl activity centers which provide measurable standards for habitat conservation. MRC and the Service meet frequently to discuss northern spotted owl study results provided by the company and this information is used by both the Service and MRC to develop measures that conserve the species through an iterative process that will assist in the development of the HCP/NCCP. In reviewing the SORP and monitoring results, we find that the SORP and protective measures therein provide substantial conservation benefits for the northern spotted owl and its habitat at a landscape scale.

The standards and measures described in the SORP are included in the ''Planning Agreement'' (dated August 5, 2009) that MRC entered into with the California Department of Fish and Game (CDFG) for preparation of the NCCP element of the HCP/NCCP. Planning Agreements are mandatory under the California Natural Community Conservation Planning Act, and inasmuch as the northern spotted owl standards and measures are included in MRC's planning agreement, they are mandatory. MRC has revised them when requested by the Service, as part of a voluntary partnership with the Service.

In addition, MRC has two State-level planning documents that are in effect now and which contain substantial long-terms benefits for northern spotted owl habitat. One is the company's 2008 Option A plan, entered into with CALFIRE, which sets sustainable long-term timber harvest levels and controls on standing forest inventory, and the other is the companion 2012 Management Plan, also entered into with CALFIRE, which outlines company-specific management practices used in conjunction with the Option A harvesting program. Together, these documents have enabled the company to maintain its forest certification through the Forest Stewardship Council (FSC) which gives the company access to certain wholesale lumber markets that promote ''green'' certified wood products. The State-level planning documents have also enabled the company to obtain registration through the California Climate Action Registry which is the designated clearinghouse for carbon-credit sellers under California's developing cap-and-trade program. The company's long-term management direction under Option A (2008) and the Management Plan (2012) is to greatly expand their stock of standing forest inventory, with a near-doubling of that inventory over the next nine decades. While we do not consider here the northern spotted owl conservation measures in the company's proposed HCP in support of 4(b)(2) exclusion, since that plan is not yet finalized, we do note that practically all of the long-term habitat and demographic objectives in the proposed HCP are dependent on the forest inventory trajectory that is established and in effect under Option A and the Management Plan, and are partly dependent on the distribution and array of silvicultural treatments that is specified under the Management Plan. Time intervals, measurable targets, and enforcement mechanisms for forest inventory development are already in place through the State-level forest planning processes, whether or not the proposed HCP is finalized. The company's long term commitment to expanding standing forest inventory is also demonstrated by their status as a seller in the State's emerging carbon credit market. In order to sell carbon credits, the seller has to possess surplus carbon; in forest management terms, the only way to have a continuous supply of surplus carbon is to have a body of inventory that is on a continuous-net-growth trajectory. The 2012 Management Plan also explicitly documents some of the company's internal management direction on the northern spotted owl with regard to the linkages between future forest conditions and owl habitat utilization, direction on the acquisition and analysis of owl breeding site surveys, and future development of northern spotted owl habitat models.

Following are summaries of specific measures in the 2012 Management Plan that will have direct, indirect, near-term and long-term benefits for the northern spotted owl, and which are in effect currently: (1) The company, having inherited a severely depleted forest inventory from the previous owners, has a standing policy to rebuild inventories, which will result in a doubling of total standing volume by the ninth decade of the planning horizon; (2) total harvest levels through the 100-year planning horizon are constrained to a graduating percentage of periodic growth volume, from a current 48 percent to 84 percent in the tenth decade of the plan; (3) a shift in the use of uneven-aged silviculture from a current 65 percent of harvest acres to 99 percent in the fifth decade of the plan; (4) protection policies for unharvested old-growth stands and previously harvested stands containing residual old-growth trees; (5) wildlife tree and snag retention requirements that meet or exceed Service recommendations and exceed current State Forest Practice rules; (6) a minimum forest floor large woody debris (LWD) standard on general forest land of 70 cubic feet per ac (4.9 cubic meter per ha) based on minimum-sized logs 16 in (41 cm) diameter and 10 ft (3.3 m) in length, increasing to 98 cubic feet per ac (6.9 cubic meter per ha) in riparian areas; and (7) a hardwood management policy that maintains a minimum hardwood basal area of 15 square feet per ac (3.4 square m per ha) in mixed conifer-hardwood stands. Each policy outlined above will result in: (a) A long term increase in standing forest biomass per unit of land area; or (b) increased spatial continuity of vegetative types that are suitable northern spotted owl habitat; or (c) retention of specific features such as old-growth trees or stands, and retention of a minimum level of hardwoods, snags, and wildlife trees. All of these policies will either lead to maintenance or enhancement of northern spotted owl habitat suitability or lead to emergence of suitable habitat where it is currently not present, thereby benefiting the conservation of the northern spotted owl and its habitat.

The company has completed a draft of their proposed HCP/NCCP, and the northern spotted owl is one of the covered species in this document. The company has submitted the HCP application to the Service. If the HCP/NCCP is approved and permits issued, the term of the incidental take permit and counterpart State permit would be 80 years. The combined draft Environmental Impact Statement (EIS) and State draft Environmental Impact Report (EIR) is scheduled for issuance in fall of 2012, and a final HCP/NCCP and final EIS/EIR is anticipated in spring or summer, 2013. However, as noted above, we have not taken the proposed HCP/NCCP into account in determining the level of protection currently provided to the northern spotted owl on MRC land, as we have not completed processing the permit application and a final decision has not been made whether it meets issuance criteria. We cite to the development of this HCP/NCCP only in terms of evidence of MRC's commitment to partnering with the Service for the conservation of the northern spotted owl.

Benefits of Inclusion—We find there are minimal benefits to including MRC lands in critical habitat. As discussed above, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands that might trigger such consultation is limited since there is little likelihood of an action that will involve Federal funding, authorization, or implementation. In addition, since the lands under in question are occupied by the northern spotted owl, if a Federal nexus were to occur, section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species through a jeopardy analysis. Because one of the primary threats to the northern spotted owl is habitat loss and degradation, the consultation process under section 7 of the Act for projects with a Federal nexus will, in evaluating effects to the northern spotted owl, evaluate the effects of the action on the conservation or function of the habitat for the species regardless of whether critical habitat is designated for these lands. Although the standards for jeopardy and adverse modification are not the same, the additional conservation that could be attained through the section 7 prohibition on adverse modification analysis would not likely be significant in this case because of the conservation agreements already in place.

Another potential benefit of including lands in a critical habitat designation is that the designation can serve to educate landowners, State and local government agencies, and the public regarding the potential conservation value of an area, and may help focus conservation efforts on areas of high conservation value for certain species. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. However, in this case the educational value of critical habitat is limited. As evidenced by their extensive forest management planning, this forestland owner is knowledgeable about the species.

The designation of critical habitat may also indirectly cause State or county jurisdictions to initiate their own additional requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, CALFIRE has indicated to us that it is unlikely to impose any new requirements on project proponents if critical habitat is designated in areas already subject to California Forest Practice Rules. Therefore, we believe this potential benefit of critical will be limited.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 232,584 ac (94,123 ha) of lands currently owned by the MRC are substantial. We have created a close partnership with the company through the development of the SORP and the resulting draft HCP/NCCP. The SORP contains provisions that will improve inventory of redwood, Douglas-fir, and other conifers across MRC's ownership and includes measures that will return forest types to those that support the northern spotted owl. In addition, the SORP stipulates a series of actions intended to increase canopy cover and move management of forest stands to uneven-aged management to promote multilayered canopies and protect old growth stands and individual trees with old-growth structural features. The SORP also contain provisions that will result in stands being grown in Watercourse and Lake Protection Zones (WLPZ) that exceed current State Forest Practice requirements and that meet the Service's recommended standards for standing tree basal area and retention of large woody debris in watercourse protection zones. All of these measures are consistent with recommendations from the Service for the conservation of the northern spotted owl, and will afford benefits to the species and its habitat.

Other MRC actions also demonstrate their commitment to the Federal-State-private partnership. The company's Management Plan in connection to their FSC forest certification is already in effect. That Plan has numerous measures within it that the company has been implementing on the ground for several years without any inducement from the cooperating Federal and State agencies. Much of the Management Plan is concerned with harvest scheduling and how the company will remedy its current deficit in standing forest inventory. The major part of that remedy is found in the 10-decade harvesting schedule in the Management Plan, which tightly constrains harvest levels in the early decades of the Plan and relaxes the constraint in later decades. The company has implemented the designed harvest schedule since 2000, which is supported in the certification audit reports of 2005 and 2010. This means that MRC has, in fact, foregone a portion of their potential short-term harvest revenues for nearly 12 years to fulfill a Management Plan that is not under Federal purview. Company policies embodied in the Management Plan will result in (a) a long term increase in standing forest biomass per unit of land area; or (b) increased spatial continuity of vegetative types that are suitable northern spotted owl habitat; or (c) retention of specific features such as old-growth trees/stands, retention of a minimum level of hardwoods, snags, and wildlife trees. All of these policies will either lead to maintenance of northern spotted owl habitat suitability or lead to emergence of suitable habitat where it is currently not present.

Excluding the approximately 232,584 ac (94,123 ha) owned and managed by MRC from critical habitat designation will provides significant benefit in terms of sustaining and enhancing the excellent partnership between the Service and the company, with positive consequences for conservation. The willingness of MRC to voluntarily undertake conservation efforts for the benefit of the northern spotted owl and work with the Service to develop new conservation plans for the species will continue to reinforce those conservation efforts and our partnership, which contribute toward achieving recovery of the northern spotted owl. We consider this voluntary partnership in conservation vital to our understanding of the northern spotted owl status of species on MRC lands and in the redwood region, and necessary for us to implement recovery actions such as habitat protection and restoration, and beneficial management actions for species.

The designation of critical habitat could have an unintended negative effect on our relationship with non-Federal landowners due to the perceived imposition of government regulation. If lands within the area managed by MRC for the benefit of the northern spotted owl are designated as critical habitat, it could have a chilling effect on our continued ability to seek new partnerships with future participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement various conservation actions (such as SHAs, HCPs, and other conservation plans, particularly large, regional Conservation Plans that involve numerous participants and/or address landscape-level conservation of species and habitats) that we would be unable to accomplish otherwise. In addition, MRC serves as a model of voluntary conservation by a private landowner, and may aid in fostering future voluntary conservation efforts by other parties in other locations for the benefit of listed species. We consider the positive effect of excluding proven conservation partners from critical habitat to be a significant benefit of exclusion.

The Benefits of Exclusion Outweigh the Benefits of Inclusion—We have reviewed and evaluated the exclusion of approximately 232,584 ac (94,123 ha) of land owned and managed by MRC from the critical habitat designation. The benefits of including these lands in the designation are comparatively small, since the habitat on the covered lands is already being monitored and managed under the current Management Plan and the Timber Management Plan to improve the habitat elements that are equivalent to the physical or biological features that are outlined in this critical habitat rule. We therefore anticipate little, if any, additional protections through application of the section 7 prohibition on adverse modification due to the designation of critical habitat on these lands.

The potential educational benefits of inclusion are also limited. The company has an active monitoring program on over 150 northern spotted owl activity sites and is making increasing contributions to our knowledge of the species through focused research. In addition, there is a growing local constituency for current land management direction as a result of the company's outreach efforts in the form of public informational presentations and tours of the property. In this instance, any potential educational benefits of inclusion would have much less practical effect than any of the scientific and informational activities that the company has initiated to date.

In contrast, the benefits derived from excluding this ownership and enhancing our private lands partnership with MRC are significant. We have developed a solid working relationship with MRC, and expect this beneficial conservation partnership to continue. The benefits of this partnership are significant, because MRC has demonstrated that its actions will contribute substantially to the conservation of the northern spotted owl and its habitat and influence long-term management outcomes across the entire ownership. We noted the positive conservation benefits that accrue from exclusion from critical habitat, including relief from perceived potentially duplicative regulatory burden and the increased potential of pursuing additional conservation agreements with other private landowners. As discussed above, MRC has developed a long-standing practice of managing its lands in a sustainable nature that benefits the northern spotted owl and its habitat. We also discussed the long-term value of the partnership with MRC, and evidence of the company's commitment to that partnership through voluntary implementation and coordination of conservation actions. We will not repeat that discussion here, but point to it as the strongest among all factors we considered in the weighing of the benefits of exclusion against the benefits of inclusion.

We have determined that the additional regulatory benefits of designating critical habitat, afforded through the section 7(a)(2) consultation process, are minimal because of limited Federal nexus and because conservation measures specifically benefitting the northern spotted owl and its habitat are in place as a result of our partnership with the company and as demonstrated by the provisions of the SORP and other planning documents, as discussed above. The potential educational and informational benefits of critical habitat designation on lands containing the physical or biological features essential to the conservation of the northern spotted owl would be minimal, because MRC is making substantial contributions to our understanding of the ecology of the northern spotted owl and its habitats in the redwood region, and continues to disseminate useful information through public education events. Therefore, in consideration of the factors discussed above in the *Benefits of Exclusion* section, including the relevant impact to current and future partnerships, we have determined that the benefits of exclusion of lands owned by the MRC outweigh the benefits of designating these areas as critical habitat.

Exclusion Will Not Result in Extinction of the Species—We have determined that the exclusion of 232,584 ac (94,123 ha) from the designation of critical habitat for the northern spotted owl on lands owned and managed by MRC will not result in extinction of the species. Conservation efforts that are currently in effect through the SORP (and not taking into account the draft HCP/NCCP) will adequately protect the geographical areas containing the physical or biological features essential to the conservation of the species. For projects having a Federal nexus and affecting northern spotted owls in occupied areas, as is the case here, the jeopardy standard of section 7 of the Act, coupled with current land management measures that are not under Federal purview, would provide assurances that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are within the Mendocino Redwood Company ownership boundary totaling 232,854 ac (92,123 ha).

State of Washington

Scofield Corporation Deed Restriction (Formerly Habitat Conservation Plan)

In this final designation, the Secretary has exercised his authority to exclude 40 ac (16 ha) of lands from critical habitat, under section 4(b)(2) of the Act, that are covered under the Scofield Corporation Deed Restriction in the East Cascades North CHU. A incidental take permit based on an HCP, was issued to Scofield Corporation in 1996 (noticed February 20, 1996 (61 FR 6381), issued April 3, 1996). The permit had a duration for only one year, but as provided in the permit terms, the lands under this HCP are now covered by a Deed Restriction for those lands in perpetuity. This HCP and deed restriction include 40 ac (16 ha) of forest lands in Chelan County, Washington. The HCP-covered forest-management activities and the associated incidental take permit included only the northern spotted owl. The HCP provided for mitigation and minimization measures by retaining a buffer of intact habitat, implementing selective timber harvest practices, and placing a perpetual deed restriction on the property permanently prohibiting further timber harvest or tree removal except with the express written consent of the Service. These measures were designed to ensure the retention of some northern spotted owl habitat and approximately 72 percent of the total number of trees after harvest.

At the time the permit was approved, the HCP-covered lands included a single northern spotted owl site with most of its habitat on adjacent Federal lands. The amount of habitat was low, due to natural eastside Cascades characteristics and recent fire. Approximately 55 percent of the mature trees in the 40-acre project area were allowed to be removed, which in the short term further reduced the availability of potential nesting, roosting, or foraging sites for northern spotted owls. However, the adverse effects on this northern spotted owl pair due to loss of habitat was likely low, because the habitat was marginal Type C (young forest marginal) at best, and surveys in the project area suggested low use by northern spotted owls. In addition, the no-harvest buffer along the highway ensured that is less than 40 ac (16 ha) was affected by the action, which is a small portion of the suitable habitat that is available for use by northern spotted owls within the median home range of that site as well as the eastern Cascades.

Under the HCP, about 55 percent of the mature trees and 28 percent of the total number of trees in the project area were allowed to be harvested. Selective harvest resulted in retention of different size and age classes of trees to contribute to stand structure and species diversity, important components to northern spotted owl habitat. Thinning the stand will allow younger age-class trees to grow, and continue to contribute to the multilayer structure of the stand. Since the project area is being allowed to grow and develop into perpetuity, suitable northern spotted owl habitat will be available in the future. This potential habitat will complement habitat that is likely to occur on adjacent national forest lands being managed as late-successional forest. In the long-term, the potential for the project area to become northern spotted owl habitat and remain in that condition is substantially greater than it would have been without the HCP. In addition, the Deed Restriction identified in the land contract provides for the permanent protection of this habitat.

Benefits of Inclusion—We find that there is minimal benefit from designating critical habitat for the northern spotted owl within the Scofield Deed Restriction because, as explained above, these lands are already managed for the conservation of the species under the deed restrictions. Section 7 is unlikely to provide additional regulatory protection, not only because Federal actions on this small 40-acre parcel are unlikely, but also because any such Federal action would have to be consistent with the Deed Restriction. Thus the existence of this Deed Restriction reduces any incremental benefits that may be provided by section 7. The Deed Restriction provides for the needs of the northern spotted owl by providing northern spotted owl dispersal habitat and improving conditions. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measureable protections. In addition, the conservation measures identified within the Deed Restriction seek to achieve conservation goals for northern spotted owls and their habitat, and thus can be of greater conservation benefit than the designation of critical habitat, which does not require specific management actions.

A potential benefit of including lands in a critical habitat designation is that the designation can serve to educate landowners and the public regarding the potential conservation value of an area, and may help focus conservation efforts on areas of high conservation value for certain species. However, the additional educational and informational benefits that might arise from critical habitat designation have been largely accomplished through the public review and comment of the HCP/Environmental Assessment, as well as the Implementation Agreement. In addition, through the Deed Restriction, the current landowner and any future owner are made fully aware of the needs of the northern spotted owl on this parcel.

Benefits of Exclusion—A benefit of excluding lands within HCPs from critical habitat designation is the unhindered, continued ability to seek new partnerships with future HCP participants including States, counties, local jurisdictions, conservation organizations, and private landowners, which together can implement conservation actions that we would be unable to accomplish otherwise. In particular, if lands within the Scofield Corporation Deed Restriction area are designated as critical habitat, it would likely have a negative effect on our ability to establish new partnerships to develop HCPs with smaller landowners who occupy key landscapes. It could be perceived as adding redundant Federal regulation on top of the HCP's requirement to protect the land in perpetuity. By excluding these lands, we may encourage additional conservation actions in the future.

Benefits of Exclusion Outweigh the Benefits of Inclusion—In summary, we determine that the benefits of excluding the Scofield Corporation lands subject to the Deed Restriction from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat. We find that including this area in the designation would result in minimal, if any, additional benefits to the northern spotted owl, as explained above. Excluding this parcel from critical habitat could result in real benefits by encouraging other small landowners to participate in northern spotted owl conservation efforts by demonstrating that we will not impose redundant regulatory burdens when they undertake meaningful conservation efforts. The management strategies of the Scofield Deed Restriction are designed to maintain and enhance habitat for the northern spotted owl. The Scofield Deed Restriction includes forest-management practices and habitat conservation objectives that benefit the northern spotted owl and its habitat, which exceeds any conservation value provided as a result of a critical habitat designation.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of approximately 40 ac (16 ha) of lands covered under the Scofield Deed Restriction will not result in extinction of the northern spotted owl because it provides northern spotted owl dispersal habitat and improves habitat conditions, and it the possibility for the project area to become northern spotted owl habitat and remain in that condition is substantially greater than without the HCP. Further, the protection provided by the Scofield Deed Restriction would provide a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. We find that exclusion of these lands within the Scofield Deed Restriction will not result in extinction of the northern spotted owl. Based on the above discussion, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude from this final critical habitat designation portions of the proposed critical habitat units or subunits that are covered by the Scofield Corporation Deed Restriction totaling about 40 ac (16 ha).

Exclusion of Private Lands

State of California

Our proposed designation included 123,348 ac (49,917 ha) of privately-owned lands without existing Federal conservation agreements in the State of California that we identified as critical habitat for the northern spotted owl.

Forest management and forest practices on private lands in California, including harvesting for forest products or converting land to another use are regulated by the State under Division 4 of the Public Resources Code, and in accordance with the California Forest Practice Rules (California Code of Regulations, (CCR) Title 14, Sections 895–1115). Under this framework, the California Department of Forestry and Fire Protection (CALFIRE) is the designated authority on forest management and forest practices on private lands in California.

All private land timber harvesting in California must be conducted in accordance with a site-specific timber harvest plan (THP) that is submitted by the owner and is subject to administrative approval by CALFIRE. The THP must be prepared by a State-registered professional forester, and must contain site-specific details on the quantity of timber involved, where and how it will be harvested, and the steps that will be taken to mitigate potential environmental damage. The THP and CALFIRE's review process are recognized as the functional equivalent to the environmental review processes required under the California Environmental Quality Act of 1970 (CEQA). The policy of the State with regard to the northern spotted owl can be characterized as one of take-avoidance. The Director of CALFIRE is not authorized to approve any proposed THP that would result in take of a federally-listed species, including the northern spotted owl unless that taking is authorized under a Federal Incidental Take Permit (review process is outlined in 14 CCR 919.9 and 919.10). This latter point creates an incentive for private landowners to enter into Federal safe harbor agreements or habitat conservation plans. CALFIRE also regulates the conversion permitting process in which private forest and woodland can be converted to agricultural uses (in contrast, conversions of forest and woodlands to residential, commercial, and industrial uses are evaluated and permitted under local land use planning authorities).

Benefits of Inclusion—We find there are minimal benefits to including these lands in critical habitat. As discussed above, the principal benefit of including an area in critical habitat is the requirement that Federal agencies consult with the Service under section 7(a)(2) of the Act to ensure actions they fund, authorize, or carry out are not likely to result in the destruction or adverse modification of any designated critical habitat. Section 7(a)(2) also requires that Federal agencies must consult with us on actions that may affect a listed species and refrain from undertaking actions likely to jeopardize the continued existence of such species.

Our Final Economic Analysis (IEC 2012b) concludes that critical habitat designation for the northern spotted owl is unlikely to directly affect timber harvests on private lands in California because of the low likelihood that such harvests would be simultaneously connected to a Federal permitting or funding action. Without a pending Federal action, there is no basis for initiating a consultation process under section 7 of the Act. In northern California, the Service has seen very few section 7 actions resulting from Federal permitting or funding activity on private lands. The U.S. Army Corps of Engineers (Corps) through the U.S. Environmental Protection Agency (EPA) are the Federal agencies responsible for regulating section 404 of the Clean Water Act, which deals with discharge of dredged or fill material into waters of the United States. In the areas identified as critical habitat for the northern spotted owl the Corps has not taken jurisdiction over activities associated with stream alteration or fill and has deferred to the State of California for regulating these activities. As a result many proposed actions involving water quality issues and stream disturbance are not referred to the Service for section 7 consultation. The majority of the water quality permitting actions in California are now administered by the California Department of Fish and Game (CDFG) and by Regional Water Quality Control Boards. Water quality permit reviews by the Corps are very uncommon. When Federal consultation does occur, the affected areas are typically limited to streams or roadways adjacent to streams and thus in areas not considered habitat for the northern spotted owl. CALFIRE has indicated (in its correspondence of July 6, 2012) that it has no plans to enact additional requirements for protection of the northern spotted owl in response to a possible critical habitat designation of private lands in the State.

We, therefore, conclude that the requirement that permitting and funding agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species because the possibility of a Federal nexus for a project on these lands that might trigger such consultation is limited (there is little likelihood of an action that will involve Federal funding, authorization, or implementation). In addition, since the lands in question are occupied by the northern spotted owl, if a Federal nexus were to occur, section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species through a jeopardy analysis. Because the possibility of a Federal nexus on these private lands is limited, the additional regulatory benefits to the species and its habitat through inclusion in critical habitat, if any, are anticipated to be minimal. In addition, existing State regulations provide protections for the northern spotted owl and its habitat, and these protections are in continuous effect. The protections to the critical habitat of the northern spotted owl, by contrast, come into effect only in the event of a Federal action.

Another benefit of including lands in a critical habitat designation is that it serves to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. In the case of the northern spotted owl, any potential educational benefits that might be attributable to critical habitat designation are minimized by the existing State regulatory framework for the northern spotted owl in timber harvest planning. Private landowners who harvest timber in proximity to northern spotted owl activity sites are required to conduct surveys of owl activity and report those results in their proposed timber harvest plans that are submitted to CALFIRE for approval, so critical habitat designation will not result in any additional data collection. While the State's existing take-avoidance strategy for the northern spotted owl does not necessarily provide for long term conservation of suitable habitat, it does serve an important informational service with private landowners through the timber harvest planning process. Thus, CALFIRE's existing regulatory framework provides adequate and consistent education to the affected community regarding the northern spotted owl and its conservation needs.

Similarly, the great majority of industrial and non-industrial forest landowners, along with the in-house and consulting biologists who conduct the owl survey work, already voluntarily submit their survey results to the CDFG for entry into the California Natural Diversity Database (CNDDB), which is the State's clearinghouse for occupancy, activity, and spatial data on special status species. It is highly unlikely that inclusion in the final critical habitat designation could cause any increases in landowner and biologist participation in the CNDDB reporting. Voluntary participation rates are currently very high, and we have no evidence to suggest that inclusion in critical habitat would increase those rates any further.

In this case the educational value of critical habitat is further limited by the fact that the northern spotted owl is a high-profile species, and most forestland owners in the range of the northern spotted owl are knowledgeable about the species. The release of the Revised Recovery Plan for the Northern Spotted Owl in 2011 was preceded by outreach efforts and public comment opportunities, and provided information about the northern spotted owl and its conservation needs to a wide constituency. Furthermore, we conducted extensive outreach efforts on the proposed revision of critical habitat, including multiple public information meetings and opportunities for public comment. Through these outreach opportunities, land owners, State agencies, and local governments have become aware of the status of and threats to the northern spotted owl, and the conservation actions needed for recovery.

Another potential benefit of the designation of critical habitat is that it may indirectly cause State or county jurisdictions to initiate their own additional protective requirements in areas identified as critical habitat. These measures may include additional permitting requirements or a higher level of local review on proposed projects. However, CALFIRE has indicated to use that it is unlikely to impose any new requirements on project proponents if critical habitat is designated in areas already subject to California Forest Practice Rules. Therefore, we believe this potential benefit of critical will be limited.

Finally, there may be some ancillary benefits if the designation resulted in changed timber management practices on these private lands. These benefits could include but are not limited to: public safety benefits by increasing resiliency of timber stands, improved water quality, aesthetic benefits, and carbon storage. However, as discussed above, the possibility of a Federal nexus on these private lands is limited, so changes in timber management as a result of critical habitat, and any attendant ancillary benefits, are anticipated to be minimal.

Benefits of Exclusion—The benefits of excluding from designated critical habitat the approximately 123,348 ac (49,917 ha) of private lands in California are relatively greater.

Excluding the approximately 123,348 ac (49,917 ha) of private lands from critical habitat designation will sustain and enhance the conservation partnership between the Service and CALFIRE. The Service is currently working with CALFIRE to explore avenues for more comprehensive conservation planning for the northern spotted owl in northern California that goes beyond the existing take-avoidance strategy. Development of a landscape scale analysis and plan (e.g., general conservation plan) would provide for greater protections to the northern spotted owl and could incorporate critical habitat conservation elements within that planning process. Current revisions and improvements to the CNDDB database would aid in the development of this plan, with the ability to evaluate status and trends across the region versus on a singular THP or Non-industrial Timber Management Plan (NTMP) level. Critical habitat designation would be viewed as another layer of regulatory process to that already overseen by CALFIRE and could impede landowner support for the development of this larger programmatic conservation plan and undercut the efforts of CALFIRE to contribute to such a discussion. We received several public comments objecting to this perceived redundancy in regulation. Excluding those private lands from the designation would avoid a chilling effect on the partnership between the Service and the affected State regulatory agencies in California regarding administration of their existing conservation programs to protect and conserve northern spotted owls on private lands. We consider the maintenance of our partnership between the Service and the affected State regulatory agencies in California to be a significant benefit of exclusion.

In addition, there are many other opportunities for private landowners to enter into conservation agreements without Federal involvement that will benefit northern spotted owls. Landowners can obtain ''green'' forest certification through the Forest Stewardship Council (FSC) or the Sustainable Forestry Initiative (SFI) that enables access to certain wholesale lumber markets. They can register their property with the California Climate Action Registry to gain access to the emerging carbon credit market in California, or they can sell conservation easement rights on their properties to a land trust. In all cases, the landowner gains immediate economic benefits in exchange for agreeing to a management program on their lands that meets the objectives of the certification or registration entity, or the land trust. All of these instruments, by design, involve the conservation and expansion of standing forest inventory and forest cover on the participating ownerships. Whether by design or not, that will lead to the long-term improvement of existing northern spotted owl habitat suitability and to the emergence of suitable habitat in areas where it is currently unsuitable. These market-based agreements have the long term potential for significantly more on-the-ground benefits for the northern spotted owl on private lands than would the limited regulatory and educational benefits that would result from critical habitat designation.

The economic incentives for landowners to enter into these agreements are independent of a critical habitat designation. We are not certain how designation might affect perceptions and priorities among the grantors in agreements (i.e., the certification and registration entities and the land trusts). For example, land trusts operate on limited funds and we do not know how critical habitat designation might influence them in prioritizing properties for easement acquisition; that is, whether it might lead them to look more or less favorably on designated lands, or treat some geographic areas preferentially over others. Thus, exclusion from designation could avoid any uncertain, and possibly detrimental, effects on both buyers (land trusts, certification entities) and sellers (landowners) in market-based conservation programs (IEC 2012b, p. 5–21).

Excluding these lands may reduce the perception that some private landowners have that they are being subjected to redundant and unnecessary regulation. As noted above, all private land timber harvesting in California must be conducted in accordance with a site-specific THP that is submitted by the owner and is subject to administrative approval by CALFIRE. The Director of CALFIRE is not authorized to approve any proposed THP that would result in take of a federally-listed species, including the northern spotted owl, unless that taking is authorized under a Federal Incidental Take Permit. The additional overlay of Federal critical habitat on these private lands may result in lack of support for the development of a programmatic conservation agreement with CALFIRE and their valuable contribution of information to the CNDDB due to their perception of duplicative and burdensome regulation specific to the northern spotted owl.

Benefits of Exclusion Outweigh the Benefits of Inclusion—We have reviewed and evaluated the exclusion of approximately 123,348 ac (49,917 ha) of privately-owned lands in the State of California from the critical habitat designation. The benefits of including these lands in the designation are comparatively small. We find there is little likelihood of a Federal nexus on these private lands that would trigger the regulatory protections of critical habitat under section 7 of the Act. We therefore anticipate little, if any, additional protections through a supplemental analysis of potential adverse modification due to the designation of critical habitat on these lands.

The potential educational benefits of inclusion are also limited. Under existing State regulations, private landowners who harvest timber in proximity to northern spotted owl activity sites are required to conduct surveys of owl activity consistent with the Service-recommended protocol and report those results in their proposed timber harvest plans that are submitted to CALFIRE for approval, so landowners are already aware of the presence of the northern spotted owl and its habitat needs, and critical habitat designation will not result in any additional data collection. The State of California's existing take-avoidance strategy for the northern spotted owl provides an important informational service with private landowners through the timber harvest planning process. Therefore, in this instance, any potential educational benefits of inclusion are minimal.

In contrast, the benefits derived from excluding private lands and enhancing our partnership with California State regulatory agencies are relatively greater. The minimal benefits of inclusion are outweighed by the benefits of fostering conservation partnerships with CALFIRE that would relieve private landowners of what they might perceive as duplicative regulations. Exclusion could also encourage the partnership and collaboration in development of the landscape conservation planning between the Service and CALFIRE by focusing efforts towards that planning effort versus applying a regulatory process that would have limited private land involvement.

We also considered the avoidance of potential issues associated with regulatory uncertainty due to critical habitat designation to be a significant benefit of exclusion. For example, there may be a significant benefit of exclusion from designation that would accrue due to the avoidance of any uncertain, and possibly detrimental, effects on both buyers (land trusts, certification entities) and sellers (landowners) in market-based conservation programs that stand to provide significant conservation benefits to the northern spotted owl.

We have determined that maintaining our partnership with California State regulatory agencies provides a greater benefit than would the regulatory and educational benefits of critical habitat designation. Therefore, in consideration of the factors discussed above, we have determined that the benefits of exclusion of private lands in California outweigh the benefits of designating these areas as critical habitat.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of 123,348 ac (49,917 ha) of private lands in northern California that are not currently under a Federal agreement from critical habitat for the northern spotted owl will not result in the extinction of the species. Habitat protection provisions in the current California forest practice regulation on private forestlands provide some level of protection for the species and its habitats. We reiterate here that under the California State Code (14 CCR 919.9 and 919.10), the Director of CALFIRE is not authorized to approve any proposed THP that would result in take of a federally-listed species unless that taking is authorized under a Federal Incidental Take Permit. For projects having a Federal nexus and affecting northern spotted owls in occupied areas, as is the case here, the jeopardy standard of section 7 of the Act, coupled with current land management measures that are not under Federal purview, would provide assurances that this species will not go extinct as a result of excluding these lands from the critical habitat designation. Further, the exclusion of these lands from the final critical habitat designation does not preclude advances in our scientific knowledge of the species and using that knowledge to effectively advocate future improvements in State forest practice policies and procedures. Based on the preceding analysis, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude private lands totaling 123,348 ac (49,917 ha) from the final critical habitat designation.

State of Washington

In Washington we proposed 133,895 ac (54,186 ha) of private lands within Spotted Owl Special Emphasis Areas (SOSEAs) as critical habitat; all of these lands were identified as under consideration for exclusion. However, as described in Changes from the Proposed Rule, many of the small, private parcels were removed from the final designation upon a determination that they did not meet the definition of critical habitat, leaving. The remaining areas of private lands in Washington contained in this designation covered by HCPs or SHAs and are private industrial forest lands; these private lands are not currently covered by HCPs or SHAs but are covered under the WDNR Forest Practices Rules (FPR) and largely located in SOSEAs. We have excluded areas covered by HCPs and SHAs because, for the reasons discussed above, the benefits of excluding them outweigh the benefits of including them in critical habitat. We sought to make our designation of private lands in Washington as consistent as possible with Washington State regulations governing forest practices on private lands. Most of the remaining private lands are located only within SOSEAs, areas designated by the State to provide for demographic and/or dispersal support as necessary to complement the northern spotted owl protection strategies on Federal land within or adjacent to the SOSEAs. We find that for these lands, too, the benefits of excluding them in critical habitat outweigh the benefits of including them.

In Washington, any private timber harvest must obtain a permit from, and comply with, the Washington Forest Practices Act (RCW 76.09) as well as the Washington Forest Practices Rules (WAC 222). In the absence of a federally-approved HCP covering northern spotted owls or a State-approved special wildlife management plan, suitable northern spotted owl habitat in State-designated SOSEAs on non-federal lands is protected by the special Washington Forest Practices Rules in State-designated SOSEAs. Within SOSEAs, the Forest Practices rules provide protection for suitable northern spotted owl habitat. The Washington Forest Practices Rules maintain the viability of each northern spotted owl site center by protecting: (a) All suitable spotted owl habitat within 0.7 mile of each spotted owl site center; and (b) a total of 2,605 acres of suitable spotted owl habitat within the median home range circle with a radius of 1.8 miles. Under the rules, proposed forest practices likely to adversely affect spotted owl habitat in either category (a) or (b) above are likely to have significant adverse impacts to the northern spotted owl, and such activities would require a Class IV special forest practices permit and an environmental impact statement per the State Environmental Policy Act. The overarching policy goal of the Washington Forest Practices Rules is to complement the conservation strategy on Federal lands, and as such the SOSEAs are adjacent to Federal lands. SOSEAs are designed to provide a larger landscape for demographic and dispersal support for northern spotted owls. The long-term goal is to support a viable population of northern spotted owls in Washington.

In Washington, the Forest Practices Board (the State regulatory rule-making body) has a long-standing relationship with the Service and collaborates extensively on northern spotted owl conservation. The Service provided extensive technical assistance in the development of the Board's existing northern spotted owl rules. The Board was recognized in Recovery Action 18 in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, p. III–57) for its ongoing owl conservation efforts and encouraged to continue to use its existing processes ''to identify areas on non-federal lands in Washington that can make strategic contributions to spotted owl conservation over time. The Service encourages timely completion of the Board's efforts and will be available to assist as necessary.'' The Board convened the Northern Spotted Owl Implementation Team (NSOIT). The NSOIT has been tasked to develop incentives for landowners to conserve northern spotted owl habitat, identify the temporal and spatial allocation of conservation efforts on non-federal lands, and make recommendations to the Board, should any rules need to be updated. The NSOIT is also conducting a pilot project testing different thinning prescriptions in northern spotted owl habitat. These efforts have evolved over years of collaboration and are designed to change the dynamic away from fear and resistance to partnership and participation. On November 13, 2012, the Board took another step for northern spotted owl conservation and expanded the scope of the NSOIT to investigate and recommend, in coordination with the Service, voluntary programmatic tools for private landowners to support northern spotted owl conservation and provide regulatory certainty for landowners (WDNR *in litt.*). This step further demonstrates Washington's willingness to use its authority and processes to support northern spotted owl conservation. The Service has and continues to provide funding to support the work of the NSOIT.

Benefits of Inclusion—The areas of private land retained in our final designation at issue here support both essential demographic and dispersal needs of spotted owls, and highlight the important conservation roles of private lands in Washington. Designation of these private lands may raise public awareness of conservation actions needed for spotted owl recovery, although the educational benefit of the designation is somewhat limited currently since these areas have already been identified as SOSEAs, since 1997.

We find there are minimal benefits to including these lands in critical habitat. The designation of critical habitat invokes the provisions of section 7. Our Final Economic Analysis (IEC 2012b, p. ES–17) concludes that critical habitat designation for the northern spotted owl is unlikely to directly affect timber harvests on private lands in Washington because of the low likelihood that such harvests would be simultaneously connected to a Federal permitting or funding action. Without a pending Federal action, there is no basis for initiating a consultation process under section 7 of the Act. As discussed previously, the designation of critical habitat invokes the provisions of section 7. However, in this case, we find the requirement that Federal agencies consult with us and ensure that their actions are not likely to destroy or adversely modify critical habitat will not result in significant benefits to the species. The possibility of a Federal nexus for a project on these lands is small unless it was a larger project covering adjacent Federal lands as well, in which case section 7 consultation would already be triggered and the Federal agency would consider the effects of its actions on the species. In addition, most of the habitat on these private lands would be assumed to be occupied, further minimizing to some extent the margin of conservation that could be attained through section 7. Any incremental benefits would be further minimized because of the protections already in place In addition, it would be small in comparison to the benefits already derived under the WDNR FPR.

There is minimal incremental benefit from designating critical habitat for the northern spotted owl within private lands covered by the WDNR Forest Practices Rules (FPR) because these lands are already managed for the conservation of the species through the WDNR FPR. The conservation measures provided by that process will provide greater protection to northern spotted owl habitat than the designation of critical habitat, which provides regulatory protections only in the event of a Federal action. In addition, the final rule designation would provide for protection of fewer acres than the existing FPR. The WDNR FPR provides for the needs of the northern spotted owl by protecting and preserving landscape levels of suitable northern spotted owl nesting, roosting, and foraging habitat as well as foraging and dispersal habitat in strategic landscapes, and implementing species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. The WDNR FPR also contains provisions that address ownership changes and provides for the ability to make ongoing adjustments in a number of forms, including active adaptive forest management. The ability to change is crucial to meet new recovery challenges. The Service continues to be work with WDNR to provide technical assistance in the implementation of these rules. The WDNR FPR contains provisions that address ownership changes and the outcomes expected by the Service. Therefore, designation of critical habitat would be redundant on these lands, and would not provide additional measureable protections.

Including lands in a critical habitat designation does serve to educate landowners, State and local governments, and the public regarding the potential conservation value of an area. This helps focus and promote conservation efforts by other parties by identifying areas of high conservation value for northern spotted owls. Designation of critical habitat would inform State agencies and local governments about areas that could be conserved under State laws or local ordinances, such as the Washington State Growth Management Act, which encourage the protection of ''critical areas'' including fish and wildlife habitat conservation areas. Any information about the northern spotted owl and its habitat that reaches a wider audience, including parties engaged in conservation activities, is valuable. However, WDNR, as the State's natural resource agency, is knowledgeable about the species and has made substantial contributions to our knowledge of the species. The additional educational and informational benefits that might arise from critical habitat designation here have been largely accomplished through the public review and comment during reviews of the FPR and associated with the modification of the FPR, and through implementation of the FPR by landowners. The existing public process for FPR development provides for extensive opportunities for engagement in the development and refinement of the rules. The FPR includes intensive public involvement and is frequently a topic of open and public discussion during meetings of the Washington State Forest Practices Board, whose meetings are open to the public and frequently televised. This level of exposure in local newspapers and television stations exceeds the level of education that would come from a designation that would be read by few people in the public. Moreover, the rulemaking process associated with critical habitat designation includes several opportunities for public comment, and thus also provides for public education.

Finally, there may be some ancillary benefits if the designation resulted in changed timber management practices on these private lands. These benefits could include but are not limited to: public safety benefits by increasing resiliency of timber stands, improved water quality, aesthetic benefits, and carbon storage. However, as discussed above, the possibility of a Federal nexus on these private lands is limited, so changes in timber management as a result of critical habitat, and any attendant ancillary benefits, are anticipated to be minimal.

Benefits of Exclusion—With regard to the benefits of exclusion from designation, although the final economic analysis (FEA) noted that one possible outcome of the critical habitat designation would be that the State could revise its regulations, and in a worst case scenario such revision could result in some private acres no longer being harvestable, we note that the likelihood of such revision actually occurring is characterized as speculative (IEC 2012b, p. 5–20). The FEA notes two possible outcomes of critical habitat designation, one being no change in Forest Practices Rules, the other is that State would revise their regulations and designate all suitable habitat overlapping with Federal critical habitat as ''critical habitat state.'' However, Washington DNR representatives only offered examples of potential responses to Federal designation of critical habitat in Washington, and did not comment upon the likelihood that any of these scenarios would occur (IEC 2012b, p. 5–11). The FEA also makes note of the potential indirect effects of critical habitat on private lands, in terms of private landowners possibly reacting by changing their timber harvest practices in response to perceived regulatory uncertainty as a result of critical habitat (IEC 2012b, p. 5–19).

In particular, a benefit of excluding lands covered under the WDNR FPR from critical habitat designation is that it would encourage the State and other parties to continue to work for owl conservation. If lands within the WDNR FPR area are designated as critical habitat, it would also likely have a negative effect on our ability to continue to partner with the WDNR on this conservation. In particular, the WDNR comment letter (WDNR 2012) states that if inclusion of private land is warranted, then WDNR requests that the Service ''create and bolster incentive based conservation opportunities for private landowners''. This recognizes the potential negative effects to their existing collaborative approach. By excluding these lands, we preserve our current private and local conservation partnerships and encourage additional conservation actions in the future because other parties see our exclusion as a sign that the Service will not impose duplicative regulatory burdens on landowners who are already have a regulatory responsibility under the WDNR FPR. As described in Changes from the Proposed Rule, many of the small, private parcels were removed from the final designation upon a determination that they did not meet the definition of critical habitat. The remaining areas of private lands (40,732 ac; 16,483 ha) in Washington contained in this designation are private industrial forest lands; these private lands are not currently covered by HCPs or SHAs but are covered under the WDNR Forest Practices Rules (FPR). Of these, 37,000 ac (14,974 ha) occur within the spotted owl circles currently regulated by the existing FPR. It is unlikely that the benefit of overlaying an additional regulatory burden within the SOSEAs to protect an additional 4,000 ac (1,619 ha) would be a significant benefit within the range of the owl. Excluding these private lands from the designation would avoid a chilling effect on the partnership between the Service and the affected State regulatory agencies regarding administration of their existing conservation programs to protect and conserve northern spotted owls on private lands. We consider the maintenance of our partnership between the Service and the affected State regulatory agencies to be a significant benefit of exclusion.

Benefits of Exclusion Outweigh the Benefits of Inclusion—The benefits of including these lands in the designation are small. The WDNR FPR contains provisions for protecting and maintaining northern spotted owl habitat that provides for comprehensive measures applied across a large landscape that will benefit spotted owls. WDNR personnel are extremely knowledgeable regarding the ecology of the northern spotted owl and have contributed to the body of scientific information about the northern spotted owl. The landowners subject to these State regulations are also informed by them. In this instance, the regulatory and educational benefits of inclusion have much less benefit than the continued benefit of the WDNR FPR including the educational benefits derived from the FPR.

The WDNR FPR provides for significant conservation and management within geographical areas that contain the physical or biological features essential to the conservation of the northern spotted owl and help achieve recovery of this species. Exclusion of private lands already covered under the WDNR FPR will help foster the partnership we have developed with WDNR. Furthermore, this partnership may aid in fostering future cooperative relationships with other parties in other locations for the benefit of listed species.

In summary, we determine that the benefits of excluding private lands already covered under the WDNR FPR from the designation of critical habitat for the northern spotted owl outweigh the benefits of including this area in critical habitat. We find that including these lands would result in minimal, if any, additional benefits to the northern spotted owl, as explained above. The WDNR FPR includes species-specific avoidance and minimization measures, rule enforcement procedures, and forest-management practices and habitat conservation objectives that benefit the northern spotted owl and its habitat, which exceeds substantially minimizes the incremental any conservation value provided as a result of a critical habitat designation. Given the active and ongoing efforts of the State of Washington to address northern spotted owl conservation, we have determined that maintaining our partnership with WDNR, in conjunction with the conservation measures under the WDNR FPR, provides a greater benefit to the northern spotted owl than would the regulatory and educational benefits of critical habitat designation. We also have determined that the potential incremental educational and ancillary benefits of critical habitat designation on lands containing the physical or biological features essential to the conservation of the northern spotted owl would be minimal, because WDNR has already made significant contributions to our understanding of the ecology of the northern spotted owl, and continues to do so through implementation of Recovery Action 18 and through participation in range wide demographic studies.

Exclusion Will Not Result in Extinction of the Species—We have determined that exclusion of approximately 40,732 ac (16,483 ha) of private lands covered under the WDNR FPR will not result in extinction of the northern spotted owl. The WDNR FPR protects and preserves landscape levels of suitable northern spotted owl nesting, roosting, and foraging habitat as well as foraging and dispersal habitat in strategic landscapes, and implements species-specific conservation measures designed to avoid and minimize effects to northern spotted owls. The Board has adopted a Wildlife Work Plan that requires rule review and revision should new information warrant that. We find that exclusion of private lands currently covered under the WDNR FPR will not result in extinction of the northern spotted owl. Therefore, the Secretary is exercising his discretion under section 4(b)(2) of the Act to exclude these private lands from this final critical habitat designation that are currently covered under the WDNR FPR totaling about 40,732 ac (16,483 ha).

Congressionally Reserved Natural Areas and State Park Lands

Our decision to exclude congressionally reserved natural areas and State park lands from this rule is based on the unique circumstances associated with this critical habitat designation. Before making a final decision of whether to exclude congressionally and State reserved natural areas, we weighed the relative benefits and costs a designation of these lands would confer and compared them to the costs and benefits of no designation. Our final decision is that these areas are essential to the conservation of the northern spotted owl, but a designation of these areas in this particular case would confer no current or potential regulatory benefit and a very minor education benefit. The primary habitat threat to the northern spotted owl is from commercial timber harvest. Since commercial timber harvest is not allowed on these lands, there would be little benefit to additional section 7 consultation on effects to critical habitat. We also agree with the National Park Service that a designation would impose some, albeit relatively small, additional administrative costs to land managers who would need to consult with the Service if their actions or programs might affect northern spotted owl critical habitat. Likewise, we find that State Park lands could experience some additional minor administrative costs as a consequence of this designation, especially those State Parks jointly managed with Redwood National Park and those that may use Federal funding for research and monitoring or program and capital improvements. However, we find that even these minimal costs would outweigh the minor informational benefits of including these areas in the critical habitat designation.

Benefits of Inclusion—The proposed critical habitat rule published on March 8, 2012 (77 FR 14062), as part of ''Possible Outcome 3'' in Table 1 (p. 14068), proposed to exclude 2,631,736 ac (1,065,026 has) of congressionally reserved lands and 164,776 ac (66,682 ha) of State Park lands from final critical habitat. These Federal reserved lands include all National Parks and Monuments, Wilderness Areas, Wild and Scenic Rivers, National Scenic Areas, and other congressionally designated areas identified in the proposed rule. State Parks lands included Iron Horse State Park in Washington, and all or portions of 30 State Parks in California, including Jedediah Smith, Del Norte Coast, Prairie Creek, Grizzly Creek, Humboldt Redwoods, DeWitt Redwoods, Richardson Grove, Reynolds Wayside, Smithe Redwoods, Standish-Hickey, Wm. Standley, Russian Gulch, Mendocino Headlands, Mendocino Woodlands, Van Damme, Montgomery Woods, Navarro Redwoods, Hendy Woods, Mailliard, Salt Point, Austin Creek, Armstrong State Reserve, Tomales Bay, Samuel P. Taylor, Mount Tamalpais, Robert Louis Stevenson, Bothe—Napa Valley, Sugarloaf Ridge, Jack London, and Annadel State Park.

A primary purpose of these congressional and State reserved natural areas is to conserve natural ecosystems, including those of the northern spotted owl and its habitat, and educate the public regarding the conservation of these areas. Unlike other Federal and State lands that have multiple use mandates that include commercial harvest of timber in the range of the spotted owl, such as National Forests, State Forests, and forests managed by the BLM, these reserved natural areas are unlikely to have uses that are incompatible with the purposes of critical habitat because the primary threat to spotted owl critical habitat—commercial timber harvest—is prohibited on these lands. These natural areas are managed under explicit Federal and State laws and policies consistent with the conservation of the northern spotted owl, and there is generally little or no timber management beyond the removal of hazard trees or fuels management to protect structures, roads, human safety, and important natural attributes. For example, the Wilderness Act provides conservation for the northern spotted owl because it prohibits commercial activities unrelated to wilderness recreation. Thus, not only is commercial timber harvest directly barred on these Federal lands, but the Wilderness Act also precludes the construction of roads and most uses of mechanical equipment. 16 U.S.C. 1133. The fundamental purpose of the National Park System, established by the Organic Act and reaffirmed by the General Authorities Act, as amended, begins with a mandate to conserve park resources and values. This mandate is independent of the separate prohibition on impairment and applies with respect to all park resources and values, even when there is no risk that any park resources or values may be impaired. *See* 16 U.S.C. sections 1–4.

Similarly, all of the State Parks lands proposed for exclusion occur in California except for 104 ac (42 ha) in Washington. California State Parks are managed by the California Department of Parks and Recreation. This Agency's mission is to ''administer, protect, provide for recreational opportunity, and develop the State Park System * * *'' We are unaware of any commercial timber harvests in California or Washington State Parks.

Therefore, any habitat-disturbing activities that might occur as the land managers carry out their conservation programs (e.g., trail maintenance, education and outreach, operations and maintenance, etc.) are likely to be relatively minor and are unlikely to be regulated by a critical habitat designation. On the Federal reserved lands, the section 7 prohibition on the destruction or adverse modification of critical habitat would be redundant and unlikely to add any protection to these important habitat areas. Likewise, many of these State Parks have close working relationships with Federal agencies and may experience, through those Federal partners, a section 7 nexus or other administrative costs if the States utilize Federal funds or require a Federal permit for their activities. For example, several State Parks in California (i.e., Del Norte Redwoods, Prairie Creek Redwoods, and Jedediah Smith Redwoods) are jointly managed with Redwood National Park through an agreement signed in 1994. In the San Francisco Bay Area, the National Park Service manages an inventory and monitoring program that includes actions by State Parks and other Federal partners such as the U.S. Geological Survey. Further, land managers monitor spotted owl territories within these reserved areas as part of long term population monitoring efforts, and barred owl populations are also monitored as part of spotted owl recovery efforts. For example, spotted owl territories in Crater Lake National Park have been monitored since 1992, and there are multiple spotted owl monitoring and conservation efforts occurring in many these parks throughout the species' range. A critical habitat designation on these State Parks may introduce some additional administrative costs but confer no increase in regulatory protection. Therefore, we believe there would be no regulatory benefits to inclusion of these lands in critical habitat.

We also believe that a critical habitat designation for these specific natural areas would confer minimal additional educational benefit toward spotted owl conservation. These areas are generally well known for their value to the conservation of listed species due to the education and communication programs of the natural area management agencies during the time since the listing of the spotted owl. Educational materials are distributed and other communication programs occur regarding the conservation of late successional forests and the species that inhabit them such as the spotted owl (see, e.g., Olympic National Park Web site featuring spotted owl information at *http://www.nps.gov/olym/naturescience/animals.htm,* or *http://www.nps.gov/muwo/naturescience/life-of-spotted-owls.htm* for NPS lands in central California). We also note that the management agencies overseeing these congressionally and State reserved natural areas have a positive history of over 20 years of conserving northern spotted owls and supporting research and conservation of the owl on their protected lands. While in other cases we have found benefits where critical habitat would highlight the importance of the habitat to owl conservation for future planning and management purposes, in the case of these lands, management is already consistent with habitat protection. Therefore, it is unlikely that designation of critical habitat of these areas would provide any significant informational benefits to the land managers or the public.

Benefits of Exclusion—We attempted to quantify the potential increase in administrative costs for the Service associated with a proposed designation of critical habitat in congressionally reserved land allocations. There is generally little or no timber management beyond removal of hazard trees or fuels reduction to protect structures and road maintenance, in addition to fire-management activities. Management guidelines for congressionally reserved lands are generally protective, so we do not anticipate requesting any changes of proposed management as a result of a critical habitat designation, and we would not anticipate reaching an adverse modification determination. In reserve areas where we do consult, the designation of critical habitat would likely add an adverse-modification analysis to an existing consultation.

Total incremental effects would likely be about 4–6 hours of staff time per action for both the action agency and the Service, although this estimate could vary widely depending on the size and scope of the action.

The final economic analysis (FEA) (IEC 2012b) quantified this potential for an increase in administrative costs, and they described the potential indirect impacts due to time delays for project processing and regulatory uncertainty. The analysis states, ''While critical habitat is not expected to generate changes to forest management practices or to testing or training missions on NPS or DOD lands, these areas may be subject to new or increasingly complex section 7 consultations as a result of critical habitat designation. Activities that may involve section 7 consultations include the construction or maintenance of visitor facilities on NPS lands and access roads to projects or military training including the use of vehicles, explosives, and soldiers. DOD and NPS will likely experience an additional administrative burden to provide biological assessments for projects in consultations with the Service as a result of critical habitat designation'' (IEC 2012b, p. 4–4). The FEA forecast an additional 16 informal consultations with NPS on planned or ongoing recreation and habitat management projects (IEC 2012b, p. 4–27). (Although the text refers to the NPS lands, the same rationale generally applies to other federally reserved lands in the proposed exclusion.) The FEA did not quantify the potential for direct incremental economic impacts on State Park lands, but it does identify the potential for indirect impacts due to time delays and regulatory uncertainty. Again, it is expected that these impacts would be relatively minor, but they nevertheless are not offset by a proportional increase in conservation benefits that would accrue as a consequence of this critical habitat designation on these lands.

Benefits of Exclusion Outweigh the Benefits of Inclusion—In sum, we find there are no regulatory benefits and such minimal educational benefits to including these lands in the designation that they are outweighed by the minor increase in administrative costs. We reach this conclusion for several reasons: (1) A critical habitat designation of these reserved areas in the range of the spotted owl would provide no additional regulatory benefits beyond what is already on these lands due to their permanent status as fully protected lands and, importantly, the fact that commercial timber harvest is not permitted on these lands under Federal and State law and policy; (2) the designation of these reserve areas would confer little additional educational benefits associated with the conservation of the spotted owl, as these educational messages are already being communicated in many of these areas under existing programs; and (3) as identified by the economic analysis and the NPS, there is the potential for a small but measureable increase in administrative costs, time delays, and regulatory uncertainty for the Service and Federal and State land managers if these lands were designated, without any offsetting positive conservation benefits to justify the increased administrative costs.

After weighing these relative costs and benefits, the Secretary has chosen to exercise his discretion under Section 4(b)(2) of the Act to exclude these lands from final critical habitat. As part of this review we have determined the Federal agencies are managing these reserved natural areas under statutes that already impose a clear conservation mandate consistent with the specific needs of the northern spotted owl, and a critical habitat designation would confer no additional conservation benefits to the spotted owl that offset the potential increase in administrative costs. In making this decision, we also note the historic role of congressionally and State reserved natural areas as part of northern spotted owl critical habitat. In 1992, the Service concluded that certain congressionally reserved parks and wilderness areas were essential to spotted owl conservation, but we declined to include these lands in the final designation of critical habitat because their current classification and management was deemed adequate to meet spotted owl conservation goals (January 15, 1992; 57 FR 1796, p. 1806). Likewise, in 2008, the Service revised northern spotted owl critical habitat and again concluded that congressionally reserved natural areas would not be included in final critical habitat for the same reasons as those identified in the 1992 decision (August 13, 2008; 73 FR 47325, p. 47334). Although not a factor in this section 4(b)(2) weighing, this determination will maintain the consistent management approach for spotted owls that has occurred on these lands over the last 20 years and should minimize the potential for confusion among land managers and the public.

This analysis is based in large part on the particular conservation requirements of the northern spotted owl and is specific to this designation. Thus, our determination that the benefits of exclusion outweigh the benefits of inclusion in this case does not necessarily have a bearing on future critical habitat designations.

Exclusion Will Not Result in Extinction of the Species—We conclude that this exclusion of congressionally and State reserved natural areas would not result in the extinction of the species. As described above, all of these areas are managed under State and Federal law to provide for the conservation of species and their natural habitat, including the northern spotted owl. A critical habitat designation would not enhance or incrementally improve this dedicated management or increase the protections of these lands, nor would its absence somehow fail to provide protections that otherwise would not be present. Therefore, this exclusion of lands from final critical habitat would not result in any appreciable risk of extinction to the species because these lands will continue to be managed to provide for the conservation of the spotted owl.

Cumulative Analysis—Exclusion Will Not Result in Extinction of the Species

We have determined that exclusion of approximately 4,056,759 ac (1,641,777 ha) of lands from this final designation of critical habitat will not result in extinction of the northern spotted owl. We have excluded these areas based, in part, on the significant conservation benefits afforded to the northern spotted owl and its habitat on these lands through the positive conservation measures provided through SHAs, HCPs, or other agreements with private landowner partners with a proven track record of conservation actions. Each of these agreements, as discussed here, provides significant conservation benefits to the species in terms of maintaining, enhancing, or recruiting additional suitable habitat for the northern spotted owl, and implementing species-specific conservation measures designed to avoid and minimize impacts to northern spotted owls. Further, for projects having a Federal nexus and affecting northern spotted owls in the excluded areas, all of which are occupied by the species, the jeopardy standard of section 7 of the Act provides a level of assurance that this species will not go extinct as a result of excluding these lands from the critical habitat designation. The species is also protected by section 9 of the Act, which prohibits the take of listed species. Congressionally and State reserved natural areas excluded are managed under State and Federal law and policy to provide for the conservation of species and their natural habitat, including the northern spotted owl. These lands will continue to be managed under a clear conservation mandate, and exclusion of these lands from critical habitat will not deprive the species or its habitat of any protections that are not already present. Although we did not assume that all private lands without specific conservation agreements would continue to fully provide for the conservation of the owl, we determined that the exclusion of these lands would not lead to the extinction of the species, due to existing State protections and the fact that the areas excluded constitute such a small percentage of the overall designation. For these reasons, we conclude that the exclusion of these areas under section 4(b)(2) of the Act will not cumulatively result in the extinction of the species.

Consideration of Indian Lands

In accordance with the Secretarial Order 3206, ''American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act'' (June 5, 1997); the President's memorandum of April 29, 1994, ''Government-to-Government Relations with Native American Tribal Governments'' (59 FR 22951); Executive Order 13175, ''Consultation and Coordination with Indian Tribal Governments'' (November 6, 2000, and as reaffirmed November 5, 2009); and the relevant provision of the Departmental Manual of the Department of the Interior (512 DM 2), we believe that fish, wildlife, and other natural resources on Indian lands may be better managed under Indian authorities, policies, and programs than through Federal regulation where Indian management addresses the conservation needs of listed species. In addition, such designation may be viewed as unwarranted and an unwanted intrusion into Indian self-governance, thus compromising the government-to-government relationship essential to achieving our mutual goals of managing for healthy ecosystems upon which the viability of threatened and endangered species populations depend.

In developing the proposed revised critical habitat designation for the northern spotted owl, we considered inclusion of some Indian lands. As described in the above section Criteria Used to Identify Critical Habitat, and detailed in our supporting documentation (Dunk *et al.* 2012b, entire), we evaluated numerous potential habitat scenarios to determine those areas that are essential to the conservation of the northern spotted owl. In all cases, we assessed the effectiveness of the habitat scenario under consideration in terms of its ability to meet the recovery goals for the species. Furthermore, the habitat scenarios under consideration included a comparison of different prioritization schemes for landownership; we prioritized areas under consideration for critical habitat such that we looked first to Federal lands, followed by State, private, and Indian lands. Indian lands are those defined in Secretarial Order 3206 ''American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act'' (June 5, 1997), as: (1) lands held in trust by the United States for the benefit of any Indian tribe or individual; and (2) lands held by any Indian Tribe or individual subject to restrictions by the United States against alienation. In evaluating Indian lands under consideration as potential critical habitat for the northern spotted owl, we further considered the directive of Secretarial Order 3206 that stipulates ''Critical habitat shall not be designated in such areas unless it is determined essential to conserve a listed species. In designating critical habitat, the Services shall evaluate and document the extent to which the conservation needs of the listed species can be achieved by limiting the designation to other lands.''

Although some Indian lands identified in our habitat modeling demonstrated the potential to contribute to the conservation of the northern spotted owl, our analysis did not suggest that these areas were essential to conserve the northern spotted owl. This determination was based on our relative evaluation of the various habitat scenarios under consideration; if the population performance results from our habitat modeling indicated that we could meet the recovery goals for the species without relying on Indian lands, we did not consider the physical or biological features on those lands, or the lands themselves, to be essential to the conservation of the species, therefore they did not meet our criteria for inclusion in critical habitat. Our evaluation of the areas under consideration for designation as critical habitat indicated that we could achieve the conservation of the northern spotted owl by limiting the designation of revised critical habitat to other lands. Therefore, no Indian lands are included in the revised designation of critical habitat.

XII. Summary of Comments and Responses

We requested written comments from the public on the proposed revised designation of critical habitat for the northern spotted owl during an initial 90-day public comment period, which opened with the publication of the proposed revised rule on March 8, 2012 (77 FR 14062), and closed on June 6, 2012. On June 1, 2012, we published the notice of availability of the draft economic analysis and draft environmental assessment associated with the proposed revised designation of critical habitat (77 FR 32483), and extended the comment period for the proposed rule an additional 30 days, through July 6, 2012, thereby providing a total comment period of 120 days. In addition, we held two public information meetings in Redding, California on June 4, 2012; two in Tacoma, Washington, on June 12, 2012; one in Portland, Oregon on June 20, 2012; and two in Roseburg, Oregon, on June 27, 2012. We also held a public hearing in Portland, Oregon, on June 20, 2012. In addition, we contacted appropriate Federal, State, County, and local agencies; scientific organizations; and other interested parties and invited them to comment on the proposed rule, draft economic analysis, and draft environmental assessment during these comment periods. In addition, in response to requests from several Counties, and to ensure that all affected Counties and State fish and wildlife agencies in Washington, Oregon, and California were able to thoroughly review and comment as provided by section 4(b)(5)(A)(ii) of the Act, the Service provided an additional opportunity for those entities to comment until August 20, 2012.

During the comment period(s), we received over 33,000 comments (many of which were form letters), directly addressing the proposed revised critical habitat designation. During the June 20, 2012, public hearing, eight individuals or organizations provided comments on the proposed revised designation. All substantive information provided by commenters has either been incorporated directly into this final designation or addressed below. Comments received were grouped into general categories specifically relating to the proposed revised critical habitat designation, and are addressed in the following summary, and incorporated into the final rule as appropriate. We received a number of highly technical comments regarding the modeling process used to develop critical habitat. These technical questions are addressed in the final Modeling Supplement (Dunk *et al.* 2012b) rather than in the following section. We also received several comments regarding perceived effects attributed to the original listing of the northern spotted owl (June 26, 1990; 55 FR 26114), but are not addressing those comments because they do not apply to this rulemaking, which is limited to the revised designation of critical habitat for the northern spotted owl.

Comments From Peer Reviewers

In accordance with our peer review policy published on July 1, 1994 (59 FR 34270), we solicited expert opinions from 40 knowledgeable individuals with scientific expertise that included familiarity with the species, the geographic region in which the species occurs, and conservation biology principles. We received responses from 15 of the peer reviewers.

We reviewed all comments received from the peer reviewers for substantive issues and new information regarding critical habitat for the northern spotted owl. The peer reviewers generally supported the modeling process used to inform the identification of critical habitat and the resulting size and distribution of the proposed revised designation. Reviewers were divided on the risks posed by climate change and forest health, and whether active management should be applied within critical habitat.

We asked reviewers to address a number of specific questions with regard to the proposed rule. The questions posed to the peer reviewers and a summary of their responses are provided below; peer reviewer comments, clarifications, and suggestions have been incorporated into the final rule as appropriate. Our responses to issues raised by the peer reviewers are presented in the subsequent summaries of comments and responses.

Question 1a: Given the assumptions about barred owl effects, does this critical habitat network provide a sufficient amount and distribution of habitat for the northern spotted owl?

Peer Review Response: Of the seven reviewers who provided a response to this question, four indicated that it was impossible to determine whether the critical habitat network was adequate with barred owls present across the area. Two reviewers believed the network was adequate, and one believed it was too small given barred owl impacts.

Question 1b: Have the physical or biological features that are essential to the conservation of the owl been properly described? Do the areas identified as proposed critical habitat adequately capture these features? Are there areas we identified that should not be included in the designation?

Peer Review Response: Of the five reviewers who addressed this question, all believed the physical or biological features were properly described. A number of these reviewers did have suggestions for revising descriptions of these features in specific forest types and we have incorporated these suggestions into the final rule.

Question 2: Does the critical habitat network adequately encompass the geographic range of the northern spotted owl and represent the range of habitat types used by the species?

Peer Review Response: Only three reviewers specifically addressed this question. All agreed that the network encompassed the geographic range and habitat types used by owls. One reviewer expressed concern that additional lands in the southwest Washington lowlands should be included to improve landscape connectivity, and a second reviewer indicated that maintaining areas of marginal habitat where northern spotted owls could persist in the face of encroachment by barred owls may be particularly important. See our response to *0* for a detailed discussion regarding inclusion of lands in southwest Washington and inclusion of marginal habitat.

Question 3: We have identified areas on Federal lands in the ''Matrix'' classification (i.e., areas designated for timber harvest under the NWFP) as proposed critical habitat, as well as some State and private lands where Federal lands are lacking. Do you agree or disagree with this approach? Why or why not?

Peer Review Response: Eight reviewers addressed this question, and all agreed that inclusion of matrix lands in critical habitat was supported. One reviewer noted that the barred owl issue needs to be addressed (see response to *0* for detailed discussion of this issue), and another reviewer was surprised that all habitat-capable lands in the western portion of the species' range were not included in critical habitat (see *0* for a more detailed discussion of this issue).

Question 4a: Does the proposed rule appropriately cite the scientific literature on ecological forestry to recommend restoration of ecological processes and the conservation of late-successional forests while also providing sufficient habitat conservation for northern spotted owls?

Peer Review Response: Ten reviewers addressed this issue. Most supported the idea that land managers consider the application of ecological forestry principles. Five believed the rule cited appropriate literature, and several other expressed general support, but recommended consideration of additional published research. Three reviewers disagreed with some of the science that was cited, or the interpretation of that science, and noted that the discussion did not adequately address studies that have documented negative effects of timber management on northern spotted owls and their prey. Several reviewers recommended that active management should be conducted in an adaptive management framework. We addressed these issues in revisions to the section *An Ecosystem-based Approach to the Conservation of the Northern Spotted Owl and Managing Its Critical Habitat.*

Question 4b: Do the proposed guidelines for vegetation management, including forest fuels treatments and restoration of fire regimes, represent an appropriate application of ecological science?

Peer Review Response: Responses to this question were varied. Eight reviewers expressed overall support for the concept, although several recommended providing more specific management information. Four reviewers indicated that parts of the document were unclear on whether ecological science was applied appropriately, and highlighted the lack of understanding about how such management actions may affect owls and their prey. Two reviewers specifically indicated that they did not think that approach is appropriate. Several recommended conducting active management activities in an adaptive management framework, until the science becomes clearer regarding how northern spotted owls are affected by projects intended to restore forest health or apply ecological forestry principles. We addressed active adaptive forest management in the section *An Ecosystem-based Approach to the Conservation of the Northern Spotted Owl and Managing Its Critical Habitat.*

Question 4c: Do you believe the proposed rule appropriately balances the potential risks of taking action with the potential risks of a passive (i.e., ''no action'') management approach, especially in the face of ongoing climate change and the need to manage for the entire forest ecosystem, not just northern spotted owls?

Peer Review Response: Peer reviewers were split in their opinions on this question, and responded with varying degrees of specificity. Eight reviewers generally supported the suggestion that land managers consider an active management approach in managing forest landscapes, although not all stated whether the discussion of this concept in the proposed rule balanced the respective tradeoffs. Five reviewers believed that the risks were not appropriately balanced, that the discussion was too vague in weighing the tradeoffs, or that there is too little specific scientific understanding of the explicit tradeoffs to conduct an informed discussion. Several of these reviewers indicated that there was too much emphasis on active management in the preamble to the proposed rule given the lack of understanding about how ecological forestry and restoration management might affect owls. In contrast, one reviewer noted that the consequences of not applying management in some areas (e.g., fire-prone areas) were not sufficiently addressed. We have addressed the need to conduct additional research in an adaptive management framework in the section *An Ecosystem-based Approach to the Conservation of the Northern Spotted Owl and Managing Its Critical Habitat.*

Question 5a: Is there relevant information available we did not incorporate into the critical habitat modeling process (thoroughness), and have we interpreted the existing scientific information in a reasonable way (scientific consistency)?

Peer Review Response: The 15 reviewers generally agreed that we did include the appropriate information and interpreted it in a reasonable way. Recommendations to incorporate more realistic barred owl encounter rates, use individual home ranges rather than pair ranges in the modeling process, and analyze the effects of proposed exclusions were suggested. We address these issues in our responses to *Comment (11), Comment (38),* and *Comment (139).* One reviewer questioned the accuracy of GNN data for identifying northern spotted owl habitat. We address the question regarding the accuracy of GNN data in our response to *Comment (19*). In addition, some reviewers asked for more detail regarding the modeling process. Many of the responses to comments provided here present such detail, and we have incorporated additional discussion in our separate Modeling Supplement (Dunk *et al.* 2012b).

Question 5b: The modeling process attempted to incorporate both scientific uncertainty and demographic (stochastic) variation. Were methods used to incorporate uncertainty and variability appropriate?

Peer Review Response: Six reviewers addressed this question specifically. Most had suggestions for improving our methods including addressing temporal variation in demographic rates, providing confidence intervals on estimates, and conducting sensitivity analyses. We address specific comments in more detail in the Modeling Comments section below, as well as in our separate Modeling Supplement (Dunk *et al.* 2012b).

Question 5c: Does the proposed critical habitat rule correctly express the key assumptions and uncertainties underlying the scientific and technical information it used, particularly in regard to northern spotted owl habitat, demographic trends, and influence of barred owls on northern spotted owls?

Peer Review Response: In general, the reviewers agreed that the rule did address key assumptions and uncertainties; however, most identified specific areas these could be improved. We address these comments in more detail in the Modeling Section below, as well as in our separate Modeling Supplement (Dunk *et al.* 2012b).

Question 5d: Was the combination of analytical methods (MaxEnt, Zonation, HexSim) with professional judgment (please see Criteria Used to Identify Critical Habitat, pp. 14096–14101 in the proposed rule (March 8, 2012; 77 FR 14062) for details) appropriate for identifying critical habitat? Are there additional analyses you would recommend?

Peer Review Response: Of the 15 peer reviewers, 1 thought that HexSim was not an appropriate model given its complexity, and 2 expressed concern about the utility of the MaxEnt model for identifying habitat. The majority of peer reviewers thought that the combination of analytical methods we used was appropriate. We address the question regarding the use of HexSim and MaxEnt in our responses to *Comments (20, 21, 22, 26, and 43)* as well as in our separate Modeling Supplement (Dunk *et al.* 2012b).

A number of peer reviewers had additional comments about the concept of active management. Since the preambles to the proposed and final rules discuss this concept, we have addressed their comments below. However, we emphasize that this rule does not take any action or adopt any policy, plan or program in relation to active forest management. The discussion is provided only for consideration by Federal, State, and local land managers, as well as the public, as they make decisions on the management of forest land under their jurisdictions and through their normal processes.

Additional peer reviewer comments are addressed in the following summary and incorporated into the final rule as appropriate.

Comments on Lands Included in Critical Habitat and Exclusions

Comment (1): Several reviewers commented that proposed critical habitat failed to include habitat that linked the Olympic peninsula to other regions, and also did not include low-elevation habitat along the margins of the Willamette Valley, Puget Trough, Umpqua Valley, and Rogue River Valley. Some reviewers indicated that they thought this was a fault of the modeling methods used.

Our Response: There are multiple reasons why the areas described in the above comments were not included in the revised critical habitat. First, the habitat model using MaxEnt was at the 500-ac (200-ha) scale, and was thus unlikely to identify small, isolated habitat fragments. This is not a failure of the modeling, but rather a consequence of these areas (identified in the comments) having very little northern spotted owl habitat; such small, fragmented areas do not meet our criteria for critical habitat, and are therefore not included in final the critical habitat designation. Second, to incorporate additional information such as connectivity and unique forest situations, the Service also utilized expert knowledge and current owl location data (among other factors) to determine what is essential for conservation of the species. In Phase 3 of the critical habitat development process, as described in Dunk *et al.* 2012b, we evaluated areas where connectivity appeared to be deficient, and added in habitat to strengthen connectivity. However, most of the areas identified in these comments (particularly in western Washington) consist largely of cutover industrial timberlands, are not occupied by northern spotted owls, do not contain the primary constituent elements for critical habitat, and are not otherwise essential to the conservation of the species because they do not provide high-quality habitat or areas where restoration of habitat is need to provide essential connectivity or demographic support. These areas were not included in the 1992 or 2008 critical habitat designations for the same reasons. Without additional information about the location and habitat conditions of specific parcels in the areas mentioned in this comment, we are unable to further evaluate the benefits of including them in the revised designation.

Comment (2): One reviewer questioned the fact that portions of several late-successional reserves (LSRs) including a portion of the Okanogan-

Wenatchee National Forest in the eastern Washington Cascades and lands in the Western Klamath region that were affected by the Biscuit Fire were not included in the critical habitat proposal.

Our Response: Both of the areas described in this comment generally exhibit low relative habitat suitability (RHS) values. The portion of the Okanogan-Wenatchee LSR that was not included contains much high-elevation forest and dry forest seldom occupied by the northern spotted owl. The Biscuit Fire area described by the reviewer is composed of low RHS due to a combination of fire effects and ultramafic soils.

Comment (3): One peer reviewer and several public commenters were concerned about congressionally reserved areas not being included in proposed critical habitat.

Our Response: All congressionally reserved lands that met the criteria for critical habitat were included in the proposed revised designation. We sought public comment on whether they should be excluded from the final critical habitat designation. Based on further analysis and public comment, they are excluded in the final revised critical habitat designation. Our final decision is that these areas are essential to the conservation of the northern spotted owl, but as these areas are managed under a conservation mandate that provides for the needs of the northern spotted owl, we could find no benefits to the designation that outweighed the minor administrative costs associated with including these areas. Therefore the benefits of exclusion outweighed those of inclusion, and since such exclusion will not result in the extinction of the species, these congressionally reserved areas have been excluded from the final designation.

Comment (4): Several reviewers highlighted the importance of keeping State lands, congressionally reserved lands, and some private lands without HCPs or other agreements in critical habitat.

Our Response: We agree that these lands are important for the conservation of northern spotted owls. However, Federal parks and wilderness areas (and any other congressionally reserved lands) including State parks, as well as private lands, have been excluded in the final revised designation of critical habitat for the northern spotted owl. Some State lands are included in the final critical habitat designation, unless such lands had an HCP, SHA, or other conservation measures in place that led to their exclusion under section 4(b)(2) (see Exclusions).

Comment (5): Several reviewers indicated that the largest reserve designs may be the best for northern spotted owl conservation.

Our Response: Designation of critical habitat is constrained by the statutory language in section 3(5) of the Act, which states that critical habitat must either have been occupied by the species at the time it was listed and contain the physical or biological features essential to the conservation of the species, or, if unoccupied at the time of listing, be essential to the conservation of the species. Furthermore, section 3(5)(c) of the Act specifies that except in rare circumstances, critical habitat should not include the entire geographical area which can be occupied by the species. We concur that in areas where high-quality habitat is lacking, designating all areas capable of developing in to suitable habitat in the future might provide more robust networks. However, the addition of large areas of currently unsuitable habitat as suggested in this comment would likely not meet the intent and mandate of the statute. If occupied at the time of listing, such lands would not provide the requisite essential features. If unoccupied at the time of listing, such lands would only be included in critical habitat if we found them to be essential to the conservation of the species. Our evaluation of various potential habitat networks as we developed this critical habitat designation demonstrated that these lands are not likely to contribute substantially more owls to the rangewide population than the area designated as final critical habitat, thus we did not consider them to be essential to the conservation of the species.

Comment (6): One reviewer stressed the need to retain Recovery Action 10 and 32 lands in critical habitat.

Our Response: Recovery Action 10 and Recovery Action 32 do not constitute specific areas of mapped lands that could be included in critical habitat designation. Rather, they are broad landscape-level conservation recommendations contained in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) for identification and conservation of important habitats that apply to all land ownership categories and Federal land management allocations, including designated critical habitat. While consistency with these and other recovery actions is not required, Federal land management agencies generally try to conduct activities in a manner consistent with the guidance provided in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011).

Comments on Competition From the Barred Owl

Comment (7): One reviewer indicated that recovery efforts need to focus on barred owl management in addition to critical habitat.

Our Response: Barred owls and loss or degradation of habitat are primary factors impacting northern spotted owls. As we noted in the proposed critical habitat rule, habitat protection is necessary, but not sufficient alone, to recover the northern spotted owl. This revised designation of critical habitat is only one of many conservation actions that will contribute to the recovery of the northern spotted owl. The Service is currently working on a final environmental impact statement under NEPA for experimental barred owl removal to address the threat posed to northern spotted owls by the barred owl. Nonhabitat-based threats, such as barred owls, are specifically addressed in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), and do not fall within the scope of this critical habitat rule. The Revised Recovery Plan, not this critical habitat rule, should be considered the comprehensive recovery document for the northern spotted owl.

Comments Regarding the Northwest Forest Plan (NWFP)

Comment (8): Several reviewers indicated that the relationship between proposed critical habitat and the Northwest Forest Plan was unclear.

Our Response: We have attempted to clarify the language regarding the relationship between critical habitat and the Northwest Forest Plan (NWFP). The NWFP provides land management guidance for most of the Federal lands identified as critical habitat, and we anticipate that the Standards and Guidelines for the NWFP will continue to direct management actions on these lands, unless amended sometime in the future. We emphasize that critical habitat does not replace or supersede the Standards and Guidelines of the NWFP. Active management is discussed in the preamble of this rule only to encourage land managers to consider the range of management flexibility already contained in the NWFP. We acknowledge the importance of the NWFP as a management strategy for conserving northern spotted owls and late-successional forest habitat, and our suggestions for special management considerations needed to address the threats to the physical or biological features essential to the conservation of the northern spotted owl (see Special Management Considerations or

Protections, above) are consistent with the directives of the NWFP.

Comment (9): One reviewer noted that LSR areas and locations on the East Cascades were designed under the assumption of static landscapes, not the dynamic landscapes we now recognize.

Our Response: We have recognized that the Standards and Guidelines for management under the NWFP differ across eastern and western forests, and that eastern forests are very dynamic. This condition was recognized in the NWFP, and the Standards and Guidelines of the NWFP allow for active management in such areas (USDA and USDI 2004, pp. C–12—C–13).

Comments on the Modeling Process

Here we provide a summary of general comments received on the modeling process that we used, in part, to identify revised critical habitat for the northern spotted owl. The habitat modeling framework we utilized was originally developed for the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), and Appendix C of the Revised Recovery Plan provides a detailed description of the modeling framework and the extensive testing and cross-validation that was done at each stage of development. In addition, we note that the modeling framework that we applied here to assist in the identification of critical habitat for the northern spotted owl was independently the subject of prior peer review and public comment for the recovery plan. Particularly detailed or technical comments on the habitat modeling that we received in relation to this critical habitat rule are addressed separately in our Modeling Supplement, Dunk *et al.* 2012b, in an effort to reduce the length and improve the readability of this rule.

Comment (10): One reviewer suggested that the modeling of habitat networks and scenarios should consider a wider range of options or composites with greater emphasis on sustainability of owl populations, not efficiency. The present document is biased in favor of efficiency, not conservation of old forest habitat.

Our Response: We evaluated each of the potential critical habitat networks with respect to the guiding principles we developed, which were based on the statutory definition of critical habitat and informed by the recovery criteria for the northern spotted owl as established in the 2011 Revised Recovery Plan. The recovery criteria for the northern spotted owl are aimed at achieving sustainable northern spotted owl populations across the range of the species. In terms of identifying critical habitat, we use the term ''efficient'' to convey that we sought to include the highest-quality habitat with the greatest potential contribution to recovery and minimize as much as possible the amount of relatively lower quality habitat in determining what is essential to conservation of the species. In areas of insufficient high-quality habitat, lower quality habitat may still provide the PCEs and may be essential in terms of providing sufficient habitat overall to sustain the population. We also sought to rely on public lands to the extent possible.

Efficiency never trumped owl performance in our selection process; the population performance of the northern spotted owl in response to the scenarios evaluated was our first concern. However, given two or more nearly equal population performance outcomes, we did look for efficient solutions; that is, given the choice between two nearly equivalent habitat networks in terms of northern spotted owl population performance, we chose the network that achieved roughly the same level of performance provided by a relatively greater proportion of public lands or smaller overall designation. Old forest habitat and areas of high RHS are nearly identically represented in the largest networks we evaluated (Z70, Composites 1, 3, 4, and 7).

Comment (11): One reviewer suggested the use of individual, rather than pair home range size estimates in the HexSim model.

Our Response: Because our spotted owl population model is a females-only model, it was most appropriate to use individual home range sizes. Thus our model will not simulate the resource constraints that could result from male owl's consumption of limited food resources. We strove to construct the simplest model structure that captured the essential ecological processes; doing so made our northern spotted owl model more straightforward to develop and easier to understand. We evaluated how well the HexSim model was calibrated to actual populations, by comparing simulated spotted owl populations from our model with actual densities of northern spotted owls as measured within demographic study areas (Appendix C, p. C–73). We found that simulated populations were quite similar to actual populations, suggesting that the females-only model produced reasonably accurate estimates. Finally, because we used the HexSim model to compare the relative differences in population size resulting from different reserve design assumptions, any biases that may have been introduced into the process from the use of a females-only model would essentially be zeroed out, since that bias would be the same across all populations; in such a case, the net relative difference would still be accurately reflected between populations.

Comment (12): One reviewer noted that we did not include baseline scenarios that provide clear insight concerning the contributions that State, private, and Indian lands might make in the long run. They note that excluding consideration of some large areas by virtue of land ownership may have attendant effects on demographic results by inadvertently imposing ''pinch points'' along the north-south axis of the critical habitat area. The main concern was that northern spotted owl recovery may be quite limited by the initial assumptions made about excluding State, private, and Indian lands based on their current conditions; remaining alternatives considered may all be poorer as a result.

Our Response: We did not make initial assumptions about the population contributions potentially made by State, private, and Indian lands, or about the feasibility of including those lands in proposed critical habitat. Our initial comparisons of Zonation-derived reserve designs included both ''ALL lands'' and ''PUBLIC lands'' scenarios (Appendix C, p. C–49–52); these habitat networks did not restrict our evaluation to particular land ownerships, but allowed us to evaluate all lands regardless of ownership. Thus, we evaluated the contribution of all land ownerships before narrowing down the habitat network designs based on policy and cost-benefit analyses (meaning the weighing of relative population performance versus total area in the designation), as fully described in our Modeling Supplement (Dunk *et al.* 2012b). As discussed in this rule and in that supplement, we sought to maximize the reliance on public lands to the extent possible, but only if it did not compromise the population metrics essential to conservation of the northern spotted owl. In addition, as described in the section Consideration of Indian Lands, we conducted this analysis in accordance with the Secretarial Order 3206 directive to consider ''the extent to which the conservation needs of the listed species can be achieved by limited the designation to other [non-Indian] lands.'' As we did not identify any Indian lands that were essential to the conservation of the northern spotted owl, we did not include any such lands in the designation.

Comment (13): One reviewer asked whether foraging habitat was considered separately from nesting/roosting habitat in the Step 1 modeling, or if suitable habitat was modeled as nesting/roosting/foraging?

Our Response: Foraging habitat was separate from nesting/roosting habitat, as explained in Appendix C to the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, p. C–24).

Comment (14): One reviewer noted a potential failure to acknowledge the importance of winter migration behavior to spatial and habitat requirements of territorial northern spotted owls.

Our Response: We attempted to incorporate some degree of winter habitat requirements by using annual home ranges in HexSim. To our knowledge, the data we could use in HexSim to incorporate broader movements does not exist throughout the northern spotted owl's range. To the extent that northern spotted owls move away from their territories during the nonbreeding period, and if habitat use differs appreciably in the breeding season and nonbreeding season, it is possible that our approach did not include all areas that may be important to northern spotted owls. However, we are unaware of a consistent methodology that we could use to overcome this potential shortcoming.

Comment (15): One reviewer requested that we consider the effects of fire in the modeling process used to define critical habitat, and how critical habitat should be protected from the effects of fire.

Our Response: Our process incorporated several different possible vegetation growth and loss scenarios, and modeled a variety of potential northern spotted owl responses to differing management strategies. These scenarios were based on observed rates of habitat change measured between 1996 and 2006. As such, they incorporate habitat loss to fire and other causes, and project it into the future as a rate of change. We considered explicitly modeling fire probabilities and fire effects into the scenarios, but the complexity and high degree of uncertainty made this unfeasible. Incorporating fire impacts would have had a similar proportional effect to the relative outputs of each modeled scenario, thereby not elucidating real differences between the effectiveness of the modeled scenarios. The question of protecting critical habitat from the effects of fire is beyond the scope of this rulemaking.

Comment (16): One reviewer suggested that estimating the rate of population change (λ, or lambda) at 10-year intervals makes interpretation more difficult, especially with respect to the results from demographic studies, where λ is estimated as an annual interval.

Our Response: Our use and estimate of the finite rate of population change was not intended to be compared to estimates from demographic study areas or the meta-analysis (e.g., Forsman *et al.* 2011). We used lambda as one basis for comparison between the various alternative potential critical habitat networks considered to determine what is essential to the conservation of the northern spotted owl, using different assumptions related to the barred owl and the amount of suitable habitat. Thus, our use of lambda at 10-year intervals was appropriate for our intended use of relative population performance between habitat scenarios under consideration.

Comment (17): One reviewer indicated that one aspect that seemed to be lacking in the designation of critical habitat was whether the model correctly predicted areas currently occupied by northern spotted owls based on relative habitat suitability. The reviewer suggested that one way to accomplish this would be to examine the spatial distribution of critical habitat in relation to the existing demographic study areas and other areas with a history of surveys for northern spotted owls.

Our Response: To evaluate how well the modeling process identified areas likely to be occupied by northern spotted owls, we tested the predictive ability of the model by comparing our RHS model outputs with the distribution of known northern spotted owl locations (independent data sets) from the years 1996 and 2006, and in both cases found a high predictive accuracy. The results of this comparison are presented on pages C–38 to C–41 in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011).

Comment (18): One reviewer indicated that the models are likely to be ''overfit'' (an overfit model that is overly sensitive to small fluctuations in data inputs, and will consequently have poor predictive results), even though cross-validation results by modeling region showed that all models were relatively robust to prediction (Table C19, Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011)). The reviewer indicated that this point needs to be more clearly disclosed. Several commenters expressed concern about the number of covariates in the RHS models, and the potential for overfitting.

Our Response: We carefully evaluated the modeling procedures we used to identify spotted owl habitat and test the resulting models using both cross-validation and independent data sets. Based on the results of our evaluations, we disagree that our models are overfit. We have clarified the procedures used and results of model testing in the final Modeling Supplement (Dunk *et al.* 2012b). MaxEnt is designed to reduce the effects of the potential model over-fitting through its use of regularization. The main consequence of overfitting that we wished to guard against was that of having models so tightly fit to the training data that they were not generalizable (i.e., that they did not work well at classifying test data or data that did not contribute to the model's development). Our extensive cross-validation (randomly removing 25 percent of the data, each of 10 times within each modeling region) and evaluation of each model's full and cross-validated performance revealed that the models were not overfit (see Table C–16). Furthermore, where we had adequate independent data, the models performed almost identically on them as on the training data (see Table C–17). We share the reviewers concerns with overfitting models, and we directly evaluated whether the consequences of overfitting were realized and found that they were not. Thus, the conclusions on page C–41 of the Revised Recovery Plan (USFWS 2011) under ''Model evaluation summary'' remain valid.

Comment (19): Some reviewers and commenters suggested that the GNN database used to develop the relative habitat suitability (RHS) map is inappropriate for use in designating critical habitat because it does not depict what actual vegetative components exist on the ground but is a computer simulation of what might exist. The reviewer stated that since the base vegetation layer does not accurately represent stand conditions on the ground, it is impossible to show what stands contain PCEs and which do not. Several reviewers suggested that a formal accuracy assessment of the GNN data is needed and suggested that model predictions of habitat conditions should be verified. One reviewer indicated that inaccuracies in the GNN database probably led to errors with MaxEnt predictions of owl distributions. The reviewer suggested that there is little science to support the assumptions that GNN data for vegetative variables believed to be important to northern spotted owls were equally accurate across modeling regions, and there is little certainty that relevant processes were sufficiently captured so as to reliably predict owl population performance. The reviewer further claims the Service did not assess the accuracy of the GNN data. Finally, the reviewer states that Dr. Larry Irwin, National Council for Air and Stream Improvement (NCASI) conducted an analysis of how well the GNN–LT data correlated with actual measurements on the ground, and concluded that there is a very low correlation between GNN–LT predictions and reality. Further, the reviewer states that GNN–LT was developed for mid- to large-scale spatial analysis, not the designation of critical habitat.

Our Response: We concur that the RHS models and subsequent modeling steps are dependent on the reliability of the GNN vegetation layer. A description of our use of GNN and accuracy assessments for the GNN variables used in our RHS models are presented in detail on pages C–16 to C–19 of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011). Based on our data needs, these accuracy assessments, and independent verification of the performance of GNN estimates, we have determined that GNN represents the best scientific information available for habitat modeling throughout the range of the northern spotted owl.

As described in detail in Appendix C, we selected the GNN vegetation database for a number of reasons; most importantly it is the layer developed for use in the Northwest Forest Plan monitoring program. In addition, it is the only vegetation layer available that covers all land ownerships across the entire range of the northern spotted owl. Past efforts to model, map, and quantify habitat selection by northern spotted owls at regional scales have often suffered from lack of important vegetation variables, inadequate spatial coverage, or coarse resolution of available vegetation databases (Davis and Lint 2005). To develop rangewide models of relative habitat suitability for northern spotted owls, we required maps of forest composition and structure of sufficient accuracy to allow discrimination of attributes used for nesting, roosting, and foraging by northern spotted owls (the essential physical or biological features). GNN, developed for the NWFP's effectiveness monitoring program, provides detailed maps of forest composition and structural attributes for all lands within the NWFP area (coextensive with the range of the northern spotted owl). Although the GNN approach is a method for predictive vegetation mapping, it is based on input of empirical forest attribute data from inventory plots (Forest Inventory and Analysis, current vegetation analysis, etc.) and modeled relationships between plots and predictor variables from Landsat thematic mapper imagery, climatic variables, topographic variables, and soil parent materials.

The GNN maps come with a large suite of diagnostics detailing map quality and accuracy; these are contained in model region-specific accuracy assessment reports available at the LEMMA Web site (*http://www.fsl.orstu.edu/lemma/*). Accuracy assessments apply to the GNN model(s), rather than the satellite imagery. We provide Pearson correlation coefficients of GNN structural variables used in Table C–1 of the Revised Recovery Plan (USFWS 2011, pp. C–18 to C–19), and local accuracy assessments (kappa coefficients) for individual species' variables in Table C–2. For developing models of northern spotted owl habitat, we generally selected GNN structural variables with plot correlation coefficients greater than 0.5 for an individual modeling region (42 percent had correlation coefficients greater than 0.7). On a few occasions when expert opinion or research results suggested a particular variable might be important, we used variables with plot correlations from 0.31 to 0.5. For species composition variables, we attempted to use only variables with kappas greater than 0.3. However, because we combined species' variables into groups that expert opinion and research suggested may represent influent community types, we occasionally accepted variables with kappas greater than 0.2 and less than 0.3 for individual variables within a group.

The GNN vegetation database was specifically developed for mid-to large-scale spatial analysis, suggesting that accuracies at the 30-m pixel scale may be less influential to results obtained at larger scales. Because we were interested in the utility of GNN at our analysis area (500 ac (200 ha)) spatial scale, we additionally conducted less formal assessments where we compared the distribution of GNN variable values at a large sample of actual locations (known northern spotted owl nest sites and foraging sites) to published estimates of those variables at the same scale. In addition, we received comparisons of GNN maps to a number of local plot-based vegetation maps prepared by various field personnel. Based on these informal evaluations, we determined that GNN represents a dramatic improvement over past vegetation databases used for modeling and evaluating northern spotted owl habitat, and used GNN maps as the vegetation data for our habitat modeling.

Our primary objective in Step 1 of the modeling process was to develop MaxEnt models that perform well at predicting northern spotted owl habitat by developing models that had good discrimination ability, were well calibrated, were robust, and had good generality. Our detailed evaluations of model performance, cross-validation, and comparison with independent data sets (described in pages C–30 to C–41 in Appendix C of the Revised Recovery Plan) demonstrate that at the scale MaxEnt models were developed and evaluated, we met these objectives. Acknowledging that all vegetation databases will exhibit some degree of error, if the GNN layer was inadequate for predicting northern spotted owl habitat, we would not expect the reliable predictive models that we obtained. Thus, as described above, given our data needs, we believe the GNN database represents the best available information for the purposes of identifying critical habitat for the northern spotted owl. We are unaware of any alternative existing scientific information, and no viable suggestions were offered by reviewers or commenters.

Comment (20): One reviewer indicated that inaccuracies in the GNN database and inherent problems with MaxEnt probably led to errors with MaxEnt predictions of owl distributions. The reviewer suggested that there is little science to support the assumptions that GNN data for vegetative variables believed to be important to northern spotted owls were equally accurate across modeling regions, and there is little certainty that relevant processes were sufficiently captured so as to reliably predict owl population performance.

Our Response: As noted earlier, no vegetation database will be free of error; the important question is whether the database used is accurate enough to support the intended analysis objectives. We acknowledge that there may be some errors in the GNN database, yet the MaxEnt models we developed performed very well at predicting habitat suitability for northern spotted owls (one would not expect reliable predictive models if the underlying databases were highly inaccurate—one would expect poorly performing models). Our evaluation of the MaxEnt models developed indicate that the models for all modeling regions were well calibrated and showed quite similar patterns in terms of strength of selection (Figure C–5, USFWS 2011). Cross-validation results showed that all models were robust (i.e., equally accurate when applied to different subsets of the spotted owl sample; USFWS 2011, Table C–19), and comparison of model results with independent test data showed the models had good ability to predict known northern spotted owl locations (USFWS 2011, Table C–20). Overall, these evaluations suggest our models of relative habitat suitability were robust and have good generality (are good at predicting northern spotted owl habitat in areas other than areas that provided the data for development of the model). As detailed in our response to *0* based on our data needs, accuracy assessments, and independent verification, amongst other information, we believe the GNN database represents the best available scientific data for our purposes.

We are uncertain about what ''inherent problems with MaxEnt'' the reviewer may be referring to; MaxEnt has been thoroughly evaluated in the scientific literature and found to perform very well for predicting species distributions and habitat suitability. Peer-reviewed papers by Elith *et al.* (2006), Wisz *et al.* (2008), Graham *et al.* (2008), Phillips *et al.* (2009), and Willems and Hill (2009) all compared MaxEnt to other modeling tools on identical data sets (sometimes hundreds of species), sample sizes, and geographic areas. MaxEnt always performed very well and was consistently a top-performing model. Based on the accurate performance of the model and the thorough, independent scientific evaluations of MaxEnt on a number of taxa, geographic regions, and sample sizes, we believe we have utilized the best available scientific information to model habitat suitability for the northern spotted owl. We note that 13 out of the 15 peer reviewers agreed that the use of MaxEnt was appropriate for our purposes.

Comment (21): One reviewer stated that although the Service claimed in the proposed rule that the modeling process defined areas that contain the physical and biological features essential for conservation of the species, that in reality MaxEnt provides no scientific support for the PCEs described in the proposed rule, and the proposed rule cites no other scientific basis for them. The reviewer indicates that MaxEnt simply ranks pixels in an area based on the ''best'' habitat definition supplied to it, and that the habitat definitions chosen by MaxEnt do not represent what the spotted owl needs and do not delineate the physical or biological features essential for the conservation of the species.

Our Response: The comment mischaracterizes the relationship between our habitat modeling and the identification of PCEs for the northern spotted owl. We did not use the habitat modeling to define the PCEs for the species. As stated in the proposed rule (March 8, 2012; 77 FR 14062, p. 14082), and reiterated in this rule, the physical or biological features essential to the conservation of the species (and associated primary constituent elements (PCEs)) of critical habitat for the northern spotted owl, are identified based on ''* * * studies of the habitat, ecology, and life history of the species as described in the final listing rule published in the **Federal Register** on June 26, 1990 (55 FR 26114), the Revised Recovery Plan for the Northern Spotted Owl released on June 30, 2011, the Background section of this proposal, and the following information.'' The following section of the proposed rule, titled Physical or Biological Features, provided an expansive discussion of the scientific basis for the identification of the essential physical or biological features of critical habitat for the northern spotted owl, accompanied by numerous supporting citations from the scientific literature, which informed our description of the PCEs. The modeling was not used to describe the PCEs of critical habitat; rather, it was used to identify the areas most likely to contain the PCEs and the areas most likely to have been occupied by northern spotted owls based on habitat suitability at the time of listing, as well as identify the specific areas essential to the conservation of the species. This is an important distinction. The habitat models were constructed from a rigorous assessment of current knowledge of the physical and biological features that influence northern spotted owl habitat suitability, and are supported by a solid scientific basis. We recognize that there may have been some poorly worded statements in the proposed rule that led to some confusion regarding the intersection of the PCEs and the modeling framework. We have clarified the language in this final rule to make it clear that we did not use models to define the PCEs for the northern spotted owl, but that we used the PCEs to develop maps of relative habitat suitability across the range of the northern spotted owl as one step in the identification of critical habitat for the species.

Comment (22): One reviewer recommended that the Service: (a) evaluate the rate at which MaxEnt may misclassify locations that do not contain spotted owls; and (b) provide evidence that MaxEnt accurately incorporates the factors that reflect the best environmental conditions for optimal population performance among northern spotted owls.

Our Response: Our models were developed to identify areas likely occupied at the time of listing based on relative habitat suitability (RHS), not to identify areas that do not contain owls. Furthermore, the presence of owls on territories can vary across space and time. There any many possible reasons that an organism (northern spotted owl in this case) may not occupy apparently suitable habitat for a period of time (e.g., death, competition, population is not at equilibrium with its environment). We did not use the RHS values to predict the number of years a site would be occupied or the reproductive rates at territories. The RHS layers we developed have been subjected to rigorous cross-validation and testing with independent data, as explained in Appendix C of the Revised Recovery Plan (USFWS 2011). Our assessment of the estimated on-the-ground conditions at high, intermediate, and low RHS values corresponds very closely to the published literature on northern spotted owl habitat use and selection, thus addressing (b). See also our responses to *Comments (19), (20),* and *(21),* among others.

Comment (23): One reviewer stated that comparisons with other evaluations of northern spotted owl habitat demonstrate the flaws in the modeling. In comparison with NWFP land use allocations, the modeling process includes 2.7 million ac (1.1 million ha) of lands that, up until now, had not been viewed as being needed for the recovery of the spotted owl. Overlaying the proposed critical habitat designation with USDA Pacific Northwest Research Station's 2011 data on old growth forests shows that only 36 percent of proposed critical habitat comprises late-successional old growth forest. Overlaying the proposed designation with USDA Pacific Northwest Research Station's 2011 report allocating spotted owl habitat into unsuitable, marginal, suitable and highly suitable shows that 50 percent of proposed critical habitat is either unsuitable or marginal habitat, and only 24 percent of the acres are classified as highly suitable.

Our Response: The designation of critical habitat is guided by the statutory language of the Act, and is highly species-specific in terms of its direction to identify specific areas that provide the physical or biological features essential to the conservation of the listed species in question—in this case, the northern spotted owl. Late-successional reserves under the NWFP, on the other hand, were established for the conservation of multiple species of varying taxa (birds, mammals, amphibians, fishes, etc.) and, in some areas, encompass forest types not used by northern spotted owls. For these reasons, the comparison of critical habitat with NWFP land use allocations is inappropriate, because they are intended to serve different purposes. The 2.7 million ac (1.1 million ha) of lands the reviewer refers to are presumably the congressionally reserved natural areas (wilderness areas and national parks) that are now excluded in this designation. These lands have consistently been viewed as essential to the recovery of the northern spotted owl since the species was listed. However, they were not included in previous designations due to our interpretation of the definition of critical habitat under section 3(5)(A) of the Act at that time and because their current classification and management was deemed adequate to meet northern spotted owl conservation goals. A primary purpose of these congressionally reserved natural areas is to conserve natural systems, including threatened and endangered species and their habitats, including the northern spotted owl. These areas are managed consistent with the conservation of the northern spotted owl, and we could find no benefit of inclusion that would outweigh the potential administrative costs associated with the designation of critical habitat on these lands.

Based on our modeling process, we found that northern spotted owl population performance under a habitat network represented by the 1994 NWFP was relatively poor compared with several other reserve designs (Dunk *et al.* 2012b). This result is not surprising considering the influence of barred owls and continued habitat loss to wildfire. Similarly, the results of this commenter's comparison of proposed critical habitat to maps of old growth forest and the nesting habitat model from the 2011 NWFP monitoring report would be anticipated, because the NWFP models represent only a portion of the habitat elements and spatial extent used by northern spotted owls. In particular, the classification of habitat into unsuitable, marginal, suitable, and highly suitable pertains only to forest structure used for nesting at the pixel scale, whereas our models are based on landscape-level habitat selection and incorporate the broader array of habitats used by northern spotted owls (including non-old growth). We believe the commenter is attempting to make ''apples and oranges'' type comparisons of habitat, and for the reasons described above, we disagree with the statement that such comparison demonstrate flaws in our modeling.

Comment (24): One reviewer stated that the Zonation model was not designed to develop a conservation network and that this model does not make a judgment as to what is essential for the conservation of the species. As characterized by the reviewer, Zonation does not use the presence or absence of PCEs as input so it does not show where the PCEs are essential. According to the reviewer, what it does is take the relative habitat suitability index of the MaxEnt model (which itself does not depict the presence or absence of PCEs), further smooth them by assigning new values at the home range size of 3,424 ac, (1,386 ha) and determines how little land is required to capture some percent of habitat values based on the parameters provided by the Service. It does this by removing the areas with the lowest habitat values first until the specified percentage of the habitat values are left. The reviewer contends that the Service used Zonation outputs that captured 70 percent of the habitat values as the basis for the proposed revision of critical habitat, and that this in no way supports the premise that these areas are essential for the conservation of the species. The reviewer claims that Zonation only shows a computer's calculation of the minimum amount of land needed to encompass 70 percent of the habitat value, which is a purely artificial data point created from smoothed indices of a relative habitat suitability index based on biased spotted owl locations overlaid on a hypothetical landscape using conglomerated data. The reviewer states there is no way to determine if the areas captured by these solutions actually contain the PCEs, and the Service has no idea how accurate the model is in predicting use by spotted owls.

Our Response: We disagree with the reviewer's statement in that it mischaracterizes the intended purpose of Zonation, the way the model works, and how the Service used it. The Zonation model was designed specifically for the purpose of developing conservation networks (Moilanen and Kojala 2008). However, we did not simply employ the Zonation model to provide a critical habitat network. As described in our response to *Comment (21*), and as detailed at length in our Modeling Supplement (Dunk *et al.* 2012b), we used the PCEs for the northern spotted owl to develop maps of relative habitat suitability for the species across its range; this step then informed the development of the spotted owl habitat conservation planning model (Zonation), thus the presence of PCEs is the foundation of the entire habitat modeling framework, and is fundamental to our identification of critical habitat for the northern spotted owl. We used Zonation to provide a series of alternative networks that were then compared in terms of relative simulated spotted owl population performance (using HexSim). After comparing a wide range of Zonation-derived scenarios, the top-performing alternatives for each modeling region were assembled into composite maps for further evaluation in HexSim. Development of composite maps also involved modification of reserve designs based on expert opinion and policy. In many modeling regions, the proposed critical habitat deviates substantially from the strictly Zonation-derived reserve designs, because use of the modeling was only one step in the process of identifying critical habitat. Finally, the Service verified that the resulting proposed critical habitat met the statutory criteria of critical habitat by evaluating the proportion of proposed critical habitat that was occupied by known northern spotted owl home ranges at the time of listing and that provides the essential physical or biological features, and by evaluating any areas that may have been unoccupied at the time of listing to determine whether they are essential to the conservation of the species. In addition, to address any uncertainty regarding occupancy, we evaluated all of the critical habitat under the higher standard of section 3(5)(a)(ii) of the Act. Please see Criteria Used to Identify Critical Habitat for further information.

Comment (25): One reviewer stated that the process used by the Service to define what constitutes nesting, roosting, and foraging habitats in the proposed rule produced results in staggering differences compared to historical definitions. According to this reviewer, not only are they totally different from what has been viewed as valid definitions for almost 20 years, but they are also totally unrecognizable on the ground. The reviewer claims the proposed rule utilizes habitat definitions derived from analysis of the hypothetical GNN–LT vegetation layer coupled with abiotic factors, which only make sense in computer modeling. The reviewer states that MaxEnt does not use these definitions to identify NRF (nesting/roosting/foraging) habitat but rather assigns an RHS value based on how many of the factors are present. Finally, the reviewer says that the Service claims to be using these factors to determine if stands contain the PCEs when, in fact, they do not.

Our Response: We are unsure of the basis for this comment, since the definitions of nesting, roosting (NR) and foraging (F) habitats used in this critical habitat rule are very similar to definitions used in past assessments, including previous designations of critical habitat for the northern spotted owl, and the definitions we use are based primarily on the information found in the published scientific literature. In fact, all NR and F models tested were derived from literature reviews and expert opinion, including input from timber industry scientists and managers. The relative habitat suitability models incorporate these NR and F definitions (submodels), as well as broader environmental features such as elevation and slope position, that are also well-described in the northern spotted owl literature. The remainder of the comment mischaracterizes our habitat suitability modeling; a thorough explanation of that modeling is found in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011). In addition, please see our response to *Comment (19)* for details on how the PCEs were defined and incorporated into the process of mapping RHS.

Comment (26): One reviewer stated that the Service modified input variables given to HexSim to produce ''composites,'' and the Service cannot show that these contain the PCEs and that they are essential, and there is no statistical difference between the different composites. By only displaying mean values, the reviewer claims the Service creates a false appearance that the difference between these alternatives is real. The Service does not show that the differences result in any real difference in achieving recovery objectives, they merely state it as a matter of fact. This is a misuse of modeling data, the reviewer states, and not best available science.

Our Response: This comment misunderstands the process used to develop composite maps, and the subsequent comparison of HexSim results. Composite maps are maps where different reserve designs were selected for each modeling region based on their ability to achieve recovery goals. These region-specific designs were combined across the range of the owl to create a ''composite map.'' We evaluated composite maps in an iterative manner to identify the design that best met recovery goals and our guiding principles. Composites were not created by modifying HexSim input variables; rather, they represent a range of reserve design alternatives that were subsequently tested in HexSim. Appendix C and Dunk *et al.* (2012b) provide ample evidence that all of the composites contain the physical and biological features used by the owl; comparison of HexSim results is the process by which the Service evaluates what amount and distribution of these features is essential to the conservation of the northern spotted owl. As stated in our proposed rule, this final rule, and in Dunk *et al.* 2012b, we assessed various composites by comparing the relative (emphasis added) performance of various habitat scenarios. That is, we used metrics such as relative differences in extinction risk and population size (which include upper and lower confidence intervals) to evaluate the ability of different composites to achieve recovery objectives for the northern spotted owl. In fact, we expressly stated ''simulations from these models are not meant to be estimates of what will occur in the future, but rather provide information on trends predicted to occur under different network designs'' (March 8, 2012; 77 FR 14062, p. 14097). There were statistically significant differences in population performance, both at the modeling region and range-wide scales among our composites (see Appendix C, USFWS 2011 and the Modeling Supplement (Dunk *et al.* 2012b) for additional details). We therefore disagree with the commenter's claims about misuse of modeling data and best available science.

Comment (27): One reviewer stated that the boundaries of the proposed revision of critical habitat are impossible to identify on the ground. They can only be defined by use of global positioning satellite receivers that have had the boundaries created by the Zonation computer model inputted to them.

Our Response: Critical habitat is defined by the features as discussed in this final critical habitat designation and shown on accompanying maps. Specific coordinates and descriptions that define the boundaries of critical habitat are available online at *http://www.fws.gov/oregonfwo,* at *http://www.regulations.gov* at Docket No. [FWS–R1–ES–2011–0112], and from the Oregon Fish and Wildlife Office (see **FOR FURTHER INFORMATION CONTACT**); maps are available online at *http://criticalhabitat.fws.gov/crithab/.*

Comment (28): One reviewer states that the Service did not use pixel by pixel data, but conglomerated the pixel data into indices that represent the 500-ac (200-ha) circle around each pixel, which increased the error associated with the predictions. The reviewer claims this wipes out all the actual stands that might actually be used by spotted owls and instead assigns each pixel a conglomerate value for each habitat variable based on averages. Therefore, the reviewer asserts there are many areas that do not contain the PCEs.

Our Response: This comment mischaracterizes the method used to evaluate habitat quality, and the basic definition of habitat for northern spotted owls. As described in Appendix C of the Revised Recovery Plan (USFWS 2011), habitat suitability consists of several factors including, but not limited to, the actual forest ''stands'' used by owls. Our relative habitat suitability models are based on the amount, edge, and core of actual stands classified as nesting/roosting habitat and amount of foraging habitat; i.e., the PCEs identified in this rule. We therefore do not ''wipe out'' the actual stands as suggested by the reviewer, but rather measure their relative importance given additional landscape features such as elevation and slope position. This allowed us to better identify the landscape features where owls could establish a viable territory. Simply mapping out ''the actual stands that might be used'' would have provided a highly fragmented habitat network consisting of many ''stands'' not likely to be used by spotted owls. The comment also ignores the fact that we extensively tested the RHS model and found it accurately predicts spotted owl habitat, and we evaluated the proposed critical habitat network and found that the areas proposed were predominantly occupied by known spotted owl sites at the time of listing. See also our responses to *Comment (19)* through *Comment (24).*

Comment (29): One reviewer stated that Phase 1 results suggested that the Redwood Coast modeling region was among the most stable, but questioned how this could be when there are very few remaining northern spotted owls in Redwood National Park, where barred owls are now the predominate species. The reviewer states this was also not reflected in the Phase 2 modeling results (Table 6) (Dunk *et al.* 2012a).

Our Response: We obtained recent (2006) verified northern spotted owl location data from many sources in the Redwood Coast modeling region. These data strongly suggest that the high densities of barred owls observed within Redwood National Park are not occurring in the remainder of the modeling region, where large numbers of northern spotted owl territories persist. We therefore used demographic data from the Green Diamond monitoring study to parameterize (put variables into) HexSim for the region.

Comment (30): One reviewer suggested that we include an appendix that shows each of the decision points in the development of the proposed critical habitat network in systematic detail, and suggested this would be an adequate remedy and make the entire modeling process open and transparent, and repeatable by persons external to this process.

Our Response: We attempted to make explicit the key assumptions and decision points used in the modeling process, and the guiding principles we followed for application of professional judgment in refining reserve networks were included in the proposed rule. Much of what the reviewer asks for is presented in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011). In addition, we have tried to make assumptions and decision points more explicit in our final Modeling Supplement (Dunk *et al.* 2012b) that is available to the public at *http://www.regulations.gov.*

Comment (31): One reviewer suggested that a major flaw in the modeling is that the habitat is held constant for 350 years and any area with an RHS value less than 35 is assumed to be non-habitat. The reviewer states that by holding the habitat constant and not allowing it to grow, the Service greatly overestimates the amount of land needed to reach relative population levels. The reviewer claims this also results in a double standard for areas currently classified by MaxEnt as having low RHS values—in the modeling process they are excluded and not allowed to grow into habitat, yet they are included as critical habitat because the Service claims they will be necessary for population growth.

Our Response: The reviewer misunderstands the method we used to simulate habitat change through time. Habitat was not held constant during the HexSim simulations; we measured the rates of change in habitat quality (RHS) between the 1996 and 2006 GNN layers and projected those rates into the future. This allowed for losses in habitat quality caused by timber harvest, wildfires, and other causes as well as gains due to forest growth to occur through time in a plausible fashion. Because the remainder of this comment is based on this faulty premise, the other points in this comment are, in turn, unfounded.

Comment (32): One reviewer noted that throughout the modeling process, means of the response variables (e.g., Table 8 of Dunk *et al.* 2012a) should be accompanied by either standard errors or 95 percent confidence intervals. Otherwise, the reviewer states, it is difficult to determine how precise these estimates were, especially when comparing different scenarios.

Our Response: We agree, and this was an oversight that we have corrected in the final version of our Modeling Supplement (Dunk *et al.* 2012b).

Comment (33): One reviewer thought more could have been done to evaluate uncertainty in the original habitat suitability models by running replicate samples in MaxEnt and then capturing the range of variation in resulting habitat designations.

Our Response: Table C–19 in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) presents results from the cross-validation results, in terms of performance differences between models based on replicate samples. Those results showed that there was very little difference between the performance of the models when replicate samples were evaluated, giving us confidence in the generality of our model (that is, the model worked reliably well across a range of situations tested).

Comment (34): One reviewer requested additional sensitivity analysis to quantify the influence of different parameter settings within HexSim on modeled population performance, which would have been particularly useful for evaluating the implications of scientific uncertainty.

Our Response: We agree and in the final Modeling Supplement (Dunk *et al.* 2012b) we have incorporated the results of sensitivity analyses conducted on nine HexSim parameters.

Comment (35): One reviewer noted that the original supplement on habitat modeling that accompanied our proposed rule (Dunk *et al.* 2012a) did not report measures of variance in the population estimates or pseudo-extinction thresholds used to compare habitat network scenarios. The reviewer noted that reporting standard errors or ranges of those population estimates would help in the comparison of the efficacy of different network designs.

Our Response: Our failure to report measures of variation in population estimates was an oversight that we have corrected in the Modeling Supplement (Dunk *et al.* 2012b). The estimated extinction risk thresholds that we reported were the total number of simulations in which that threshold was exceeded (i.e., the population fell below the extinction threshold). It would not be appropriate to provide measures of variation around these. The measure itself is interpreted as the ''probability of exceeding pseudo-extinction threshold X.''

Comment (36): One reviewer noted that model results showed that the barred owl encounter rate can have a disproportionately large influence on persistence outcomes of the HexSim model. The reviewer states that the Service evaluated four barred owl scenarios (Dunk *et al.* 2012a), but none of these considered the more critical survival parameter and the major reductions in adult survival that barred owls generate in the model. Thus, the reviewer states that one is unable to assess the relative contributions of barred owl encounter rates versus barred owl survival reductions to persistence of simulated northern spotted owl populations.

Our Response: In the northern spotted owl HexSim model we used, barred owls only affected northern spotted owl survival, not occupancy or reproduction. Thus, the impact of barred owls in HexSim results is only from their reduction of northern spotted owl survival. Based on advice we obtained from species experts, we limited barred owl impacts on northern spotted owls to survival alone. We did not simulate barred owl impacts on reproduction, territory establishment, site fidelity, or movement behavior. We also did not simulate barred owl predation on northern spotted owl nestlings. This recommendation (to simulate barred owl impacts only on northern spotted owl survival) was a reflection of limitations on rangewide data availability regarding these factors.

Comment (37): One reviewer suggested that we allow the barred owl effect in the HexSim model to vary with resource acquisition class. For example, the barred owl effect on survival might be more severe when an owl is in the ''low'' resource class but incrementally reduced in the medium and high resource classes (i.e., as resources become less limiting so do the negative effects of competition with barred owls).

Our Response: Resource acquisition classes are a component of the HexSim model. In the model, resources available to an owl are a function of the mean RHS value of habitat within its home range and fall into three categories: High, medium, or low (USFWS 2011, p. C–60). This is a good suggestion, and could potentially help refine the HexSim model for the northern spotted owl. It would not, however, improve the model's ability to identify those specific areas that contain the physical or biological features essential to the conservation of the northern spotted owl, or that are essential to the conservation of the species (section

3(5)(a) of the Act). The relative performance of various composite potential critical habitat networks would be unlikely to change if we were to change the analysis as the reviewer suggests, because the proposed change would affect all potential critical habitat networks in the same way. The relative performance of the habitat networks under consideration, which is what we were able to assess (as opposed to absolute outcomes), would therefore remain the same, and our ultimate determination of the critical habitat network that provides what is essential to the conservation of the northern spotted owl in the most efficient design would be unchanged.

Comment (38): One reviewer suggested that modeling of habitat networks should incorporate more realistic encounter rates between northern spotted owls and barred owls, so that estimates of sustainability of northern spotted owl populations are not overly optimistic.

Our Response: As we have noted in both the proposed rule and this rule, the designation of critical habitat is only one of many conservation actions that may contribute to the recovery of the northern spotted owl. The designation of critical habitat is intended to help address habitat-based threats to a listed species; it is not expected to independently lead to recovery absent other actions to ameliorate additional, non-habitat based threats. We are also bound, however, by the statutory definition of critical habitat, which requires that we identify those areas that provide the physical or biological features essential to the conservation of the species, or are otherwise essential (if not occupied at the time of listing). The task of identifying where on the landscape these essential areas lay was complicated by the barred owl, a non-habitat based threat. In some cases, the negative influence of the barred owl on the simulated performance of our modeled northern spotted owl populations completely masked the potential contribution of varying areas of relative habitat suitability, thus rendering it impossible to determine which specific areas provide the essential physical or biological features. Our HexSim modeling suggested that if barred owl encounter rates within each modeling region were to be maintained at their currently estimated rates (from Forsman *et al.* 2011), there was little variation in northern spotted owl population performance among any of the potential critical habitat networks (even doubling the size of the habitat network produced no discernible difference). The only avenue that allowed us to discriminate between potential networks and isolate and evaluate the contribution of specific areas of habitat that are essential to the conservation of the northern spotted owl, as directed by the statute, was to adjust the encounter rates with barred owls to some reasonable level, as might potentially be achieved through management actions. This harkens back to our statement earlier that we do not assume critical habitat will provide for the recovery of the species in a vacuum; rather, we must assume that other recovery actions will occur in coincidence with the protections provided by critical habitat. We assumed changes in barred owl encounter probabilities in our comparisons of potential critical habitat networks that, in our judgment, represented changes that could realistically be achieved with management aimed at reducing encounter rates (and without prescribing the nature of that management). In most cases, only relatively modest changes to the currently estimated encounter probabilities between barred owls and northern spotted owls were required to allow us to discern the underlying differences between varying habitat network designs, and to enable the identification of the specific areas essential to the conservation of the species. In fact, for Phase 2 and 3 modeling (MaxEnt and HexSim; see Dunk *et al.* 2012b for details), we decreased barred owl encounter probabilities in only 3 of 11 modeling regions, and increased encounter probabilities in 8 of 11 modeling regions. The mean absolute value of change (from currently estimated encounter probabilities to what we assumed in Phases 2 and 3) among modeling regions was 0.081 (range = 0.005 (in the KLE) to 0.335 (in the OCR)). Our population performance results do not suggest that the habitat scenarios considered were overly optimistic in regard to sustainability of northern spotted owl populations (Dunk *et al.* 2012b).

Comment (39): One reviewer suggested incorporating the relative probability of controlling barred owls as part of the designation of various critical habitat units. The reviewer noted that to be able to assess habitat factors in the modeling process, the barred owl effect had to be set below known values in selected areas, suggesting that these designated critical habitat units will not contribute to northern spotted owl conservation in the absence of barred owl control. The reviewer further stated that the apparent sensitivity of the HexSim model to the barred owl covariate indicates that barred owl management will be the overriding factor in the success of critical habitat being able to achieve the northern spotted owl recovery goals. The reviewer suggested that if the Service wants to capture uncertainty in this modeling exercise, the probability of controlling barred owl numbers should be factored into the modeling process based on logistical, ownership, and social factors.

Our Response: We agree with the reviewer's suggestions in theory. However, we are unaware of currently available scientific information that would enable us to reliably estimate the influence of ''logistical, ownership, and social factors'' on the probability of effective barred owl control across the range of the northern spotted owl (over 50 million ac (20 million ha)). Lacking any such specific data, such exercise would be arbitrary and speculative, and would likely introduce greater uncertainty into the modeling. We appreciate that the reviewer recognizes the sensitivity of the model to barred owl encounter rates, and the reason why we had to make slight adjustments to those rates in some areas to identify critical habitat for the northern spotted owl (see our response to *Comment (38),* above).

Comment (40): One reviewer indicated that basing the demographic trends on the last meta-analysis (Forsman *et al.* 2011) is overly optimistic since these results are already badly outdated. The reviewer states that the last meta-analysis was conducted after the 2008 field season, with survival rates estimated through 2007 and realized rate of population change through 2006. The reviewer states that, according to personal communications with researchers in other demographic study areas, many of the study areas shown as stable in the 2008 meta-analysis are now in precipitous decline due to rapid increases in barred owl populations. The reviewers suggests that, although it would only be qualitative, the Service could contact the leads from the various northern spotted owl demographic study areas to see if there have been substantial changes in barred owl versus northern spotted owl numbers.

Our Response: This is a good point, and we heard similar comments from several field researchers and principal investigators of the northern spotted owl demographic studies. In Step 3 of the modeling process, we obtained the most recent annual reports from the demographic study areas and evaluated the more recent estimates of barred owl densities, and included a scenario representing high barred owl densities such as those described in this comment. Because we used more recent estimates of barred owl encounter rates, spotted owl population trends simulated in HexSim showed a more rapid decline than that estimated in the recent meta-analysis; this was especially evident in the Tyee demographic study area. We therefore believe that our modeling process incorporated the idea expressed in this comment.

Comment (41): One reviewer indicated that bounding experiments with HexSim are needed to suggest the sort of spatial, temporal, and population controls that may be needed for the barred owls to create a high likelihood of success for critical habitat. The reviewer suggests the Service has thus far determined the barred owl encounter rates that were needed to achieve reasonably stable northern spotted owl population dynamics.

Our Response: This is a good suggestion, but not necessary to identify lands meeting the definition of critical habitat. Because we evaluated northern spotted owl population performance across a gradient of barred owl encounter probabilities ranging from 0.0 to 0.7, our modeling already revealed that northern spotted owls are likely to do very poorly at high barred owl encounter probabilities. This provided a general understanding of the influence of various barred owl encounter rates and demonstrated the range of values (bounds) where population performance that met recovery criteria was possible. This is why we set 0.375 as a ceiling to barred owl encounter probabilities. The reviewer's suggestion is more relevant to the specifics of potential barred owl control efforts, such as have been recommended by the Revised Recovery Plan on an experimental basis (USFWS 2011). The Service is currently considering such efforts and has published an environmental impact statement on experimental barred owl removal options. That is a separate recovery effort, however, is not connected to this rulemaking.

Comment (42): Several reviewers expressed concern that the way that barred owl encounters were represented in the model as homogeneous probabilistic reductions in northern spotted owl survival may fail to capture important spatial patterns of interaction between the species within subregions, and it may overestimate (one reviewer) or underestimate (second reviewer) the negative impacts of barred owls on northern spotted owl population persistence. The reviewers suggested the uncertainty surrounding the specific impacts of barred owls, and the analysis in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl further justify the need for an intensive barred owl removal experiment to understand the overall impact that barred owls are having on northern spotted owls.

Our Response: This point is well taken by the Service. As the reviewer mentioned, ''empirical information required for a realistic representation of barred owl interaction effects across the range of the northern spotted owl is not available at this time.'' The Service did evaluate several different barred owl encounter probabilities, which largely differed among the 11 modeling regions, but were identical within modeling regions. The modeling framework we used is capable of including a spatially explicit barred owl effect, if such specific data should become available. Given the uncertainties about variation in barred owl impacts within modeling regions, it is possible that our modeling overestimated or underestimated negative barred owl impacts. However, because we used HexSim to compare relative population performance among alternative potential critical habitat networks, and used the best available estimates of barred owl effects, we believe the representation of barred owl impacts we used allowed us to accurately evaluate which networks, on a comparative basis, best met the objectives in our guiding principles for identifying lands meeting the definition of critical habitat for the northern spotted owl.

Comment (43): One reviewer believed that the HexSim model was not an appropriate choice for this modeling process because the reviewer indicated it was overly complex, too individually based, and included variables where there was no, little, or very incomplete data, such as territory searching behavior, and floater dynamics, etc. In addition, the reviewer expressed skepticism that the modeling approach used would be repeatable, because of its complexity.

Our Response: We disagree. We have articulated our rationale for using the HexSim model in Appendix C to the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, pp. C–53–C–56) and again in our Modeling Supplement (Dunk *et al.* 2012b). We acknowledge that there are many possible approaches to identifying and evaluating alternative potential critical habitat networks. However, we contend that our approach represents the best available science and is appropriate for identifying areas meeting the definition of critical habitat because it enabled us to evaluate numerous possible networks of habitat and compare simulated population responses of northern spotted owls to environmental conditions in a spatially-explicit manner that enabled us to determine those areas that meet the definition of critical habitat for the species. Our approach is detailed in the section Criteria Used to Identify Critical Habitat, but in brief, the use of HexSim enabled us to evaluate which of the habitat scenarios under consideration had the greatest potential to meet the recovery objectives for the northern spotted owl, based on relative population performance.

To identify the areas that meet the definition of critical habitat for the northern spotted owl, we elected to use a spatially explicit, individual-based modeling approach. We did so because we required an approach that enabled comparison of a wide range of spatially explicit conditions such as variation in habitat conservation networks. Individual-based models allow for the representation of ecological systems in a manner consistent with the way ecologists view such systems as operating. That is, emergent properties such as population increases or declines are the result of a series of effects and interactions operating at the scale of individuals. Individuals select habitat based on what is available to them, disperse as a function of their individual circumstance (age), compete for resources, etc.

Grimm and Railsback (2005) noted that individual-based models need to be simple enough to be practical, but have enough resolution to capture essential structures and processes. We are fortunate to have a tremendous quantity and quality of data available for the northern spotted owl; the species is therefore ideally suited for a spatially-explicit, individual-based model, such as HexSim. While not developed specifically for the northern spotted owl, HexSim (Schumaker 2011) was designed to simulate a population's response to changing on-the-ground conditions by considering how those conditions influence an organism's survival, reproduction, and ability to move around a landscape. We developed a HexSim spotted owl scenario based on the most up-to date demographic data available on spotted owls (Forsman *et al.* 2011), published information on spotted owl dispersal and home range sizes, as well as a variety of other parameters. Evaluation and calibration of the HexSim output included comparison with owl numbers in demographic study areas and dispersal histograms. Based on our assessment of the model, we are confident it performs as intended, in terms of allowing us to reliably assess the relative performance of alternative habitat conservation networks. We further note that the majority of peer reviewers supported the modeling framework we applied in the identification of critical habitat for the northern spotted owl.

Comments on Active Forest Management

Comment (44): Five peer reviewers and numerous public commenters indicated that active forest management should be conducted in areas that are not currently high value for northern spotted owls and in an adaptive management framework given the uncertainties regarding how such management practices will impact northern spotted owls and their prey.

Our Response: The Service expects to support and design, in concert with the BLM, USFS, and researchers, scientific studies on the effects of ecological forestry projects in northern spotted owl critical habitat, to gain a better understanding of the short-term and long-term impacts of these silvicultural treatments on northern spotted owls, their prey and forest vegetative structure. We are currently designing and funding just such a study through Oregon State University for the pilot project in the Middle Applegate Watershed. We expect these types of research studies to inform the design of future ecological forestry projects within the range of the northern spotted owl.

A key difference between using active adaptive forest management to evaluate risks associated with ecological forestry and the Service's ongoing efforts to address risks associated with expanding barred owl populations is that, for barred owls, a single experiment has the potential to address many of the most important uncertainties pertinent to future management, allowing the Service to define a schedule for progress. Addressing uncertainties about ecological forestry will likely require multiple research efforts, each tailored to specifics of different geographic areas and different ecological interactions. Collaboration among programs, similar to the collaboration supporting long-term demographic studies of northern spotted owls, will likely be needed to conduct adaptive management studies of habitat treatments. Integrative initiatives, such as the USFS's Collaborative Forest Landscape Restoration Program, may also play an important role. Adaptive management of ecological forestry techniques will take time, and will require continuation of the ongoing dialogue between researchers and forest management practitioners regarding how to simultaneously meet the goals of forest restoration and northern spotted owl conservation. Coordination among research projects also will be essential to generating reliable information about diverse interactions as efficiently as possible.

Comment (45): One reviewer and a public comment suggested that the emphasis of management within northern spotted owl critical habitat should be on ecological restoration rather than ecological forestry.

Our Response: In general, in northern spotted owl critical habitat, we would like to see land managers consider activities to restore and maintain northern spotted owl habitat and the natural ecological processes (e.g., fire regime, natural vegetational succession patterns, etc.) of the owl's forest ecosystems. However, we also recognize that ecological restoration, in and of itself, is often not the management goal of all lands included in critical habitat. This critical habitat rule does not dictate what land managers do on Federal State, or private lands. However, in areas where land managers are considering competing land management goals (e.g., northern spotted owl habitat conservation vs. commercial timber harvest), we encourage them to consider an ecological forestry approach to better meet the needs of the northern spotted owl, the goals of the land managers, and long-term forest health. As described in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), the field of ''ecological forestry'' is emerging as a dominant paradigm of forest management; related to this emergence are concepts such as ''natural disturbance emulation'' and ''retention forestry'' (see, e.g., Gustafsson *et al.* 2012, entire; Franklin *et al.* 2007, entire; Kuuluvainen and Grenfell 2012, entire; North and Keeton 2008; Long 2009, entire; Lindenmayer *et al.* 2012; entire). The Service believes that application of these ecological forestry goals and principles, including those generally described in Johnson and Franklin (2009, entire; 2012, entire), may result, in some situations, in fewer adverse impacts to northern spotted owl critical habitat when compared to application of traditional silviculture as currently applied or permitted on private, State, and Federal matrix lands.

Comment (46): Several reviewers commented that studies have demonstrated negative effects of forest thinning on northern spotted owls and their prey, and expressed concern that negative effects of these practices may be further exacerbated by barred owls. These reviewers were uneasy with such types of activities occurring near owl territories, and recommended that if conducted, these actions be done at small scales and be subject to rigorous scientific scrutiny.

Our Response: We are not recommending that commercial thinning or other treatments be conducted near active owl territories or in good quality owl habitat. We also encourage an active adaptive forest management approach to improve the understanding about effects of ecological forestry approaches on northern spotted owl, barred owls, and other species of concern.

Comment (47): Three reviewers recommended that we give full consideration to recent publications of Hessburg *et al.* (2007) and Baker (2012) for guidance on how to restore and manage dry forests in the eastern Cascades.

Our Response: Both this final critical habitat rule and the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) cite Hessburg *et al.* (2007, p. 21), and we continue to recommend land managers consider their findings and recommendations regarding dry forest management within the range of the northern spotted owl. Since publication of the proposed critical habitat rule, we have reviewed Baker (2012, entire) as well as many other recently published studies addressing forest health and the risk of wildfire in the Pacific Northwest. We acknowledge some of the conclusions of Baker (2012, p. 21) and Williams and Baker (2012, p. 9) that portions of the dry forests of the Pacific Northwest experienced high-severity fires as well as mixed and low-severity fires. However, we also acknowledge the conclusions of many other researchers that large areas within the range of the owl that once burned frequently with low-moderate intensity regimes are currently outside of historical conditions (cited below). A variety of management measures (e.g., prescribed fire, mechanical treatment, etc.) can be considered in such areas where the goal is to influence wildfires to reduce adverse impacts of climate change, manage forest carbon levels, reduce fire severity and retain desirable forest conditions (i.e., conserve older trees), or protect high-value wildlife habitats (including northern spotted owls), riparian areas, and biodiversity (Davis *et al.* 2012, entire; Stephens *et al.* 2009, p.310–318; Stephens *et al.* 2012a, p. 12; Stephens *et al.* 2012b, entire; Chmura *et al.* 2012, p. 1134; Syphard *et al.* 2011,

p. 381; Safford *et al.* 2012, pp. 26–27; Roloff *et al.* 2012, pp. 7–9, Roberts *et al.* 2011, p. 617, Messier *et al.* 2012, pp. 67–70; Franklin *et al.* 2008, p. 46; Ager *et al.* 2007, pp. 53–55).

Such management considerations are completely consistent with the intent of the NWFP (Standards and Guidelines, p. C–12—C–13). We continue to recommend that land managers carefully distinguish and target areas that are high priority for ecological restoration (e.g., Franklin *et al.* 2008, p. 46; Schoennagel and Nelson 2011, entire; Ager *et al.* 2012, p. 280), and that they also minimize short-term impacts to northern spotted owls to the greatest possible extent. We suggest using a process such as provided by Spies *et al.* (2012, entire) to help prioritize actions and consider tradeoffs such as northern spotted owl conservation, restoration of ecological conditions, and other land management goals. Given the wide geographic area of this critical habitat designation and the variety of landscape conditions and fire regimes, more precise planning and implementation should be done at the appropriate landscape scales such as the National Forest scale, consistent with the goals of the Northwest Forest Plan.

Comment (48): One reviewer and a public comment recommended that the Johnson and Franklin (2009) ecological forestry framework should not be used because it is based on the wrong reference framework.

Our Response: While we recognize that there is some scientific disagreement about the specific ecological forestry practices recommended by Drs. Johnson and Franklin,we believe the commenters may have misinterpreted our references to this unpublished report. First, Johnson and Franklin (2009) is only referenced three times in the final critical habitat rule: Once as a general reference for ecological forestry, once in relation to how active management is generally not necessary to maintain old growth conditions in moist forests, and again to highlight that alteration of fuel loads in moist forest could have undesirable ecological consequences and thus should be discouraged. Second, we continue to encourage forest land managers to consider the application of ecological forestry principles to their commercial timber harvest (see response to peer review question 4a-c, above), and we believe that application of these principles in many instances may result in better long-term ecological conditions for northern spotted owls and other forest wildlife when compared to the application of traditional silviculture methods. The methods presented by Johnson and Franklin (2009) are one example of how ecological forestry can be applied. We recognize that there are a variety of approaches, and the best management practices for any area are highly dependent on site-specific conditions.

Comment (49): One reviewer recommended a zoning process for determining where active management would be appropriate. Such a zoning process would include identification of areas where management is not needed or should be avoided, areas where future habitat could be enhanced by treatment, and areas where management is needed to meet broader landscape goals. In addition, monitoring and reporting of progress towards desired goals is essential if this strategy is to be successful.

Our Response: The Service supports the concept of land managers identifying areas where active management would be appropriate on the lands under their jurisdiction. However, it is not appropriate for this critical habitat rule to attempt to do this; it should be done by land managers consistent with their planning procedures. As the reviewer also suggested, these details will need to be worked out at regional scales and planning levels (see response to peer review comment 4, above). Several examples of strategies for prioritizing landscapes for management treatment in eastern Washington include Davis *et al.* (2012, entire) and Franklin *et al.* (2008, pg. 46).

Comment (50): One reviewer encouraged the Service to recognize the highly transient nature of grand fir on the eastern Cascades.

Our Response: We have recognized this in the rule. While we did not explicitly identify all forest types in all regions, we have recognized the patchy and transient nature of east Cascades forests.

Comment (51): One reviewer asked that we identify which (specific) ecological processes will be enhanced by management and how management will be coordinated across large landscapes.

Our Response: We agree that additional guidance and coordination among management agencies would be helpful to coordinate landscape-level planning; however, such guidance and coordination is beyond the scope of this rulemaking. To the extent possible we have provided additional detail regarding restoration and management of ecological processes in revisions to the following sections of this rule: *An Ecosystem-based Approach to the Conservation of the Northern Spotted Owl and Managing Its Critical Habitat, Special Management Considerations or Protections,* and *Determination of Adverse Effects and Application of the ''Adverse Modification'' Standard.*

Comment (52): There were a number of general comments about analysis of fire risk and ecological benefits of contemporary fire regimes in dry and mixed-severity forests.

Our Response: The issue of forest health and fire risk in the Pacific Northwest is complex, and there is a wide variety of legitimate scientific viewpoints on forest management in the face of uncertainty. Although some scientists do not believe management intervention is appropriate and advocate a mostly passive (i.e., hands-off) approach to forest ecosystem management, many others believe science-based intervention is necessary to restore and maintain important ecological processes and components of biodiversity, including the northern spotted owl.

We agree with the majority of scientists who suggest that forest ecosystems at global, national, and regional levels are undergoing significant changes due to climate change and past management activities (Collins *et al.* 2012, pp. 8–12; Miller *et al.,* 2012, p. 201; Miller *et al.,* 2009, p. 28; Moritz *et al.* 2012, entire; Westerling *et al.* 2011, p. S459; Marlon *et al.* 2012, p. E541). Impacts from wildfire, changes in precipitation, insect and invasive weed outbreaks, and forest disease appear to be increasing when compared to historic patterns and are putting some components of native biodiversity at risk (Perry *et al.* 2011, p. 712). Although some researchers disagree on the magnitude of these changes and what to do about them (e.g., Hanson *et al.* 2009, p. 5; Baker 2012, p. 21; Williams and Baker 2012, p. 9; Dillon *et al.* pp. 18–20), our review of the recent scientific literature found that most researchers believe that changes in wildfire frequency, severity, and total burned area are occurring or are expected to varying degrees in the Pacific Northwest. Most of these researchers recommend consideration of certain types of active management responses to achieve goals such as increasing forest resilience to climate change, conserving extant biodiversity, and reducing wildfire severity (e.g., Stephens *et al.* 2009, pp. 316–318; Safford *et al.* 2012, pp. 26–27; Messier *et al.* 2012, p. 69; Hessburg *et al.* 2007, entire; Chmura *et al.* 2012, p. 1134; Stephens *et al.* 2012b, pp. 557–558; Fule *et al.* 2012, p. 76; Halofsky *et al.,* pp. 15–16; Reinhardt *et al.* 2008, pp. 2003–2004; Heyerdahl *et* *al.* 2008, p. 47; Latta *et al.* 2010; Littell *et al.* 2009, pp. 1018–1019, Littell *et al.* 2010, p. 154; Spies *et al.* 2010, entire). Several of these studies identify the potential for degraded ecological conditions and increased fire risk to affect northern spotted owls (Buchanan 2009, pp. 114–115; Healey *et al.* 2008, pp. 1117–1118; Roloff *et al.* 2012, pp. 8–9; Ager *et al.* 2007, pp. 53–55; Ager *et al.* 2012, pp. 279–282; Franklin *et al.* 2009, p. 46; Kennedy and Wimberly 2009, pp. 564–565). We recommend that these issues related to active management in dry forests be considered by Federal land managers as they follow the direction on pages C–12 and C–13 of the Northwest Forest Plan Standards and Guidelines.

Comment (53): One reviewer recommended that the Service prepare a draft environmental impact statement (DEIS) under NEPA with regard to active management in northern spotted owl critical habitat.

Our Response: This rule revises the critical habitat designation for the northern spotted owl by identifying those specific areas that meet the definition of critical habitat for the species. It does not take any action or adopt any policy, plan, or program related to active forest management. The only effect of critical habitat is that Federal agencies must consult with the Service on their activities that may affect designated northern spotted owl critical habitat, and our discussion of active forest management is not intended in any way to prescribe or mandate the types of activities Federal agencies must submit for consultation. It is provided only for Federal, State, local, and private land managers to consider as they make decisions on the management of forest land under their jurisdictions and through their normal processes.

Comment (54): One reviewer criticized the proposed rule for promoting ecological forestry for economic and political reasons rather than basing recommendations on sound science.

Our Response: We disagree. We have included a discussion of ecological forestry principles because, in many instances, it may represent a reasonable and solid scientific approach to managing forest ecosystems where multiple—and sometimes competing—management goals need to be reconciled or accommodated (see, e.g., Gustafsson *et al.* 2012, entire; Franklin *et al.* 2007, entire; Kuuluvainen and Grenfell 2012, entire; North and Keeton 2008, entire; Long 2009, entire; Lindenmayer *et al.* 2012, entire). Our primary goal in this critical habitat designation is to identify the specific areas that meet the definition of critical habitat for the northern spotted owl. In addition, we identify those types of measures that promote the conservation of critical habitat, identify special management measures that may be needed within critical habitat, and identify activities that may affect or adversely modify critical habitat. Our overall emphasis in this designation is clearly on the maintenance and restoration of northern spotted owl habitat, but we also provide general guidance for consideration by land managers on what types of activities may affect northern spotted owl habitat and how to minimize the adverse impacts of those activities. Reference to the principles of ecological forestry as a suggestion for land managers to consider is a scientifically appropriate way to help achieve this goal, and is consistent with the recommendations of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), as well as the Standards and Guidelines of the NWFP (e.g., USDA and USDI 1994, p. A–1, Standards and Guidelines, pp. C–12, C–13).

Comment (55): A number of reviewers submitted line-specific edits and revisions.

Our Response: These revisions have been made to the text, where appropriate.

Comments From Federal Agencies

Comment (56): The USFS and several public commenters supported the inclusion of congressionally reserved areas including Wilderness Areas, National Parks, and similar lands for a variety of reasons, including accurately reflecting the area contributing toward recovery, highlighting the conservation value and role of this minimally managed habitat, and to encourage barred owl and other needed management activities.

Our Response: National parks, wilderness areas, and similar lands provide large areas of high-quality habitat for the northern spotted owl. All congressionally reserved lands (e.g., wilderness areas, national parks) proposed for designation have been excluded in this final designation of critical habitat. We agree that such areas play an important role in the conservation of the northern spotted owl under their current management. However, their current conservation value is so great that we could not find any minimal benefits of including them in that outweighed the relatively minor administrative costs of including them in critical habitat, therefore the benefits of excluding them outweighed the benefits of including them. In addition, exclusion of these lands will have no negative conservation impact on their future management and they will continue to function as intended for spotted owl recovery.

Comment (57): The Bureau of Land Management (BLM) and several public commenters identified specific concerns with the proposed critical habitat maps, including revisions to land ownership or management on both public and private land, and questions regarding the mapping scale and resolution. Several commenters submitted revised or corrected maps for the Service to consider in developing the final rule.

Our Response: We thank the commenters for the information provided. We have replaced the NWFP ownership designations used on the proposed critical habitat map with an updated BLM ownership map to correct many errors. In cases where mapping errors may have been made in our proposed critical habitat, such errors were corrected.

Comment (58): The BLM requested we provide maximum clarity with regard to the Act's section 7 consultation process in an effort to reduce the cost and burden of the consultation process.

Our Response: We have provided background and information to help the Federal action agencies assess whether their projects ''may affect'' proposed northern spotted owl critical habitat, the standard to determine whether consultation is required. If further clarification is needed, the Service is glad to provide action agencies with technical assistance to help determine whether or not their proposed action has the potential to affect critical habitat.

Comment (59): The BLM requested additional clarification about how the proposed critical habitat sought to ''ensure sufficient spatial redundancy in Critical Habitat within each recovery unit,'' and the purpose and expectations for these inclusions.

Our Response: In the development of habitat conservation networks, the intent of spatial redundancy is to increase the likelihood that the network and populations can sustain habitat losses by inclusion of multiple populations unlikely to be affected by a single disturbance event. This is essential to the conservation of the northern spotted owl because disturbance events such as fire can potentially remove large areas of habitat with negative consequences for northern spotted owls. Redundancy provides a type of ''emergency back-up'' system to sustain populations in the wake of such events. While the modeling and evaluation process used by the Service did not formally analyze redundancy, we incorporated spatial redundancy at two scales: By (1) making critical habitat subunits large enough to support multiple groups of owl sites; and (2) distributing multiple critical habitat subunits within a single geographic region. This was particularly the case in the fire-prone Klamath and Eastern Cascades portions of the range.

Comment (60): The BLM provided additional data and mapping layers as well as an alternative approach for designating critical habitat on public lands.

Our Response: Through a series of meetings and work sessions, the Service has reviewed the materials provided by the BLM, and we evaluated and incorporated many of their suggested changes, where appropriate and consistent with our criteria for identifying critical habitat, in developing the final critical habitat designation. Based on BLM's suggestions, we removed relatively small areas of lower quality habitat that had been included in proposed critical habitat and added in relatively small areas of high-quality habitat that improved connectivity or created larger habitat blocks.

Comments From State Agencies

Comment (61): Washington DFW requested that the rule clarify the extent to which management actions with short-term negative impacts to northern spotted owl habitat is consistent with the recovery needs of the northern spotted owl, particularly in areas of Washington State where northern spotted owl populations are greatly depressed.

Our Response: Each situation should be considered on a case-by-case basis, but, generally, actions that have short-term negative impacts may be consistent with the recovery needs of northern spotted owl when the intent of the action is (1) to improve long-term conditions for the species or (2) to improve the overall condition of the ecosystem. It could be argued either that where populations are greatly depressed there is more need for these actions or, conversely, that there is less flexibility to conduct these actions depending on the specifics of the action and the habitat needs of the owl in that area. These are issues that must be addressed in consultation and through the level one team process; assessing that level of detail is beyond the scope of this rulemaking. We have revised the rule (see section: An Ecosystem-based Approach to the Conservation of the Northern Spotted Owl and Managing Its Critical Habitat) to provide additional suggestions regarding what management actions may benefit northern spotted owls and what actions are unlikely to do so. Additional guidance is available in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011).

Comment (62): The Washington Department of Fish and Wildlife supported a coordinated and strategic management plan for dry forest landscapes and expressed a need for the critical habitat rule to consider coordination to implement effective management, reduce conflict, and explore the possibility of Federal funding for landscape strategies.

Our Response: The landscape assessment approach for the East Cascades provides the best basis for development of strategies to manage dry forest landscapes. Products of the landscape assessment can be used to describe the rationale for management actions. The Service is available to work with land managers to assist in the development and implementation of landscape assessments, but this rule does not mandate any specific management within the critical habitat network, which would be beyond the scope of this rulemaking.

Comment (63): Several State and public commenters disagreed with the need to include private lands (and in some cases State lands) in the final rule for a variety of reasons. The commenters did not provide specific information on any particular lands, but provided general reasons that they thought the broad categories of private and State lands should be excluded from the final designation, including concerns of economic issues, uncertainty, private land stewardship, added regulatory burdens (including a disproportionate burden on small landowners), reduction in land value, State land overlays, consistency with existing laws and policy, potential disincentives for conservation or negative impacts to habitat, the need to maintain partnerships with landowners, the need to develop incentives for conservation partnerships, the need to compensate for lack of land use, the need to focus protections on public lands, the lack of notification of private landowners by the Service about the proposed rule, concern that designation penalizes landowners who have retained suitable habitat, and a lack of need for or benefits from additional protections. One commenter suggested that Congress intended the Federal agencies to acquire any private or State lands that are designated as critical habitat.

Our Response: We recognize that the greatest benefit of critical habitat may be realized on actively-managed Federal lands, since the regulatory effect of critical habitat is the requirement that Federal agencies ensure that any actions that they carry out, fund, or authorize do not destroy or adversely modify designated critical habitat. In addition, Federal agencies have a mandate under section 7(a)(1) of the Act to carry out programs for the conservation of endangered species and threatened species. For these reasons, we looked first to Federal lands for the critical habitat essential to the conservation of the northern spotted owl, as described in the section Criteria Used to Identify Critical Habitat and supporting methodology (Dunk *et al.* 2012b).

Section 3(5)(A) of the Act states that critical habitat is defined as (1) the specific areas within the geographical area occupied by the species at the time it was listed that provide the physical or biological features essential to the conservation of the species and which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it was listed, upon a determination by the Secretary that such areas are essential for the conservation of the species. Further, section 4(b)(2) of the Act mandates that such determinations shall be made on the basis of the best scientific data available and after taking into consideration the economic impact, the impact on national security, and any other relevant impact, of specifying any particular area as critical habitat.

The language of the Act does not restrict the designation of critical habitat to specific land ownership such as Federal lands; thus, lands of all ownerships are considered if they meet the definition of critical habitat. Areas may be excluded from the final designation if the Secretary finds that the benefits of exclusion outweigh the benefits of inclusion under section 4(b)(2) of the Act, or if we determine, based on public comment or other information received following the issuance of the proposed rule, that such areas do not meet the definition of critical habitat (for example, areas that were occupied at the time of listing but do not provide the essential physical or biological features, or areas that may not have been occupied at the time of listing and were proposed for designation, but are not essential to the conservation of the species).

As described in the proposed rule (March 8, 2012; 77 FR 14076, p. 14099), we evaluated critical habitat scenarios that prioritized Federal lands first as well as scenarios without regard to land ownership in determining what is essential to the northern spotted owl. In all cases, if the scenarios under consideration provided equal contribution to recovery, we chose the scenario that prioritized publicly owned lands. State and private lands were included only if they were essential to the conservation of the species (i.e., were determined to have been occupied at the time of listing and contain the physical or biological features essential to northern spotted owl conservation or may have been unoccupied at the time of listing but are essential to the conservation of the owl). However, based on information received during the public comment period, in several cases we refined the critical habitat boundaries to remove areas of private lands that we determined do not meet the criteria and therefore do not meet the definition of critical habitat. In other instances, the Secretary has chosen to exert his discretion to exclude lands, including private lands, based on a careful weighing and balancing of the benefits of inclusion versus the benefits of exclusion, as provided in section 4(b)(2) of the Act, including consideration of conservation agreements, such as HCPs or SHAs, and the Service's desire to support existing and effective State conservation programs (see Exclusions). However, such exclusion does not indicate that these areas are not essential for the conservation of the species, only that the benefits of exclusion outweigh those of inclusion.

We retained some State-owned lands in all three states included in this critical habitat designation. In general we retained these lands because we found they provided essential contributions to the conservation of spotted owls, especially in terms of complementing the distribution of habitat on Federal lands or filling gaps in Federal ownership. We also found that the benefits of inclusion associated with public education and raising State and local agency awareness of the conservation needs of spotted owls outweighed anticipated minor increases in regulatory requirements, when Federal involvement occurred. See Changes from the Proposed Rule for more information on State lands retained in the final critical habitat designation.

The Service does not compensate private or State landowners for perceived limitations on land use associated with critical habitat designation. Designation of private or other non-Federal lands as critical habitat has no regulatory impact on the use of that land unless there is Federal involvement in proposed management activities. Identifying non-Federal lands that are essential to the conservation of a species alerts State and local government agencies and private landowners to the value of habitat on their lands, and may promote conservation partnerships. There is no indication that Congress intended the Service to acquire all private and State property that is essential to the conservation of listed species and designated as critical habitat.

We provided advance public notice of the proposed rule to revise critical habitat for the northern spotted owl through several avenues. Notice was provided with publication of the proposed rule in the **Federal Register** on March 8, 2012 (77 FR 14062) as well as through numerous local press releases at that time. In addition, notice of public information meetings in each of the three States affected by the proposed rule, as well as a public hearing, was published in the **Federal Register** on May 8, 2012 (77 FR 27010) and again on June 1, 2012 (77 FR 32483); the meetings and hearing were also announced in newspapers of local circulation in the affected areas.

Comment (64): Numerous commenters (State and public) requested that the final rule exclude lands already covered by conservation agreements, such as habitat conservation plans and safe harbor agreements, for a variety of reasons, including concerns about additional or duplicative Federal overlays and regulatory burdens, a lack of need for inclusion, policy consistency, the potential for designation to jeopardize existing agreements or remove incentives for additional conservation, and a recognition of the past conservation benefits of these voluntary agreements. In addition, it is argued that there is no need for an additional Federal overlay on lands that already have conservation designations or governing regulations such as parks, wilderness areas, HCPs, SHAs, and State forest practices rules.

Our Response: Please see our response to *Comment (63),* above. As described, we individually evaluated each conservation agreement in place within the proposed critical habitat designation, including State and private lands with HCPs, SHAs, conservation easements, or other established conservation partnerships. Following a careful weighing of the benefits of exclusion versus inclusion, the Secretary has chosen to exert his discretion to exclude lands covered by such agreements. In addition, the Secretary has chosen to exclude all congressionally-reserved natural areas (wilderness areas, national parks), State parks, and private lands from the final designation. Please see the Exclusions section of this document for details of the analyses that led to the exclusion of these areas from the final designation.

Comment (65): Numerous State commenters (CALFIRE, Oregon Department of Forestry, Washington Department of Fish and Wildlife, Washington Department of Natural Resources), Federal (USFS, BLM), and public commenters disagreed with the need to include public lands including Federal lands (e.g., ''matrix'' land, adaptive management areas, experimental forests, O&C Lands, and congressionally reserved wilderness areas, national scenic areas, and national parks), State lands (e.g., State parks, State forests, State forest trust lands), and county lands in the final rule for a variety of reasons, including additional and redundant regulatory burdens and requirements, economic and social impacts, potential inconsistency with existing laws and policy, existing protections, a lack of additional conservation benefits, limits on research or needed management activities (e.g., fuel reduction, restoration, or insect control), mapping errors, insufficient justification supporting inclusion, and potential disincentives for preserving habitat.

On the other hand, numerous commenters (both from other State agencies, as well as the public) supported the inclusion of public lands including Federal lands, State lands, tribal lands, and county lands for a variety of reasons, highlighting the conservation the value of this habitat, consistency with the best available science, the need for increased protections in some lands, and the realization there would be limited to no impacts to management.

Our Response: The critical habitat designation includes those lands that meet the definition of critical habitat in the Act, and which the Service has determined are essential to provide for the conservation of the northern spotted owl. In designating these lands, we have further considered their ownership, management, contribution to northern spotted owl conservation, existing protections, economic impacts, and other relevant factors, and determined it is appropriate and necessary to include them in the final critical habitat network to best ensure successful northern spotted owl conservation.

Where possible we prioritized the inclusion of Federal lands over other land ownerships, but where Federal lands were sparse or nonexistent we incorporated other ownerships in order to design and designate an effective critical habitat network. As noted in our response to *Comment 64,* in cases where our analysis of the benefits of exclusion outweighed those of inclusion, such as when conservation agreements and partnerships have been developed with the Service, we have excluded State or other public lands from the final designation (see Exclusions).

Our proposed rule (77 FR 10462; March 8, 2012) identified several different possible outcomes of that proposed revision, depending on various areas considered for exclusion. Among the exclusions of public lands under consideration were all congressionally-reserved natural areas and all State lands. Of the congressionally-reserved natural areas under consideration, we have excluded all congressionally-reserved natural areas and State Parks from this final designation (see Exclusions). In addition, private lands were also excluded, following a careful analysis of the benefits of inclusion versus exclusion. In other cases, lands were retained in the final designation for a variety of reasons; for lands that were considered or proposed for exclusion, but not excluded in this final designation, those decisions are described in the section Changes from the Proposed Rule.

We recognize the concern over the inclusion of certain Federal lands in the designation of critical habitat for the northern spotted owl, and particularly of lands in the matrix land use allocation or the O&C lands. As described in the section Criteria Used to Identify Critical Habitat and elsewhere in this rule, we looked to Federal lands first for the conservation of the northern spotted owl, in part because Federal agencies have a statutory mandate to contribute to the conservation of listed species. Secondly, because the protections of critical habitat are triggered only in the case of a Federal nexus, those protections are always in place on Federal lands; thus the benefit of including Federal lands in critical habitat can potentially be significant. Finally, we only included lands in the designation if they meet the definition of critical habitat; that is, if they play a truly essential role in the conservation of the species. In some areas, for example the O&C lands, our modeling results indicated that those Federal lands make a significant contribution toward meeting the conservation objectives for the northern spotted owl in that region, and that we cannot attain recovery without them. Likewise, in addition to our modeling results, peer review of both the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as well as our proposed rule to revise critical habitat, suggested that retention of high quality habitat in the matrix is essential for the conservation of the species. Population performance based on reserves under the NWFP, for example, fared very poorly compared to this final designation of critical habitat. As described in the section Changes from the Proposed Rule, we tested possible habitat networks without many of these matrix lands, which resulted in a significant increase in the risk of extinction for the northern spotted owl.

Similarly, for the reasons outlined above, we have retained experimental forests on Forest Service lands in critical habitat. This designation includes areas within seven Forest Service experimental forests: H.J. Andrews Experimental Forest, Pringle Falls Experimental Forest, South Umpqua Experimental Forest, and Cascade Head Experimental Forest in Oregon; Wind River Experimental Forest and Entiat Experimental Forest in Washington; and Yurok Redwood Experimental Forest in California. Three of these seven experimental forests are already included in the 2008 critical habitat designation. Our evaluation of these seven experimental forests demonstrates that these areas contain high value occupied habitat for northern spotted owls within their borders. In many cases, the habitat in these experimental forests represents essentially an island of high value habitat in a larger landscape of relatively low value habitat; this is especially true in the Coast Range, a region where peer reviewers particularly noted a need for greater connectivity and preservation of any remaining high quality habitat. These considerations, in conjunction with the inherent benefits of critical habitat on Federal lands, described above, lead us to conclude that there are significant benefits to the inclusion of these experimental forests in critical habitat. As discussed earlier in this document, we recognize the valuable role of these experimental forests, and we encourage continued research and adaptive management on these forests. All of these forests are occupied by the northern spotted owl and we are already consulting with the Forest Service in these areas under the jeopardy standard. The incremental impact of critical habitat is therefore limited to the cost of consultation for the additional adverse modification analysis and any potential project modifications to avoid adverse modification or destruction, if needed; we did not consider the benefit of avoiding these costs through exclusion to outweigh the benefits of inclusion for these areas. As noted in this document, we fully support the research activities in these experimental forests and intend to continue working cooperatively with the Forest Service to ensure the successful continuation of their scientific mission in these areas.

In sum, the best scientific information available indicates that the Federal lands we have included in this final designation are essential to the conservation of the species, and we have retained such areas in the final designation.

Comment (66): Several State and public commenters noted that the northern spotted owl critical habitat designation includes areas of younger forest that may not include the PCEs, and questioned whether this was an artifact of the modeling process or an intentional inclusion of lands for the future development of PCEs and expansion of the northern spotted owl population, as stated in the rule.

Our Response: The essential conservation goal of the critical habitat network is to provide for a stable or increasing northern spotted owl population trend, which we determine will result from, in part, the retention of existing high-value habitat and the development of additional habitat to support more northern spotted owls than currently exist. Some areas of younger forest that do not currently contain all of the PCEs are essential for this purpose. In such cases, we evaluated these areas as if they were unoccupied at the time of listing, and included them in the designation only if we determined that they are essential to the conservation of the species.

Comment (67): Several commenters (State and public) identified specific concerns with the proposed critical habitat maps, including revisions to land ownership or management on both public and private land, noting the inadvertent inclusion of some lands that did not meet the definition of critical habitat and questions regarding the mapping scale and resolution. Several commenters submitted revised or corrected maps for the Service to consider in developing the final rule.

Our Response: We thank the commenters for the information provided. Numerous edits and changes were made to the maps in the final rule, where appropriate, including assessment of specific lands identified to determine whether they met the definition of critical habitat. For example, in the State of Washington, we determined that many small woodlot owners possess lands that do not provide the PCEs for the northern spotted owl, or that the lands initially identified in the proposed rule are too fragmented or isolated to be essential to the conservation of the species (see *Comment (107)*); such lands were removed from the final designation because they do not meet the definition of critical habitat. In several cases, landowners contacted us and asked for the exclusion of their lands, but we determined that those landowners were not included in the proposed critical habitat. In some cases, changes have been addressed narratively (e.g., the clarification that no private lands in Oregon met the definition of critical habitat and, therefore, were not included in the proposed rule and are not included in the final designation). In cases where mapping errors may have been made in our proposed critical habitat, such errors were corrected.

Comment (68): Several State, Federal (USFS and BLM), and public commenters requested clarification on the implementation of, or modification of, the 500-ac (200-ha) circle we recommended for assessing the effects of an action to critical habitat.

Our Response: Based on both public and agency comment and requests for clarification, the final rule does not identify the 500-acre (200-ha) circle as a recommended scale for determining the effects of an action, but does reference it as a potentially useful scale that could be used in the section 7consultation process. How to best apply it, or other potential scales, will be determined during the consultation process initiated by Federal action agencies proposing projects that may affect areas designated as critical habitat by this rule.

Comment (69): Several State and public commenters questioned the relationship of the impact of barred owl competition on the northern spotted owls, and amount of habitat needed in the critical habitat designation and whether recovery can be achieved without addressing the impacts of the barred owl. Some of these commenters believe barred owl management should occur prior to designation of additional critical habitat areas.

Our Response: The survival of northern spotted owls depends in large part on the protection of habitat. This protection remains crucial to the recovery of the northern spotted owl regardless of whether barred owls are present or not. However, given that barred owls and northern spotted owls are now occupying similar habitats, it is essential to maintain sufficient habitat that meets the needs of northern spotted owls. The extent to which northern spotted owls persist (sometimes undetected) on areas with high barred owl densities is unclear; however, with a second species competing for similar habitat, providing more of that habitat is predicted to increase the ability for northern spotted owls to persist in the presence of barred owls. We identified critical habitat for the northern spotted owl with this essential need in mind. The potential management of barred owls is beyond the scope of this rulemaking, which is limited to the identification of critical habitat for the northern spotted owl. If management of barred owls is implemented and assessed, as is currently occurring under a separate process, the Service may reconsider this critical habitat designation and revise as appropriate.

Comment (70): Two comments suggested the definition of northern spotted owl habitat and patterns of habitat use were inadequate.

Our Response: Northern Spotted owls require areas that are primarily closed canopy with sufficient roost sites and small mammal populations to provide prey. Descriptions of these habitats vary across the range of the species, beyond the simple categories of moist and dry forest, making a specific definition at the landscape scale problematic. In developing the final critical habitat designation for the species, we have provided what we believe are the most specific and useful descriptions of the PCEs for northern spotted owls possible, based on the best scientific information available at this time. We have and will continue to seek new, more detailed information on habitat use over time.

Comment (71): A number of comments (State and public) encouraged an ecosystem approach to land management.

Our Response: The designation of critical habitat for the northern spotted owl is consistent with the NWFP and the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), both of which take an ecosystem approach to management and recovery actions. The requirement of any such management approach, however, is beyond the scope of this rulemaking, which is limited to the identification of critical habitat for the northern spotted owl.

Comment (72): Several comments (State and public) suggested approaches that provide incentives for landowners to conserve habitat.

Our Response: The Service administers several programs promoting incentive-based conservation efforts on non-Federal land (e.g., Safe Harbor Agreements, Habitat Conservation Plans, and Partners for Fish and Wildlife agreements). We highly encourage landowners to explore opportunities to participate in these and other conservation programs.

Comment (73): The Washington Department of Natural Resources suggested the Service better align designated critical habitat with the agency's management objectives, to more efficiently manage for northern spotted owl conservation.

Our Response: California, Oregon, and Washington have their own natural resource management paradigms; we intend to work with each State within the context of their management objectives to protect northern spotted owl critical habitat and work together toward the recovery of the species.

County Comments

Comment (74): Jefferson County, Washington, requested that we apply critical habitat protections to a considerable amount of owl habitat, and suggested considering additional habitat designations between the Olympics and the Cascade Mountains, in order to increase connectivity and ensure owl recovery.

Our Response: In our process of identifying areas that meet the definition of critical habitat for the northern spotted owl, we identified a critical habitat network that provides the essential life-history functions for the northern spotted owl, including demographic support and connectivity between populations. Our modeling results indicate the spatial extent of the critical habitat designation throughout the range, including between the Olympic Peninsula and the Western Cascades in Washington is sufficient to meet essential recovery requirements. Other areas outside the designation, such as those suggested by the county, do not meet the definition of critical habitat because they are not essential to the conservation of the species, even though we agree with the county that these lands are important and will increase connectivity.

Comment (75): Wasco County, Oregon, commented that it was in the interest of the community to minimize regulatory burdens from designated critical habitat.

Our Response: We recognize that the designation of critical habitat is often perceived as a potential regulatory burden. However, we wish to reiterate that the regulatory effect of critical habitat is the requirement for Federal agencies to consult with the Service on actions they carry out, fund, or authorize that may affect the designated critical habitat of threatened species or endangered species. Critical habitat does not directly impose regulatory restrictions on State land managers or on private landowners where there is no such Federal nexus. We do not believe the designation of critical habitat will result in a significant regulatory burden on Federal land activities because of (1) the cooperative nature of our consultation process under the Act with the Forest Service and BLM, and (2) because of the existing requirement that these agencies have to consult on the effects of proposed actions on northern spotted owls. Our approach was to design a critical habitat network that provides for essential northern spotted owl recovery needs but designate as small an area as possible, and to rely primarily on public lands. We have excluded all congressionally-reserved natural areas (wilderness areas, national parks), State parks, and private lands from this final designation of critical habitat.

Comment (76): Del Norte County, California, expressed concern that the proposed critical habitat designation will create a regulatory hurdle that will impede the construction of vital infrastructure projects (roads, bridges, power lines, and other utilities).

Our Response: Chapter 7 of the DEA discusses the potential economic impacts to road and bridge construction and maintenance, and installation and maintenance of power transmission lines and other utility pipelines. The analysis concludes that all potential conservation efforts associated with linear projects are expected to result from the presence of the northern spotted owl, not the designation of critical habitat, and are thus considered baseline impacts (see paragraphs 315 through 320 of the DEA). Incremental costs attributable to critical habitat are limited to the administrative costs of additional staff time spent by Federal agency staff and the Service to include critical habitat effects analyses in the section 7 consultation on these projects. Therefore, we do not believe that the designation of critical habitat for the northern spotted owl will result in significant regulatory burden to these projects.

Comment (77): Del Norte County, California; Wasco County, Oregon; and Klickitat and Skamania Counties, Washington, requested exclusion of all lands including Federal, State, and private lands within these counties in the final rule. They expressed concern regarding economic issues, a lack of appropriate northern spotted owl habitat within the counties, a lack of evidence that including these lands would actually help the species recover or avoid extinction, and a lack of need for or benefits from additional protections due to existing standards and guidelines.

Our Response: The critical habitat designation includes those lands the Service determined are essential to provide for the conservation of the northern spotted owl through a state-of-the-art modeling process that incorporated the latest expert knowledge on the habitat needs of northern spotted owls. In designating these lands we have considered their ownership, management, contribution to northern spotted owl conservation, existing protections, economic impacts, etc., and determined it is appropriate and necessary to include them in the final critical habitat network to best ensure successful northern spotted owl conservation. Each of these counties contains habitat that supports northern spotted owl populations that are essential to the conservation of the species.

We recognize that the greatest benefit of critical habitat is realized on Federal lands since the regulatory effect of critical habitat is the requirement that Federal agencies ensure that any actions that they carry out, fund, or authorize do not destroy or adversely affect designated critical habitat. In addition, Federal agencies have a mandate under section 7(a)(1) of the Act to carry out programs for the conservation of endangered species and threatened species. For these reasons, we looked first to Federal lands for the critical habitat essential to the conservation of the northern spotted owl, as described in Criteria Used to Identify Critical Habitat, above, and supporting methodology (Dunk *et al.* 2012b).

Section 3(5)(A) of the Act states that critical habitat is defined as (1) the specific areas within the geographical area occupied by the species at the time it was listed that contain the physical or biological features essential to the conservation of the species and which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it was listed, upon a determination by the Secretary that such areas are essential for the conservation of the species. Further, section 4(b)(2) of the Act mandates that such determinations shall be made on the basis of the best scientific data available and after taking into consideration the economic impact, the impact on national security, and any other relevant impact of specifying any particular area as critical habitat.

The language of the Act does not restrict the designation of critical habitat to specific land ownership such as Federal lands; thus, lands of all ownerships are considered if they satisfy the scientific criteria indicating that they meet the definition of critical habitat for the specific species. Areas may be removed from the final designation should the Secretary exercise his discretion to exclude such areas subsequent to a weighing of the benefits of exclusion versus inclusion under section 4(b)(2), or if we should determine, based on public comment or other information received following the issuance of the proposed rule, that such areas do not meet the definition of critical habitat (for example, areas that were occupied at the time of listing but do not provide the essential physical or biological features, or areas that may not have been occupied at the time of listing and were proposed for designation, but are not essential to the conservation of the species).

As described in the proposed rule (March 8, 2012; 77 FR 14076, p. 14099), we evaluated critical habitat scenarios that prioritized Federal lands first as well as scenarios without regard to landownership. In all cases, if the scenarios under consideration provided equal contribution to recovery, we chose the scenario that prioritized publicly owned lands. State and private lands were included only if they were essential to achieve conservation of the species after considering the contribution of Federal lands. Based on information received during the public comment period, in several cases we refined the critical habitat boundaries to remove areas of private lands that do not meet our criteria for critical habitat (for example, new information indicating that the areas in question lack the PCEs, due to recent timber harvest, stand-replacing fires, or other such events). In others, the Secretary has chosen to exclude lands from the designation. In such cases, exclusion does not signal a determination that these areas are not essential to the conservation of the species, but only that the Secretary has determined that the benefits of exclusion outweigh those of inclusion. All congressionally-reserved natural areas (wilderness areas, national parks), State parks, and private lands have been excluded from this final designation of critical habitat for the northern spotted owl (see Exclusions).

We reduced critical habitat in all four of these counties across all ownerships as we refined our proposal. In response to comments, we used additional information sources to very carefully identify and retain areas that were best suited to meeting the unique conservation needs for northern spotted owl conservation that are associated with the geographic location of these counties.

The Columbia River, which forms the southern boundaries of Skamania and Klickitat counties, presents a formidable obstacle to dispersal of northern spotted owls. Maintaining demographic exchange between northern spotted owl populations in Washington and Oregon requires both maintenance of a robust population of potentially dispersing owls, and quality habitat as near to the Columbia River as possible to increase the likelihood of dispersing owls successfully crossing the river. Critical habitat in Skamania and Klickitat counties plays a key role in preventing the demographic isolation of Washington spotted owls, and preventing isolation is widely recognized as an essential feature of sustaining wildlife populations. The designated lands in Wasco County, Oregon, contribute to this cross-Columbia River connection, as well as providing sites for northern spotted owl reproduction. In Del Norte County, California, designated lands contribute to demographic support to the overall northern spotted owl population, but also function for connectivity across the landscape and for habitat that can be colonized by young owls. In short, the designated lands in all these counties are part of a network that supports northern spotted owl sites for reproduction, habitat available for colonization by young, and habitat that connects populations across the range of the species, all of which are, in concert, essential to provide for the conservation of the species.

Our economic analysis indicated that Del Norte and Skamania counties may be more sensitive to future changes in timber harvests, industry employment, and Federal land payments, due to recent socioeconomic trends. Timber harvest changes related to critical habitat designation are one potential aspect of this sensitivity. Between 1989 and 2009, timber industry employment declined by 70 percent or more in Del Norte and Skamania counties. These counties also experienced the greatest declines in timber harvests and timber industry employment. Skamania County is also highly reliant on Federal payments to counties, with these payments representing between 26 and 50 percent of total revenues. We considered all these factors while evaluating comments from these counties.

The potential impact of the designation of critical habitat on timber harvest levels, and whether that change will be positive or negative, is uncertain. Therefore, how critical habitat designation may impact the timber industry in terms of future harvest levels, employment, and revenue-sharing payments to counties is also uncertain. As outlined in the economic analysis timber harvest may increase, decrease or stay substantially the same as recent timber harvest levels depending on how the Forest Service and BLM decide to manage their lands within the designation. Furthermore, timber industry employment is affected not only by harvest trends but also by fluctuations in national and international markets; changes in land ownership; and increasing mechanization and productivity in the industry. Our economic analysis also indicated the potential for beneficial economic and ancillary effects of spotted owl conservation due to critical habitat designation, but monetizing effects such as improved water quality and aesthetic improvements remains challenging. Finally, our analysis of the incremental impacts of critical habitat designation suggested that the annual administrative costs associated with designation were likely to be relatively low.

Our weighing of the relative benefits of inclusion in critical habitat integrated (1) the relative sensitivity of counties to economic impacts associated with critical habitat designation, (2) uncertainty regarding potential economic effects, (3) our expectation that incremental administrative costs may be minor, and (4) modeling results that indicated essential conservation functions of habitat in these counties. Based on these factors the Secretary has chosen not to exert his discretion to exclude these lands from critical habitat.

Comment (78): Del Norte County, California, requested that the Service exclude all congressionally reserved areas from critical habitat.

Our Response: All congressionally reserved natural areas have been excluded from this final designation of critical habitat, as described in the Exclusions section of this document.

Comment (79): One commenter stated that the O&C Act limits the authority of the Service in designating critical habitat.

Our Response: The O&C Act (pertaining to lands in Oregon and California) does not limit the Service's authority to designate critical habitat for the northern spotted owl. The designation of critical habitat is not a land use allocation and does not impose management prescriptions. Under section 7(a)(2) of the Act, each Federal agency must insure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of the designated ''critical habitat'' of the species. 16 U.S.C. 1536(a)(2). To help action agencies comply with this provision, section 7 of the Act and the implementing regulations set out a detailed consultation process for determining the impacts of a proposed activity on species listed as threatened or endangered, or its designated ''critical habitat.'' 16 U.S.C. 1536; 50 CFR part 402. In *Seattle Audubon Society* v. *Lyons* (''*Lyons''*), 871 F. Supp. 1291 (W.D. Wash. 1994), the district court held that ''the O&[C Act] does not allow the BLM to avoid its conservation duties under NEPA or the Act * * *'' *Id.* at 1314. The critical habitat designation does not preclude the sustained-yield timber management of O&C lands consistent with the above requirements of the Act.

Comment (80): One commenter stated that the Service failed to explain why revising the designation of critical habitat for the northern spotted owl is ''exempt'' under sections 2 and 3 of the Executive Order 13132 on Federalism.

Our Response: We have complied with E.O. 13132 by explaining why the rule does not have federalism implications, impose substantial direct compliance costs on State and local governments, or preempt State law so that a federalism summary impact statement pursuant to section 6 of the executive order is not required. The designation of critical habitat directly affects only the responsibilities of Federal agencies through section 7(a)(2) of the Act. The Act does not directly impose other duties with respect to critical habitat on either States or local governments and as a result does not have substantial direct effects on the States and local governments, the relationship between the national government and the States, or the distribution of powers and responsibilities among the various levels of government. Sections 2 and 3 of E.O. 13132 set out Fundamental Federalism Principles and Federalism Policymaking Criteria, respectively. Within the framework of the Act, which requires the Service to designate critical habitat to the maximum extent prudent and determinable, we have adhered to the concepts discussed in these sections. For example, even though the rule does not have federalism implications, we strongly urged the States and county governments to provide comments to us and provided them an additional period for comment to ensure they had an opportunity for thorough review. Our economic analysis examined potential indirect impacts of the rule on all who may participate in section 7 consultations, and that was available for comment by the States and counties as well. In addition, we have also taken into account State law protections for northern spotted owl critical habitat in our decisions whether to exclude areas under section 4(b)(2) of the Act.

Comment (81): Several counties, including Del Norte County, California, and Wasco County, Oregon, expressed concerns about the impact of barred owls on the northern spotted owl, and questioned whether recovery can be achieved without addressing the impacts of the barred owl. Some of these commenters believe barred owl management should occur prior to designation of additional critical habitat areas.

Our Response: The survival of northern spotted owls depends in large part on the protection of habitat—this protection remains crucial to the recovery of the northern spotted owl regardless of whether barred owls are present or not. Given that barred owls and northern spotted owls are now occupying similar habitats, it is essential to maintain sufficient habitat that meets the needs of northern spotted owls. The extent to which northern spotted owls persist (sometimes undetected) on areas with high barred owl densities is unclear. With a second species competing for similar habitat, providing more of that habitat may increase the ability for northern spotted owls to persist in the presence of barred owls. If management of barred owls is implemented and assessed, the Service may reconsider this critical habitat designation and revise as appropriate.

In our separate actions investigating possible barred owl management, we can, and are, modeling some approaches with and without barred owl competition effects on the northern spotted owl, and will continue to do so as new information becomes available. Recent research (Wiens 2012) indicates that population performance of both northern spotted owls and barred owls is greatest when high-quality habitat is most abundant, and most peer reviewers supported the approach of conserving more habitat to help offset the impact of the barred owl on the northern spotted owl.

County Comments on Active Management and Fire Management

Comment (82): Several counties including Wasco County, Oregon, and Del Norte County, California, requested that the Service promote active management activities within critical habitat to reduce fire risk and reduce fuels, and raised the concern that critical habitat designation could reduce or delay the ability of land managers to manage fuels and thus increase risks from wildfire.

Our Response: This rule does not establish management prescriptions for lands designated as critical habitat. However, the Service has made considerable effort to discuss, for the benefit of land managers, potential approaches to active forest management in dry forests, including actions that manage fuels and restore ecosystem health. We encourage land managers to consider active management of their forests that balances short-term impacts with long-term beneficial effects that ultimately support long-term conservation of the northern spotted owl. In dry forests, this could include using a landscape assessment approach to improve the estimation of effects of management actions on northern spotted owl habitat and to better identify and prioritize areas for treatments. The assessment may be used to provide support and rationale for treatment, especially in areas where active forest management actions appear to be in conflict with the conservation of high-value northern spotted owl habitat.

The draft economic analysis (DEA) addressed the potential impacts of critical habitat on fire management in Chapters 4 and 8. In Chapter 4, the DEA discussed the fact that ecological fire salvage activities could result in incremental economic effects. Due to data limitations and fire location uncertainty, however, these effects were not quantified. In the benefits discussion in Chapter 8, the DEA recognized that it is possible that the designation could result in increased resiliency of timber stands associated with improved timber management practices, such as thinning, partial cutting, and active adaptive forest management and monitoring. These efforts may reduce the threat of catastrophic events such as wildfire, drought, and insect damage. This in turn may generate benefits in the form of reduced property damage.

Comment (83): Jefferson County, Washington, encouraged the Service to determine adverse modification at a finer scale, such as the owl's home range.

Our Response: The final rule establishes that the scale of the adverse modification determination will be ''the entire designated critical habitat, as described below, with consideration given to the need to conserve viable populations within each of the physiographic provinces identified in the Revised Recovery Plan (USFWS 2011, Recovery Criterion 2).'' The Service believes the entire designated critical habitat is the appropriate scale for this analysis because our determination is whether implementation of the Federal action would preclude the critical habitat from serving its intended conservation function or purpose. That conservation role of critical habitat is to conserve the listed species throughout its range, which is closely aligned with the entire critical habitat designation. Therefore, the entire designation is the most appropriate scale for the adverse modification determination. However, a proposed action that compromises the capability of a subunit or unit to fulfill its intended conservation function or purpose (e.g., demographic, genetic, or distributional support for spotted owl recovery) could represent an appreciable reduction in the conservation value of the entire designated critical habitat.

Comment (84): Wasco County, Oregon, requested that the Service do an Environmental Impact Statement to ensure a full analysis of the effects of the critical habitat designation has been done, including a fuller picture of potential economic and social impacts.

Our Response: The critical habitat proposal was fully compliant with NEPA. Economic and social effects are not intended by themselves to require preparation of an environmental impact statement. 40 CFR 1508.14. We have determined, for the reasons contained in our Finding of No Significance, that an environmental impact statement is not necessary.

Comment (85): Klickitat County, Washington, asserts that the Service has not adequately considered ''forest vulnerabilities'' and potential economic impacts to local communities, and is inconsistent with the Presidential Memorandum to the Secretary of the Interior dated February 28, 2012.

Our Response: We disagree with the assertion that the Service has not adequately considered ''forest vulnerabilities'' in this designation of critical habitat. If we correctly understand ''forest vulnerabilities'' to include all those natural and human induced disturbance processes that have the potential to change the structure and function of forests, these factors played a prominent role in our entire approach to this designation. We believe this rule, along with the Revised Recovery Plan for the Northern Spotted Owl, provides a thorough explanation of how past management and future disturbance can affect habitat quality for spotted owls, and especially how ecological forestry might be used to manage these effects.

The purpose of the economic analysis is to provide the Secretary of the Interior with information to consider potential economic impacts and analyze whether the benefits of excluding a particular area may outweigh the benefits of including that particular area as critical habitat based on potential disproportionate economic impacts. Chapter 6 of the FEA provides a detailed socioeconomic profile of each of the 23 counties (including Klickitat County, Washington) containing proposed critical habitat subunits. The analysis presents data on the percent change in timber production between 1990 and 2010 for each county, and on the percent growth of annual industry employment between 1989 and 2009 for each county. In addition, the analysis presents data on Federal land payments to each of the 23 counties as a percent of the total local government revenue in FY 2009, demonstrating the relative importance of these funds to each County's budget. We find the information provides sufficient context for understanding relative economic circumstances and the potential incremental impacts of the designation to local communities across the designation.

The section ''Consistency with Presidential Directive'' in our Executive Summary describes how we have addressed the points raised in President Obama's Memorandum of February 28, 2012.

Comment (86): Jefferson County, Washington, encouraged the Service to consider the effects of critical habitat designation on ecosystem services, such as drinking water, hunting and fishing, carbon storage, and erosion and flood control.

Our Response: The Service recognizes that much attention has been paid nationally and globally to valuing ecosystem services provided by landscapes. Published, peer-reviewed studies provide information on values of multiple categories of ecosystem services (e.g., agricultural production, water quality regulation, carbon storage and sequestration, recreation, aesthetic values, etc.) across a variety of land use types (e.g., wetlands, forests, etc.). Over the past 20 years, multiple studies have relied on this literature to develop large-scale benefits transfer analyses in order to estimate a total value of a parcel of land, a watershed, a State, or even the planet (e.g., Costanza 1997, as described in the comment letter). We believe that improving native ecosystems is a benefit to the species that rely on them, is consistent with the goal of the Act and will improve all these ecosystem functions.

Public Comments

Active Forest Management

Comment (87): One commenter agreed that the Service is not able to predict the outcome of section 7 consultations, but expressed concern that land management decisions would be made, using the critical habitat rule for justification of these outcomes. A suggestion was made to eliminate or modify portions of the critical habitat rule that encourage active management within critical habitat.

Our Response: The Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) and the NWFP recommends certain types of active forest management within the range of the northern spotted owl to meet various management goals. Our critical habitat rule refers to these recommendations. The Revised Recovery Plan encourages careful consideration and incorporation of specific and appropriate information when deciding which actions, if any, are appropriate for active forest management within critical habitat. However, we are not able to predict where or what types of actions will be proposed within northern spotted owl critical habitat, nor is it within the authority of this rulemaking to prescribe where or what types of actions will take place. The actual management activities that may take place within critical habitat will depend on future management decisions by the land managing agencies consistent with their land use plans and the legal authorities under which they operate, and in consultation with us under section 7 of the Act for those activities involving a Federal nexus.

Comment (88): Several commenters raised concern over the creation of early-seral habitats. The points raised a concern over the removal of current habitat to create early-seral habitat, expressed a need to make use of natural disturbances to achieve early-seral habitat, and questioned the appropriateness of creating early-seral habitat inside critical habitat.

Our Response: Recent research has informed land managers on the biological value of complex early-seral habitats. The Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) suggests that management of early-seral habitats be considered where they are underrepresented and would improve landscape and biological diversity. Within that context, thinning and targeted variable-retention harvest in moist forests could be considered, where the conservation of complex early-seral forest habitat is a management goal. This approach provides a contrast to traditional clear-cutting that does not mimic natural disturbance or create viable early-seral communities that grow into high-quality habitat (Dodson *et al.* 2012, p. 353; Franklin *et al.* 2002, p. 419; Swanson *et al.* 2011, p. 123; Kane *et al.* 2011, pp. 2289–2290; Betts *et al.* 2010, p. 2127, Hagar 2007, pp. 117–118). Swanson (2012, entire) provides a good overview and some management considerations. The Revised Recovery Plan does not suggest that high-quality owl habitat or areas currently on a trajectory to become high-quality owl habitat be removed to create early-seral conditions. The Revised Recovery Plan recommends such treatments, if considered by the land management agencies, be applied in matrix areas consistent with the Standards and Guidelines of the NWFP.

Comment (89): One commenter asked how the Service and managers will evaluate forest management strategies without information on the potential effects of these strategies to determine whether they are positive, neutral, or negative.

Our Response: Commercial thinning has been shown to negatively affect northern spotted owls and their prey, and we have included a more detailed discussion of this issue in the final rule. In areas where active management may be appropriate for consideration, the goal is to conserve and restore ecological function; however, we recognize that management agencies may have multiple management goals. In areas where actions such as commercial thinning may be considered (e.g., the matrix land use allocation), we are not encouraging them in areas of high-quality owl habitat.

Comment (90): One commenter requested consideration of the forest thinning direction contained in *Ecologically Appropriate Restoration Thinning in the Northwest Forest Plan Area* (Kerr 2012) as an option for future critical habitat management.

Our Response: We appreciate this suggestion and have integrated the information in this reference into our discussions of forest thinning.

Comment (91): One commenter requested that special management considerations for the East Cascades emphasize management for well-distributed, large, contiguous blocks habitat across the landscape.

Our Response: Special Management Considerations for the East Cascades are identified that management may be required to address the threats to the essential physical or biological features in this region from past activities. Widespread management of large, fully contiguous blocks of habitat east of the Cascades is not ecologically sustainable in many places, due to the dynamic ecological processes and fire regimes that shape the distribution of forested habitats in this region (Williams 2012, entire). We do, however, recommend land managers consider the conservation of larger blocks of current habitat on areas of landscapes where it is more likely to be resistant or resilient to fire and other natural disturbance. We encourage the use of landscape assessments to identify areas important for ecological process restoration and areas that are valuable for northern spotted owl conservation and recovery (see, e.g., NWFP Standards and Guidelines p. C–13).

Comment (92): One commenter noted that the Service should emphasize protection of mid-seral forests so that they may develop into high-quality habitat.

Our Response: We recommend that habitats with high value to the conservation of the northern spotted owl be conserved. High-value habitat includes mid-seral forests as one component. Mid-seral forests that are generally not occupied by northern spotted owls, however, may be appropriate areas for land management agencies to consider for active forest management that may increase their rate of development into high-quality habitats.

Comment (93): One commenter noted that past active management resulted in excessive logging and road building, which led to the threatened and endangered status of species in the Pacific Northwest. Included in this comment are concerns over active management harming water quality, diminishing recreational activities, and increasing fire risk if followup actions (e.g., removal of slash, removal of burn piles, prescribed fire) are not carried out.

Our Response: We have identified the major threats to owl recovery in this rule, including traditional timber harvest that resulted in the removal of large areas of old forest. Active management, in general, may affect water quality and recreational opportunities, but it may also restore habitat conditions or reduce fire risk if implemented properly. We encourage land managers to be mindful of these concerns and to protect important areas from long-term adverse impacts wherever possible.

Comment (94): Several commenters expressed concern that logging in critical habitat and LSRs would increase the risk of extinction of the northern spotted owl, degrade owl habitat, increase the risk of fire, damage forest health, and damage watershed health. Commenters expressed concern about specific logging prescriptions that appear to remove trees or degrade areas that could function as habitat for northern spotted owl, such as mistletoe removal, post-fire logging, or disease management activities. In addition, several thousand commenters submitted similar comments in general support of protections against logging the mature and old-growth forests of the Pacific Northwest and Northwest California due to economic and environmental benefits.

Our Response: The critical habitat rule identifies habitats with high value to the recovery of the northern spotted owl that are essential and will receive regulatory protections under section 7 of the Act where a Federal nexus exists. We emphasize that careful consideration should be given to any forest management activities occurring within northern spotted owl critical habitat. The Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) indicates that active forest management, when applied at appropriate scales and locations, could be a valuable tool in the recovery of the species and conservation of forest ecosystems. Further, we recommend that the focus of these treatments be outside of high-value habitat for northern spotted owls wherever possible and that high-quality habitats be conserved and recruited. Work inside of LSRs should be in accordance with the NWFP Standards and Guidelines. We again note that, although we encourage land management agencies to follow the recommendations for the Revised Recovery Plan for the Northern Spotted Owl, it is beyond the authority of this rulemaking to mandate specific management activities within critical habitat. The actual management activities that may take place within critical habitat will depend on future management decisions by the land managing agencies consistent with their land use plans and the legal authorities under which they operate.

Comment (95): One commenter suggested our treatment of the effects of forest thinning on owls and of fire was incomplete and biased towards supporting thinning treatments in critical habitat.

Our Response: We recognize that more research would be helpful to better understand how northern spotted owls respond to various vegetation management treatments, especially those implemented to address long-term forest health and increasing risk of wildfire. Thinning and other vegetation management may have either negative or beneficial impacts to northern spotted owl habitat depending on how, when, and where the treatments are implemented.

The existing information about the tradeoffs associated with active and passive management in dry forests indicates that strategic application of active management may offer a higher likelihood of achieving conservation objectives than no management. Although passive management can be viewed as more precautionary, this view is rooted in a perspective that considers risks to northern spotted owl habitat from natural disturbance to be relatively low. However, we believe that the weight of evidence from both tracking of habitat removal due to natural disturbance and results from modeled simulations of fire dynamics suggest that risks of habitat loss due to natural disturbance is high enough to warrant consideration of strategic active management within critical habitat by land managers, especially in forested plant associations that typically have frequent or mixed-severity fire regimes (Buchanan 2009, pp. 114–115; Healey *et al.* 2008, pp. 1117–1118; Roloff *et al.* 2012, pp. 8–9; Ager *et al.* 2007, pp. 53–55; Ager *et al.* 2012, pp. 279–282; Franklin *et al.* 2009, p. 46; Kennedy and Wimberly 2009, pp. 564–565). In the final rule, we have refined and expanded our discussion of ways land managers might implement active management to minimize potential risks to northern spotted owls and their habitat, and provide appropriate safeguards in the face of scientific uncertainties surrounding disturbance dynamics in dry forests and northern spotted owl responses to management. In addition, active adaptive forest management may prove to be an essential tool for reducing uncertainties and increasing the conservation effectiveness of active management for northern spotted owl habitat.

Comment (96): Several commenters expressed concern over the justification of projects that encourage timber harvest in suitable northern spotted owl habitat, including the pilot projects guided by Drs. Johnson and Franklin that are occurring in BLM's pilot projects out of the Roseburg and Coos Bay BLM offices.

Our Response: The Service is working with land managers and scientists to minimize impacts to northern spotted owl's essential habitat, and owl conservation as a consequence of timber harvest and other vegetation management projects. We worked closely with Dr. Norm Johnson, Dr. Jerry Franklin, and the Roseburg and Coos Bay BLM offices to evaluate these pilot projects, which are not in LSRs and are consistent with requirements of the NWFP. The Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) recommends applying ecological forestry techniques as a way of reducing impacts to northern spotted owl habitat in areas proposed for timber harvest. In general, northern spotted owl habitat in moist forests that is on a trajectory for development into late-successional conditions is not in need of active management to enhance its development. The Service recommends that land managers consider thinning and other regular management in critical habitat, when the goal is to improve or maintain northern spotted owl habitat and long-term forest health. Specific conditions vary as will determinations of where, when and how to apply management. The actual management activities that may take place within critical habitat will depend on future management decisions by the land managing agencies consistent with their land use plans and the legal authorities under which they operate, and in consultation with us under section 7 of the Act for those activities involving a Federal nexus.

Comment (97): Several commenters suggested that the Service should include a full analysis of the risks to northern spotted owl habitat from fire, in an effort to support the recommendations for active forest management, and should also include an analysis of the effects to northern spotted owl habitat from post-fire logging activities in the final rule.

Our Response: First, we must clarify that this critical habitat rule does not take any action or adopt any policy, plan, or program in relation to active forest management. The discussion is provided only for consideration by Federal, State, local, and private land managers, as well as the public, as they make decisions on the management of forest land under their jurisdictions and through their normal processes. Second, there is considerable scientific uncertainty over the risk of fire to northern spotted owl habitat. Where data are available, the literature shows that high-severity fire and increased frequency of fire may be a risk to the nesting function of northern spotted owl habitat (e.g., Kennedy and Wimberly 2009, p. 565). The literature so far is unclear, not only on how much high-severity fire may be a risk to northern spotted owls, but also regarding what spatial arrangement and amount of burned and unburned vegetation or different burn severities may be beneficial or detrimental to northern spotted owl occupancy and habitat use. We address this issue in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), in which we also suggested an adaptive management framework to test hypotheses that will help address this uncertainty. Recovery Action 12 in the Revised Recovery Plan summarizes the literature on post-fire logging and recommends that these types of silvicultural activities focus on conserving and restoring those habitat elements that take a long time to develop (e.g., large trees, medium and large snags, downed wood).

Comments on Ecological Forestry

Comment (98): One commenter noted that the Service is promoting timber harvest activities that are compatible with northern spotted owl critical habitat, but regulations prevent this work from occurring.

Our Response: We believe the activities recommended in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) and discussed in this critical habitat rule are compatible with the Standards and Guidelines of the NWFP. We encourage land management agencies to consider active management of forests that balance short-term impacts with long-term beneficial effects that ultimately support long-term conservation of the northern spotted owl.

Comment (99): One commenter noted that ecological forestry practices are not clearly defined and according to the rule will be different in each situation.

Our Response: Land management decisions on when and where to apply ecological forestry practices are context-specific, based on local conditions, and will be made by the appropriate land managers. The prescription of specific management practices is beyond the authority of this rule. This critical habitat rule and the Revised Recovery Plan (USFWS 2011, entire) provide an overview and multiple scientific references on ecological forestry. We are available to work with land managers to provide technical assistance in further defining ecological forestry practices at finer scales, should land managers be interested in applying such techniques.

Comment (100): Several commenters raised concerns that critical habitat designation would reduce or delay the ability of land managers to manage fuels, that more implementation of fuels reduction activities are needed, that fire resiliency needs to be achieved, and that we consider timber and nontimber resources to manage fuels.

Our Response: The Service has made considerable effort to discuss recommendations and descriptions of active forest management in dry forests, including actions that manage fuels and restore ecosystem health, in this critical habitat rule. This rule is different from previous designations of northern spotted owl critical habitat in that we are recommending a ''hands on'' approach to forest management within critical habitat. We encourage land managers to consider active management of forests that balance short-term impacts with long-term beneficial effects, which ultimately supports long-term conservation of the northern spotted owl. In dry forests, we recommend that land managers consider a landscape assessment approach to improve the estimation of effects of management actions on northern spotted owl habitat and to better identify and prioritize areas for treatments. The assessment may be helpful, especially in areas where other landscape or biodiversity management goals may conflict with the conservation of high-value northern spotted owl habitat. We note that this rule can only provide general advice as to those activities that may be consistent with the designation of critical habitat for the northern spotted owl. The actual activities proposed within critical habitat are dependent upon decisions by the land managers themselves, in accordance with their land use plans and legal authorities.

Comments on Exclusions

Comment (101): Several comments questioned why the proposed critical habitat did not include private lands in Oregon but did in Washington or California, and encouraged the Service to exclude private lands in all three States in the final rule, due to concerns around the regulatory burdens of critical habitat and the lack of need for additional protections, in light of existing conservation agreements and State laws.

Our Response: In this designation of critical habitat, we relied on public lands to the maximum extent possible in determining what lands met the definition of critical habitat in that they either contain essential physical or biological features or are themselves essential for the species' conservation. We looked first to Federal lands for critical habitat; however, in areas of limited Federal ownership, some State and private lands provide areas determined to be essential to the northern spotted owl, by contributing to demographic support and connectivity to facilitate dispersal and colonization. State and private lands were included only where essential to achieve conservation of the species, and State lands were prioritized over private lands. In Oregon, Federal and State lands identified were sufficient to meet the conservation needs of the owl; in Washington and California, there were some areas where Federal and State lands were not sufficient to meet the population metrics essential to recovery for the species, and some private lands were identified as essential for contributing to the conservation of the species. These private lands were subsequently excluded from the final designation under section 4(b)(2) of the Act (see Exclusions). As discussed in our response to *Comment (104),* such exclusion does not signal that these lands are not important for the conservation of the northern spotted owl, but only that the Secretary has determined that the benefits of excluding these areas outweighs the benefits of including them.

We received several comments from private landowners expressing concern that their land uses would be restricted by the designation of critical habitat, or that jobs would be lost if critical habitat is designated on private lands. Some landowners were under the false impression that their access to Federal funds would be restricted, or that they would be unable to complete forest health improvement projects on their lands if critical habitat were designated there. We reiterate that the regulatory effect of critical habitat is the requirement for Federal agencies to consult with the Service on actions they carry out, fund, or authorize that may affect the designated critical habitat of endangered or threatened species. Activities can continue on private lands with critical habitat in place; it is only if Federal funding or permits are required that the Federal agency involved would need to consult with the Service to insure that the proposed action does not destroy or adversely modify critical habitat. However, as a consequence of the exclusion of all private lands from this final designation of critical habitat for the northern spotted owl, concerns such as those expressed above should be moot.

Comment (102): One commenter expressed concern about the potential impact of designating critical habitat on private lands related to the California Environmental Quality Act (CEQA) regulations, and cited to the marbled murrelet, California red-legged frog, California tiger salamander, and western snowy plovers as examples of increased regulatory impact resulting from critical habitat designation.

Our Response: Our economic analysis concluded that private lands in California and subject to CEQA must comply with the California Forest Practice Rules already in place, regardless of critical habitat. Further, the economic analysis reports that CALFIRE is unlikely to request additional protective measures for habitat beyond those already required by these regulations. Subsequently, we conclude the incremental costs of the designation would be limited to the potential for additional administrative burden under CEQA (IEC 2012b, p. 5–19).

The only other potential regulatory impact to private landowners which we would foresee from the designation of northern spotted owl critical habitat may occur when a proposed project has a Federal nexus (e.g., Federal funding or authorization) and the project may affect designated critical habitat. However, as all private lands have been excluded from this final designation of critical habitat, this should no longer be a concern.

The Service is unaware that the designation of critical habitat for the marbled murrelet, California red-legged frog, California tiger salamander, or the western snowy plover has led to any increase in regulatory impacts to private landowners. While private landowners may have experienced an increased regulatory burden with the listing of these species under the Endangered Species Act, we are not aware of an increased regulatory impact associated with the designation of critical habitat for these species.

Comment (103): One commenter expressed concern that the regulatory burden imposed by critical habitat designation on private lands in California will be exacerbated, because the Service is no longer providing technical assistance for California forest landowners who wish to prepare State-required timber harvest plans.

Our Response: We believe the commenter was mistaken in stating that the Service is no longer available to assist private landowners in the preparation of timber harvest plans in California, as the Service's technical assistance program is still operational and available to assist private landowners in this regard. The Service does not review every timber harvest plan, but is available for review when requested after the initial review by CALFIRE. In addition, since all private lands have been excluded from this final designation of critical habitat, the concern regarding potential exacerbation of regulatory burden is no longer relevant.

Comment (104): Numerous commenters supported including private lands, and urged the Service not to exclude these areas in the final rule for a variety of reasons, including the conservation value of including all lands identified as suitable habitat, the need for connectivity, existing management flexibility and a lack of additional regulatory burden, the opportunity to build cooperative management agreements, and concerns that exclusion is not supported by the best available science and would signal that these lands are not important to the recovery of the species.

Our Response: The Act specifically requires the Service to designate critical habitat for listed species to the maximum extent prudent and determinable, and does not restrict such designation to particular land ownership. Rather, areas that meet the definition of critical habitat, as determined on the basis of the best scientific data available, are proposed for designation. However, section 4(b)(2) of the Act further provides that the Secretary, in designating critical habitat and making revisions, shall take into consideration the economic impact, the impact on national security, and any other relevant impact of specifying any particular area as critical habitat. The Secretary may then choose to exercise his discretion to exclude any area from critical habitat if he determines that the benefit of exclusion outweighs the benefits of specifying such areas as part of the critical habitat, unless that exclusion would result in the extinction of the species.

Lands excluded under section 4(b)(2) are still considered essential to the conservation of the species. Such areas were identified as critical habitat because they either provide the essential physical or biological features, if occupied, or were otherwise determined to be essential, if unoccupied. Exclusion should never be interpreted as meaning that such areas are unimportant to the conservation of the species. Exclusion is based upon a determination by the Secretary that the benefit of excluding these essential areas outweighs the benefit of including them in critical habitat.

In this case, the Secretary has chosen to exercise his discretion to exclude non-Federal lands from the final designation of critical habitat if an existing conservation agreement or partnership is in place that provides benefits that are greater than the benefits that would be provided by the designation of critical habitat. Such exclusions have only been made following a careful weighing of both the benefits of inclusion and the benefits of exclusion. We wish to emphasize that the exclusion of lands from the critical habitat designation should not be construed as a message that these lands are not important or essential for the conservation of the northern spotted owl, nor should exclusion be interpreted as some indication that these lands are now somehow subject to habitat degradation or destruction because they are not included in critical habitat. Lands excluded on the basis of conservation agreements and the recognition of conservation partnerships are fully expected to continue to make an important contribution to the conservation and recovery of the owl absent the designation of critical habitat. Such lands are excluded only if we have evidence that such expectations for future contributions of the habitat on these lands are well-founded, as evidenced by a conservation easement, habitat conservation plan, safe harbor agreement, or other instrument, or by a proven track record of conservation by the partner in question. The details of our considered analyses of each area under consideration for exclusion are provided in the Exclusions section of this document (above).

Comment (105): Numerous commenters requested that the final rule include lands covered by conservation agreements in the final rule for a variety of reasons, including consistency with existing policy, a need for connectivity, the habitat value of these areas, a lack of explicit population recovery objectives, a need for increased protections and legal safeguards, concerns about the conservation effectiveness and appropriate implementation of these agreements, and a need for additional analysis before they are excluded.

Our Response: As described earlier, the Service carefully evaluated each conservation agreement or partnership under consideration for exclusion on its own merits, and weighed the benefits of exclusion versus inclusion. As described in our response to *Comment (104),* above, we emphasize that the exclusion of such lands does not signal that they are not important to the conservation or recovery of the northern spotted owl, and indeed such exclusions are made only on the basis of our determination that the benefits of exclusion outweigh those of inclusion, and that such exclusion will not result in the extinction of the species.

Comment (106): Several commenters requested that the final rule exclude particular land areas in private ownership (including but not limited to Usal Redwood Forest Company, Hawthorne Timber Company, Mendocino Redwood Company, Rayonier, Sierra Pacific, Pope timberlands, Merrill & Ring's lands, Weyerhaeuser Mineral, SDS Lumber Co., Olympic Resource Management, Green Diamond, and Wauna Lake Club) for a variety of reasons, including economics, additional regulatory burdens and uncertainty, a lack of conservation benefits, mapping errors, effects on existing and future conservation easements and agreements, State protections, ongoing voluntary conservation activities, potential disincentives for preserving habitat, and possible negative impacts to existing partnerships and relationships.

Our Response: No private lands are included in the final designation of critical habitat. Many of these lands were excluded under section 4(b)(2) of the Act; our detailed evaluation of these exclusions is provided in the Exclusions section of this document. In some cases, lands were removed following a review of habitat conditions on the specific parcels identified using 2011 National Agricultural Imagery Program (NAIP) imagery, in response to public comment. Upon review, we determined that lands identified by Rayonier, Pope Resources, Olympic Resource Management, and Weyerhauser Mineral did not meet the definition of critical habitat. Therefore, these lands were removed from the final designation.

Some landowners asked for exclusion from the proposed critical habitat, but were not actually included in the proposed designation in the first place. An example of such a case is Merrill and Ring lands. In other cases, commenters did not submit sufficient location information for us to be certain of the location of the parcel in question; Wauna Lake Club, for example, fell into this category.

In cases where mapping errors may have been made in our proposed critical habitat designation, such that lands that do not meet the definition of critical habitat for the northern spotted owl were inadvertently included within the proposed designation, the mapping in the final rule was corrected, so that those lands are removed from the final designation. Sierra Pacific lands in California, for example, were inadvertently included in the proposed designation due to a mapping error; these lands were removed from the final designation. We similarly made any corrections to area total errors that were identified in comments on the proposed rule, and thank landowners for bringing these corrections to our attention.

All specific requests for exclusion and records of our consideration of those requests are in our record, and available upon request (see **FOR FURTHER INFORMATION CONTACT**).

Comment (107): More than 50 private landowners in Washington State requested individual exclusions for their lands for a variety of reasons, including economics, additional regulatory burdens, a lack of conservation benefits, fire risks, mapping errors, existing conservation agreements, and disincentives for voluntary conservation measures and for preserving habitat.

Our Response: Upon further review, using the underlying aerial photo imagery from the 2011 National Agricultural Imagery Program (NAIP) and Ruraltech's 2007 forestland parcel data, we determined that the vast majority of Small Forest Landowner parcels we examined had either highly fragmented, little, or no northern spotted owl habitat currently present. Based on the combination of parcel size, current habitat conditions, and spatial distribution, we concluded that private lands coded as Small Forest Landowner parcels do not provide the PCEs for northern spotted owls, nor are they essential to the conservation of the species; thus, these areas do not meet the definition of critical habitat, and we have removed them from the final designation of critical habitat for Washington State.

We removed from the final critical habitat designation lands described in 17 comments after confirming that these lands did not contain the PCEs, or that they were too small, fragmented, or isolated to contribute to spotted owl conservation, and therefore did not meet the definition of critical habitat. Lands owned by 19 other commenters that requested removal were not within proposed critical habitat. The land of one commenter was removed to correct a mapping error in the proposed rule. We excluded another commenter's lands due to their completion of a SHA. Finally, 16 commenters did not provide sufficient location information to enable us to unambiguously identify their parcels. Of these 16, we inferred that we likely removed 6 from the final critical habitat designation because the size of the commenters' parcels were very small, making it likely that our process of removing small forest landowners from the final designation included the properties of these commenters. For the remaining 10 commenters, lack of location and parcel size information in the comments we received made it impossible for us to determine or infer whether these parcels were included in our final critical habitat designation. However, as all private lands were excluded from critical habitat under section 4(b)(2) of the Act (see Exclusions), no private lands remain in the final designation.

Public Comments on Critical Habitat Boundaries

Comment (108): One commenter noted that the inclusion of the term ''necessary'' within the definition of ''conserve'' (16 U.S.C. 1532(2)) indicates that Congress intended a ''high threshold'' for designating land as critical habitat, and that land designated must be required to bring the species to the point of no longer needing the protection of the Endangered Species Act. The commenter further asserts that the Service must show that all specific areas proposed as critical habitat are necessary, essential, and required for the continued existence of the species.

Our Response: The use of ''necessary'' in the definition of conservation does not change the requirements related to critical habitat. Furthermore, the Act provides that the Service ''to the maximum extent prudent and determinable * * * shall * * * designate any habitat of [the species] which is then considered to be critical habitat.'' 16 U.S.C. 1533(a)(3)(A); see also *Center for Biological Diversity* v. *FWS,* 450 F.3d 930, 935 (9th Cir. 2006) (noting Congress' use of the word ''shall'' and holding that ''[i]t follows that critical habitat designations are mandatory''). There are only two exceptions to the mandate that critical habitat be designated at the time of listing. First, designation may be temporarily delayed if critical habitat is ''not determinable,'' e.g., it cannot be identified based on current scientific information. 16 U.S.C. 1533(a)(3)(A); 50 CFR 424.12(a). Second, designation is not required if it is ''not prudent,'' see id., but Congress intended that finding to be made ''only rarely.'' S. Rep. 106–126, at 4 (1999); see also H.R. Rep. 95–1625, at 16–17 (1978) (designation required except in ''rare circumstances'').

We agree that the rule should designate either (1) specific areas within the geographical area occupied by the species at the time of listing that contain physical or biological features essential to the conservation of the species and which may require special management considerations or protection, or (2) specific areas outside the geographical area occupied at the time of listing that are essential to the conservation of the species. We have identified the specific areas that were occupied at the time of listing through historical surveys. We have determined that other areas were occupied at the time of listing (based on the presence of suitable habitat as well as the high probability that nonterritorial and dispersing subadult owls were present). In addition, we analyzed all areas as if they were not occupied and applied the standard applicable to unoccupied habitat. We used the methodology described in both the proposed and final rules to determine which unoccupied areas are essential to the conservation of the species, and have explained why unoccupied habitat in each subunit is essential to the conservation of the species.

For occupied areas, the attributes of forest composition and structure, and characteristics of the physical environment associated with nesting, roosting, and foraging habitat—physical or biological features used by the species—were identified based on published research results and expert opinion and incorporated into a predictive habitat model. We determined that, for the most part, the physical or biological features supporting these known sites are essential to the conservation of the species (the exceptions are owl sites that were isolated or in areas of marginal quality). The special management considerations are described by geographic region and in the subunit descriptions. However, large areas within the species' geographical range had not been surveyed at the time of listing, and we have determined that a designation based solely on the locations of those known territories would not be adequate to conserve the species. Therefore, we used habitat information based on habitat selected by those known owl pairs to identify other areas that were likely supporting northern spotted owl territories at the time of listing or that could support the species' recovery in the future. We then determined where these areas are essential to conservation of the species based on a spatially explicit northern spotted owl population model as described in the proposed rule, and again in this final rule.

Comment (109): One commenter stated that one or more of the PCEs are too general in nature and should be more narrowly clarified or defined. In particular, the comment suggested that PCE #1 and #4 seem to be met by all forested lands.

Our Response: PCE 1 (Forest types that may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographical range) identifies the specific forest types that support northern spotted owl life-history needs across the species' range, but is more narrowly refined in that it must exist in concert with one of the other PCEs to meet the definition of critical habitat. PCE 4 (habitat to support the transience and colonization phases of dispersal) is described in the preamble of the proposed rule as those forests with at least an average diameter at breast height (DBH) of 11 inches (28 centimeters) and at least a 40 percent canopy cover. We have included these metrics in the regulatory portion of the final rule to more narrowly clarify the forest structure that meets this PCE. In addition, it is only where these PCEs in the appropriate arrangement and quantity are essential to the conservation of the northern spotted owl that they are selected for designation as critical habitat.

Comment (110): Several commenters believe that additional lands beyond those already designated as northern spotted owl critical habitat are not necessary for northern spotted owl recovery, and the increase in total area is not supported by the science. The commenters suggest that including them will reduce or eliminate timber harvest on designated lands.

Our Response: The continued decline of the overall northern spotted owl population demonstrates that the threats to the species are still having a significant impact on northern spotted owl occupancy, reproduction, and survival. As described in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), the main threats to northern spotted owls are the past and continued loss of habitat and the competitive effects of barred owls. The increase in designated critical habitat area to help offset these threats is supported by northern spotted owl experts, researchers, and scientific peer reviewers. The results of our modeling efforts presented in Appendix C of the 2011 Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011, Appendix C) and in the Modeling Supplement for this rule (Dunk *et al.* 2012b) show that the 2008 critical habitat network performed worse (greater population declines over time, higher extinction risk) than the 2012 Revised Critical Habitat this revised designation.

The Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) recommends active management of some forest lands using ecological forestry approaches in appropriate stands such that we believe there are widespread opportunities for continued timber harvest management within the range of the northern spotted owl.

Comment (111): One commenter noted that the Endangered Species Act requires that designated critical habitat only include those areas ''occupied at the time of listing,'' and that any additional areas defined by the Secretary must be essential to conserving the species. The commenter argued that the standards for designating critical habitat for occupied and unoccupied habitat differ, and that Congress did not intend the phrase ''conserve'' to include extending the range of a species. The commenter also asserted that stating that substantially all of the occupied and unoccupied area is necessary does not comply with the statutory requirements.

Our Response: Congress specifically provided for designating unoccupied areas where doing so is essential to the conservation of the species. Congress expressly recognized that ''conservation'' could require designation of areas unoccupied at the time of listing. In this rule, we are designating unoccupied habitat in places where it is essential to the species' recovery; however, we are not designating critical habitat outside the historical range of the species. We are also not designating critical habitat everywhere within the present range of the northern spotted owl.

The proposed rule did not say that ''substantially all of the occupied and unoccupied area is necessary.'' The proposed rule explained how much of each subunit was occupied based on historical survey data, and why the areas of potentially unoccupied habitat in each subunit are essential to the conservation of the species. In addition, the methodology used to determine what is essential was explained in the proposed rule and this final rule.

Comment (112): Several commenters suggested that there was insufficient evidence to determine whether lands proposed as critical habitat were occupied at the time of listing, and questioned the data used for assessing northern spotted owl populations, both at the time of listing and at the present time.

Our Response: Occupancy by individuals of wide-ranging species can be difficult to definitively demonstrate or verify, particularly when different areas are utilized by individuals at different times in their life stages, and when the species responds to survey techniques in a variety of ways. Effectively detecting territorial northern spotted owls in a home range is a well-established technique, but locating nonterritorial or transient northern spotted owls is more difficult, even though they occupy many areas between established home ranges of territorial owls. The Service determined that most of the areas within critical habitat that have the PCEs were occupied at the time of listing by the species. However, as stated in the rule, we have determined all areas within critical habitat to be essential for the conservation of the species. Areas essential to the conservation of the species are not required to be occupied at the time of listing to be included in critical habitat.

For the purpose of developing and evaluating revised critical habitat for the northern spotted owl, we used a definition of ''geographical area occupied by the species'' at the time it was listed consistent with the species' distribution, population ecology, and use of space. We based our identification of ''occupied'' geographical area on: (1) The distribution of verified northern spotted owl locations and (2) scientific information regarding northern spotted owl population structure and habitat associations. While there were approximately 1,500 northern spotted owl pairs identified at the time of listing (1990), subsequent surveys across a larger percentage of the landscape in the mid and late 1990s detected more than 4,000 pairs. Because adult northern spotted owls are long-lived and have high site fidelity, it is reasonable to assume that these sites identified as occupied several years post-listing were also occupied by owls at the time of listing.

In addition, we are not stating that all critical habitat was occupied at the time of listing, but as clearly identified in the proposed rule and this final rule under the section Unoccupied Areas (77 FR 14062, p. 14099), we acknowledge the uncertainty regarding whether some areas were occupied at the time of listing or not (especially those areas used for dispersal or which were likely occupied based on habitat suitability). Therefore, we have evaluated these areas as if they were unoccupied at the time of listing and have found them to be essential to the conservation of the species.

Comment (113): One commenter questioned how some ''occupied'' habitat areas can be considered nonessential while other ''non-occupied'' habitat was considered essential for the conservation of the species.

Our Response: To conserve the northern spotted owl it is essential to have larger, connected areas that are managed for the development of their habitat even though some of those areas may not currently be occupied by the species. As habitat develops over time, both within occupied and unoccupied areas, we anticipate northern spotted owls will colonize the unoccupied habitat and positively contribute to population demographics which contribute to conservation of the species. The closer these currently unoccupied areas are to the improved sites over time the more likely dispersing northern spotted owls will be able to successfully colonize them. By evaluating northern spotted owl population metrics, such as relative population size, population trend, and extinction risk that resulted from each scenario evaluated, we designated only those lands that contain the physical and biological features essential to conserve the northern spotted owl, or that are essential themselves. This network has the potential to support an increasing or stable population trend of northern spotted owls that exhibits relatively low extinction risk, both rangewide and at the recovery unit scale, and achieves adequate connectivity among recovery units. It does not include every known northern spotted owl site. Occupied northern spotted owl sites that are not included are isolated or in small groups with other sites and will provide relatively less demographic contribution to the population than those sites that are in larger, contiguous groups. Therefore, we determined that they did not contain the physical and biological features essential to northern spotted owl conservation.

Comment (114): Numerous commenters requested we maximize the total area included in the designation by including the most area in any of the composites or by including all northern spotted owl habitat across all ownerships.

Our Response: We have designated critical habitat based on the identification of those areas meeting the definition of critical habitat or that are otherwise essential to the conservation of the northern spotted owl. Toward this end, maximizing land area is not the key factor. Our goal was to designate critical habitat that is essential for northern spotted owl recovery but achieves the desired results on as small an area as possible (i.e., it is efficient). This reduces any potential regulatory burdens and land management conflicts, which will increase the likelihood of success at meeting our goals. In addition, designating areas beyond that necessary to achieve the conservation of the species would indicate that we had included areas beyond what is truly essential to the conservation of the species, and exceeded the intent of the statute.

Comment (115): Several commenters suggested revisions to the boundaries of the proposed critical habitat, including several proposed additions (e.g., lands near Cascade-Siskiyou National Monument, Coquille tribal land, Coos Bay Wagon Road lands, the Olympics/ Western Cascade area, etc.) for several reasons, including the conservation value of the habitat, increased connectivity benefits for dispersal and gene flow, the need for additional protections to avoid habitat degradation, and consistency with the best available science and existing policy.

Our Response: When determining what is essential to the conservation of the northern spotted owl, we prioritized Federal, then State, and finally private or Tribal lands. Where Federal and State lands were sufficient to provide for the essential conservation needs of the northern spotted owl as demonstrated through our population modeling in HexSim, no additional lands were added. In addition, in accordance with the provisions of the Act, not all habitat that could be occupied by northern spotted owls was included in the designation. Only areas that meet the definition of critical habitat for the species were designated.

In Washington, we added suggested areas to critical habitat only where updated information about land ownership indicated a change in ownership from private ownership to Federal ownership. This was based on our prioritization of landownerships in the designation, as described above, wherein we looked to Federal lands first for critical habitat, and included State and finally private or Tribal lands only where necessary to achieve the conservation of the species. These areas had not initially been included in the proposal because the ownership information we used had indicated these lands were privately owned, and therefore they were not prioritized for inclusion. These additions occurred in the central Cascade Range of Washington where many sections of industrial timberlands in checkerboard ownership with Federal lands had recently been transferred to Federal ownership. This area of the central Cascades surrounding Snoqualmie Pass has repeatedly been identified as essential to maintaining demographic linkages among spotted owl populations from northern to southern Washington, and from the west slope to the east slope of the Washington Cascades.

Public Comments Regarding the Northwest Forest Plan (NWFP)

Comment (116): Several commenters stated that the rule needs to be more explicit about how it relates to the NWFP, and that the NWFP should direct the management of the critical habitat lands.

Our Response: We have clarified the relationship between the critical habitat rule and the NWFP under the ''Forest Management Activities in Northern Spotted Owl Critical Habitat'' heading. The designation of critical habitat for the northern spotted owl identifies the areas essential for the conservation of the species; it does not supersede the Standards and Guidelines for lands in the NWFP. The Service believes the NWFP has functioned as intended for the retention and development of late-successional forest habitat (Thomas *et al.* 2006; Davis 2012). The NWFP was developed with the expectation that emerging scientific data would be incorporated into the management of Federal forest lands. The discussions of active forest management in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) and this preamble are based on numerous recent scientific study results. We wish to be clear, however, that the inclusion or exclusion of NWFP reserves in the designation of critical habitat changes neither the land allocation nor the Standards and Guidelines for those lands under the NWFP. Nevertheless, we believe that our discussion of active forest management is consistent with the objectives of the NWFP.

Comment (117): One commenter suggested that lands currently managed under the NWFP do not require additional management considerations or protections from designated critical habitat.

Our Response: The Service is not relieved of its statutory obligation to designate critical habitat based on the contention that it will not provide additional conservation benefit. We do not agree with the argument that specific areas and essential features within critical habitat do not require special management considerations or protection because adequate protections are already in place. In Ctr. for Biological Diversity v. Norton, 240 F. Supp. 2d 1090 (D. Ariz. 2003), the court held that the Act does not direct us to designate critical habitat only in those areas where ''additional'' special management considerations or protection is needed. If any area provides the physical or biological features essential to the conservation of the species, even if that area is already well managed or protected, that area still qualifies as critical habitat under the statutory definition if special management is needed.

Comment (118): Numerous commenters asserted the proposed critical habitat rule would result in the weakening of the NWFP, including the dismantling or eradication of the late-successional (and riparian) reserves, and that we should use a variety of approaches explicitly elucidated in the final rule to maintain the LSR network.

Our Response: In designating critical habitat the Service is required to use the best available science to identify specific areas that provide the PCEs or are otherwise essential to the conservation of the species. Our modeling effort and other data identified some nonreserved areas that are high value for the northern spotted owl and essential to the conservation of the species. Additionally, there are portions of reserved allocations that are of relatively low value to the northern spotted owl. As a result of incorporating the best available science, our modeling process demonstrated that the critical habitat network identified here is more effective at conserving the northern spotted owl than the NWFP network of reserves. This is not unexpected, as the LSR network was never intended solely for the benefit of northern spotted owls, but was created to provide for many late-successional species. However, the designation of critical habitat does not change the existing NWFP land use allocations or Standards and Guidelines. The inclusion or exclusion of NWFP reserves as critical habitat changes neither the land allocation nor the Standards and Guidelines for those lands. The Service encourages continued implementation of the NWFP and adherence to the Standards and Guidelines for reserve management.

Comment (119): Several commenters noted the critical habitat rule should adopt the Standards and Guidelines of the NWFP in an effort to protect northern spotted owl habitat, including all late-successional and old-growth forests.

Our Response: In designating critical habitat we are required to identify those lands essential to the conservation of the species through application of the best available science. Our incorporation of state-of-the-art modeling programs, techniques, and data identified those areas, many of which contained late-successional or old-growth forest. However, the purpose of this rule is to designate critical habitat, not to adopt specific standards for its management. The Revised Recovery Plan for the Northern Spotted

Owl (USFWS 2011) recommends the retention of structurally complex forests where they currently exist (Recovery Action 32). We did not find, however, that retaining all northern spotted owl habitat is essential for the conservation of the species, so not all habitat was included.

Public Comments on Competition From Barred Owls

Comment (120): Several commenters recommended that the Service should objectively determine whether the barred owl threat has so overwhelmed the northern spotted owl as to make additions to critical habitat unnecessary, and noted that dealing with the barred owl and habitat threats separately could be detrimental to northern spotted owl recovery.

Our Response: The scientific information available at this time is not adequate to statistically assess the effect of barred owls on any specific conservation strategy or agency action, though these strategies include efforts to address barred owls. The extent to which northern spotted owls remain (sometimes undetected) on areas with high barred owl densities is unclear. However, the threat posed by barred owls does not relieve the Service of its statutory obligation to designate critical habitat for the northern spotted owl under section 4(a)(3)(A) of the Act. Furthermore, suitable habitat is essential for northern spotted owls to persist, with or without barred owls. Our modeling approach for designating critical habitat included barred owl effects on spotted owl population performance. Recent research (Wiens 2012) indicates that population performance of both northern spotted owls and barred owls is greatest when high-quality habitat is most abundant, and most peer reviewers supported the approach of conserving more habitat to help offset the impact of the barred owl on the northern spotted owl.

Public Comments on the Modeling Process

Comment (121): One commenter was critical that the process for combining different models in different modeling regions was unclear, and was also critical that a nonrandom sampling of nesting centers and the approach used to create a contiguous underlying RHS (Relative Habitat Suitability) map using MaxEnt modeling software.

Our Response: Although the RHS values within one modeling region may not be directly comparable to another's, the similarity of each modeling region's strength of selection curves (see Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011)), suggested that the interpretation of RHS values was similar between/among regions. Furthermore, Zonation was run within modeling regions (see Appendix C of the Revised Recovery Plan) to ensure that potential critical habitat units and subunits were well distributed throughout the northern spotted owl's range. We are aware of only one effort to date that has utilized random sampling of a relatively large region within the range of the northern spotted owl (Zabel *et al.* 2003). The demographic study areas were not randomly located, nor were the northern spotted owl location data we used. Thus, the chance exists that it is biased in some way. Nonetheless, given the relatively large sample sizes, and the geographic and habitat variation that exists around northern spotted owl sites in the samples we used, we contend that this is the best data available to use. The Service acknowledges that there is uncertainty in this process, and that this is unavoidable. There exists no perfect rangewide habitat map, no perfect (large) random sample of owl locations, no randomly allocated demographic study areas from which to draw strong range-wide inferences about population trends, nor a perfect understanding of the northern spotted owl's life history. That said, we have used the best data available, thoroughly documented our approach and presented our evaluation of the usefulness of the models we used, and we find they provide a strong foundation using the best available science for informing decisions about critical habitat.

Comment (122): One commenter indicated a need to clarify the basis for the thinning of northern spotted owl location data used in modeling.

Our Response: The basis of the thinning is articulated on pages C–20 and C–21 of Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011).

Comment (123): One commenter indicated that the assumptions for this modeling process were not completely spelled out nor were their validities addressed. For example, the modeling of habitat suitability assumes that core use areas and home ranges of northern spotted owls are relatively constant in size throughout their geographic range, but this assumption is not well supported by the proposed critical habitat, Appendix C of the 2011 recovery plan, or the published literature. Core use areas and home ranges increase in size for northern spotted owls in the northern part of their range versus those in the southern part (Thomas *et al.* 1990). Second, the modeling process for evaluating habitat suitability under MaxEnt assumes that some moderate amount of edge and degree of forest fragmentation is good for demography and fitness of northern spotted owls throughout their geographic range based on Franklin *et al.* (2000), yet this relationship has been shown mainly for northern California and one area in Oregon (Olson *et al.* 2005), not the remainder of the subspecies' range in Oregon and Washington. For example, Dugger *et al.* (2005) found no relationship between the amount of edge and demographic performance of northern spotted owls in southern Oregon; consequently, the validity of this assumption for the entire range of the subspecies is questionable.

Our Response: We did use one spatial scale throughout the northern spotted owl's range for our MaxEnt modeling. We also assumed that territories, in our northern spotted owl HexSim model, were of uniform size (3 hexagons) throughout the northern spotted owl's range. We did not, however, assume home ranges were of equal size throughout the range (see table C–24 in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011)). We also did not assume that edge or forest fragmentation was good for northern spotted owl demographic performance in our MaxEnt models. We did, however, allow for edge metrics to be included in the models where they had clear effects on the MaxEnt models; however, we did not force them in to the models in modeling regions where they had no effect. It is important to note that, unlike studies that have attempted to evaluate competing mechanistic hypotheses regarding northern spotted owl habitat/climate-demographic relationships (e.g., Franklin *et al.* 2000, Dugger *et al.* 2005), in our MaxEnt modeling process, we did not attempt to evaluate competing hypotheses. Instead, we attempted to develop MaxEnt models that had good discrimination ability, were well calibrated, and were robust (see our response to *Comment (20);* additional discussion is provided on pages C–30 to C–32 of the Revised Recovery Plan, USFWS 2011).

Comment (124): One commenter requested more justification for the choice of features in MaxEnt modeling. For example, the threshold feature was used, but the product feature was excluded. They predicted that product features in particular might be relevant to biological hypotheses (e.g., when nesting habitat is low, increases in foraging habitat don't increase occupancy, but when nesting habitat is greater, foraging habitat has a greater impact on occupancy).

Our Response: We could have allowed all MaxEnt feature types to be used in our process. The product (interaction) feature would have resulted in even more complex models. However, we were able to develop models without additional complexity (e.g. interaction terms) that worked well for the purposes for which they were developed. Results from model cross-validation and comparisons with independent data sets (USFWS 2011, Appendix C, Table 19, pp. C–39 to C–41) showed that our models were well calibrated and had good ability to predict spotted owl locations (USFWS 2011, Appendix C, Table 20).

Comment (125): Several commenters requested more detail regarding how the different Zonation scenarios from Phase 1 in Appendix C of the Revised Recovery Plan were selected for inclusion in proposed critical habitat. In particular, the reviewers believed that Zonation 70 and 90 scenarios would have provided better modeled northern spotted owl population performance.

Our Response: We assume that the question is about why the 30, 50, and 70 percent of habitat value were chosen for the initial Zonation networks. They were chosen to provide relatively broad side-boards, particularly in regard to network size. To have started with even more extreme side-boards (e.g., Z10 and Z90) would have been excessive because these configurations would have included either a very large amount of land that doesn't have features that would support owls (Z90) or an area so small (Z10) that viable owl populations could not be sustained. It is true that a Z90 scenario would have provided much more area of potential critical habitat, but the amounts of high RHS (> 0.5) in Z70 are nearly identical to those in Z90. In fact, Z50ALL contained 92%, 98%, 99%, and 100% of RHS bins 0.6–0.7, 0.7–0.8, 0.8–0.9, and > 0.9, respectively. Z90ALL contained 100% of the RHS from each bin, but encompassed a much larger area (i.e., for very little added inclusion of high RHS areas, Z90 included millions of additional acres). In effect, moving from Z70 to Z90 adds a lot more area; however, the additional lands added do not contribute much to spotted owl population performance.

Zonation 70 was considered, and subsequently modified in various composite networks we evaluated. We found that simply increasing the area of potential critical habitat networks did not always result in better performance of simulated owl populations in HexSim (e.g., Composite 7 was 13.9 million ac (5.625 million ha) and had an ending population that did not differ (95 percent confidence intervals overlapped) from composites with from 18.2 to more than 20 million ac (7.4 to more than 8.1 million ha)). In some modeling regions, our modeling results suggest that owl populations are likely to remain relatively low; in part due to the relatively small amount of mid-to-high RHS area in them. The population results for Zonation 40, 60, 80 and 90 are provided in our Modeling Supplement (Dunk *et al.* 2012b).

Comment (126): One commenter indicated there were key assumptions used in the modeling process that should be more clearly documented. The reviewer indicated that the proposed critical habitat document refers the reader to the Dunk *et al.* (2012a) Modeling Supplement for a discussion of these assumptions but they were unable to locate them in this document. Not only should the assumptions of the modeling be included in the proposed critical habitat, but the validity of the assumptions should also be addressed.

Our Response: The key assumptions used in our modeling process are provided in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), and referenced in our proposed rule. Appendix C also provides a thorough discussion of our process of testing and cross-validating our models. We have also clarified this in the final version of our Modeling Supplement (Dunk *et al.* 2012b).

Comment (127): One commenter noted that the modeling of population response and viability under HexSim assumed that recruits into the population become co-owners of their mother's territories, yet most owls are recruited into the population in different areas after extensive dispersal over several months and sometimes years. They asked to what extent are these assumptions valid, and how would lack of validity potentially affect the results of the modeling process?

Our Response: In the northern spotted owl HexSim model we assumed that juvenile birds, prior to dispersal, co-owned their mother's territory. However, juveniles were forced to disperse in the model. The recruits are only co-owners until they fledge, and fledging always takes place in the first year of life. Further, in the modeling two post-fledging females did not share a territory.

Comment (128): One commenter noted that composite 3 performed poorer than composite 1 based on population performance, yet composite 4 was based on the network in composite 3 and composite 5 was based, in part, on that in composite 4. This sequence of models based on the poor performance of composite 3 does not make sense from an ecological or conservation stand point. It is obvious that composites 1–7 do not represent the complete range of habitat networks that might provide for sustainable populations of northern spotted owls in most of the modeling regions. They contend that there should have been more attention paid to increasing habitat for northern spotted owls and providing for sustainable populations in all modeling regions instead of increasing efficiency. They understood the need to make any habitat network efficient but believed that this was a case where efficiency has trumped conservation of habitat for the northern spotted owl and other species associated with old forest ecosystems.

Our Response: Relatively poorer performance (as noted by the reviewer) is not equivalent to ''poor performance.'' In fact, the 95 percent confidence intervals of the mean estimated population sizes at time-step 350 overlapped for composites 1, 3, 4 (highest point estimate), 5, 6, and 7 indicating that the differences may not be statistically significant. Furthermore, although Composite 3 did perform worse than Composite 1 in terms of exceeding pseudo-extinction thresholds, Composite 7's performance was nearly identical to Composite 1's. Thus, we disagree with the assertion that our sequence was based on poorly performing composites. There are an infinite number of possible potential critical habitat networks that could have been evaluated. Efficiency, as used by the Service in this effort, did entail reducing the size of potential critical habitat networks, because our charge under the statutory definition of critical habitat is to designate only those lands occupied at the time of listing that contain essential physical and biological features or unoccupied lands that are essential.

Comment (129): One commenter indicated that the process for comparing GNN (vegetation) data with owl nest sites and foraging areas is unclear. The reviewer asked whether GNN data indicated that nest site centers were characterized by large, old trees with closed canopy forests and stated that this process needs better explanation.

Our Response: The process for developing models of nesting and foraging habitat is described in detail on pages C–14 through C–43 in Appendix C of the 2011 Revised Recovery Plan for the Northern Spotted Owl. Nesting and roosting habitat was characterized by large, old trees with closed canopies; however, the specific vegetation characteristics included in the models varied by region. Our confidence that the GNN layer was sufficiently accurate to support our modeling process was based on several formal and informal evaluations. First, we evaluated northern spotted owl habitat modeling conducted by the Northwest Forest Plan Interagency Monitoring Program (Davis *et al.* 2011), which was also based on the GNN data. This effort used GNN and MaxEnt to predict northern spotted owl nesting habitat, obtaining models quite similar to the NR models in our modeling effort. We also obtained less formal, but very useful, feedback from a number of USFS scientists who had made comparisons between GNN output and their own field-typed northern spotted owl nesting habitat with good results. Finally, as described in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011), we evaluated the reliability of the MaxEnt models' predictions (RHS) and found that the models had good ability to predict northern spotted owl locations. Systematic inaccuracy of the GNN data would be unlikely to result in the accurate predictions we obtained in our modeling. In addition, please see our responses to *Comment (19)* through *Comment (22)* for details on our testing, cross-validation, and use of GNN and MaxEnt.

Comment (130): One commenter stated that more information on the ''independent test data sets'' used for model cross-validation is necessary before they are acceptable as an adequate test. In particular, if these data sets suffer from the same non-random sampling as the training data, then they will not aid in determining whether the RHS and AUC values are biased by the nature of the sampling or not.

Our Response: As described in Appendix C of the Revised Recovery Plan (USFWS 2011, p. C–20), we expended substantial effort on the verification of both the spatial accuracy and territory status of each site center used in our data set. We received high quality data from northern spotted owl demographic study areas (DSAs), and obtained a large set of additional locations from the NWFP Effectiveness Monitoring Program. We also obtained and verified data sets from private timber companies, the USFS Region 5 NRIS database, and a number of research and monitoring projects throughout the range of the northern spotted owl. We are aware of only one effort to date that has utilized random sampling of a relatively large region within the range of the northern spotted owl (Zabel *et al.* 2003). Because of the spatial extent of the range of the northern spotted owl (more than 23 million acres), we do not have the luxury of having equal survey effort throughout the region. The demographic study areas are not randomly located, nor are the northern spotted owl location data we used. Nonetheless, given the relatively large sample sizes, and the geographic and habitat variation that exists around northern spotted owl sites in the samples we used, we consider this information to represent the best available scientific data for our purposes, and are not aware of any alternative data sets.

Comment (131): One commenter expressed concern that the encounter rates of northern spotted owls with barred owls found in Forsman *et al.* (2011) were reduced downward to a maximum rate of 0.375 even though there is strong evidence in Forsman *et al.* (2011) that the rate is higher in some modeling regions, and Wiens *et al.* (2011) has shown that abundance of barred owls (and encounter rates) is much higher in the Coast Ranges of Oregon than initially thought or is documented in Forsman *et al.* (2011). The lower encounter rates of northern spotted owls with barred owls that were used in Phases 2 and 3 of the modeling represent more optimistic performances of northern spotted owls to habitat conditions than is likely to occur in reality. The reviewer contends that it would have been more appropriate to use Zonation 70 or even 90 to a greater extent in some modeling regions, than to arbitrarily reduce the barred owl encounter rate to a maximum of 0.375 in order to provide for sustainable populations in all modeling regions.

Our Response: The modeling we conducted suggested that the larger the barred owl encounter probability was, there was less variation in northern spotted owl population performance among potential critical habitat networks (even when network size varied by more than a factor of 2); effectively all populations did uniformly poorly. However, when barred owl encounter probabilities were lower (e.g., 0.25), considerable variation in northern spotted owl performance among potential critical habitat networks resulted. Thus, under extremely high barred owl encounter probabilities, our modeling suggested that even large amounts of area in potential critical habitat networks did not compensate for those barred owl impacts. Thus, in order to identify potential critical habitat areas for the northern spotted owl, we made assumptions about barred owl encounter probabilities in each of the 11 modeling regions. The assumed changes in encounter probabilities we used in Phases 2 and 3 of our modeling were, in most cases, relatively modest changes from the currently estimated encounter probabilities. In fact, for Phase 2 and 3 modeling, we decreased barred owl encounter probabilities in only 3 of 11 modeling regions, and increased encounter probabilities in 8 of 11 modeling regions. Mean absolute value of change (from currently estimated to what we assumed in Phases 2 and 3) among modeling regions was 0.081 (range = 0.005 (in the KLE) to 0.335 (in the OCR)). For additional detail, please see our response to *Comment (38).*

Comment (132): One commenter suggested that we use an occupancy analysis on the long-term demographic study areas rather than modeling habitat with MaxEnt to better address barred owl effects.

Our Response: Barred owl impacts were included in HexSim. In our response to comments made on Appendix C in the Draft Revised Recovery Plan for the Northern Spotted Owl (75 FR 56131; September 15, 2010), the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) addressed the choice we made to use MaxEnt and the full data set of owl site center locations that was available to us, rather than rely solely on data from the Demographic Study Areas.

Comment (133): One commenter contended that a separate analysis of BLM checker-boarded lands in western Oregon is needed in order to understand the performance of northern spotted owl populations under the different habitat networks and composites on those lands.

Our Response: The number of possible owner/district/region-centric analyses that we could have evaluated was nearly infinite. The BLM's ownership was considered in the same way that other ownerships were. In developing the critical habitat designation, we prioritized public lands over private lands.

Comment (134): One commenter noted that for most of the study areas, the estimates from HexSim compared favorably to the empirical estimates from the field studies except for the South Cascades (CAS) and Klamath (KLA) Study Areas. In one case (CAS), the estimate from HexSim was much larger than that from the field studies, and in the other case (KLA) the estimate from HexSim was significantly smaller than from the field studies. These differences and inconsistencies raise some concerns for the validity of the modeling results from HexSim. The commenter asked for some explanation for these differences and inconsistencies, and whether the input parameters for HexSim need to be revised.

Our Response: We are aware of these differences, as noted in Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011). We evaluated multiple changes to the northern spotted owl HexSim model's settings, but those changes did not result in overall better agreement between HexSim population estimates and empirical estimates from demographic study areas (DSAs). To some extent, this issue is the result of the spatial scale at which we ran the northern spotted owl HexSim model. The overall results, in our view, were quite good—but not in every specific case. Although there were discrepancies at these local areas, we believe that the scale at which we evaluated information for potential critical habitat networks (modeling regions and the entire geographic range of the northern spotted owl in the United States, which is at least an order of magnitude larger than a demographic study area) was appropriate. We provide additional justification in the following paragraphs.

The KLA DSA is quite small, and is distributed across the Klamath East and Klamath West modeling regions. The CAS DSA is large, and is distributed across the Klamath East and East Cascades South modeling regions. There were no simulated northern spotted owl life-history parameters that varied based on demographic study area location. Some demographic data (resource target and home range size) did, however, vary by modeling region.

HexSim simulation data show that the East Cascades South modeling region exchanged owls principally with the Klamath East and West Cascades South modeling regions. The Klamath East modeling region exchanged owls principally with the East Cascades South and Klamath West modeling regions, with relatively small numbers of immigrants coming from the West Cascades South region. The Klamath West modeling region exchanged owls principally with the Klamath East modeling region, with the next highest number of emigrants and immigrants being associated with the Oregon Coast and Redwood Coast regions, respectively.

The simulated CAS DSA population size is roughly 45 owls too large, whereas the KLA DSA population size is about 55 owls too small. These two DSAs are spread across three modeling regions, with both DSAs residing partly in the Klamath East region. Because the Klamath East modeling region exhibits high rates of simulated immigration and emigration with the other two modeling regions in question (see previous paragraph), the discrepancy in simulated DSA population sizes is not a big concern. The sum of the simulated CAS and KLA DSA population sizes is almost exactly equal to the combined field estimates for those two regions. This suggests that HexSim's simulated northern spotted owl population size and distribution is quite accurate at the scale of the DSA for most DSAs, and for these two DSAs in particular, it is similarly accurate, just at a slightly larger spatial scale.

Comment (135): One commenter asked what publication or data set were used for establishing the barred owl influence on northern spotted owl reproduction in the HexSim model.

Our Response: In the northern spotted owl HexSim model we used, barred owls did not have any influence on northern spotted owl reproduction, but did on adult survival. This has been clarified.

Comment (136): Several commenters requested that the Service integrate industry data into the modeling process and that attention be given to the assumptions and limitations of the models and whether or not the assumptions and model outputs have been validated.

Our Response: The modeling process incorporated data sets, expert opinion, and published information from the timber industry. We carefully evaluated the appropriateness of our models, data sets, and assumptions and tested the outputs and products of the modeling effort; we therefore are confident that our process was rigorous and met our objectives. Please see Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) for a discussion of the rigorous testing and cross-validation we conducted on our models, as well as our responses to *Comment (19)* through *Comment (22).*

Comment (137): One commenter raised concerns about leaving out high RHS value habitat on State and private lands in Washington, and provided recommendations of specific areas to include in critical habitat designation.

Our Response: The modeling process that the Service developed to help identify potential critical habitat is most appropriately used to make relative comparisons of alternative scenarios. While we sought to make the models as realistic as possible to achieve meaningful relative comparisons, these modeling tools are not designed to predict specific future outcomes. We are confident in the ability of the modeling routine to rank a set of scenarios from best to worst and provide insights about the degree of difference among them. But population metrics provided by the models are better viewed as relative indices than as predictions. This caution about interpretation of model output is particularly relevant to modeling regions with low amounts of total habitat area, such as in the State of Washington. In the modeling environment, small population sizes tend to lead to high variation in outcomes among iterations. Furthermore, competitive effects of barred owls played a large role in determining population outcomes, especially in Washington where encounter rates between barred owls and northern spotted owls are high.

We used the objectives and criteria in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) to guide our critical habitat proposal. Only after we had a critical habitat network that we considered essential to meet recovery objectives did we impose the secondary criterion of network efficiency. We retested networks after efficiency modifications were made to ensure they were still likely to meet recovery objectives. We included State or private lands only where our modeling results indicated Federal land was insufficient to provide what is essential for recovery.

As described in the section Criteria Used to Identify Critical Habitat, we have included in this designation only those areas occupied at the time of listing that provide the essential physical or biological features, or areas unoccupied at the time of listing that we have determined are otherwise essential to the conservation of the northern spotted owl. We appreciate the commenter's suggestion of additional areas for consideration, and we did evaluate all areas on the basis of RHS throughout the range of the northern spotted owl, including State and private lands in southwest Washington. We have included in this final designation all areas that we have determined are essential to the conservation of the species. A determination that certain areas are not essential should not, however, be interpreted to mean that such areas do not have the potential to contribute to the recovery of the species, and we encourage landowners to participate in other recovery efforts to achieve conservation on their lands (for example, as identified in Recovery Actions 14 and 15 of the Revised Recovery Plan (USFWS 2011)). In addition, we identified some State and private lands in Washington as essential for the conservation of the northern spotted owl, but all of the private lands and some of the State lands were subsequently excluded under section 4(b)(2) of the Act (see Exclusions). As discussed in our response to *Comment (104),* above, exclusion of areas is not the same as a determination that those areas are not essential; it only reflects the Secretary's determination that the benefits of excluding such areas outweighs the benefits of including them in critical habitat.

Comment (138): One commenter claimed that critical habitat includes nearly all suitable habitat—occupied or not—and was driven by the artificial constraints incorporated into the recovery plan—namely the manipulation of the barred owl interaction model. According to the commenter, absent these artificial constraints, the model would have predicted that none of the alternatives will conserve the species in the face of barred owls, therefore none of the lands wherein there is significant barred owl interaction are ''essential'' for the survival of the species. The commenter further stated that given the significant impact on the human environment by restricting management of the lands within this region, the Service needs to clearly provide the public with an estimation of the scientific reliability of their ability to conserve the northern spotted owl, and this information is critical to weighing the social and economic ramifications of the proposed action.

Our Response: The proposed critical habitat rule did not include ''nearly all suitable habitat'' and our evaluation indicated that the large majority of the proposed designation was occupied at the time of listing and contains the physical and biological features essential to conservation of the species. It also identified other areas essential to the species' conservation, which represent only a small portion of the proposed critical habitat. Contrary to the commenter's assertion, the barred owl impacts used in the population modeling process were similar to or slightly higher than those reported in most modeling regions; barred owl effects were reduced in only three of 11 regions (Table 2 in Modeling Supplement). This was done to enable the identification of areas essential to the spotted owl's recovery; threats that are not habitat-based are addressed through implementation of actions in the recovery plan. The current influence of barred owls on occupancy by northern spotted owls does not negate the role of habitat in the recovery of the species. The Service clearly noted in the proposed rule that the areas proposed as critical habitat are essential, but not sufficient absent other management actions, to recover the northern spotted owl.

Comment (139): One commenter was concerned that the proposed rule did not present an effects analysis for the proposed exclusions that indicates how northern spotted owl populations would likely respond if these lands were excluded.

Our Response: Many of the potential exclusions put forth in the proposed critical habitat rule would be unlikely to affect the outcome of our population modeling. This is because those exclusions, if made, would be based on their having some existing habitat protections (e.g., wilderness areas, national parks, HCPs, SHAs) that we would reasonably expect to continue into the future, and thus our treatment of them in the modeling would be the same as if they were included in a critical habitat network. If we were to exclude lands without consideration of continued conservation, we agree that this could change the results of our population modeling. However, since this is not the case, and no such lands were excluded from this final rule, we did not need to conduct such an analysis in this final rule.

Comment (140): One commenter was critical that no analysis was provided as to the relative effectiveness of the new critical habitat network in also capturing habitat for other late-seral/old-growth-associated species of concern, and encouraged an analysis of the effects of the proposed critical habitat network on multi-species conservation goals, by overlaying critical habitat boundaries on data on occurrence and habitat distribution for other species of concern.

Our Response: Analyzing the effects of the proposed critical habitat network on multi-species conservation goals is beyond the scope of the critical habitat designation process for the northern spotted owl. Furthermore, the results of such an analysis would not affect the selection of the final critical habitat designation for the northern spotted owl, as the statutory language defines critical habitat with reference to a particular listed species.

Comment (141): One commenter suggests that the Service fails to explain to the public why, in order to model sustainable northern spotted owl populations, it was required to arbitrarily select an interaction rate with barred owls that was not based on science-based field studies. Rather, the commenter states, it was based on the assumption that barred owls would be addressed through their extirpation from wide swaths of the Pacific Northwest (''Modeling and Analysis Procedures used to Identify and Evaluate Potential Critical Habitat Networks for the Northern Spotted Owl,'' USFWS Feb. 28, 2012, pp. 14–15), an assumption that is neither legally nor scientifically supportable.

Our Response: The Service made no assumption, written or otherwise, that the barred owl would be extirpated from any portion of the northern spotted owl's range. The ''ceiling'' on barred owl encounter rates that was used in the modeling (Phases 2 and 3 from Dunk *et al.* 2012a) was not arbitrary, but based on the results from several scenarios presented and compared during Phase 1 modeling. As explained in both Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) and Dunk *et al.* 2012b, the barred owl encounter rates used in the testing and selection of the proposed critical habitat designation are, in most modeling regions, similar to or even slightly above the currently estimated encounter rates. Only in portions of Washington were encounter rates reduced in order to identify essential habitat absent the undue influence of barred owls, but certainly not to the extent of ''extirpation of wide swaths'' as suggested in this comment. For additional details, please see our response to *Comment (38).*

Comment (142): One commenter stated that the original critical habitat designations were based on forest stand characteristics whereas the new designations are based on computer simulations that are untested and unreliable, and that this is not an improvement on the existing science. The commenter states that northern spotted owl populations have continued to decline as suitable habitat has increased; therefore, there are factors other than habitat that are decimating northern spotted owls, namely barred owls and catastrophic fires, and increasing the size of habitat will do nothing to save them.

Our Response: While it is true that northern spotted owl populations continue to decline, we have no evidence to suggest that suitable habitat has increased rangewide. Furthermore, we recognize that loss or degradation of habitat is not the only threat affecting northern spotted owl populations. However, as we have stated, comprehensive recovery actions for the northern spotted owl are provided in the Revised Recovery Plan (USFWS 2011). The existence of other, non-habitat based threats does not relieve the Service of its statutory obligation to designate critical habitat for the species to the maximum extent prudent and determinable.

We believe the commenter may not have understood that the computer programs that we used were developed, to the extent that it was defensible to do so, with empirically derived information, and thus were also ultimately based on real forest stand characteristics. In cases where this was not possible, a rationale for parameter inputs was provided (see Appendix C of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) and Dunk *et al.* 2012b). For example, actual weather station data are not available across the entire range of the northern spotted owl; however, temperature and precipitation models that provide site-specific climate data across the species' range provide these data. Additional explanation of the extensive degree to which our models were tested and cross-validated is also provided there, as well as in our responses to *Connet (19)* through *Comment (22),* among others.

Comment (143): Several commenters noted that the Service should redo its habitat modeling by including active management as a setback of owl habitat and to determine how long it will take for treated areas to recover to suitable nesting, roosting, and foraging habitat.

Our Response: The analysis suggested in this comment is predicated on the availability of reliable information on the extent to which active management may potentially be implemented within the boundaries of critical habitat, if at all. As we have noted throughout this rule, the discussion of active management provided is for use by Federal, State, local, and private land managers, as well as the public, as they make decisions on the management of forest land under their jurisdictions and through their normal processes. We are attempting to emphasize that critical habitat is not necessarily a ''hands off'' designation, depending on the nature of the habitat and the action under consideration, and we encourage land managers to consider the flexibility of management options available to them consistent with the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) and the Standards and Guidelines of the NWFP (USDA, USDA 1994). However, as noted in our economic analysis of the designation, predicting what land managers may choose to do is an exercise in uncertainty; land managers may choose to refrain from any management actions, may continue to manage lands as they currently do, or make choose to implement alternative active management practices. Given that we do not know whether land managers will even attempt to implement active management, much less how often or on what scale, attempting to model the effects of those actions on RHS would be purely speculative and, for our purposes, uninformative.

Other Public Comments

Comment (144): Two comments were submitted regarding how proposed critical habitat (not specific to a particular land use allocation) will negatively impact future development within counties.

Our Response: The forested areas included in the critical habitat designation are primarily managed for forest products, including timber production. We are not aware of any development projects proposed within the area of this revised designation, and our final economic analysis did not identify any such potential impacts.

Comment (145): Two commenters asserted that the regulatory mechanisms for protecting critical habitat on State and private lands were insufficient to adequately protect northern spotted owl habitat.

Our Response: The statutory authority defining and regulating critical habitat is the Endangered Species Act (Act). Section 7(a)(2) of the Act specifically provides that protections to critical habitat via consultation are triggered by actions authorized, funded, or carried out by Federal agencies (referred to as a ''Federal nexus''). If there is no Federal nexus involved in a proposed action, the law does not require consultation with the Service. The Act does not provide a direct regulatory mechanism for protecting critical habitat on State or private lands absent a Federal nexus.

Comment (146): One commenter requested that the Secretary identify those lands being designated for the purpose of expanding the range or dispersing the northern spotted owl into unoccupied areas.

Our Response: The designated lands are entirely within the range of the northern spotted owl and the vast majority of lands were occupied by northern spotted owls at the time of listing. This designation does not identify any areas for the purpose of expanding the range of the species. We have included some small areas that may have been unoccupied at the time of listing for the purposes of accommodating potential population growth. Each of the subunit descriptions in this rule describes the subset of area, if any, that was identified to assist with northern spotted owl movement across broad landscapes, to provide connectivity between established populations, or to provide for population expansion. Population expansion, as used here, is meant to describe population growth in terms of increased numbers of individuals within an area, not range expansion. In Oregon we have designated two areas specifically to assist in the movement of northern spotted owls between the Oregon coast (ORC) and the western Cascades south (WCS) critical habitat units. In Washington, many historically occupied areas included in critical habitat are currently unoccupied due to reductions in spotted owl populations. Full occupancy of these formerly occupied areas (population growth or expansion) would provide for conservation of the spotted owl without expanding the range. Relative to past critical habitat designations for the spotted owl, we also included additional areas in northern Washington into the current critical habitat designation. These areas may increase the potential for dispersal of owls to and from British Columbia, Canada, in the future. Currently, such exchange is unlikely due to low abundance of spotted owls in this landscape on both sides of the international border. All of this area is within the current geographic range of the northern spotted owl, and does not expand that range beyond its historical boundaries.

Comment (147): One commenter questioned how the Service had applied a ''significant contribution'' standard to occupied and unoccupied areas.

Our Response: We considered a specific area to make a ''significant contribution'' to the conservation of the species if adding or removing that area from the habitat network under consideration resulted in an appreciable change in the population performance in that modeling region.

Comment (148): One commenter requested additional clarification of the terms ''largely occupied'' or ''approximately occupied'' at the time of listing for particular subunit areas.

Our Response: These terms have been clarified in the final rule. For each subunit, the proposed rule explained that the specified percentage ''was covered by verified northern spotted owl home ranges at the time of listing.'' As an example, such subunit descriptions then went on to say: ''[w]hen combined with likely occupancy of suitable habitat and occupancy by nonterritorial owls and dispersing subadults, we consider this subunit to have been largely occupied at the time of listing. In addition, there may be some smaller areas of younger forest within the habitat mosaic of this subunit that were unoccupied at the time of listing. We have determined that all of the unoccupied and likely occupied areas in this subunit are essential for the conservation of the species to meet the recovery criterion that calls for continued maintenance and recruitment of northern spotted owl habitat. The increase and enhancement of northern spotted owl habitat is necessary to provide for viable populations of northern spotted owls over the long-term by providing for population growth, successful dispersal, and buffering from competition with the barred owl.'' Thus, the specified percentage is based on actual surveys. However, as described in Criteria Used to Identify Critical Habitat, we also determined that all areas designated are essential to the conservation of the northern spotted owl, using the more restrictive standard for unoccupied areas, to ensure all areas were appropriately designated even if there was any uncertainty about its occupancy status at the time of listing.

Comment (149): One commenter requested additional clarification about how the ''time of listing'' occupancy analysis relates to information suggesting that old growth and late-successional habitat features may not be optimal for the northern spotted owl in the Oregon Coast Range.

Our Response: Northern spotted owls live in a variety of forest types and rely on forests of varying structure to survive during different parts of their life cycles. The occupancy data from the time of listing reinforces that the northern spotted owl requires older forest structure to maintain viable reproducing populations throughout much of its range. This commenter appeared to be referring to studies that have shown that northern spotted owls will use younger forests in the Oregon Coast Ranges (Glenn *et al.* 2004) and appear to benefit from some degree of younger forest interspersed in older forest in southwest Oregon (Olson *et al.* 2004) and northern California (Franklin *et al.* 2000). However, none of these studies suggest that old growth and late-successional forest are not optimal habitat for northern spotted owls.

Comment (150): One commenter requested that the Service acknowledge the benefits of grazing on public lands as a tool to manage vegetation which provides the northern spotted owl with easier access to prey. The commenter also expressed concern that the expansion of critical habitat would limit grazing.

Our Response: We are not aware of any research or scientific publications on grazing and northern spotted owl foraging use, and the commenter did not provide supporting information. In any case, this rule does not prescribe limitations on grazing.

Comment (151): One commenter requested that regeneration harvest be restored on all Federal forests within the Northwest Forest Plan boundary, in particular on the Olympic Peninsula. The commenter suggested that regeneration harvest would help restore forest health, create jobs, provide revenue from timber harvest, and reduce effects of forest fires on northern spotted owl habitat.

Our Response: This rule is limited to the designation of critical habitat for the northern spotted owl. While the preamble discusses some management techniques for consideration by land managers, specific management prescriptions for Federal lands within the NWFP is beyond the scope of this rulemaking.

Comment (152): Several commenters suggested narrowing the scale at which the Service assesses whether a proposed action destroys or adversely modifies critical habitat to better reflect northern spotted owl biology, to better capture localized negative trends, or to align with the intent of the Endangered Species Act.

Our Response: In accordance with Service policy, the adverse modification determination is made at the scale of the entire designated critical habitat, unless the critical habitat rule identifies another basis for the analysis (USFWS and NMFS 1998). The adverse modification determination for the northern spotted owl will occur at the scale of the entire designated critical habitat, as described above in the section Determinations of Adverse Effects and Application of the ''Adverse Modification'' Standard, with consideration given to the importance of the conservation function of units and subunits within each of the recovery units identified in the Revised Recovery Plan (USFWS 2011, Recovery Criterion 2). The Service believes the entire designated critical habitat is the appropriate scale for this analysis, because our determination is based on whether implementation of the Federal action would preclude the critical habitat as a whole from serving its intended conservation function or purpose. However, a proposed action that compromises the ability of a subunit or unit to fulfill its intended conservation function or purpose could represent an appreciable reduction in the conservation value of the entire designated critical habitat.

Comment (153): Several commenters suggested that the Service cannot legally designate land as critical habitat that does not currently contain primary constituent elements (PCEs), and should not designate lands that may become habitat in the future.

Our Response: In our proposed designation of critical habitat for the northern spotted owl, we identified primarily areas that were occupied at the time of listing as critical habitat; all such areas support the PCEs and subsequently the essential physical or biological features as identified in this rule. In addition, some areas that may not have been occupied at the time of listing are designated as critical habitat, because we determined that such areas are essential to the conservation of the species. These areas make up a relatively small percentage of the total designation. Because the loss or degradation of habitat was one of the primary threats that led to the listing of the species, the restoration of habitat is required to achieve the recovery of the species, as identified in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011). In some areas, the recovery goal of achieving viable populations across the range of the owl cannot be achieved without the development of some areas that are presently younger forest into additional habitat capable of supporting northern spotted owl populations into the future.

We evaluated all areas anticipated to develop into suitable habitat in the future as if they were unoccupied at the time of listing, to determine whether such areas are essential to the conservation of the species. We included such areas in the final designation of critical habitat only if they were essential to the conservation of the species because they provide connectivity between occupied areas, room for population expansion or growth, or the ability to provide sufficient suitable habitat on the landscape for owls in the face of natural disturbance regimes, such as fire. In addition, recent research indicates that northern spotted owls require additional habitat area to persist in the face of competition with barred owls. Finally, in some areas where habitat loss or degradation was historically severe, areas of currently degraded habitat may be in need of restoration to provide the large, contiguous areas of nesting, roosting and foraging habitat required by the species. Section 3(5)(A)(ii) of the Act provides for the designation of critical habitat in specific areas outside the geographical area occupied at listing upon a determination that such areas are essential for the conservation of the species. As the Secretary has determined that these areas of younger forest that may have been unoccupied at the time of listing are essential to the conservation of the species, the law provides for their designation as critical habitat.

Economic Analysis Comments

Comments From States

Comment (154): The California Department of Forestry and Fire Protection (CALFIRE) states that the designation of Jackson Demonstration State Forest land as critical habitat could result in costly section 7 consultations that might prohibit or delay the approval or implementation of environmental restoration projects. It identifies water quality permits under the Clean Water Act for timber harvesting plans as a potential future nexus, while noting that currently, a waiver of waste discharge requirements can be applied to discharges related to timber harvest activities on non-Federal lands in the North Coast Region. It identifies current litigation threatening this exemption.

Our Response: Chapter 5 of the Final Economic Analysis (FEA) provides extensive discussion of the potential Federal nexuses necessitating section 7 consultation on State and private lands (paragraphs 209 through 221). Specifically, it discusses the Clean Water Act (CWA) permitting requirements and a recent ruling by the Ninth Circuit that has the potential to increase permitting requirements for silviculture operations as sources of point-source pollution. *Northwest Environmental Defense Ctr.* v. *Brown,* 640 F.3d 1063 (9th Cir.). However, in light of the fact the United States Supreme Court has granted a *writ of certiorari* to review this ruling, the economic analysis concludes that considerable uncertainty surrounds this litigation and whether it will in fact change the permitting requirements for silvicultural operations within the next 20 years. Due to this uncertainty, we assume for purposes of our economic analysis the current CWA exemption and subsequent lack of a Federal nexus continues, and therefore do not anticipate direct effects on private or State lands associated with Clean Water Act permitting activities, and therefore do not anticipate any significant impacts to the restoration projects resulting from the designation of critical habitat. Please see the discussion of the Jackson Demonstration State Forest in the section Changes from the Proposed Rule for more details.

Comment (155): CALFIRE provides additional information describing the current management of the Jackson Demonstration State Forest and northern spotted owl habitat.

Our Response: We have added additional discussion of baseline practices at Jackson Demonstration State Forest to Chapter 5 of the FEA.

Comments From Federal Land Managers

Comment (156): U.S. Bureau of Land Management (BLM) asked for clarification as to how the DEA used the data provided by their agency.

Our Response: The BLM provided more detailed geospatial data than other agencies; therefore, when BLM data are aligned with the Service data layers and USFS historical and projected timber harvest, the analysis endeavors to utilize a consistent data set across land ownership types. For example, while BLM provided data on 30 years of planned timber harvest, as well as stand age (i.e., over and under 80 years of age), the analysis focuses on timber harvest projections for the first decade to derive a 20-year projection and does not incorporate stand age, because this information was not available for other areas. Specifically, the draft economic analysis (DEA) used a filtering approach to identify those specific areas where incremental timber harvest effects may occur. Further explanatory detail on these methods has been added to Chapter 4 of the final economic analysis (FEA).

Comment (157): The BLM requested further clarification on how the Service considered the effects on long-term, sustained-yield timber production due to the shift in management objectives for the Matrix lands that are proposed to be designated as critical habitat.

Our Response: The DEA and FEA state that the obligation of the agencies is to consult with the Service to ensure that their actions are not likely to destroy or adversely modify critical habitat and may opt from a wide range of management options, consistent with their land use plans and statutory authorities. It is challenging to predict how the land management agencies will respond or on what actions they will consult. Therefore, there is considerable uncertainty regarding long-term effects, if any, on sustained yield timber production due to a potential shift in management objectives within the revised critical habitat designation. A range of potential effects are discussed qualitatively in the analysis.

Comment (158): The U.S. Forest Service questioned the DEA assumption about the distribution of timber harvested from Federal lands, and stated that the average estimated annual yield per acre may understate actual timber harvest, as well as the assumption that USFS harvest projections include only thinning activities and do not anticipate future regeneration harvest activities.

Our Response: In an ideal world, the economic analysis would utilize detailed geospatial data showing when and where Federal timber harvest is projected to occur. However, lacking data on the narrowly defined areas where timber harvest is projected to occur, and where critical habitat may have an incremental effect on these harvests, the analysis broadly applies projected timber harvest across all Federal land acres. Using this approach, the DEA used timber harvest projections ranging from 14 to more than 200 bf per acre per year across critical habitat subunits, as described in Chapter 4 of the DEA (IEC 2012a, p. 4–18). The DEA based FS Region 6 projections on historical timber harvest quantities provided by USFS. Therefore, planned changes to timber harvest were not contemplated. To address this uncertainty in the amount of timber that could potentially be harvested in the future (i.e., if changes to timber harvest should occur), the FEA scales existing baseline projections upward to account for a potential 20-percent increase in timber harvest projection on USFS lands. The FEA also revised the language regarding projected timber activities to clarify that they may include both thinning and regeneration harvest.

Comment (159): The U.S. Forest Service stated that the DEA assumption about the distribution of timber harvested from Federal lands is problematic and that the average estimated yield of 63 BF per acre per year may understate actual timber harvest. In Region 6, the FY 2013 and FY 2013 NWFP timber program is expected to increase by 20 percent in terms of acres and volume. USFS also disagrees with the assumption that ''USFS harvest projections include only thinning activities and do not anticipate future regeneration harvest activities (page 4–18).''

Our Response: In the Final Economic Analysis, we rely on data provided by USFS Region 5 and Region 6 to estimate annual projected timber harvest amounts. Each region provided an annualized projection of future timber harvest (Region 5) or a 5-year historical annual average timber harvest (Region 6) by national forest. Using GIS acreage data for each national forest, we calculate an average annual timber harvest yield in BF/acre/year. We then estimate a baseline average annual timber harvest yield for each critical habitat subunit based on the number of acres and the proportion of the subunit within each national forest.

To estimate potential incremental economic impacts of the proposed critical habitat designation, we focused on matrix lands that are likely to be unoccupied by the northern spotted owl. We did not estimate that there will be incremental economic impacts across the entire proposed critical habitat, so the comparison to the USFS expected harvest for the entire National Forest System across the entire range of the northern spotted owl is inappropriate. There are approximately 9.5 million acres of USFS lands in the proposed critical habitat. Of these, 6.9 million acres are reserves and 2.6 million are matrix lands. Of the matrix lands, approximately 1.1 million acres are predominantly younger forests (considered to be unoccupied) and 1.6 million acres are northern spotted owl habitat. Furthermore, we estimate that approximately 6.5 percent of northern spotted owl habitat is likely to be unoccupied. We find that incremental economic impacts to USFS timber harvest are relatively more likely in unoccupied matrix lands or approximately 1,158,314 acres of 2,629,031 total acres of all USFS matrix lands.

For example, in USFS Region 5, there are approximately 956,000 acres of matrix lands. The data provided by Region 5 suggest that the annualized projected timber harvest in these matrix lands is 105.4 MMBF (as noted in the comment). However, we estimate that incremental economic impacts due to the critical habitat designation would be relatively more likely to occur in unoccupied areas. We presume that there will not be incremental impacts to timber harvest due to critical habitat in occupied areas as these areas are already sufficiently managed for NSO conservation in the baseline. In Region 5, there are approximately 502,500 acres of matrix lands that are likely to be unoccupied (100 percent of predominantly younger forests and 6.5 percent of northern spotted owl habitat). Thus our area of potential impact is smaller than that contemplated in the comment. Our estimate of baseline timber yield within these areas, however, is consistent with those presented in the comment and FS data. Specifically, the annualized projected timber harvest in these unoccupied matrix lands is 55.5 MMBF. Therefore, when we contemplate a 20 percent reduction in timber harvest due to critical habitat in matrix lands that may potentially experience incremental impacts, we calculate a reduction of approximately 11.1 MMBF (20 percent of 55.5 MMBF), versus a reduction of 21.1 MMBF (20 percent of 105.4 MMBF). In sum, our baseline timber yield and harvest projections are consistent with the USFS data cited in the comment; we are simply assessing impacts on a more constrained set of acres where incremental impacts are relatively more likely to occur.

Note also that the DEA based USFS Region 6 projections on historical timber harvest quantities provided by USFS. Therefore, planned changes to timber harvest were not contemplated. To address this uncertainty, the FEA scales existing baseline projections upward to account for a potential 20 percent increase in timber harvest projection on USFS lands. The FEA also revises the language regarding projected timber activities to clarify that they may include both thinning and regeneration harvest. However, this does not materially affect the results of the analysis.

Finally, we note that our estimate of the area of younger forest in the matrix where incremental impacts may occur is most likely an overestimate. As stated above, we estimated that of the matrix lands, approximately 1.1 million acres are predominantly younger forests (considered to be unoccupied). This estimate, however, was based on the total area of younger forest in the matrix within the proposed designation regardless of patch size. As we noted in our incremental effects memorandum (IEC 2012b, p. B–7), it would be unusual for an agency to contemplate a timber sale or other activity on a very small patch of younger forest; based on our experience, we assumed roughly 40 ac (16 ha) as the minimum patch size of younger forest on which we would anticipate potential incremental impacts. As the estimate of younger forest within the matrix used in the economic analysis did not screen out patches less than 40 ac (16 ha) in size, the resulting total of 1.1 million acres is likely an overestimate of the area of younger forest where incremental impacts may occur on matrix lands. In addition, the final designation represents a net reduction of matrix lands where economic impacts are relatively more likely to occur and this reduction was not analyzed in the FEA (see Changes from the Proposed Rule). It is also important to note that, even if there were likely to be higher economic impacts, we would not exclude these lands from designation under section 4(b)(2) because a critical habitat designation in these areas will likely have regulatory benefits in conserving this essential habitat.

Comment (160): The USFS suggested that additional person-hours for consultations to consider critical habitat issues may be higher than described in the DEA.

Our Response: The USFS currently plans projects outside of existing critical habitat that may be included in the revised critical habitat. Therefore, the administrative burden may include additional consultations beyond the additional hours contemplated for consultations that would already occur absent critical habitat. The FEA makes note of this potential incremental increase in administrative burden.

Comments on the Economic Analysis From the Public

Comment (161): One submission noted that the proposed rule does not make clear the specific restrictions imposed on designated private lands. Furthermore, many submissions note that the resulting regulatory uncertainty will likely reduce the market value of designated private lands, contributing to the loss of multiple-use, working forests that provide other valuable types of habitat and jobs, or result in timber management practices designed to ensure private lands do not become northern spotted owl habitat. Potential third-party litigation risk also contributes to this uncertainty.

Our Response: The proposed rule provided a detailed description of the protection provided to areas designated as critical habitat (see 77 FR 14081; March 8, 2012). Specifically, section 7 of the Act requires that Federal agencies ensure, in consultation with the Service, that any action they authorize, fund, or carry out is not likely to result in the destruction or adverse modification of critical habitat. Chapter 5 of the DEA provided explicit discussion of the potential for State and private landowners to request Federal permits, thereby necessitating consultation under section 7. Furthermore, the chapter acknowledged the concerns raised in the comments regarding the potential impact of regulatory uncertainty on the market value of private lands, including potential changes in State regulations in response to the designation and changes in private timber harvest practices resulting from greater perceived investment risk, and discusses the existing data limitations preventing estimation of the monetary value of such impacts (see DEA paragraphs 259 through 281). Additional information provided through public comment and supporting the existing analysis has been added to Chapter 5 of the FEA.

All private lands have been excluded from this final designation of critical habitat for the northern spotted owl (see Exclusions).

Comment (162): One submission states that all private and State lands in Washington are already subject to State and Federal regulations providing protection for the northern spotted owl; therefore, designating these lands results in duplicative regulation that is contrary to Executive Order 13563 and the President's memorandum dated February 28, 2012. An additional submission recommends that the Service rely instead on existing State regulations and cooperative approaches.

Our Response: The Service is required under the Act to designate critical habitat to the maximum extent prudent and determinable for listed species regardless of State laws. This process is separate from and additional to the listing of a species under the Act and is specifically needed for the northern spotted owl because habitat loss is one of the primary threats to its conservation. The requirement to designate critical habitat is not replaced by State regulations or classification of lands. Please note that, as discussed in our section on Exclusions, above, we were able to exclude all private lands proposed as critical habitat in the State of Washington and California.

Comment (163): One submission questions the DEA's estimate that 117,628 ac (47,602 ha) in Washington may be subject to incremental effects, noting that the calculation is unclear. The comment suggests the correct acreage is 133,895 ac (53,558 ha). Furthermore, two submissions express concern that the State could change the definition of suitable habitat to include all designated private lands, implying the potential increased regulatory burden identified in the DEA may be understated.

Our Response: As noted in Exhibit 5–6 of the DEA, area calculations in the DEA were based on the GIS data layers provided by the Service to the economists preparing the DEA on March 1, 2012. The area estimates derived from these data layers differ slightly from those provided in the proposed rule due to minor boundary adjustments under consideration by the Service. A total of 178,147 ac (72,094 ha) of private land in Washington were proposed for designation, of which 60,519 (24,491 ha) were subject to existing or proposed conservation plans, leaving 117,628 ac (47,602 ha) that may be subject to indirect impacts. As discussed in detail in paragraphs 227 through 235 of the DEA, interviews with Washington State regulators revealed that even if all private lands were designated and subsequently defined by the State as suitable habitat, the State would defer to approved habitat conservation plans (HCPs) or Safe Harbor Agreements (SHAs). Thus, indirect incremental impacts for 60,519 ac (24,491 ha) are unlikely. Of the remaining 117,628 ac (47,602 ha), much of this area may already fall within mapped Home Range Circles for the northern spotted owl and thus are already considered to be suitable habitat. Finally, whether the State will make any changes to its regulations is highly uncertain. However, as all private lands in the State of Washington have been excluded under section 4(b)(2) of the Act (see Exclusions), the concerns expressed by the commenter are moot.

Comment (164): One submission states that the DEA does not account for additional, unforeseen regulatory costs and project delays associated with the regulation of critical habitat by California State agencies.

Our Response: Chapter 5 of the DEA provides a detailed account of our discussions with the California Department of Forestry and Fire Protection (CALFIRE) to understand whether the State would regulate harvests on private timberlands differently if those lands are federally designated critical habitat (see paragraphs 246 through 257). Given the extensive baseline protections provided by California's Forest Practice Rules and the California Environmental Quality Act, CALFIRE does not anticipate any changes as a result of the designation.

Comment (165): Two submissions note that private landowners obtain Federal funding for forest health improvements, fire resiliency projects, and watercourse restoration. Access to these funds may be restricted or delayed because of the designation, resulting in decreased incentives for landowners to complete such projects.

Our Response: As all private lands have been excluded from this final designation of critical habitat for the northern spotted owl, the concerns expressed by these commenters are no longer relevant.

Comment (166): One private landowner stated that the economic impacts of the northern spotted owl listing and protection prior to critical habitat designation are relevant considerations in the exclusion process.

Our Response: Section 4(b)(1)(A) of the Act provides that the listing of a species is determined based solely on the basis of the best scientific and commercial data available. However, under section 4(b)(2) of the Act, the Service may consider economic impacts, and other relevant impacts of designating a specific area as critical habitat. Therefore, when designating critical habitat and evaluating specific areas under section 4(b)(2) of the Act for potential exclusion, we consider the incremental impacts of critical habitat designation, above the ''baseline'' conservation measures resulting from listed status. These incremental impacts (economic or other factors) are then evaluated relative to the conservation benefit of including the specific area in the critical habitat designation. If the costs outweigh the benefits, then the Secretary may exercise his discretion to exclude the area, provided that the exclusion does not result in the extinction of the species.

Comment (167): One submission takes issue with the DEA's conclusion that the approval of HCPs and reinitiation of consultations on existing HCPs will result only in minor administrative burden. Interpretive disputes around the adverse modification of critical habitat can readily lead to costly delays, litigation, and pressure to modify existing and proposed HCPs as well as other projects. Critical habitat designations on private lands discourage the development of HCPs and take away stability over long-term investment horizons.

Our Response: The reinitiation of consultation on an existing HCP is the responsibility of the Service and requires the formulation and addition of an adverse modification analysis. Those consultations that already include an effects determination and no jeopardy determination for northern spotted owls will have incorporated an analysis of the effects of the action (the HCP) on northern spotted owl habitat, which will be similar to the adverse modification analysis except that additional analysis could be needed on impacts to the conservation function of the critical habitat subunit. Only where an HCP would be anticipated to cause adverse modification of a newly designated critical habitat network would significant modification likely be necessary, and we have not found any HCPs that fall into this category for this designation. As for HCPs that are under development the need to minimize impacts to northern spotted owl habitat in an effort to minimize impacts to northern spotted owls is likely to suffice to bring the impacts below the threshold of destruction or adverse modification, thereby reducing the time and energy necessary to complete an HCP as indicated in the Economic Analysis. We note that we have excluded all lands covered by an HCP pursuant to section 4(b)(2).

Comment (168): Several comments provided additional information on the relationship between the amount of private forestland available for harvest and employment. The three comment letters refer to the results of a recent study prepared by Forest2Market on the economic contribution of forestry-related industries to Washington State's economy. They state that for every 1,000 ac (400 ha) of private forestland in Washington, there are 5 jobs in forestry-related industries (or 11 to 15 jobs including indirect and induced employment), an associated $224,000 to $233,000 in wages (or $495,000 to $631,000 including indirect and induced employment), and up to $30,000 in taxes and fees annually. The commenters then use these relationships to estimate the total number of jobs supported by private working forestland proposed for critical habitat designation.

They conclude that if private acres in Washington are designated as critical habitat, all of these jobs, and the associated wages, taxes, and fees, will be lost. In other words, a total of 1,650 jobs, $74.3 million in annual wages, and $4.5 million in annual taxes and fees to counties will be lost. If the Washington multipliers are extended to all 1.3 million private acres proposed in Washington and California, more than 19,000 jobs could be affected. A separate comment states that for every 1,000 ac (400 ha) of private working forestland in California taken out of production, 12 jobs are lost. Using the resultant multiplier of 0.012 jobs per acre, the comment states that the 1.27 million ac (514,000 ha) of private land proposed for critical habitat designation in California represents more than 15,000 jobs.

Our Response: The comments assume the designation of critical habitat precludes any timber harvests on private lands (i.e., all employment associated with designated acres will be lost). Chapter 5 of the economic analysis examines the potential for harvests to be precluded on private lands and concludes that existing baseline protections in the form of habitat conservation plans (HCPs) and Safe Harbor Agreements (SHAs) are likely to provide sufficient protection to much of the habitat without additional restrictions (see paragraphs 211 and 212 of the DEA). We note that all private landowners with HCPS or SHAs that were proposed for exclusion from critical habitat in the proposed rule were excluded from the final designation. In addition, private landowners of small woodlots in Washington were removed from critical habitat upon a determination that their lands either do not provide the PCEs or are not essential to the conservation of the species. Finally, the remaining 307,308 ac (124,364 ha) of private lands in the proposed designation in California and Washington, which we identified as possibly subject to incremental changes in harvests as a result of the indirect effects of critical habitat designation should a Federal nexus exist, have been excluded from the final designation (see Exclusions). However, here we explain how we derived our estimates of the relationship between private timberland, harvest levels, and employment in the economic analysis.

On some private lands, uncertainty on the part of landowners over whether the designation will result in future restrictions may create an incentive for those landowners to shorten harvest rotations, cutting timber earlier than is financially optimal (see paragraphs 263 through 269 of the FEA). We did not anticipate that private landowners will be precluded from harvesting timber as a result of the designation; rather, we assumed they may harvest earlier than they would have absent the designation. As a result, the estimates noted in the comment of lost employment and associated wages, fees, and revenues anticipated in the comments are likely overstated.

In Washington, 21,715 ac (8,788 ha) of private land in the proposed designation are identified by the State as suitable habitat for the northern spotted owl, but are not currently designated as ''critical habitat state.'' It is possible that the State may reclassify these areas as ''critical habitat state'' in response to the Federal designation, which would impose significant administrative costs on landowners, such that landowners would likely forego future harvests. However, such a regulatory change on the part of the State is uncertain (see complete discussion in paragraphs 231 through 235, 269, and 276 through 279 of the FEA). These private lands are not included in the final designation, as the result of either refinements to critical habitat (determinations that small private landholdings either do not contain the PCEs, or are not essential to the conservation of the species) or exclusions under section 4(b)(2) of the Act.

Thus, the DEA estimated that at worst, it is possible that 21,715 ac (8,788 ha) in Washington may not be harvested, or approximately 1,086 ac (439 ha) per year over the 20-year timeframe of our analysis. Estimating the impact of such a small change in harvestable acres on employment is difficult and likely to be highly dependent on the location and timing of the foregone harvests. The relationships between acres and jobs, revenues, or fees and taxes presented in the comments may not be applicable to such small, marginal changes in harvestable acres.

For example, the ratio of 5 jobs for every 1,000 ac (400 ha) likely represents the average jobs created per acre when total acres of forestland are divided by total timber employment in the State (the Forest2Market report is not clear about whether its ratios represent average or marginal changes). A marginal estimate, on the other hand, would look at the number of jobs associated with the ''next'' 1,000 acres of harvest given existing employment levels and harvestable acres, as the relationship between jobs and acres may not be perfectly linear. Employment associated with the next 1,000 acres of harvest may be larger or smaller than the average. Furthermore, it is possible that other private acres may be harvested as substitutes for the 21,715 ac (8,788 ha) that could be restricted if the State changes its regulations, diminishing the rule's effect on employment. Thus, even if we knew with certainty that the State of Washington will change its regulations as a result of the designation, forecasting potential changes in employment is challenging given existing data limitations.

Comment (169): One comment states that the SDS Lumber Company is the only remaining mill in Klickitat County, and that designating approximately 29,000 ac (11,700 ha) of private forest in Klickitat and Skamania Counties, including approximately 16,000 ac (6,500 ha) of SDS and Broughton Lumber Company land, will have direct and significant impacts on its 300 employees.

Our Response: SDS and Broughton Lumber Company have developed a Safe Harbor Agreement in collaboration with the Service. As described in the Exclusions section of this document, SDS lands within the proposed critical habitat covered by this SHA have been excluded from the final designation.

Comment (170): One comment states that Rayonier (a forest products company) already protects 100 of the 540 ac (40 of the 220 ha) of its land in Washington proposed for critical habitat, making the remaining 440 ac (180 ha) especially important to Rayonier, local communities, and the people who work in forest industry. A reduction in logging on these 440 ac

(180 ha) would directly reduce logging and trucking jobs and have downstream effects in the community.

Our Response: We determined that the lands owned by Rayonier did not meet our definition of critical habitat, therefore these lands are not included in our final designation (see *Comment (106)).* Therefore, we do not anticipate any potential impact of critical habitat in terms of possible reduced harvests on Rayonier lands or effects on local employment due to this rulemaking.

Comment (171): One comment noted that the ''checkerboard'' and intermingled Federal and private ownership patterns make it difficult, if not impossible, for many timberland owners to haul their timber products without the use of some type of Federal road use permit. Access to existing or new roads may be precluded by critical habitat concerns.

Our Response: This issue is addressed in Chapter 5 (p. 5–6) of the FEA. The report notes that a review of Federal consultations over the last 3 years indicates that no consultations related to the northern spotted owl have resulted from application for this type of permit. Representatives of the USFS and BLM further noted that formal consultation of this type of activity is not prioritized, and that any request for consultation would likely be limited to hauling activity and would not include the timber harvest activity itself. As a result, we do not anticipate any direct effects on State or private lands as a result of this potential nexus.

Comment (172): One comment notes that the DEA does not address potential affects to the U.S. Treasury and Federal job losses.

Our Response: Project modification costs quantified in the DEA result from changes in the quantity of timber harvested on Federal lands. As discussed in detail in Chapter 4 of the DEA, section 7 consultations on the sale of timber from Federal lands may result in an increase, decrease, or no change in harvest levels, based on several plausible assumptions. The direct cost (or benefit) of these section 7 project modifications is a loss (or gain) in Federal revenues collected by the U.S. Forest Service and the U.S. Bureau of Land Management resulting from the associated timber sales. Stumpage values related to these effects are summarized in Exhibit ES–4 of the DEA. With available data, we are unable to discern how these timber harvest changes may affect employment at Federal agencies.

Comment (173): One commenter suggested that the DEA fails to comply with the requirements of Executive Order 12866, which requires the Secretary to base his decision on the best reasonably available economic information, and circular A–4, which provides guidance for complying with Executive Order 12866. The commenter states that the DEA applies different standards of information and analysis in its assessment of the effect of the proposed rule on timber production and its assessment of other important ancillary benefits of the designation, as well as the baseline applied in the analysis.

Our Response: An assessment of ancillary benefits is not possible without first assessing the effect of the proposed rule on timber production; the ancillary benefits derive from changes in timber management practices. Therefore, accurately assessing changes in timber production is critical for multiple facets of the economic analysis. The results of this assessment suggest that incremental changes in annual harvests are likely to be small, less than one percent of total harvests in the 56 counties overlapping the designation. While quantification of the value of foregone timber (or timber brought back into production as a result of the regulation) is relatively straightforward, because market data provide an indication of the value of this resource, estimating the marginal changes in terms of the distributional impacts on communities of these small changes in harvests, or the marginal changes in ecosystem services, is challenging and requires significantly more data and sophisticated modeling tools. Thus, both are discussed qualitatively in the FEA.

Regarding the assessment of ancillary benefits, Circular A–4 states, ''You should begin by considering and perhaps listing the possible ancillary benefits and countervailing risks. However, highly speculative or minor consequences may not be worth further formal analysis. Analytic priority should be given to those ancillary benefits and countervailing risks that are important enough to potentially change the rank ordering of the main alternatives of the analysis'' (Circular A–4, p. 26). This text provides some discretion to the Agency to determine whether the quantification of ancillary benefits is necessary. As described in responses to earlier comments, the application of best available data and tools to estimate the incremental changes in ecosystem services resulting from the designation of critical habitat would require significant effort and some data that do not currently exist. Because the Service has not excluded areas where such benefits are possible (i.e., Federal matrix lands), quantification of ancillary benefits would not change the regulatory outcome.

With regard to baseline definition, the comment suggests the analysis should incorporate potential future changes in timber markets, changes in external factors affecting costs and benefits, changes in future regulations, and likely future compliance with other regulations. With regard to future demand for timber, the analysis relies on the best available data provided by the USFS and BLM regarding baseline harvest levels (see FEA paragraphs 166 through 175). Data to predict future changes in the demand of timber products are highly speculative, given current economic conditions (e.g., demand for timber is largely driven by the housing market). We have no reason to anticipate other regulatory changes that would affect the designation of critical habitat, and the comment provides no additional information on this topic. Finally, we consider the degree of compliance with section 7 of the Act in the absence of critical habitat in determining the likelihood of future consultations (see, for example, the discussion in paragraphs 181 through 186 of the FEA).

Comment (174): One comment claims that the DEA distorts the impacts of the proposed critical habitat designation on Douglas County by including ''metropolitan areas that have little to no critical habitat nor similarities to Douglas County's social and economic environment.''

Our Response: Chapter 6 of the DEA provided a detailed socioeconomic profile of each of the 23 counties (including Douglas County) containing proposed critical habitat subunits with higher proportions of Federal forests that are relatively more likely to experience incremental impacts due to the designation of critical habitat. The analysis presents data on the percent change in timber production between 1990 and 2010 for each county, and on the percent growth of annual industry employment between 1989 and 2009 for each county. In addition, the analysis presents data on Federal land payments to each of the 23 counties as a percent of the total local government revenue in FY 2009, demonstrating the relative importance of these funds to each county's budget. The analysis then concludes that five counties (including Douglas County) may be more sensitive to additional incremental changes in timber harvests, industry employment, and Federal land payments. Such data are not readily available at a sub-county level. We believe, however, the information provides sufficient context for understanding relative economic circumstances across the designation.

Comment (175): One comment states that designating O&C lands as critical habitat is inconsistent and in direct conflict with the statutory provisions of the O&C Act and Sec. 701(b) of FLPMA (Federal Lands Policy management Act). (''O&C lands'' refers to certain areas in western Oregon established under the O&C Act of 1937, and ''O&C'' counties represent those counties containing O&C lands). The Association of O&C Counties asserts that the proposed critical habitat designation will prevent 18 O&C counties from receiving sufficient revenues on a sustainable basis as required by the O&C Act, and will result in employment and income impacts on a local and regional scale.

Our Response: The designation of critical habitat is not a land use allocation. Under section 7(a)(2) of the Act, each Federal agency must insure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of the designated critical habitat of the species. 16 U.S.C. 1536(a)(2). To help action agencies comply with this provision, section 7 of the Act and the implementing regulations set out a detailed consultation process for determining the impacts of a proposed activity on species listed as threatened or endangered, or its designated critical habitat. 16 U.S.C. 1536; 50 CFR Part 402. In *Seattle Audubon Society* v. *Lyons* (''Lyons''), 871 F. Supp. 1291 (W.D. Wash. 1994), the district court held that ''the O & [C Act] does not allow the BLM to avoid its conservation duties under NEPA or ESA * * *'' Id. at 1314. The critical habitat designation does not preclude the sustained yield timber management of O&C lands consistent with the above requirements of the Act. The economic impact to local counties of this critical habitat designation will be determined by the timber management direction the Federal land managers take within critical habitat lands. We believe the ecological forestry techniques discussed in this designation could allow for timber harvest that is consistent with critical habitat objectives and section 7(a)(2), thereby providing increased revenues to affected counties. The Service encourages land managers to consider use of this type of forest management in critical habitat where appropriate.

As discussed in detail in Chapters 3 and 6 of the FEA, the O&C counties currently elect to receive Secure Rural Schools and Community Self-Determination Act (SRS) rather than revenue-sharing payments from BLM under the O&C Act. These payments are supplemented by Payments in Lieu of Taxes (PILT) (see paragraphs 128 through 130 of the FEA). Even absent the designation of critical habitat, the magnitude of future payments under these programs is highly uncertain given that these Federal programs have not been reauthorized (i.e., SRS) or funded (i.e., PILT) by Congress. If SRS and PILT payments continue, the changes in harvests on BLM lands will have minimal to no effect on payments, because SRS and PILT are not directly linked to harvest levels. However, if Congress decides to reduce or end payments under SRS and PILT, counties will shift back to receiving revenue-sharing payments under the O&C Act, and changes in timber harvests on BLM lands will affect the size of these payments. Importantly, we note that under the third scenario analyzed in the DEA, the potential decrease in harvest from BLM lands represents approximately 2 percent of total harvests from BLM lands in these counties (Based on BLM transaction data over the last four quarters (2011Q4–2012Q3) viewed at *http://www.blm.gov/or/resources/forests/blm-timber-data.php*). Thus, if affected, impacts to revenue payments resulting from the designation are likely to be small.

Comment (176): One commenter states increased timber production often has been associated with deteriorating indicators of socio-economic well-being in nearby rural communities, including income, percent living in poverty, and housing conditions, and noted a positive relationship between the health of local economies and the presence of unlogged Federal forests.

Our Response: The comment cites extensively from a report by the National Resources Council (NRC) (NRC 2000). The committee was asked to evaluate the nature of possible economic and social costs and benefits of alternative forest management practices. The committee wrote, ''[a]lthough the question is easy to ask, it is hard to answer. Few social-impact studies clearly tie social and economic outcomes with specific forest-management practices, such as old-growth harvest rates, the use of clearcutting as a harvest technique, or the relative intensity of silvicultural practices'' (p. 163). The committee went on to review a meta-analysis of the relationship between varying levels of timber dependence and measures of community well-being, which finds for most relationships that ''well-being went up as timber dependency went down'' (p. 163). Furthermore, the committee cited studies suggesting that ''wilderness and amenity protection can have a positive influence on certain measures of community well-being, although in-migration brings its own difficulties'' (NRC 2000, p. 164).

The NRC report concluded, ''[d]iverse economic conditions create diverse opportunities and thus temper the effects of timber industry fluctuations on local communities'' (p. 165). It went on to note that ''[a]s the importance of extractive industry declines, the Pacific Northwest communities are looking toward tourism as a way to bolster their economies * * * However, tourism by itself is not a substitute for timber industry jobs'' (NRC 2000, p. 167).

In summary, the NRC report suggests that economically diverse communities are better off than communities that are highly dependent on the timber industry, and preserving wilderness can attract new economic activity to communities. We have added text summarizing the NRC findings in the FEA. However, the designation of critical habitat does not preserve wilderness. Furthermore reducing timber harvests does not guarantee that other sources of economic activity, such as tourism or in-migration by wealthy, highly educated individuals, will generate enough new economic activity to replace lost timber-related jobs and wages. Finally, the designation is likely to reduce or increase annual timber harvests from Federal lands by less than one percent. Thus, any changes in economic diversity resulting from the rule are likely to be difficult to measure.

Comment (177): One comment suggests that the proposed critical habitat designation will create a regulatory hurdle that will impede the construction of vital infrastructure projects (roads, bridges, power lines, and other utilities).

Our Response: Chapter 7 of the DEA discusses the potential economic impacts to road and bridge construction and maintenance, and installation and maintenance of power transmission lines and other utility pipelines. The analysis concludes that all potential conservation efforts associated with linear projects are expected to result from the presence of the northern spotted owl, not the designation of critical habitat, and are thus considered baseline impacts (see paragraphs 315 through 320 of the DEA). Incremental costs attributable to critical habitat are limited to the administrative costs of additional hours spent by Federal agency staff and the Service to consider critical habitat during section 7 consultation on these projects.

Comment (178): Many comments describe the adverse impacts that changes in the timber industry have had on local and regional employment levels, government revenues, and overall socioeconomic conditions. Several of these comments request that these impacts be taken into consideration in the economic analysis.

Our Response: Chapter 3 of the DEA describes how, over the past 20 years, the Pacific Northwest timber industry has undergone significant changes that have manifested in reduced timber-related jobs and revenues. The analysis provides detailed data on the changes in timber production levels between 1990 and 2010, and on the changes in industry employment and payroll between 1989, 1999, and 2009 in each of the 56 counties where critical habitat was proposed. This information is intended to provide context for the analysis and illustrate the importance of the timber industry to local economies. In addition, Chapter 6 of the DEA provides a detailed socioeconomic profile of the 23 counties containing proposed critical habitat subunits that contain a higher proportion of Federal lands that are relatively more likely to experience incremental impacts due to the designation of critical habitat. The chapter examines trends in timber harvests, industry employment, and Federal land payments in these counties, and concludes that certain counties may be more sensitive to additional incremental changes in timber harvests, industry employment, and Federal land payments.

Comment (179): The Small Business Administration (SBA) expressed concern that the Service does not have an adequate factual basis for certifying that the rule will not have a significant economic impact on a substantial number of small businesses. It disagrees with the Service's assertion that small businesses are not directly regulated by the proposed rule and states that the Service incorrectly analyzes the universe of affected small businesses by counting the number of consultations required by the designation, as opposed to the number of all small businesses affected by these consultations. SBA also notes that the DEA states private landowners may be affected if they have federally funded or permitted activities on Federal or private land, such as participation in timber sales or timber management projects or application for a section 10 permit.

Our Response: The Service agrees with SBA's statement that small entities (businesses, governments) may be affected by the designation of critical habitat as third parties involved with consultation under section 7 of the Act with Federal action agencies. However, we disagree that these entities are directly regulated. This position is supported by existing case law regarding the certification requirements under the Regulatory Flexibility Act (RFA), the Small Business Regulatory Enforcement Fairness Act (SBREFA) (see paragraphs 378 through 381 of the DEA), and SBA's handbook, ''A guide for Government Agencies: How To Comply With the Regulatory Flexibility Act (2003). However, we believe it is good policy to assess these indirect impacts to third parties if we have sufficient available data to complete the necessary analysis, whether or not this analysis is strictly required by the RFA. Therefore, where third parties are anticipated to participate in consultations under section 7 of the Act with Federal action agencies, these entities are included in the screening analysis (see paragraphs 383 through 392 of the DEA). Please refer to the discussion under Regulatory Flexibility Act later in this final rule and the FEA for a more complete discussion of our factual basis for certification under RFA that this rule will not result in a significant impact to a substantial number of small entities.

Comment (180): An additional entity asserts that the Service is incorrect in stating that only Federal agencies will be ''directly regulated'' by critical habitat designation. It contends that private sector entities relying directly or indirectly on Federal timber sales are also directly regulated. The entity cites case law, stating, ''The RFA requires consideration of *'the small entities which will be subject to the proposed regulation—that is, those small entities to which the proposed rule will apply.' Cement Kiln Recycling Coalition v. E.P.A.,* 225 F. 3d 855, 869 (DC Cir. 2001).'' A critical habitat designation ''applies to'' private parties as much as Federal agencies; a private party seeking a Federal permit that may affect designated critical habitat cannot obtain the permit until a consultation is completed under section 7 of the Act, and has the statutory right to participate in that consultation. Thus, such entities must be considered under the RFA.

Our Response: The Service's current understanding of recent case law, including the *Cement Kiln* case, is that Federal agencies are only required to evaluate the potential incremental impacts of rulemaking on those entities directly regulated by the rulemaking; therefore, they are not required to evaluate the potential impacts to those entities not directly regulated. The language from the *Cement Kiln* case quoted by the commenter merely restates the language of the RFA itself. Several court decisions, including the *Cement Kiln* decision, have interpreted that language to require Federal agencies to analyze the rule's effects on any small entities that are subject to—that is, directly regulated by—the rule, rather than requiring Federal agencies to consider every potential impact that a regulation may have on indirectly affected small entities. *See also Am. Trucking Ass'ns* v. *Envtl. Prot. Agency,* 175 F.3d. 1027 (D.C. Cir. 1999); *Mid-Tex Elec. Coop.* v. *Fed. Energy Regulatory Comm'n,* 773 F.3d 327 (D.C. Cir. 1985); *et al.*

The regulatory mechanism through which critical habitat protections are realized is section 7 of the Act, which requires Federal agencies, in consultation with the Service, to insure that any action authorized, funded, or carried out by the Agency is not likely to adversely modify critical habitat. The designation of critical habitat for an endangered or threatened species only has a regulatory effect where a Federal action agency is involved in a particular action that may affect the designated critical habitat. Under these circumstances, only the Federal action agency is directly regulated by the designation, and, therefore, consistent with the Service's current interpretation of RFA and recent case law, the Service may limit its evaluation of the potential impacts to those identified for Federal action agencies. Under this interpretation, there is no requirement under the RFA to evaluate the potential impacts to entities not directly regulated, such as small businesses. However, EO's 12866 and 13563 direct Federal agencies to assess costs and benefits of available regulatory alternatives in quantitative (to the extent feasible) and qualitative terms. Consequently, it is the current practice of the Service to assess to the extent practicable these potential impacts if sufficient data are available, whether or not this analysis is believed by the Service to be strictly required by the RFA. In other words, while the effects analysis required under the RFA is limited to entities directly regulated by the rulemaking, the effects analysis under the Act, consistent with the EO regulatory analysis requirements, can take into consideration impacts to both directly and indirectly impacted entities, where practicable and reasonable.

Therefore, as discussed in the previous response, where third parties are anticipated to participate in section 7 consultations, these entities are still included in the screening analysis if sufficient data is available to complete the necessary analysis. The direct compliance costs of section 7 consultations concerning timber sales are the administrative costs of conducting the consultation, which are primarily borne by the Service and the Federal Action Agency, and potential changes in revenues to Federal agencies from timber sales.

Potential impacts to the profitability of timber industry entities resulting from changes in the price or availability of timber represent an indirect effect of the regulation. In this case, we note that potential changes in timber harvests are anticipated to be less than one percent of average annual harvests in the region subject to the designation.

Comment (181): The SBA states that the Service underestimates the economic impact of the rule on the timber industry and private landowners because, in its screening analysis, it only considers administrative costs of section 7 consultations, rather than quantifying the costs of project modifications resulting from those consultations.

Our Response: Project modification costs quantified in the DEA result from changes in the quantity of timber harvested on Federal lands. As discussed in detail in Chapter 4 of the DEA, section 7 consultations on the sale of timber from Federal lands may result in an increase, decrease, or no change in harvest levels, based on several plausible assumptions. We note that if future harvests are restricted, total annual harvests could decrease by 24.56 million board feet (MMBF). This decrease represents less than one percent of 2010 total harvest and the average annual harvests between 2006 and 2010 across the 56-county area overlapping proposed critical habitat. The designation may also result in an increase in annual harvests of 12.28 MMBF, or less than half a percent of total annual harvests in the 56-county area. Finally, it is possible that harvest levels will not change a result of the designation. In summary, the proposed rule is anticipated to have a minor impact on future harvest levels. Although the Service has estimated these potential impact scenarios relative to the total harvest, the agency acknowledges that the designation of critical habitat may have indirect impacts on industry subsectors and/or related sectors with high concentrations of small businesses. However, a more detailed analysis capturing these impacts is not available to the agency at this time.

The direct cost (or benefit) of these section 7 project modifications is a loss (or gain) in Federal revenues collected by the U.S. Forest Service and the U.S. Bureau of Land Management resulting from the associated timber sales. Stumpage values related to these effects are summarized in Exhibit ES–4 of the DEA. In the FEA, we include additional information in the RFA/SBREFA screening analysis (Appendix A) describing these project modification costs, which are borne entirely by Federal agencies.

The potential indirect effects of these lost Federal revenues, in terms of implications for County revenue sharing programs, are discussed in Chapter 6 of the DEA (see paragraphs 293 through 299). In addition, Chapter 6 also identifies the counties with Federal lands more likely to experience changes in harvest levels as a result of the designation and provides background information on harvest and employment trends in these counties.

Comment (182): Several commenters stated that the DEA misrepresented the baseline or underestimates timber harvest impacts on Federal lands. One commenter in particular asserts that the true baseline is best represented by the land management plans that have been adopted by BLM and FS, in which planned annual harvest volumes may total 840 MMBF across all lands encompassed by the NWFP.

Our Response: The baseline projection should represent the best estimate of the world absent critical habitat, given the best available data. Relying on this criterion, the baseline projection first focuses on areas of the proposed designation where incremental impacts to Federal timber harvest are relatively more likely to occur as a result of critical habitat. As identified in the Incremental Effects Memorandum, these areas include matrix lands that are likely to be unoccupied by the northern spotted owl, representing approximately 1.4 million acres of matrix lands out of approximately 12 million Federal acres in the proposed designation. Given that incremental impacts, if any, are likely to occur primarily in these more discrete areas, a projection utilizing the range-wide planned harvest levels contemplated under the NWFP would overstate baseline conditions.

Second, based on historical experience, projected actual timber harvest in the baseline on USFS and BLM lands is likely to be less than that in the formally-approved land management plans under the NWFP. Federal land managers have not achieved this level of timber harvest over the past several years, and do not anticipate this level of harvest in the future, providing further confirmation that the identified long-term sustained yield of 840 MMBF associated with these plans would overstate the baseline.

For those matrix areas where incremental effects may be relatively more likely to occur, the FEA utilizes a variety of planned, historical actual, and projected actual timber harvest data provided by BLM and FS to derive the annual baseline projection, which totals approximately 123 MMBF. This projection is then appropriately caveated, with the FEA noting that within the discrete areas of each subunit where incremental effects may occur, the subunit level projection could vary materially from future actual timber harvest in these areas.

We note further, however, that based on comments received from Federal land managers, we have added an additional sensitivity analysis to Chapter 4 of the FEA. Specifically, the sensitivity analysis tests alternative assumptions concerning: (a) The percentage of northern spotted owl habitat on BLM matrix lands that is likely to be unoccupied, which increases the acreage where incremental timber harvest impacts may occur and thus the baseline projection; and (b) the baseline harvest projection for USFS Region 6, where we assume a 20 percent increase in baseline timber harvest relative to historical yields.

Comment (183): Several commenters questioned whether the DEA was meaningful, because it displays results as a menu of choices, including a potential increase in timber harvest on Federal lands. In addition, one commenter contemplated a potential reduction in annual planned harvest volumes of 500 MMBF as a result of critical habitat designation.

Our Response: The DEA presented alternative scenarios due to considerable uncertainty regarding the specific projects that may be proposed or management options that Federal land managers may consider. These scenarios are intended to present a range of estimates for the potential incremental impacts of various options for complying with section 7 available to Federal agencies. Based on the best available data and information, these decisions, including the adoption of ecological forestry practices, may result in harvest levels being maintained (as described in Scenario #1), increased (Scenario #2), or decreased (Scenario #3). This range of estimates is not meant to be interpreted as ''over 100 potential outcomes.'' Statistical analyses frequently account for uncertainty by presenting a range of estimates in which each individual data point is not considered an independent outcome. One purpose of this analysis was to aid the Secretary in determining if any lands should be excluded due to the financial burden associated with the designation, and this analysis does so by identifying the subunits and relevant landowners for whom incremental impacts are relatively more likely to occur, as demonstrated through these scenarios.

With respect to the representation of the potential 500 MMBF reduction in annual timber harvest, this figure overstates any possible effect of critical habitat. This volume is roughly equivalent to the total harvest on the National Forest System and BLM lands in the NWFP area in recent years, and is roughly five times the baseline harvest projection for potentially-affected areas. The figure implies that the designation will largely preclude any timber harvest whatsoever on Federal lands operated under the NWFP. Based on the historical record of actual timber harvest volumes and the best available information concerning potential future harvest activity under the designation, we reject this representation.

Comment (184): One comment suggested that the DEA underestimated the administrative costs associated with consultations.

Our Response: The additional burden of 4 to 6 hours described in the FEA reflects an incremental impact to consultations that would already occur due to the listing of the species. These costs do not reflect the total cost of consultations that would occur absent the critical habitat designation. The FEA discusses additional consultations that would not have occurred but for the critical habitat designation.

Comment (185): One commenter stated that the high-impact economic estimate based on a $250/mbf stumpage value underestimates the true economic costs of the proposed designation, and that a stumpage rate of $350/mbf is more realistic.

Our Response: The stumpage values in the economic analysis ($100 to $250/mbf) reflect a wide range of historical values for timber harvest from Federal lands for the years 2000 to 2011 (the most recent estimates that were available). Average stumpage prices vary by forest, species, product, and year, reflecting, among other things, shifts in economic demand. Exhibit 4–11 presents a weighted average of stumpage values across USFS National Forests and BLM districts within the proposed critical habitat designation for each Federal land manager. These values best represent the average price of timber sold in areas of concern where incremental effects are relatively more likely to occur. Please see chapter 4.4.3 of the FEA for further explanation of how we arrived at these values. However, even if we apply the $350/mbf figure, the annual high-impact result would increase by $2.5 to $2.9 million, which is still a relatively small incremental impact.

Comment (186): One submission noted that a number of Pacific Northwest Ski Areas Association (PNSAA) member ski areas operate on National Forest System (NFS) land potentially within the range of the northern spotted owl. The primary request of the comment is that areas covered by special use permits (SUPs) under which the ski areas operate be excluded from the final designation. The comment goes on to note potential burdens critical habitat designation may entail for these areas and their economic impact. This economic activity and any related regulatory impacts are not addressed in the draft economic analysis.

Our Response: While ski areas are found on a very small proportion of the forested lands in the Pacific northwest, our analysis found these lands provide essential high-value northern spotted owl habitat to the critical habitat network. Currently, impacts to northern spotted owl habitat in these areas are subject to the section 7 consultation process for effects to northern spotted owls. Our experience shows that ski area development actions generally tend not to conflict with northern spotted owl and critical habitat conservation needs, so we do not anticipate any significant regulatory burden associated with the designation of these lands as critical habitat. Removing lands managed under ski area special use permits would increase fragmentation of the critical habitat network and potentially continuous tracts of northern spotted owl habitat. Therefore, there is a greater benefit to the species associated with retaining ski areas in the critical habitat designation. In situations involving the imminent loss of human life or property the managing agency should implement emergency section 7 measures to avoid compromising public safety. A note regarding ski area activities and their economic impact has been added to Chapter 1 of the FEA.

Comment (187): Several submissions commented upon how critical habitat may affect wildfire risks and related coverage of this issue in the draft economic analysis. One comment asserts that critical habitat makes fuel management more difficult, resulting in the destruction of habitat. Another comment notes the prospect of reduced fire risk under critical habitat due to restoration of riparian forests or road closure.

Our Response: The FEA addresses the potential impacts of critical habitat on fire management in Chapters 4 and 8. In Chapter 4, the FEA discusses the fact that ecological fire salvage activities contemplated as part of proposed critical habitat designation on both reserved and nonreserved lands may result in incremental economic effects. Due to data limitations and fire location uncertainty, however, these effects are not quantified. In the benefits discussion in Chapter 8, the FEA recognizes that it is possible that the designation could result in increased resiliency of timber stands associated with improved timber management practices, such as thinning, partial cutting, and adaptive management and monitoring. These efforts may reduce the threat of catastrophic events such as wildfire, drought, and insect damage. This in turn may generate benefits in the form of reduced property damage.

Comment (188): One comment noted that the DEA only considers impacts related to logging, and limits its coverage of many other economic purposes that critical habitat may negatively affect.

Our Response: Based on a review of the consultation record, recognized threats to the species, and other related information, the FEA focuses on those economic activities that could be materially affected by the designation. These activities include timber harvest on public and private lands, fire management activities, and linear projects (roads, gas pipelines, utility lines, etc.). We are not aware of other economic activities that will be materially affected by the designation. In addition, the FEA qualitatively considers potential benefits from the designation on certain activities, including recreation.

Comment (189): Multiple submissions assert that the DEA does not sufficiently consider the cumulative economic impacts of northern spotted owl conservation efforts since the time of its listing, instead focusing primarily on the potential incremental impacts of the proposed critical habitat designation prospectively.

Our Response: The U.S. Office of Management and Budget's (OMB) guidelines for best practices concerning the conduct of economic analysis of

Federal regulations direct agencies to measure the costs of a regulatory action against a baseline, which it defines as the ''best assessment of the way the world would look absent the proposed action.'' (OMB, ''Circular A–4,'' September 17, 2003, available at *http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf.*) The baseline utilized in the DEA is the existing state of regulation, prior to the designation of critical habitat, which provides protection to the species under the Act, as well as under other Federal, State, and local laws and guidelines. To characterize the ''world without critical habitat,'' the DEA also endeavors to forecast these conditions into the future over the timeframe of the analysis, recognizing that such projections are subject to uncertainty. This baseline projection recognizes that the northern spotted owl is already subject to a variety of Federal, State, and local protections throughout most of its range, due to its threatened status under the Act and regardless of the designation of critical habitat.

Significant debate has occurred regarding whether assessing the impact of critical habitat designations using this baseline approach is appropriate, with several courts issuing divergent opinions. Courts in several parts of the country, including the 9th Circuit Court of Appeals, which has jurisdiction in Washington, Oregon, and California, have ruled that the consideration of economic impacts in the designation of critical habitat should be based on the incremental impacts of the designation. See, e.g., *Home Builders Association of Northern California* v. *United States Fish and Wildlife Service,* 616 F.3d 983 (9th Cir. 2010), cert. denied, 179 L. Ed. 2d 301; *Arizona Cattle Growers* v. *Salazar,* 606 F.3d 1160 (9th Cir. 2010), cert. denied, 179 L. Ed. 2d 300.

Chapter 3 of the FEA provides extensive discussion of the historical and current economic conditions against which critical habitat is designated. Specifically, the document provides data, by each of the 56 counties overlapping the proposed rule, on changes in timber harvests, timber industry employment, and timber industry payroll since 1989. It also provides a detailed discussion of the existing revenue-sharing programs related to timber harvests and the data describing which counties are most reliant on these programs.

Comment (190): One comment states that, while accepted in the academic literature, existence values, contingent values, recreational hedonic values, and other nonmarket values that might be assigned to critical habitat designation are unreliable and irrelevant where the only benefit of relevance to the decisionmaker is the conservation of a listed species. The Act calls for a cost-effectiveness approach where the Service should seek to minimize the economic costs and burdens that must be incurred to designate only that habitat that is essential for species conservation. Other benefits are irrelevant and should not be offset against the costs.

Our Response: The valuation of nonmarket goods as part of the evaluation of the benefits of proposed Federal regulations is a widely accepted and regularly applied practice. The U.S. Office of Management and Budget (OMB) explicitly recommends the use of revealed preference (recreational demand models, hedonics) and stated preference methods (contingent valuation) in its guidance to Federal agencies (Circular A–4) on best practices for preparing regulatory analysis required by Executive Order 12866. Circular A–4 includes criteria for conducting and applying stated preference studies, which are commonly used to measure existence values. Chapter 8 of the FEA describes the data limitations preventing the Service from quantifying or estimating the value of these benefits. Thus, the direct benefits of the designation are described qualitatively.

In weighing the benefits of including an area in critical habitat as opposed to excluding it, ancillary benefits may be considered, although we agree with the comment that the most relevant benefit of designating critical habitat for the northern spotted owl are the benefits to the species' conservation and recovery. However, ancillary benefits are relevant only to a decision whether to exclude an area under section 4(b)(2) of the Act, not to the threshold determination that an area meets the definition of critical habitat. We agree that only lands that meet the definition of critical habitat (areas occupied at the time of listing containing features essential to the species' conservation or unoccupied areas that are themselves essential to the species' conservation) should be designated.

Comment (191): One comment states that most of the economic benefits (e.g., existence value, wildlife viewing, ecosystem services) derive from the listing; the incremental benefit of critical habitat is negligible to nonexistent.

Our Response: As discussed in detail in the DEA, particularly Chapter 4, the designation of critical habitat may result in changes in timber management practices. These physical changes are likely to support the conservation and recovery of the northern spotted owl. As described in Chapter 8 of the DEA (paragraphs 342 through 343), the benefits of the regulation in terms of improved probability of northern spotted owl conservation and recovery are difficult to quantify due to existing data limitations.

Comment (192): Several commenters asserted that in not attempting to quantify environmental and ecosystem services benefits, the Service is not employing the best available science regarding the benefits that endangered species and their critical habitat provide, and is undervaluing the economic benefits of the designation. The comment asserts that multiple global efforts have been developed to quantify ecosystem services in order to inform policy, promote incorporating ecosystem services into decision making, and provide guidelines to assess costs and benefits of policies and better account for ecosystem service effects. Commenters encourage the Service to make a credible (if rapid) attempt to value ecosystem service benefits and consider ecosystem services.

Our Response: The Service recognizes that much attention has been paid nationally and globally to valuing ecosystem services provided by landscapes. Published, peer-reviewed studies provide information on values of multiple categories of ecosystem services (e.g., agricultural production, water quality regulation, carbon storage and sequestration, recreation, aesthetic values, etc.) across a variety of land use types (e.g., wetlands, forests, etc.). Over the past 20 years, multiple studies have relied on this literature to develop large-scale benefits transfer analyses in order to estimate a total value of a parcel of land, a watershed, a State, or even the planet (e.g., Costanza 1997, as described in the comment letter).

The first comment focuses in particular on the potential relevance to the DEA of a large-scale benefits transfer estimate developed for the Skykomish watershed. This study is characterized as a ''rapid ecosystem service valuation.'' In general, the authors first identified land cover types present in the watershed, identified the categories of ecosystem services relevant to those types, and then researched existing studies valuing those categories of ecosystem service benefits. From the available literature, the authors estimated a range of values for each category of ecosystem service by relying on the low end and high end estimates identified. The authors then summed across relevant ecosystem service values to estimate a value range for each land cover type, and summed across the land cover types within the watershed to estimate a value range for the entire Skykomish watershed of $245 million to $3.3 billion per year.

While case- and site-specific modeling to value ecological benefits is preferable, the Service agrees that benefits transfer methods may be useful in the absence of resources for intensive primary research. To use these methods in support of Federal rulemakings, OMB has developed guidelines for conducting credible benefits transfer. A rapid assessment of ecosystem services, such as that developed for the Skykomish, is unlikely to meet the criteria specified by OMB. Multiple responses to similar large-scale benefits transfer studies have highlighted the theoretical and practical problems associated with estimating and extrapolating per-acre estimates of values taken from other studies of ecosystem services (e.g., Bockstael *et al.,* 2000).

First, this approach ignores site-specific factors affecting the production of services by not accounting for variations in the condition or quality of an ecosystem. For example, a less dense or degraded forest area stores less carbon than a dense, healthy forest. The extent to which a given acre of land delivers ecosystem services also depends on the surrounding land uses. For example, a wetland downslope of cropland may provide a valuable service by filtering nitrogen runoff and decreasing the total amount of the nutrient reaching a water supply, whereas a wetland surrounded by forest is unlikely to intercept such runoff to begin with and, therefore, would not provide this service. By relying on site-specific studies valuing these types of services in other areas—the Skykomish study relies on a variety of studies of ecosystems all across the country—these differences are not taken into account. In addition, benefits transfer for rapid assessments, such as the Skykomish study, fail to account for differences in values associated with differences in socioeconomic context between sites. For example, the recreational value of a forest depends on multiple site-specific socioeconomic factors such as accessibility (landownership and proximity to roads and towns). In transferring values of ecosystem services from other studies, the Skykomish study fails to account for such ecological and socioeconomic context affecting these values. This represents one reason we do not rely on the values presented in this study in the DEA.

Second, rapid assessments do not provide information on the effects of changes in the condition or quality of an ecosystem on the associated service values. The Skykomish study assigns an equal value to all ‘‘forest’’ acres and therefore does not provide any information to support an analysis of the ecosystem service benefits of changes in the management of a forest. It is the incremental change in the value of a service provided that is relevant to the DEA. For example, the DEA concludes critical habitat designation for the northern spotted owl may result in the harvest of fewer board feet of timber in a portion of the forests. Decreased harvest of trees may not change the land cover type (forest) as characterized in the rapid assessment; it simply affects the density of the trees in given areas. The rapid assessment approach does not address such differences across areas within a land use type (i.e., forests); rather, it is more useful in comparing the ecosystem services provided across different land use types (i.e., deserts, prairie, forests, marshes) and is therefore of limited use in evaluating tradeoffs associated with changes in the condition of a given ecosystem.

Consequently, absent a full-scale change from one ecosystem type to another, the rapid assessment approach to valuing benefits of critical habitat designation does not provide a valid approach to quantifying the ecological benefits of critical habitat designation for the northern spotted owl. While the DEA provides information on the types of services associated with the ecosystems types potentially affected by the designation, it does not attempt to perform a rapid assessment of the values of these services, for the reasons stated.

Comment (193): One commenter suggested that the Service could employ any of three approaches to value ecosystem service benefits of critical habitat designation: (1) The Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model; (2) the Ecosystem Services Review Method; and (3) the Wildlife Habitat Benefits Estimation Toolkit. The comment states that all three are available and ready for immediate, widespread use. A second comment states that the Service is far behind the ecosystem services valuation curve.

Our Response: The Service recognizes that multiple tools exist that focus on evaluating ecosystem service benefits of land management changes. The authors of the DEA have experience with a number of these methods, including the InVEST tool and the Wildlife Habitat Benefits Estimation Toolkit. As a practical matter, the InVEST tool could be used to evaluate potential ancillary benefits of critical habitat for the northern spotted owl. The tool comprises a series of biophysical and economic models that aim to translate changes in a given landscape into changes in the delivery of multiple ecosystem services. These models are data-intensive and require site-specific information.

For each ecosystem service, InVEST relies on two separate models: One that estimates the biophysical change in the delivery of a service and, for some services, a second economic model that monetizes that change. For example, to estimate the change in water quality resulting from changes in the management of a given forest, the following types of detailed, on-the-ground, data would be required as inputs to the biophysical model: A digital elevation model, soil depth, plant available water content (the fraction of water that can be stored in the soil profile for plants' use), root depth of vegetative cover, evapotranspiration, nutrient or sediment loading for each land use type across the landscape, the vegetation filtering capacity of the land cover (as a function of the type and density of vegetation), and pre-existing water quality conditions for model calibration (e.g., nitrogen, phosphorus, or sediment concentrations). While some of these data are available; some would need to be generated at a relatively fine level of resolution in order to model the incremental changes in the ability of the landscape to filter pollutants likely to result from the designation. The InVEST tool values this service in terms of changes in treatment costs for nutrients or sediment. These costs are likewise site-specific.

This effort is particularly significant in light of the conclusion of the DEA that the critical habitat designation is most likely to generate only minor incremental changes in the management of land uses within the designation. The key change is a potential increase or decrease in timber harvest of less than one percent in the region. While the analysis describes qualitatively that this change potentially could generate some marginal improvements in services such as water quality regulation, these benefits are expected to be relatively minor, ancillary benefits of the rule. The same is true of application of other models to evaluate benefits, such as the Multiscale Integrated Model of Ecosystem Services (MIMES), also described in the comment. Finally, the areas most likely to produce these ancillary benefits (e.g., Federal matrix lands) are included in the final designation; thus additional analysis of the ancillary benefits of including these areas would not change the final regulatory decision. The DEA therefore provides qualitative information to the Service regarding potential ancillary benefits.

The objective of the Ecosystem Services Review (ESR) Method is to provide companies with information on how their business depends on ecosystem services, whether their business affects their (or others') ability to access these services, and opportunities to capitalize on and minimize effects on these services. The ESR is not a quantitative tool but a series of steps embedded in a spreadsheet model to help users incorporate consideration of ecosystem services into business decisionmaking. While useful to corporations, it is unclear how this tool may be used to improve the benefits discussion in the DEA. Section 8.2 of the DEA describes potential categories of ancillary ecosystem service benefits that may result from the designation and where (in which units) these benefits may occur. This information is provided for the Service to consider alongside the costs. The ESR does not provide a means to value these services.

The Wildlife Habitat Benefits Estimation Toolkit is a benefits transfer tool developed by the Defenders of Wildlife and Colorado State University for the purposes of valuing ecosystem services associated with species and habitat conservation, such as property values, recreation, and existence values. The benefits transfers facilitated by this toolkit suffer from some of the same issues as the rapid assessment described above. The policy context or sites subject to analysis are most often not transferable to the issue being evaluated: In this case, the land management changes resulting from the critical habitat designation for the northern spotted owl.

Comment (194): One organization stated the DEA is incomplete, in part because it focuses too narrowly on impacts to the timber industry, while the final designation will also affect the economies of the region in other ways. Specifically, two comments stressed that the analysis should consider the total value of the goods and services provided by forests in this region, including reduced wildfire threats, reduced impacts of droughts, reduced threat of insect damage, reduced property damage due to these risk reductions, increased quality or quantity of recreational activities, aesthetic improvements for people passing on nearby roads, carbon sequestration, and improved water quality.

Our Response: The economic analysis's focus on changes in timber harvest practices is appropriate because this activity is the conduit for all other ''on-the-ground'' changes, positive or negative, resulting from the designation. Increases or decreases in timber harvests could positively or negatively affect regional socioeconomic conditions. Thus, Chapter 3 of the DEA provides context explaining historical and current conditions, and Chapter 6 identifies counties that may experience the greatest impacts. The same changes in timber harvests could affect the northern spotted owl's conservation and recovery, discussed in Chapter 8 of the DEA. Finally, these changes in timber harvests are the driver of the potential changes in other ecosystem services, including recreational opportunities, described in the comment. These ancillary benefits are also described in Chapter 8 of the DEA.

Responses provided to earlier comments review the best available modeling tools for quantifying and valuing ecosystem services and describe why these tools were not employed in this instance. In the FEA, we expand our qualitative discussion of potential ancillary benefits to include the broader set of ecosystem service categories discussed in the comment.

Comment (195): One organization states that OMB's Circular A–4 is fundamentally flawed in excluding the flow of ecosystem services from the baseline and recommending discounting practices that are inconsistent with ecosystem service valuation. The comment further states that Circular A–4 is insufficient because it provides the Service with a rationale to avoid quantifying the benefits of critical habitat designation by allowing for a qualitative assessment where benefits are ''difficult to quantify.''

Our Response: The conceptual framework of the FEA is to evaluate impacts by comparing the world without critical habitat (baseline) to the world with critical habitat. The difference between these two states represents the incremental impacts of the rule. Thus, the FEA does not exclude the flow of ecosystem services from the baseline. To understand how the flow of ecosystem services may change, one must first understand the categories and magnitude of existing services. In this way, while not explicitly quantified in the analysis, the current flow of ecosystem services is implicitly captured in our characterization of the baseline condition.

Put another way, the organization appears to be asking us to first present the total value of all services provided by forests included in proposed designation. Then, our analysis would estimate the value of the incremental change in quality and quantity of these services as a result of the designation. Such an effort would be equivalent, on the cost side of the analysis, to first presenting the total value (in terms of stumpage prices) of all the timber found in proposed critical habitat, and then presenting the value of the change in the amount of timber harvested as a result of the regulation. On both sides of the equation, providing a monetized estimate of the value of the baseline resources is not a necessary step to understanding the value or the change in services resulting from the designation. Correctly *characterizing* the baseline conditions is necessary, but valuation efforts appropriately focus on what will change, rather than what exists today.

Substantial debate surrounds the selection of appropriate discount rates for ecosystem services. While Circular A–4 recommends applying discount rates of 7 and 3 percent for regulatory analyses, it does not preclude the application of alternative discount rates for comparison. The comment recommends assessing ecosystem services benefits using discount rates of zero and one percent, in addition to three and seven percent. Because ecosystem services are not quantified in the economic analysis, we do not consider additional sensitivity analysis around the discount rate assumption.

Further, such an effort would require some data that are not currently available.

Comment (196): One comment states that the cost of avoiding carbon emissions is less than the cost of climate mitigation, and several studies have shown that changing forest practices is one of the more efficient and economical ways to store carbon and reduce emissions. Given that carbon storage is just one of the many important ecological services provided by mature and old forest, every effort should be made to avoid as much warming as possible by protecting mature forests.

Our Response: We have added discussion of the potential for increased carbon sequestration to Chapter 8 of the FEA.

Comment (197): A comment asserts that the Presidential Memorandum to the Secretary of the Interior on the northern spotted owl is not consistent with the Endangered Species Act because it states that ''the benefits of excluding private lands and State lands may be greater than the benefits of including those areas in critical habitat.'' The commenter is concerned that this statement is made in the Presidential Memorandum without an attempt to quantify ecosystem services benefits of the designation on these lands, and these benefits are therefore given an effective price of zero.

Our Response: We do not believe that the directive in the Presidential memorandum is inconsistent with section 4(b)(2) of the Act, which states that the Secretary may exclude areas from critical habitat if the benefits of exclusion outweigh the benefits of inclusion, as long as failure to designate such areas will not result in extinction of the species. The purpose of the economic analysis is to provide the Secretary of the Interior with information to support analysis of where the benefits of excluding a particular area may outweigh the benefits of including that particular area as critical habitat. In providing the qualitative discussion of benefits, the FEA does not assign zero values to these potential benefits; this discussion is provided for the Secretary to consider alongside the quantitative information provided.

Comment (198): One commenter stated that the DEA estimates the benefits of increased timber production in terms of the market value of the logs, but ignores the costs to Federal agencies of producing the logs (i.e., costs of managing the land for timber production and executing the timber sales), and that the total cost to taxpayers may exceed the logs' market value.

Our Response: In support of its comment that the costs to Federal agencies (and ultimately taxpayers) of timber sales exceeds the revenues from the sales, the commenting organization cites several studies from the early 1980s, as well as a more recent report published by the Congressional Research Service (CRS) in 2004 (Gorte, R.W. 2004, Below Cost Timber Sales: An Overview, CRS, Order Code RL32485).

We agree that whether the net benefit of timber sales in terms of costs and revenues is positive has been the subject of much debate. CRS summarizes this debate and notes ''the estimates of financial results of [USFS] timber sales vary widely. This disparity is due to differences in basic approach—profit-and-loss, cash flow, or other approach—and in assumptions about relevant costs'' (Gorte, R.W. 2004, summary page). In particular, CRS notes differing assumptions regarding which Agency costs are relevant and how to allocate those costs to specific sales may result in different answers using the same basic accounting approach.

CRS also notes that the USFS sells timber for many reasons, such as ''to generate receipts, to supply wood for manufacturers, to provide employment, to expand access for motorized vehicles, to alter the composition and distribution of vegetation in the area, and more'' (p. 5). The ''value'' of all of these positive attributes of the sales may not be captured in the stumpage price paid by the loggers or mills purchasing the timber, as many of these attributes represent market externalities. Furthermore, ''the multiple outputs, environmental impacts, and differing time scales of timber sales and related activities make identifying relevant costs and comparing them with relevant revenues problematic. Two decades of debate have not resolved the dilemma, and further debate seems unlikely to result in widespread agreement'' (Gorte, R.W. 2004, p. 7).

Thus, whether the Federal agency costs of baseline timber sales anticipated in the absence of critical habitat, or new sales potential generated by the designation, exceed revenues is unknown. However, the fact that these sales are often conducted for multiple purposes, such as improved ecosystem services or regional employment, and those purposes may have value that is not captured in stumpage prices, suggests that our assumption that the benefits of the sales exceed costs is not unreasonable.

Comments on the Economic Analysis From Counties

Comment (199): Several counties including Wasco, Del Norte, Klickitat, and Skamania Counties expressed criticism of the Draft Economic Analysis, including concerns about the incremental analysis approach and the negative economic impact of reducing or restricting commercial timber harvest on local communities (employment, tax base, quality of life, and other socioeconomic impacts).

Our Response: The economic impact to local counties of this critical habitat designation will be determined in large part by the timber management direction the Federal land managers take within critical habitat lands. Project modification costs quantified in the FEA primarily result from changes in the quantity of timber harvested on Federal lands. As discussed in detail in Chapter 4 of the DEA, section 7 consultations on the sale of timber from Federal lands may result in an increase, decrease, or no change in harvest levels, based on several plausible assumptions. We note that if future harvests are restricted, total annual harvests could decrease by 24.56 million board feet (MMBF). This decrease represents less than one percent of 2010 total harvest and the average annual harvests between 2006 and 2010 across the 56-county area overlapping proposed critical habitat. The designation may also result in an increase in annual harvests of 12.28 MMBF, or less than half a percent of total annual harvests in the 56-county area. Finally, it is possible that harvest levels will not change as a result of the designation. In summary, the designation is anticipated to have a minor impact on future harvest levels.

The DEA used a filtering approach to identify those specific areas where incremental timber harvest effects may occur. Further explanatory detail on these methods has been added to Chapter 4 of the FEA. In addition, the chapter also notes the potential effects to the baseline timber projection related to increasing the percentage of matrix lands with northern spotted owl habitat that are likely to be unoccupied.

Comment (200): Two small county governments submitted comment stating the proposed rule would have disproportionate impacts on local employment, payroll, and county services funded by revenues-sharing programs and taxes. They provide data describing economic conditions in the 1970s and 1980s, and describe the economic decline experienced since the owl was listed in 1991.

Our Response: We recognize that many small governments have experienced significant changes in employment, payroll, and county revenues as a result of the decline in the timber industry over the last 21 years. Chapter 3 of the DEA provides detailed data by county describing these changes and providing context for the analysis. Chapter 6 provides information specific to the counties where changes in Federal timber harvests are relatively more likely. We note that these counties are not directly regulated by the designation of critical habitat for the northern spotted owl; rather, potential impacts result from changes in harvest practices on Federal lands or where other Federal actions may be involved.

Given the numerous factors affecting the future of the industry, including changes in the availability of Federal timber, mechanization, transfer of capital investment away from the region, closure of less efficient mills, and fluctuating demand for wood products, we are unable to provide quantitative projections of future timber-related employment. Furthermore, as discussed in Chapters 3 and 6 of the DEA, uncertainty regarding the future of existing county revenue-sharing programs, such as PILT and SRS, confound our ability to predict potential changes in county revenues. However, we note that reasonable assumptions suggest overall changes in harvest levels resulting from the designation are likely to be less than one percent of current levels. Chapter 6 of the DEA discusses the counties most likely to see the largest changes. In addition, most of the costs cited by the commenter, if not all, are attributable to the listed status of the northern spotted owl, rather than the incremental effects of critical habitat.

Comment (201): Several county governments reference a report prepared by the Sierra Institute for Community and Environment and Spatial Informatics Group, titled ''Response to the Economic Analysis of Critical Habitat Designation for the Northern Spotted Owl by Industrial Economics,'' and submitted as a public comment. Funding for the report was provided by the National Forest Counties and Schools Coalition. The report states that the DEA's assessment is insufficient in its documentation of cumulative socioeconomic impacts and current socioeconomic conditions. It provides detailed discussion and data concerning a variety of characteristics for communities potentially affected by the designation, including: Number of mills and mill closures; employment patterns; revenue-sharing payments to counties; family income; poverty levels; home ownership; health outcomes and factors; and enrollment in programs such as School Free and Reduced-Price Meals (FRPM).

Our Response: Chapter 3 of the DEA is intended to provide context to the decision maker regarding historical changes in the timber industry in the Pacific Northwest in terms of production, employment, income, and county revenues. It also discusses multiple possible causes contributing to these changes, including protection of the northern spotted owl. The Sierra Institute for Community and Environment report provides additional socioeconomic information supplementing the background information provided in Chapter 3. Text summarizing the contents and availability of this report has been added to the FEA. We note that verification of the data provided by the Sierra Institute for Community and Environment is complicated by the fact that citations are not provided for the majority of the report's figures and data.

Comment (202): The Sierra Institute for Community and Environment states in several places in its report that the DEA argues the loss of 30,000 jobs in the timber industry between 1990 and 2010 was offset by regional gains in population and employment of 15 percent and 18 percent, respectively. They state that the DEA errs by assuming that job gains in one time period offset losses in another, and that job gains (and losses) are equally distributed across the region. In addition, they claim that the DEA does not analyze or sufficiently discuss the issue of disparity and does not discuss how areas with a proportionally greater amount of employment in the timber industry are affected by the proposed critical habitat designation.

Our Response: The authors are referring to information provided in paragraphs 14 and 106 of the DEA, which present regional job loss figures and changes in regional population and employment. The DEA simply presents these facts; it makes no assumptions, and draws no conclusions, about whether lost timber jobs are offset by overall employment gains in the region or how job losses and gains are distributed across the region. Detailed analysis of rate and nature of reemployment of former timber industry employees is complex and beyond the scope of the DEA.

Chapter 6 of the DEA attempts to address potential disparity in the distribution of regional impacts of the designation. It combines background information on timber industry harvest and employment trends (presented in Chapter 3), and county dependency on revenue-sharing payments, with information about subunits where changes in timber harvest are possible (Chapter 4). It highlights the counties most likely to be affected by the rule based on proximity to affected subunits, and identifies which of these counties have already experienced the most significant declines in the industry over the last 20 years. The report notes that these counties may be more sensitive to future changes in timber harvests.

Definitely linking changes in timber harvests to timber-related jobs in certain communities is challenging. Timber industry jobs are not necessarily closely correlated with the amount of timber being harvested in that specific county; some mills or related manufacturers (e.g., wood product manufacturers) may rely on resources harvested from outside their immediate community. In its presentation of historical data on regional mill closures, the Sierra Institute for Community and Environment acknowledges, ''Other reasons for mill closure also include, but are not limited to, industry closing older, less efficient mills, closure of mills that handled only larger trees coupled with less old-growth timber available, and shipping raw logs and cants out of the region for processing elsewhere. Additional study is needed'' (page 31).

Teasing out the precise location of potential regional impacts resulting from critical habitat designation is particularly challenging due to the relatively small overall change in harvest anticipated to result from the final rule (at worst, a less than one percent decline in annual harvest). This marginal change in available Federal timber is unlikely to cause large-scale changes in the regional industry. Identification of who will experience impacts requires better understanding of potential substitutes and the degree of flexibility in the current production system, as well as proprietary information about the financial characteristics and operations of individual mills. Such data are not available to us and are not provided in the Sierra Institute for Community and Environment's report.

Comment (203): The Sierra Institute for Community and Environment report states that the DEA fails to link job losses to socioeconomic conditions and that this is required by the February 2012 Presidential Memo.

Our Response: The Presidential Memorandum directs the Secretary of the Interior to: (1) Publish, within 90 days of the date of this memorandum, a full analysis of the economic impacts of the proposed rule, including job impacts, and make the analysis available for public comment. The DEA satisfied this direction. It estimates the incremental change in social costs and benefits that may result from the proposed rule, as required by Executive Order 12866, following OMB's guidance on best practices as defined in *Circular A–4,* and consistent with existing case law; and, it provides a separate analysis of potential job impacts in Chapter 6.

The memorandum did not require the Secretary to take the additional step of developing complex models to link changes in timber industry employment to changes in socioeconomic conditions, such as poverty rates, homeownership, and participation in food assistance programs, as suggested by the report authors. Furthermore, the authors of the Sierra Institute for Community and Environment report acknowledge that linking changes in socioeconomic factors to changes in land management, and specifically to critical habitat designation, is challenging due to time constraints and complex data requirements (see, for example, pages 94, 105, 168 of the Sierra Institute for

Community and Environment report). As a result, the organization does not estimate these changes in its report.

Comment (204): The Sierra Institute for Community and Environment report states that an unintended consequence of critical habitat designation is that private landowners ''do nothing'' due to the increased cost of compliance, and that this has real social and environmental costs, such as reducing job availability and revenues and increasing fire risk.

Our Response: As described in Chapter 5 of the DEA, there is a potential for increased compliance costs, such as preparing environmental impact statements. In Washington, the DEA indicated that this may occur only in the event that the State Forest Practices Board redefines all suitable habitat overlapping Federal critical habitat within SOSEAs as ''critical habitat state'' (see paragraphs 227 through 232 of the DEA). The likelihood of such an outcome is uncertain. If it occurs, we estimated that at most 21,715 ac (8,788 ha) of proposed private lands could be incrementally affected. The remaining lands are already considered ''critical habitat state'' or are protected by existing or proposed HCPs and SHAs. The potential social and environmental costs of not harvesting these 21,715 ac (8,788) over the 20-year timeframe of the analysis are too small to measure.

In California, the FEA states that one stakeholder noted that landowners may be required to provide additional documentation under CEQA to demonstrate that their management plan timber harvest plan will mitigate impacts to critical habitat. Since CALFIRE has stated that it is unlikely to require additional protective measures for designated critical habitat beyond those already required by State regulation, any incremental costs would be limited to the possibility for additional CEQA review.

The FEA also identifies possible changes to timber harvest practices suggested by private parties as potentially occurring due to regulatory uncertainty, ranging from harvesting existing trees as early as feasible to discontinuing use of the property for timber production. However, due to the high degree of uncertainty over whether these impacts may occur, we were not able to quantify the potential effects.

We note that all private lands were excluded from critical habitat for the northern spotted owl under section 4(b)(2) of the Act (see Exclusions), therefore none of the potential scenarios considered by the DEA are germane to the final designation.

Comment (205): The Sierra Institute for Community and Environment report states that the DEA is insufficient because it does not adequately characterize cumulative socioeconomic impacts. The authors state that ''understanding current condition requires an understanding of what has transpired in recent years and trend [sic], which are, for the most part, not factors in the analysis.'' They also question why the Entrix report and the 2012 analysis ''ended up in inconsistent places with respect to baseline and included incremental impacts.''

Our Response: The DEA provides data on historical changes in timber industry production, employment, and income (see Chapter 3). It also provides information about trends in county revenue-sharing payments. This information is included in order to provide the Secretary with context for the incremental impacts of the analysis.

The OMB guidelines for best practices (*Circular A–4*) concerning the conduct of economic analysis of Federal regulations direct agencies to measure the costs of a regulatory action against a baseline, which it defines as the ''best assessment of the way the world would look absent the proposed action.'' The baseline utilized in the DEA is the existing state of regulation, prior to the designation of critical habitat, which provides protection to the species under the Act, as well as under other Federal, State, and local laws and guidelines. To characterize the ''world without critical habitat,'' the DEA also endeavors to forecast these conditions into the future over the timeframe of the analysis, recognizing that such projections are subject to uncertainty. This baseline projection recognizes that the northern spotted owl is already subject to a variety of Federal, State, and local protections throughout most of its range, due to its threatened status under the Act, and regardless of the designation of critical habitat.

Significant debate has occurred regarding whether assessing the impact of critical habitat designations using this baseline approach is appropriate, with several courts issuing divergent opinions. In 2010 and 2011, courts in several parts of the country, including the Ninth Circuit Court of Appeals, which has jurisdiction in Washington, Oregon, and California, ruled that decisions concerning designation of critical habitat should be based on the incremental impacts of the rule. The 9th Circuit cases were appealed to the Supreme Court, which declined to hear them.

The Entrix report analyzing the 2008 designation was prepared under subcontract to Industrial Economics, Incorporated (IEC), the authors of the 2012 analysis, and project managers from IEC worked closely on both efforts. The difference in the two analyses regarding whether to quantify impacts resulting from baseline regulatory protections is due to the change in case law described in the previous paragraph.

Comment (206): The Sierra Institute for Community and Environment report questions why the background data provided on timber industry employment and harvests do not factor into the overall assessment and analysis of impacts. The report states that the analysis does not address localized and community-level impacts.

Our Response: As described above, Chapter 6 of the DEA combines data from Chapters 3 and 4 of the analysis to identify counties that may be particularly susceptible to changes in timber harvests resulting from the designation. Employment and harvest trend data are generally available at the county level through publicly available sources, such as State natural resource agencies, the U.S. Census, and the U.S. Bureau of Labor Statistics. Assessing distributional impacts as a finer level of resolution is challenging given a lack of data. In addition, linking changes in community outcomes to the designation would require complex modeling that is beyond the scope of this analysis given the numerous other confounding factors and the relatively small changes in annual harvest that could result from the designation.

Comment (207): The Sierra Institute for Community and Environment report states that counties, municipalities, and schools were ''given short shrift'' in the DEA and that there was no substantive exchange about the conditions of counties or municipalities for the analysis. In addition, other economist commenters also said that they were not consulted for the DEA.

Our Response: During preparation of the draft, IEC contacted many stakeholders, including Federal agencies, State governments, and representatives of the timber industry, and sought to obtain economic and other relevant information from publicly available sources. They collected and analyzed data on historical changes in timber harvests and timber industry employment and payroll for each of the 56 counties overlapping the proposed designation and reviewed literature related to impacts to regional communities, including counties. IEC conducted research on county revenue sharing programs and presented data on the proportion of total county revenues derived from these programs. Two of the eight report chapters in the FEA focus exclusively on historical and current conditions in the counties, identifying those that are most likely to experience incremental impact and those that are likely to be more sensitive to changes in in harvests resulting from the proposed regulation.

IEC also reached out directly to County representatives. On June 6, 2012, IEC emailed representatives of Siskiyou, Skamania, and Douglas Counties, as well as the Association of O & C Counties, the Association of Oregon Counties, and the Washington State Association of Counties, and offered to meet with them via conference call. On June 25, 2012, IEC received a letter from representatives of Skamania, Douglas, and Siskiyou Counties requesting a meeting with all of the counties that may be affected by the designation. Since the comment period closed on July 6, 2012, the Service determined that there was not time to arrange a meeting with all 56 counties. However, on July 20, 2012, per section 4(b)(5) of the Act, we again invited all State agencies and affected jurisdictions to submit their comments on the proposed critical habitat revision.

Comment (208): The Sierra Institute for Community and Environment report questions the DEA's statement that employment in California, Oregon, and Washington increased only three percent between 2000 and 2010. The report states that reliance on Bureau of the Census and Bureau of Labor Statistics for employment data, such as the data presented in Exhibits 3.6 and 3.7 of the DEA, will result in an undercount of employment. Lastly, the authors state that they were unable to replicate the numbers in the tables because the methodology is inadequately specified.

Our Response: In both the Executive Summary and Chapter 3, the DEA reported that total employment in California, Oregon, and Washington increased by three percent between 2000 and 2010. IEC has added the source for this data, which is the Bureau of Economic Analysis (BEA), to the FEA. The BEA provides data on total annual State employment, which IEC used to determine the tri-State area employment increase between 2000 and 2010. The data is publically available and can be found online at BEA's Interactive Data Web site at *http://www.bea.gov/itable/*.

The data source for Exhibits 3.6 through 3.8 of the DEA, which present historical timber industry employment and payroll data for each county that contains proposed critical habitat (as well as for each State and for the entire study area), is the U.S. Census Bureau's County Business Patterns. Data for the County Business Patterns excludes data on self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees. More information on these exclusions can be found at *http://www.census.gov/econ/cbp/methodology.htm.* While a certain amount of undercoverage may occur, we believe the data provide the best available information from a reliable source. The exhibits list the SIC and NAICS codes that were used to estimate industry employment, as well as the Web site where the data can be found (*http://censtats.census.gov*).

Comment (209): The Sierra Institute for Community and Environment report states active forest management occurs on National Park Service lands in Shasta County.

Our Response: We make note of this representation in the FEA.

Comment (210): The Sierra Institute for Community and Environment report disagrees with the results of Scenario 3 of the Federal lands analysis (described in Section 4.4.2.3 of the DEA). The authors state that the DEA bases its analysis of incremental changes in timber harvests on a period in which there is a severe downturn in the economy and wood products industry and that this results in an undercount of likely impacts. They state that the analysis ''relies on 5 years (2006 to 2010) of harvest data to base future timber harvests.'' In addition, they state that estimates of harvest totals are generalized and not linked to subunit timber harvest totals.

Our Response: The DEA and FEA rely on historical actual harvest data for USFS Region 6 because it represented the best available data for purposes of the analysis. For USFS Region 5, the analysis relies on projected actual timber harvests by forest, provided by USFS. For BLM lands, the FEA utilizes BLM-provided data on timber harvest projections by critical habitat subunit for three decades of incremental impact estimates, by land allocation type, forest conditions, and harvest type. To conduct the analysis, these various timber projections needed to be converted to board feet, per-acre, per-year measurements, by critical habitat subunit. In an ideal world, the FEA would utilize detailed geospatial data showing when and where Federal timber harvest is projected to occur. However, lacking data on the narrowly defined areas where timber harvest is projected to occur, and where critical habitat may have an incremental effect on these harvests, the analysis broadly applies projected timber harvest across all Federal lands. Using this approach, the FEA uses timber harvest projections ranging from 14 to more than 200 BF-per-acre per-year across critical habitat subunits, as described in Chapter 4. In sum, the FEA does not rely exclusively on historical data, and variable projected harvests are linked to specific subunits to the extent possible.

Comment (211): The Sierra Institute for Community and Environment questions the baseline timber harvest projection used in the DEA, stating that it fails to draw a distinction between dry and wet forests and those that are commercially viable and those that are not.

Our Response: As noted in the prior response, the economic analysis endeavors to distinguish potential future harvest levels by forest type and characterization, and by areas within each subunit, to the extent possible given the best available information.

Comment (212): The Sierra Institute for Community and Environment report claims that the DEA does not provide sufficient analysis of indirect incremental effects of the critical habitat designation on private landowners. To assess the effects of potential changes in Washington State regulations resulting from critical habitat designation, the authors suggest, ''There may not be adequate estimates of the probability or the total number of acres that could be included, but probabilistic models coupled with a sensitivity analysis could offer insight into the impact and are possible to develop'' (Sierra Report 2012, p. 13).

Our Response: Chapter 5 of the FEA provides a detailed discussion of the sources of the data required to quantify the potential indirect effects of the designation on private lands (see paragraphs 279 through 287), including the number of acres where landowners are likely to alter current timber management practices; the characteristics of the stands (type of tree, age, etc.) subject to changes in the timing of harvests; current and revised harvest schedules; financial models of the change in the present value of existing lands that incorporate information about stumpage prices, stand growth curves, and the opportunity cost of capital to private timber managers; and information regarding the probability that the Washington Forest Practices Board will undertake regulatory changes. Basic data are not available for most of these elements, and thus, information necessary to create distributions describing these data elements and assumptions, which are required for probabilistic models, are scarce. Any distributions would likely be vague (for example, the probability of the Washington Forest Practices Board changing its regulations would range from zero to 100%, with an equal probability of any point in between these two endpoints). While it is technically possible to build a Monte Carlo-type probabilistic model using such vague probability distributions, the lack of data for meaningful inputs would render the results uninformative. We also note that private lands have been excluded from the final rule pursuant to section 4(b)(2) of the Act.

Comment (213): The Sierra Institute for Community and Environment report states that it is important for the DEA to quantify potential impacts of critical habitat designation on SRS and PILT payment programs. The authors state that it is not difficult to quantify the effects that future changes in timber harvests from Federal lands resulting from critical habitat designation would have on these payment programs. The authors also state that the analysis does not make clear that the revenue-sharing programs for Federal lands only continues if SRS is reauthorized after 2013.

Our Response: The Sierra Institute for Community and Environment is mistaken in its statement on page 14 of its report that the revenue-sharing programs for Federal lands only continue if SRS is reauthorized after 2013. It is true that if SRS is not reauthorized, the payments received by counties could be substantially different. However, as described in paragraphs 128 through 129 of the FEA, the U.S. Forest Service (USFS) 25% Fund and the Bureau of Land Management Oregon and California Land Grant (BLM O&C) Revenue-Sharing Payments (50 percent of commercial receipts) are permanently authorized by Congress and have dedicated funding sources in the form of commodity receipts. States and counties currently elect to receive SRS payments instead of revenue-sharing payments from the USFS 25% Fund and the BLM O&C Revenue-Sharing Program. In the absence of SRS (and possibly a second program called Payments in Lieu of Taxes, or PILT), the older programs would still be available and would serve as the sources of revenue-sharing payments.

Exhibit 3–9 in the FEA illustrates the relative magnitude of historical payments under all four programs, and Exhibit 3–10 provides information on percent of local government revenue that is made up of payments from these programs. Current SRS and PILT payments are based on historical revenue payments under preexisting programs and are allocated based on formulas considering a variety of factors. If these programs are re-authorized and funded, changes in revenues from Federal lands designated as critical habitat would first filter through the national allocation scheme and then through the State formulas, making it difficult to predict changes in payments. If these programs are not reauthorized and funded, then the payments would change each year based on a 7-year rolling average of receipts for USFS lands and the prior year's receipts for BLM O&C lands, and would also be filtered through the State's allocation formulas. Given the uncertainty associated with the future of SRS and PILT, the varying allocation schemes associated with the programs, and the relatively small change in anticipated harvests, the potential change in revenue-sharing payments is difficult to predict. Importantly, we note that the reauthorization and funding of SRS and PILT is unrelated to the decision to designate critical habitat for the northern spotted owl.

Environmental Analysis Comments

Comment (214): One commenter believed that the Secretary has not met the NEPA standard of full cooperation with State and county agencies in two different ways: (1) By setting a public comment timeframe that limits the agencies' ability to fully and knowingly provide comments; and (2) by denying the county the opportunity to be a cooperating agency under CEQ regulations and DOI policy.

Our Response: We believe the 30-day public comment period is adequate for review and comment on the draft environmental analysis and is consistent with the public comment period on many NEPA documents. In addition, we provided counties with an extended opportunity to comment, as described in Previous Federal Actions, above. With regard to cooperating agencies, neither CEQ nor DOI regulations discuss cooperating agencies in the context of environmental assessments because they are generally concise documents prepared to determine whether the proposed action will significantly affect the quality of the human environment and whether an environmental impact statement (EIS) is needed. Thus, environmental assessments normally do not warrant use of formally designated cooperating agencies. Because we initiated the NEPA analysis with an environmental assessment, we did not formally appoint any agency as a cooperating agency.

Comment (215): Several commenters requested the Service complete an environmental impact statement to address the effects of thinning, ecological forestry, and other active management activities on northern spotted owl populations. Commenters believe an EIS needs to be done for the critical habitat rule for a number of reasons, including that effects are significant; critical habitat designation could harm, rather than recover, the northern spotted owl; there is a need to accurately identify relevant environmental concerns and to take a ''hard look'' at these concerns; and the analysis in the draft environmental assessment is insufficient to prove effects are not significant (i.e., presents no information to justify a finding of no significant impact (FONSI)).

Our Response: This rulemaking is limited to the designation of critical habitat for the northern spotted owl. This final rule does not mandate or prescribe specific management activities, and the implementation of thinning, ecological forestry, or other types of activities is not required by this rulemaking. Should any such activities be proposed by the land management agencies when implementing specific projects on their managed lands, the only effect of this critical habitat rule is that Federal agencies will have to consult with the Service on their activities that may affect designated northern spotted owl critical habitat and ensure that their actions are not likely to destroy or adversely modify critical habitat, as those terms are used in section 7 of the Act. Our critical habitat proposal was fully compliant with NEPA, although we note that we elected to develop an environmental assessment pursuant to NEPA in this case entirely at our discretion, and not as a legal requirement. The proposal presented an overview of the state of the science on active management for consideration by land managers. It does not require any specific management actions. Any plans or project-level decisions concerning active forest management are appropriately made by land managers in accordance with their normal planning and project implementation procedures, and are beyond the authority of this rulemaking. Actions proposed on Federal lands must be consistent with the requirements of the NWFP and associated plans, and these plans have already undergone NEPA compliance. Step-down implementation of specific actions such as thinning projects on USFS or BLM lands also require NEPA compliance on a case-by-case basis.

Comment (216): One commenter stated that the barred owl EIS should not be a separate analysis document from the NEPA analysis done for the critical habitat rule, but that a single EIS should be prepared to address the entire proposal.

Our Response: The barred owl EIS represents an action entirely separate from the present critical habitat rulemaking, and is an evaluation of an experiment stemming from the recommendations of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011). The Federal action requiring NEPA for the barred owl EIS is the issuance of a permit under the Migratory Bird Treaty Act for the scientific collection of barred owls, as well as additional permits that may be required for the experiment. In contrast, the designation of critical habitat is a statutory requirement under the Act, and is an entirely separate action from the issuance of necessary permits for research, take, or special use. We have addressed the barred owl EIS as an ongoing action in the cumulative effects analysis section of the environmental assessment of this rulemaking.

Comment (217): Commenters believed that the Draft Environmental Assessment is predecisional because it has committed to completing the NEPA process in a preordained timeline that does not allow sufficient time to meet the NEPA requirements of an EIS.

Our Response: An EIS is required only when an action is determined to have likelihood of significant impact on the human environment. Completion of an environmental assessment is a step in the NEPA process to determine whether or not impacts of the Federal action are significant and thus require an EIS. We have not predetermined the outcome of our environmental assessment. Rather, we have used the environmental assessment to establish whether or not impacts of the designation of critical habitat for the northern spotted owl are significant. Although there is a court-ordered schedule for completion of this critical habitat rule, if our environmental assessment had determined that impacts were significant, we would have sought an extension of time to complete our NEPA analysis. Our environmental analysis was consistent with the spirit and intent of NEPA, and was not predecisional. Further, our experience of evaluating the possible effects of critical habitat under NEPA suggested that an environmental assessment was the appropriate place to start.

Comment (218): One commenter described errors in public scoping in that we did not disclose our purpose and need during the scoping process.

Our Response: Public scoping is not required for the development of an environmental assessment. As stated in the environmental assessment, we used internal scoping (internal discussions among Service divisions regionally and nationally, and among staff with long-term experience with land-use activities conducted within critical habitat on Federal and non-Federal lands) to identify concerns, potential impacts, relevant effects of past actions, and possible alternative actions (October 15, 2008; FR 73 61292).

Comment (219): One commenter described several errors and inaccuracies in defining the purpose and need. Specifically: (1) The stated purpose of achieving the greatest conservation and recovery for the northern spotted owl is erroneous and more than required to meet the Act, and is also too narrow, overly restricting the range of reasonable alternatives; (2) the court-ordered due date of November 15 does not drive the need but rather the need is whatever was the Service's motivation in arranging the date with the court; and (3) the purpose of complying with the Act is not a purpose but an agency duty.

Our Response: Regarding item number 1, the commenter only partially described the purpose. The full purpose stated in the draft environmental assessment was to ''achieve the greatest relative conservation and recovery goals for the northern spotted owl but simultaneously minimize effects to other land and resources uses.'' We disagree that the purpose, as a whole, is more than required to meet the Act. Rather, our intent is to designate lands meeting the definition of critical habitat (i.e., areas occupied at the time of listing that contain the features essential to the species' conservation or unoccupied areas that are themselves essential to the species' conservation), determining what is essential in a way that minimizes effects on resource uses to the extent possible, and then using the exclusion process provided by section 4(b)(2) of the Act to weigh the benefits of inclusion versus the benefits of exclusion. This is what we mean by using the term ''relative.'' This balance does not result in more action than is required to meet the provisions of the Act, and we have clarified this in the environmental assessment. Regarding item number 2, we did not mean to imply that the court deadline drives the need. The need is to revise critical habitat pursuant to a court-ordered remand of the 2008 designation (Carpenters' Industrial Council (CIC) v. Salazar, 734 F. Supp. 2d126 (D.D.C. 2010) * * *); we have clarified this point in the final environmental assessment, available at *http://www.regulations.gov* and at *http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/CriticalHabitat/default.asp.* Regarding item number 3, the purpose of an action proposed by the Service or any other Federal agency, based on common NEPA practice and Federal NEPA guidance includes but is not limited to statutory authority. The Service cannot carry out an action that is inconsistent with our authorities, hence our purpose explicitly included reference to those authorities.

Comment (220): One commenter believed there was an inadequate range of alternatives. Furthermore, they believed that the alternatives the Service noted in the draft environmental assessment as considered but not fully developed were not fully considered because there was no environmental review of these alternatives.

Our Response: NEPA requires that we must analyze those alternatives necessary to permit a reasoned choice (40 CFR 1502.14). When there are potentially a very large number of alternatives, NEPA requires that we analyze only a reasonable number to cover the full spectrum of alternatives that are consistent with the purpose and need. We did consider but excluded some modeling outcomes from further analysis. NEPA allows the elimination of an action alternative from detailed analysis for a variety of reasons including ineffectiveness, technical or economic infeasibility, inconsistency with management objectives of the area, remote or speculative implementation, and substantial similarity in design and effects of an alternative that has been analyzed. We disagree with the commenter in that NEPA does not require an ''environmental review'' of alternatives eliminated from detailed study, but rather, a brief discussion of the reasons for their having been eliminated (40 CFR 1502.16(a)). We have further clarified our reasons for eliminating these alternatives from further analysis in the final NEPA document.

Comment (221): One commenter believed we did not adequately identify the range of issues that could be affected by critical habitat designation. They further pointed out that limiting our analysis to threatened and endangered species and stating in the environmental assessment that it is not possible to analyze effects on the other 1,200 species is wrong because it is possible and has been done for such actions as the NWFP.

Our Response: Only potentially significant issues must be the focus of the environmental analysis. Issues that are not significant (i.e., related to potentially significant effects) can be eliminated from detailed study, ''narrowing the discussion of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment.'' (40 CFR 1501.7(a)(2), 40 CFR 1501.7(a)(3)). We have further elaborated in the final environmental assessment (available at *www.regulations.gov* and at *http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/CriticalHabitat/default.asp*) why we found that these issues will not have a significant effect on the human environment. Regarding our statement that it is not possible to analyze effects on 1,200 species given that such an analysis was done in the NWFP, we agree this was in error and will remove that language from the final environmental assessment. However, we do not find that this impels us to analyze effects on all 1,200 late-successional species. In the case of the NWFP, the intent of the revision to USFS and BLM land management plans was to provide comprehensive management of habitat for late-successional and old-growth forest species. Thus, it was prudent to examine those species as part of the NWFP analysis. We do not believe that such a level of analysis is necessary for this purpose and have thus limited our analysis to effects on listed species to ensure critical habitat designation does not reduce their potential for recovery.

Comment (222): Three commenters believed the analysis failed to disclose that current habitat set-asides have not produced measurable success in northern spotted owl recovery, and that expanding critical habitat will also fail because barred owls are the primary causal factor in the northern spotted owl decline. On a related topic, one commenter felt the environmental assessment failed to describe how the proposed action would lead to recovery and why other alternatives would not.

Our Response: Threats to northern spotted owls are described in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as habitat loss and competition from the barred owl. We acknowledge in this rule and the final environmental assessment that we need to address both of these threats if we are to recover the northern spotted owl. As to the need to describe how the proposed action would lead to recovery while other alternatives would not, we do not need to show that alternatives not chosen would not lead to recovery; we merely need to disclose the effects of each alternative on the relevant issues, in this case, primarily northern spotted owl populations, to provide information to decisionmakers. Recovery of northern spotted owls will require addressing multiple issues, of which habitat loss is only one and will be partly addressed through critical habitat designation.

Comment (223): One commenter noted we did not analyze the effects of eliminating LSRs as part of the critical habitat designation.

Our Response: This comment is based on a misunderstanding of the critical habitat designation, which does not eliminate the Late-Successional Reserve Network of the Northwest Forest Plan.

Comment (224): One commenter believed we failed to fully disclose the existing regulatory structure, and also failed to fully disclose the disincentives to landowners to retain habitat, resulting in the potential elimination of northern spotted owl habitat.

Our Response: We noted in the draft environmental assessment the potential for landowners to prematurely harvest existing habitat, maintain shorter harvest rotations, or change from forest management to development. We received several comments from landowners indicating their intention to deforest their property if designated as critical habitat. We acknowledge that possibility for some landowners in the final environmental assessment (available at *www.regulations.gov* and at *http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/CriticalHabitat/default.asp*) based on these comments, but cannot describe the extent or degree of these effects based on the comments we received. We also note that, in our preferred alternative, all private lands were excluded from this designation.

Comment (225): One commenter disagreed with what effects we considered speculative and not reasonably foreseeable, and believed we are obligated to display environmental consequences of potential effects even if actual outcomes are unknown.

Our Response: DOI NEPA regulations define reasonably foreseeable future action as, ''activities not yet undertaken, but sufficiently likely to occur, that a Responsible Official of ordinary prudence would take such activities into account in reaching a decision. These Federal and non-Federal activities that must be taken into account include, but are not limited to, activities for which there are existing decisions, funding, or proposals identified by the bureau. Reasonably foreseeable future actions do not include those actions that are highly speculative or indefinite.'' 43 CFR 46.30. We contend that the actions we consider not reasonably foreseeable meet this definition.

Comment (226): Two commenters indicated we failed to examine cumulative and connected actions in an economic and social context.

Our Response: We have completed an economic analysis that addresses economic and social aspects of the designation of critical habitat. In addition, the Council on Environmental Quality's implementing regulations indicate that economic and social effects are not by themselves intended to require preparation of an EIS, but should be considered if an EIS is prepared (40 CFR 1508.14). Our purpose in preparing an environmental assessment was to determine whether an EIS should be prepared. Because we determined that the critical habitat revision resulted in a finding of no significant impact (FONSI), it was determined that an EIS was not necessary to evaluate social and economic impacts.

Comment (227): One commenter noted we failed to analyze the economic effects of the northern spotted owl listing decision as a cumulative and connected action of critical habitat designation.

Our Response: We agree that the environmental assessment should consider all relevant cumulative effects, which may include the effects of past actions, as necessary to determine whether a finding of no significant impact is warranted. One element of that determination is ''[w]hether the action is related to other actions with individually insignificant but cumulatively significant impacts. Significance exists if it is reasonable to anticipate a cumulatively significant impact on the environment. Significance cannot be avoided by terming an action temporary or by breaking it down into small component parts.'' 40 CFR 1508.27(b)(7). As discussed in the previous comment, ''human environment'' is defined to include the natural and physical environment and the relationship of people with that environment except that economic or social effects are not intended by themselves to require preparation of an environmental impact statement. 40 CFR 1508.14. In this environmental assessment we have considered the potential effects of the designation added to other past, present, and reasonably foreseeable future actions that would affect the identified resources of concern to determine whether this would result in significant impacts to the human environment as defined for purposes of an environmental assessment. We have added the past action of listing the northern spotted owl to our cumulative effects analysis and considered those effects on the resources of concern identified in the environmental assessment.

Comment (228): One commenter contended that just because future action will undergo NEPA analysis does not relieve the Service of its NEPA duty to analyze the effects of the critical habitat proposal.

Our Response: We can analyze the indirect effects of the critical habitat designation only to the degree that we are reasonably certain of the actions that may occur within critical habitat, how they might be modified as a result of the section 7 process, and what the environmental impacts of those modifications might be. To that end, we have met our NEPA obligation. As individual Federal actions are developed with more information on location, activity type, magnitude, duration, and intensity, all things we cannot assess at this point in time, those actions will be subject to NEPA and analyzed in further detail.

Comment (229): One commenter believed it was incorrect for the Service to assume agencies will implement 100% of actions in the recovery plan [Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011)] and that we must assume agencies will implement NWFP requirements without further matrix restrictions.

Our Response: We have included as part of our range of possible outcomes the possibility that agencies will implement only the NWFP requirements, without implementing any additional recovery plan actions that may restrict actions in the matrix. However, we believe that is not the only possible scenario, given that we have examples of agencies implementing discretionary actions from the northern spotted owl recovery actions that are in addition to the Standards and Guidelines of the NWFP.

XIII. Required Determinations

Regulatory Planning and Review (Executive Orders 12866 and 13563)

Executive Order 12866 provides that the Office of Information and Regulatory Affairs (OIRA) will review all significant rules. The Office of Information and Regulatory Affairs has determined that this rule is significant because it will raise novel legal or policy issues.

Executive Order 13563 reaffirms the principles of E.O. 12866 while calling for improvements in the nation's regulatory system to promote predictability, to reduce uncertainty, and to use the best, most innovative, and least burdensome tools for achieving regulatory ends. The executive order directs agencies to consider regulatory approaches that reduce burdens and maintain flexibility and freedom of choice for the public where these approaches are relevant, feasible, and consistent with regulatory objectives. E.O. 13563 emphasizes further that regulations must be based on the best available science and that the rulemaking process must allow for public participation and an open exchange of ideas. We have developed this rule in a manner consistent with these requirements.

Regulatory Flexibility Act (5 U.S.C. 601 et seq.)

Under the Regulatory Flexibility Act (RFA; 5 U.S.C. 601 *et seq.*) as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 (5 U.S.C. 801 *et seq.*), whenever an agency must publish a notice of rulemaking for any proposed or final rule, it must prepare and make available for public comment a regulatory flexibility analysis that describes the effects of the rule on small entities (small businesses, small organizations, and small government jurisdictions). However, no regulatory flexibility analysis is required if the head of the agency certifies the rule will not have a significant economic impact on a substantial number of small entities. The SBREFA amended the RFA to require Federal agencies to provide a certification statement of the factual basis for certifying that the rule will not have a significant economic impact on a substantial number of small entities.

According to the Small Business Administration, small entities include small organizations such as independent nonprofit organizations; small governmental jurisdictions, including school boards and city and town governments that serve fewer than 50,000 residents; and small businesses (13 CFR 121.201). Small businesses include manufacturing and mining concerns with fewer than 500 employees, wholesale trade entities with fewer than 100 employees, retail and service businesses with less than $5 million in annual sales, general and heavy construction businesses with less than $27.5 million in annual business, special trade contractors doing less than $11.5 million in annual business, and forestry and logging operations with fewer than 500 employees and annual business less than $7 million. To determine if potential economic impacts to small entities may result from this designation, and whether these potential impacts may be significant, we considered the types of activities that might trigger regulatory impacts under this designation as well as types of project modifications that may result. In general, the term ''significant economic impact'' is meant to apply to a typical small business firm's business operations.

The Service's current understanding of recent case law is that Federal agencies are only required to evaluate the potential impacts of rulemaking on those entities directly regulated by the rulemaking; therefore, they are not required to evaluate the potential impacts to those entities not directly regulated. The designation of critical habitat for an endangered or threatened species only has a regulatory effect where a Federal action agency is involved in a particular action that may affect the designated critical habitat. Under these circumstances, only the Federal action agency is directly regulated by the designation, and, therefore, consistent with the Service's current interpretation of RFA and recent case law, the Service may limit its evaluation of the potential impacts to those identified for Federal action agencies. Under this interpretation, there is no requirement under the RFA to evaluate the potential impacts to entities not directly regulated, such as small businesses. However, E.O.'s 12866 and 13563 direct Federal agencies to assess costs and benefits of available regulatory alternatives in quantitative (to the extent feasible) and qualitative terms. Consequently, it is the current practice of the Service to assess to the extent practicable these potential impacts if sufficient data are available, whether or not this analysis is believed by the Service to be strictly required by the RFA. In other words, while the effects analysis required under the RFA is limited to entities directly regulated by the rulemaking, the effects analysis under the Act, consistent with the E.O. regulatory analysis requirements, can take into consideration impacts to both directly and indirectly impacted entities, where practicable and reasonable.

We acknowledge that in some cases, third-party proponents of the action subject to permitting or funding, though not directly regulated, may participate in a section 7 consultation with the Federal action agency. Moreover, E.O.'s 12866 and 13563 direct Federal agencies to assess all costs and benefits of available regulatory alternatives in quantitative (to the extent feasible) and qualitative terms. We believe it is good policy to assess these impacts if we have sufficient data before us to complete the necessary analysis, whether or not this analysis is strictly required by the RFA. While the Service does not consider this regulation to directly regulate these entities, in our draft economic analysis, we have conducted an evaluation of the potential number of third parties participating in consultations on an annual basis in order to ensure a more complete examination of the potential incremental effects of this rule in the context of the RFA. As discussed earlier in our March 8, 2012, proposed rule (77 FR 14062), our notice of availability of the draft economic analysis (77FR 32483; June 1, 2012), and in the draft economic analysis itself, we determined that the incremental effects of this revised designation are relatively small due to the extensive conservation measures already in place for the species, due to its being listed under the Act, and because of measures provided under the NWFP and other conservation programs. The FEA affirms these conclusions, and we have determined that these conclusions are applicable to this final revised designation of critical habitat for the northern spotted owl. Thus, even taking into account those entities not directly regulated, we certify that the revised designation of critical habitat for the northern spotted owl will not have a significant economic impact on a substantial number of small entities.

Importantly, the incremental regulatory and economic impacts of the rule must be *both* significant and substantial to prevent certification of the rule under the RFA and to require the preparation of a regulatory flexibility analysis. If a substantial number of small entities are affected by the critical habitat designation, but the per-entity economic impact is not significant, the Service may certify. Likewise, if the per-entity economic impact is likely to be significant, but the number of affected entities is not substantial, the Service may also certify. Because per-entity impacts are currently uncertain, our evaluation focused on the number of small entities potentially affected as third parties to consultation with Federal agencies that may be directly regulated by the designation

While developing our draft economic analysis (DEA), we determined that there may be third-party participants to consultations involved with timber harvest and linear projects. In estimating the potential number of entities involved with consultations on timber harvest, we used the projection of 1,000 consultations over the 20-year time horizon of the DEA related to timber harvest management, providing an assumption of 50 consultations per year. We predict that many of these consultations will not involve third parties, but data is lacking about third-party participation rates. For the sake of our evaluation, we took a more inclusive approach and assumed that third parties are involved with these consultations and that each party is a small entity, providing an annual estimate of 50 small entities that may be involved over the 20-year time horizon of the study. This is likely an overestimate of the number of third parties involved with timber management consultations and therefore an even greater overestimate of the number of small entities involved because many of those third parties will not be small entities. The DEA further explored the projection of small businesses in timber-related sectors in the geographic areas overlapping the critical habitat designation, which differed depending on the specific data sets used, either 7,140 entities or 2,616 entities. Using our conservative estimate of 50 small entities involved annually, the proportion of entities in the timber harvest management sector potentially impacted by the designation would be 0.70 percent and 1.9 percent, respectively, over the 20-year time horizon of the study.

The RFA does not explicitly define the specific proportion of any given sector that would represent a substantial number, but leave that determination to the discretion of the agency issuing the regulation. While the Service or the Department of Interior does not have a specific policy concerning what proportion of any given sector impacted would represent a substantial number, the Service, as a matter of practice, uses a value of 3% to evaluate whether the regulation may impact a substantial number. In other words, if a regulation is determined to have an impact on less than 3% of entities in a given sector, then the agency makes a determination that a substantial number is not affected. Whereas, if it is determined that the proportion of entities impacted by a given regulation is equal to or greater than 3%, then the agency further evaluates available data to make a specific determination for that regulation.

Applying the aforementioned criteria to the specific proportion of the timber harvest management sector, we have concluded that these proportions do not represent a substantial number of small business entities potentially affected in the timber harvest management sector. Please refer to Appendix A of the FEA for further details of our evaluation.

Next, we explored the potential impact to third parties that may be involved with consultations related to linear projects (i.e., roads, pipelines, and powerlines). On the basis of similar conservative assumptions explained in the DEA, we concluded that there may be a total of 11 projects in a given year that may involve third parties. If we similarly assume that each of these parties represent small entities, then we estimate that 11 small entities in a given year could be impacted by the designation. While there is greater uncertainty as to the number of small entities involved with linear projects, we believe that the relative proportion these 11 entities represent is unlikely to constitute a substantial number. Further, the projected impacts to third parties resulting from the consultations on linear projects are anticipated to be solely administrative in nature. Thus, even with the uncertainty as to whether the proportion of entities potentially effected is may be substantial (although we think that it is not), we have determined that the potential impacts to these entities would not be significant as they would only be the result of additional administrative costs, which are relatively minor. Therefore, based on our conservative estimates in identifying third parties in this sector that potentially may be impacted, the projected number of entities and types of impacts, we concluded that the designation would not result in a significant impact to a substantial number of small business entities in this sector.

These conclusions were reaffirmed in our FEA. Please refer to Appendix A of the FEA for further details of our evaluation. In development of the final economic analysis (FEA) and taking into consideration all information and comments received, and based on our conservative evaluation of the number of entities in the timber management and linear project sectors potentially impacted, the proportion of the affected entities to those representing the sector in the study area, and the types of impacts, we again determined that the revised critical habitat designation will not have a significant economic impact on a substantial number of small business entities. In Appendix A of the FEA, we acknowledge that the primary economic impact of the project modifications resulting from the consultations described above is a change in Federal revenues generated by timber sales. In other words, if harvests are increased or decreased as a result of the designation, the USFS and BLM will receive more or less revenues, respectively, from the sale of this timber. However, these Federal agencies are not, as noted, small businesses. Furthermore, entities bidding for new timber sales on Federal lands would not incur costs as a result of this critical habitat designation because they will only pay for the value of the sale after any modifications are made as part of the section 7 consultation process. In other words, any impact of this regulation on those entities would be indirect.

In the FEA, we evaluated the potential indirect economic effects on small business entities resulting from conservation actions related to the listing of the northern spotted owl and the designation of critical habitat. The analysis is based on the estimated impacts associated with the rulemaking, as described in Chapters 4 through 8 and Appendix A of the analysis, and evaluates the potential for economic impacts related to: (1) Timber management, (2) barred owl management, (3) northern spotted owl surveys and monitoring, (4) fire management, (5) linear projects (i.e., roads, pipelines, and powerlines), (6) restoration, (7) recreation, and (8) administrative costs associated with consultations under section 7 of the Act.

With respect to Federal lands, consultations with Federal land managers, the Service, and other experts indicate varying opinions regarding potential critical habitat effects on timber management practices, and noted the difficulty and limitations of deriving precise measures of positive or negative incremental change. Therefore, the FEA considered three alternative scenarios, which are described in Chapter 4 and summarized in Exhibit ES–4 of the FEA. These scenarios include: (1) Administrative costs only; (2) potential positive incremental impacts to timber harvest on Federal lands; and (3) potential negative incremental impacts to timber harvest on Federal lands. Furthermore, the economic analysis presents a potential low impact and high impact outcome for each of the three scenarios. Thus under the positive impact scenario, the estimated annualized *increase* in timber harvest revenue on Federal lands range from $1,230,000 to $3,070,000. Under the negative impact scenario, the annualized *decrease* in timber harvest revenue on Federal lands ranges $2,460,000 to $614,000,000. In all three scenarios, the estimated annualized administrative costs on Federal lands are from $185,000 to $316,000.

In response to public comment, a sensitivity analysis was performed on the baseline timber harvest projections, to better inform the alternative impact scenarios in the FEA. The economic analysis uses a baseline harvest projection of approximately 122.80 million board feet (MMBF) per year. In the sensitivity analyses, the baseline timber harvest projection increases by up to an additional 27.99 MMBF per year. Therefore, the range of incremental impacts to Federal timber harvest widens from a potential increase in stumpage value of $3,580,000 (under the increased timber harvest scenario) to a potential decrease of $7,860,000 (under the decreased timber harvest scenario) per year.

In addition, Exhibit ES–4 of the FEA presents our qualitative conclusions concerning potential timber harvest impacts to private lands, and notes that there may be possible negative impacts associated with regulatory uncertainty, and new regulation in the State of Washington, and concludes that zero timber harvest impacts are likely to occur on State lands. Finally, Exhibit ES–4 notes the potential incremental administrative costs related to linear projects, which are estimated to be between $10,800 on the low end and $19,500 on the high end.

The FEA also confirms our conclusion that between less than one percent and two percent of potentially effected small entities in the 56 county study area may participate as third parties in section 7 consultations related to timber harvests on an annual basis. In addition, approximately 11 electricity transmission or natural gas pipeline companies may participate in section 7 consultations in a given year. While we believe that this number does not represent a significant proportion of entities in this sector, the impacts to these entities are expected not to be significant as they are anticipated to be solely administrative in nature.

The FEA also explains that these estimates almost certainly overstate rather than understate the number of affected entities, perhaps to a significant degree, because: (1) Not all section 7 consultations will involve a third party; (2) not all third parties will be small entities; and (3) the same entity may consult more than once in a single year. We have also constrained the population of potentially affected entities to those found in counties overlapping critical habitat, as opposed to including others within the States of Washington, Oregon, and California. In addition, as described elsewhere in this rule, the greatest impact of section 7 will likely occur in unoccupied habitat, due to the fact that consultation would already occur in occupied habitat due to the presence of the listed species. We estimate that the vast majority of the areas being designated in this rule were occupied at the time of listing.

Finally, our analysis of potential impacts to small entities is overestimated because it was based on the proposed designation, which has been reduced by 4,197,484 ac (1,697,903 ha) in this final rule. Designated Federal lands are reduced by 2,849,745 ac (1,151,297 ha) due to the elimination of lands that we have determined do not meet the definition of critical habitat, the exemption of DOD lands under section 4(a)(3) of the Act, and the exclusion of Congressionally-reserved lands under section 4(b)(2) of the Act. Designated State and private lands are reduced by 1,647,170 ac (665,843 ha) due to the elimination of some lands that do not meet the definition of critical habitat and the exclusion of State parks and private lands under section 4(b)(2) of the Act.

In summary, we considered whether this designation would result in a significant economic impact on a substantial number of small entities. Based on the above reasoning, relevant case law, and currently available information, we concluded that this rule will not result in a significant economic impact on a substantial number of small entities. We are reaffirming our certification that this revised designation of critical habitat for the northern spotted owl will not have a significant economic impact on a substantial number of small entities, and a regulatory flexibility analysis is not required.

Energy Supply, Distribution, or Use (Executive Order 13211)

Executive Order 13211 (Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use) requires agencies to prepare Statements of Energy Effects when undertaking certain actions. While this final rule to designate revised critical habitat for the northern spotted owl is a significant regulatory action under Executive Order 12866, it is not expected to significantly affect energy supplies, distribution, or use. Therefore, this action is not a significant energy action, and no Statement of Energy Effects is required.

Unfunded Mandates Reform Act (2 U.S.C. 1501 et seq.)

In accordance with the Unfunded Mandates Reform Act (2 U.S.C. 1501 *et seq.*), we make the following findings:

(1) This rule will not produce a Federal mandate. In general, a Federal mandate is a provision in legislation,

statute, or regulation that would impose an enforceable duty upon State, local, or Indian governments, or the private sector, and includes both ''Federal intergovernmental mandates'' and ''Federal private sector mandates.'' These terms are defined in 2 U.S.C. 658(5)–(7). ''Federal intergovernmental mandate'' includes a regulation that ''would impose an enforceable duty upon State, local, or Indian governments'' with two exceptions. It excludes ''a condition of Federal assistance.'' It also excludes ''a duty arising from participation in a voluntary Federal program,'' unless the regulation ''relates to a then-existing Federal program under which $500,000,000 or more is provided annually to State, local, and Indian governments under entitlement authority,'' if the provision would ''increase the stringency of conditions of assistance'' or ''place caps upon, or otherwise decrease, the Federal Government's responsibility to provide funding,'' and the State, local, or Indian governments ''lack authority'' to adjust accordingly. At the time of enactment, these entitlement programs were: Medicaid; Aid to Families with Dependent Children work programs; Child Nutrition; Food Stamps; Social Services Block Grants; Vocational Rehabilitation State Grants; Foster Care, Adoption Assistance, and Independent Living; Family Support Welfare Services; and Child Support Enforcement. ''Federal private sector mandate'' includes a regulation that ''would impose an enforceable duty upon the private sector, except (i) a condition of Federal assistance or (ii) a duty arising from participation in a voluntary Federal program.''

The designation of critical habitat does not impose a legally binding duty on non-Federal Government entities or private parties. Under the Act, the only regulatory effect is that Federal agencies must ensure that their actions do not destroy or adversely modify critical habitat under section 7. While non-Federal entities that receive Federal funding, assistance, or permits, or that otherwise require approval or authorization from a Federal agency for an action, may be indirectly impacted by the designation of critical habitat, the legally binding duty to avoid destruction or adverse modification of critical habitat rests squarely on the Federal agency. Furthermore, to the extent that non-Federal entities are indirectly impacted because they receive Federal assistance or participate in a voluntary Federal aid program, the Unfunded Mandates Reform Act would not apply, nor would critical habitat shift the costs of the large entitlement programs listed above onto State governments.

(2) We have determined that this rule will not significantly or uniquely affect small governments because the designation of critical habitat imposes no obligations on State or local governments. By definition, Federal agencies are not considered small entities, although the activities they fund or permit may be proposed or carried out by small entities. Consequently, we do not believe that the critical habitat designation would significantly or uniquely affect small government entities. As such, a Small Government Agency Plan is not required. Further, it will not produce a Federal mandate of $100 million or greater in any year, that is, it is not a ''significant regulatory action'' under the Unfunded Mandates Reform Act.

Takings (Executive Order 12630)

In accordance with Executive Order 12630 (Government Actions and Interference with Constitutionally Protected Private Property Rights), we have analyzed the potential takings implications of designating critical habitat for the northern spotted owl in a takings implications assessment. As discussed above, the designation of critical habitat affects only Federal actions. Although private parties that receive Federal funding or assistance or require approval or authorization from a Federal agency for an action may be indirectly impacted by the designation of critical habitat, the legally binding duty to avoid destruction or adverse modification of critical habitat rests squarely on the Federal agency. The takings implications assessment concludes that this designation of critical habitat for the northern spotted owl does not pose significant takings implications for lands within or affected by the designation.

Federalism (Executive Order 13132)

In accordance with Executive Order 13132 (Federalism), we have determined that this rule does not have direct federalism implications that would require a federalism summary impact statement; however, we are aware of the State-level interest in this rule, and we both summarize below and explain in more detail in other parts of this package activities and responsibilities on Federal, State, and private lands.

From a federalism perspective, the designation of critical habitat directly affects only the responsibilities of Federal agencies. As explained in detail earlier, section 7(a)(2) of the Act requires Federal agencies—and only Federal agencies—to ensure that the actions they authorize, fund, or carry out are not likely to destroy or adversely modify critical habitat. The Act imposes no other duties with respect to critical habitat, either for States and local governments, or for anyone else. As a result, the rule does not have substantial direct effects either on the States, or on the relationship between the national government and the States, or on the distribution of powers and responsibilities among the various levels of government. However, in keeping with Department of the Interior and Department of Commerce policy and the federalism principles set forth in Executive Order 13132, we requested information from, and coordinated development of, this revised critical habitat designation with appropriate State resource agencies in Washington, Oregon, and California, on the effects of revised designation of critical habitat. We received comments from the Washington State Department of Natural Resources, Washington Department of Fish and Wildlife, Oregon Department of Forestry, the State of Oregon, and California Department of Forestry and Fire Protection (CALFIRE), as discussed in the Summary of Comments and Responses section of the rule, above. In addition, we received comments from the following counties:

- Washington: Jefferson County, Klickitat County, Skamania County, and Skagit County;
- Oregon: Hood River County, Jackson County, Linn County, Douglas County, and the Association of O&C Counties; and
- California: Del Norte County, Tehama County, Regional Council of Rural Counties, Siskiyou County, and Trinity County.

We used this information to more thoroughly evaluate the probable economic and regulatory effects of the proposed designation in our final economic analysis, to inform the development of our final rule, and to consider the appropriateness of excluding specific areas from the final rule. We found that the revised designation of critical habitat for the northern spotted owl has little incremental impact on State and local governments and their activities.

The revision of critical habitat also is not expected to have substantial indirect impacts. As explained in more detail above, activities within the areas proposed to be designated as critical habitat are already subject to a broad range of requirements, including: (1) The various requirements of the Northwest Forest Plan, including those applicable to its Late-successional Reserves, Riparian Reserves, and ''survey and manage'' restrictions; (2) the prohibition against ''taking'' northern spotted owls under sections 4(d) and 9 of the Act; (3) the prohibition against Federal agency actions that jeopardize the continued existence of the northern spotted owl under section 7(a)(2) of the Act; (4) the prohibition against taking other federally listed species that occur in the area of the designated critical habitat (e.g., salmon, bull trout, and marbled murrelets); and (5) the prohibition against Federal agency actions that jeopardize the continued existence of such other listed species. All of these requirements are currently in effect and will remain in effect after the final revision of critical habitat.

Some indirect impacts of the rule on States are, of course, possible. Section 7(a)(2) of the Act requires Federal agencies (action agencies) to consult with the Service whenever activities that they undertake, authorize, permit, or fund may affect a listed species or designated critical habitat. States or local governments may be indirectly affected if they require Federal funds or formal approval or authorization from a Federal agency as a prerequisite to conducting an action. In such instances, while the primary consulting parties are the Service and the Federal action agency, State and local governments may also participate in section 7 consultation as an applicant. It is therefore possible that States may be required to change project designs, operation, or management of activities taking place within the boundaries of the designation in order to receive Federal funding, assistance, permits, approval, or authorization from a Federal agency. Also, to the extent that the designation of critical habitat affects timber harvest amounts on Federal land, county governments that receive a share of the receipts from such harvests may be affected. However, while non-Federal entities that receive Federal funding, assistance, or permits, or that otherwise require approval or authorization from a Federal agency for an action, may be indirectly impacted by the designation of critical habitat, the legally binding duty to avoid destruction or adverse modification of critical habitat rests squarely on the Federal agency.

On the other hand, the designation of critical habitat will likely have some benefit to State and local governments because the areas that contain the physical or biological features essential to the conservation of the species are more clearly defined, and the elements of the features of the habitat necessary to the conservation of the species are specifically identified. It may also assist local governments in long-range planning (rather than having them wait for case-by-case section 7 consultations to occur).

Civil Justice Reform (Executive Order 12988)

In accordance with Executive Order 12988 (Civil Justice Reform), the Office of the Solicitor has determined that the rule does not unduly burden the judicial system and that it meets the requirements of sections 3(a) and 3(b)(2) of the Order. We have revised critical habitat in accordance with the provisions of the Act. To assist the public in understanding the habitat needs of the species, the rule identifies the elements of physical or biological features essential to the conservation of the species. The designated areas of critical habitat are presented on maps, and the rule provides several options for the interested public to obtain more detailed location information, if desired.

Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.)

This rule does not contain any new collections of information that require approval by OMB under the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 *et seq.*). This rule will not impose recordkeeping or reporting requirements on State or local governments, individuals, businesses, or organizations. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number.

National Environmental Policy Act (42 U.S.C. 4321 et seq.)

It is our position that, outside the jurisdiction of the U.S. Court of Appeals for the Tenth Circuit, we do not need to prepare environmental analyses pursuant to the National Environmental Policy Act (NEPA), 42 U.S.C. 4321 *et seq.,* in connection with designating critical habitat under the Act for the reasons outlined in a notice published in the **Federal Register** on October 25, 1983 (48 FR 49244). This position was upheld by the U.S. Court of Appeals for the Ninth Circuit (in a challenge to the first rulemaking designating critical habitat for the northern spotted owl. *Douglas County* v. *Babbitt,* 48 F.3d 1495 (9th Cir. 1995), cert. denied 516 U.S. 1042 (1996)).

However, at our discretion, we undertook an environmental assessment for this revised critical habitat designation, and notified the public of the availability of the draft environmental assessment for the proposed rule, for review and comment. We took all substantive comments into consideration, both to make revisions or corrections in the environmental assessment, and in the decisionmaking process made in finalizing the determination. In our final environmental assessment, we were able to make a finding of no significant impact (FONSI) from this rulemaking action. The final environmental assessment is available at *www.regulations.gov* and at *http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/CriticalHabitat/default.asp.*

Government-to-Government Relationship With Tribes

In accordance with the President's memorandum of April 29, 1994 (Government-to-Government Relations with Native American Tribal Governments; 59 FR 22951), Executive Order 13175, ''Consultation and Coordination with Indian Tribal Governments'' (November 6, 2000, and as reaffirmed November 5, 2009), and the Department of the Interior's manual at 512 DM 2, we readily acknowledge our responsibility to communicate meaningfully with recognized Federal Tribes on a government-to-government basis. The United States recognizes the right of Indian tribes to self-government and supports tribal sovereignty and self-determination, and recognizes the need to consult with tribal officials when developing regulations that have tribal implications. In accordance with Secretarial Order 3206 of June 5, 1997 (American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act), we readily acknowledge our responsibilities to work directly with tribes in developing programs for healthy ecosystems, to acknowledge that Indian lands are not subject to the same controls as Federal public lands, to remain sensitive to Indian culture, and to make information available to tribes. Even though we have determined that there are no Indian lands that meet the definition of critical habitat for the northern spotted owl, and therefore no Indian lands are included in this designation, we will continue to coordinate and consult with tribes regarding resources within the revised designation that are of cultural significance to them.

XIV. References Cited

A complete list of references cited in this rulemaking is available on the Internet at *http://www.regulations.gov* and upon request from the Oregon Fish and Wildlife Office (see **FOR FURTHER INFORMATION CONTACT**).

Authors

The primary authors of this package are the staff members of the Oregon Fish and Wildlife Office.

List of Subjects in 50 CFR Part 17

Endangered and threatened species, Exports, Imports, Reporting and recordkeeping requirements, Transportation.

Regulation Promulgation

Accordingly, we amend part 17, subchapter B of chapter I, title 50 of the Code of Federal Regulations, as set forth below:

PART 17—ENDANGERED AND THREATENED WILDLIFE AND PLANTS

■ 1. The authority citation for part 17 continues to read as follows:

Authority: 16 U.S.C. 1361–1407; 16 U.S.C. 1531–1544; 16 U.S.C. 4201–4245; Pub. L. 99–625, 100 Stat. 3500; unless otherwise noted.

■ 2. Amend § 17.95(b) by revising the critical habitat entry for ''Northern Spotted Owl *(Strix occidentalis caurina)*'' to read as follows:

§ 17.95 Critical habitat—fish and wildlife.

* * * * *

(b) *Birds.*

* * * * *

Northern Spotted Owl *(Strix occidentalis caurina)*

(1) Critical habitat units are depicted for the States of Washington, Oregon, and California on the maps below.

(2) Critical habitat for the northern spotted owl includes the following four primary constituent elements set forth in paragraph (2)(i) (primary constituent element 1) through paragraph (2)(iv) (primary constituent element 4) of this entry. Each critical habitat unit must include primary constituent element 1 and primary constituent element 2, 3, or 4:

(i) Primary constituent element 1: Forest types that may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographical range. These forest types are primarily:

(A) Sitka spruce;

(B) Western hemlock;

(C) Mixed conifer and mixed evergreen;

(D) Grand fir;

(E) Pacific silver fir;

(F) Douglas-fir;

(G) White fir;

(H) Shasta red fir;

(I) Redwood/Douglas-fir (in coastal California and southwestern Oregon); and

(J) The moist end of the ponderosa pine coniferous forest zones at elevations up to approximately 3,000 ft (900 m) near the northern edge of the range and up to approximately 6,000 ft (1,800 m) at the southern edge.

(ii) Primary constituent element 2: Habitat that provides for nesting and roosting. In many cases the same habitat also provides for foraging (primary constituent element (3)). Nesting and roosting habitat provides structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks for adults and young. This primary constituent element is found throughout the geographical range of the northern spotted owl, because stand structures at nest sites tend to vary little across the northern spotted owl's range. These habitats must provide:

(A) Sufficient foraging habitat to meet the home range needs of territorial pairs of northern spotted owls throughout the year; and

(B) Stands for nesting and roosting that are generally characterized by:

(1) Moderate to high canopy cover (60 to over 80 percent).

(2) Multilayered, multispecies canopies with large (20–30 inches (in) (51–76 centimeters (cm)) or greater diameter at breast height (dbh)) overstory trees.

(3) High basal area (greater than 240 ft^2/acre; 55 m^2/ha).

(4) High diversity of different diameters of trees.

(5) High incidence of large live trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and other evidence of decadence).

(6) Large snags and large accumulations of fallen trees and other woody debris on the ground.

(7) Sufficient open space below the canopy for northern spotted owls to fly.

(iii) Primary constituent element 3: Habitat that provides for foraging, which varies widely across the northern spotted owl's range, in accordance with ecological conditions and disturbance regimes that influence vegetation structure and prey species distributions. Across most of the owl's range, nesting and roosting habitat is also foraging habitat, but in some regions northern spotted owls may additionally use other habitat types for foraging as well. The foraging habitat PCEs for the four ecological zones within the geographical range of the northern spotted owl are generally the following:

(A) *West Cascades/Coast Ranges of Oregon and Washington.*

(1) Stands of nesting and roosting habitat; additionally, owls may use younger forests with some structural characteristics (legacy features) of old forests, hardwood forest patches, and edges between old forest and hardwoods.

(2) Moderate to high canopy cover (60 to over 80 percent).

(3) A diversity of tree diameters and heights.

(4) Increasing density of trees greater than or equal to 31 in (80 cm) dbh increases foraging habitat quality (especially above 12 trees per ac (30 trees per ha)).

(5) Increasing density of trees 20 to 31 in (51 to 80 cm) dbh increases foraging habitat quality (especially above 24 trees per ac (60 trees per ha)).

(6) Increasing snag basal area, snag volume (the product of snag diameter, height, estimated top diameter, and including a taper function), and density of snags greater than 20 in (50 cm) dbh all contribute to increasing foraging habitat quality, especially above 10 snags/ha.

(7) Large accumulations of fallen trees and other woody debris on the ground.

(8) Sufficient open space below the canopy for northern spotted owls to fly.

(B) *East Cascades.*

(1) Stands of nesting and roosting habitat.

(2) Stands composed of Douglas-fir and white fir/Douglas-fir mix.

(3) Mean tree size (quadratic mean diameter greater than 16.5 in (42 cm)).

(4) Increasing density of large trees (greater than 26 in (66 cm)) and increasing basal area (the cross-sectional area of tree boles measured at breast height), which increases foraging habitat quality.

(5) Large accumulations of fallen trees and other woody debris on the ground.

(6) Sufficient open space below the canopy for northern spotted owls to fly.

(C) *Klamath and Northern California Interior Coast Ranges.*

(1) Stands of nesting and roosting habitat; in addition, other forest types with mature and old-forest characteristics.

(2) Presence of conifer species such as incense-cedar, sugar pine, and Douglas-fir and hardwood species such as bigleaf maple, black oak, live oaks, and madrone, as well as shrubs.

(3) Forest patches within riparian zones of low-order streams and edges between conifer and hardwood forest stands.

(4) Brushy openings and dense young stands or low-density forest patches within a mosaic of mature and older forest habitat.

(5) High canopy cover (87 percent at frequently used sites).

(6) Multiple canopy layers.

(7) Mean stand diameter greater than 21 in (52.5 cm).

(8) Increasing mean stand diameter and densities of trees greater than 26 in (66 cm) increases foraging habitat quality.

(9) Large accumulations of fallen trees and other woody debris on the ground.

(10) Sufficient open space below the canopy for northern spotted owls to fly.

(D) *Redwood Coast.*

(1) Nesting and roosting habitat; in addition, stands composed of hardwood tree species, particularly tanoak.

(2) Early-seral habitats 6 to 20 years old with dense shrub and hardwood cover and abundant woody debris; these habitats produce prey, and must occur in conjunction with nesting, roosting, or foraging habitat.

(3) Increasing density of small-to-medium sized trees (10 to 22 in; 25 to 56 cm), which increases foraging habitat quality.

(4) Trees greater than 26 in (66 cm) in diameter or greater than 41 years of age.

(5) Sufficient open space below the canopy for northern spotted owls to fly.

(iv) Primary constituent element 4: Habitat to support the transience and colonization phases of dispersal, which in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCEs 2 or 3), but which may also be composed of other forest types that occur between larger blocks of nesting, roosting, and foraging habitat. In cases where nesting, roosting, or foraging habitats are insufficient to provide for dispersing or nonbreeding owls, the specific dispersal habitat PCEs for the northern spotted owl may be provided by the following:

(A) Habitat supporting the transience phase of dispersal, which includes:

(1) Stands with adequate tree size and canopy cover to provide protection from avian predators and minimal foraging opportunities; in general this may include, but is not limited to, trees with at least 11 in (28 cm) dbh and a minimum 40 percent canopy cover; and

(2) Younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, if such stands contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the transience phase.

(B) Habitat supporting the colonization phase of dispersal, which is generally equivalent to nesting, roosting and foraging habitat as described in PCEs 2 and 3, but may be smaller in area than that needed to support nesting pairs.

(3) Critical habitat does not include:

(i) manmade structures (such as buildings, aqueducts, runways, roads, other paved areas, or surface mine sites) and the land on which they are located; and

(ii) meadows, grasslands, oak woodlands, or aspen woodlands as described below existing on January 3, 2013 and not containing primary constituent elements 1 and 2, 3, or 4 as described in paragraph (2) of this entry.

(A) Meadows and grasslands include: dry, upland prairies and savannas in valleys and foothills of western Washington, Oregon, and northwest California; subalpine meadows; and grass and forb dominated cliffs, bluffs and grass balds found throughout these same areas. These areas are dominated by native grasses and diverse forbs, and may include a minor savanna component of Oregon white oak, Douglas-fir, or Ponderosa pine.

(B) Oak woodlands are characterized by an open canopy dominated by Oregon white oak. These areas may also include ponderosa pine, California black oak, Douglas-fir, or canyon live oak. The understory is relatively open with shrubs, grasses and wildflowers. Oak woodlands are typically found in drier landscapes and on south-facing slopes. This exception for oak woodlands does not include tanoak (*Notholithocarpus densiflorus*) stands, closed-canopy live oak (*Quercus agrifolia*) woodlands and open-canopied valley oak (*Quercus lobata*) and mixed-oak woodlands in subunits ICC–6 and RDC–5 in Napa, Sonoma, and Marin Counties, California.

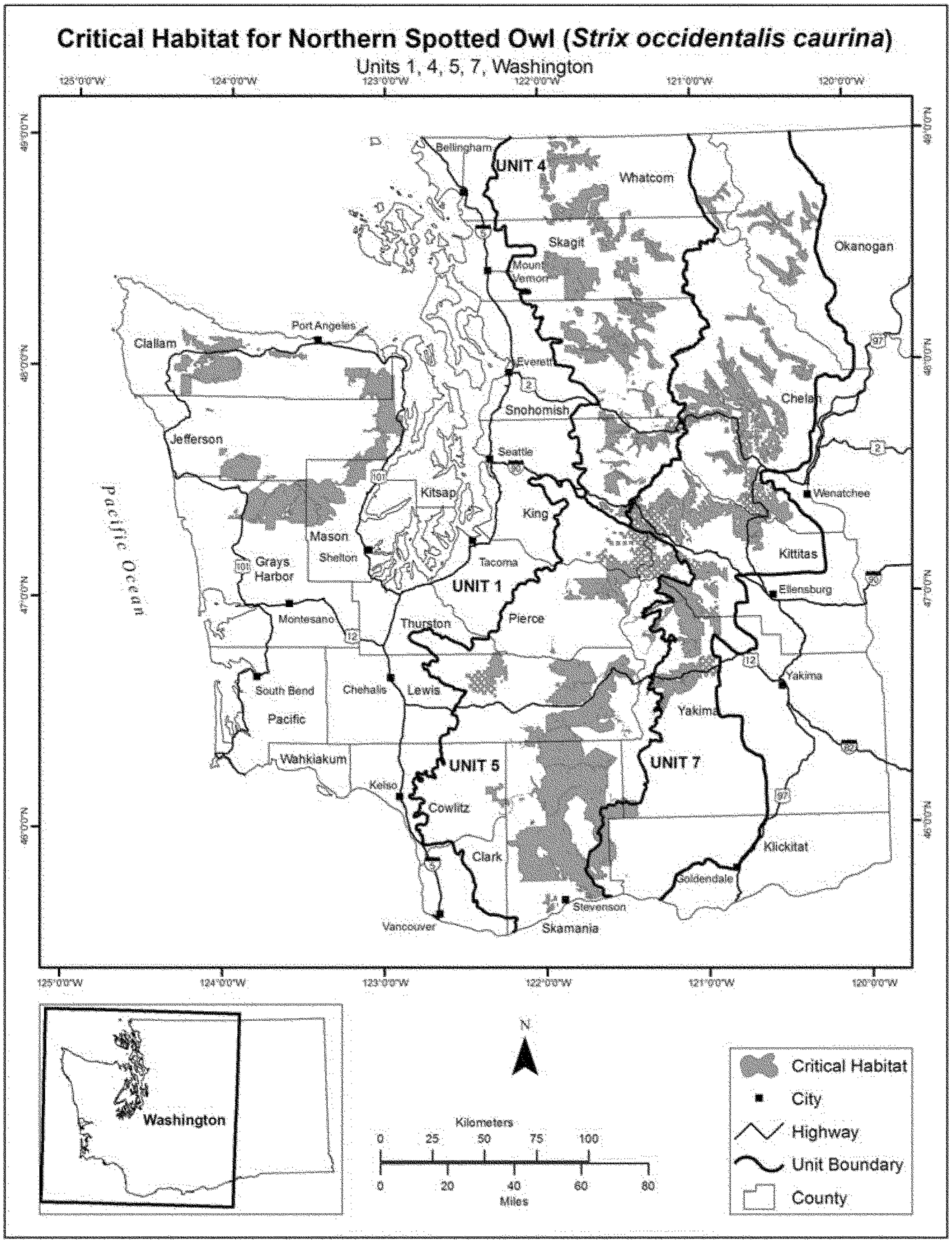
(C) Aspen (*Populus* spp.) woodlands are dominated by aspen trees with a forb, grass or shrub understory and are typically found on mountain slopes, rock outcrops and talus slopes, canyon walls, and some seeps and stream corridors. This forest type also can occur in riparian areas or in moist microsites within drier landscapes.

(4) We have determined that the physical and biological features in habitat occupied by the species at the time it was listed, as represented by the primary constituent elements, may require special management considerations or protection as required by 16 U.S.C. 1532(5)(A). However, nothing in this rule requires land managers to implement, or precludes land managers from implementing, special management or protection measures.

(5) *Critical habitat map units.* The designated critical habitat units for the northern spotted owl are depicted on the maps below. The coordinates or plot points or both on which each map is based are available at the field office Internet site (*http://www.fws.gov/oregonfwo*), *http://www.regulations.gov* at Docket No. FWS–R1–ES–2011–0112, and at the Service's Oregon Fish and Wildlife Office. You may obtain field office location information by contacting one of the Service regional offices, the addresses of which are listed at 50 CFR 2.2.

(6) **Note:** Index map of critical habitat units for the northern spotted owl in the State of Washington follows:

Index Map of Critical Habitat Units in the State of Washington



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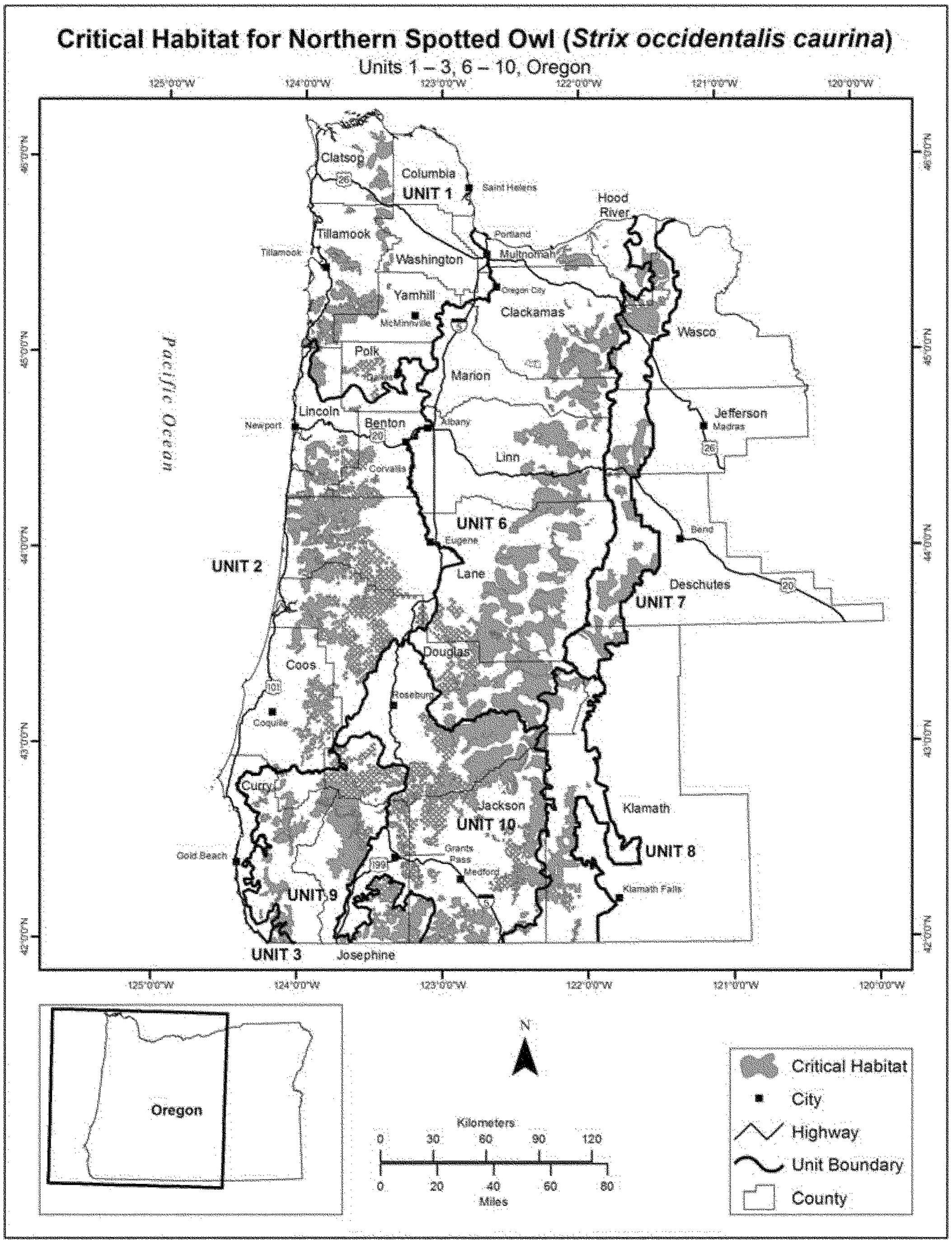
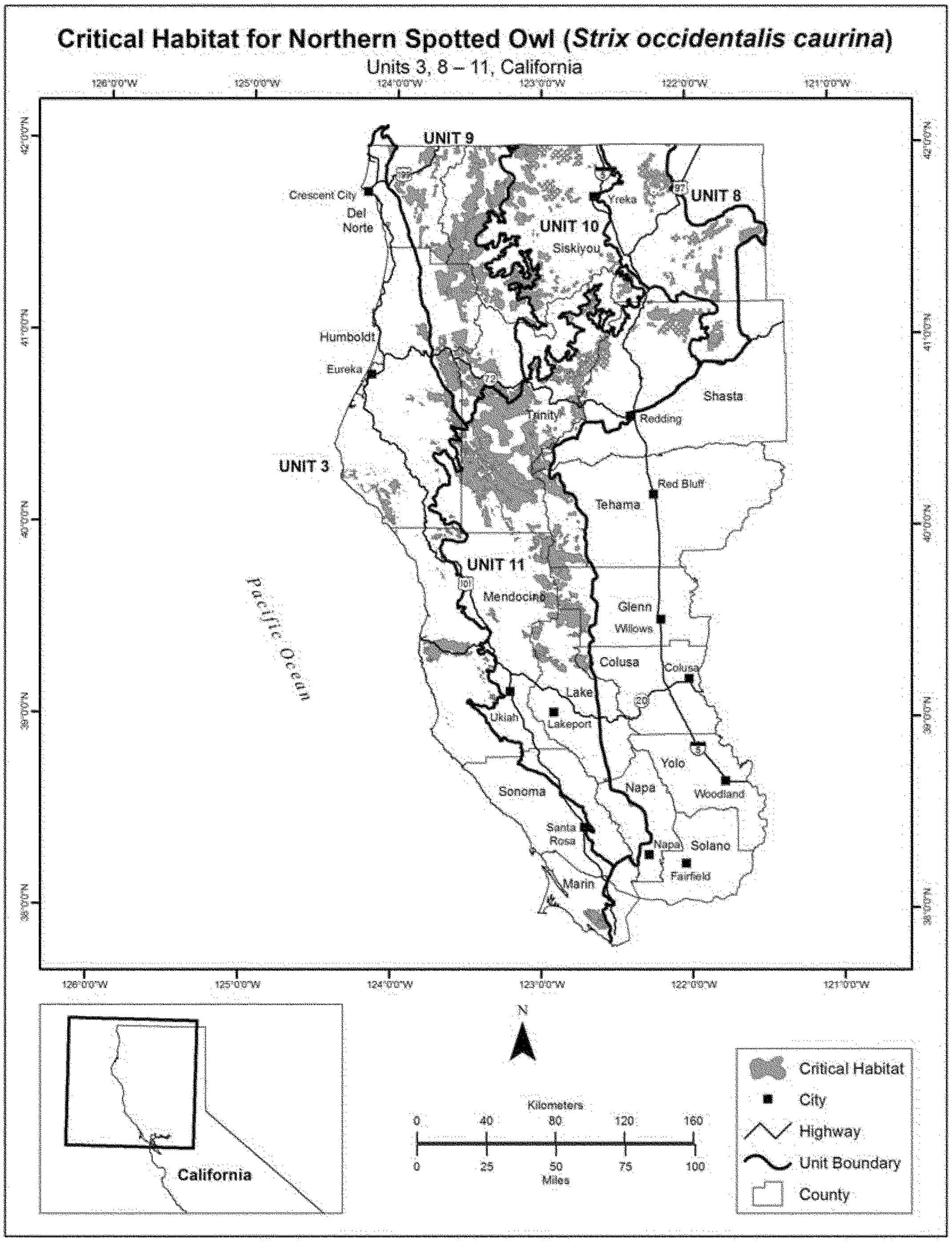
(7) **Note:** Index map of critical habitat units for the northern spotted owl in the State of Oregon follows:

Index Map of Critical Habitat Units in the State of Oregon

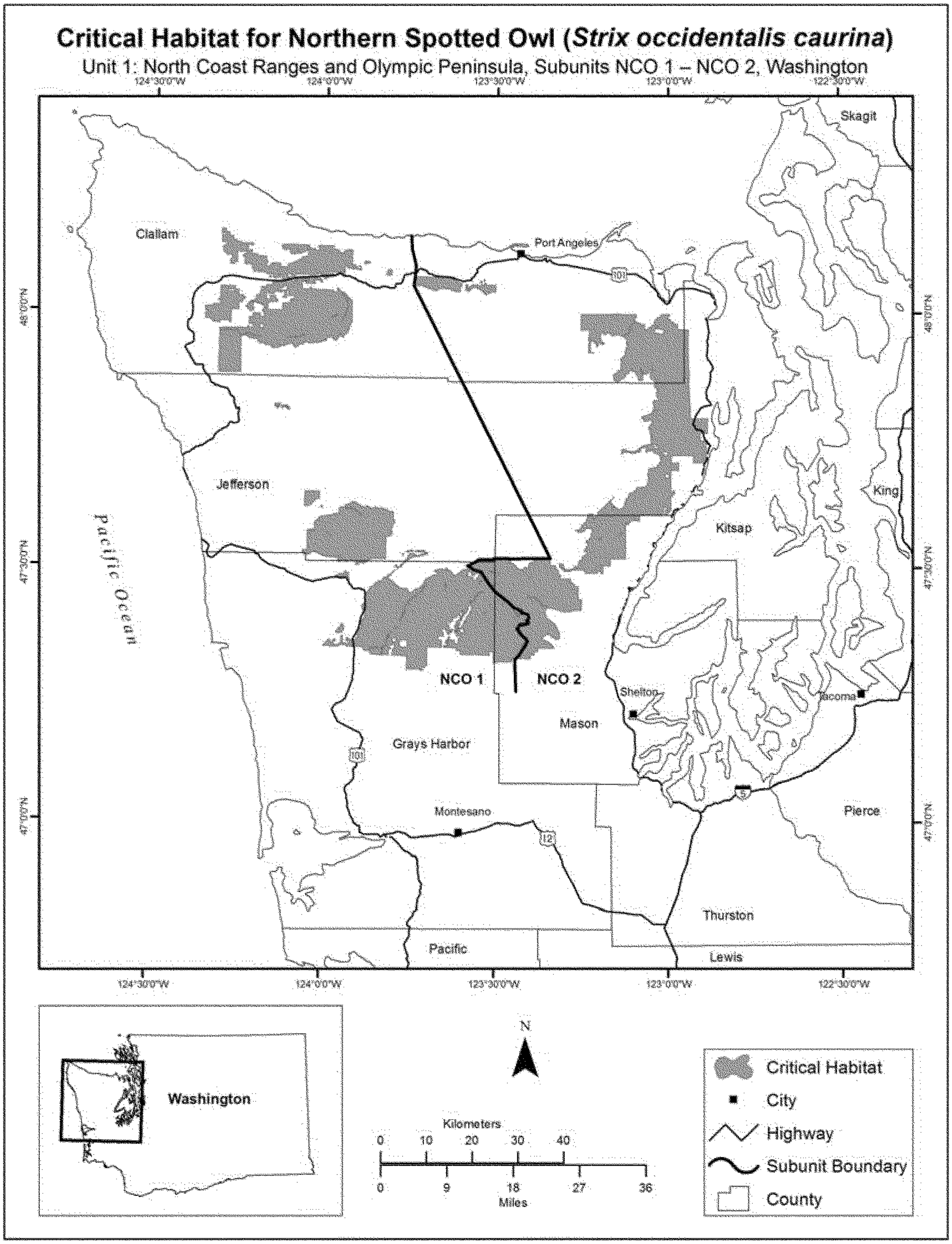


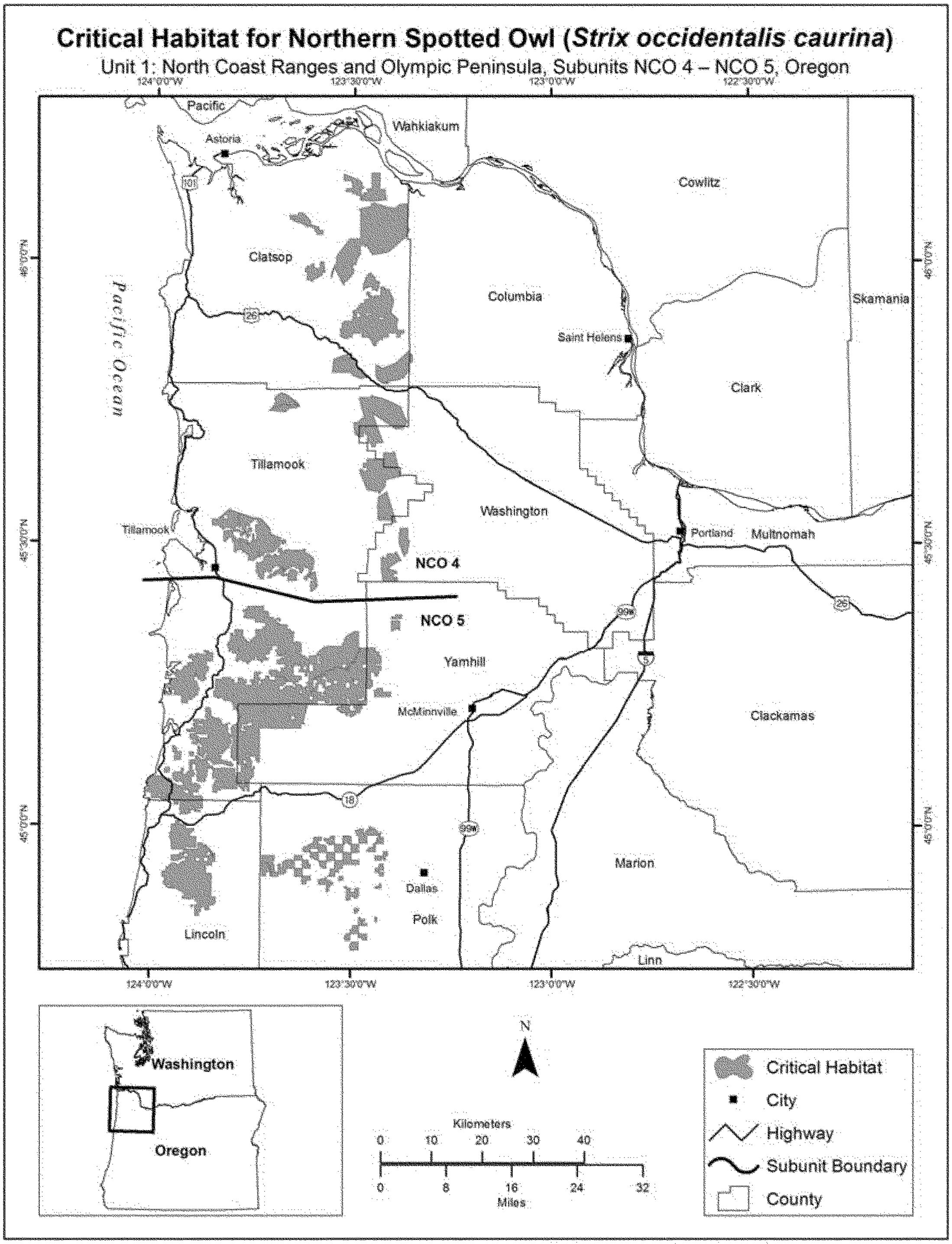
(8) **Note:** Index map of critical habitat units for the northern spotted owl in the State of California follows:

Index Map of Critical Habitat Units in the State of California

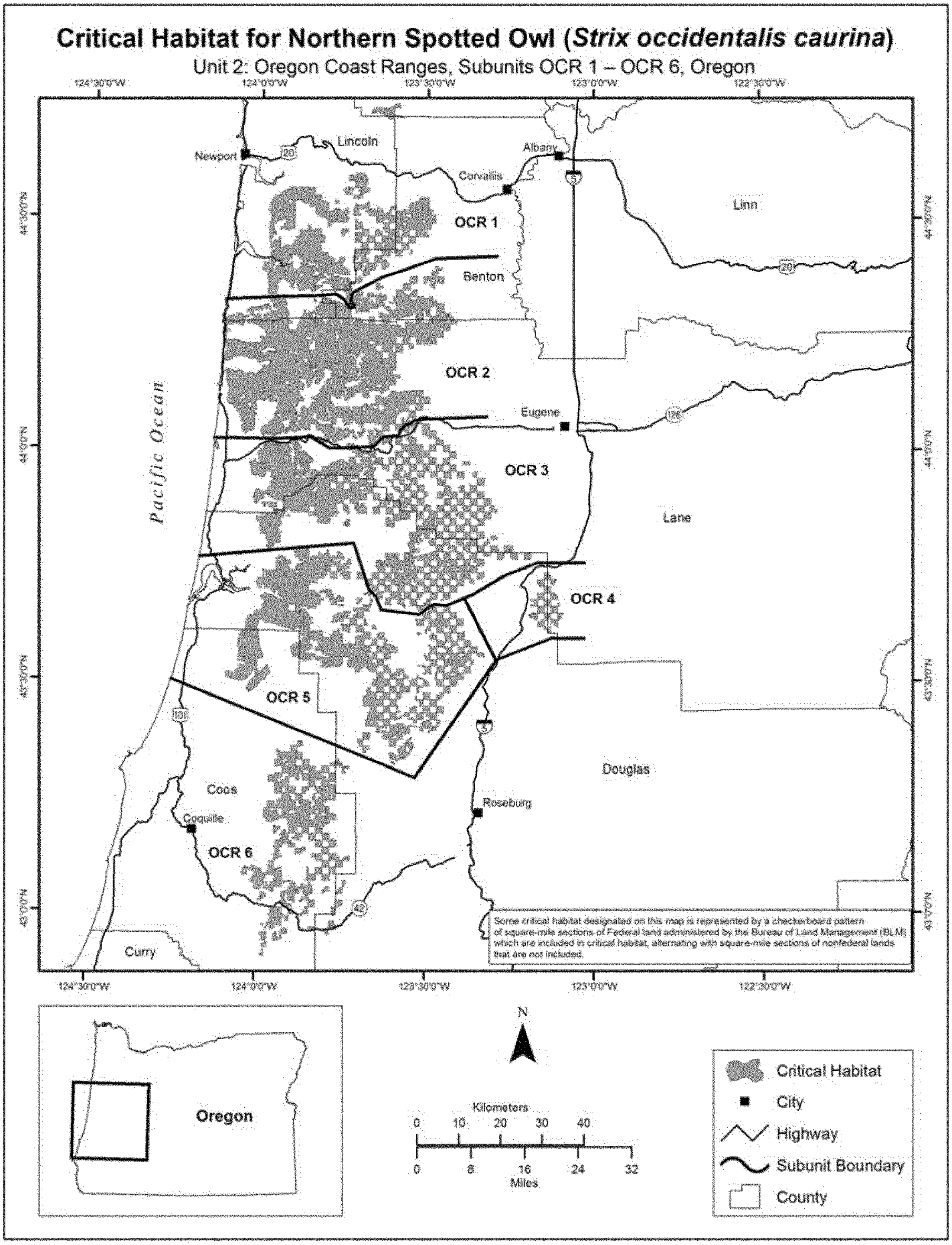


(9) Unit 1: North Coast Ranges and Olympic Peninsula, Oregon and Washington. Maps of Unit 1: North Coast Ranges and Olympic Peninsula, Oregon and Washington, follow:

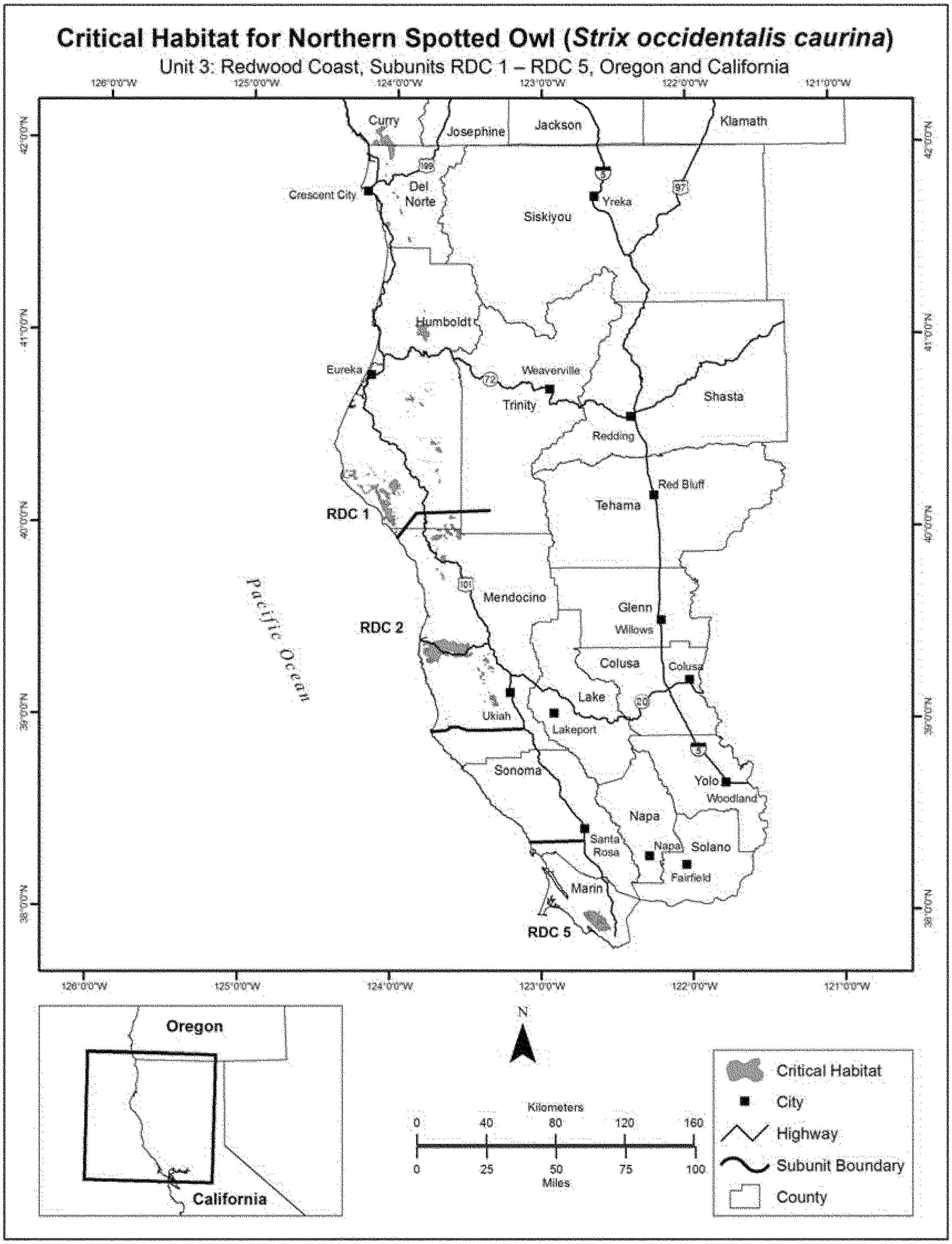

Critical Habitat for Northern Spotted Owl (Strix occidentalis caurina)
Unit 1: North Coast Ranges and Olympic Peninsula, Subunits NCO 1 – NCO 2, Washington
Skagit
Clallam
Port Angeles
Jefferson
Pacific Ocean
King
Kitsap
NCO 1
NCO 2
Shelton
Tacoma
Mason
Grays Harbor
Montesano
Pierce
Thurston
Pacific
Lewis
Washington
Kilometers
0 10 20 30 40
0 9 18 27 36
Miles
N
Critical Habitat
City
Highway
Subunit Boundary
County


Critical Habitat for Northern Spotted Owl (*Strix occidentalis caurina*)
Unit 1: North Coast Ranges and Olympic Peninsula, Subunits NCO 4 – NCO 5, Oregon
Pacific
Astoria
Wahkiakum
Cowlitz
Clatsop
Columbia
Skamania
Saint Helens
Clark
Pacific Ocean
Tillamook
Washington
Tillamook
Portland
Multnomah
NCO 4
NCO 5
Yamhill
McMinnville
Clackamas
Marion
Dallas
Polk
Lincoln
Linn
Washington
Oregon
N
Kilometers
Miles
Critical Habitat
City
Highway
Subunit Boundary
County

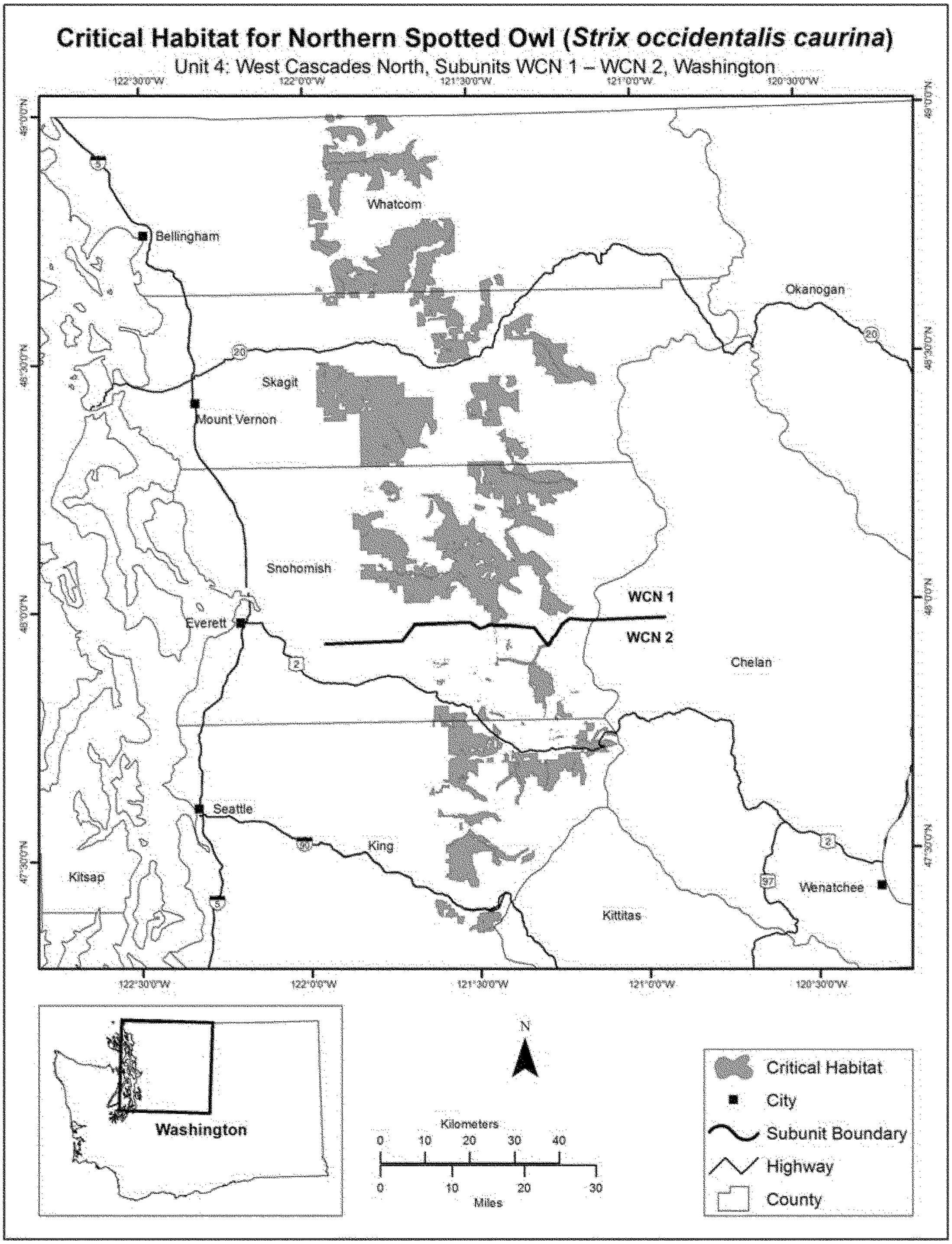
(10) Unit 2: Oregon Coast Ranges, Oregon. Map of Unit 2, OregonCoast Ranges, Oregon, follows:



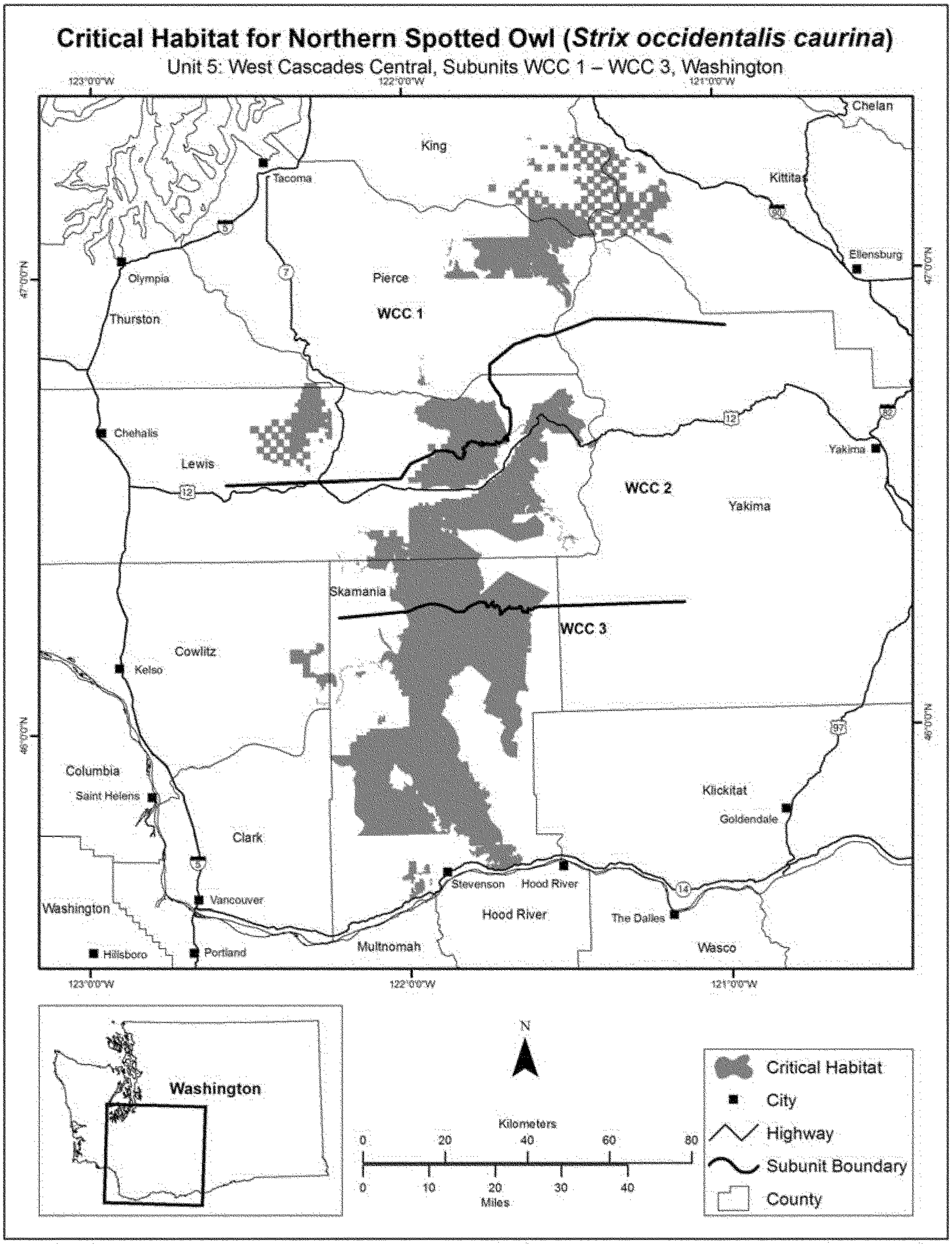
(11) Unit 3: Redwood Coast, Oregon and California. Map of Unit 3, Redwood Coast, Oregon and California, follows:



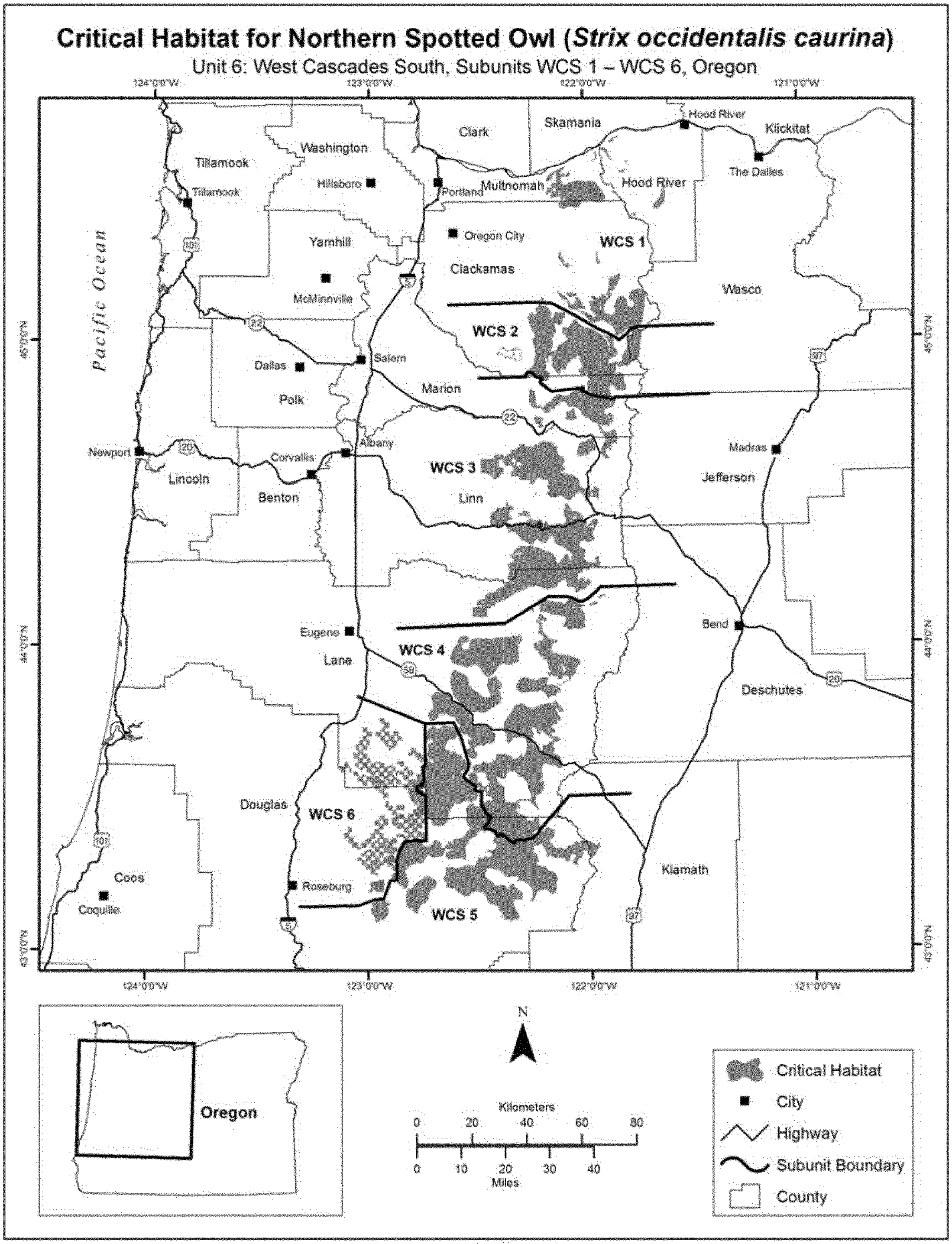
(12) Unit 4: West Cascades North, Washington. Map of Unit 4, West Cascades North, Washington, follows:



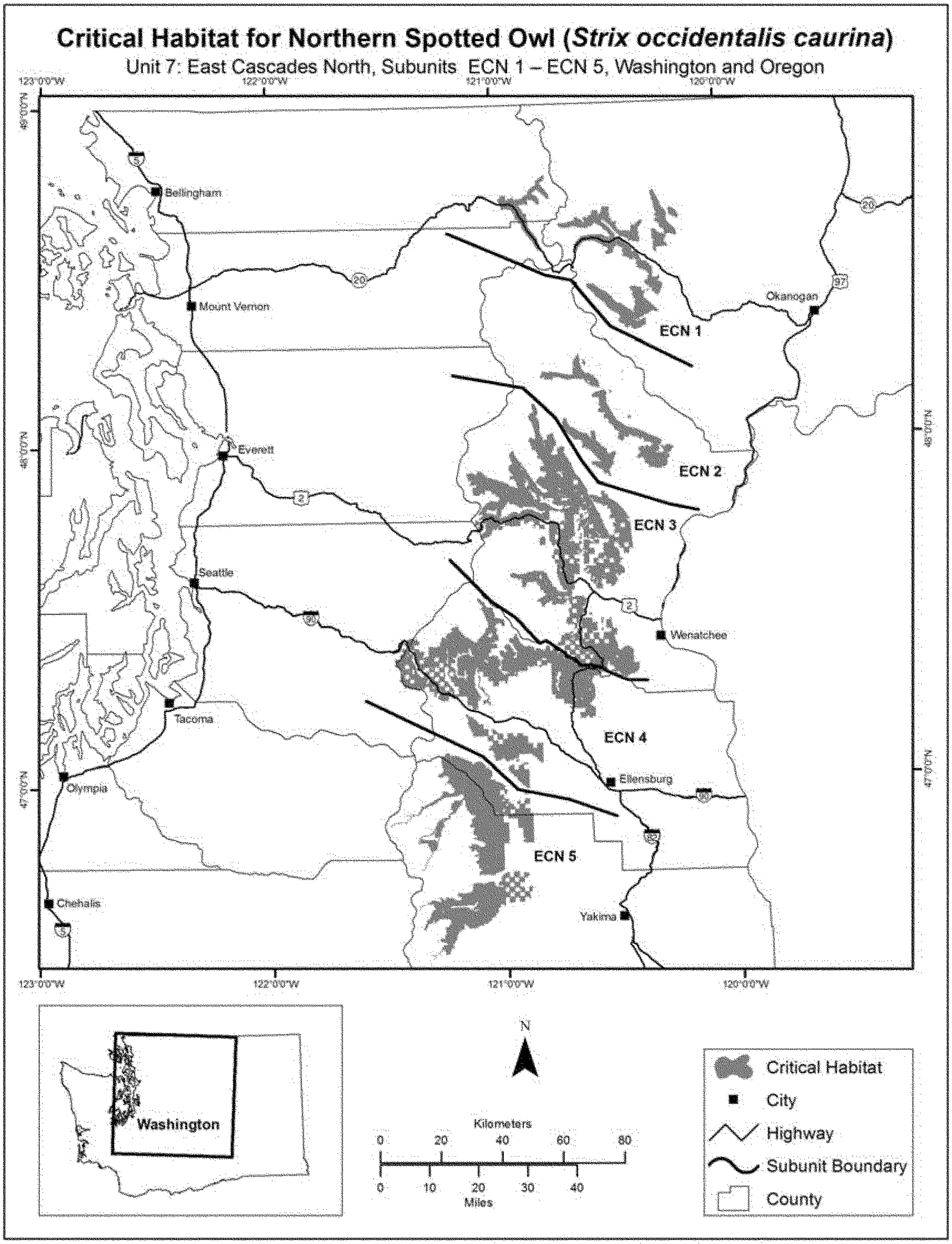
(13) Unit 5: West Cascades Central, Washington. Map of Unit 5, West Cascades Central, Washington, follows:

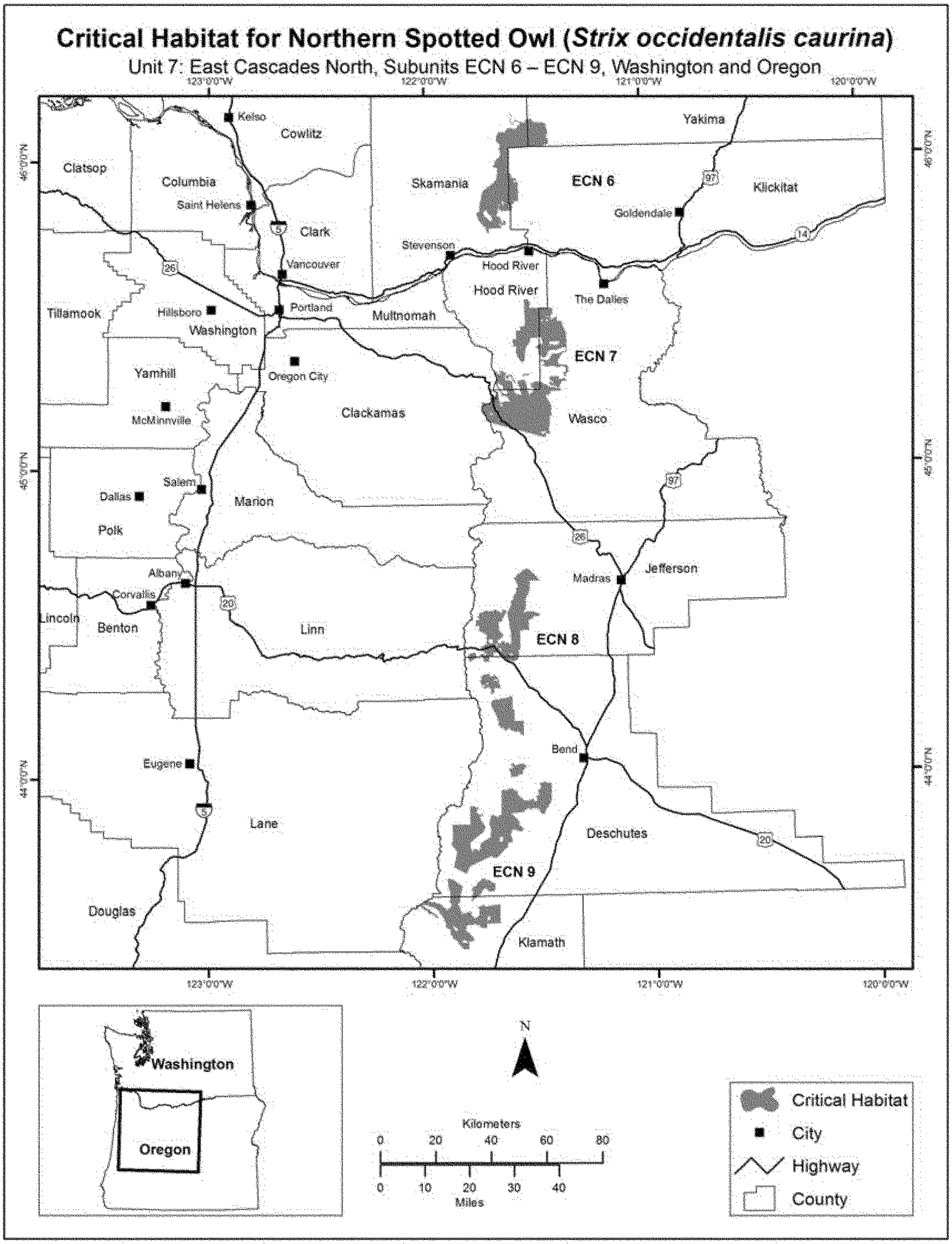


(14) Unit 6: West Cascades South, Washington. Map of Unit 6, West Cascades South, Washington, follows:

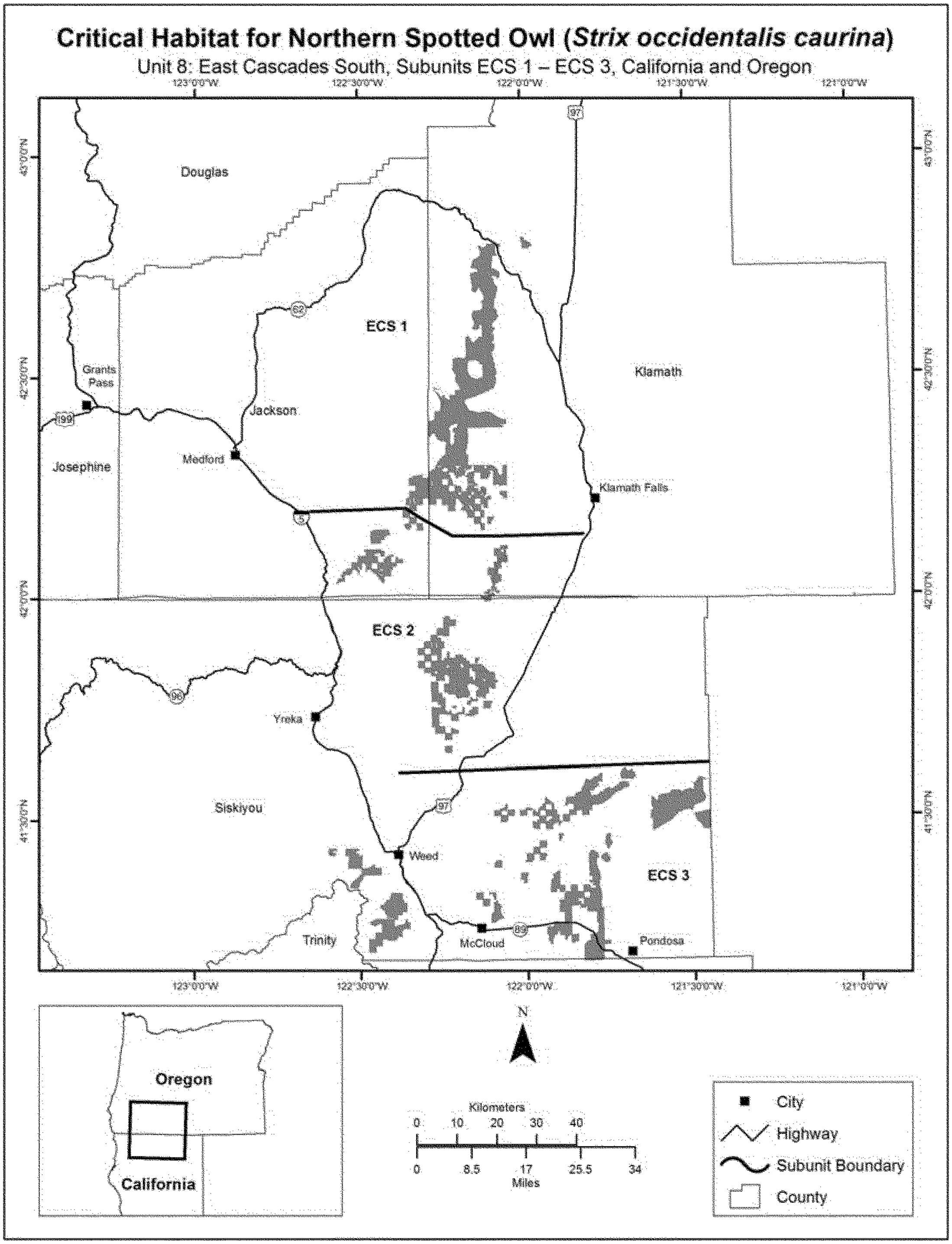


(15) Unit 7: East Cascades North, Washington and Oregon. Maps of Unit 7, East Cascades North, Washington and Oregon, follow:

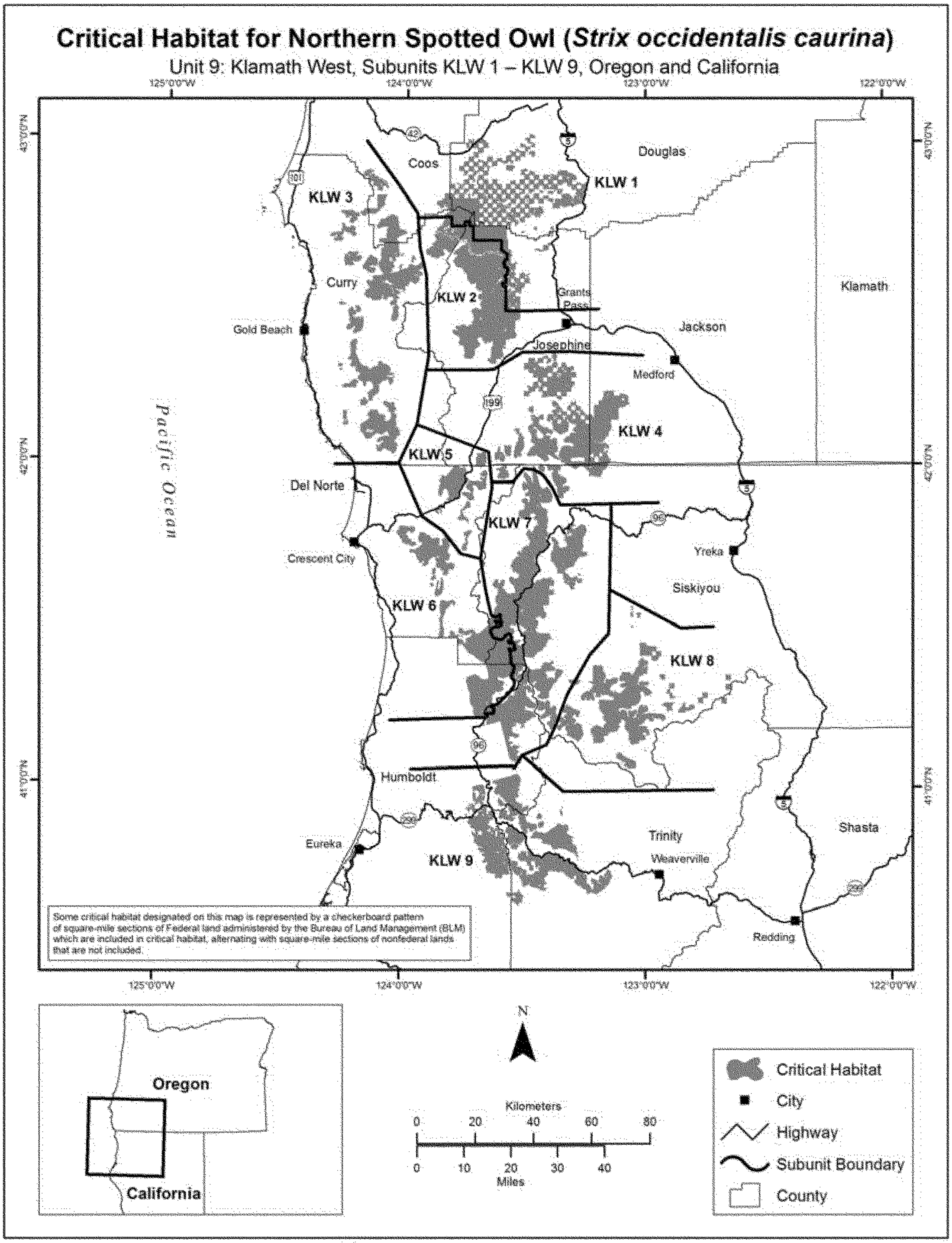



Critical Habitat for Northern Spotted Owl (Strix occidentalis caurina)
Unit 7: East Cascades North, Subunits ECN 6 – ECN 9, Washington and Oregon
ECN 6
ECN 7
ECN 8
ECN 9
Kelso
Cowlitz
Yakima
Clatsop
Columbia
Skamania
Klickitat
Saint Helens
Goldendale
Clark
Stevenson
Hood River
The Dalles
Vancouver
Tillamook
Hillsboro
Portland
Multnomah
Washington
Yamhill
Oregon City
McMinnville
Clackamas
Wasco
Salem
Dallas
Marion
Polk
Albany
Madras
Jefferson
Corvallis
Lincoln
Benton
Linn
Bend
Eugene
Lane
Deschutes
Douglas
Klamath
Washington
Oregon
N
Kilometers
Miles
Critical Habitat
City
Highway
County

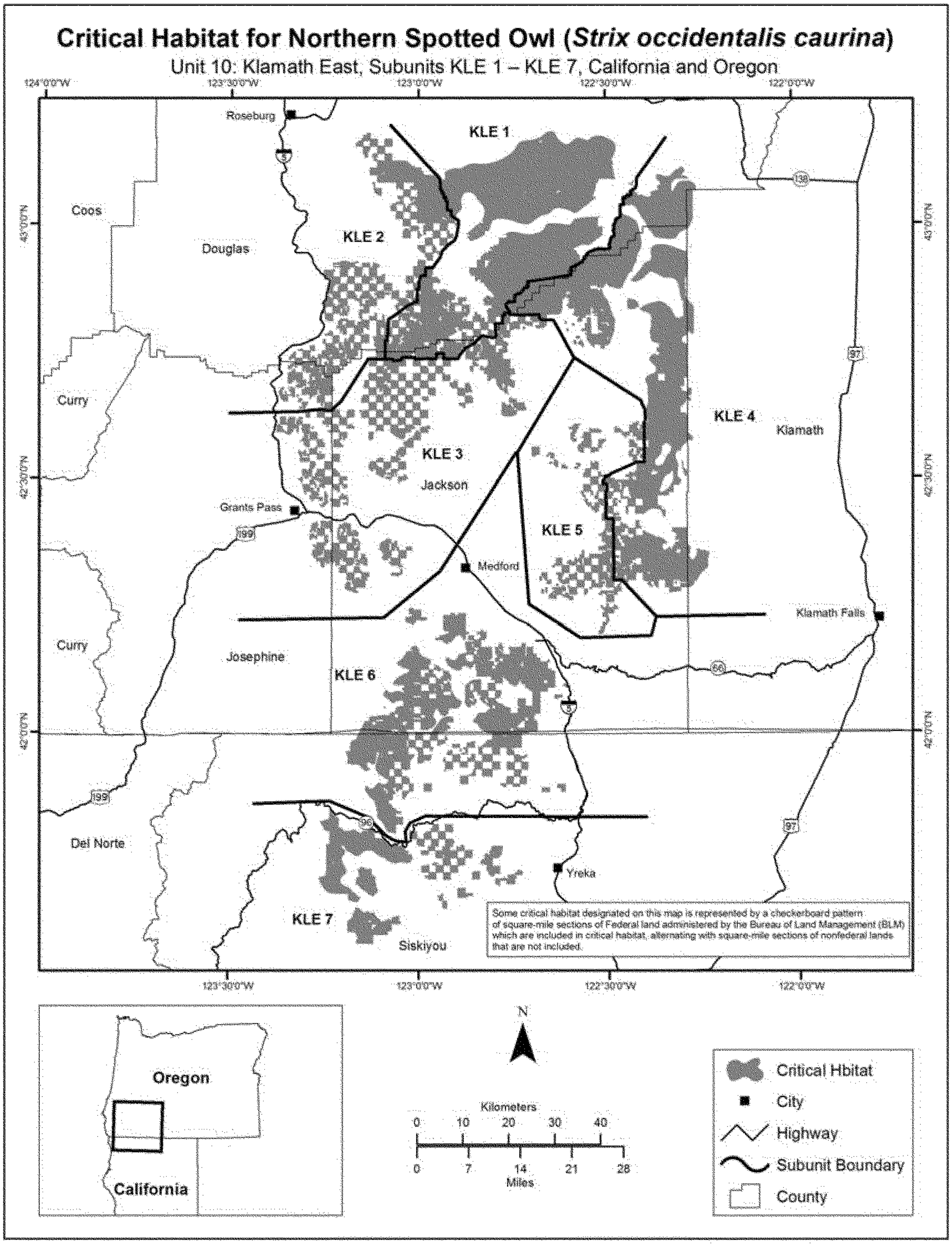
(16) Unit 8: East Cascades South, California and Oregon. Map of Unit 8, East Cascades South, California and Oregon, follows:



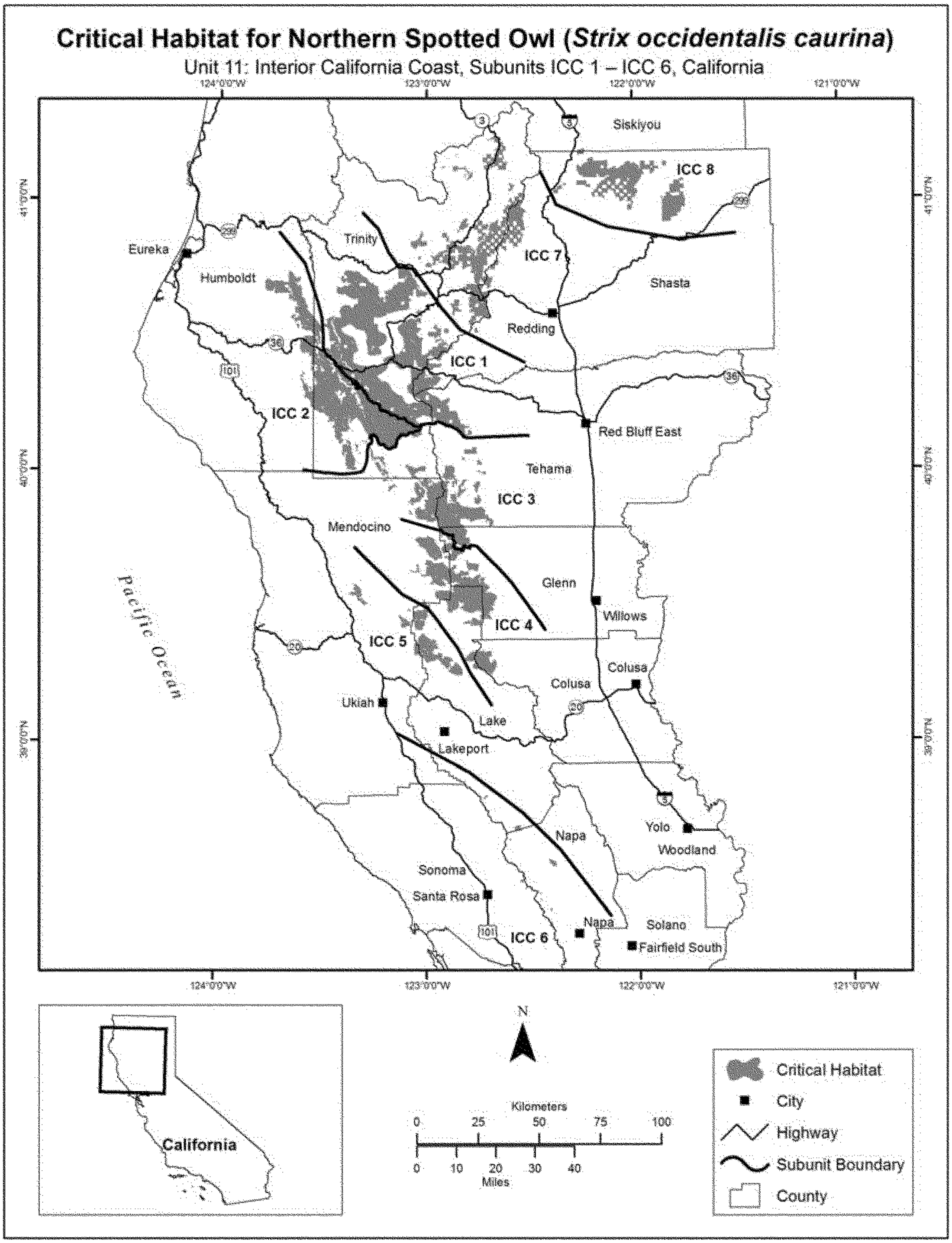
(17) Unit 9: Klamath West, Oregon and California. Map of Unit 9: Klamath West, Oregon and California, follows:



(18) Unit 10: Klamath East, California. Map of Unit 10: Klamath East, California, follows:



(19) Unit 11: Interior California Coast, California. Map of Unit 11: Interior California Coast, California, follows:



* * * * *

Dated: November 20, 2012.

Rachel Jacobson,

Principal Deputy Assistant Secretary for Fish and Wildlife and Parks.

[FR Doc. 2012–28714 Filed 12–3–12; 8:45 am]

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U.S. Fish & Wildlife Service

Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*)

Cover photo:

Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*)

Region 1
U.S. Fish and Wildlife Service
Portland, Oregon

Approved: Robyn Thorson
Regional Director, U.S. Fish and Wildlife Service

Date: JUN 2 8 2011

Disclaimer

Recovery plans describe reasonable actions and criteria that are considered necessary to recover listed species. Recovery plans are approved and published by the U.S. Fish and Wildlife Service ("Service" or "we" in narrative, (except as otherwise indicated) "USFWS" in citations, "FWS" in tables) and are sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. The 2011 Revised Recovery Plan for the Northern Spotted Owl (Revised Recovery Plan) does not necessarily represent the view or official position of any individual or organization—other than that of the Service—involved in its development. Although the northern spotted owl is a subspecies of spotted owl, we sometimes refer to it as a species when discussing it in the context of the ESA or other laws and regulations.

Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions. The objectives in this Revised Recovery Plan will be achieved subject to availability of funding and the capability of the involved parties to participate while addressing other priorities. This Revised Recovery Plan replaces, in its entirety, the 2008 Recovery Plan.

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Citation

U.S. Fish and Wildlife Service. 2011. Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*). U.S. Fish and Wildlife Service, Portland, Oregon. xvi + 258 pp.

Electronic Copy

A copy of the Revised Recovery Plan and other related materials can be found at: http://www.fws.gov/species/nso.

Acknowledgments

The Service gratefully acknowledges the effort and commitment of the many individuals involved in the conservation and recovery of the northern spotted owl who participated in the preparation of both the 2008 Recovery Plan and this Revised Recovery Plan. Without their individual expertise and support, this Revised Recovery Plan would not have been possible as it is the culmination of many years of labor. This Revised Recovery Plan is the culmination of many hours of discussion, research and analysis by a large number of scientific experts and managers over several years.

This revision to the 2008 Recovery Plan has been led by the Service and builds upon the efforts of numerous individuals from several different agencies, academia, State governments and private organizations; their names and affiliations are listed in Appendix H. The Service is indebted to all of these individuals for the information provided during the preparation of this Revised Recovery Plan. Their names, affiliations, and roles are listed below. Their participation in the revision process does not imply these contributors or their sponsoring agencies agree with the recommendations and conclusions of this Revised Recovery Plan.

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EXECUTIVE SUMMARY

Current Status

The northern spotted owl (*Strix occidentalis caurina*) (spotted owl) inhabits structurally complex forests from southwest British Columbia through the Cascade Mountains and coastal ranges in Washington, Oregon, and California, as far south as Marin County (Appendix A). After a status review (USFWS 1990a), the spotted owl was listed under the Endangered Species Act (ESA) as threatened on June 26, 1990 (USFWS 1990b) because of widespread loss of spotted owl habitat across the spotted owl's range and the inadequacy of existing regulatory mechanisms to conserve the spotted owl. Past habitat loss and current habitat loss are also threats to the spotted owl, even though loss of habitat due to timber harvest has been greatly reduced on Federal lands over the past two decades. Many populations of spotted owls continue to decline, especially in the northern parts of the subspecies' range, even with extensive maintenance and restoration of spotted owl habitat in recent years. Managing sufficient habitat for the spotted owl now and into the future is important for its recovery. However, it is becoming more evident that securing habitat alone will not recover the spotted owl. Based on the best available scientific information, competition from the barred owl (*S. varia*) poses a significant and complex threat to the spotted owl.

Based on the best available scientific information, competition from the barred owl (*S. varia*) poses a significant threat to the spotted owl.

Habitat Requirements

Scientific research and monitoring indicate spotted owls generally rely on mature and old-growth forests because these habitats contain the structures and characteristics required for nesting, roosting, and foraging. Although spotted owls can disperse through highly fragmented forested areas, the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated or described.

Delisting

In order to consider a species recovered, analysis of five listing factors must be conducted and the threats from those factors reduced or eliminated. The five listing factors are:

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range;
B. Overutilization for commercial, scientific, or educational purposes;
C. Disease or predation;
D. Inadequacy of existing regulatory mechanisms;
E. Other natural or manmade factors affecting its continued existence.

Recovery Strategy

Currently, the most important range-wide threats to the spotted owl are competition with barred owls, ongoing loss of spotted owl habitat as a result of timber harvest, habitat loss or degradation from stand replacing wildfire and other disturbances, and loss of amount and distribution of spotted owl habitat as a result of past activities and disturbances. To address these threats, this recovery strategy includes four basic steps:

1. Completion of a rangewide habitat modeling tool;
2. Habitat conservation and active forest restoration;
3. Barred owl management; and
4. Research and monitoring.

In addition to describing specific actions to address the barred owl threat, this Revised Recovery Plan continues to recognize the importance of maintaining habitat for the recovery and long-term survival of the spotted owl.

The U.S. Fish and Wildlife Service (Service) recognizes the barred owl constitutes a significantly greater threat to spotted owl recovery than was envisioned when the spotted owl was listed in 1990. As a result, the Service recommended in the 2008 Recovery Plan that specific actions to address the barred owl threat begin immediately. These actions are currently underway, and this Revised Recovery Plan builds on these actions.

In addition to describing specific actions to address the barred owl threat, this Revised Recovery Plan continues to recognize the importance of maintaining and restoring high value habitat for the recovery and long-term survival of the spotted owl.

Maintaining and restoring sufficient habitat is important to address the threats the spotted owl faces from a loss of habitat due to harvest, loss or alteration of habitat from stand replacing fire, loss of genetic diversity, and barred owls (Forsman *et al.* 2011). The 2008 Recovery Plan established a network of Managed Owl Conservation Areas (MOCAs) across the range of the species. Based on scientific peer review comments the Service is not incorporating the previously recommended MOCA network into this Revised Recovery Plan. We will update spotted owl critical habitat; in the interim, we recommend land managers continue to implement the standards and guidelines of the Northwest Forest Plan (NWFP) throughout the range of the species, as well as fully consider other recommendations in this Revised Recovery Plan. We also support the updating of existing land management plans.

The estimated time to delist the species is 30 years if all actions are implemented and effective. While the 2008 Recovery Plan identified an interim 10-year timeframe, this revision identifies several actions that will take many years to implement effectively. Therefore, the Service believes that this Revised Recovery Plan can be fully implemented in a 30-year timeframe. A longer time to delisting would be required if these assumptions are not met. Total cost for delisting over these 30 years is $127.1 million (see Section IV; Implementation Schedule and Cost Estimates for specific costs).

Due to the uncertainties associated with the effects of barred owl interactions with the spotted owl and habitat changes that may occur as a result of climate change, the Service intends to implement this Revised Recovery Plan aggressively and will use the 5-year review process to evaluate recovery implementation and success. The Service and other implementers of this Revised Recovery Plan will have to employ an active adaptive management strategy to achieve results and focus on the most important actions for recovery. Adaptive management is a systematic approach for improving resource management by learning from the results of explicit management policies and practices and applying that learning to future management decisions.

After the 2008 Recovery Plan was finalized, an inter-organizational Northern Spotted Owl Recovery Plan implementation structure was established that included multiple interagency recovery implementation teams. This implementation structure will be reevaluated and updated in accordance with this Revised Recovery Plan.

Recovery Goal

The goal of every Recovery Plan is to improve the status of the species so it can be removed from protection under the ESA. The long-term goal for the spotted owl is the same.

Recovery Objectives

The objectives of this Revised Recovery Plan are:

1. Spotted owl populations are sufficiently large and distributed such that the species no longer requires listing under the ESA;
2. Adequate habitat is available for spotted owls and will continue to exist to allow the species to persist without the protection of the ESA; and
3. The effects of threats have been reduced or eliminated such that spotted owl populations are stable or increasing and spotted owls are unlikely to become threatened again in the foreseeable future.

Recovery Criteria

There are four Recovery Criteria in this Revised Recovery Plan. Recovery Criteria are measurable, achievable goals that we believe will result from implementation of the recovery actions in this Revised Recovery Plan. Achievement of these criteria will take time and is intended to be measured over the life of the plan, not on a short-term basis and should not be considered near-term recommendations. Not all recovery actions necessarily need to be implemented for the Service to consider initiating the delisting process based on the statutory criteria for determining whether a species should be listed (16 U.S.C. § 1533(a)(1)).

Recovery Criterion 1 – Stable Population Trend: The overall population trend of spotted owls throughout the range is stable or increasing over 10 years, as measured by a statistically reliable monitoring effort.

Recovery Criterion 2 – Adequate Population Distribution: Spotted owl subpopulations within each province (*i.e.*, recovery unit) (excluding the Willamette Valley Province) achieve viability, as informed by the HexSim population model or some other appropriate quantitative measure.

Recovery Criterion 3 – Continued Maintenance and Recruitment of Spotted Owl Habitat: The future range-wide trend in spotted owl nesting/roosting and foraging habitat is stable or increasing throughout the range, from the date of Revised Recovery Plan approval, as measured by effectiveness monitoring efforts or other reliable habitat monitoring programs.

Recovery Criterion 4 – Post-delisting Monitoring: To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation within the States of Washington, Oregon, and California, as required in section 4(g)(1) of the ESA.

Recovery Actions

Recovery actions are near-term recommendations to guide the activities needed to accomplish the recovery objectives and achieve the recovery criteria. This Revised Recovery Plan presents 33 actions that address overall recovery through maintenance and restoration of spotted owl habitat, monitoring of avian diseases, development and implementation of a delisting monitoring plan, and management of the barred owl. These actions are organized following the five listing factors described earlier.

Organization of Revised Recovery Plan

This Revised Recovery Plan is organized into four main sections with supporting appendices and retains the structure of the 2008 Plan. After Section I the Introduction, Section II gives a summary of recovery goals, objectives, and strategy. This section also gives an overview of how this recovery strategy for spotted owls fits within a broader ecosystem management approach. Section III describes recovery units, criteria, and the actions that are necessary to recover the species. These recovery actions are organized according to the five factors considered when a species is listed under section 4(a)(1) of the ESA. Section IV outlines the Plan's implementation schedule and cost estimates.

This Revised Recovery Plan also includes several appendices. These appendices provide background information, literature cited, a description of the spotted owl habitat modeling tool, and other important supporting information.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Acronyms and Abbreviations

BLM	U.S. Bureau of Land Management
BOWG	Barred Owl Work Group
CAL FIRE	California Department of Forestry and Fire Protection
CDFG	California Department of Fish and Game
CI	confidence interval
CO_2	carbon dioxide
dbh	diameter at breast height
DCA	Designated Conservation Area
DFLWG	Dry forest Landscape Work Group
ENSO	El Niño-Southern Oscillation
ESA	Endangered Species Act
FEMAT	Forest Ecosystem Management Assessment Team
FS	U.S. Forest Service
FWS	U.S. Fish and Wildlife Service
HCA	Habitat Conservation Area
HCP	Habitat Conservation Plan
ISC	Interagency Scientific Committee
KPWG	Klamath Province Work Group
LRMP	Land and Resource Management Plan (for BLM and FS)
LSR	Late-Successional Reserve
MOCA	Managed Owl Conservation Area
NPS	National Park Service
NRF	Nesting/roosting and foraging
NSO	Northern spotted owl
NSOIT	Northern Spotted Owl Implementation Team
NWFP	Northwest Forest Plan
ODF	Oregon Department of Forestry
PDO	Pacific Decadal Oscillation
SE	standard error
SEI	Sustainable Ecosystems Institute
SHA	Safe Harbor Agreement
SOSEA	Spotted Owl Special Emphasis Areas
TBD	to be determined
USFWS	U.S. Fish and Wildlife Service (Service)
USGS	U.S. Geological Survey
WDNR	Washington Department of Natural Resources
WNV	West Nile virus

I. INTRODUCTION

Development of This Revised Recovery Plan

This Revised Recovery Plan builds extensively on the 1992 Draft Recovery Plan for the Northern Spotted Owl (USFWS 1992b), the 1994 NWFP (USDA and USDI 1994a, b), and the 2008 Recovery Plan for the Northern Spotted Owl (USFWS 2008b).

In 1993, President Clinton announced the NWFP which was intended to serve three roles: (1) a program to manage forests to achieve both sustainable timber production and protection of biological diversity; (2) a system for coordinating Federal agency implementation of the forest management efforts and receiving advice from non-federal interests; and (3) an initiative for providing economic assistance for those individuals and communities who were adversely affected by the reduction in the timber program. The 1994 NWFP signaled a unique approach to Federal land management in that it sought to embody (Pipkin 1998):

1. A shift to an ecosystem approach that crosses jurisdictional boundaries;
2. Active and meaningful public participation;
3. A balancing of commodity production and ecosystem viability;
4. Increased adaptive management efforts that support reevaluation and adjustments based on science;
5. A commitment to improved interagency processes; and
6. Federal agencies sharing responsibility for the implementation of a set of standards and guidelines for managing a common resource.

Due to its broad, over-arching nature and comprehensive scientific information, the 1994 NWFP was widely viewed as the Federal government's contribution to the recovery of the spotted owl since it contained the information used to develop the draft 1992 Northern Spotted Owl Recovery Plan. The NWFP was directly incorporated into 4 National Forest land and resource management plans (LRMPs) and amended the LRMPs or resource management plans (RMPs) that guide the management of each of the 15 National Forests and 6 Bureau of Land Management (BLM) Districts across the range of the spotted owl. These plans adopted a series of reserves and management guidelines that were intended to protect spotted owls and their habitat as well as other species.

As time passed, the public and land managers expressed a desire for a spotted owl recovery plan that explicitly outlined and described the management actions and habitat needs of the species. The U.S. Fish and Wildlife Service (Service) responded by publishing in May, 2008, the Recovery Plan for the Northern Spotted Owl, which was created after 2 years of scientific meetings, peer review, input from a wide variety of experts and more than 70,000 public comments.

The 2008 Recovery Plan identified two predominant threats: increasing competition from barred owls, and habitat loss from timber harvest and fire. The main elements of the 2008 Recovery Plan included: (1) a network of conservation areas on Federal lands west of the Cascade Crest; (2) a new approach to habitat management on Federal lands east of the Cascade Crest that maintains spotted owl habitat in a fire-prone landscape; (3) barred owl removal experiments; and (4) maintenance of substantially all older forests on Federal lands west of the Cascade Crest to reduce spotted owl and barred owl competitive interactions as we evaluate barred owl management options.

In June 2008, the Service received reviews of the 2008 Recovery Plan from the American Ornithologists' Union, Society for Conservation Biology and The Wildlife Society. These scientific peer reviews were consistent in their comments, noting that the recovery plan provided a "solid conceptual framework for recovery." However, the comments were critical of several key aspects of the 2008 Recovery Plan, particularly addressing threats posed by habitat loss from fire and concerns regarding the adequacy of reserves and their management.

Both the 2008 Recovery Plan and the 2008 revised critical habitat designation for the northern spotted owl, which is based on the 2008 Recovery Plan, were challenged in court, *Carpenters' Industrial Council v. Salazar*, 1:08-cv-01409-EGS (D.D.C.). In addition, on December 15, 2008, the Inspector General of the Department of the Interior issued a report entitled "Investigative Report of the Endangered Species Act and the Conflict between Science and Policy," which concluded that the integrity of the agency decision-making process for the 2008 Recovery Plan was potentially jeopardized by improper political influence. As a result, the Federal government filed a motion in the lawsuit for remand of the 2008 Recovery Plan and the 2008 critical habitat designation. On September 1, 2010, the Court issued an opinion remanding the 2008 Recovery Plan to the Service for issuance of a revised recovery plan within nine months. On May 6, 2011, the Court granted our request for a 30-day extension to allow time to consider the comments we received on Appendix C, which describes the modeling process, during an additional 30-day comment period. This Revised Recovery Plan is the result of the process to consider revisions to the 2008 Recovery Plan.

This Revised Recovery Plan is based on the best scientific information available, addressing the scientific peer reviewers' comments and including more recent scientific information involving climate change and habitat modeling. This Revised Recovery Plan focuses largely on five topics:

1. Conservation of spotted owl sites and high value spotted owl habitat;
2. Ecological forestry and active forest restoration to meet the challenges of climate change and altered ecological processes;
3. The threat posed by barred owls and management options to address it;
4. The potential need for State and private lands to contribute to spotted owl recovery in certain areas; and

5. Completion of a habitat modeling framework as an informational tool to better enable future land management decisions.

While this document retains some aspects of the 2008 Recovery Plan such as the strategy to assess and address threats from the barred owl and support for forest restoration treatments, it presents the most comprehensive, up-to-date evaluation of spotted owl science, conservation needs and management alternatives. With it, the Service seeks to engage Federal, State and private landowners in developing a comprehensive, landscape-level approach that furthers the recovery of the spotted owl.

The following is a chronology of the process involved in writing this Revised Recovery Plan.

- September 2010: 2010 Draft Revised Recovery Plan released for public comment and scientific peer review.
- Fall, 2010: Service holds eight stakeholder briefings and workshops regarding development of the habitat modeling tool.
- October 2010: Service posts to website a map depicting the results of the first two steps of the modeling tool.
- December 2010: Service posts summary results of the third step of the modeling tool.
- November 15, 2010: public comment period closes, but is extended until December 15, 2010.
- April 22, 2011: 30-day public comment period opened for review of and comment on updated spotted owl habitat modeling information contained in draft Appendix C.

Recovery Planning and Timeframes

The Endangered Species Act of 1973, as amended (16 USC 1531 *et seq*.)(ESA), establishes policies and procedures for identifying and conserving species of plants and wildlife that are endangered or threatened with extinction. To help identify and guide species recovery efforts, section 4(f) of the ESA directs the Secretary of the Interior to develop and implement recovery plans for listed species. These plans are to include:

1. A description of site-specific management actions necessary for conservation and survival of the species;
2. Objective, measurable criteria that, when met, will allow the species to be delisted; and
3. Estimates of the time and funding required to achieve the plan’s goals and intermediate steps.

Recovery plans are not regulatory documents; rather, they are created by the Service as guidance to bring about recovery and establish criteria to be used in evaluating when recovery has been achieved. There may be many paths to recover a species. Recovering a wide-ranging species takes time and significant effort from a multitude of entities. Recovering a species is a dynamic process, and judging when a species is recovered requires an adaptive management approach that is sensitive to the best available information and risk tolerances. Given the adaptive nature of this iterative process, recovery may be achieved without fully following the guidance provided in this Revised Recovery Plan.

Recovery Plan Objectives, Criteria, and Actions

The ultimate goal of this Revised Recovery Plan is to recover the spotted owl so that protections afforded by the ESA are no longer necessary, allowing us to delist the species. Its objectives describe a scenario in which the spotted owl's population is stable or increasing, well-distributed, and affected by manageable threats. To meet this goal and these objectives, interim expectations are defined to guide us as we learn more about the multiple uncertainties surrounding this species.

This Revised Recovery Plan was developed using the best scientific information available and a "step-down" approach of objectives, criteria and actions. Recovery objectives are broad statements that describe the conditions under which the Service would consider the spotted owl to be recovered. Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the ESA are no longer necessary and the species may be delisted. Recovery actions are the Service's recommendations to guide the activities needed to accomplish the recovery criteria. Recovery actions are recommended throughout the U.S. range of the spotted owl and are designed to address the specific threats identified in this Revised Recovery Plan. Implementation of the full suite of recovery actions will involve participation from the States, Federal agencies, non-federal landowners and the public.

The recovery criteria and actions are described at the beginning of this Revised Recovery Plan. Information concerning the spotted owl's biology is in Appendix A, and a description of the threats to the spotted owl is presented in Appendix B.

Five-year Status Reviews

A 5-year review of a listed species is required by section 4(c)(2) of the ESA, and considers all new available information concerning the population status of the species and the threats that affect it. This process can serve as an integral component of tracking recovery implementation, updating scientific understanding and evaluating status of the species. The Service conducts these periodic reviews to ensure the listing classification of a species as threatened or endangered is accurate. A 5-year status review considers the best scientific and commercial information that has become available since the original listing determination or last review such as: species biology, habitat conditions, conservation measures, threat status and trends, and any other new information. The Service publishes a notice in the Federal Register announcing the initiation of these reviews and provides the public an opportunity to submit relevant information regarding the species and its threats.

A 5-year review is intended to indicate whether a change in a species listing classification is warranted. Changes in classification recommended in a 5-year review could include delisting, reclassification from threatened to endangered (*i.e.*, uplisting), reclassification from endangered to threatened (*i.e.*, downlisting), or no change is warranted at this time. The 5-year review does not involve rule-making, so no change to a species classification is made at the time a review is completed. If a change is recommended in the completed review, the Service would need to initiate a separate rule-making process to propose the change.

Delisting Process

When sufficient progress toward recovery has been made, a separate effort will assess the spotted owl's status in relation to the five listing factors found in section 4(a)(1) of the ESA to determine whether delisting is appropriate (see Executive Summary). A change in status (downlisting or delisting) requires a separate rule-making process based on an analysis of the same five factors (referred to as the listing factors) considered in the listing of a species, as described in section 4(a)(1) of the ESA. These include:

A. The present or threatened destruction, modification, or curtailment of its habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms;
E. Other natural or manmade factors affecting its continued existence.

This subsequent review may be initiated without all of the recovery criteria in this Revised Recovery Plan having been fully met. For example, one or more criteria may have been exceeded, while other criteria may not have been fully accomplished. In this instance, the Service may judge that, overall, the threats have been minimized sufficiently and the species' population health is robust enough to be considered for delisting. If sufficient progress toward recovery has not been made, the spotted owl may retain its current status. If the spotted owl's condition deteriorates, it may be necessary to change its status to "endangered."

New recovery opportunities or scientific information may arise that were unknown at the time this Revised Recovery Plan was created. New opportunities may encompass more effective means of achieving recovery or measuring recovery. In addition, new information may alter the extent to which criteria need to be met for recognizing recovery of the species. Conversely, new information may result in new challenges, and achieving recovery may be more difficult than we now believe.

Assumptions Made in Drafting the Revised Recovery Plan

There are numerous land management plans and strategies being implemented to help recover the spotted owl. This Revised Recovery Plan is not meant to negate or supplant these other plans. However, these plans may be subject to change, so this Revised Recovery Plan is meant to be a stand-alone document that describes steps necessary to recover the spotted owl. The recommendations described in the Revised Recovery Plan are meant to be successful on their own; that is, they are not dependent on the continuance of any other conservation or management plan to be successful, unless specifically noted.

Implementation of the full suite of recovery actions will involve participation from the States, Federal agencies, non-federal landowners and the public.

Listing History and Recovery Priority

The spotted owl was listed as threatened on June 26, 1990. On a scale of 1C (highest) to 18 (lowest) (USFWS 1983a, b), the Service recovery priority number for the spotted owl is 12C. We assigned this number per our guidelines for the following reasons: the spotted owl faces a "moderate" degree of threat which equates to a continual population decline and threat to its habitat, although extinction is not imminent. It received a "low recovery potential" because there is uncertainty regarding our ability to alleviate the barred owl impacts to spotted owls and the techniques are still experimental; and because of the spotted owl's taxonomic status as a subspecies and inherent conflicts with development, construction, or other economic activity given the economic value of older forest spotted owl habitat (USFWS 1983a, b). Despite the definitions that led us to a 12C Recovery priority number, the Service is optimistic regarding the spotted owl's potential for recovery if immediate challenges such as barred owls are managed.

The spotted owl was listed in 1990 as a result of widespread loss and adverse modification of spotted owl habitat across its entire range and the inadequacy of existing regulatory mechanisms to conserve the spotted owl.

Reasons for Listing and Assessment of Threats

The spotted owl was listed as threatened throughout its range "due to loss and adverse modification of spotted owl habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USFWS 1990b:26114). More specifically, threats to the spotted owl included low populations, declining populations, limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of populations within physiographic provinces, predation and competition, lack of coordinated conservation measures, inadequacy of regulatory mechanisms and vulnerability to natural disturbance (USFWS 1992b). These threats were characterized for each province as severe, moderate, low or unknown (USFWS 1992b). The range of the spotted owl is divided into 12 physiographic provinces from Canada to northern California and from the Pacific Coast to the eastern Cascades (see Appendix A, Figure A-1). Declining habitat was recognized as a severe or moderate threat to the spotted owl throughout its range, isolation of populations was identified as a severe or moderate threat in 11 provinces, and a decline in population was a severe or moderate threat in 10 provinces. Together, these three factors represented the greatest concerns about range-wide conservation of the spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces, and low populations was a severe or moderate concern in eight provinces, suggesting that these factors were also a concern throughout the majority of the spotted owl's range. Vulnerability to natural disturbances was rated as low in five provinces.

The Service conducted a 5-year review of the spotted owl in 2004 (USFWS 2004b), based in part on the content of an independent scientific evaluation of the status of the spotted owl (Courtney *et al.* 2004) performed under contract with the Service. For that evaluation, an assessment was conducted of how the threats described in 1990 might have changed by 2004. Some of the key ideas relative to threats identified in 2004 were: (1) "Although we are certain that current harvest effects are reduced, and that past harvest is also probably having a reduced effect now as compared to 1990, we are still unable to fully evaluate the current levels of threat posed by harvest because of the potential for lag effects" (Courtney and Gutiérrez 2004:11-7); (2) "Currently the primary source of habitat loss is catastrophic wildfire, although the total amount of habitat affected by wildfires has been small" (Courtney and Gutiérrez 2004:11-8); and (3) "We are convinced that Barred Owls are having a negative impact on Spotted Owls at least in some areas" (Gutiérrez *et al.* 2004:7-43) and "there are no grounds for optimistic views suggesting that Barred Owl impacts on Northern Spotted Owls have been already fully realized" (Gutiérrez *et al.* 2004:7-38).

On June 1, 2006, we convened a meeting of seven experts to help identify the most current threats facing the species. Six of the seven were experts on the biology of the spotted owl, and a seventh was an expert on fire ecology. The workshop was conducted as a modified Delphi expert panel in which the seven experts scored the severity of threat categories. The baseline assumption of this meeting was that existing habitat conservation strategies (*e.g.,* the NWFP) would be in place. With that assumption, the experts identified and ranked threats to the spotted owl. The 2007 Recovery Team then had an opportunity to interact with them to discuss their individual rankings and thoughts on spotted owl threats. The experts re-ranked the threats if they felt this was relevant given the substance of the discussion.

These experts identified past habitat loss, current habitat loss, and competition from barred owls as the most pressing threats to the spotted owl, even though timber harvest recently has been greatly reduced on Federal lands. They noted that evidence of these three threats is presented in the scientific literature. The range of threat scores made by the individual experts was narrowest for barred owl competition and slightly greater for habitat threats, indicating that there was more agreement about the threat from barred owls. The experts identified disease and the effect of climate change on vegetation as potential and more uncertain future threats.

The experts also ranked the threats by importance in each province. Among the 12 physiographic provinces, the more fire-prone provinces (Eastern Washington Cascades and Eastern Oregon Cascades, California Cascades, Oregon and California Klamath) scored high on threats from ongoing habitat loss as a result of wildfire and the effects of fire exclusion on vegetation change. West-side provinces (Western Washington Cascades and Western Oregon Cascades, Western Washington Lowlands, Olympic Peninsula, and Oregon Coast Range) generally scored high on threats from the negative effects of habitat fragmentation and ongoing habitat loss as a result of timber harvest. The province with the fewest number of threats was Western Oregon Cascades, and the provinces with the greatest number of threats were the Oregon Klamath and the Willamette Valley. For a more complete description of the threats, see Appendix B.

Barred Owls

It is the Service's position that the threat from barred owls is extremely pressing and complex, requiring immediate consideration. Barred owls have been found in all areas where surveys have been conducted for spotted owls. In addition, barred owls inhabit all forested areas throughout Washington, Oregon, and northern California where nesting opportunities exist, including areas outside of the specific range of the spotted owl (Kelly and Forsman 2003, Buchanan 2005, Gutiérrez *et al.* 1995, 2007, Livezey 2009a). Consequently, the Service assumes barred owls now occur at some level in all areas used now or in the past by spotted owls.

The workshop panel unanimously identified past habitat loss, current habitat loss, and competition from barred owls as the most-pressing threats to the spotted owl, even though timber harvest recently has been greatly reduced on Federal lands.

Addressing the threats associated with past and current habitat loss must be conducted simultaneously with addressing the threats from barred owls. Addressing the threat from habitat loss is relatively straightforward with predictable results. However, addressing a large-scale threat of one raptor on another, closely related raptor has many uncertainties.

At this time, the long-term removal of significant numbers of barred owls, along with a suite of other recovery actions, will be assessed as a possible approach to recover the spotted owl. Before considering whether to fund and fully implement such an action, however, the Service needs to be confident this removal would benefit spotted owls. The Service is currently developing a draft Environmental Impact Statement to assess the effects of barred owl removal experiments proposed in this Revised Recovery Plan.

Because barred owls compete with spotted owls for habitat and resources for breeding, feeding and sheltering, ongoing loss of habitat has the potential to intensify the competition by reducing the total amount of these resources available to the spotted owl and bringing barred owls into closer proximity with the spotted owl. In order to reduce or not increase this potential competitive pressure while the threat from barred owls is being addressed, this Revised Recovery Plan now recommends conserving and restoring older, multi-layered forests across the range of the spotted owl.

Habitat Management

In addition to addressing the barred owl threat, the Service agrees with scientific experts that it is necessary to conserve the highest value spotted owl habitat to address the key threats. The 2008 Recovery Plan recommended establishing Managed Owl Conservation Areas (MOCAs) on Federal lands to provide the important habitat needed for the species to recover over the long-term. The Service is not making this recommendation in this Revised Recovery Plan. Instead, we rely on the habitat conservation network of the NWFP, in addition to other habitat conservation recommendations contained within this Revised Recovery Plan. In addition, we have completed a range-wide, multi-step habitat modeling tool, described in Appendix C, that will help evaluate and inform the Service's designation of critical habitat, and the development of future land management plans by Federal land managers, and the consideration of management options by State, Tribal, or private landowners as recommended by this Revised Recovery Plan.

In addition, given the continued decline of the species, the apparent increase in severity of the threat from barred owls, and information indicating a recent loss of genetic diversity for the species, this Revised Recovery Plan also recommends retaining more occupied spotted owl sites and unoccupied, high value spotted owl habitat on all lands. Vegetation management actions that may have short-term impacts but are potentially beneficial to occupied spotted owl sites in the long-term meet the goals of ecosystem conservation. Such actions may include silvicultural treatments that promote ecological restoration and are expected to reduce future losses of spotted owl habitat and improve overall forest ecosystem resilience to climate change, which should result in more habitat retained on the landscape for longer periods of time.

In the more disturbance-prone provinces on the east side of the Cascade Mountains and in the Klamath Province, the Dry Forest Landscape and Klamath Province Work Groups (these are recovery implementation teams established as recommended by the 2008 Recovery Plan) are working to develop strategies that incorporate the dynamic natural disturbance regime in a manner that provides for long-term ecological sustainability through the restoration of ecological processes while conserving spotted owl habitat over the long-term. Some land management units, such as the Okanagan-Wenatchee National Forest, have published such strategies (USDA 2010).

II. RECOVERY GOAL, OBJECTIVES, CRITERIA, AND STRATEGY

Recovery Goal

The long-term goal of this recovery plan is to improve the status of the spotted owl so it can be removed from protection under the ESA.

Recovery Objectives

The objectives of this Revised Recovery Plan are:

1. Spotted owl populations are sufficiently large and distributed such that the species no longer requires listing under the ESA;
2. Adequate habitat is available for spotted owls and will continue to exist to allow the species to survive without the protection of the ESA; and
3. The effects of threats have been reduced or eliminated such that spotted owl populations are stable or increasing and spotted owls are unlikely to become threatened again in the foreseeable future.

Recovery Criteria

There are four recovery criteria in this Revised Recovery Plan. Recovery criteria are measurable, achievable goals that we believe will result from implementation of the recovery actions in this Revised Recovery Plan. Achievement of these criteria will take time and is intended to be measured over the life of the plan, not on a short-term basis and should not be considered near-term recommendations. This plan is designed to meet these criteria at which time the Service will make a decision about whether to propose delisting the spotted owl. Not all recovery actions need to be implemented and not all recovery criteria need to be fully achieved for the Service to consider delisting.

Recovery Criterion 1 - Stable Population Trend: The overall population trend of spotted owls throughout the range is stable or increasing over 10 years, as measured by a statistically-reliable monitoring effort.

Recovery Criterion 2 – Adequate Population Distribution: Spotted owl subpopulations within each province (*i.e.*, recovery unit) (excluding the Willamette Valley Province) achieve viability, as informed by the HexSim population model or some other appropriate quantitative measure.

Recovery Criterion 3 – Continued Maintenance and Recruitment of Spotted Owl Habitat: The future range-wide trend in spotted owl nesting/roosting and foraging (NRF) habitat is stable or increasing throughout the range, from the date of Revised Recovery Plan approval, as measured by effectiveness monitoring efforts or other reliable habitat monitoring programs.

Recovery Criterion 4 – Post-delisting Monitoring: To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation within the States of Washington, Oregon, and California (as required by section 4(g)(1) of the ESA).

Recovery Strategy

Currently, the most important range-wide threats to the spotted owl are competition with barred owls, ongoing loss of spotted owl habitat as a result of timber harvest, loss or modification of habitat from uncharacteristic wildfire, and loss of amount and distribution of spotted owl habitat as a result of past activities and disturbances. To address these threats, this recovery strategy includes five basic steps:

1. Development of a range-wide habitat modeling framework;
2. Barred owl management;
3. Monitoring and research;
4. Adaptive management; and
5. Habitat conservation and active forest restoration.

These five steps are described in detail below.

Development of Range-wide Habitat Modeling Framework

The first step in this recovery strategy is to develop a state-of-the-science modeling framework for evaluating spotted owl habitat and populations. Scientific peer reviewers were critical of the 2008 Recovery Plan's MOCA reserve strategy and the general lack of updated habitat modeling capacity. The Service agreed with this concern; the MOCA recommendation is not contained in this Revised Recovery Plan.

When listed as threatened in 1990 (USFWS 1990), habitat loss and fragmentation of old-growth forest were identified as major factors contributing to declines in spotted owl populations. As older forest became reduced to smaller and more isolated patches, the ability of spotted owls to successfully disperse and establish territories was reduced (Lamberson *et al.* 1992). Lamberson *et al.* (1992) identified that there appeared to be a sharp threshold in the amount of habitat below which spotted owl population viability plummeted. In order to promote spotted owl recovery, earlier plans including the 1992 Draft Recovery Plan for the Northern Spotted Owl (USFWS 1992) and the Northwest Forest Plan (USDA and USDI 1994) established spotted owl habitat reserve networks to promote species recovery. The goal of these conservation reserves was to achieve a high likelihood of long-term persistence while minimizing impacts on resources with economic value. For territorial species such as the spotted owl, Lamberson *et al.* (1994) concluded that size, spacing and shape of reserved areas all had strong influence on population persistence, and reserves that could support a minimum of 20 spotted owl territories were more likely to maintain spotted owl populations than smaller reserves. They also found that juvenile dispersal was facilitated in areas large enough to support at least 20 spotted owl territories. In addition to size, spacing between reserves had a strong influence on successful dispersal (Lamberson *et al.* 1992). Forsman *et al.* (2002) reported dispersal distances of 1,475 spotted owls in Oregon and Washington for 1985–1996. Median maximum dispersal distance (the straight-line distance between the natal site and the farthest location) for radio-marked juvenile male spotted owls was 12.7 miles, and that of female spotted owls was 17.2 miles (Forsman *et al.* 2002: Table 2). Dispersal data and other studies on the amount and configuration of habitat necessary to sustain spotted owls provided the foundation for developing previous spotted owl habitat reserve systems.

Although we are not recommending a new habitat conservation network, we recommend utilizing the best available information, including modeling data, to evaluate and refine such a network that will continue to support the recovery of the spotted owl. The NWFP currently provides a network of reserve land use allocations that protects habitat for late-successional forest species, including the demographic and dispersal needs of the spotted owl. Anthony *et al.* (2006) and Forsman *et al.* (2011) have reported that demographic rates for spotted owls on long-term Federal monitoring areas that contained late-successional reserves were higher than those from other long-term study areas. We believe a habitat conservation network designed using the best available science is necessary to recover the spotted owl. The NWFP reserve network, in addition to other habitat conservation recommendations in this Revised Recovery Plan (*e.g.*, Recovery Actions 10, 32 and 6), meets that need in the near term until the Forest Service and BLM revise their respective management plans. We recommend that any future revisions in Federal land management plans take into account the need for appropriately spaced, large habitat conservation areas for spotted owls. The upcoming critical habitat revision process will help identify whether any additional areas or adjustments to that network are warranted.

Therefore, we recommend continued application of the reserve network of the NWFP until the 2008 designated spotted owl critical habitat is revised and/or the land management agencies amend their land management plans taking into account the guidance in this Revised Recovery Plan. We have developed a modeling framework that can provide information for numerous spotted owl recovery actions and management decisions, including revisions to the spotted owl critical habitat designation. This spatially-explicit modeling effort is designed to allow for a more in-depth evaluation of various habitat features that affect the distribution of spotted owl territories and the factors influencing spotted owl populations. Different land management scenarios can then be evaluated for their relative potential contribution to spotted owl recovery. This modeling effort is described in detail in Appendix C. The Service hopes this modeling framework or similar approaches will be used by Federal, State, and private scientists to make better informed decisions concerning what areas should be conserved for spotted owls.

Barred Owl Management

The second step in this recovery strategy is to move forward with a scientific evaluation of potential management options to reduce the impact of barred owls on spotted owls. Barred owls pose perhaps the most significant short-term threat to spotted owl recovery. This threat is better understood now than when the spotted owl was listed. Barred owls have reduced spotted owl site occupancy, reproduction, and survival. Because the abundance of barred owls continues to increase, effectively addressing this threat depends on initiating action as soon as possible. The recovery actions address research involving the competition between spotted and barred owls, experimental control of barred owls and, if recommended by research, management of barred owls. Discussion of the barred owl threat occurs throughout this document, especially in Listing Factor E and Appendix B.

Monitoring and Research

The third step in this recovery strategy is to continue implementing a robust monitoring and research program for the spotted owl. This Revised Recovery Plan recommends activities be implemented to track progress toward recovery, to inform changes in recovery actions by a process of adaptive management, and ultimately to help determine when delisting is appropriate. The following primary elements of this strategy will provide information required to evaluate progress toward the Recovery Criteria. The monitoring and research results can be considered within the 5-year review process which is required under the ESA.

Monitoring of Spotted Owl Population Trend

Currently, this monitoring is done within a network of demographic study areas, but it may be possible to monitor trends using other reliable methods. Recognizing that the demographic monitoring efforts are costly, it is recommended that, in the absence of another method that would provide reliable trend data at an improved cost-effectiveness, these existing studies should be continued while other methods are piloted and tested. The current demographic studies provide region-specific demographic data that provide the basis for many of the current and proposed studies of spotted owl ecology. Also, because monitoring in the demographic study areas has been ongoing for approximately two decades, the data from these efforts allow trend estimates in the near-term that would not be available for a considerable length of time if new methods were implemented.

A Comprehensive Effort of Barred Owl Research and Monitoring

This is needed to experimentally determine the effects of barred owls on spotted owls and to incorporate this information into management to reduce negative effects to a level that would promote spotted owl recovery.

Given the immediacy of the barred owl threat, the continuation of monitoring in the demographic study areas provides a timely opportunity to integrate barred owl removal experiments to assess any demographic response of spotted owls to removal of barred owls. Assessing the demographic response will help the Service determine whether the effects of this threat could be reduced or eliminated by a larger-scale control program.

Continued Habitat Monitoring

The Effectiveness Monitoring program initiated by the NWFP includes tracking the status and trends of spotted owl habitat (Davis and Lint 2005). This monitoring program will allow us to assess progress towards meeting **Recovery Criterion 3: Continued Maintenance and Recruitment of Spotted Owl Habitat** and help the Service determine whether the threat of habitat loss has been reduced or eliminated such that spotted owls are unlikely to become threatened again in the foreseeable future.

Inventory of Spotted Owl Distribution

The recovery of the spotted owl is predicated on maintaining the current rangewide distribution of the species within each of the 12 provinces (see Recovery Unit discussion). When trend data indicate that populations are stable or increasing in the provinces as specified in Recovery Criterion 1, sampling should also be considered to evaluate spotted owl distribution in all provinces.

Explicit Consideration for Climate Change Mitigation Goals Consistent with Spotted Owl Recovery Actions

There is significant overlap between many of the spotted owl recovery goals described in this Revised Recovery Plan and opportunities to mitigate impacts due to climate change. The Service is applying Secretarial Order No. 3289: *Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources* into our forest management activities. This Secretarial Order directs DOI agencies to analyze potential climate change impacts when undertaking long-range planning exercises, developing multi-year management plans, and making major decisions regarding potential use of resources under the Service's purview. This direction applies to this Revised

Recovery Plan, which includes a detailed treatment of climate change and its potential impact on spotted owl recovery.

Adaptive Management

Risk, Uncertainty and Changing Management

When writing a recovery plan, the Service must use the best scientific information available. However, the information available rarely addresses all of the questions at hand, meaning there is usually some degree of uncertainty. Hence, recovery plans include an element of risk management (especially for wide-ranging species which face a multitude of threats) because the Service must make recommendations and decisions in the face of incomplete information and uncertainty.

In the face of significant scientific uncertainty, we propose aggressive strategies to address the threats from habitat loss, barred owls and climate change. It is understood that this Revised Recovery Plan's expression of risk, as embodied by the recovery strategy and actions, may not match the risk tolerance of every interested party. However, it is the conclusion of the Service that the actions in this Revised Recovery Plan are necessary to achieve the plan's goal for the conservation and survival of the species.

In order to deal with uncertainty and risk the Service will employ an active program of adaptive management. Adaptive management includes identifying areas of uncertainty and risk, implementing a research and monitoring approach to clarify these areas, and making decisions to change management direction that is not working while still maintaining management flexibility (see Thomas *et al.* 1990, USFWS 1992b). Where possible, the implementation of the recovery actions included within this Revised Recovery Plan should be designed in a manner that provides feedback on the efficacy of management actions such that the design of future actions can be improved.

What is Adaptive Management?

Adaptive management is a systematic approach for improving resource management by learning from the results of explicit management policies and practices and applying that learning to future management decisions (Holling 1978, Walters 1986, Gregory *et al*. 2006). This tool is useful when there is substantial uncertainty about appropriate strategies for managing natural resources. Although adaptive management is a form of "learning by doing," its purposefulness and systematic approach distinguish it from learning by trial and error where management direction changes in the face of failed policies and actions (Stankey *et al*. 2005, Gregory *et al.* 2006). Bormann *et al.* (2007:187) provide a practical description of and purpose for adaptive management:

> "Adaptive management requires exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on what is known, implementing one—or if possible, more than one—of these alternatives, monitoring to learn which alternative best meets the management objectives, and then using results to update knowledge and adjust management actions. Adaptive management is not an end in itself, but a means to more effective decisions and enhanced benefits; thus, its true measure is in how well it helps meet environmental, social, and economic goals, adds to scientific knowledge, and reduces tensions among stakeholders."

Key components of adaptive management include: (1) treating management actions and policies as formal experiments that yield new information; (2) embracing risk and uncertainty as opportunities for learning; and (3) applying the knowledge gained from management experiments to subsequent actions (Holling 1978, Stankey *et al*. 2003, Stankey *et al.* 2005). We elaborate on each of these components below.

Treating management actions as experiments is a fundamental component of the adaptive management process. Key to this is clearly articulating questions about the effects of implementing management actions, formally re-casting these questions as testable hypotheses, implementing them as experiments to be tested, and monitoring the results. Yet this is often where the process fails. For example, in a critique of the NWFP adaptive management program, Stankey *et al*. (2003) found a major fault to be a predominant reliance on decision-making approaches that were informal and incremental, yet widely accepted as an adaptive management approach. Articulating measurable management objectives and forming them into explicit hypotheses that can be tested is what ultimately separates adaptive management from learning by trial and error.

The second key component in successfully implementing adaptive management, as identified above, requires embracing risk and uncertainty as opportunities for learning. The need for adaptive management is driven by the existing uncertainty surrounding appropriate management treatments and how ecosystems may respond to those treatments. A risk-averse mentality of not acting until more information is known may ultimately result in implementing ongoing, ineffectual policies that may not only further threaten resources of concern, but also suppress experimental actions that could provide learning to inform and improve future management. While there are costs and risks in applying experimental treatments, failing to experiment also carries costs and risks (Wildavsky 1988, as cited in Stankey *et al*. 2003). As Stankey *et al*. (2003:45) noted, "The irony here is that while continuation of policies that have not worked seems to ensure continued failure, undertaking actions where outcomes are uncertain is resisted because of the inability to ensure that unwanted effects will not result." Testing clearly formed hypotheses in a systematic manner under identifiable, bounded settings and monitoring the outcomes will go far in improving future management and developing more resilient policies while minimizing risk to resources.

The knowledge gained from testing hypotheses must be documented and applied to future actions if learning is to happen and if the policy or decision-making process is to be informed and improved. Thus, it is vital that the question asked as part of the experiment is relevant to managers. To speed the pace of learning, Williams *et al.* (2009) recommend that alternative management options be applied and tested, and that these options are sufficiently different to produce observable responses that can be detected by monitoring.

Goals and Steps in an Adaptive Management Process for the Spotted Owl

The overarching purpose of implementing adaptive management for spotted owl recovery is to reduce key scientific uncertainties with respect to spotted owl management and recovery and apply that knowledge to future spotted owl management decisions. An adaptive management program must deliver biological and ecological information relevant to spotted owl recovery; key objectives to facilitate this need are:

1. Identify and fill key gaps in our knowledge base
2. Improve our understanding of ecosystem responses, thresholds and dynamics
3. Learn about the effectiveness of alternate management policies and activities
4. Document and disseminate the knowledge gained so that it is available in future management

Several sources of information are available that outline steps in designing and implementing adaptive management programs (Williams *et al.* 2009, BCMFR undated). Typical steps in adaptive management include:

1. Assess and define the problem – including defining measurable management objectives and potential management treatments, along with key indicators and projected responses for each objective.

2. Design the management treatment and monitoring plan – including clarifying response thresholds that will trigger management adjustments, and identifying which management adjustments are needed.

3. Implement the management treatment and monitoring program – including documenting any deviation from the plan.

4. Monitor treatment implementation and results following the protocol designed in Step 2.

5. Evaluate results – including comparing outcomes to forecasts made in Step 1, as well as communicating results to others facing similar management issues.

6. Adjust or revise hypothesis and management as necessary – including identifying where uncertainties have been reduced and where they remain unresolved, as well as adjusting the model used to predict outcomes developed in Step 1 so that it reflects the hypothesis supported by the results.

The Service encourages existing recovery plan work groups to develop Steps 1 and 2 in the above adaptive management steps for problems relevant to their chartered tasks. Developing a clearly articulated problem and objective statement, combined with an implementation and monitoring plan, will provide an adaptive management framework that allows us to learn from future management activities. Work groups will forward frameworks to the Service for presentation to the Regional Interagency Executive Committee for consideration at the executive level under the existing Northwest Forest Plan process. The Service will work with these agencies to look for opportunities to implement Steps 3 through 6 of the above adaptive management steps consistent with the framework developed under Steps 1 and 2.

Below is a list of potential questions that may drive development of an adaptive management framework. It is not meant to be comprehensive, nor is it necessarily a prioritized list. Further articulation of these questions may be needed to develop frameworks that will be most informative. Additional questions are expected to arise as the Revised Recovery Plan is implemented. For example, results gleaned from Recovery Action 8, as well as implementation of the modeling process described in Appendix C, are expected to provide additional questions for adaptive management.

Questions that may for consideration under adaptive management include:

- What vegetation management treatments best accelerate the development of forest structure associated with spotted owl habitat functions while maintaining or restoring natural disturbance and provide greater ecosystem resiliency? What are the effects of these vegetation management treatments on spotted owl occupancy, demography, and habitat use immediately following treatment and at specified time periods after treatment? What are the effects of these treatments on spotted owl prey abundance and availability immediately following treatments and at specified time periods after treatment? What are the effects of the above vegetation management treatments on the habitat components that spotted owls and their prey use? How effective are these vegetation management treatments in developing desired forest structure and how long does this development take?
- What are the effects of wildland and prescribed fire on the structural elements of spotted owl habitat (compare burned and unburned areas, as well as different fire severities)? What are the effects on spotted owl habitat use? What are the effects of these fires on abundance of spotted owl prey? How does the scale of high severity burn patches affect foraging use by spotted owls? How does the

pattern and distribution of burned and unburned patches, or patches of differing burn severities, affect spotted owl use for foraging, roosting, and nesting?

- Can strategically-placed restoration treatments be used to reduce the risk of spotted owl habitat being burned by high severity fire within dry forest ecosystems?
- What are the effects of epidemic forest insect outbreaks on spotted owl occupancy and habitat use immediately following the event and at specified time periods after treatment?
- What is the nature of the competitive interaction between spotted and barred owls, and how might those interactions be managed in terms of direct intervention (*e.g.,* barred owl control) or indirectly through habitat management (*e.g.,* vegetation management treatments)?

Habitat Conservation and Active Forest Restoration

The fifth component of this recovery strategy is derived from the stated purpose of the ESA: "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." Consistent with this purpose, it is the Service's goal that this spotted owl recovery strategy be embedded within -- and be consistent with -- a broader framework of conservation of forest ecosystems for the Pacific Northwest. This approach will provide more resilient forested habitat in the face of climate change and other stressors, thereby conserving more spotted owl habitat on the landscape for longer periods of time. Species-specific needs of the spotted owl should not be the sole determinant of landscape management decisions. Rather, spotted owl recovery objectives should fit within a broader strategy whose goals include the conservation of the full assemblage of species and ecological processes in that landscape so that it will be more resilient to future losses of spotted owl habitat or ecosystem change resulting from climate change and other disturbances.

The NWFP was developed to meet this goal for spotted owls and many other late-successional forest species. It continues to provide the basic landscape conservation framework for Federal lands in the range of the spotted owl (Noon and Blakesley 2006, Strittholt *et al.* 2006, Spies *et al.* 2010a,b), and the recommendations in this Revised Recovery Plan affirm and build upon the scientific principles of the NWFP. These principles include managing for the maintenance of ecological processes and applying adaptive management strategies to gain new scientific insight (FEMAT 1993, pg. VIII-5).

Although spotted owl recovery still relies heavily upon the principles of the NWFP as its foundation, there have been several significant developments that affect spotted owl recovery since the NWFP was first implemented 17 years ago. These include:

- *The continued decline of the spotted owl populations and low occupancy rates in large habitat reserves, and the growing negative impact from barred owl invasions of spotted owl habitats* (Forsman *et al.* 2011, Dugger *et al.* in press), *which is greater than anticipated in the NWFP*. We recommend increased conservation and restoration of spotted owl sites and high-value spotted owl habitat to help ameliorate this impact.
- *Climate change combined with effects of past management practices are exacerbating changes in forest ecosystem processes and dynamics, including patterns of wildfires, insect outbreaks and disease, to a degree greater than anticipated in the NWFP* (Perry *et al*. 2011). Land managers need to consider this uncertainty and how best to integrate knowledge of management-induced landscape pattern and disturbance regime changes with climate change when making spotted owl management decisions.
- *Scientific principles of forest management continue to evolve since implementation of the NWFP. "Ecological forestry," "natural disturbance-based management," "resilience management" and other related perspectives have emerged as accepted forest management approaches* (Long 2009, Moritz *et al.* 2011). We recommend spotted owl management decisions be implemented within a broader landscape approach based on the conservation of natural ecological patterns and processes.

These issues are not mutually exclusive, and spotted owl recovery depends on the integration of all three. Extant, high-quality spotted owl habitat must be managed, restored, and conserved in the face of a declining population and the potential threats from barred owls. Active, restoration-focused management to address climate change and dynamic ecosystem processes is also necessary in many areas, with the goal of maintaining or restoring forest ecosystem structure, composition and processes so they are sustainable and resilient under current and future climate conditions. Each of these issues is described in more detail below, and site-specific recommendations addressing these issues are contained in various recovery actions later in this Revised Recovery Plan.

This Recovery Strategy requires action in the face of uncertainty. We agree with Carey (2007, pg. 345, 349): "(A)ctive management for ecological values trades short-term negative effects for long-term gains…Collaborative management must be willing to accept short-term impacts and short-term risks to achieve long-term benefits and long-term risk reduction; overly zealous application of the precautionary principle often is a deliberate, conscious management decision to forego long-term increases in forest health and resilience to avoid short-term responsibility or controversy."

In other words, land managers should not be so conservative that, to avoid risk, they forego actions that are necessary to conserve the forest ecosystems that are necessary to the long-term conservation of the spotted owl. But they should also not be so aggressive that they subject spotted owls and their habitat to treatments where the long-term benefits do not clearly outweigh the short-term risks. Finding the appropriate balance to this dichotomy will remain an ongoing challenge for all who are engaged in spotted owl conservation. All Federal actions will be subject to section 7 consultation allowing for site-specific analyses of the effect on spotted owls.

If carefully applied, we believe this Recovery Strategy and the recommendations in this Revised Recovery Plan will recover the spotted owl and sustain its recovery in the long-term by conserving the ecosystem upon which it relies. We also believe this approach is a land management perspective that is embraced by most forest ecologists and biologists and is well published in the scientific literature. It builds on what is already occurring in parts of the Pacific Northwest (see USDA 2010 and Gaines *et al.* 2010) and is consistent with the basic tenets of the NWFP. It provides opportunities for land managers to address multiple management goals in an integrated fashion, including recovery of the spotted owl, conservation of other fish and wildlife species, habitat restoration, fuels management, and timber production. It may also provide a common ground where adversarial stakeholders in the forest management debate can find some agreement and move forward.

III. Recovery Units, Criteria, and Actions

Recovery Units

Unlike previous versions of the spotted owl recovery plan, this Revised Recovery Plan identifies discrete recovery units throughout the entire range of the spotted owl such that each unit provides an essential survival and recovery function for the species. Recovery units defined on this basis are useful for purposes of managing the species and for applying the jeopardy standard under section 7 of the ESA to proposed Federal actions (USFWS and NMFS 1998, NMFS and USFWS 2010). When a proposed Federal action is likely to impair or preclude the capacity of a recovery unit to provide both the survival and recovery function it provides, that action may represent jeopardy to the species, provided the analysis describes not only how the action affects the recovery unit's capability but also the relationship of the recovery unit to both the survival and recovery of the listed species as a whole (NMFS and USFWS 2010).

In this Revised Recovery Plan, recovery units differ from management units, and are also not synonymous with critical habitat units; the former is a unit of the listed species, the latter is a unit of the species' habitat.

The recovery units defined in this Revised Recovery Plan are intended to assist managers in re-establishing or maintaining: (1) historical or current genetic flow between spotted owl populations; (2) current and historic spotted owl population and habitat distribution; and (3) spotted owl meta-population dynamics. Because the recovery units are defined on a biological basis, the recovery criteria for the spotted owl address each identified recovery unit.

In 1990, the Interagency Scientific Committee decided to subdivide the range of the spotted owl into "smaller areas for practical and analytical purposes" and used the physiographic provinces as a basis for their analysis (Thomas *et al.* 1990: 61). The physiographic provinces (also referred to as "provinces") incorporate physical, biological and environmental factors that shape broad-scale landscapes. The provinces reflect differences in geology (*e.g.*, uplift rates, recent volcanism, tectonic disruption) and climate (*e.g.*, precipitation, temperature, glaciation). In turn, these factors result in broad-scale differences in soil development, natural plant communities and ultimately, forest zones. Studies have demonstrated biological differences in the numbers, distribution, habitat use patterns, and prey of spotted owls relative to the different forest zones that occur within its range (Thomas *et al.* 1990). The Northern Spotted Owl Recovery Team (USFWS 1992b) divided the range of the spotted owl into 12 provinces based on differences in vegetation, soils, geologic history, climate, land ownership and political boundaries.

Given the above definitions and background information, the physiographic provinces meet the criteria for use as recovery units (see Figure A-1 in Appendix

A). The provinces collectively cover the range of the species, and each is essential for the conservation of the spotted owl (Thomas *et al.* 1990). The provinces are based on physical, biological and environmental factors that affect spotted owl numbers, distribution, habitat use patterns, habitat conditions, and prey species abundance. These provinces have been scientifically accepted, have been in use since 1990, and are integrated into management regimes and administrative purposes. In addition, most of the physiographic provinces contain long-term monitoring areas for the spotted owl, which yield robust scientific information to assess population dynamics and trends within each area and provide a good basis for analysis at recovery-unit and range-wide scales. Their long-standing monitoring information, biological basis and accepted use by managers should lead to an efficient transition to their adoption as recovery units. Using this rationale, we are proposing to adopt the physiographic province designations in place since 1990 as recovery units, with the exception of the Willamette Valley province, which is comprised largely of non-habitat for the spotted owl.

Recovery Criteria

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the ESA are no longer necessary and the species may be delisted. However, meeting all or most of the recovery criteria does not automatically result in delisting, and does not meeting all criteria preclude delisting. A change in status (downlisting or delisting) requires a separate rule-making process based on an analysis of the same five factors (referred to as the listing factors) considered in the listing of a species, as described in section 4(a)(1) of the ESA. These include:

A. The present or threatened destruction, modification, or curtailment of its habitat or range;
B. Overutilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. The inadequacy of existing regulatory mechanisms; and
E. Other natural or manmade factors affecting its continued existence.

Recovery criteria in this Revised Recovery Plan represent our best assessment of the conditions that may result in a determination in a 5-year review that delisting the spotted owl is warranted, which we would follow by a formal regulatory rule-making process to delist the species. Recovery actions are the Service's recommendations to guide the activities needed to accomplish the recovery criteria. Ultimately, a positive response by spotted owl populations to the recovery actions will mean recovery is occurring. Such a positive response will be measured in accordance with the population-related recovery criterion.

When the Service listed the spotted owl, we identified population decline, small population size, and related demographic conditions as threats. In the current assessment, these conditions were viewed as results of other threats and not threats *per se*. However, recovery actions are identified here that are intended to address and ameliorate such demographic conditions and address the key threats to the species. Recovery criteria are measurable and achievable goals that we believe will result from implementation of the recovery actions in this Revised Recovery Plan. Achievement of these criteria will take time and is intended to be measured over the life of the plan, not on a short-term basis.

Recovery Criterion 1 - Stable Population Trend: The overall population trend of spotted owls throughout the range is stable or increasing over 10 years, as measured by a statistically-reliable monitoring effort.

Recovery Criterion 2 – Adequate Population Distribution: Spotted owl subpopulations within each province (*i.e.*, recovery unit) (excluding the Willamette Valley Province) achieve viability, as measured by the HexSim population model or some other appropriate quantitative measure.

Recovery Criterion 3 – Continued Maintenance and Recruitment of Spotted Owl Habitat: The future range-wide trend in spotted owl nesting, roosting, foraging habitat is stable or increasing throughout the range, from the date of Revised Recovery Plan approval, as measured by effectiveness monitoring efforts or other reliable habitat-monitoring programs.

Recovery Criterion 4 – Post-delisting Monitoring: To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation within the States of Washington, Oregon, and California (as required by section 4(g)(1) of the ESA).

Recovery Actions

In this Revised Recovery Plan, we have retained some of the original recovery actions from the 2008 Recovery Plan, introduced some new recovery actions, and revised some from the 2008 Recovery Plan to reflect new information, and updated status, in order to clarify our intent or respond to public comments. Generally, recovery actions follow the order of the listing factors. However, the first recovery action pertaining to implementation of this Revised Recovery Plan and Recovery Actions 2-4, which address Recovery Criterion 1, do not fit into any of the listing factors and so are presented first. The first recovery criterion assesses the spotted owl's population status. The Service believes this criterion is the best way to assess whether the five listing factors—that is, the threats facing the spotted owl—are addressed. For a more complete description of the threats to the spotted owl addressed by these recovery actions, see Appendix B.

Northern Spotted Owl Recovery Implementation Oversight

This Recovery Action pertains to all listing factors.

- ***Recovery Action 1: For each State, the FWS will designate offices that will coordinate implementation of the spotted owl recovery plan. These offices will work with local and regional partners to best ensure actions taken within that management jurisdiction are meeting the intention of the recovery plan while taking local context and variation into account. The Oregon Fish and Wildlife Office will remain the overall lead for the species and provide technical assistance and oversight to the other FWS offices as needed.*** We have established and lead an interagency and inter-organizational Northern Spotted Owl Implementation Team (NSOIT) designed to help coordinate implementation of this Revised Recovery Plan throughout the range of the species.

Monitoring and Inventory

These Recovery Actions also pertain to all listing factors.

- ***Recovery Action 2: Continue annual monitoring of the population trend of spotted owls to determine if the population is decreasing, stationary or increasing.*** Monitoring in demographic study areas is currently the primary method to assess the status of populations of spotted owls. Other statistically valid monitoring methods (*i.e.*, analytically robust and representative of the entire province and range) may be possible and could potentially fulfill this recovery action.

- ***Recovery Action 3: Conduct occupancy inventory or predictive modeling needed to determine if Recovery Criteria 1 and 2 have been met.*** It is expected this inventory will begin when it appears the spotted owl is close to meeting Recovery Criterion 1. Modeling techniques have improved recently, so predictive modeling may be part of the methodology for estimating spotted owl occupancy across the range.

LISTING FACTOR A: THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF THE SPECIES' HABITAT OR RANGE.

The key threats identified that relate to this listing factor are: (1) loss of habitat and changes in distribution of habitat as a result of past activities and disturbances, due especially to timber harvest and permanent conversion of habitat; and (2) ongoing habitat loss from natural disturbance (especially fire), timber harvest, and permanent conversion of habitat (see Appendix B).

Therefore, this Revised Recovery Plan recommends two basic strategies to address these threats: (1) conserve more occupied habitat and unoccupied high-value habitat; and (2) encourage and initiate active management actions that restore, enhance, and promote development of high value habitat, consistent with broader ecological restoration goals.

- ***Recovery Action 4: Use the habitat modeling process described above and in Appendix C to identify and implement recovery actions and conservation measures that would contribute to spotted owl recovery, including testing the efficacy of various habitat conservation network scenarios at conserving spotted owl habitat. Use the results from this effort to inform decisions concerning the possible development of habitat conservation networks.***

The following discussion provides the background and justification for the various recovery actions that address Listing Factor A. First, it is important to understand the potential changes in spotted owl habitat conditions and landscape ecological processes due to ongoing climate change. These changes are occurring throughout the spotted owl's range but are currently most serious in the drier portions of the range, and they affect both the species' habitat and its distribution. Second, we address emerging scientific principles of forestry science and "ecological forestry," and how forest scientists are trying to manage spotted owl habitat for resiliency and uncertainty in the face of climate change. And third, we discuss how the science of spotted owl recovery can fit within and be compatible with the broader forest ecosystem science and strategies that land managers are applying in order to be make spotted owl conservation efforts sustainable into the future. These strategies differ from moist forests to dry forest, and on Federal land versus private lands. Specific recovery actions are presented in the context of the relevant sections where management issues are discussed.

Climate Change and Forest Ecosystems

Climate change, combined with effects from past management practices, is exacerbating changes in forest ecosystem processes and dynamics to a greater degree than originally anticipated in the NWFP. This includes patterns of wildfire, insect outbreaks, drought, and disease. Many researchers believe there is a need to manage forests within an increasingly dynamic and unpredictable future that is driven by climate change (Perera *et al.* 2004, Millar *et al.* 2007, Kurz *et al.* 2008, Heyerdahl *et al.* 2008, Blate *et al.* 2009, Kennedy and Wimberly 2009, Krawchuk *et al.* 2009, Littell *et al.* 2008, 2009, 2010, Reinhardt *et al.* 2008, Johnson and Franklin 2009, Mitchell *et al.* 2009, Spies *et al.* 2010a,b). The preponderance of recent scientific research and opinion on climate change has coalesced around several key points concerning temperature, precipitation, wildfire, and insect and disease outbreaks.

Temperature and Precipitation

In the Pacific Northwest, mean annual temperatures rose 0.8° C (1.5° F) in the 20th century and are expected to continue to warm from 0.1° to 0.6° C (0.2 ° to 1 ° F) per decade (Mote and Salathe 2010). Global climate models project an increase of 1 to 2 percent in annual average precipitation, with some predicting wetter autumns and winters with drier summers (Mote and Salathe 2010). University of Washington researchers (Salathe *et al.* 2009) have developed finer-resolution, regional, predictive climate models that account for local terrain and other factors that affect weather (*e.g.*, snow cover, cloudiness, soil moisture, and circulation patterns) in the Pacific Northwest. These models agree with the global climate models in projecting warmer, drier summers and warmer, wetter autumns and winters for the Pacific Northwest, which will result in diminished snowpack, earlier snowmelt, and an increase in extreme heat waves and precipitation events.

On the cooler, moister west side of the Cascades, the summer water deficit is projected to increase two- to three-fold over current conditions (Littell 2009). East of the Cascade Crest, summer soil deficits may not change as much or may even moderate slightly over current conditions (Elsner *et al.* 2009). Researchers expect some ecosystems to become more water-limited, more sensitive to variability in temperature, and more prone to disturbance (McKenzie *et al.* 2009). There is evidence that the productivity of many high-elevation forests, where low summer temperature and winter snowpack limits the length of the growing season, is increasing in the Pacific Northwest as temperatures rise, potentially increasing the elevation of the tree line (Graumlich *et al.* 1989, Case and Peterson 2009). Conversely, productivity and tree growth in many low-elevation Pacific Northwest forests is likely to decrease due to the longer, warmer summers (Case and Peterson 2009). This may result in a change in species composition or reduction in the acreage of existing low-elevation forests.

Wildfire

Wildfire size and frequency have been increasing in the dry, fire prone forests of the western U.S. as a result of changing climatic conditions and past management activities (Westerling *et al.* 2006, Heyerdahl *et al.* 2008, Reinhardt *et al.* 2008, Wiedinmyer and Hurteau 2010, Spies *et al.* 2010a), although some researchers have suggested finer scale exceptions to this general pattern (Odion *et al.* 2004, Heyerdahl *et al.* 2008, Krawchuk *et al.* 2009, Hanson *et al.* 2009, 2010). According to Schafer *et al.* (2010), "An increase in fire activity is expected for *all* major forest types in Oregon" (emphasis original), and areas burned by fire in the Pacific Northwest are likely to increase substantially in the coming century (Hessburg *et al.* 2005, 2007, Kennedy and Wimberly 2009, Littell *et al.* 2009, 2010, Shafer *et al.* 2010).

Natural landscape resilience mechanisms have been decoupled by fire exclusion and wildfire suppression activities (Hessburg *et al.* 2005, Moritz *et al.* 2011).

Before the era of management, patchworks of burned and recovering vegetation, caused by mostly small and medium-sized fires, reduced the likelihood of the largest fires, which usually resulted from extreme weather events. Twentieth-century fire suppression eliminated most of these fires, and forest landscapes are now susceptible to large wildfires.

Stand-replacing events and disturbances will speed up ecological "conversions" (*e.g.*, forests to shrublands) (Joyce *et al.* 2008, Blate *et al.* 2009, Littell *et al.* 2010). Dry forests are at greater risk to large scale disturbances (Agee and Skinner 2005, Mitchell *et al.* 2009), but recent research suggests "that large disturbances are likely in west-side forests that have not traditionally been thought of as fire prone," and "it is therefore reasonable to expect increased fire activity" in such forests (Littell *et al.* 2010). Dry forests are treated in greater detail later in this section.

Older forests in the range of the spotted owl are being lost due to fire (Spies *et al.* 2006, 2010b, Ager *et al.* 2007a, Clark 2007, Healey *et al.* 2008, Kennedy and Wimberly 2009, Hanson *et al.* 2009, 2010), especially east of the Cascades and in the Klamath Province. However, some patches of habitat may be more resistant to climate change effects than others. A study on the east side of the Cascade Mountains found that areas of high soil and fuel moisture had historically created fire refugia where late-successional forest persisted longer (Camp *et al.* 1997). These patches were often near streams or valley bottoms, had perched water tables, or were near headwalls where soil moisture was higher. They were also often at higher elevations where total precipitation was higher or on northern aspects of mountains where terrain was shaded longer. Daley *et al.* (2009) found that cold air pooling in some mountain valleys may decouple or shelter the local microclimate from regional climate conditions. These studies imply that some areas on the landscape may resist climate-driven disturbances that may affect spotted owls and their habitat.

Insect and Disease Outbreaks

Climate change is affecting the location, size and intensity of insect outbreaks, which in turn affect fire and other forest processes (Joyce *et al.* 2008, Kurz *et al.* 2008, Littell *et al.* 2009, 2010, Latta *et al.* 2010, Spies *et al.* 2010a). Warming temperatures have led to mountain pine beetle outbreaks, with large-scale effects in some western forests, including in the eastern Cascades. In warmer winters more mountain pine beetles survive and shorten their generation time, resulting in larger and more severe outbreaks. Drought can heighten the susceptibility of host trees to attack (Littell *et al.* 2010). Littell *et al.* (2010) suggest that the greatest likelihood of mountain pine beetle attack is when conditions are hot and dry combined with a fairly short period of extreme vapor pressure deficit, when trees are most vulnerable. In the future, outbreaks are projected to increase at higher elevations and decrease at lower elevations (Littell *et al.* 2010), with uncertain implications for spotted owls. Littell *et al.* (2010) have projected that the combination of increased tree susceptibility and mountain pine beetle outbreaks could lead to the loss of pine species in the eastern Cascades as early as the 2040s.

Mixed conifer stands in the eastern Cascades, which include pine species, provide den sites and food resources for bushy-tailed woodrats, an important prey species of spotted owls (Lehmkuhl *et al.* 2006a). Warmer winters have also been shown to increase the incidence of Swiss needle cast, a fungal disease in Douglas-fir on the Oregon coast (Manter *et al.* 2005) inhibiting tree growth, and causing severe chlorosis and defoliation. We are uncertain how significantly this will affect spotted owl habitat.

Effects of Weather and Climate on Spotted Owl Demography

The influence of weather and climate on spotted owl populations was evidenced in northern California (Franklin *et al.* 2000), Oregon, and Washington (Glenn 2009). Climate accounted for 84 and 78 percent of the temporal variation in population change of spotted owls in the Tyee and Oregon Coast Range study areas, respectively (Glenn 2009). Climate and barred owls together accounted for nearly all (~100 percent) of the changes in spotted owl survival in the Oregon Coast Range (Glenn 2009).

Wet, cold weather during the winter or nesting season, particularly the early nesting season, has been shown to negatively affect spotted owl reproduction (Olson *et al.* 2004, Dugger *et al.* 2005), survival (Franklin *et al.* 2000, Olson *et al.* 2004, Glenn 2009), and recruitment (Franklin *et al.* 2000). Cold, wet weather may reduce reproduction and/or survival during the breeding season due to declines or decreased activity in small mammal populations so that less food is available during reproduction when metabolic demands are high (Glenn 2009). Wet, cold springs or intense storms during this time may reduce the time it takes for an adult bird to starve (Franklin *et al.* 2000). Cold, wet weather may also inhibit the male spotted owl's ability to bring food to incubating females or nestlings (Franklin *et al.* 2000). Cold, wet nesting seasons may increase the mortality of nestlings due to chilling (Franklin *et al.* 2000) and reduce the number of young fledged per pair per year (Franklin *et al.* 2000, Glenn 2009). Wet, cold weather may decrease survival of dispersing juveniles during their first winter thereby reducing recruitment (Franklin *et al.* 2000).

Drought or hot temperatures during the previous summer have also reduced spotted owl recruitment and survival (Franklin *et al.* 2000, Glenn 2009). Drier, warmer summers and drought conditions during the growing season strongly influence primary production in forests, food availability, and the population sizes of small mammals (Glenn 2009). Northern flying squirrels, for example, forage primarily on ectomycorrhizal fungi (truffles), many of which grow better under mesic, or moist, conditions (Lehmkuhl *et al.* 2004). Drier, warmer summers, or the high-intensity fires, which such conditions support, may change the range or availability of these fungi, affecting northern flying squirrels and the spotted owls that prey on them. Periods of drought are associated with declines in annual survival rates for other raptors due to a presumed decrease in prey availability (Glenn 2009).

Survival, recruitment, and reproduction increased with precipitation in the late spring or summer (Olson *et al.* 2004, Glenn 2009). Olson *et al.* (2004) found that while survival decreased with early-nesting season precipitation, it increased with late-nesting season precipitation. This is probably due to reducing the potential for drought to occur.

In addition to effects on habitat, the heat itself may have physiological effects on spotted owls. Weathers *et al.* (2001) suggest California spotted owls (*Strix occidentalis occidentalis*) are less heat-tolerant than other owls responding to temperatures of 30 to 34 ^{o} C (86 ^{o}– 93 ^{o} F) with increased breathing rates, fluffing of feathers, and wing drooping. Northern spotted owls in an earlier study (Barrows 1981) showed signs of heat stress at even more modest temperatures of 27 to 31 ^{o} C (81 ^{o}–88 ^{o} F). We have no current information on how this affects survival or reproduction.

The presence of high-quality habitat appears to buffer the negative effects of cold, wet springs and winters on survival of spotted owls as well as ameliorate the effects of heat. High-quality spotted owl habitat was defined in a northern California study area as a mature or old growth core within a mosaic of different seral stages (Franklin *et al.* 2000). The high-quality habitat might help maintain a stable prey base, thereby reducing the cost of foraging during the early breeding season when energetic needs are high (Carey *et al.* 1992, Franklin *et al.* 2000).

Barred Owls, Spotted Owls, and Climate Change

Although the scientific literature has explored the link between climate change and the invasion by barred owls, changing climate alone is unlikely to have caused the invasion (Livezey 2009b). In general, climate change can increase the success of introduced or invasive species in colonizing new territory (Dale *et al.* 2001). Invasive animal species are more likely to be generalists, such as the barred owl, than specialists, such as the spotted owl and adapt more successfully to a new climate than natives (Dukes and Mooney 1999).

Implications for Spotted Owl Conservation

While a change in forest composition or extent is likely as the result of climate change, the rate of that change is uncertain. In forests with long-lived dominant tree species, mature individuals can survive these stresses, so direct effects of climate on forest composition and structure would most likely occur over a longer time scale (100 to 500 years) in some areas than disturbances such as wildfire or insect outbreaks (25 to 100 years)(McKenzie *et al.* 2009). Some changes appear to be already occurring. Regional warming and consequent drought stress appear to be the most likely drivers of an increase in the mortality rate of trees in recent decades in the western United States. The increase was evident across regions (Pacific Northwest, California), elevations (*i.e.*, topography), tree size, type of trees, and fire-return-intervals (van Mantgem *et al.* 2009).

As summarized above, it is clear that ecosystem-level changes are occurring within the spotted owl's forest habitat. Therefore, many of the recovery actions proposed for spotted owls must take into account the uncertainty associated with climate change predictions. There are short-term risks and tradeoffs for long-term benefits when assessing the relative merits of active management (Roloff *et al.* 2005, Spies *et al.* 2006, Carey 2007, Millar *et al.* 2007, Blate *et al.* 2009). As discussed below, landscape-level adaptive management strategies that include active management of forest habitat should be encouraged (Wright and Agee 2004, Lee and Irwin 2005, Carey 2007, Keeton *et al.* 2007, Littell *et al.* 2008). Millar *et al.* (2007) suggest a conceptual framework for managing forested ecosystems in a way that helps ecosystems accommodate changes adaptively. These "adaptation" strategies include: (1) resistance options (to forestall impacts and protect highly valued resources), (2) resilience options (to improve the capacity of ecosystems to return to desired conditions after disturbance), and (3) response options (to facilitate transition of ecosystems from current to new conditions). This framework has value in planning actions to help spotted owls accommodate future climate changes and is discussed in more detail below.

Part of the Service-wide priority for responding to climate change is to conduct species and habitat vulnerability assessments, an analytical tool for determining how climate change will affect a species, habitat, or ecosystem and for developing strategies to safeguard these resources (USFWS 2009). Methodologies have been developed in recent years to conduct vulnerability assessments, some of which may be useful for determining appropriate recovery actions, given the climate change effects on the spotted owl and its habitat (Stein 2010).

Recovery implementation for spotted owls should also, wherever feasible, look for opportunities where managing for spotted owl habitat also meets other societal priorities concerning climate change. For example, the highest densities of forest biomass carbon storage in North America occur in the conifer forests of the Pacific Northwest (Sundquist *et al.* 2009, Keith *et al.* 2010). Older forests with longer rotations may be more effective at sequestering carbon than younger, more intensively managed tree plantations (Schulze *et al.* 2000, Luyssaert 2008), but all forest lands may have value for the purpose of carbon sequestration. Effectiveness in this goal may depend on very specific prescriptions and locales. Preliminary research funded by the Service indicates that forests in Oregon have tremendous potential for carbon sequestration on State forest lands in the Coast Range (Davies *et al*. 2011), and nearby lands likely have similar potential. Likewise, managing for carbon sequestration means it is also necessary to manage forest biomass and the risks of stand replacing wildfire (Canadell and Raupach 2008). As of this writing it is unclear what role, if any, Federal and State forest lands will ultimately play in mitigating climate change, but some policy analysts have begun to frame this issue (see Depro *et al.* 2008).

Therefore, to be consistent with the Secretarial Order as well as other Service initiatives (*e.g.*, Landscape Conservation Cooperatives), we are recommending researchers emphasize ecological and economic overlap between recovery actions for spotted owls and action to mitigation climate change. For example, more research should be conducted on the relative compatibility or conflict between thinning a forest to reduce fire risk, its impact on long-term spotted owl habitat quality, and the action's mitigation of climate change impacts. Although thinning activity removes carbon from the forest system in the short-term, it may reduce the risk of a subsequent carbon release through fire or disease outbreak, and it also encourages carbon being concentrated in fewer, larger trees that approximate old-growth structure of pre-fire suppression forests (Hurteau *et al.* 2008). The validity of such a concept is not in dispute among mainstream scientists but, as discussed elsewhere in this document, there is significant disagreement regarding where, when, and how to implement such management measures to optimize the potential for positive outcomes.

- ***Recovery Action 5 – Consistent with Executive Order 3226, as amended, the Service will consider, analyze and incorporate as appropriate potential climate change impacts in long-range planning, setting priorities for scientific research and investigations, and/or when making major decisions affecting the spotted owl.***

Spotted Owls and Ecological Forestry

As documented above, there is a strong scientific consensus that Pacific Northwest forests will be – and already are – undergoing significant changes from current conditions due to past management practices, shifting disturbance patterns, and changing climate influences. There is a variety of scientific opinion regarding the extent to which land managers can manage or positively influence these changes (Millar *et al.* 2007, Reinhardt *et al.* 2008), and how such shifts may affect spotted owls (see, *e.g.*, Hanson *et al.* 2009, 2010 and Spies *et al.* 2010b). To address this uncertainty, we propose applying "active forest management" as part of a spotted owl recovery strategy that includes "ecological forestry and restoration" as described by Franklin *et al.* (2007), Carey (2007), Johnson and Franklin (2009), Long (2009), and Spies *et al.* (2010a), among others. We recommend that land managers consider implementing forest restoration activities where the best available science suggests ecosystems and spotted owls would benefit in the long-term.

We recognize that this recommendation may be controversial. As described below, some forest areas need or would benefit from restoration treatments, whereas others are at less risk or the science is less clear about how to treat certain areas. We make this recommendation to apply ecological forestry and restoration in many parts of the spotted owl's range because:

- Climate change is rapidly altering forest ecosystems within the range of the spotted owl with some unpredictable or potentially undesirable outcomes (Lenihan *et al.* 2008, Littell *et al.* 2010, Shafer *et al.* 2010, Spies *et al.* 2010a);
- The Service, forest managers, and policy makers must take reasonable but proactive steps to conserve forest ecosystems and spotted owls in the face

of past management and future uncertainty (Agee 2002, Carey 2007, Gaines *et al.* 2010); and

- There is a scientific and social consensus emerging that land managers must restore more sustainable (resistant and resilient) ecological processes to forests at various landscape scales (Hessburg *et al.* 2004, Millar *et al.* 2007, Long 2009, Moritz *et al.* 2011).

First, it is worth noting that this recommendation is consistent with a primary goal of the NWFP – the conservation of ecological processes (FEMAT 1993, App. VIII) – and thus should be addressed within the existing planning and adaptive management framework currently in place for Federal lands in the range of the spotted owl. The concept of "conservation of ecological processes" has long been an underlying principle of "ecosystem management" and should be familiar to most land managers in the Pacific Northwest. Ricklefs *et al.* (1984) proposed this concept to include basic ecological cycles on large landscapes, such as the soil formation cycle and the hydrological cycle, with the understanding that fish and wildlife resources are integral to these cycles. That is, conserve the ecological processes and you conserve fish and wildlife. In the 1980s and 1990s, ecosystem management emerged as a dominant theme in managing large landscapes across varied ownerships. Some examples include management of the Greater Yellowstone Ecosystem, the Florida Everglades, the coastal sage scrub of Southern California and the forests of the Pacific Northwest with the NWFP. The NWFP explicitly includes this goal of conserving natural processes (FEMAT 1993, App. VIII).

Natural disturbance processes – wildfire, disease, insect outbreaks and windthrow – are important forces that influence spotted owl habitat. The scientific study and emulation of these processes has emerged as a "dominant paradigm in North American forest management" (Long 2009). Much of this work has occurred in the Pacific Northwest and has direct applicability to forest management in the range of the spotted owl (*e.g.*, Franklin *et al.* 2002, Perera *et al.* 2004, Hessburg *et al.* 2004, Wright and Agee 2004, Nitschke 2005, Drever *et al.* 2006, Noss *et al.* 2006, Carey 2007, Franklin *et al.* 2007, O'Hara 2009, Johnson and Franklin 2009, Long 2009, Odion *et al.* 2010, Swanson *et al.* 2010). A good synopsis of disturbance-based management for forested systems is provided by North and Keeton (2008:366):

> "Disturbance-based forest management is a conceptual approach where the central premise might be summarized as 'manipulation of forest ecosystems should work within the limits established by natural disturbance patterns prior to extensive human alteration of the landscape' (Seymour and Hunter 1999). Although such an objective seems like a simple extension of traditional silviculture, it fundamentally differs from past fine-filter approaches that have manipulated forests for specific objectives such as timber production, water yield, or endangered species habitat. Some critics have argued that this approach leaves managers without clear guidelines because the scale and processes of ecosystems are poorly defined, making it difficult to directly emulate the ecological effects of natural disturbances.

> Disturbance-based management, however, readily acknowledges these uncertainties. It emphasizes a cautious approach, targeted at those specific management objectives, such as provision of complex habitat structures, reduced harvesting impacts, and landscape connectivity that can be achieved. Although this approach will require changes in how management success is evaluated, disturbance-based management is likely to minimize adverse impacts on complex ecological processes that knit together the forest landscape."

The Service continues to recommend that active forest management and disturbance-based principles be applied throughout the range of the spotted owl with the goal of maintaining or restoring forest ecosystem structure, composition and processes so they are sustainable and resilient under current and future climate conditions in order to provide for long-term conservation of the species. The majority of published studies support this general approach for Pacific Northwest forests, although there is some disagreement regarding how best to achieve it. We received widely varying recommendations for meeting this goal from knowledgeable scientists. Most of this variance in opinion is due to the scientific uncertainty in: (1) accurately describing the ecological "reference condition" or the "natural range of variability" in historical ecological processes, such as fire and insect outbreaks across the varied forest landscape within the range of the spotted owl (*e.g.*, see Hessburg *et al.* 2005, and Keane *et al.* 2002, 2009); and (2) confidently predicting future ecological outcomes on this landscape due to rapid, climate-driven changes in these natural processes, with little precedent in the historical (or prehistoric) record (Drever *et al.* 2006, Millar *et al.* 2007, Long 2009, Littell *et al.* 2010).

These are very real problems that should be addressed with more research (Strittholt *et al.* 2006, Kennedy and Wimberly 2009). In the meantime, addressing this uncertainty in a careful but active manner is the challenge of this Revised Recovery Plan and of forest management in general. The Service agrees with those climate scientists and forest researchers who propose that decision makers must deploy a suite of reactive and proactive approaches to cope with the impacts of climate change on forest lands, while taking into account both short- and long-term timeframes and differing landscape scales (Millar *et al.* 2007, Joyce *et al.* 2008, Reinhardt *et al.* 2008, Blate *et al.* 2009, Gaines *et al.* 2010, Spies *et al.* 2010a, Moritz *et al.* 2011). This strategy should incorporate the concept of "adaptation" into forest management decisions (Drever *et al.* 2006, Joyce *et al.* 2008, Long 2009, Littell *et al.* 2010). Adaptation options include: (1) resisting change; (2) promoting resilience to change; and (3) allowing forest ecosystems to respond to change (Millar *et al.* 2007, Joyce *et al.* 2008, Blate *et al.* 2009, Littell *et al.* 2010).

Resistance strategies are usually deployed to protect high-value resources, such as human structures or very rare habitats. They can be expensive and labor intensive, and include actions such as fire suppression across large and rugged landscapes. Resilience-enhancing adaptations include managing within the bounds of natural disturbance processes by emulating these processes through prescriptive actions (Peterson *et al.* 1998, Franklin *et al.* 2002, Drever *et al.* 2006, Joyce *et al.* 2008). This approach will likely lead to the restoration and maintenance of forest ecosystems which are resilient to a wide range of environmental challenges or scenarios (Long 2009). Allowing forest ecosystems to change as resilience thresholds are crossed means minimizing dramatic and abrupt transitions from one ecosystem condition to another (*e.g.*, forest to shrubland), thereby also minimizing disruptions to important ecological processes (*e.g.*, species dispersal, hydrological cycle, etc.) (Hessburg *et al.* 2005, Blate *et al.* 2009).

Maintaining or improving ecosystem resilience in the face of climate change should be a fundamental goal of forest land managers (Hessburg *et al.* 2005, Reinhardt *et al.* 2008, Lawler 2009, Littell *et al.* 2010). "Resilient forests are those that not only accommodate gradual changes related to climate but tend to return toward a prior condition after disturbance either naturally or with management assistance" (Millar *et al.* 2007). Managing for resilient forests should also be considered a fundamental recovery goal for spotted owls. Federal land managers should apply ecological forestry principles where long-term spotted owl recovery will benefit, even if short-term impacts to spotted owls may occur (Franklin *et al.* 2006) to improve the resiliency of the landscape in light of threats to spotted owl habitat from climate change and other disturbances. For example, managers should promote spatial heterogeneity within patches and local and regional landscapes, restore lost species and structural diversity (including hardwoods) within the historical range of variability, and restore ecological processes to historical levels and intensities (Franklin *et al.* 2002, 2007, Drever *et al.* 2006, Long 2009). This includes early-successional ecosystems on some forest sites (Swanson *et al.* 2010, Perry *et al.* 2011). Some of these management actions may degrade spotted owl habitat in local areas in the short-term (Franklin *et al.* 2006, Spies *et al.* 2006, 2010a), but may be beneficial to spotted owls in the long-term if they reduce future losses of ecosystem structure or better incorporate future disturbance events to improve overall forest ecosystem resilience to climate change (Roloff *et al.* 2005, Ager *et al.* 2007a, Spies *et al.* 2010a).

Of course, trade-offs that affect spotted owl recovery will need to be assessed on the ground, on a case-by-case basis with careful consideration given to the specific geographical and temporal context of a proposed action. There is no "one right prescription." Specific patch-level prescriptions are impossible to make in this Revised Recovery Plan given the tremendous variety in conditions and land management goals across the species' range. Each forest is unique (Agee 2002), and landscape and site-specific assessments need to be made (Lee and Irwin 2005). Prescriptive management goals to address climate change concerns vary across the spectrum of forest types, landscapes, and ownership (Millar *et al.* 2007). When considering a potential restoration treatment project, it will be necessary for land managers working with the Service and other interested stakeholders to weigh the potential tradeoffs between short-term impacts to spotted owl habitat versus longer-term ecosystem restoration outcomes. While our understanding of short- and long-term effects of ecosystem restoration actions on spotted owls is limited at this time, research on effects of more traditional forest management practices on spotted owls and their prey has been conducted and is discussed below. These studies provide data that should inform development of restoration projects to develop desired future conditions while best maintaining existing spotted owls on the landscape. In addition, projects with these types of effects on Federal land will undergo section 7 consultation to assess the impact to the spotted owl.

Effects of Forest Management Practices on Spotted Owls

Before applying ecological forestry principles and implementing the recommendations in this Plan, it is necessary to summarize the scientific understanding of how various forest management practices affect spotted owls. Historically, many of the timber management practices used in the Pacific Northwest have had detrimental consequences for spotted owls. Clearcuts, shelterwoods and heavy commercial thinning operations have typically converted spotted owl habitat to non-habitat. Several peer-reviewed publications (Forsman *et al.* 1984, Zabel *et al.* 1992, Buchanan *et al.*1995, Hicks *et al.* 1999, Meiman *et al.* 2003), three master's theses (Solis 1983, Sisco 1990, King 1993) and a number of reports (Anthony and Wagner 1999, Irwin *et al.* 2005, Irwin *et al.* 2008, Irwin *et al.* 2010) specifically addressed effects of timber harvest (primarily thinning operations) on spotted owls, and results of these studies were summarized by Hansen and Mazurek (2010). In most of these studies, one to two spotted owls were affected by thinning projects, and data on thinning effects were collected incidental to larger research objectives. Furthermore, timber harvest activities in these studies were generally not designed or intended to develop future spotted owl habitat.

Among those studies that reported spotted owl responses to thinning or other timber harvest activities, four studies (Forsman *et al.* 1984, King 1993, Hicks *et al.* 1999, Meiman *et al.* 2003) found spotted owls were displaced by contemporary harvest near the nest or activity center. Based on observations of nine spotted owl territories where harvest occurred during the study, Forsman *et al.* (1984) suggested that negative effects (decreased reproduction, site abandonment) of thinning or selective harvest were most likely associated with higher-intensity thinning, timber harvest close to the nest area and when the affected owl site had low amounts of alternative habitat available. Similarly, Meiman *et al.* (2003) reported that a male spotted owl expanded his home range and shifted foraging and roosting away from a thinning operation located close to the nest tree. Consequently, they recommended harvest operations not be conducted near spotted owl nest sites. While harvest activities tend to decrease use by spotted owls during and immediately following the action, spotted owl use of previously logged forest (selectively logged or thinned) was demonstrated in a number of cases: four of these 12 studies reported nesting attempts, five reported roosting, and nine described foraging activities in stands that had been thinned or selectively logged one to five decades earlier (Hansen and Mazurek 2010). Given the small number of spotted owls studied, the information provided in these studies is insufficient for drawing firm conclusions about the effects of thinning prescriptions on spotted owls.

Another important consideration is the effect of vegetation management on spotted owl prey species, including northern flying squirrels, dusky-footed woodrats, bushy-tailed woodrats and other small mammals. The northern flying squirrel's relationships with forest seral stages, forest structure and land management have been a topic of considerable research and debate. Some studies have found that densities of flying squirrels are highest in old forests (Carey *et al.* 1992, Carey 1995), whereas others have suggested that the species is a generalist with respect to seral stage or stand age (Rosenberg and Anthony 1992, Waters and Zabel 1995, Ransome and Sullivan 1997). Studies of the effects of timber harvest on northern flying squirrels have generally found negative responses to thinning, although results have varied across studies. Several studies have suggested that forest thinning can temporarily (*e.g.*, up to 20 years) reduce the availability of truffles, which are a key food resource for northern flying squirrels and other small mammals on which spotted owls depend (Waters *et al.* 1994, Colgan *et al.* 1999, Luoma *et al.* 2003, Meyer *et al.* 2005). However, studies in British Columbia did not find any significant short-term differences in densities, movements or reproduction of flying squirrels in young, commercially-thinned stands versus unthinned young stands (Ransome and Sullivan 2002, Ransome *et al.* 2004). Carey (2000) found lower abundances of flying squirrels in recently-thinned (within 10 years) stands in Washington than in stands that were clear-cut 50 years prior to the study, with retention of both live and dead trees. He attributed his results to the apparently negative effects of commercial thinning on canopy connectivity, downed wood and truffle communities in the area. Wilson (2010) also reported most thinning is likely to suppress flying squirrel populations for several decades, but the long-term benefits of variable-density thinning for squirrels are likely to be positive. He emphasized that developing the next layer of trees is critical if the goal is to accelerate late-seral conditions and promote prey for spotted owl, and complex structure favorable to squirrels may be achieved sooner in younger stands where there is a shorter vertical distance between the ground and the bottom of the canopy.

Mixed results have also been reported in studies that examined effects of thinning on woodrats. Dusky-footed woodrats occur in a variety of conditions, including both old, structurally complex forests and younger seral stages, and are often associated with streams (Raphael 1987, Carey *et al.* 1992, 1999, Williams *et al.* 1992, Sakai and Noon 1993, Anthony *et al.* 2003, Hamm and Diller 2009). Research has suggested that thinning or associated practices (*e.g.*, burning slash piles) could be detrimental to dusky-footed woodrats if it reduces hardwoods, shrubs or downed wood, yet treatments could ultimately benefit woodrats if they result in growth of shrubs or hardwoods (Williams *et al.* 1992, Innes *et al.* 2007). Bushy-tailed woodrats may be more limited by abiotic features, such as the availability of suitable rocky areas for den sites (Smith 1997) or the presence of streams (Carey *et al.* 1992, 1999). Similar to dusky-footed woodrats, forms of thinning that reduce availability of snags, downed wood or mistletoe could negatively impact bushy-tailed woodrat populations (Lehmkuhl *et al.* 2006a). A study of dusky-footed woodrats in the redwood region of California, however, did not find an association between abundances of woodrats and different intensities of commercial thinning (Hamm and Diller 2009).

Results from these studies suggest that active management projects should explicitly evaluate the short-term impacts to spotted owls and their prey while considering the long-term ecological benefits of such projects, especially in spotted owl core-use areas. Spotted owl home ranges generally have a greater proportion of older forest within the core-use area and more diverse forest conditions on the periphery of their ranges (Swindle *et al.* 1999). The studies referenced above primarily described effects of commercial timber harvest; management designed under an ecological forestry framework should avoid existing high value habitat, if possible, while meeting long-term restoration goals. Within provincial home ranges but outside core-use areas, opportunities exist to conduct vegetation management to enhance development of late-successional characteristics or meet other restoration goals in a manner compatible with retaining resident spotted owls. Restoration activities conducted near spotted owl sites should first focus on areas of younger forest less likely to be used by spotted owls and less likely to develop late-successional forest characteristics without vegetation management. Vegetation management should be designed to include a mix of disturbed and undisturbed areas, retention of woody debris and development of understory structural diversity to maintain small mammal populations across the landscape.

At regional landscape scales, managers should consider how spotted owls fit into a larger ecological framework. Additional factors including historical disturbance regimes and different forest vegetation communities need to be considered. The following section addresses these regional differences in more detail. As ecological forestry is considered and applied in the Pacific Northwest, forest ecosystem management goals will differ between moist and dry forests, and between northern interior portions of the range versus coastal areas in California (Spies *et al.* 2006, Strittholt *et al.* 2006, Mitchell *et al.* 2009). The following sections provide some principles for land managers to consider in these differing forests within the spotted owl's range.

Habitat Management in Moist Forests

A primary spotted owl recovery goal of this Revised Recovery Plan for moist forests is to conserve older stands that are either occupied or contain high-value spotted owl habitat; this recovery goal is discussed in greater detail later under Recovery Action 10 and Recovery Action 32. On Federal lands these recommendations apply to reserved and non-reserved land allocations.

Managers of the moist forest landscapes recognize that emulating natural disturbance patterns at large landscape levels will be very difficult (Wimberly *et al.* 2004). In contrast to dry forests, short-term fire risk is generally lower in the moist forests that are the dominant condition on the west side of the Cascade Range, and disturbance-based management for forests and spotted owls here should be different. Silvicultural treatments are generally not needed to maintain existing old-growth forests on moist sites (Wimberly *et al.* 2004, Johnson and Franklin 2009). Efforts to alter either fuel loading or potential fire behavior in these sites could have undesirable ecological consequences (Johnson and Franklin 2009, Mitchell *et al.* 2009). Potential management in older forests, either for climate-related management or spotted owl recovery, must explicitly weigh the relative pros and cons of such activities.

However, this recommendation should be reassessed regularly as new scientific information emerges regarding climate change. For example, Littell *et al.* (2010) suggest climate-driven fire risk may increase on the west-side in moist forests, and Shafer *et al.* (2010) conclude that fire activity is expected to increases in all forest types in Oregon. Although these model predictions are still highly variable, the recommendations of mainstream climate scientists (Littell *et al.* 2010, Shafer *et al.* 2010) should be incorporated into longer-term planning. Wimberly *et al.* (2004) give some recommendations to consider in the Oregon Coast Range that address historical fire regimes and disturbance patterns.

Even with uncertain model predictions, there are younger or less diverse moist forest areas outside of old-growth stands where active management could promote ecological goals, including spotted owl recovery. The most current evaluations suggest climate change in the Pacific Northwest is affecting processes in addition to wildfire, including insect and disease outbreaks and changes in species composition (Latta *et al.* 2010, Littell *et al.* 2010, Spies *et al.* 2010a). Therefore, ecological forestry and active management in the range of the spotted owl should address issues in addition to wildfire dynamics. For example, where past management practices have decreased age-class diversity and altered the structure of forest patches, targeted vegetation treatments could simultaneously reduce fuel loads and increase canopy and age-class diversity (Franklin *et al.* 2002, 2006, Wimberly *et al.* 2004, Littell *et al.* 2010). Likewise, there may be post-disturbance opportunities to restore more natural, early successional forest conditions that provide more ecological benefits to spotted owls (and other native forest species) than do traditional clearcuts and young, even-aged stands (Swanson *et al.* 2010).

Long-term spotted owl recovery could benefit from forest management where the basic goals are to restore or maintain ecological processes and resilience. Therefore, we recommend application of disturbance-based principles to such decisions (Franklin *et al.* 2002, 2006, 2007, Drever *et al.* 2006, Noon and Blakesley 2006, Carey 2007, Long 2009, Swanson *et al.* 2010). For example, some treatments may accelerate the development of spotted owl nesting habitat (Wimberly *et al.* 2004, Andrews *et al.* 2005), even if it temporarily degrades existing dispersal habitat (Franklin *et al.* 2006). This issue needs more applied research, and land management experiments should target this need. There are areas in moist LSRs where stands average 50 years or older that are uniform and not likely to achieve desired complexity or resilience on their own, yet may develop structural complexity more quickly with treatment (Bailey and Tappeiner 1998, Latham and Tappeiner 2002, Carey 2003). These areas should be considered for restoration treatments designed to encourage development of late-successional structural complexity and promote resilience in the face of expected climate-driven changes (Johnson and Franklin 2009). Much of this activity can, and should, be carried out in all Federal land classifications consistent with the NWFP Standards and Guidelines. In some cases, it may be appropriate to seek exemptions to the 80-year old threshold for silvicultural activities in LSRs if a clear conclusion can be reached that spotted owl recovery and/or ecosystem restoration goals would be met. Research and monitoring on the specific effects of such treatments on spotted owls and their prey is needed and should evaluate effects on both spotted owl recovery as well as broader forest management goals.

In general, to advance long-term spotted owl recovery and ecosystem restoration in moist forests in the face of climate change and past management practices, we recommend the following principles be applied by land managers:

1. Conserve older stands that have occupied or high-value spotted owl habitat as described in Recovery Actions 10 and 32. On Federal lands this recommendation applies to all land-use allocations outside of Congressionally Reserved Areas.
2. Management emphasis needs to be placed on meeting spotted owl recovery goals and long-term ecosystem restoration and conservation. When there is a conflict between these goals, (*e.g.*, short-term adverse impact but expected long-term benefit), managers should make tradeoffs explicit and seek Service input if necessary. Use a sliding scale to prioritize landscapes (*e.g.*, watersheds, stands, etc.) for treatment.
3. Continue to manage for large, continuous blocks of late-successional forest.
4. Regeneration harvest, if carried out, should apply ecological forestry principles as recommended by Franklin *et al.* (2002, 2007), Drever *et al.* (2006), Johnson and Franklin (2009), Swanson *et al.* (2010), and others cited above.
5. Use pilot projects and applied management to test or demonstrate techniques and principles (Noon and Blakesley 2006). In the near term, to reduce conflict and potential inconsistencies with existing Federal land management plans, locate such pilot projects wherever possible in Matrix and Adaptive Management Areas. However, we continue to recommend that such actions be considered in LSRs if a determination is made that treatments would meet broader ecosystem restoration goals.

- ***Recovery Action 6: In moist forests managed for spotted owl habitat, land managers should implement silvicultural techniques in plantations, overstocked stands and modified younger stands to accelerate the development of structural complexity and biological diversity that will benefit spotted owl recovery.***

Implement LSR treatments per the Standards and Guides of the NWFP. In addition, LSR thinning in plantations older than 80 years of age should occur in cases where long-term beneficial effects to spotted owls will be realized from enhancing within-stand structural diversity. The treatment should emphasize the retention of the oldest and largest trees in the stands or any trees with characteristics that create stand diversity (*e.g.*, bole and limb deformities) and should focus on structural diversity in the mid- to upper- story layers, but not at the expense of large snags or existing species diversity. Cases where facilitating a thinning operation necessitates felling existing remnant trees over 120 years old should be rare. We recommend the use of fungal inoculation, mechanical methods, or other tools as needed to create snags. The Service is available to participate in local or regional efforts to provide guidance on these sorts of prescriptions. Any LSR thinning in plantations greater than 80 years old, if appropriate, should occur where nesting and roosting habitat is needed within LSRs to bolster spotted owl populations and should be considered within the interagency structure of the Level 1 teams.

Likewise, in areas with regeneration harvest in moist forest Matrix lands, any harvest should be designed using ecological forestry principles that emphasize retention of larger and older trees, snags and downed wood of varying size and decay classes, and live trees with decay and deformities (see Swanson *et al.* 2010). Unlike traditional regeneration harvests, applying these measures retain important habitat features while also encouraging eventual development of late-successional conditions.

Habitat Management in Dry Forests

Although the dry forest portion of the spotted owl's range hosts a minority of the overall population, management of spotted owl habitat in these drier areas is an extremely complex undertaking. Changing climate conditions, dynamic ecological processes, and a variety of past and current management practices render broad management generalizations impractical. Recommendations for spotted owl recovery in this area also need to be considered alongside other land management goals – sometimes competing, sometimes complimentary – such as fuels management and invasive species control. In some cases, failure to intervene or restore forest conditions may lead to dense stands heavy with fuels and in danger of stand-replacing fires and insect and disease outbreaks. As a consequence, the dry forest discussion below provides substantial detail on spotted owl ecology in such areas, including a more specific treatment of the effects of climate, fire, and insect and disease outbreaks on spotted owl habitat.

In general, we recommend that dynamic, disturbance-prone forests of the eastern Cascades, California Cascades and Klamath Provinces should be actively managed in a way that reconciles the overlapping goals of spotted owl conservation, responding to climate change and restoring dry forest ecological structure, composition and processes, including wildfire and other disturbances (Noss *et al.* 2006, Spies *et al.* 2006, 2010a, Agee and Skinner 2005, Healey *et al.* 2008, Mitchell *et al.* 2009). Vegetation management of fire-prone forests can retain spotted owl habitat on the landscape by altering fire behavior and severity (Reinhardt *et al.* 2008, Haugo *et al.* 2010, Wiedinmyer and Hurteau 2010) and, if carefully and strategically applied, it could be part of a larger disturbance management regime for landscapes that attempts to reintegrate the relationship between forest vegetation and disturbance regimes, while also anticipating likely shifts in future ecosystem processes due to climate (Gartner *et al.* 2008, Noss *et al.* 2006, Lawler 2009, Mitchell *et al.* 2009, Littell *et al.* 2010, Swanson *et al.* 2010, Moritz *et al.* 2011). Such an approach is more likely to achieve ecologically and socially acceptable outcomes, and could enable transitions to more acceptable disturbance regimes, even if it includes more frequent but less severe wildfires (Allen *et al.* 2002, Wright and Agee 2004, Hessburg *et al.* 2005, 2007, Strittholt *et al.* 2006, Reinhardt *et al.* 2008). Some areas, such as dry portions of the Klamath Province, have a different fire ecology than areas in the East Cascades and may not be subject to the same generalizations (Odion *et al.* 2004, 2010, Skinner *et al.* 2006, Hanson *et al.* 2009, 2010); this should be evaluated at a finer scale by recovery implementation teams and interested land managers.

Specific silvicultural practices that promote forest resilience and that can be applied to various forest types are given by Franklin *et al.* (2002, 2006, 2007), Hessburg *et al.* (2004, 2005, 2007), and Drever *et al.* (2006). Short-term decisions to increase forest ecosystem adaptations to climate-driven drought stresses may include vegetation management around older individual trees to reduce competition for moisture (Wright and Agee 2004, Agee and Skinner 2005, Reinhardt *et al.* 2008, Johnson and Franklin 2009, Haugo *et al.* 2010, Littell *et al.* 2010). Longer-term strategies may include protecting or restoring multiple examples of ecosystems and promoting heterogeneity among and within forest stands with the potential for natural adaptation to future (and unpredictable) climate changes (Hessburg *et al.* 2005, Kennedy and Wimberly 2009, Blate *et al.* 2009). In many areas, fire could be encouraged to perform its ecological role of introducing and maintaining landscape diversity (DellaSala *et al.* 2004, Reinhardt *et al.* 2008, Odion *et al.* 2010), although it may be desirable to manage fire severity or return intervals through vegetation management at various temporal and landscape scales (Agee and Skinner 2005, Haugo *et al.* 2010, Littell *et al.* 2010, Spies *et al.* 2010a, Moritz *et al.* 2011).

There is an ongoing debate, as captured in Hanson *et al.* (2009, 2010) and Spies *et al.* (2010b), regarding the relative merits of active management in dry forest landscapes and the potential positive and negative impacts to spotted owls (Spies *et al.* 2006). This debate focuses on uncertainty and seems to be one of degree rather than fundamental difference in long-term conservation goals. We would like to build on areas of agreement for spotted owl recovery, but we recognize that many of these recommendations are controversial due to political and socio-economic reasons (*e.g.*, see Spies *et al.* 2010a). However, given the need for action in the face of uncertainty (Agee 2002, Roloff *et al.* 2005, Carey 2007, Millar *et al.* 2007, Reinhardt *et al.* 2008, Littel *et al.* 2010, Mote *et al.* 2010, Shafer *et al.* 2010), we continue to recommend that land managers implement a program of landscape-scale, science-based adaptive restoration treatments in disturbance-prone forests that will reconcile the goals of conserving and encouraging spotted owl habitat while better enabling forests to: (1) recover from past management measures, and (2) respond positively to climate change with resilience (Spies *et al.* 2006, 2010a,b, Millar *et al.* 2007, Reinhardt *et al.* 2008, Haugo *et al.* 2010, Keane *et al.* 2009, North *et al.* 2010, Littell *et al.* 2010, Stephens *et al.* 2010). This should provide more high quality spotted owl habitat sooner and for longer into the future which will greatly benefit spotted owl recovery in the long-term. Several authors provide clear recommendations for how to consider reconciling spotted owl habitat management with vegetation management in the eastern Cascades (Lehmkuhl *et al.* 2007, Buchanan 2009, Gaines *et al.* 2010, USDA 2010).

Disturbance Regimes of Dry Forests Within the Range of the Spotted Owl

Ecological disturbance regimes derive from complex interactions among vegetation, climate, topography, and other biotic and abiotic factors that vary over space and time. Fire and other disturbances have been fundamentally important to shaping landscape patterns and processes in the dry forest systems (Hessburg *et al.* 2000a, 2005, 2007, Dale *et al.* 2001, Hessburg and Agee 2003, Skinner *et al.* 2006, Skinner and Taylor 2006, Perry *et al.* 2011). Fire regimes have been described for the Eastern Washington Cascades, Eastern Oregon Cascades, California Cascades, and Klamath Provinces (Hessburg *et al.* 2000a, 2005, 2007, Hessburg and Agee 2003, SEI 2008, Skinner *et al.* 2006, Skinner and Taylor 2006, Perry *et al.* 2011), though there is not agreement on some regime descriptions (Hanson *et al.* 2009, 2010, Spies *et al.* 2010b).

Additional research has advanced our understanding of the occurrence of low, mixed, and high-severity fires in dry forest fire regimes typically considered as low severity only (*e.g.,* see Baker *et al.* 2007, Hessburg *et al.* 2007, Beaty and Taylor 2008, Brown *et al.* 2008, Collins and Stephens 2010, Perry *et al.* 2011). In dry forests of the eastern Cascades of Washington, for example, surface-fire dominated mixed severity fires were found to be more prominent historically than previously thought (Hessburg *et al.* 2007), rendering more spatial and temporal variability in landscape patterns of disturbed and recovering vegetation. Kennedy and Wimberly (2009) found similar results for the Deschutes National Forest in the eastern Cascades of Oregon. Consequently, dry forest landscapes historically comprised a complex arrangement of fire regimes and patch sizes (Hessburg *et al.* 2005, 2007, Skinner *et al.* 2006, Skinner and Taylor 2006, Perry *et al.* 2011), creating spatial and temporal patterns and variability in vegetation and fuels that reinforced self-similar patterns (Turner and Romme 1994, Peterson 2002, Hessburg and Agee 2003, Bigler *et al.* 2005, Skinner *et al.* 2006, North and Keeton 2008, Moritz *et al.* 2011). This temporal and spatial variability in vegetation and fuels has been substantially altered by human activities and are key features that must be included in restoring dry forest ecosystems.

Past Management Actions

Over the past two centuries, Euro-American settlement has substantially transformed the inland northwest of the U.S. Anthropogenic activities that have altered the landscape include timber harvesting, mining, livestock grazing, fur trapping, constructing roads and rail lines, development of towns and settlements, agricultural conversion, fire suppression and fire exclusion. These activities have so altered the patterns of vegetation and fuels, and subsequent disturbance regimes, that contemporary landscapes no longer function as they did historically (Hessburg *et al.* 2000a, 2005, Hessburg and Agee 2003, Skinner *et al.* 2006, Skinner and Taylor 2006).

Fire exclusion, combined with the removal of fire-tolerant structures (*e.g.,* large, fire-tolerant tree species such as ponderosa pine, western larch, and Douglas-fir), have reduced the resiliency of the landscape to fire and other disturbances, at least in those forest types outside of the wetter, higher severity fire regime types (Agee 1993, Hessburg *et al.* 2000a, Hessburg and Agee 2003). In the eastern Cascades of Washington and Oregon, forest types that historically had understories of grass and shrubs have shifted to shade-tolerant conifer understories which are denser and less tolerant of fire than historic understories. This has resulted in an overall increase in the area of fire-intolerant forest-types at the expense of fire-tolerant forest types (Hessburg *et al.* 2000a, Hessburg and Agee 2003). Additionally, these understories compete with fire-tolerant tree species for limited water, thus exacerbating drought stress on the structural components that will be important in restoring dry forest ecosystems. These understories result in an altered fuel bed that exhibits increased flame length, fireline intensity and rate of spread over historic understories, putting any remnant fire-tolerant structural features at greater risk of loss to fire (Hessburg *et al.* 2000a).

In addition to the stand structure, the spatial distribution of these stands also influences fire activity across the landscape. The spatial distribution of fire intolerant-stands among the fire-tolerant stands has been fundamentally altered through past management. Past management has homogenized the patchy vegetative network and reduced the complexity that was more prevalent during the pre-settlement era (Skinner 1995, Hessburg and Agee 2003, Hessburg *et al.* 2007, Kennedy and Wimberly 2009). Therefore, rather than existing as patches of fire-intolerant vegetation types being spatially separated, they have become more contiguous, and are more prone to conducting fire, insects, and diseases across large swaths of the landscape (Hessburg *et al.* 2005). This homogenized landscape may be altering the size and intensity of today's fires and further altering landscape functionality (*e.g.,* Everett *et al.* 2000). This alteration in the disturbance regime further affects forest structure and composition. Not only do these landscapes not exhibit the structure or function that they historically had (Hessburg and Agee 2003, Naficy *et al.* 2010), the shift from fire and drought-tolerant species to shade-tolerant species is a shift in the opposite direction in terms of forest types that will be most resilient to projected future climates (Haugo *et al.* 2010).

Projected Effects of Climate Change in Dry Forest Ecosystems

The implications of climate change on dry forest ecosystems are multi-faceted. The effects and interrelationships are complex and not fully understood. A comprehensive treatment of this topic is beyond the scope of the recovery plan.

Instead, we lay out some of the possible implications of climate change on ecosystem structures and processes that are relevant to dry forest management, and restoration and spotted owl recovery.

Mean temperatures have increased in the Pacific Northwest and northern California. Models project an even more substantial increase than what occurred over the twentieth century (Cayan *et al.* 2008, Mote and Salathe 2010). Seasonally, most models predict the greatest increases during the summer rather than winter months (Cayan *et al.* 2008, Mote *et al.* 2010). Regional models that further consider local geographical features show an increased warming above global model predictions. For example, the loss of snowpack in the Cascades is projected to increase temperatures above those projected in the global models, likely due to the increased heat absorption caused by snowpack loss. This results in many areas of the Cascade Range showing greater rates of winter and spring warming, which is expected to hasten the loss of snowpack and further increase drought stress on trees (Salathe *et al.* 2008), as well as lengthen the fire season (Westerling *et al.* 2006).

The magnitude and direction of changes in mean annual precipitation in the Pacific Northwest and northern California are less clear than for temperature (Cayan *et al.* 2008, Westerling and Bryant 2008, Mote and Salathe 2010). This region is located in a transition zone between projected increased precipitation in the southern portion of North America and projected decreased precipitation in the northern part of the continent (Mote and Salathe 2010). Model projections for northern California range from slight increases in precipitation to decreases of 10-20 percent, with no noticeable change in seasonal precipitation (Cayan *et al.* 2008). In the Pacific Northwest, models are ambiguous in their projections of annual precipitation trends. Seasonal predictions are less ambiguous, however, with most predicting increased winter precipitation and decreased summer precipitation (Mote and Salathe 2010), though regional models project local differences (Salathe *et al.* 2008). Even if increases in annual precipitation should occur, summer water deficits in the Pacific Northwest are projected to increase by 2-3 times due to increased temperatures and decreased summer precipitation (Littell *et al.* 2010). Some projections call for decreases in the amount, frequency, and intensity of precipitation in drier parts of the world, including the western U.S., potentially increasing the vulnerability to drought (Sun *et al.* 2007), while in northern California, some models call for a slight increase in the number and magnitude of large precipitation events (Cayan *et al.* 2008). Due to increasing temperatures throughout the west, more precipitation is expected to fall as rain rather than snow, reducing snow accumulation. Snowpacks are already declining (Stewart *et al.* 2005) and showing decreased water content throughout western North America (Mote *et al.* 2005). Warmer temperatures are expected to result in snow continuing to melt earlier than in the past (Mote *et al.* 2005, Cayan *et al.* 2008), further increasing drought stress on dry forests.

Changes to the range and composition of current vegetation species are expected as local climates transform and become more favorable for some species and less favorable for others (van Mantgem *et al.* 2009, Allen *et al.* 2010, Haugo *et al.* 2010, Littell *et al.* 2010, Shafer *et al.* 2010). For example, Littell *et al.* (2010) predict a 32 percent increase in the area of forests in Washington that will be severely water-limited by the 2020s, with further increases of 12 percent by 2040 and another 12 percent by 2080. Specific to the range of the spotted owl, this effect is most likely to occur in the eastern Cascades in the northern part of the state. As a result, shifts in the range of Douglas-fir and several pine species are expected (Littell *et al.* 2010). A statewide analysis of forests in California indicates evergreen forests will decline while mixed evergreen forests will increase under all climate scenarios modeled (Lenihan *et al.* 2008). Total forest cover is expected to increase by 23 percent statewide in California under the cooler and wetter climate scenarios, whereas forest cover is projected to decrease by 3 and 25 percent under the warmer and drier models used (Lenihan *et al.* 2008). Where climate becomes less suitable for tree species, particularly in areas that become drier, these tree species are likely to decline in growth and become more vulnerable to mortality agents such as fire or insects that may result in large-scale mortality (Littell *et al.* 2010).

Increased mortality rates of trees have already been attributed to drought and heat stress caused by increasing temperatures (van Mantgem *et al.* 2009, Allen *et al.* 2010). Mortality is expected to increase further as temperatures warm and drought stress increases, even in systems that are not water limited (Allen *et al.* 2010). Water limitation is expected to increase across a significant portion of the eastern Cascades of Washington (Littell *et al.* 2010). The degree to which trees may succumb to drought stress is not entirely clear, however, when one considers other effects brought on by climate change. The increase in atmospheric CO_2 is expected to have a fertilization effect on tree growth, allowing them to more efficiently use water and reduce their susceptibility to drought stress (Huang *et al.* 2007). However, this efficiency may not be sustainable in the long-term (Huang *et al.* 2007, Lindroth 2010). For example, CO_2-enhanced growth may diminish over time as other nutrients become limited; specifically, as nitrogen demand and its subsequent storage in plant biomass increase, its availability to plant growth is expected to decrease, resulting in systems becoming nitrogen limited (Huang *et al.* 2007, Lindroth 2010). Others project that warmer temperatures will eventually increase water stress and evaporative demand, regardless of precipitation amount or water use efficiency (Nielson *et al.* 2006, Barber *et al.* 2000).

The effect of changing disturbance regimes such as fire and insects will likely be more abrupt and rapid than the changes in vegetation composition, distribution, and productivity in response to climate change (Littell *et al.* 2010). Interactions among these disturbances can alter forest structure and function more rapidly than what is predicted to occur through modeling of vegetation redistribution or disturbance alone. In periods of rapid climate change during the Holocene, fire was often the catalyst for changing vegetation (Whitlock *et al.* 2003). How climate change affects fire regimes will vary with the energy or water limitations of the varying ecosystems (Littell *et al.* 2009). In energy-limited wildfire regimes (*e.g.,* ecosystems with abundant fuels, such as productive forests), increasing temperatures are likely to substantially increase fire risk, regardless of precipitation; conversely, in moisture-limited regimes (*e.g.,* particularly dry ecosystems with limited fuels such as grass and shrublands), changes in both temperature and precipitation will influence their fire risk (Westerling and Bryant 2008). Predicting specifics of disturbance processes is difficult not only because of the uncertainties in the climate models, but also the synergistic interactions among disturbance agents (*e.g.,* Simard *et al.* 2011). In addition, there are other variables not easily modeled that will likely affect disturbance processes under future climate scenarios (Fried *et al.* 2004, Spracklen *et al.* 2009, Littell *et al.* 2010). These include changes in vegetation composition and distribution, as well as changes in ignitions caused by changing climate or by human activity. For example, while mountain pine beetle attacks are projected to be more successful, it is not known how changes in the range of beetles and host trees may affect this success. If vegetation range changes occur rapidly as a result of increased fire, a subsequent spatial heterogeneity across the landscape could substantially reduce the risk of beetle outbreaks (Littell *et al.* 2010).

Multi-year climatic patterns tied to sea surface temperatures in the Pacific Ocean have been linked to fire activity within the Pacific Northwest. Specifically, the El Niño-Southern Oscillation (ENSO) results in an alteration of temperature and precipitation patterns that cycle, on average, every four years, though annual cycles occur (Mote *et al.* 2010). The Pacific Decadal Oscillation (PDO) is a manifestation of ENSO which cycles between cool and warm phases every 20-30 years (Mantua *et al.* 1997). Prior to the onset of fire exclusion in the 20th century, increased fire activity has been associated with warm phases of the PDO (Hessl *et al.* 2004, Heyerdahl *et al.* 2008). Gedalof *et al.* (2005), however, found no difference in fire activity in the latter half of the 20th century between warm and cool phases of the PDO, but they did find a relationship with smaller scale annual and inter-annual variability in the PDO. The PDO entered a warm phase in 1977 (Mantua *et al.* 1997), and it may now be reversing into a cooler phase (JPL 2008), or it may be losing its decadal persistence (Mote *et al.* 2010, NOAA 2011). Given past associations between fire activity and PDO, it could be argued that the next several decades will result in a decrease in fire activity in the Pacific Northwest. However, making such an inference of cause and effect should be done with caution (Hessl *et al.* 2004). The onset of fire exclusion in the 20th century may confound associations of fire activity with PDO (Mote *et al.* 1999). Furthermore, our understanding of how ENSO and PDO will respond to climate change and our ability to extrapolate their influence on disturbance regimes is poor (McKenzie *et al.* 2004).

Though there is uncertainty with how climate change may specifically alter fire regimes, McKenzie *et al.* (2004) proposed several inferences that can be made given our understanding of fire-climate interactions and our understanding of vegetation response to fire. The first inference is that warmer and drier summers will produce more frequent and extensive fires. Second is that reduced snowpack and earlier snowmelt will likely extend the time span of moisture deficits in water-limited systems. Finally, drought stress on plants will increase as a result of the drier conditions and longer moisture deficits, increasing their vulnerability to other multiple disturbances such as fire and insects; these disturbances often have a synergistic effect.

Evidence is already accumulating to support some of the inferences made by McKenzie *et al.* (2004). The frequency of large (>400 hectares) wildfires and the total area burned by these fires has substantially increased in the western U.S. (Westerling *et al.* 2006), despite active fire suppression. Westerling *et al.* (2006) links this trend to an increase in spring and summer temperatures and earlier spring snowmelts, both of which can result in earlier and longer fire seasons. Given the link between climate and wildfire activity, the authors underscore the urgency to ecologically restore forests that have undergone substantial alterations from past land uses. Specific to California and the Pacific Northwest, an analysis of wildland fires between 1984-2005 showed a significant trend of increasing average fire size, and what appears to be a trend towards an increasing proportion of area burned as a result of large fires (Schwind 2008). Trends in burn severity were less conclusive.

Various authors have projected increases in fire potential in response to projected climate changes, both globally (*e.g.,* Liu *et al.* 2010) as well as in areas encompassing parts or all of the spotted owl range. Littell *et al.* (2010) predicted for Washington that by the 2080s, there will be two to three times as much area burned as what burned between 1916 and 2006; specific to the forested ecosystems of the eastern Cascades, Littell *et al.* (2010) predict a near doubling by the 2080s of the mean area burned between 1980 and 2006 (from 63,000 to 124,000 ha). Westerling and Bryant (2008) projected a 15-90 percent increase in fire in northern California by 2070-2099. Though unquantified, an increase in fire activity is expected in all forest types in Oregon (Shafer *et al.* 2010). Spracklen *et al.* (2009) projected that Pacific Northwest forests will experience some of the greatest increases in mean annual area burned in the western U.S., with a projected increase of 78% by 2050 over that burned between 1996-2005. Whitlock *et al.* (2003) suggest that fire frequency or severity may increase under climate projections. However, in areas where changing climate is expected to reduce combustible vegetation, fire activity could decrease (Westerling and Bryant 2008, Krawchuk *et al.* 2009).

Frequent and extensive outbreaks of native forest insects, such as bark beetles and spruce budworm, have occurred historically in the western U.S. (*e.g.*, Amman and Cole 1983, Brookes *et al.* 1987, Swetnam and Lynch 1989, Hessburg *et al.* 1994). However, anthropogenic influences through past management and fire suppression have altered the landscape vegetation patterns, subsequently altering the timing, duration and magnitude of outbreaks (Swetnam and Lynch 1989, Hessburg *et al.* 1994). Climate change is predicted to further exacerbate the situation by redistributing forest insects as well as intensifying all aspects of forest insect outbreak behavior (Logan *et al.* 2003). Temperatures drive the life history of insects and determine their geographic range. As highly mobile species living in a warmer world, insects are expected to readily expand their range and invade new habitats (Logan *et al.* 2003). Increased CO2 levels may further favor sap-feeding insect species such as bark beetles (Whittaker 1999). Yet predicting specific responses is difficult because climate relationships with some forest insect outbreaks are poorly understood (*e.g.*, see Swetnam and Lynch 1993 regarding spruce budworm).

Recent bark beetle outbreaks have exceeded the magnitude of outbreaks documented during the prior 125 years in parts of the U.S. (Raffa *et al.* 2008). It appears that human activities have influenced recent increases in bark beetle activity (Logan and Powell 2001, Logan *et al.* 2003). Changing climate, particularly increased temperature and drought, combined with management that has favored continuous, uninterrupted distributions of host tree species (*e.g.,* Douglas-fir and true fir species), tend to foster outbreaks (Hicke and Jenkins 2008, Raffa *et al.* 2008). Unusually hot and dry weather is already responsible for increased insect outbreaks in forests in several North American localities, from pinyon pine in the southwest U.S. (Breshears *et al.* 2005) to lodgepole pine forests in British Columbia where the beetle outbreak is larger than any recorded in Canada (Carroll *et al.* 2004 as cited in Whitehead *et al.* 2006, Taylor *et al.* 2006). In addition, increased stand densities of lodgepole pine have increased their susceptibility to bark beetle outbreaks throughout the western U.S. (Hicke and Jenkins 2008). There is evidence of irruptive thresholds being crossed by insects in Alaska and British Columbia, whereby the outbreak continues in a self-sustaining mode even after the extreme drought conditions that initiated the attack have subsided (Raffa *et al.* 2008). However, not all outbreaks appear to be exceeding known historical magnitudes. In Colorado for example, mountain pine beetle activity does not exceed historical activity levels, although the insects are moving outside of their known historical range and into higher elevation (Romme *et al.* 2006); the authors, however, point out that it is difficult to know if this movement is truly outside of their historical range given the lack of historical data on beetle distributions.

With respect to forest pathogens, Kliejunas *et al.* (2009) summarize the literature on the relationship between climate change and tree diseases in western North America. They note that while there is great uncertainty with how specific pathogens will respond to climate change, general inferences can be made, all of which can vary by ecosystem and specific climate conditions. Similar to forest insects, pathogen distributions are expected to change, including invasion of new areas by nonnative pathogens. The epidemiology of plant diseases is also expected to change, complicating the prediction of disease outbreaks. The rate that pathogens evolve and overcome host resistance may increase in a rapidly changing climate. With increasing temperatures, we should expect an increase in overwintering survival of pathogens, as well as an increase in disease severity. Predicted drought stress on many host species will increase their vulnerability to, and exacerbate the effect of, many pathogens. Finally, with the exception of extremely dry conditions, climate change may alter fungal pathogens that could have a profound change on rates of wood decay, shortening the length of time valuable legacies like down wood can be retained in the ecosystem (Yin 1999).

Interactions between disturbance processes also need to be considered, but are not well understood. For example, the fuel composition created by mountain pine beetle outbreaks in lodgepole pine is thought to facilitate the stand-replacing fires favorable to lodgepole reproduction (Logan and Powell 2001). However, the evidence is mixed as to whether insect mortality increases the risk or severity of fire (Fleming *et al.* 2002, Bebi *et al.* 2003, Hummel and Agee 2003, Lynch *et al.* 2006, Parker *et al.* 2006, Romme *et al.* 2006, Kulakowski and Veblen 2007, Jenkins *et al.* 2008, Simard *et al.* 2011). Some studies recorded situations where probability or severity of burns was higher in beetle-killed stands than in control stands (Bigler *et al.* 2005, Lynch *et al.* 2006). Others found no difference in severity or probability of fires occurring in beetle-killed stands compared to control stands (Bebi *et al.* 2003, Lynch *et al.* 2006, Kulakowski and Veblen 2007). Furthermore, high-severity fires that did occur were consistent with the typical fire regime of affected forests, even without the insect outbreaks (see Romme *et al.* 2006). Still other research has found that the likelihood of active crown fire was actually reduced in beetle killed stands than in control stands, potentially due to decreases in the canopy fuels caused by beetle mortality (Simard *et al.* 2011). Finally, Bigler *et al.* (2005) observed that while beetle outbreaks may have contributed to fire severity, other contributors such as pre-fire stand structure and composition were more of an influence.

At a minimum, insect outbreaks substantially alter the fuel complex and ultimate vegetative composition within a stand (Jenkins *et al.* 2008), and such alteration can potentially affect fire activity. Insect mortality does more to affect fire behavior than just increase the dead fuel load. The removal of overstory canopy can decrease the surface fuel moistures, alter understories, and allow for greater wind speeds through the stand, which can affect fire behavior. These changes in stand structure and composition may be more influential drivers of fire risk and severity than the actual direct increase in fuels caused by beetle outbreaks (Bigler *et al.* 2005, Lynch *et al.* 2006). These factors change through time and will influence the behavior of fires that enter the stand at any given time. In short, the relationships between insects and fire are complex with no simple, single conclusion that can be drawn (Romme *et al.* 2006).

In summary, the implications of climate change on dry forest ecosystems are broad and multi-faceted. Though models are not all in agreement, it appears likely that there will be at least some level of summer water deficit, even if overall precipitation increases. This increase in water limitation increases the risk of fire activity and creates drought stress on trees, making them more susceptible to insect attacks. Interactions among these disturbances can have synergistic effects. The existing condition of increased stand densities and decreased landscape heterogeneity further exacerbates the vulnerability of these systems to disturbance, as well the potential magnitude and intensity of the event itself, particularly in those fire regimes that were predominately of mixed- and low-severity (Schoennagel *et al.* 2004, Keeton *et al.* 2007). Ecosystem functions that are already altered due to past management will be further altered with projected climate change.

Effects of Fire on Spotted Owl Habitat

Research on all three spotted owl subspecies indicates variability in the degree to which spotted owls use post-fire sites, depending on fire severity and the function of the site for spotted owls (*i.e.*, nesting, roosting, or foraging). A few studies have looked at spotted owl occupancy of nesting territories and survival rates in burned areas. In southwest Oregon, lower occupancy and survival rates of northern spotted owls were found in burned areas compared to unburned areas, but the results were confounded by prior management of the area and harvest after the fire (Clark 2007, Clark *et al.* 2011). Jenness *et al.* (2004) found decreased occupancy of Mexican spotted owls in burned areas compared to unburned areas, although the authors considered the relationship statistically weak. Roberts *et al.* (2011) found no difference in occupancy of California spotted owls between burned and unburned areas, although their burned areas were predominately of low and moderate severity. Bond *et al.* (2002) compared survival rates of all three subspecies of spotted owls in burned sites with overall survival estimates recorded in the literature and found them to be similar.

Spotted owl reproduction and nesting have been observed in burned landscapes and in core areas in which some portion was burned by high-severity fire (*i.e.,* fires with typically 70-100% overstory mortality). It is not known whether there is a maximum amount of high severity fire within a nesting core that would preclude nesting of spotted owls, and there have been no long-term studies to determine how long spotted owls may remain in a burned-over area. Specific to the actual nest tree, Bond *et al.* (2009) did not find any of their four nest trees located in a high severity burn. Nest trees, however, have been observed in patches with low to moderate severity burn (Gaines *et al.* 1997, Clark 2007, Bond *et al.* 2009). For spotted owls nesting in burned areas, reproductive rates are generally similar to unburned areas (Gaines *et al.* 1997, Bond *et al.* 2002, Clark 2007).

While spotted owls have been observed roosting in forests experiencing the full range of fire severity, most roosting owls were associated with low or moderate severity burns (Clark 2007, Bond *et al.* 2009). Specifically, Bond *et al.* (2009) found spotted owls selecting low severity burns for roosting and avoiding high severity burns. In addition, roost sites from which stand measurements were taken had high levels of canopy closure (*i.e.,* greater than 60 percent) and a large tree component, regardless of burn severity (Clark 2007, Bond *et al.* 2009). Spotted owls have been observed foraging in forest areas that experienced fire events of all severities, and seemed especially attracted to edges where burned forest met unburned stands (Clark 2007, Bond *et al.* 2009). This is consistent with other observations of spotted owl habitat use in the Klamath Province, where increased edge between old-growth forest and other vegetation types were important habitat components (Franklin *et al.* 2000). Clark (2007) found that spotted owls did not use large patches of high severity burns, and Bevis *et al.* (1997) found spotted owls shifting their use away from areas burned at a higher severity to those burned at a lower severity; however, the results in both studies may be confounded due to post-fire logging that occurred in the burn areas. Bond *et al.* (2009) found owls selecting burned areas, including high-severity burns, over unburned areas for foraging when those areas were within 1.5 kilometers of a nest or roost site. Bond *et al.* (2009) postulated that selecting burned patches over unburned patches for foraging may be due to increased presence of prey, such as the dusky-footed woodrat, a species associated with open stands and increased shrub and herbaceous cover.

It is unknown whether spotted owl selection of high-severity burns for foraging would prevail in that portion of its range where dusky-footed woodrats are not available (eastern Washington Cascades and most of eastern Oregon Cascades). In these areas, northern flying squirrels are the principle prey species (Forsman *et al.* 2001, 2004, Sztukowski and Courtney 2004) and are more closely tied to closed canopy forest (Lehmkuhl *et al.* 2006a, b). It is difficult to tease out the relationship between prey abundance and prey selection by spotted owls, but studies suggest that variability in diet among spotted owls may be due to spatial variation in prey abundance (Forsman *et al.* 2001, 2004, Roberts and van Wagtendonk 2006). The degree that other prey species are available to spotted owls in post-burn areas outside of the range of the dusky-footed woodrat may affect their use of post-fire landscapes in this area.

There is evidence of spotted owls occupying territories that have been burned by fires of all severities. The limited data on spotted owl use of burned areas seems to indicate that different fire severities may provide for different functions. For example, spotted owls appear to select high severity burns for foraging, but avoid roosting or nesting in these sites. However, there are multiple confounding factors and uncertainties in the data on this topic which limit the strength of the conclusions that can be drawn. Few studies occur in areas where post-fire logging has not taken place, which confounds conclusions regarding non-use of burned areas. Studies that looked at habitat use by radio-marked spotted owls either have low sample sizes or suffer from other confounding effects. For example, Clark (2007) had the largest sample size of radio-marked spotted owls (n=26), but interpretation is confounded by prior management history as well as logging that occurred in the burned area post-fire. The largest sample size of radio-marked spotted owls monitored in burned areas that were not harvested post-fire was seven (Bond *et al.* 2009).

There are no long-term studies to look at how spotted owl habitat use of these sites changes through time since the burn; so far, habitat use studies have all occurred within four years of the fire. Survey information on spotted owls is not always adequate to allow rigorous comparison of spotted owl occupancy in the burn area before and after fire. Likewise, when adequate occupancy data is available pre-fire, the fate of spotted owls tied to sites that are deemed unoccupied after fire are often unknown; whether these spotted owls died in the fire, abandoned the area, or shifted their use to alternate sites within or adjacent to the burned area is rarely known. It is not clear whether spotted owls outside the range of the dusky-footed woodrat, a species tied to habitats consistent with the early seral conditions created by fire, would show similar use of burned areas as those spotted owls in areas where this prey species is available. Finally, we have a poor understanding of how spotted owl occupancy and habitat use are affected by the geographic scale of the disturbance, as well as the spatial arrangement and amount of unburned patches and patches exhibiting different burn severities within a home range. We can conclude that fires are a change agent for spotted owl habitat, but there are still many unknowns regarding how much fire benefits or adversely affects spotted owl habitat.

Restoring Dry Forest Ecosystems

Dry forest ecosystems exhibit tremendous complexity in structure and process, as well as in the relationships among and within biotic and abiotic components. Historically it was topography and disturbance regimes such as insects and fire that shaped the distribution and composition of vegetation across the landscape, with patches of shade-tolerant and fire-intolerant conifers spatially isolated from one another in the drier forest types. The disturbance regimes, along with the vegetation structure, composition and distribution have been substantially altered since Euro-American settlement. As a consequence, dry forest systems no longer function as they once did (Hessburg *et al.* 2005). There is not agreement on some regime descriptions within the range of the spotted owl (*e.g.,* Hanson *et al.* 2009, 2010, Spies *et al.* 2010b), and our understanding of fire regimes in certain dry forest types is changing (*e.g.,* Hessburg *et al.* 2007, Perry *et al.* 2011). Complicating the matter is the ongoing climate change that will likely increase the stressors on these systems. We may accurately predict some ecosystem changes and not others, but we can be confident that dry forest ecosystems will change in the face of projected climate change. Consequently, there are risks in any management decision we make, whether it be action or no action, active or passive management (Agee and Skinner 2005). Any actions we take should move dry forest systems on a path that will develop and retain the resiliency in the ecosystem to adequately respond to whatever changes do occur. The key to developing that resiliency is to restore the inherent forest structure and composition and to reintegrate the relationship between forest vegetation and the disturbance regimes.

As noted earlier in this document, our intent in this Revised Recovery Plan is to embed spotted owl conservation and recovery within broader dry forest ecosystem restoration efforts to increase the likelihood spotted owl habitat will remain on the landscape longer and develop as part of this fire adapted community instead of being consumed by uncharacteristic wildfires. Herein we borrow from original objectives described in SEI (2008). Our first objective is to develop and maintain adequate spotted owl habitat in the near term to allow spotted owls to persist in the face of threats from barred owl expansion and habitat alterations from fire and other disturbances. The second objective is to restore landscapes that are resilient to fire and other disturbances in the near term, and more resilient to alterations projected to occur with ongoing climate change. The final objective is to restore function of a variety of ecological services provided by late-successional and old forests. It is not our intent, nor do we believe it would be consistent with the above objectives, to do landscape-wide treatments for the purpose of excluding disturbance events such as fires, including high-severity fires. On the contrary, we are looking to support the disturbance regimes inherent to these systems and believe our management should be consistent with the counsel of Hessburg *et al.* (2007:21):

> "Restoring resilient forest ecosystems will necessitate managing for more natural patterns and patch size distributions of forest structure, composition, fuels, and fire regime area, not simply a

> reduction of fuels and thinning of trees to favor low severity fires."

We define resiliency as the "ability of a system to absorb change and variation without flipping into a different state where the variables and processes controlling structure and behavior suddenly change (Holling 1996:734-735)." Key to managing systems for resilience are to keep options open, view events in a regional rather than local context, and to manage for heterogeneity (Holling 1973). Furthermore, managers need to acknowledge our limited understanding and assume that unexpected events will happen. Therefore, managing for resilience does not require the need for precision in predicting future events, "but only a qualitative capacity to devise systems that can absorb and accommodate future events in whatever unexpected form they may take" (Holling 1973:21).

To accommodate future disturbances and restore ecosystem resiliency, we believe it is essential to restore ecosystem structure, composition and processes. Restoring ecosystem structures that provide resiliency will necessitate maintaining and restoring the biological legacies that typically persist through disturbance events and influence the recovery process in the post-disturbance landscape (Franklin *et al.* 2000). With respect to the dry forest landscapes, structural legacies include not only the large trees that tend to be fire tolerant, but the snags and downed wood that were created as a result of the disturbance event. Structural legacies serve valuable functions such as reproductive structures that facilitate plant propagation, modifying microclimates, or improving connectivity through the disturbed area (Franklin *et al.* 2007).

Restoring ecosystem composition that provides resiliency will necessitate managing for vegetative heterogeneity both within and among stands. Compositional, as well as structural heterogeneity, are influenced by tree growth and decline, competition among plants and the resulting mortality, as well as small-scale disturbances (Franklin *et al.* 2002, 2007). Heterogeneity in the patterns of vegetation composition and structure are key features of resilient forests (*e.g.,* Stephens *et al.* 2008). Complex arrangements and spatial patterns of vegetation produce a similar variability in fire behavior and effect, maintaining ecosystem heterogeneity (Stephens *et al.* 2010).

Restoring ecosystem processes that provide resiliency will aid in developing the vegetation structures, composition, patterns, and distributions advocated above. This would include managing for high-severity disturbance events in the appropriate landscape context. High severity fires, for example, provide valuable habitat for fire-dependent species (*e.g.,* Hutto 2008), as well as important seral conditions that contribute to biodiversity (Swanson *et al.* 2010). Conversely, specific locations on the landscape may be identified where it is desirable to manage the vegetation so that fire severity is reduced (*e.g.,* in wildland urban interface or in areas where human activities have increased available fuel (see Odion *et al.* 2004), or in areas where it is desirable to reduce the risk to valued structural legacies).

We believe restoring ecosystem processes will contribute to developing and maintaining ecosystem structure and heterogeneity, increasing the resiliency to disturbance events and ongoing climate change (Schoennagel *et al.* 2004, Fettig *et al.* 2007, Hessburg *et al.* 2007, Klenner *et al.* 2008, Stephens *et al.* 2008, 2010). Restoring these features would further allow the disturbance processes to play their inherent role in maintaining these features (Noss *et al.* 2006). The following treatment principles were derived from multiple sources (SEI 2008, Gaines *et al.* 2010, Hanson *et al.* 2010). We believe them to be consistent with the stated objectives above, and will be important to accommodating future disturbances and restoring ecosystem resiliency. These principles should be part of any dry forest restoration treatment:

1. Emphasize vegetation management treatments outside of spotted owl core areas or high value habitat where consistent with overall landscape project goals. The proportion of Federal land in the dry forest provinces that is currently spotted owl habitat ranges from 18 percent in the Eastern Washington Cascades to 42 percent in the Oregon Klamath Province (Davis and Lint 2005, Davis and Dugger in press). Thus, there are many opportunities to restore ecosystem components in areas that will have little direct effects on spotted owls. Where treatments will occur within spotted owl core areas or high value habitat, we recommend monitoring owl response to treatments or apply treatments as part of an adaptive management process to improve our understanding of how these activities affect spotted owls.

2. Design and implement restoration treatments at the landscape level. Treatments need to be placed in context with the surrounding landscape to be most effective and to accommodate the inherent disturbance regime (see USDA 2010).

3. Retain and restore key structural components, including large and old trees, large snags and downed logs. Retaining these structural features will conserve habitat, legacy, seed stock, and genetic values. In addition, vegetation management to reduce moisture competition and improve the vigor of these older trees will also be necessary. An emphasis should also be placed on retaining tree species that are fire and drought tolerant in those vegetation types that exhibit fire regimes typically of low or mixed severity or typically dominated by predominately a surface -fires regime. However, older trees likely present before fire exclusion should also be retained, regardless of their fire tolerance.

4. Retain and restore heterogeneity within stands (*i.e.,* manage for fine-scale mosaic within stands). This includes both vertical and horizontal diversity.

5. Retain and restore heterogeneity among stands (*i.e.,* manage for meso-scale mosaics across a landscape). Retain patches of denser, moister forests that are good quality spotted owl habitat, as appropriate, within the landscapes where fire may be more frequent but less severe, consistent with historic variability or modeled future variability, and

where its occurrence maintains and provides for desired levels of species and structural diversity.

6. Manage roads to address fire risk.
7. Use wildfires to meet vegetation management objectives where appropriate.

Some form of vegetation management will be necessary to address many of the restoration principles described above. This can be done through a variety of methods, including mechanical removal such as thinning, prescribed burning, or using naturally ignited fires burning within a specified prescription to meet ecological objectives (*i.e.*, wildland fire for resource use). There are risks associated with these treatments in their potential to disturb soils, affect long-term productivity, and increase the risk of exotic plant invasions. Managers need to account for and minimize these risks as they plan and implement restoration treatments. There is also limited information on the effects of these types of treatments on spotted owls; the few studies that have looked at effects of thinning on spotted owls were limited to prescriptions designed to increase stand productivity and decrease stand complexity rather than improve stand structure for spotted owl. To fill this knowledge gap, restoration treatments implemented inside spotted owl core areas or high value habitat should be initiated under a monitoring or adaptive management study to test their effects on spotted owl occupancy, demographic performance and habitat use.

Restoring the large and old fire-tolerant trees and structure requires more than simply retaining them where they are found. In places where fire exclusion or past management has increased the density of surrounding trees, the densities of these smaller trees will need to be reduced to decrease the competition for water and resultant susceptibility to drought stress and insect attack (Thomas *et al.* 2006). Reducing the stand basal area around residual target trees, including large trees present prior to settlement, can be effective in improving the vigor of several tree species (Larsson *et al.* 1983, Feeney *et al.* 1998, Kolb *et al.* 1998, Latham and Tappeiner 2002). This increased vigor helps individual trees to withstand drought stress and better ward off attacks from sap-feeding insects such as bark beetles (Amman and Logan 1998, Schmid and Mata 2005, Fettig *et al.* 2007), but only if done before an outbreak begins (Shore *et al.* 2006, Romme *et al.* 2006). Thinning to improve tree vigor may not be as effective in reducing a stand's susceptibility to defoliating insects, such as western spruce budworm (Muzika and Liebhold 2000), but it may reduce insect densities and ultimate stand damage if the treatment is focused on reducing the tree host species within the stand (Swetnam and Lynch 1993, Su *et al.* 1996).

Mountain pine beetles, at least in lodgepole pine stands, tend to prefer larger trees (Safranyik and Carroll 2006). Their preference for tree size is less clear in ponderosa pine stands (Olsen *et al.* 1996, Negron and Popp 2004). Thus, while thinning lodgepole stands may improve tree vigor and resistance, the larger remnant trees may increase the likelihood of beetle colonization in the stand, particularly once an outbreak begins (Mitchell and Preisler 1991, Preisler and Mitchell 1993). This risk needs to be considered when managing vegetation to reduce risk of insect attack. Finally, when treating vegetation to reduce susceptibility to insect attack, care needs to be taken to ensure treatments do not increase risk of attack through injury (Jenkins *et al.* 2008).

Vegetation management for the purpose of altering fuels to modify fire behavior at specific locations can be effective (Omi and Martinson 2002, Pollet and Omi 2002, Martinson *et al.* 2003). This assumes, however, that surface fuels generated from the stand treatment were reduced or removed. Otherwise, severities can actually be higher with treatment (Weatherspoon and Skinner 1995, Raymond and Peterson 2005, Prichard *et al.* 2010). In addition, retaining structures that are fire resistant (*e.g.*, retaining the largest trees) will improve effectiveness (Omi and Martinson 2002, Agee and Skinner 2005). Fire severity, however, results from a complex interaction of fuels (including composition and moisture), topography (including slope percent , elevation, and aspect), and fire weather (including wind and temperature). Variations in each of these components and interactions among them will influence fire behavior and its resultant burn severity. Understanding how these components interact within local fire regimes is important to implementing effective restoration treatments. For example, thinning and underburning have resulted in lower fire severities than those observed in untreated stands across a variety of geographical areas and vegetation types (*e.g.,* Pollet and Omi 2002). However, the mixed evergreen forests of the Klamath Province may exhibit stand development pathways that result in different fire susceptibilities (see Perry *et al.* 2011). For example, lower fire severities were observed in stands with longer fire-free periods as well as in untreated stands with closed canopies or with larger, more mature forest conditions, when compared to treated stands (Weatherspoon and Skinner 1995, Odion *et al.* 2004, Alexander *et al.* 2006, Thompson and Spies 2009). Severities of past fires may be a major determinant of future fire severity; for example, in the Klamath Province, stands burned by high severity fires in the previous one or two decades have been observed to reburn at high severity (Odion *et al.* 2010, Thompson *et al.* 2007, Thompson and Spies 2010). Aspect and slope have been tied to fire severity is some areas (*e.g.*, Alexander *et al.* 2006) but not others (*e.g.*, Turner *et al.* 1999). Fire severity within a given patch may be affected by the surrounding landscape (*e.g.* Weatherspoon and Skinner 1995). Finally, extreme fire weather events can overwhelm a stand's resistance to fire, resulting in high severity burns regardless of the topography, fuel condition or prior management (Martinson *et al.* 2003, Skinner *et al.* 2006). Thus, treatments to reduce fire severity need to be strategically located and designed with specific objectives and a clear understanding of how the local landscape responds to the many variables that influence fire severity.

Fuel treatments have other limitations that need to be considered in their application. Treatments require maintenance if they are to remain effective (Agee and Skinner 2005, Reinhardt *et al.* 2008). In addition, treatments that are not maintained may actually result in fire behavior that is more deleterious than expected without treatment (Ager *et al.* 2007b). Finally, given the stochastic nature of fires, without extremely large-scale treatments that may be neither economically nor socially feasible, there is a low probability of fires intercepting fuel breaks (Rhodes and Baker 2008). However, modeling indicates that strategic placement can improve treatment leverage (*i.e.,* increase the ratio of acres experiencing reduced fire severity to acres treated) (*e.g.,* Loehle 2004, Schmidt *et al.* 2008). Fuel treatments need to be strategically located with clear objectives. They should not be used for the purpose of "fireproofing" the forest. Rather, they should be designed to increase the acceptability of wildfire through reducing fire behavior and severity in local areas, rather than simply to reduce fire occurrence, size, or amount of burned area per se (Reinhardt *et al.* 2008).

Vegetation management treatments that are strategically located in a landscape context are encouraged to restore structural elements, restore heterogeneity within and among stands, and which increase resiliency to future fires and other disturbance events. A necessity of any vegetation management treatment, regardless of its purpose, is to ensure that slash and other residual fuels generated as part of the project are adequately treated so as not to increase fire severity or risk (Agee and Skinner 2005). Treatments should allow us to incorporate future disturbance events as a means to restore and maintain desired ecosystem components and heterogeneity (Noss *et al.* 2006, Reinhardt *et al.* 2008). Prescribed fire may be a means to reintroduce fire as an ecosystem process, but will likely need to be implemented at scales much greater than what has been done in the past to be effective (Baker 1994, Taylor 2000); such a scale may not be socially or politically acceptable at this time (Stephens and Ruth 2005, Schulte *et al.* 2006). Developing wildfire management plans to allow the use of wildfires to meet vegetation management objectives is another tool that the Service encourages.

Need for Active Management

The characterization of fire risk in the dry forest provinces within the range of the spotted owl has recently been argued in the scientific literature (Hanson *et al.* 2009, 2010, Spies *et al.* 2010b). In short, Hanson *et al.* (2009) concluded that, given the low risk of high-severity fire in these provinces, there is time to conduct needed research to fill key information gaps before committing to a large-scale strategy of active management. We acknowledge the value that some high-severity fires may provide to spotted owls in areas where these effects have been studied, though there are many limitations with the existing data to make strong conclusions. We also agree with the authors that an adaptive management framework should be in place so that we can learn from our management efforts as we go forth, and have included an adaptive management discussion in this plan. However, given the highly altered condition of the existing dry forest ecosystem and the effects of ongoing climate change on the currently compromised functions, we believe restoration of dry forest ecosystem structures and processes must begin now and cannot wait for all key information gaps to be filled.

As an example, the Gotchen Risk Reduction and Restoration Project was designed to reduce fire risk and promote forest health in the Gotchen LSR and the surrounding landscape of the Eastern Washington Cascades on the Gifford

Pinchot National Forest. Forest health in the area had declined dramatically due to a history of selective timber harvest, fire suppression, and widespread tree mortality caused by insects and diseases (USFS 2003). The project included over 2,200 acres of strategic thinning and fuels treatments to reduce the risk of catastrophic wildfire including some degradation of spotted owl habitat deemed necessary to achieve the objectives of the project. Treatment areas included over 1,000 acres of suitable spotted owl habitat, but direct impacts to spotted owls were minimized by avoiding treatments near known spotted owl nest sites.

There are some questions under adaptive management that may be answered within the next several years, the results of which can be applied to future management decisions (*e.g.,* how do spotted owls use areas treated with specific vegetation management prescriptions intended to promote structural features conducive to spotted owl habitat?). Other questions, particularly population-based questions such as how spotted owls respond to disturbance processes, may take decades before clear conclusions can be drawn from those studies. The risk in waiting this long before pursuing restoration activities is a continued loss of valued ecological structures (*e.g.,* large, fire-tolerant trees) to increased drought stress that is projected with future climate change, as well as continued decoupling of vegetation patterns from disturbance processes. In the immediate future, we need to pursue restoration activities that are strategic and that focus on restoring and maintaining ecosystem structure, composition, patterns and processes with an eye towards maintaining resiliency in the face of future climate change.

We also stress this cannot be done successfully without an aggressive adaptive management framework to learn from treatments. Land managers should use pilot projects and active management to test or demonstrate techniques and principles (Noon and Blakesley 2006). In the near term, to reduce conflict and potential inconsistencies with existing Federal land management plans, we recommend locating such projects wherever possible in Matrix and Adaptive Management Areas. However, we continue to recommend that such actions be considered in LSRs as well (Gaines *et al.* 2010). An example of a site-specific plan that could be emulated in other areas is the Okanogan-Wenatchee National Forest Restoration Strategy (USDA 2010). This strategy applies many of the concepts described in this Plan to meet the overlapping goals of spotted owl recovery and ecosystem management.

Conclusions Regarding Dry Forest Management

Given the complexity of the disturbance regimes in dry forest systems, response of spotted owls to these disturbances, and the projected influence that climate change will play on these regimes, this Revised Recovery Plan recognizes that active management of vegetation within the dry forest landscape is needed to restore ecosystem resiliency consistent with spotted owl conservation objectives. Restoration of forest ecosystems that are resilient to the endemic disturbance regimes and adaptive to impending climate change is a primary goal of any dry forest recovery strategy and needs to include some form of active management to achieve that objective. Our knowledge is far from complete, and management to restore these systems will be challenging. These knowledge gaps need to be addressed through a well-defined adaptive management approach that reduces biological risk to the spotted owl and provides information to inform future management decisions.

The 2008 Plan called for establishing an interagency, science-based Dry forest Landscape Work Group (DFLWG) as a recovery implementation team to assist the Service in designing a strategy for managing the Klamath Provinces, the Eastern Washington Cascades, Eastern Oregon Cascades, and California Cascades Provinces. Shortly after publication of the 2008 Plan, the Service created another recovery implementation team, the Klamath Province Work Group to address dry forest issues in the Klamath Provinces, leaving the DFLWG to cover the Cascades portion of the dry forest landscape (To more clearly identify the geographic responsibility of the DFLWG, we are renaming it the Dry Cascades Work Group as part of this recovery plan). Both of these work groups were tasked with helping identify landscape-scale approaches to managing these areas based on the restoration of ecosystem processes.

- ***Recovery Action 7: Create an interagency Dry Cascades Work Group that is available to assist land managers in developing and evaluating landscape-level recovery strategies for the Eastern Washington, Eastern Oregon, and California Cascades Provinces, including monitoring and adaptive management actions.***

The DFLWG has been working to evaluate and develop landscape approaches to restoring forest ecosystem structure and processes in support of spotted owl recovery. The work group members represented a broad array of expertise in different technical fields from different geographical areas. Researchers and practitioners comprised the work group, and members brought forward different interpretations of the research in dry forest systems. After this plan is finalized, the Service will appoint a new recovery implementation team, the Dry Cascades Work Group, using a similar diverse array of expertise to continue this work and find areas of agreement upon which a strategy for the dry Cascades provinces can be developed.

This implementation team will be available to help local land management units with the design and development of new prescriptions and treatments for fuel reduction and other dry forest management strategies through training, workshops or other information transfer methods. It may also be asked to develop an integrated strategy for all the Eastern Washington, Eastern Oregon, and California Cascades Provinces. This may include:

1. Recommending relevant research.
2. Standardizing, to the extent possible, new recommendations for prescriptions and treatments for fuel reduction and other dry forest management to facilitate regional comparisons by meta-analysis and to maximize the scientific and management value of studies.

3. Standardizing, to the extent possible, experimental designs to assist with comparability across the region and to ensure statistically valid results.
4. Assisting in the development or evaluation of plans that include landscape specific habitat objectives, treatment strategies, and projected outcomes.
5. Developing monitoring techniques and coordinating effort. Given the uncertainties concerning sustaining spotted owl habitat in dry forest landscapes, monitoring is imperative. Characteristics that may be important to monitor in any dry forest landscape managed for spotted owl habitat include:
   - Total spotted owl habitat area and condition;
   - Dispersal habitat and condition;
   - Effectiveness of spatial isolation on spotted owl habitat clusters;
   - Pattern, amount, and timing of management activities and natural disturbances;
   - Preferred timing of follow-up treatments by area;
   - Patch recruitment potential and timing as replacement spotted owl habitat relative to fledging success; interactions with barred owls; and stand-level prey response to treatments, including habitat elements that support prey (mistletoe, snags, downed wood, forage lichens, truffle abundance);
   - Spotted owl response to habitat and dispersal areas; and
   - Occupancy breeding pairs or single spotted owls

- ***Recovery Action 8: In Eastern Washington, Eastern Oregon and California Cascades Provinces, analyze existing data on spotted owl occupancy pre- and post-fire and establish a consistent database to track owl occupancy response to fires across the dry Cascades provinces.***

Data currently exist that may aid our understanding of spotted owl occupancy of sites after a fire. Most National Forest units in these provinces annually monitor known spotted owl sites for occupancy, and they have accumulated occupancy data sets in burned and unburned areas. Members of the DFLWG have begun compiling and analyzing existing data on occupancy rates of spotted owls in burned and unburned sites, as well as fire extent and severity in the burned sites, to determine how fire influences occupancy rates of spotted owls. We anticipate the DCWG will continue this effort. Existing data on pre- and post-fire vegetation structure is also being analyzed to determine possible connections between pre-fire estimates of fuel loads, fire severity, and subsequent spotted owl occupancy to inform risk analysis efforts. These data should be entered into a database to track future data on spotted owl occupancy and fires. Data collection standards should be established to aid comparison of data among the provinces to aid in comparison across the provinces, though these standards will be subject to change if methodology improvements become available. This synthesis and analysis will inform land managers about how fuel loads in and adjacent to spotted owl habitats can be managed.

- ***Recovery Action 9: Create an interagency Klamath Province Work Group that is available to assist land managers in developing and evaluating landscape-level recovery strategies for the Oregon and California Klamath physiographic province, which include monitoring and adaptive management actions.***

The KPWG was formed as a recovery implementation team as a result of Recovery Action 8 in the 2008 Recovery Plan, and has been operating since 2008. During the course of several meetings and workshops in 2008 and 2009, the KPWG established a multi-step approach for evaluation of potential alternative conservation strategies for spotted owls in the Klamath Province, a combined view of the Oregon and California Klamath Provinces. The primary steps included: (1) conduct a thorough review of the literature, spotted owl data sets, and spatial information and synthesize into a report describing spotted owl habitat in the Klamath Province, and the role of fire in developing, maintaining, modifying, and removing spotted owl habitat at multiple scales; (2) use spatially-explicit predictive models, developed and validated using current spotted owl location data from the Klamath Province, to identify areas of high-value spotted owl habitat based on forest composition and structure, climate variables, and topographic features; and (3) integrate spotted owl habitat models with models of fire occurrence and severity patterns to identify and prioritize areas for habitat protection, habitat restoration, and fuels treatment. This implementation team will be available to help land management units with the design and development of new prescriptions and treatments for fuel reduction and other dry forest management strategies through training, workshops or other information transfer methods.

Spotted Owl Habitat Conservation on All Landscapes

This Revised Recovery Plan recommends building on the principles established in the NWFP to conserve and restore more occupied and high-value spotted owl habitat, including increased conservation of habitat on some Federal "Matrix" lands and the evaluation of potential contributions from State and private lands.

This Plan does not propose a new or revised mapped habitat reserve network and continues to recommend reliance upon the LSRs of the NWFP throughout the range of the spotted owl. In addition, the Service sought remand of the 2008 spotted owl critical habitat designation in a recent court case and will consider revisions to the designation, with a final rule to be published by the end of 2012. Critical habitat designation defines and maps those geographical areas essential to the conservation of the species. Particularly in light of the fact that a revised designation based on the latest and best available information is imminent, the

Service believes it is appropriate to use the critical habitat rulemaking process to identify any essential habitat areas for the spotted owl in addition to the LSR system.

Because of the value to spotted owls, it is likely that much of the LSR network that was originally established in the NWFP process will continue to serve as the foundation for the spotted owl recovery on Federal lands. We expect that recommendations made in this Revised Recovery Plan concerning active management of spotted owl habitat, if applied by land managers, will be beneficial to spotted owl conservation and thus may not be considered as having a significant adverse effect on the spotted owl or its critical habitat in the long-term. Final decisions concerning these and other issues will be made as part of the critical habitat revision and section 7 consultation processes.

Conserving Occupied and High Value Spotted Owl Habitat

The three main threats to the spotted owl are competition from barred owls, past habitat loss, and current habitat loss (USFWS 2008b). Despite the habitat protections of the NWFP, the most recent demographic analysis (Forsman *et al.* 2011) indicates that spotted owl populations are declining on 7 of the 11 active demographic study areas at about 3 percent annually range-wide. Scientific peer reviewers and Forsman *et al*. (2011) recommended that we address this downward demographic trend by protecting known spotted owl sites in addition to the retention of structurally-complex forest habitat.

The Service recommends conserving occupied spotted owl sites throughout the range, especially those containing the habitat conditions to support successful reproduction. This recommendation is especially important in the short-term, until spotted owl population trends improve (Forsman *et al.* 2011).

Conservation of important spotted owl habitat depends on the application of a two-tiered approach to forest land management decisions as follows:

1. Conserve spotted owl sites and high-value spotted owl habitat where possible in addition to Federal conservation blocks to provide additional demographic support to the spotted owl population (see Recovery Action 10, below).
    a. This recommendation includes currently occupied as well as historically occupied sites (collectively “spotted owl sites,” see Appendix G: Glossary of Terms).
    b. Work with land managers and spotted owl field scientists to develop prescriptions and approaches to implement this recommendation. At a minimum, this prescription should retain sufficient NRF habitat within the provincial core-use area and within the provincial home range to support breeding, feeding and sheltering.

2. Maintain and restore the older and more structurally complex multi-layered conifer forests on all lands (see Recovery Action 32 under Listing factor E).

It is clear that these two recommendations overlap. It is our hope that their application on Federal, State, and private lands will more effectively address the threats of competition with and displacement by barred owls, as well as the impacts of past and current habitat loss.

This recommendation can be justified at several scales. At the scale of a spotted owl territory, several studies have shown a positive association between spotted owl fitness and spotted owl habitat or a mosaic of habitat types (Franklin *et al.* 2000, Dugger *et al.* 2005, Olson *et al.* 2004). Additionally, Dugger *et al.* (in press) found an inverse relationship between the amount of old forest within the core area and spotted owl extinction rates from territories. At the population scale, Forsman *et al.* (2011) found a positive relationship between recruitment of spotted owls into the overall population and the percent cover of spotted owl NRF habitat within study areas. This multi-scale research suggests retention of spotted owl habitat within spotted owl territories positively affects demographic rates. Because spotted owls on established territories are likely to be more successful if they remain in those locations (Franklin *et al.* 2000), managing to retain spotted owls at existing sites should be the most effective approach to bolstering the demographic contribution of a habitat conservation network and the highest priority for land managers. Retention of long-term occupancy and reproduction at established spotted owl sites will require a coordinated and cooperative effort to craft management approaches tailored to regional, provincial or local conditions.

- ***Recovery Action 10 - Conserve spotted owl sites and high value spotted owl habitat to provide additional demographic support to the spotted owl population.***

For Federal lands, create an interagency scientific team to use the latest and best available habitat modeling information and other data to identify these high value areas. This recovery implementation team will make recommendations for areas to conserve and manage based upon the following criteria and considerations:

- Use of habitat modeling to better identify high value habitat, including consideration of abiotic factors that influence spotted owl usage.

- Use of demographic monitoring and survey data, if available, to inform other measures of value, such as maintaining population distribution in underrepresented areas or to reflect the most current habitat conditions.

- How retention of specific areas may affect probability of persistence of the spotted owl population at the province scale. Use this evaluation to establish "thresholds" for recommendations of which areas to conserve or not.

- Consideration of related barred owl impacts, influence, and management decisions and the likely success of such management actions in those areas.

The intent of this recovery action is to protect, enhance and develop habitat in the quantity and distribution necessary to provide for the long-term recovery of spotted owls. The Service will use the results of this effort to inform subsequent recommendations or decisions regarding the quantity and spatial configuration of habitat necessary to support the recovery of spotted owls. The spatial depiction informed by the habitat modeling efforts will better identify areas where land managers should consider protecting, enhancing and developing habitat to support recovery of spotted owls and, where appropriate, will seek additional public review and comment (*e.g.*, as part of proposed critical habitat). Where the modeling output and/or examination on the ground indicate that forest stands could and should be enhanced or developed through vegetation management activities to improve long-term habitat conditions, or to create improved habitat for spotted owls, larger habitat patches, or increased connectivity between patches, they should generally be encouraged even if they result in short-term impacts to existing spotted owls. However, such a process should occur where a determination is made that these longer term goals outweigh short-term impacts.

Interim Guidance

In the interim time period while the above team process is formalized and carried out, we recommend the following process be followed.

When planning management activities, Federal and non-federal land managers should work with the Service to prioritize known and historic spotted owl sites for conservation and/or maintenance of existing levels of habitat. The prioritization factors to consider are reproductive status and site condition.

The site conservation priorities for reproductive status are:

- Known sites with reproductive pairs;
- Known sites with pairs;
- Known sites with resident singles; and
- Historic sites with reproductive pairs, pairs, and resident singles, respectively.

The priority for site condition is sites currently with $\geq$40% in the provincial home range (*e.g.*, 1.3 mile radius) and $\geq$50% habitat within the core home range (*e.g.*, 0.5 mile radius). This prioritization provides a guide to evaluate the relative impacts of management actions, and conservation of sites that provide the most support to spotted owl demography.

When implementing this interim process, land managers and the Service should utilize professional judgment as to the best available site-specific data (collectively across years, if appropriate). These data may be contained in agency databases, land manager files, or other sources. Managers can also decide to conduct surveys to document current status.

Land managers should prioritize vegetation management and silvicultural treatments intended to enhance habitat conditions based on:

- Status as follows:
  - Unoccupied stands
  - Miscellaneous observations sites
  - Historic sites and;
  - Known sites – resident singles;
  - Known sites – resident pairs.
- Known sites with ≤40% in the provincial home range and ≤50% habitat within the core home range
- Ability to affect meaningful structural change in ≤30 years. Land managers should generally avoid activities that would reduce nesting, roosting and foraging habitat within provincial home ranges (*e.g.*, 1.3 mile radius) of reproductive pairs. Activities which address threats from stochastic disturbance (*e.g.*, insect, disease, wildfire, etc.) by restoration action will generally be consistent with the intent of RA 10 even if short-term effects to spotted owls would occur.

In unsurveyed spotted owl habitat, the agencies and the Service should work cooperatively through the Endangered Species Act consultation process to minimize impacts to potential spotted owl sites. It is likely to be most beneficial to address these areas as early in the planning process as possible. Non-federal land managers should seek technical assistance from the FWS as appropriate.

It is not uncommon for an occupied spotted owl site to be unoccupied in subsequent years, only to be re-occupied by the same or different spotted owls two, three or even more years later (Dugger *et al.* 2009). While temporarily unoccupied, these sites provide conservation value to the species by providing habitat that can be used by spotted owls on nearby sites while also providing viable locations on which future pairs or territorial singles can establish territories. Where unique circumstances or questions arise (*e.g.,* multiple activity centers, etc.), the Service is available to assist land managers with applying this recovery action.

As a general rule, forest management activities that are likely to diminish a home range's capability to support spotted owl occupancy, survival and reproduction in the long-term should be discouraged. However, we recognize that land managers have a variety of forest management obligations and that spotted owls may not be the sole driver in these decisions. Here, active forest management may be necessary to maintain or improve ecological conditions. We support projects whose intent is to provide long-term benefits to forest resiliency and restore natural forest dynamic process, when this management is implemented in a landscape context and with carefully applied prescriptions to promote long-term forest health. Examples of active management projects include forest stand restoration, fire risk reduction, treatment of insect infestations and disease and the restoration of high quality early seral habitat as described by Swanson *et al.* (2010). It is recognized that these projects may have both short and/or long-term effects to spotted owls and that treatments will be designed to minimize impacts as much as possible in keeping with project's intent.

Given natural events such as fire, wind storms, and insect damage, not all habitat-capable lands in a spotted owl home range are likely to contain spotted owl habitat at any one time. The amount and distribution of existing habitat within a home range may determine which management options will have greater or lesser impacts to the ability of spotted owls to occupy and reproduce in those areas. This, in turn, may affect the flexibility for land managers to implement traditional timber harvests while meeting the intent of this recovery action.

In the drier and southern portions of the range, managing for dense older forest mixed with some younger or more structurally diverse stands may also be appropriate (Franklin *et al.* 2000, Olson *et al.* 2004, but see Dugger *et al.* 2005). The Service recognizes there is tremendous variation across the species' range in such habitat conditions, and therefore, we expect to work closely with the BLM, FS and other land managers to define how to best meet the intent of this recommendation.

There is a wide breadth of spotted owl occupancy data throughout the species' range. Where spotted owl occupancy data are unavailable (*e.g*., unsurveyed habitat), land managers have a variety of tools to assist in determining where likely occupied habitat is and how to implement this recovery action, including assumption of occupancy (a common practice during section 7 consultation), surveys, spotted owl modeling results, forest stand data, etc.

Monitoring data, interagency teams, and adaptive management feedback will be useful tools in future revisions of this recovery action and its implementation, and may result in more refined approaches to implementation of this recovery action in the future. In cases where active management is conducted, assessing the effectiveness of treatments within spotted owl home ranges will provide land managers valuable feedback on how to design future projects and approaches within spotted owl home ranges. Land managers and researchers have numerous tools available to assess project efficacy, including spotted owl surveys, habitat mapping, prey analysis and modeling results. When opportunities arise, integration of monitoring in an adaptive management framework would be particularly valuable. The utility of each tool is largely dependent on the pre-project data available for comparison.

Research directly evaluating spotted owl responses to vegetation management including thinning, fuels reduction, and management intended to restore ecosystem functions is needed to address: (1) whether vegetation treatments result in development of desired habitat conditions; (2) whether treatments designed to create spotted owl habitat are used by spotted owls as NRF habitat conditions develop; (3) whether thinning operations designed to create future spotted owl habitat result in site abandonment during or after the operation and what types of vegetation management operations will allow spotted owls to persist on existing territories (minimize short-term negative effects); and (4) whether fuel reduction treatments can be done in a manner consistent with retaining occupied spotted owl sites and developing future spotted owl habitat on the landscape.

- ***Recovery Action 11: When vegetation management treatments are proposed to restore or enhance habitat for spotted owls (e.g., thinnings, restoration projects, prescribed fire, etc.), consider designing and conducting experiments to better understand how these different actions influence the development of spotted owl habitat, spotted owl prey abundance and distribution, and spotted owl demographic performance at local and regional scales.***

Additional research that identifies both short-term and long-term responses of prey populations (northern flying squirrels, woodrats, and other small mammals) to thinning treatments is also needed. Such forest management experiments should recognize the management activities known to negatively affect spotted owls discussed earlier and seek to expand our understanding of practices that will improve conditions for spotted owls and their prey.

We encourage collaborative efforts among State and Federal agencies, research scientists, and other interested parties where possible. In order to address the questions presented above, both intensive field research projects and larger, retrospective analyses that examine how different forest practices influence development of spotted owl habitat over time are needed.

Post-fire Logging

Decisions to harvest timber after wildfires often are based on financial considerations, human safety, a desire to modify the composition and resource production of forests, and a desire to "clean up the forest" (Foster and Orwig 2006, Noss and Lindenmayer 2006, Lindenmayer *et al.* 2008). Possible beneficial ecological effects of post-fire timber harvest include: decreased erosion due to placement of debris on the forest floor which intercepts surface water flow; decreased buildup of insect pests due to dead tree removal; decreased magnitude and extent of lethal soil temperatures around burning coarse woody debris; and, in stands where harvest-generated slash is treated, decreased fire risk due to removal of snags (McIver and Starr 2000, Lindenmayer *et al.* 2008, Monsanto and Agee 2008, Peterson *et al.* 2009). However, support is lacking for the contention that reduction of fuels from post-fire harvest reduces the intensity of subsequent fires (McIver and Starr 2000), and planting of trees after post-fire harvest can have the opposite effect. For example, forests in southwest Oregon that were logged and planted after a 1987 fire burned more severely in a 2002 fire than areas that were not logged or planted due, evidently, to high fuel conditions in conifer plantations (Thompson *et al.* 2007).

Detrimental ecological effects of post-fire timber harvest include: increased erosion and sedimentation, especially due to construction of new roads; damage to soils and nutrient-cycling processes due to compaction and displacement of soils; reduction in soil-nutrient levels; removal of snags and, in many cases, live trees (both of which are habitat for spotted owls and their prey); decreased regeneration of trees; shortening in duration of early-successional ecosystems; increased spread of weeds from vehicles; damage to recolonizing vegetation; reduction in hiding cover and downed woody material used by spotted owl prey; altered composition of plant species; increased short-term fire risk when harvest generated slash is not treated and medium-term fire risk due to creation of conifer plantations; reduction in shading; increase in soil and stream temperatures; and alterations of patterns of landscape heterogeneity (Perry *et al.* 1989, McIver and Starr 2000, Beschta *et al.* 2004, Karr *et al.* 2004, Donato *et al.* 2006, Lindenmayer and Noss 2006, Reeves *et al.* 2006, Russell *et al.* 2006, Thompson *et al.* 2007, Lindenmayer *et al.* 2008, Johnson and Franklin 2009, Peterson *et al.* 2009, Swanson *et al.* 2010). Soil damage and erosion are higher with traditional harvesting systems (*e.g.*, tractors) than they are with advanced systems (*e.g.*, helicopters) (Klock 1975, Peterson *et al.* 2009). After the 1988 Yellowstone fire, rates of soil loss were greatest where litter cover was minimal, percent silt content was high, and postfire logging had been conducted (Marston and Haire 1990 in McIver and Starr 2000). Moreover, post-fire timber harvest activities "undermine many of the ecosystem benefits of major disturbances" (Lindenmayer *et al.* 2004:1303) and frequently "ignore important ecological lessons, especially the role of disturbances in diversifying and rejuvenating landscapes" (DellaSala *et al.* 2006:51). To avoid crisis-mode decision-making and to minimize these detrimental effects, ecologically-informed policies based on pre-fire management direction should be developed before fires occur (Lindenmayer *et al.* 2008, Johnson and Franklin 2009).

Results from the three radio-telemetry studies of spotted owls in post-fire landscapes indicate that spotted owls use forest stands that have been burned, but generally do not use stands that have been burned and logged. For example, California spotted owls tracked 4 years post-fire in burned, unlogged stands: (1) had 30 percent of their nonbreeding-season roost locations within the fire's perimeter (Bond *et al.* 2010); (2) selected low-severity burned forests for roosting during the breeding season (Bond *et al.* 2009); and (3) selected low-, medium-, and high-severity burned forests for foraging within 1.5 km of the nest or roost site, with the strongest selection for high-severity burned forest (Bond *et al.* 2009). However, for spotted owls in stands that had been harvested post-fire: (1) infrequent foraging in stands burned with low-, medium-, and high-severity fires was restricted to areas with live trees such as those in riparian areas (Clark 2007), and (2) use shifted away from burned stands during 3 years post-fire (King *et al.* 1998). Comprehensive analyses quantifying how spatial configuration of forest type, burn intensity, and post-fire logging affects spotted owl demographic and occupancy rates will provide critical information for maintaining habitat during fuels-management activities.

Consistent with restoration goals, post-fire management in these areas should promote the development of habitat elements that support spotted owls and their prey, especially those which require the most time to develop or recover (*e.g.*, large trees, snags, downed wood). Such management should include retention of large trees and defective trees, rehabilitation of roads and firelines, and planting of native species (Beschta *et al.* 2004, Hutto 2006, Peterson *et al.* 2009). We anticipate many cases where the best approach to retain these features involves few or no management activities. Forests affected by medium- and low-severity fires are still often used by spotted owls and should be managed accordingly. Many researchers supported the need to maintain habitat for spotted owl prey. For example, Lemkuhl *et al.* (2006) confirmed the importance of maintaining snags, downed wood, canopy cover, and mistletoe to support populations of spotted owl prey species. Gomez *et al.* (2005) noted the importance of fungal sporocarps which were positively associated with large downed wood retained on site post-harvest. Carey *et al.* (1991) and Carey(1995) noted the importance of at least 10 to 15 percent cover of downed wood to benefit prey. The costs and benefits of post-fire harvest to the development of habitat for spotted owls and their prey should be evaluated by interagency teams (*e.g.*, Level 1 teams) during the consultation process.

- ***Recovery Action 12: In lands where management is focused on development of spotted owl habitat, post-fire silvicultural activities should concentrate on conserving and restoring habitat elements that take a long time to develop (e.g., large trees, medium and large snags, downed wood).*** Examples of areas where we believe this recovery action would greatly benefit future spotted owl habitat development include such fire-affected areas as the Biscuit fire, the Davis fire and the B&B complex.

Habitat Definitions

While some area-specific definitions of habitat have been developed in parts of the spotted owl's range, identification of existing spotted owl habitat and the management of lands to provide new habitat in the future would benefit greatly from a range-wide set of province-specific definitions of spotted owl habitat (*e.g.,* high-quality, nesting/roosting, foraging, dispersal). Variation in habitat structure and use across the spotted owl's range drives the need for province-specific definitions. The definitions should use forest composition and structure vernacular so that spotted owl habitat can be described in forest-management terms, and may also incorporate spatial and abiotic features that help determine where spotted owls use these types of stands. As part of our habitat modeling process (Appendix C), we solicited information from spotted owl experts on the regional biotic and abiotic factors that dictated where on the landscape spotted owls nested and roosted, and on regional definitions of spotted owl foraging habitat. These data will provide a good starting point for this effort.

- ***Recovery Action 13: Standardize province-specific habitat definitions across the range of the spotted owl using a collaborative process.***

Tribal Lands

The Service received comments from a number of American Indian Tribes on the draft Revised Recovery Plan indicating concerns that Tribal lands were not recognized separately from other non-federal lands. It was not the Service's intent to imply that Tribal lands are the same as other non-federal lands. The Revised Recovery Plan is not intended to affect the American Indian Tribal governments' rights to manage their lands. We understand Tribal lands are managed in accordance with Tribal goals and objectives, within the framework of applicable laws.

The Service recognizes the special government-to-government relationship between the Federal government of the United States and American Indian Tribal governments derived from the Constitution of the United States, treaties, Supreme Court doctrine, and Federal statutes. The Service acknowledges American Indian Tribal governments as sovereign nations with inherent powers of self-governance.

The Service also recognizes American Indian Tribes have long worked to conserve and monitor spotted owls on their lands. The efforts of many Tribes have contributed to spotted owl conservation and maintained the Tribal cultural values of the spotted owl and its habitat. Many Tribal lands have been managed with a holistic perspective, including reserves and modified silvicultural practices, and therefore can be islands of high quality habitat that support many species as well as healthy ecosystems. The Service is proud of our many positive government-to-government collaborations with American Indian Tribes and the benefits to fish and wildlife conservation.

The Service is committed to engaging in regular and meaningful consultation and collaboration with American Indian Tribal governments to determine what cooperative and voluntary measures Tribes may take to support spotted owl recovery actions and address other recovery needs and opportunities for spotted owls, recognizing the special status of Tribal lands. Consistent with existing laws and policies, and to honor this spirit of consultation and collaboration, the Service will give full consideration to tribal recovery plans, habitat and modeling data, and other conservation efforts.

All of the Service's actions, including our consultation and collaboration, will take place on a government-to-government basis and be consistent with applicable executive and secretarial orders, memoranda, and policies, including Executive Order 13175, "Consultation and Coordination with Indian Tribal Governments" (11/6/2000); Secretarial Order 3206, "American Indian Tribal Rights, Federal-Tribal Responsibilities, and the Endangered Species Act" (6/5/97); Presidential Memorandum (11/5/09); the U.S. Fish and Wildlife Service's Native American Policy (6/28/94), and the Endangered Species Act.

The Service may enter Memoranda of Understanding with Tribes for (a) mutually agreeable species conservation efforts, (b) utilizing Tribal habitat and modeling data regarding the presence of threatened, endangered, or candidate species on Tribal lands, and (c) processes to discuss and resolve matters regarding each government's spotted owl recovery efforts and obligations.

State and Private Lands

This Revised Recovery Plan acknowledges the role State and private lands can contribute toward recovering the spotted owl. The relative importance of this role to spotted owl recovery should be assessed. In 1994, in its biological opinion on the NWFP, the Service concluded that the NWFP met or exceeded the standards expected for the Federal contribution to recovery of the spotted owl. The Service also concluded in that opinion that overall recovery of the species would be further evaluated to determine recovery needs on non-federal lands. Since 1994, Federal lands have provided the majority of contribution to spotted owl recovery, and in many portions of the range it provides the sole contribution. However, there are portions of the range where habitat on Federal lands are lacking or of low quality or where there is little Federal ownership, and State and private lands may be able to improve recovery potential in key areas.

Given the continued decline of the species, the apparent increase in severity of the threat from barred owls, and information indicating a recent loss of genetic diversity for the species, we recommend conserving occupied sites and unoccupied, high-value spotted owl habitat on State and private lands wherever possible. This recommendation is primarily driven by the concern associated with displacement of spotted owls by barred owls, the need to retain good quality habitat to allow for displaced or recruited spotted owls to reoccupy such habitat, and the need to retain a spotted owl distribution across the range where Federal lands are lacking. Examples of these areas include portions of southwestern Washington, northwestern Oregon (potentially including parts of the Tillamook and Clatsop State Forests), and northeastern California.
Because spotted owls on established territories are likely to be more successful if they remain in those locations (Franklin *et al.* 2000), managing to retain spotted owls at existing sites should be the most effective approach to conserving spotted owls. Retention of long-term occupancy and reproduction at established spotted owl sites will require a coordinated and cooperative effort to craft management approaches tailored to regional, provincial or local conditions.

This Revised Recovery Plan acknowledges the important role State and private lands can play toward implementing a coordinated and cooperative effort to recover the spotted owl. The relative importance of this role to spotted owl recovery can be addressed in a variety of ways. Using the rangewide habitat modeling framework will help identify areas where State and private lands can make the best contribution to spotted owl recovery. The Service will continue to work with these landowners to use a variety of voluntary incentives and approaches that will help contribute to spotted owl recovery through protection and development of unoccupied, high-quality habitat.

During the past 20 years, the Service has worked cooperatively with non-federal landowners to minimize negative impacts to spotted owls and to encourage conservation of spotted owl habitat. The Service has worked with a number of different applicants to implement habitat conservation plans (HCPs) and safe harbor agreements (SHAs) that minimize and mitigate impacts or provide for a net conservation benefit. Lands covered under section 10 of the ESA provide for the conservation of key habitat areas and occupied sites.

Although HCPs are not required to advance the recovery of listed species, voluntary recovery actions included in an HCP can promote recovery. These plans generally are designed to provide: (1) high-quality habitat and retain spotted owl sites; or (2) foraging and dispersal opportunities to make important contributions to spotted owl recovery. SHAs must provide a net conservation benefit to the species, while allowing the landowner to return to baseline habitat conditions after a pre-defined period of time. The net conservation benefits are often direct contributions to recovery, even if of a limited temporal nature. We recommend these efforts be continued and expanded in certain portions of the range to retain and recruit spotted owl habitat on State and private lands in areas with a lack of proximal high-quality habitat on Federal lands and where future distribution of spotted owls would improve long-term recovery potential. These areas include, but are not limited to, southwest Washington, northwest Oregon and the north coast of California.

This Revised Recovery Plan also identifies several recovery actions meant to encourage State and private landowners to work voluntarily toward recovery through economic incentives. There are a number of established and emerging incentive-based options that currently exist for non-federal landowners, including conservation banking and carbon sequestration that could provide valuable spotted owl habitat maintenance or restoration. Spotted owls could receive either directed or indirect benefits from ecosystem services market incentives.

- ***Recovery Action 14: Encourage applicants to develop Habitat Conservation Plans and Safe Harbor Agreements that are consistent with the recovery objectives.***

Habitat conservation plans and safe harbor agreements are important tools that non-federal landowners can voluntarily use to assist in the recovery of the spotted owl. On July 27, 2010, the Service finalized a SHA for small woodlot owners in Oregon that will enroll up to 50,000 acres of non-federal lands within the State over a total of 50 years. The primary goal of this SHA is to increase the time between harvests (*i.e.*, defer harvest), and to lightly to moderately thin younger forest stands that are currently not habitat to increase tree diameter size and stand diversity (*e.g.*, species, canopy layers, presence of snags).

- ***Recovery Action 15: The Service will solicit individual recommendations from stakeholders to develop a comprehensive set of tools and business and economic incentives that facilitate creative opportunities for non-federal landowners to engage in management strategies consistent with the recovery objectives.***

Many non-federal landowners and land managers in the region have adjusted their management strategies to emphasize short harvest rotations (*e.g.*, 40 to 50 years) and the processing of comparatively small diameter trees. Incentives should be identified and developed as a means to reward landowners and land managers for implementing "ecological forestry" practices (Franklin *et al.* 2007) designed to recruit and retain higher-quality spotted owl habitat. Such incentives may include extending tax credits for recovery–related activities that are carried out under the Farm Bill to timber production, development of State or Federal subsidies for lands that meet carbon sequestration and habitat development goals, or conservation banks that facilitate mitigation for actions that impact the spotted owl. Many of the emerging ecosystem services incentives could allow landowners to receive financial compensation for providing co-benefits that include growing higher-quality spotted owl habitat. Implementation of the incentives program could be coupled with the SHA process to provide regulatory protection for landowners who create or enhance spotted owl habitat. Aspects of this recovery action may also be implemented more efficiently at the individual state levels as described under Listing Factor D.

- ***Recovery Action 16: Federal, State, and local managers should consider long-term maintenance of local forest management infrastructure as a priority in planning and land management decisions.***

This Revised Recovery Plan documents the need for active forest management and restoration in many parts of the spotted owl's range to meet long-term ecological goals, especially in dry forest areas, which will benefit spotted owl recovery. Meeting this need will require local capability to treat, remove, and process various types of forest biomass under a variety of logistical and economic conditions.

Timber-based economies and communities in the western United States have experienced significant changes during the last half-century. Some declines in workforce can be attributed to changes in environmental regulation at the Federal, State, and local levels during this time period. However, changing domestic and international markets, competition, industry automation, and depleted supply of older timber have all combined to create a sometimes volatile and unpredictable economic environment for local timber-based economies. Many of these economic changes were well underway prior to the listing of the spotted owl and have occurred outside of the spotted owl's range as well (Raettig and Christensen 1999, Conway and Wells 1994, Power 2006).

Several representatives from smaller timber companies and rural communities have stated that the ability to implement forest restoration projects in the future will suffer because of a continued decline in local workforce, expertise, equipment, and milling or processing capacity (Storm 2007, Mason and Lippke 2009, Carrier 2010). The Service recognizes this concern and recommends it be evaluated at the State and local scales.

Although it is beyond the scope of this Revised Plan to address these broader economic issues, it is in the general interest of long-term forest health -- and therefore spotted owl recovery -- to maintain a local ability to implement forest management and restoration projects on public lands. Therefore, it is appropriate for agency land managers to take into account this need when designing, prioritizing, and locating projects. Stewardship contracting by the BLM and the USFS may be applicable to this goal (Newberry 2011).

LISTING FACTOR B: OVERUTILIZATION FOR COMMERCIAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

There is no known threat to the spotted owl relative to this listing factor, so no recovery criteria or recovery actions are identified specific to this listing factor.

LISTING FACTOR C: DISEASE OR PREDATION

Although there is no known imminent threat to the spotted owl from disease or predation (so no recovery criteria are identified specific to this listing factor) it is important to continue to monitor for diseases and pathogens so that appropriate action can be taken if necessary.

Diseases

Sudden oak death

Sudden oak death is a potential threat to spotted owl habitat (Courtney *et al.* 2004). This disease is caused by a non-native, recently introduced, fungus-like pathogen, *Phytopthora ramorum*. This pathogen has killed hundreds of thousands of oak and tanoak trees along the California coast (from southern Humboldt County to Monterey County) and hundreds of tanoak trees on the southern Oregon coast (southwestern Curry County) (Goheen *et al.* 2006).

According to Goheen *et al.* (2006:1):

> "The pathogen has a wide host range including Douglas-fir, grand fir, coast redwood, and many other tree and shrub species common in Oregon and Washington forests. Tree mortality, branch and shoot dieback, and leaf spots result from infection depending on host species and location. *Phytopthora ramorum* spreads aerially by wind and wind-driven rain and

> moves within forest canopies and tree tops to stems and shrubs and from understory shrubs to overstory trees. The pathogen survives in infected plant material, litter, soil, and water. It is moved long distances in nursery stock.…State and Federal personnel regularly survey forests and nurseries in the Pacific Northwest to detect the disease."

Due to its potential impact on forest dynamics and alteration of key prey and spotted owl habitat components (*e.g.,* hardwood trees, canopy closure, and nest tree mortality), sudden oak death poses a potential threat to spotted owls, especially in the southern portion of the spotted owl's range (Courtney *et al.* 2004).

Avian disease

At this time, no avian diseases are significantly affecting spotted owls. It is unknown whether avian diseases such as West Nile virus (WNV), avian flu, or avian malaria (Ishak *et al.* 2008) will significantly affect spotted owls. Carrying out the following monitoring action would alert us if any disease becomes a threat.

- ***Recovery Action 17: Monitor for sudden oak death and avian diseases (e.g., WNV, avian flu, Plasmodium spp.) and address as necessary.***

Monitoring is necessary to assess the degree to which sudden oak death affects spotted owl habitat and whether any avian disease becomes a threat. If one or more pathogens or diseases pose a threat to spotted owls or their habitat, specific responses would need to be developed and implemented.

Predation

Known predators of spotted owls are limited to great horned owls (Forsman *et al.* 1984), and, possibly, barred owls (Leskiw and Gutiérrez 1998). Other suspected predators include northern goshawks, red-tailed hawks, and other raptors (Courtney *et al.* 2004). Occasional predation of spotted owls by these raptors is not considered to be a threat to spotted owl populations, so no criteria or actions are identified. Actions relative to the threat from barred owls are presented in Listing Factor E.

LISTING FACTOR D: INADEQUACY OF EXISTING REGULATORY MECHANISMS

One of the original reasons for listing the spotted owl was the inadequacy of the applicable regulatory mechanisms as they existed in 1990. Although there were regulatory mechanisms in place at the time, they offered variable levels of protection to spotted owls and, to a lesser extent, spotted owl habitat. Since 1994, the NWFP has been implemented on Federal lands throughout the range of the spotted owl. On Federal lands, the Service continues to support the implementation of the NWFP and its associated Standards and Guidelines, as well as the implementation of the recovery actions in this Revised Recovery Plan. This section focuses primarily on the State regulations that cover the approximately 21 million acres of private- and State-owned forest lands in Washington, Oregon and California (see Table III-1).

State and private lands are regulated under various State authorities, and timber harvest within each state is governed by rules that provide varying degrees of protection of spotted owls or their habitat. In Washington, logging practices on State, State trust, and private lands are regulated by the Washington State Department of Natural Resources. In Oregon, the State Forest Practices Act regulates State and private lands. In California, the Forest Practice Rules and timber harvest plan review process on State and private lands substitute for an Environmental Impact Review under the California Environmental Quality Act of 1970. The California Department of Forestry and Fire Protection (CAL FIRE) is responsible for review and approval of timber harvest plans. See below for a more comprehensive treatment of each state.

Since the listing of the spotted owl, there have been some regulatory changes that have reduced the rate of habitat decline on State and private lands. However, in light of the continued decline of the species, the apparent increase in severity of the threat from barred owls, and information indicating a recent loss of genetic diversity for the species, this Revised Recovery Plan identifies a more important recovery role for State and private lands. The Service recommends the States evaluate existing spotted owl conservation efforts and consider changes where appropriate to contribute to recovery goals; specific geographical areas of interest include northeastern California, northwestern Oregon and southwestern Washington. This evaluation should consider the feasibility of restoring and conserving spotted owl habitat on non-federal lands where they can contribute to spotted owl recovery. The Service is available to assist States in evaluating the importance of spotted owl conservation efforts on State and private lands.

In addition, the Service suggests the States evaluate existing regulations affecting spotted owls and make changes where necessary and appropriate to meet recovery goals. We acknowledge the potential economic impacts such changes might have in certain parts of the spotted owl range, and we make several recommendations below to address these concerns.

Washington. In 1996, the State Forest Practices Board (Board) adopted Forest Practices Rules (Washington Forest Practices Board 1996, Washington Administrative Code 222) that would contribute to protection of spotted owls on strategic areas of non-federal lands. Adoption of the Forest Practices Rules was based in part on recommendations from a Science Advisory Group that identified important non-federal lands and recommended roles for those lands in spotted owl conservation (Hanson *et al.* 1993, Buchanan *et al.* 1994). The 1996 rule package was developed by a stakeholder policy group and then reviewed, modified, and approved by the Board.

The Board is currently working to develop an updated, long-term strategy to protect the spotted owl and its habitat on private and state forest lands. In 2008, the Forest Practices Board convened a Northern Spotted Owl Policy Working Group (Working Group). The Working Group's consensus recommendations were presented to the Board in February 2010. The Board accepted the Working Group consensus recommendations and directed Washington State Department of Natural Resources to form a Northern Spotted Owl Implementation Team (Washington NSO Implementation Team).

One of the Working Group's recommendations resulted in a rule change that reduces the likelihood that potentially important habitat near a spotted owl site center is lost through timber harvest while the Board completes its long-term conservation strategy. This rule change adds an evaluation by a three-member Spotted Owl Conservation Advisory Group whenever a site center is subject to possible decertification (and therefore loss of regulatory protections provided by the Forest Practices Rules). The purpose of this evaluation is to determine whether habitat at the site center should be maintained, regardless of the site center's occupancy status, while the Board is completing its long-term strategy.

The Board also directed the Washington NSO Implementation Team to develop a work plan, including prioritization, and directed the team to coordinate with the Federal agencies with regard to the Barred Owl control experiments. The Board also directed the Washington NSO Implementation Team to formally convene a technical team to assess spatial and temporal allocation of conservation efforts on non-federal lands using best available science.

- ***Recovery Action 18: The Washington State Forest Practices Board (Board) should use the final recovery plan and the habitat modeling tool to inform the process currently underway to identify areas on non-federal lands in Washington that can make strategic contributions to spotted owl conservation over time. The Service encourages timely completion of the Board's efforts and will be available to assist as necessary.***

Oregon. The Oregon Forest Practices Act provides for protection of 70-acre core areas around recently surveyed sites occupied by an adult pair of spotted owls capable of breeding (as determined by protocol surveys), but it does not provide for protection of resident single sites, nor of spotted owl habitat beyond these areas (ODF 2006). The Forest Practices Act does not require spotted owl surveys to identify potential nesting-pair or resident-single sites. The interim protection goals for spotted owl nesting sites initially adopted under the Forest Practices Act at the time of listing have yet to be finalized. There is a process under the Forest Practices Act (*see* Oregon Administrative Rule 629-680) to update resource (*i.e.*, spotted owl) site protection measures. Every two years the Oregon Department of Forestry reports to the Board of Forestry regarding any recommended changes to the resource site protection rules and to identify any research needed to further evaluate the protection levels. This on-going review has not been used to finalize the spotted owl resource site protection rules or to monitor their impact on spotted owls.

- ***Recovery Action 19: The Service will request the cooperation of Oregon Department of Forestry in a scientific evaluation of: (1) the potential role of State and private lands in Oregon to contribute to spotted owl recovery; and (2) the effectiveness of current Oregon Forest Practices in conserving spotted owl habitat and meeting the recovery goals identified in this Revised Recovery Plan. Based on this scientific evaluation, the Service will work with the Oregon Department of Forestry and other individual stakeholders to provide specific recommendations for how best to address spotted owl conservation needs on Oregon's non-federal lands.***

Such an analysis is beyond the scope of this Revised Recovery Plan and should be initiated as a cooperative effort between the Service and Oregon Department of Forestry. Among the issues this evaluation should address are the adequacy of the 70-acre core approach for spotted owl pair nest sites in contributing to recovery needs, an assessment of long-term residency and productivity of spotted owls in these territories, the potential application of the habitat modeling tool (Appendix C) to identify areas of high current or potential recovery value, and the potential application of these results to future land management decisions (*e.g.*, critical habitat revisions, HCPs, etc.).

Similar to the Washington Forest Practices Board's Northern Spotted Owl Policy Working Group, this group should identify voluntary and regulatory incentives that may improve spotted owl conservation on State and private lands, as well as areas where economic and other goals may be achieved while also benefiting spotted owls. The state-led Washington group provides a strong model for critically examining the contribution of State forestry regulations to spotted owl recovery.

This Oregon effort should focus on the identification of opportunities to address spotted owl recovery needs on State and private lands and an assessment of the various economic and social trade-offs necessary to meet this goal. Some specific issues this Oregon group should address are:

- potential recommendations to revise Forest Practice regulations, if appropriate and necessary;
- identification of specific opportunities to apply complimentary management goals that meet multiple economic, social, and ecological objectives compatible with spotted owl recovery, such as carbon sequestration, fuels treatment, silviculture, water quality, and recreation;
- coordination between the Oregon Department of Forestry and the Service to receive routine summaries of forest operations; and
- identification of financial and non-regulatory incentives to non-federal land managers that may encourage implementation of recovery actions on these lands (see Recovery Action 15).

California. State Forest Practice Rules, which govern timber harvest on private lands, were amended in 1990 to require surveys for spotted owls in nesting, roosting and foraging habitat and to provide habitat protection measures around activity centers (CFPR 2011, 14 CCR§§ 919.9 (a)-(g)). Under the Forest Practice Rules, a timber harvest plan cannot be approved if it is likely to result in incidental take of federally-listed species, unless the take is authorized by a Federal HCP (CFPR 2011, 14 CCR§§ 898.2(d) and (f)). The California Department of Fish and Game (CDFG) initially reviewed all Timber Harvest Plans (THPs) to ensure that take of State- and federally-listed species was not likely to occur. The Service currently provides technical assistance to CAL FIRE in its THP review of federally-listed species.

- ***Recovery Action 20: The Service will request the cooperation of CAL FIRE and individual stakeholders in an evaluation of: (1) the potential recovery role of spotted owl sites and high-quality habitat on non-federal lands in California, and (2) evaluation and implementation of appropriate conservation tools (e.g., carbon sequestration, Habitat Conservation Plans, Safe Harbor Agreements) to assist with supporting spotted owl recovery actions outlined in this Recovery Plan.***

Working with the State and stakeholders in this manner would create an opportunity to identify more locally-specific information to assist with outlining the potential contribution of private lands to spotted owl recovery. This sort of collaboration would also be an appropriate mechanism to identify and create voluntary and regulatory incentives that may improve spotted owl conservation on non-federal lands that integrate with existing State regulatory and incentive programs.

- ***Recovery Action 21: The Service will provide technical assistance to the California Board of Forestry and Fire Protection and CAL FIRE to develop scientifically based and contemporary Forest Practice Rules to provide for the breeding, feeding and sheltering of spotted owls.***

Currently, the State of California considers it a crime to “take, possess, or destroy” birds of prey, including all owl species (California Fish and Game Code: CA FISH & G § 3500 – 3857). While some barred owl removal has occurred in California forest lands under special permits, this statute could hinder the ability to reduce the effects of barred owls on spotted owls in the southern portion of the range.

- ***Recovery Action 22: If barred owl removal is determined to be effective, work with the State of California to explore options for managing barred owls using lethal means.***

Table III-1. Summary of the forestry rules that provide spotted owl protections for California, Oregon and Washington

State	NSO Surveys Required	Habitat Requirements				Noise Disturbance Restrictions			NSO Forest Rules last updated	Exceptions
		Which spotted owl sites	Size-Location	Habitat	Duration	Zone size	Duration	Restricted Disturbance Includes		
California[1]	Yes	All	Within 0.7–1.3 miles of center	Within 500 ft. of nest timber operations limited during breeding season and must retain functional nesting habitat[2] 500-1000 ft. retain functional roosting habitat[2] 500 acres spotted owl habitat in 0.7 -mile radius 1336 acres spotted owl habitat in 1.3- mile radius	All year as long as determined by CAL FIRE to be a site	500 ft.	Breeding season[3]	All timber harvest operations except planting and surveying	2009 – allowed designation of independent biological consultants to fulfill evaluation role for likelihood of take	CFPRs allow for deviations with FWS review and other sec. 7 and 10
Oregon	No	All	Nest site[4] is within 500 ft. of timber operations	70-acre no cut Core around nest with the outer edge of the Core no less than 300 ft. distance from the nest	Life of circle	0.25 mile	Critical period[5]	Timber operations except log hauling, reforestation, road maintenance, research and monitoring, ground application of chemicals, aerial applications that do not require multiple passes, and burning	2006	
Washington	No	SOSEA	Within 0.7 miles of site center Within home range of 1.8-2.7 mile radius	retain all suitable habitat [6,7] retain 40% of suitable habitat [6,7]	Life of circle	0.25 mile	Nesting season[8]	Felling and bucking, yarding, slash disposal, prescribed burning, road construction, and other such activities (operation of heavy equipment and blasting)	1996	For landowners whose forest land ownership within the SOSEA is ≤500 acres and where the activity is
		Non-SOSEA	70 acres around known nest site	retain best 70 acres[7]	Nesting season[8] only					

										>0.7 mile of the NSO site center and sec. 7, 10 and some State planning regulations

1. California Forest Practice Rules (CFPRs) rely on the Service's Guidelines as presented here.
2. Nest-Roost habitat in California is generally defined as 60-90% canopy closure, multi-layered/species canopy with trees >30 inches diameter, trees with deformities, woody debris on ground and open space below canopy to allow spotted owls to fly.
3. Breeding season for Coastal California is defined as February 1-July 30, Interior as February 1-August 31.
4. Nest site requires a pair of spotted owls.
5. The critical period in Oregon is defined as March 30 to September 30.
6. Suitable habitat in Washington is defined as: forest stands which meet the description of old forest habitat, sub-mature habitat or young forest marginal habitat per Washington Forest Practices Regulations (Washington Forest Practices Board 1996).
7. These thresholds are used as guidance in SEPA review and do not necessarily preclude harvest.
8. Nesting season in Washington is defined as March 1 to August 31.

LISTING FACTOR E: OTHER NATURAL OR MANMADE FACTORS AFFECTING ITS CONTINUED EXISTENCE

Barred Owl

The three main threats to the spotted owl are competition from barred owls, past habitat loss, and current habitat loss. Barred owls reportedly have reduced spotted owl site occupancy, reproduction, and survival (see Appendix B). Limited experimental evidence, correlational studies, and copious anecdotal information all strongly suggest barred owls compete with spotted owls for nesting sites, roosting sites, and food, and possibly predate spotted owls. The threat posed by barred owls to spotted owl recovery is better understood now than when the spotted owl was listed. Because the abundance of barred owls continues to increase, the effectiveness in addressing this threat depends on action as soon as possible.

Because the abundance of barred owls continues to increase, the effectiveness in addressing this threat depends on action as soon as possible.

There are substantial information gaps regarding ecological interactions between spotted owls and barred owls, and how those interactions may be managed to meet the Recovery Criteria. Recovery actions should provide the information needed to identify effective management approaches and guide the implementation of appropriate management strategies. Many of the following actions should be done concurrently; Figure III-1 shows how these Actions may inform one another. The Service is the primary agent to oversee implementation of any strategy for the management of barred owls.

Coordination among all agencies and non-governmental organizations that can contribute to research on ecological interactions between spotted owls and barred owls is needed to prioritize research topics, maximize funding opportunities, minimize redundancies, increase efficiency, identify potential management strategies, and communicate with decision-makers. Included as Recovery Action 21 in the 2008 Recovery Plan, the Barred Owl Work Group was appointed as a Recovery Implementation Team to implement the 2008 Recovery Plan and has provided coordination on numerous analyses, topics and issues. Currently, representatives from 10 Federal, State and non-governmental agencies and organizations comprise the Work Group helping to implement its technical and scientific functions.

This Barred Owl Work Group is chaired by the Service and guided by its charter, along with the Northern Spotted Owl Implementation Team (NSOIT). The Barred Owl Work Group has guided, and will continue to guide, implementation of numerous recovery actions addressing the barred owl threat to spotted owls.

- ***Recovery Action 23: Analyze existing data sets from the demographic study areas relative to the effects of barred owls on spotted owl site occupancy, reproduction, and survival.***

Through implementation of this recovery action, many of the long-term demographic data sets have been studied, resulting in white papers and pending publications. Additional analysis of these data has provided a greater understanding of the effects of barred owls on spotted owl detection rates, survival, site occupancy and the role of habitat in site occupancy. The Barred Owl Work Group will continue to work with the Principal Investigators of the demographic studies to mine data as appropriate.

- ***Recovery Action 24: Establish protocols to detect barred owls and document barred owl site status and reproduction.***

Protocols to detect barred owls and document important population information, including pair status and reproduction, provide vital data needed to help manage barred owls to reduce their threat to spotted owls. A subgroup of the Barred Owl Work Group was formed in 2008 to develop a barred owl-specific survey protocol. The subgroup developed a draft protocol in 2009 with the purpose of providing a high likelihood of determining barred owl presence for research studies. During the 2009 field season, the draft protocol was tested in several areas with the objectives of determining barred owl detection rates and the survey effort needed to adequately detect barred owls. These data have been analyzed allowing the subgroup to refine the protocol based on the field tests.

- ***Recovery Action 25: Ensure that protocols adequately detect spotted owls in areas with barred owls.***

The presence of barred owls has been shown to decrease the detectability of spotted owls. Consequently, the Barred Owl Work Group enlisted scientific support and analysis from many individual spotted owl researchers from the Federal, State and private sectors across the range of the spotted owl. Additional analysis of data from demographic study areas focused on addressing the questions of: 1) what are the per visit detection rates of spotted owls with and without barred owls, and 2) what are the site occupancy rates of spotted owls at historical spotted owl sites? These efforts have led to several white papers and pending publications. A draft revised spotted owl survey protocol was released for use and comment during the 2010 field season along with direction on how to transition from the 1992 protocol. Field testing of, and commenting on, several provisions of the draft protocol will occur during the next several field seasons leading to finalization of a survey protocol.

- ***Recovery Action 26: Analyze resource partitioning of sympatric barred owls and spotted owls.***

Radio-telemetry studies of sympatric spotted and barred owls help to: determine how the two species use their habitat and resources, including prey, in various areas; identify characteristics of habitats used by spotted owls in areas with substantial barred owl populations; and determine how habitat use by barred owls and spotted owls changes as barred owl numbers increase.

In anticipation of the need for this information, several research projects were initiated in 2007 and led by USGS, PNW, OSU and private industry researchers. This research is focused on interspecific competition and niche partitioning by spotted owls and barred owls. Results from the research are either incorporated in Appendix B or soon will be released in peer-reviewed publications. This information will provide the opportunity for adaptive management of this Revised Recovery Plan when it becomes available.

- ***Recovery Action 27: Create and implement an outreach strategy to educate the public about the threat of barred owls to spotted owls.***

Outreach and education are important components in addressing the barred owl threat, and we continue to look for opportunities to provide this. For example, since completion of the 2008 Recovery Plan, a Barred Owl Stakeholder Group has been formed. The Barred Owl Stakeholder Group, comprised of nearly 40 private and public stakeholders with interest in spotted owl and barred owl issues, met twice in 2009 with members of the barred owl work group and a professional ethicist to discuss the ethical considerations associated with permitting the experimental removal of barred owls and provided their individual feedback on the issue. The results of these discussions are part of the pre-scoping process, and are being considered, along with the results of public scoping, in the development of the draft EIS for issuance of a permit for barred owl removal to ensure we are aware of all potential issues. We will be conducting extensive outreach as part of the NEPA process for issuance of the Migratory Bird Treaty Act permit for the experimental removal of barred owls.

It is crucial that the general public be kept informed concerning this difficult aspect of spotted owl recovery and the potential consequences of not addressing this threat. Public outreach could include production and distribution of brochures, kiosk displays, press releases, and public meetings relative to research and management options.

- ***Recovery Action 28: Expedite permitting of experimental removal of barred owls.***

The concern regarding the current and future negative effects of barred owls on the recovery of spotted owls is considerable, and immediate research is needed. State and Federal permitting of scientifically sound research on removal experiments will be necessary to answer the question of the impacts of barred owls on spotted owls.

- ***Recovery Action 29: Design and implement large-scale control experiments to assess the effects of barred owl removal on spotted owl site occupancy, reproduction, and survival.***

We believe removal of barred owls would provide benefits to spotted owls in the vicinity of the removal and may have larger population effects. Given the rapidity and severity of the increasing threat from barred owls, barred owl removal should be initiated as soon as possible in the form of well-designed removal experiments. These experiments will have the potential to substantially expand our knowledge of the ecological interactions between spotted owls and barred owls (Dugger *et al.* in press) and the effectiveness of barred owl removal in recovering spotted owls. Removal experiments should be conducted in various parts of the spotted owl's range, including a range of barred owl/spotted owl densities, to provide the most useful scientific information.

In the fall of 2009 the Service initiated an Environmental Impact Statement for a proposed experimental removal of barred owls to determine if the removal benefits spotted owls. Public scoping was completed in January 2010 and a draft Environmental Impact Statement is in process.

- ***Recovery Action 30: Manage to reduce the negative effects of barred owls on spotted owls so that Recovery Criterion 1 can be met.***

Implement the results of research to adaptively manage the effects of barred owls to meet Recovery Criterion 1. Management could include silvicultural treatments for stand structure and composition (*e.g.*, habitat management for spotted owl prey), local or large-scale control of barred owl populations, and/or other activities at present unforeseen but informed by research results.

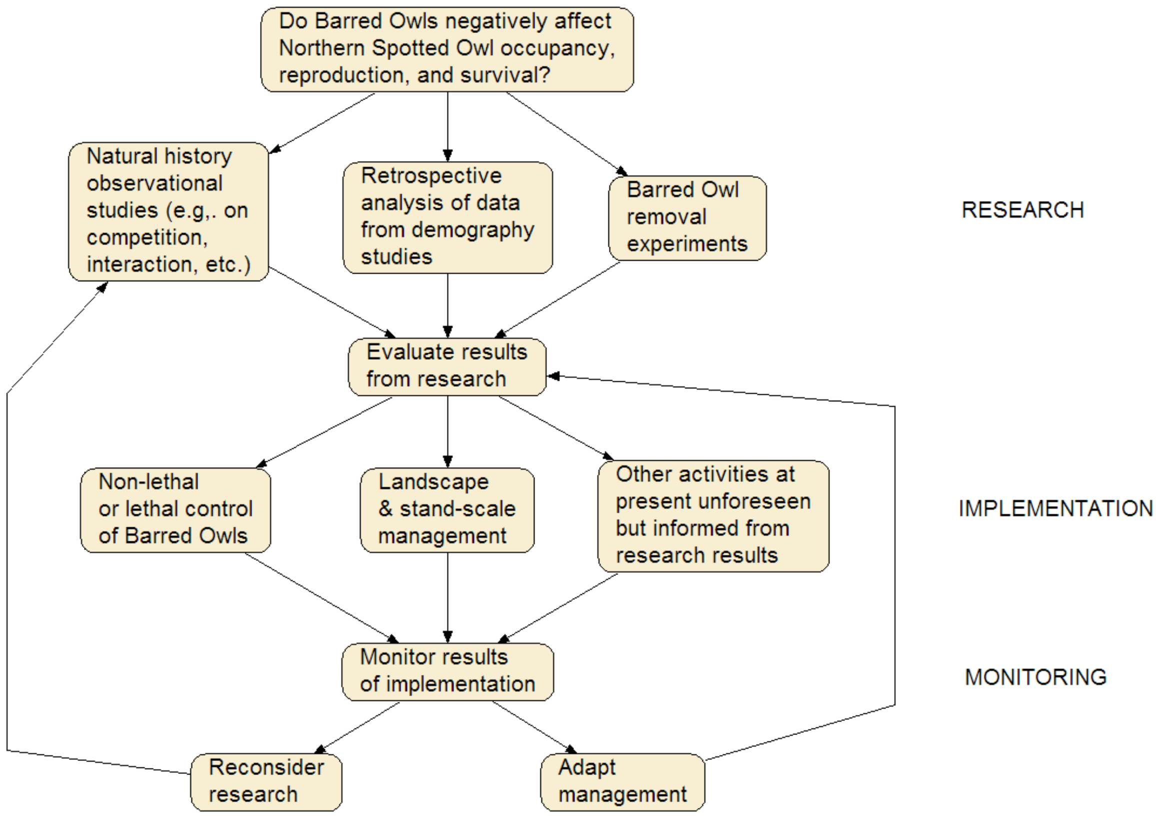


Figure III-1. Flowchart of barred owl Recovery Actions.

Conducting natural history studies (Figure III-1) is ongoing. Retrospective analysis of data from past and ongoing studies involves evaluating past data sets from demography study areas by adding barred owl covariates to test whether presence of barred owls affected detection rates, occupancy, reproduction, and survival of spotted owls (Dugger *et al.* 2009, Forsman *et al.* 2011, Dugger *et al.* in press). Many actions (*e.g.*, additional analysis of data, improving detection protocols for both species', outreach, identification of key spotted owl areas) have already begun. Preliminary findings from barred owl removal experiments could be realized in 1-3 years, whereas estimates of spotted owl vital rates may require more time. Evaluation of results from research is ongoing, and includes research already completed. Identification of management strategies should be based on research results, considerations for different geographic areas, costs, and changes in risk-levels to spotted owls over time. This may lead to the removal of barred owls through non-lethal or lethal methods. If research indicates local or large-scale maintenance removal of barred owl populations is needed, then public outreach, coordination among agencies, Migratory Bird Treaty Act permitting, and NEPA compliance would be required. Evaluation of results from research also may result in landscape and stand-scale management of spotted owl habitat and/or other activities unforeseen at present.

- ***Recovery Action 31: Develop mechanisms for landowners and land managers to support barred owl management using a collaborative process.***

Incentives, such as easily implemented safe harbor agreements or habitat conservation plans, can decrease a private landowner's concern regarding barred owl management that may result in an increase of spotted owls, as well as the associated issues that come with a listed species under the ESA.

- ***Recovery Action 32: Because spotted owl recovery requires well distributed, older and more structurally complex multi-layered conifer forests on Federal and non-federal lands across its range, land managers should work with the Service as described below to maintain and restore such habitat while allowing for other threats, such as fire and insects, to be addressed by restoration management actions. These high-quality spotted owl habitat stands are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees.***

Maintaining or restoring forests with high-quality habitat will provide additional support for reducing key threats faced by spotted owls. Protecting these forests should provide spotted owls high-quality refugia habitat from the negative competitive interactions with barred owls that are likely occurring where the two species' home ranges overlap. Maintaining or restoring these forests should allow time to determine both the competitive effects of barred owls on spotted owls and the effectiveness of barred owl removal measures. Forest stands or patches meeting the described conditions are a subset of NRF habitat and actual stand conditions vary across the range. These stands or patches may be relatively small but important in a local area, may not be easily discernable using remote sensing techniques, and likely require project-level analysis and field verification to identify.

This recommendation can be justified at several scales and is supported by the best available research. At the scale of a spotted owl territory, Dugger *et al.* (in press) found an inverse relationship between the amount of old forest within the core area and spotted owl extinction rates from territories. At the population scale, Forsman *et al.* (2011) found a positive relationship between recruitment of spotted owls into the overall population and the percent cover of spotted owl NRF habitat within study areas. Both of these studies provide scientific support for the value to spotted owls of retaining structurally complex stands on the landscape.

Because the characteristics of the stands or patches targeted by this recovery action vary widely across the range of the species, the Service believes implementation and/or mapping of this recovery action is best left to interagency teams with localized expertise. To facilitate implementation of this recovery action on Federal lands, local, interagency Level 1 teams should continue to identify RA 32 stands or patches when necessary and evaluate the effects of proposed management activities in these areas on spotted owls, with assistance from management (Level 2) and Regional Technical Specialists, as needed. This approach will continue to ensure that interagency localized expertise will be utilized in identifying and managing Recovery Action 32 stands or patches and will be the result of interagency cooperation. Non-federal landowners are welcome to utilize the tools developed during the cooperative Federal process. The Service is available to assist non-federal landowners with the implementation of this recovery action.

On-the-ground application of this action has been, and continues to be, implemented on the west side of the Cascades on Federal lands as part of the level 1 team consultation process since shortly after the 2008 Recovery Plan was finalized. Our recent experience reinforces that the BLM and FS are aware of the conservation value of this recovery action and have been proactive and collaborative in the application of Recovery Action 32.

In dry forest areas, actively manage habitat to meet the overlapping goals of spotted owl recovery, restoration of dry forest structure, composition and process including fire, insects and disease. Managers should refer to earlier discussions in this Plan for specific recommendations about landscape scale, science based adaptive restoration treatments to meet Recovery Action 32 goals. Land managers that utilize and document the application of these recommendations in their project planning are consistent with the intent of Recovery Action 32. An existing example of a site-specific plan that could be emulated at the National Forest, BLM District, or project level in other dry forest areas is the Okanogan-Wenatchee National Forest Restoration Strategy (USDA 2010).

The Dry Cascades and the Klamath Province Work Groups will both assist the Service with implementation of this recovery plan by developing multiple province-specific management strategies. Given the dynamic disturbance regimes of these provinces, the strategies developed by these two work groups may address the goals of this recovery action differently than outlined above when finalized. If these strategies require amendments to this Revised Recovery Plan the Service will provide an additional opportunity for public comment.

This recovery action may be temporary in nature, until such time as the competitive pressures of the barred owl on the spotted owl can be reduced to an extent that retention of these stands or patches is not necessary for spotted owl recovery. The 5-year review process will help inform assessments of reduction of threats posed by barred owls. If the 5-year review finds this recommendation unnecessary we will amend this Revised Recovery Plan as needed.

Post-delisting Monitoring

Once the spotted owl is delisted the Service is required to continue to monitor its population for at least 5 years to ensure it does not require the protections of the ESA after those protections have been lifted. Currently, spotted owl populations are monitored through the demographic study areas described in Appendix A under **Population Trends and Distribution**.

Recovery Criterion 4 – Post-delisting Monitoring**:** To monitor the continued stability of the recovered spotted owl, a post-delisting monitoring plan has been developed and is ready for implementation with the States of Washington, Oregon, and California (ESA 4(g)(1)).

- ***Recovery Action 33: Develop a post-delisting monitoring plan ready for implementation with the States of Washington, Oregon, and California (ESA 4(g)(1)).*** Such a plan is necessary to meet the requirements of the ESA.

IV. IMPLEMENTATION SCHEDULE AND COST ESTIMATES

Recovery plans are intended to assist the Service and other stakeholders in planning and implementing actions to recover or protect threatened or endangered species. The following implementation schedule identifies priority number, duration, potential stakeholders, responsible agencies, and estimated costs for the recovery actions described in this Revised Recovery Plan. It is a guide for planning and meeting the objectives discussed in this Revised Recovery Plan.

Due to the uncertainties associated with the effects of barred owl interactions, results from ongoing and new research, and habitat changes that may occur as a result of climate change, the actions needed to stabilize and begin to recover the spotted owl may change over time. The Service and other implementers of this Revised Recovery Plan will have to employ an active adaptive management strategy to achieve results and focus on the most important actions for recovery. This Revised Recovery Plan will be amended as necessary.

The implementation schedule and cost estimate (Table IV-1) outlines recovery actions and their estimated costs for the first 5 years of this recovery program; total costs are estimated for the entire 30-year period. The costs are broad estimates and identify foreseeable expenditures that could be made to implement the specific recovery actions. Actual expenditures by identified agencies and other partners will be contingent upon appropriations and other budgetary constraints.

The actions identified in the implementation schedule are those that, in our opinion, should bring about the recovery of this species. However, these actions are subject to modification as dictated by new findings, changes in the species' status, and the completion of other recovery actions. The priority for each action is assigned as follows:

Priority 1: An action that must be taken to prevent extinction or prevent the species from declining irreversibly in the foreseeable future.

Priority 2: An action that must be taken to prevent a significant decline in the species' population/habitat quality or some other significant negative impact short of extinction.

Priority 3: All other actions deemed necessary to meet the recovery objectives.

The column "Action Duration" indicates whether the action is one of five types. (1) Discrete actions are shown by the number of years estimated to complete the action. (2) Continuous actions are to be implemented every year once begun. (3) Ongoing actions are currently being implemented and will continue until the action is no longer necessary. (4) Intermittent actions are to be implemented as needed. (5) "TBD" (to be determined) actions are those for which the duration was not possible to estimate.

While the ESA assigns a strong leadership role to the Service for the recovery of listed species, it also recognizes the importance of other Federal agencies, States, and other stakeholders in the recovery process. The "responsible parties" identified in the implementation schedule are those partners who can make significant contributions to specific recovery tasks and who may voluntarily participate in any aspect of recovery actions listed. In some cases, the most logical lead agency has been identified with an asterisk. The identification of agencies and other stakeholders in the implementation schedule does not constitute any additional legal responsibilities beyond existing authorities. However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover the spotted owl. Also, section 7(a)(1) of the ESA directs all Federal agencies to use their authorities in furtherance of the purposes of the ESA by carrying out programs, such as these recovery actions, for the conservation of threatened and endangered species.

We listed the agencies and other parties that we believe are the primary stakeholders in the recovery process, and have the authority, expertise, responsibility, or expressed interest to implement a specific recovery action. However, the list of possible stakeholders is not limited to the parties below; other stakeholders are invited to participate.

There are four assumptions associated with these cost estimates:

1. Estimates include Federal government reimbursement of travel and per-diem costs of non-governmental employees to participate in recovery actions.
2. Responsible parties include both organizations that carry out the activity and organizations that fund the activity.
3. The cost of each Action is estimated independently, unless otherwise noted.
4. The opportunity cost of managing these lands for spotted owls instead of other uses is not included in this analysis.

For most of the actions identified in this Revised Recovery Plan, there is no way of deriving a precise cost estimate. A variety of assumptions were used to produce these estimates. For actions that called for meetings or formation of work groups, we assumed the cost of meetings based on the cost of a single Recovery Team meeting. For research and monitoring related actions, current similar research or monitoring projects were used as surrogates to estimate these costs. In some cases, researchers were asked to estimate the cost of a particular study or monitoring program. The cost estimates shown include certain actions that have no new costs (*e.g.*, certain agencies or organizations are already staffed and committed to participating in some of the actions identified).

Several actions call for habitat alteration to benefit the spotted owl. These comprise two categories: actions calling for modification of existing practices to benefit the spotted owl, and actions calling for specific types of management. For modifications of existing practices, the cost of adjusting the action during planning was estimated, rather than the actual entire cost of implementing the project since the "existing practices" cost would already be incurred by the land manager. For the actions that call for specific management, actual estimates for conducting a given type of management were used, but the cost attributable to spotted owl recovery was set at 10 percent of this total cost as an estimate of the added cost to the agencies of implementing such actions. To complete the estimates for some habitat-related actions, base numbers were obtained using the costs and accomplishments of the FS and BLM within the range of the spotted owl.

The costs are broad estimates and identify foreseeable expenditures that could be made to implement the specific recovery actions. Actual expenditures by identified agencies and other partners will be contingent upon appropriations and other budgetary constraints. There are no recovery actions for Listing Factor B.

In Table IV-1, "Land managers" means non-federal land managers, "Landowners" means non-federal landowners, and "States" means State governments of Washington, Oregon, and California. For some recovery actions the interagency Northern Spotted Owl Implementation Team is identified as a responsible party. In these cases it is likely the Northern Spotted Owl Implementation Team will coordinate within their agencies to complete these actions as opposed to the Northern Spotted Owl Implementation Team itself actually carrying out the activity.

Table IV-1. Implementation schedule and cost estimates.

Action No.	Priority No.	Action Description	Action Duration	Resp. Parties (* = lead)	FY Cost Estimate (in $1,000s)					
					30-yr Total	2011	2012	2013	2014	2015
1	1	Establish FWS spotted owl implementation structure	Continuous	FWS	180	6	6	6	6	6
2	3	Monitor population trend	Ongoing	FWS, FS, BLM*, NPS, NSOIT	69,000	2,300	2,300	2,300	2,300	2,300
3	3	Monitor occupancy through surveys or modeling	Start TBD, intermittent thereafter	NSOIT	7,500	0	0	0	0	0
Listing Factor A: The present or threatened destruction, modification, or curtailment of the species' habitat or range										
4	1	Utilize habitat modeling framework for Recovery measures	Continuous	FWS*, BLM, FS, States, NPS	140	80	60	0	0	0
5	2	FWS to consider and incorporate climate change impacts on spotted owls into planning	Continuous	FWS*	350	20	20	20	20	20
6	1	West side: Manage to accelerate structural complexity	Continuous	FS, BLM, FWS	1,750	150	150	100	50	50
7	1	Create Dry Cascades Work Group (DCWG)	Up to 10 years	FWS*, FS, BLM	230	35	35	20	20	20
8	3	Fire and occupancy data analysis	3 years	DCWG	60	25	25	10	0	0
9	1	Create Klamath Province Work Group (KPWG)	Up to 10 years	FWS*, FS,BLM	200	20	20	20	20	20
10	1	Conserve spotted owl sites and high value habitat for demographic support	Continuous	FS, BLM, FWS	1,600	100	100	50	50	50

Table IV-1. Implementation schedule and cost estimates.

Action No.	Priority No.	Action Description	Action Duration	Resp. Parties (* = lead)	FY Cost Estimate (in $1,000s) 30-yr Total	2011	2012	2013	2014	2015
11	3	Design and conduct experiments concerning habitat, prey and spotted owl fitness and thinning	Intermittent to Continuous	FS, BLM, FWS, NPS, WDNR, ODF, CAL FIRE, CDFG, landowners	1,500	50	50	50	50	50
12	2	Post-fire management in lands managed for spotted owl habitat development	Continuous	FWS, FS, BLM	0	0	0	0	0	0
13	3	Standardize habitat definitions	2 years	NSOIT, FS, BLM	200	100	100	0	0	0
14	3	Encourage development of HCPs and SHAs that are consistent with spotted owl recovery	Continuous	FWS	1,500	50	50	50	50	50
15	3	Solicit recommendations for non-federal landowner incentives	Continuous	FWS	1,500	50	50	50	50	50
16	2	Long-term maintenance of forest management infrastructure	Continuous	FS, BLM, FWS, States, Counties	0	0	0	0	0	0
Listing Factor C: Disease or predation										
17	3	Monitor and address diseases	Continuous	NSOIT	300	10	10	10	10	10
Listing Factor D: Inadequacy of existing regulatory mechanisms										
18	2	WA State Forest Practices Board evaluation of strategic non-federal spotted owl contributions	3 years	WA State Forest Practices Board*, WA Dept. of Natural Resources, WA Dept.	450	150	150	150	0	0

Table IV-1. Implementation schedule and cost estimates.

Action No.	Priority No.	Action Description	Action Duration	Resp. Parties (* = lead)	FY Cost Estimate (in $1,000s) 30-yr Total	2011	2012	2013	2014	2015
				of Fish and Wildlife						
19	2	Cooperate with ODF on scientific evaluation of potential role of State and private lands, and the effectiveness of Oregon Forest Practices rules	5 years	ODF*, FWS	450	100	100	100	100	50
20	2	Work with CAL FIRE on recovery role on non-federal lands and evaluation/implementation of conservation tools	Continuous	CAL FIRE*, FWS	730	10	80	80	80	20
21	2	FWS work with CAL FIRE to provide Forest Practice Rules for spotted owls	3 years	CAL FIRE, FWS	310	0	100	100	100	0
22	2	If necessary, work with State of California on options to allow lethal control of barred owls	4 years	State of Cal*, FWS	200	50	50	50	50	0
Listing Factor E: Other natural or manmade factors affecting its continued existence										
23	2	Analyze existing data sets for effects of barred owls	5 years	BOWG*, FWS, FS, BLM, NPS	250	50	50	50	50	50
24	2	Establish protocols to detect barred owls	2 years	BOWG*, FWS, FS, BLM, NPS	150	75	75	0	0	0
25	2	Ensure protocols adequately detect spotted owls	3 years	BOWG*, FWS, BLM, FS, NPS, States, landowners	300	100	100	100	0	0

Table IV-1. Implementation schedule and cost estimates.

Action No.	Priority No.	Action Description	Action Duration	Resp. Parties (* = lead)	FY Cost Estimate (in $1,000s) 30-yr Total	2011	2012	2013	2014	2015
26	2	Analyze resource partitioning	5 years	BOWG*, USGS, FS, FWS, NPS, BLM	1,820	190	510	440	440	120
27	2	Implement public outreach strategy	Continuous	BOWG*, FWS	48	15	5	1	1	1
28	1	Expedite permitting of experimental removals	3 years	FWS*, States	45	0	0	0	15	15
29	1	Conduct experimental removal studies	10 years	BOWG*, TBD	3,000	0	0	600	600	600
30	1	Manage negative effects of barred owls	Start time 4 years away, continuous once started	BOWG*, FS, BLM, NPS, States, FWS, landowners	31,860	0	0	0	1,180	1,180
31	2	Develop mechanisms to support barred owl management	2 years to develop; intermittent as needed	BOWG*, FWS, FS, BLM, NPS, States, landowners	360	40	40	20	0	20
32	1	Maintain high-quality habitat across all landscapes	Continuous	FWS, BLM, FS, States	1040	100	100	30	30	30
33	3	Develop delisting monitoring plan	1 year; initiation TBD	FWS	30	0	0	0	0	0
Estimated total cost for all actions for 30 years: $127.1. million										

Appendix A. Background

This section of the Revised Recovery Plan is designed to provide information necessary to understand the Revised Recovery Plan's strategy, goals, objectives, and criteria for the spotted owl. While it is not an exhaustive review, information on the spotted owl's status, basic ecology, demography, and past and current threats is included. Detailed accounts of the taxonomy, ecology, and reproductive characteristics of the spotted owl were presented in the 1987 and 1990 Status Reviews (USFWS 1987, 1990a), 1989 Status Review Supplement (USFWS 1989), Interagency Scientific Committee Report (Thomas *et al.* 1990), Forest Ecosystem Management Assessment Team (FEMAT) Report (USDA *et al.* 1993), final rule designating the spotted owl as a threatened species (USFWS 1990b), scientific evaluation of the status of the spotted owl (Courtney *et al.* 2004), and several key monographs (*e.g.*, Forsman *et al.* 2004, Anthony *et al.* 2006).

Species Description and Taxonomy

The spotted owl is a medium-sized owl and is the largest of the three subspecies of spotted owls (Gutiérrez *et al.* 1995). It is approximately 46 to 48 centimeters (18 inches to 19 inches) long and the sexes are dimorphic, with males averaging about 13 percent smaller than females. The mean mass of 971 males taken during 1,108 captures was 580.4 grams (1.28 pounds) (range = 430.0 to 690.0 grams) (0.95 pound to 1.52 pounds), and the mean mass of 874 females taken during 1,016 captures was 664.5 grams (1.46 pounds) (range = 490.0 to 885.0 grams) (1.1 pounds to 1.95 pounds) (P. Loschl and E. Forsman pers. comm. 2006). The spotted owl is dark brown with a barred tail and white spots on its head and breast, and it has dark brown eyes surrounded by prominent facial disks. Four age classes can be distinguished on the basis of plumage characteristics (Forsman 1981, Moen *et al.* 1991). The spotted owl superficially resembles the barred owl, a species with which it occasionally hybridizes (Kelly and Forsman 2004). Hybrids exhibit physical and vocal characteristics of both species (Hamer *et al.* 1994).

The northern spotted owl is one of three subspecies of spotted owls recognized by the American Ornithologists' Union. The taxonomic separation of these three subspecies is supported by genetic (Barrowclough and Gutiérrez 1990, Barrowclough *et al.* 1999, Haig *et al.* 2004), morphological (Gutiérrez *et al.* 1995), and biogeographic information (Barrowclough and Gutiérrez 1990). The distribution of the Mexican subspecies (*S. o. lucida*) is separate from those of the northern and California (*S. o. occidentalis*) subspecies (Gutiérrez *et al.* 1995). Recent studies analyzing mitochondrial DNA sequences (Haig *et al.* 2004, Chi *et al.* 2005, Barrowclough *et al.* 2005) and microsatellites (Henke *et al.* 2005) confirmed the validity of the current subspecies designations for northern and California spotted owls. The narrow hybrid zone between these two subspecies, which is located in the southern Cascades and northern Sierra Nevadas, appears to be stable (Barrowclough *et al.* 2005).

Population Trends and Distribution

There are no estimates of the size of the spotted owl population prior to settlement by Europeans. Spotted owls are believed to have inhabited most old-growth forests or stands throughout the Pacific Northwest, including northwestern California, prior to beginning of modern settlement in the mid-1800s (USFWS 1989).

The current range of the spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USFWS 1990b). The range of the spotted owl is partitioned into 12 physiographic provinces (Figure A-1) based on recognized landscape subdivisions exhibiting different physical and environmental features (Thomas *et al.* 1993). These provinces are distributed across the species' range as follows:

- Four provinces in Washington: Eastern Washington Cascades, Olympic Peninsula, Western Washington Cascades, Western Washington Lowlands
- Five provinces in Oregon: Oregon Coast Range, Willamette Valley, Western Oregon Cascades, Eastern Oregon Cascades, Oregon Klamath
- Three provinces in California: California Coast, California Klamath, California Cascades

The spotted owl has become rare in certain areas, such as British Columbia, southwestern Washington, and the northern coastal ranges of Oregon.

As of July 1, 1994, there were 5,431 known site-centers of spotted owl pairs or resident singles: 851 sites (16 percent) in Washington, 2,893 sites (53 percent) in Oregon, and 1,687 sites (31 percent) in California (USFWS 1995). By June 2004, the number of territorial spotted owl sites recognized by Washington Department of Fish and Wildlife was 1,070 (J. Buchanan pers. comm. 2010). The actual number of currently occupied spotted owl locations across the range is unknown because not all areas have been or can be surveyed on an annual basis (USFWS 1992a, Thomas *et al.* 1993). In addition, many historical sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or severe fires, and it is possible that some new sites have been established due to recruitment of new areas into NRF habitat since 1994. The totals in USFWS (1995) represent the cumulative number of locations recorded in the three States, not population estimates.

Many historical spotted owl sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or fires.

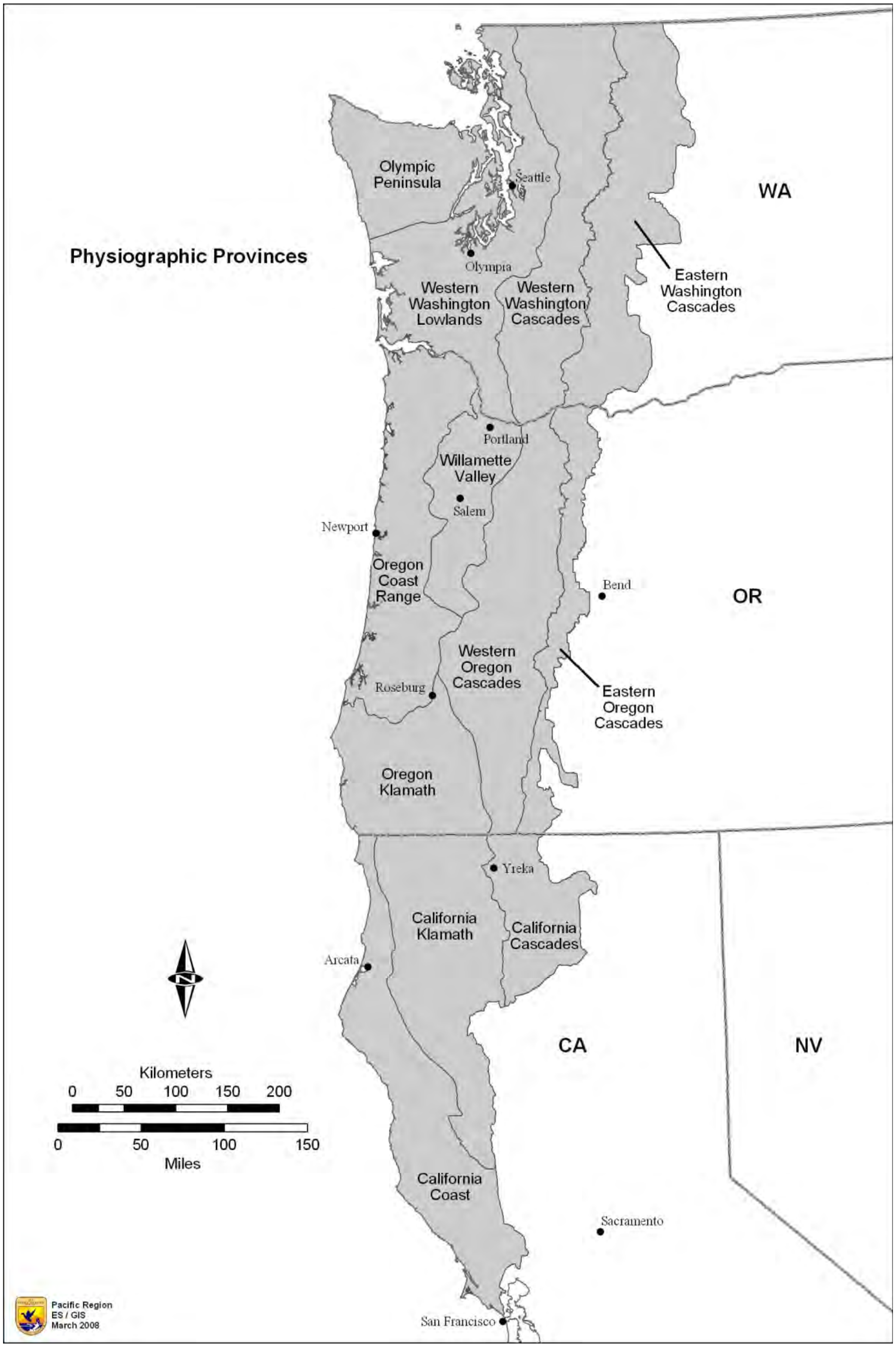


Figure A-1. Physiographic provinces within the range of the spotted owl in the United States.

Because the existing survey coverage and effort are insufficient to produce reliable range-wide estimates of population size, demographic data are used to evaluate trends in spotted owl populations. Analysis of demographic data can provide an estimate of the finite rate of population change (λ) (lambda), which provides information on the direction and magnitude of population change. A λ of 1.0 indicates a stationary population, meaning the population is neither increasing nor decreasing. A λ of less than 1.0 indicates a decreasing population, and a λ of greater than 1.0 indicates a growing population. Demographic data, derived from studies initiated as early as 1985, have been analyzed periodically (Anderson and Burnham 1992, Burnham *et al.* 1994, Forsman *et al.* 1996, Anthony *et al.* 2006, Forsman *et al.* 2011) to estimate trends in the populations of the spotted owl.

In January 2009, two meta-analyses modeled rates of population change for up to 24 years using the re-parameterized Jolly-Seber method (λ_{RJS}). One meta-analysis modeled the 11 long-term study areas (Table A-1), while the other modeled the eight study areas that are part of the effectiveness monitoring program of the NWFP (Forsman *et al.* 2011).

Point estimates of λ_{RJS} were all below 1.0 and ranged from 0.929 to 0.996 for the 11 long-term study areas. There was strong evidence that populations declined on 7 of the 11 areas (Forsman *et al.* 2011), these areas included Rainier, Olympic, Cle Elum, Coast Range, HJ Andrews, Northwest California and Green Diamond. On the other four areas (Tyee, Klamath, Southern Cascades, and Hoopa), populations were either stable, or the precision of the estimates was not sufficient to detect declines.

The weighted mean λ_{RJS} for all of the 11 study areas was 0.971 (standard error [SE] = 0.007, 95 percent confidence interval [CI] = 0.960 to 0.983), which indicated an average population decline of 2.9 percent per year from 1985 to 2006. This is a lower rate of decline than the 3.7 percent reported by Anthony *et al.* (2006), but the rates are not directly comparable because Anthony *et al.* (2006) examined a different series of years and because two of the study areas in their analysis were discontinued and not included in Forsman *et al.* (2011). Forsman *et al.* (2011) explains that the indication populations were declining was based on the fact that the 95 percent confidence intervals around the estimate of mean lambda did not overlap 1.0 (stable) or barely included 1.0. While estimates of mean λ_{RJS} are not directly comparable between Anthony *et al.* (2006) and Forsman *et al.* (2011), results from these studies indicate that rates of population decline for spotted owls have not moderated in recent years. In the most recent meta-analysis, Forsman *et al.* (2011) indicated that the number of populations that showed declines and the rates of decline on study areas in Washington and northern Oregon were noteworthy and should be cause for concern for the long-term sustainability of spotted owl populations throughout the range of the subspecies.

Demographic data suggest that populations over the 11 long-term demographic study areas decreased by about 2.9 percent from 1985 to 2006.

Table A-1. Spotted owl demographic parameters based on data from the spotted owl demographic study areas (adapted from Forsman *et al.* 2011).

Study Area	Fecundity	Apparent Survival[1]	λ_{RJS}	Population change[2]
Cle Elum	Declining	Declining	0.937	Declining
Rainier	Increasing	Declining	0.929	Declining
Olympic	Stable	Declining	0.957	Declining
Coast Ranges	Increasing	Declining since 1998	0.966	Declining
HJ Andrews	Increasing	Declining since 1997	0.977	Declining
Tyee	Stable	Declining since 2000	0.996	Stationary
Klamath	Declining	Stable	0.990	Stationary
Southern Cascades	Declining	Declining since 2000	0.982	Stationary
NW California	Declining	Declining	0.983	Declining
Hoopa	Stable	Declining since 2004	0.989	Stationary
Green Diamond	Declining	Declining	0.972	Declining

[1]Apparent survival calculations are based on model average.
[2]Population trends are based on estimates of realized population change.

The mean λ_{RJS} for the eight demographic monitoring areas (Cle Elum, Olympic, Coast Range, HJ Andrews, Tyee, Klamath, Southern Cascades, and Northwest California) that are part of the effectiveness monitoring program of the NWFP was 0.972 (SE = 0.006, 95 percent CI = 0.958 to 0.985), which indicated an estimated decline of 2.8 percent per year on Federal lands within the range of the spotted owl. The weighted mean estimate λ_{RJS} for the other three study areas (Rainier, Hoopa, and Green Diamond) was 0.969 (SE = 0.016, 95 percent CI = 0.938 to 1.000), yielding an estimated average decline of 3.1 percent per year. These data suggest that demographic rates for spotted owl populations on Federal lands were somewhat better than elsewhere; however, this comparison is confounded by the interspersion of non-federal land in study areas and the likelihood that spotted owls use habitat on multiple ownerships in some demography study areas.

The number of populations that declined and the rate at which they have declined are noteworthy, particularly the precipitous declines in the Olympic, Cle Elum, and Rainier study areas in Washington and the Coast Range study area in Oregon. Estimates of population declines in these areas ranged from 40 to 60 percent during the study period through 2006 (Forsman *et al.* 2011). Spotted owl populations on the HJ Andrews, Northwest California, and Green Diamond study areas declined by 20-30 percent whereas the Tyee, Klamath, Southern Cascades, and Hoopa study areas showed declines of 5 to 15 percent.

Decreases in adult apparent survival rates were an important factor contributing to decreasing population trends.

Decreases in adult apparent survival rates were an important factor contributing to decreasing population trends. Forsman *et al.* (2011) found apparent survival rates were declining on 10 of the study areas with the Klamath study area in Oregon being the exception. Estimated declines in adult survival were most precipitous in Washington where apparent survival rates were less than 80 percent in recent years, a rate that may not allow for sustainable populations (Forsman *et al.* 2011). In addition, declines in adult survival for study areas in Oregon have occurred predominately within the last five years and were not observed in the previous analysis by Anthony *et al.* 2006. Forsman *et al.* (2011) express concerns about the collective declines in adult survival across the subspecies range because spotted owl populations are most sensitive to changes in adult survival.

There are few spotted owls remaining in British Columbia. Chutter *et al.* (2004) suggested immediate action was required to improve the likelihood of recovering the spotted owl population in British Columbia. In 2007, the Spotted Owl Population Enhancement Team recommended to remove spotted owls from the wild in British Columbia. The primary recommendation consisted of two different options – 1) remove all spotted owls immediately and 2) remove most spotted owls in the first year and evaluate subsequently the need to remove additional spotted owls. The second option was selected for implementation (Fenger *et al.* 2007). Personnel in British Columbia captured and brought into captivity the remaining 16 known wild spotted owls. Prior to initiating the captive-breeding program, the population of spotted owls in Canada was declining by as much as 35 percent per year (Chutter *et al.* 2004). The amount of previous interaction between spotted owls in Canada and the United States is unknown (Chutter *et al.* 2004).

Life History and Ecology

Spotted owls are territorial and usually monogamous. Home-range sizes vary geographically, generally increasing from south to north (USFWS 1990b). Estimates of median size of their annual home range vary from 2,955 acres in the Oregon Cascades (Thomas *et al.* 1990) to 14,211 acres on the Olympic Peninsula (Forsman *et al.* 2001). Zabel *et al.* (1995) showed that spotted owl home ranges are larger where flying squirrels are the predominant prey and smaller where wood rats are the predominant prey. Home ranges of adjacent pairs overlap (Forsman *et al.* 1984, Solis and Gutiérrez 1990), suggesting that the defended area is smaller than the area used for foraging. The portion of the home range used during the breeding season is smaller than that used in the remainder of the year (Forsman *et al.* 1984, Sisco 1990).

The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls.

The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman *et al.* 1984, Gutiérrez *et al.* 1995). Spotted owls are sexually mature at 1 year of age, but rarely breed until they are 2 to 5 years of age (Miller *et al.* 1985, Franklin 1992, Forsman *et al.* 2002). Breeding females lay one to four eggs per clutch, with the average clutch size being two eggs; however, most spotted owl pairs do not nest every year, nor are nesting pairs successful every year (Forsman *et al.* 1984, USFWS 1990b, Anthony *et al.* 2006). The small clutch size, temporal variability in nesting success, and delayed onset of breeding all contribute to the relatively low fecundity of this species (Gutiérrez 1996).

Courtship behavior usually begins in February or March, and females typically lay eggs in late March or April. The timing of nesting and fledging varies with latitude and elevation (Forsman *et al.* 1984). After they leave the nest in late May or June, juvenile spotted owls depend on their parents until they are able to fly and hunt on their own. Parental care continues after fledging into September (Forsman *et al.* 1984, USFWS 1990b). During the first few weeks after the young leave the nest, the adults often roost with them during the day. By late summer, the adults are rarely found roosting with their young and usually only visit the juveniles to feed them at night (Forsman *et al.* 1984).

Natal dispersal of spotted owls typically begins in September and October with a few individuals dispersing in November and December (Miller *et al.* 1997, Forsman *et al.* 2002). Natal dispersal occurs in stages. Juveniles will settle for up to seven months at temporary locations between larger movements (Miller *et al.* 1997, Forsman *et al.* 2002) and may do this multiple times before establishing a territory. The median natal dispersal distance from fledging

Dispersing juvenile spotted owls experience high mortality rates, exceeding 70 percent in some studies. Known or suspected causes of mortality during dispersal include starvation, predation, and accidents.

to "permanent" settlement is about 10 miles for males and 15.5 miles for females (Forsman *et al.* 2002).

During the transience (movement) phase, dispersers used mature and old-growth forest slightly more than its availability. Habitat supporting the transience phase of dispersal contains stands with adequate tree size and canopy closure to provide protection from avian predators and minimal foraging opportunities. This may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the movement phase. While the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004), an early attempt to describe dispersal conditions in the Interagency Scientific Committee (ISC) Report (Thomas *et al.* 1990) recommended managing the forested landscape such that 50 percent of each quarter-township has a mean diameter at breast height (dbh) of at least 11 inches and a canopy closure of at least 40 percent (the 50-11-40 rule). The minimum levels of this definition describe habitat supporting the transient phase of dispersal.

Spotted owl dispersal needs are better assessed at the landscape scale than at the stand- or habitat-patch scale (Thomas *et al.* 1990). Existing land allocations and congressional designations (*e.g.*, Wilderness Areas, Wild and Scenic Rivers, etc.) contribute significantly to spotted owl dispersal in some areas, but are not evenly distributed across the landscape. For example, many wilderness areas contain little spotted owl habitat due to elevation or topography. Spotted owls are able to move successfully through highly fragmented landscapes typical of the mountain ranges in western Washington and Oregon (Forsman *et al.* 2002). Still, barriers to spotted owl dispersal do exist and likely include large tracts of unforested lands, such as the Willamette, Rogue and Umpqua valleys and broad expanses of open water, such as Hood Canal and Puget Sound (Forsman *et al.* 2002). Spotted owls have dispersed from the Coastal Mountains to the Cascades Mountains in Oregon though broad forested regions between the Willamette, Umpqua, and Rogue Valleys of Oregon (Forsman *et al.* 2002, p. 22). These "corridors" primarily support relatively rapid movement through such areas, rather than colonization**.**

During the colonization phase, mature and old growth forest was used at nearly twice its availability (Miller *et al.* 1997). Closed pole-sapling-sawtimber habitat was used roughly in proportion to availability in both phases and may represent the minimum condition for movement. Open sapling and clearcuts were used less than expected based on availability during colonization (Miller *et al.* 1997). Habitat supporting the colonization phase of dispersal is generally equivalent to roosting and foraging habitat, although it may be in smaller amounts than needed to support nesting pairs.

Successful juvenile dispersal may depend on locating unoccupied NRF habitat in close proximity to other occupied sites (LaHaye *et al.* 2001). Spotted owls regularly disperse through highly fragmented forested landscapes that are typical of the mountain ranges in western Washington and Oregon (Forsman *et al.* 2002), and have dispersed from the Coastal Mountains to the Cascades Mountains in the broad forested regions between the Willamette, Umpqua, and Rogue Valleys of Oregon (Forsman *et al.* 2002). Corridors of forest through fragmented landscapes serve primarily to support relatively rapid movement through such areas, rather than colonization.

Dispersing juvenile spotted owls experience high mortality rates (more than 70 percent in some studies (Miller 1989, Franklin *et al.* 1999, USFWS 1990b) from starvation, predation, and accidents (Miller 1989, Forsman *et al.* 2002). Parasitic infection may contribute to these causes of mortality, but the relationship between parasite loads and survival is poorly understood (Gutiérrez 1989, Hoberg *et al.* 1989, Forsman *et al.* 2002). Juvenile dispersal is thus a highly vulnerable life stage for spotted owls, and enhancing the survivorship of juveniles during this period could play an important role in maintaining stable populations of spotted owls.

Analysis of the genetic structure of spotted owl populations suggests that gene flow may have been adequate between the Olympic Mountains and the Washington Cascades, and between the Olympic Mountains and the Oregon Coast Range (Haig *et al.* 2001). Although telemetry and genetic studies indicate that close inbreeding between siblings or parents and their offspring is rare (Haig *et al.* 2001, Forsman *et al.* 2002), inbreeding between more distant relatives is fairly common (E. Forsman pers. comm. 2006).

Spotted owls are mostly nocturnal, although they also forage opportunistically during the day (Forsman *et al.* 1984, Sovern *et al.* 1994). The composition of the spotted owl's diet varies geographically and by forest type. Generally, flying squirrels are the most prominent prey for spotted owls in Douglas-fir and western hemlock forests (Forsman *et al.* 1984) in Washington and Oregon, while dusky-footed wood rats are a major part of the diet in the Oregon Klamath, California Klamath, and California Coastal Provinces (Forsman *et al.* 1984, 2001, 2004, Ward *et al.* 1998, Hamer *et al.* 2001). Depending on location, other important prey include deer mice, tree voles, red-backed voles, gophers, snowshoe hare, bushy-tailed wood rats, birds, and insects, although these species comprise a small portion of the spotted owl diet (Forsman *et al.* 1984, 2004, Ward *et al.* 1998, Hamer *et al.* 2001).

Effects to spotted owls from barred owls are described above in Listing Factor E.

Habitat Characteristics

Forsman *et al.* (1984) reported that spotted owls have been observed in the following forest types: Douglas-fir, western hemlock, grand fir, white fir, ponderosa pine, Shasta red fir, mixed evergreen, mixed conifer hardwood (Klamath montane, Marin County), and redwood. In addition, spotted owls in Marin County, California use Bishop pine forests and mixed evergreen-deciduous hardwood forests. The upper elevation limit at which spotted owls occur corresponds to the transition to subalpine forest, which is characterized by relatively simple structure and severe winter weather (Forsman 1975, Forsman *et al.* 1984).

Spotted owls generally rely on older forested habitats (Carroll and Johnson 2008) because such forests contain the structures and characteristics required for nesting, roosting, and foraging. Features that support nesting and roosting typically include a moderate to high canopy closure (60 to 90 percent); a multi-layered, multi-species canopy with large overstory trees (with dbh of greater than 30 inches); a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for spotted owls to fly (Thomas *et al.* 1990). Forested stands with high canopy closure also provide thermal cover (Weathers *et al.* 2001) and protection from predators.

Foraging habitat generally has attributes similar to those of nesting and roosting habitat, but such habitat may not always support successfully nesting pairs (USFWS 1992b). Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities (USFWS 1992b). Forsman *et al.* (2002) found that spotted owls could disperse through highly fragmented forest landscapes, yet the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004). Therefore, a more complete description of dispersal habitat may be determined in the future. There is little evidence that small openings in forest habitat influence the dispersal of spotted owls, but large, non-forested valleys such as the Willamette Valley apparently are barriers to both natal and breeding dispersal (Forsman *et al.* 2002). The degree to which water bodies, such as the Columbia River and Puget Sound, function as barriers to dispersal is unclear, although radio telemetry data indicate that spotted owls move around large water bodies rather than cross them (Forsman *et al.* 2002).

Recent landscape-level analyses in portions of southwest Oregon and California Klamath Province suggest that a mosaic of late-successional habitat interspersed with other seral conditions may benefit spotted owls more than large, homogeneous expanses of older forests in areas where woodrats are a major component of spotted owl diets (Meyer *et al.* 1998, Franklin *et al.* 2000, Zabel *et al.* 2003). In Oregon Klamath and Western Oregon Cascade Provinces, Dugger *et al.* (2005) found that apparent survival and reproduction was positively associated with the proportion of older forest near the territory center (within 730 meters) (2,395 feet). Survival decreased dramatically when the amount of non-habitat (non-forest areas, sapling stands, etc.) exceeded approximately 50 percent of the home range (Dugger *et al.* 2005). The authors concluded there was no support for either a positive or negative direct effect of intermediate-aged forest—that is, all forest stages between sapling and mature,

One study indicated that while mid-seral and late-seral forests are important to spotted owls, a mixture of these forest types with younger forest and non-forest may be best for spotted owl survival and reproduction in certain parts of the range.

with total canopy cover greater than 40 percent—on either the survival or reproduction of spotted owls. It is unknown how these results were affected by the low habitat fitness potential in their study area, which Dugger *et al.* (2005) stated was generally much lower than those in Franklin *et al.* (2000) and Olson *et al.* (2004), and the low reproductive rate and survival in their study area, which they reported were generally lower than those studied by Anthony *et al.* (2006). Olson *et al.* (2004) found that reproductive rates fluctuated biennially and were positively related to the amount of edge between late-seral and mid-seral forests and other habitat classes in the central Oregon Coast Range. Olson *et al.* (2004) concluded that their results indicate that while mid-seral and late-seral forests are important to spotted owls, a mixture of these forest types with younger forest and non-forest may be best for spotted owl survival and reproduction in their study area.

While the effects of wildfire on spotted owls and their habitat vary, in the fire-adapted portions of the spotted owl's range, low- to moderate-severity fires may contribute to this mixture of habitats. Bond *et al.* (2002) examined the demography of the three spotted owl subspecies after wildfires, in which wildfire burned through spotted owl nest and roost sites in varying degrees of severity[1]. Post-fire demography parameters for the three subspecies were similar or better than long-term demographic parameters for each of the three subspecies in those same areas (Bond *et al.* 2002). In a preliminary study conducted by Anthony and Andrews (2004) in the Oregon Klamath Province, their sample of spotted owls appeared to be using a variety of habitats within the area of the Timbered Rock fire, including areas where burning had been moderate. In 1994, the Hatchery Complex fire burned 17,603 hectares in the Wenatchee National Forest in Washington's eastern Cascades, affecting six spotted owl activity centers (Gaines *et al.* 1997). Spotted owl habitat within a 2.9 km (1.8 mile) radius of the activity centers was reduced by 8 to 45 percent (mean = 31 percent) as a result of the direct effects of the fire and by 10 to 85 percent (mean = 55 percent) as a result of delayed mortality of fire-damaged trees and insects. Direct mortality of spotted owls was assumed to have occurred at one site, and spotted owls were present at two of the six sites 1 year after the fire, with reproduction occurring at only one. In 1994, two wildfires burned in the Yakama Indian Reservation in Washington's eastern Cascades, affecting the home ranges of two radio-tagged spotted owls (King *et al.* 1997). Although the amount of home ranges burned was not quantified, spotted owls were observed using areas that burned at low and medium intensities. No direct mortality of spotted owls was observed, even though thick smoke covered several spotted owl site-centers for a week. Spotted owls have been observed foraging in areas

[1] Fire severity is defined in several ways. See the individual studies cited for further information on the definitions of fire severity.

burned by fires of all severity categories (Clark 2007, Bond *et al.* 2009). While Clark (2007) found that spotted owls did not use large patches of high-severity burns, Bond *et al.* (2009) found spotted owls selecting burned areas, even high-severity burns, when they were within 1.5 km of a nest or roost site. Results of several of these studies are confounded because of post-fire salvaging that occurred (*e.g.*, King *et al.* 1997, Clark 2007). More research is needed to further understand the relationship between fire and spotted owl habitat use.

Spotted owls may be found in younger forest stands that have the structural characteristics of older forests or retained structural elements from the previous forest. In redwood forests and mixed conifer-hardwood forests along the coast of northwestern California, considerable numbers of spotted owls also occur in younger forest stands, particularly in areas where hardwoods provide a multi-layered structure at an early age (Thomas *et al.* 1990, Diller and Thome 1999). The results of numerous studies of spotted owl habitat relationships in the Redwood zone suggest stump-sprouting and rapid growth rates of redwoods, combined with high availability of large-bodied prey (woodrats) in patchy, intensively-managed forests, enables spotted owls to maintain high densities in a wide range of forest structural conditions.

In mixed conifer forests in the eastern Cascades in Washington, 27 percent of nest sites were in old-growth forests, 57 percent were in the understory reinitiation phase of stand development, and 17 percent were in the stem exclusion phase (Buchanan *et al.* 1995). In the western Cascades of Oregon, 50 percent of spotted owl nests were in late-seral/old-growth stands (greater than 80 years old), and none were found in stands of less than 40 years old (Irwin *et al.* 2000).

In the western Washington Cascades, spotted owls roosted in mature forests dominated by trees greater than 50 centimeters (19.7 inches) dbh with greater than 60 percent canopy closure more often than expected for roosting during the non-breeding season. Spotted owls also used young forest (trees of 20 to 50 centimeters (7.9 inches to 19.7 inches) dbh with greater than 60 percent canopy closure) less often than expected based on this habitat's availability (Herter *et al.* 2002). In the Coast Ranges, western Oregon Cascades and the Olympic Peninsula, radio-marked spotted owls selected for old-growth and mature forests for foraging and roosting and used young forests less than predicted based on availability (Forsman *et al.* 1984, Carey *et al.* 1990, 1992, Thomas *et al.* 1990). Glenn *et al.* (2004) studied spotted owls in young forests in western Oregon and found little preference among age classes of young forest.

Habitat use also is influenced by prey availability. Ward (1990) found that spotted owls foraged in areas with lower variance in prey densities (*i.e.*, where the occurrence of prey was more predictable) within older forests and near ecotones of old forest and brush seral stages. Zabel *et al.* (1995) showed that spotted owl home ranges are larger and smaller where flying squirrels and wood rats, respectively, are the predominant prey.

Critical Habitat

On January 15, 1992, the Service designated critical habitat for the spotted owl within 190 Critical Habitat Units encompassing nearly 6.9 million acres (2.2 million acres in Washington, 3.3 million acres in Oregon, and 1.4 million acres in California (USFWS 1992a). Primary constituent elements (the physical and biological features of critical habitat essential to a species' conservation) identified in the spotted owl critical habitat final rule include those features that support nesting, roosting, foraging, and dispersal (USFWS 1992b). In 2008 the Service completed a revision of spotted owl critical habitat, designating 5.3 million acres (1.8 million acres in Washington, 2.3 million acres in Oregon, and 1.2 million acres in California). The primary constituent elements included suitable forest types and the areas within these containing nesting, roosting, foraging, or dispersal habitat.

Revised spotted owl critical habitat was designated based on large blocks of habitat identified for spotted owl conservation in the 2008 Recovery Plan (MOCAs) on the west side of the range (USFWS 2008a). The Service designated the Federal lands within these MOCAs as critical habitat, excluding congressionally-reserved areas such as Wilderness Areas and National Parks. Because the 2008 Recovery Plan did not include mapped areas in the eastern Cascades of Oregon and Washington, focusing instead on a landscape approach, we relied on the information used to map the areas in these provinces for the 2007 draft Recovery Plan(USFWS 2007).

As part of this recovery plan, the Service has completed a habitat modeling effort which provides a more in-depth evaluation of various habitat features that affect spotted owl habitat use, when compared to the process used to develop the MOCAs. This information will be used to evaluate potential habitat conservation network scenarios. The Service will use this information and other results of the modeling as it evaluates revisions to spotted owl critical habitat.

Conservation Efforts

Federal Lands

Since it was signed on April 13, 1994, the NWFP has guided the management of Federal forest lands within the range of the spotted owl (USDA and USDI 1994a, b). The NWFP was designed to protect large blocks of late-successional forest and provide habitat for species that depend on those forests including the spotted owl, as well as to "produce a predictable and sustainable level of timber sales and non-timber resources that will not degrade or destroy the environment" (USDA and USDI 1994a). The NWFP includes land-use allocations that would provide for population clusters of spotted owls (*i.e.,* demographic support) and maintain connectivity between population clusters. Certain land-use allocations in the NWFP contribute to supporting population clusters: LSRs, Managed Late-Successional Areas, and Congressionally Reserved

Areas. Riparian Reserves, Adaptive Management Areas and Administratively Withdrawn Areas can provide both demographic support and connectivity/dispersal between the larger blocks, but are not necessarily designed for that purpose. Matrix areas were to support timber production while also retaining biological legacy components important to old-growth obligate species that would persist into future managed timber stands.

The NWFP was directly incorporated into 4 National Forest LRMPs and amended the LRMPs that guide the management of each of the 15 National Forests and six BLM Districts across the range of the spotted owl to adopt a series of reserves and management guidelines that were intended to protect spotted owls and their habitat. The LRMPs adopted a set of reserves and standards and guidelines described in the Record of Decision for the NWFP.

The NWFP with its rangewide network of LSRs was adapted from work completed by three previous studies (Thomas *et al.* 2006): the 1990 ISC Report (Thomas *et al.* 1990), the 1991 report for the Conservation of Late-successional Forests and Aquatic Ecosystems (Johnson *et al.* 1991), and the 1993 report of the Scientific Assessment Team (Thomas *et al.* 1993). In addition, the 1992 Draft Recovery Plan for the Northern Spotted Owl (USFWS 1992b) was based on the ISC report.

The FEMAT predicted, based on expert opinion, the spotted owl population would decline in non-reserve lands over time, while the population would stabilize and eventually increase within LSRs as habitat conditions improved over the next 50 to 100 years (USDA *et al.* 1993, USDA and USDI 1994a, b). Based on the results of the first decade of monitoring, Lint (2005) could not determine whether implementation of the NWFP would reverse the spotted owl's declining population trend because not enough time had passed to provide the necessary measure of certainty. However, the results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described in the NWFP and incorporated into LRMPs (Lint 2005, Noon and Blakesley 2006). Bigley and Franklin (2004) suggested that more fuels treatments are needed in east-side forests to preclude large-scale losses of habitat to stand-replacing wildfires. Other stressors that occur in NRF habitat, such as the range expansion of the barred owl (already in action) and infection with WNV (which may or may not occur) may complicate the conservation of the spotted owl. Recent reports about the status of the spotted owl offer few management recommendations to deal with these emerging threats.

Results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described in the Northwest Forest Plan.

Non-federal Lands

In the report from the ISC (Thomas *et al.* 1990), the draft Recovery Plan (USFWS 1992b), and the report from the FEMAT (USDA *et al.* 1993), it was noted that limited Federal ownership in some areas constrained the ability to form a network of old-forest reserves to meet the conservation needs of the spotted owl. In these areas in particular, non-federal lands would be important to the range-wide goal of achieving conservation and recovery of the spotted owl.

There are 17 current and ongoing conservation plans (CP) including HCPs and SHAs that have incidental take permits issued for spotted owls—eight in Washington, three in Oregon, and six in California. The CPs range in size from 76 acres to more than 1.8 million acres, although not all acres are included in the mitigation for spotted owls. In total, the CPs cover approximately 3 million acres (9.4 percent) of the 32 million acres of non-federal forest lands in the range of the spotted owl. The period of time that the HCPs will be in place ranges from 20 to 100 years. While each CP is unique, there are several general approaches to mitigation of incidental take:

- Reserves of various sizes, some associated with adjacent Federal reserves
- Forest management that maintains or develops nesting habitat
- Forest management that maintains or develops foraging habitat
- Forest management that maintains or develops dispersal habitat
- Deferral of harvest near specific sites

Washington. In Washington State, there are over 2.1 million acres of land in conservation plans (6 HCPs and 2 SHAs). Some of these CPs focus on providing nesting, roosting habitat throughout the area or in strategic locations; while others focus on providing connectivity through foraging habitat and/or dispersal habitat. Most of the Washington HCPs have foraging as a minimal target for habitat quality. In addition, there is a long-term habitat management agreement covering 13,000 acres in which authorization of take was provided through an incidental take statement (section 7) associated with a Federal land exchange.

Two Washington HCPs are based upon municipal watershed management and will provide older forest conditions over time. One HCP occurs within checkerboard ownership in the central Cascades and focuses on connectivity through a combination of nesting habitat in strategic locations as well as a distribution of nesting habitat and foraging habitat across the ownership and the planning area. Several HCPs, a Habitat Management Agreement (via section 7), and one safe harbor agreement focus on connectivity from a dispersal standpoint, including providing foraging habitat and landscape conditions conducive to spotted owl movement and potential residence. The largest HCP in Washington State (WDNR State lands) was designed by a scientific advisory team which analyzed the manner in which State lands could contribute to support the NWFP reserves. That HCP has a system of designated areas designed to provide demographic support in some areas, and foraging and dispersal in other areas.

Oregon. The three spotted owl-related HCPs currently in effect cover more than 300,000 acres of non-federal lands. These HCPs are intended to provide some nesting habitat and connectivity over the next few decades. On July 27, 2010, the Service completed a Programmatic Safe Harbor Agreement with the Oregon Department of Forestry that will enroll up to 50,000 acres of non-federal lands within the State over a total of 50 years. It is primarily intended to increase the time between harvests (defer harvest), and to lightly to moderately thin younger forest stands that are currently not habitat to increase tree diameter size and stand diversity (species, canopy layers, presence of snags).

California. Four HCPs and 2 SHAs authorizing take of spotted owls have been approved; these CPs cover more than 622,000 acres of non-federal lands. Implementation of these plans is intended to provide for spotted owl demography and connectivity support to NWFP lands.

Appendix B. Threats

Habitat Changes

Historical Levels of Spotted Owl Habitat and Rates of Loss

In 1990, the Service estimated spotted owl habitat had declined 60 to 88 percent since the early 1800s (USFWS 1990b). This loss, which was concentrated mostly at lower elevations and in the Coast Ranges, was attributed primarily to timber harvest and land-conversion activities, and to a lesser degree to natural perturbations (USFWS 1990a). Davis and Lint (2005) compared the current condition of forests throughout the range of the species to maps from the 1930s and 1940s and found that, in Oregon and Washington, fragmentation of forests had increased substantially; in some physiographic provinces, the increase was more than five-fold. However, fragmentation in California decreased, which the authors speculate may be due to fire suppression in fire-dependent provinces (Davis and Lint 2005).

Recent Rates of Loss of Spotted Owl Habitat as a Result of Timber Harvest

Until 1990, the annual rate of removal of spotted owl habitat on national forests as a result of logging was approximately 1 percent per year in California and 1.5 percent per year in Oregon and Washington. Anticipated future rates of habitat removal on BLM lands in Oregon at that time were projected to eliminate all NRF habitat on non-protected BLM lands (except the Medford District) within 26 years (USFWS 1990b).

Since 1990, there have been only a few efforts that have produced indices or more direct estimates of trends or change in the amount of NRF habitat for spotted owls. Cohen *et al.* (2002) reported landscape-level changes in forest cover across the Pacific Northwest using remote sensing technology. Their study indicated, "a steep decline in harvest rates between the late 1980s and the early 1990s on State and Federal and private industrial forest lands" (as described in Bigley and Franklin 2004:6-11).

Recent data has become available through the NWFP monitoring efforts (Davis and Dugger in press). This information tracked changes in spotted owl nesting and roosting habitat across all ownerships from timber harvest and natural disturbances (wildfire, insects, and disease); it did not track all foraging habitat. Based on vegetation data, they produced maps of forest stands that compared the stand's level of similarity to stand conditions known to be used for nesting and roosting by spotted owls. These stands were placed into one of four categories: highly suitable, suitable, marginal, and unsuitable. Highly suitable and suitable categories are likely nesting or roosting habitat, marginal stands may occasionally contain the habitat characteristics associated with nesting or roosting (see Davis and Dugger in press for more details). Data from California covered 14 years from 1994 to 2007, data from Oregon and Washington covered 10 years from 1996 to 2006 (Table B-1). Changes in habitat were evaluated comparing mapped differences in habitat condition between the initial and final vegetation maps. Habitat was considered "lost" if its condition moved from suitable or highly suitable to marginal or unsuitable.

Harvest rates for spotted owl nesting and roosting habitat on Federal lands were highest in the California Cascades (3.0 percent, 6,500 acres) and lowest in the Olympic Peninsula (0.06 percent, 500 acres). Overall, timber harvest on Federal lands removed 0.6 percent (53,800 acres) of nesting and roosting habitat during the reporting period.

Table B-1. Spotted owl habitat loss on Federal lands resulting from harvest and natural disturbances from 1994/96[1] to 2006-7[1] (acres) (adapted from Davis and Dugger in press).

Physiographic Provinces	1994/96 acres	Harvest (%)[2]	Natural Disturbance			Total Habitat Loss	Total Percent loss[2,3]
			Wildfire	Insects and disease	Total (%)[2]		
Olympic Peninsula	763,100	**500** ***(0.06%)***	200	0	**200** ***(0.03%)***	700	**0.1%**
Eastern WA Cascades	673,600	**8,100** ***(1.2%)***	20,000	2,000	**22,000** ***(3.3%)***	30,100	**4.5%**
Western WA Cascades	1,283,000	**3,700** **(0.3%)**	700	400	**1,100** **(0.09%)**	4,800	**0.4%**
Western WA Lowlands	24,700	**400** ***(1.6%)***	0	0	**0**	400	**1.6%**
OR Coast Range	611,200	**3,300** ***(0.5%)***	0	0	**0**	3,300	**0.5%**
OR Klamath	985,000	**6,800** ***(0.7%)***	93,600	300	**93,900** ***(9.5%)***	100,700	**10.2%**
Eastern OR Cascades	402,900	**5,800** ***(1.4%)***	17,800	2,300	**20,100** ***(5.0%)***	25,900	**6.4%**
Western OR Cascades	2,258,700	**13,900** ***(0.6%)***	28,900	1,100	**30,000** ***(1.3%)***	43,900	**1.9%**
Willamette Valley	3,400	**100** ***(2.9%)***	0	0	**0**	100	**2.9%**
CA Coast	145,400	**300** ***(0.2%)***	2,100	100	**2,200** ***(1.5%)***	2,500	**1.7%**
CA Cascades	213,200	**6,500** ***(3.0%)***	1,800	300	**2,100** ***(1.0%)***	8,600	**4.0%**
CA Klamath	1,489,800	**4,400** ***(0.3%)***	71,600	1,600	**73,200** ***(4.9%)***	77,600	**5.2%**
Range-wide total	8,853,000	**53,800** ***(0.6%)***	236,700	8,100	**244,800** ***(2.8%)***	298,600	**3.4%**

[1] 1996 and 2006 for Oregon and Washington, 1994 and 2007 for California.
[2] Percent of 1994/96 habitat.
[3] Loss is the term used in Davis and Dugger (in press) to describe their data, which is summarized here.

Raphael (2006) estimated that approximately 7.5 million acres of spotted owl habitat existed on non-federal lands within California, Oregon, and Washington in 1994. Cohen *et al.* (2002) reported that, from the early 1970s through the mid-1990s, the harvest rates on private industrial lands were consistently about twice the average rate of harvest on public land. Bigley and Franklin (2004:6-11) noted that:

> "In the late 1980s and early 1990s the harvest rate was estimated at 2.4 percent per year for private industrial land. An increase in non-industrial private landowner's harvest rates started in the 1970s when the rate was 0.2 percent per year and continued to increase to the early 1990s when the rate was similar to that of the private industrial lands."

Recently, data on actual information on harvest of nesting and roosting habitat for non-federal lands became available through the NWFP monitoring program. On non-federal lands, 14.92 percent (625,600 acres) of the nesting and roosting habitat was harvested in the 10-14 years of the analysis. This compares to 0.6 percent (53,800 acres) on Federal lands in the same period.

Table B-2. Estimated amount of spotted owl nesting and roosting habitat1 at the start of the Northwest Forest Plan (baseline 1994/96[2]) and losses owing to harvest through 2006/7[2], by State and ownership (adapted from Davis and Dugger in press).

Land class	Baseline (1994/96[2])	Harvest	Total Percent loss[3]
Federal reserved			
Washington	2,274,200	7,900	0.3%
Oregon	2,699,600	6,100	0.2%
California	1,214,000	2,500	0.2%
Range-wide total	**6,187,800**	**16,500**	**0.3%**
Federal non-reserved			
Washington	470,200	4,800	1.0%
Oregon	1,561,400	23,800	1.5%
California	634,400	8,700	1.4%
Range-wide total	**2,666,000**	**37,300**	**1.4%**
Non-federal			
Washington	1,258,900	234,200	18.6%
Oregon	1,382,400	301,200	21.8%
California	1,556,700	90,200	5.8%
Range-wide total	**4,198,000**	**625,600**	14.9%
Range-wide total	**13,052,000**	**679,400**	**5.2%**

[1] See Davis and Dugger (in press) for description of habitat.
[2] 1996 and 2006 for Oregon and Washington, 1994 and 2007 for California.
[3] Loss is the term used in Davis and Dugger (in press) to describe their data, which is summarized here.

Recent Rates of Loss of NRF Habitat as a Result of Natural Events

The effects of wildfire and other natural disturbances on spotted owls and their habitat vary by location, severity, and habitat function, though most of the data is related specifically to fire. Spotted owl use of post fire habitat varies, depending on fire severity and the function of the site for spotted owls (*i.e.*, nesting, roosting, or foraging). Few studies are available to clarify this relationship, and many of these are complicated by small sample sizes, post-fire logging, lack of long-term data, and inadequate pre-fire spotted owl data. Spotted owl reproduction and nesting have been observed in the short-term in some burned landscapes and even in core areas in which some portion was burned by high-severity fire. No nest trees were found in high-severity burns, though have been observed in moderate and low severity burned areas. Spotted owls have been observed roosting in forests experiencing the full range of fire severity, though most were associated with low or moderate severity burns. Spotted owls were observed to forage in burned areas within their home range in areas where dusky-footed woodrats are a primary food source, but there is no similar data in more northern conditions. Based on this information we conclude that, while spotted owls can make use of some post-fire landscapes, fire also reduces the function of some habitat and likely removes some from immediate usability, particularly in areas of high-severity fire.

Recent data from the NWFP Effectiveness Monitoring program provides an insight into the change in spotted owl nesting and roosting habitat from natural disturbances on Federal (Table B-1) and non-federal lands (Table B-3). Changes in habitat were evaluated comparing mapped differences in habitat condition over time. Habitat was considered “lost” if its condition moved from suitable or highly suitable to marginal or unsuitable. We use the term “loss” in this case because this is how the authors describe their data, though as described above, not all burned areas are necessarily lost as habitat. The level of losses varies widely by province, from extremely low (0.03percent of the nesting and roosting habitat) in the Olympic Peninsula Province to 9.5 percent in the Oregon Klamath Province. Wildfire caused most of the loss (236,700 acres) while insects and disease resulted in 8,100 acres of habitat. On non-federal lands, the level was very low, less than 1percent in each state (Table B-3).

Table B-3. Spotted owl nesting and roosting habitat loss from natural disturbances on non-federal lands from 1994/96[1] to 2006-7[1] (acres) (adapted from Davis and Dugger in press).

State	1994/96 habitat	Fire	Insects and disease	Total	Percent habitat loss[2]
Washington	1,258,900	2,400	6,000	8,400	0.7%
Oregon	1,382,400	5,100	2,700	7,800	0.6%
California	1,556,700	5,600	1,900	7,500	0.4%
Total	4,198,000	13,100	10,600	23,700	0.6%

[1] 1996 and 2006 for Oregon and Washington, 1994 and 2007 for California.

[2] Loss is the term used in Davis and Dugger (in press) to describe their data, which is summarized here.

Summary of Recent Rates of Loss of Spotted Owl Habitat as a Result of Timber Harvest and Natural Disturbances

Range-wide, 0.6 percent (53,800 acres) of the spotted owl nesting and roosting habitat on Federal lands were lost to timber harvest and 2.8 percent (244,800 acres) to natural disturbances, primarily wildfire, resulting in a total range-wide loss of 3.4 percent (298,600 acres). The greatest percentage of Federal land habitat loss was in Oregon, specifically in the Oregon Klamath Province (10.9 percent of the habitat) due primarily to wildfire. Two provinces, the Oregon and California Klamath accounted for 60 percent of the total habitat loss on Federal lands. In contrast, less than 1 percent of the nesting and roosting habitat in the Olympic Peninsula, Western Washington Cascades, and Oregon Coast Ranges were loss during the time period.

Habitat Recruitment

Several groups have attempted to estimate the rate or amount of spotted owl habitat recruitment. Most of these estimates were not specific to spotted owl habitat. In reality, projecting the transition of a forest's age and size classes to different levels of habitat function requires extensive field verification. The SEI report (SEI 2004:6-29) provided a clear caution relative to habitat development.

> "Habitat development certainly is not a mechanistic process and there is considerable variability with predictions of habitat development. The habitat complexity that most definitions project as suitable habitat develops

> over multiple decades and is not a threshold that is achieved with an average size class. Stand age or size does not account for the history, growing conditions, species composition, and other factors that determine the rate of habitat development. There is considerable uncertainty in the transition between mid-seral stage stands and suitable habitat. These uncertainties still exist with remote sensing information or inventory methods that are not specifically designed to sample the key components of suitable habitat."

In addition, determining when a forest progresses from non-habitat to habitat on an ecologically-short time frame (10-15 years) is fraught with assumptions and potential inaccuracy. Given the uncertainty about the rate of complex forest structure, it is likely that habitat development was overestimated, although the extent of overestimation cannot be determined (Bigley and Franklin 2004).

Given the degree of uncertainty, potential inaccuracy, and disagreements between results, we cannot at this time reach any conclusions on the issue of habitat recruitment. We will continue to follow this issue as new information becomes available.

Disease

WNV has killed millions of wild birds in North America since it arrived in 1999 (McLean *et al.* 2001, Caffrey 2003, Fitzgerald *et al.* 2003, Marra *et al.* 2004). Mosquitoes are the primary carriers of this virus that causes encephalitis in humans, horses, and birds. Although birds are the primary hosts of WNV, additional non-human hosts include horses and other ungulates, felines, canines, rodents, rabbits, bats, alligators, and frogs (Hubálek and Halouzka 1999, Gubler 2007). Mammalian prey may play a role in spreading WNV, if predators like spotted owls contract the disease by eating infected prey (Garmendia *et al.* 2000, Komar *et al.* 2001). One captive spotted owl in Ontario, Canada, is known to have contracted WNV and died (Gancz *et al.* 2004), but there are no documented cases of the virus in wild spotted owls.

Health officials expect that WNV eventually will spread throughout the range of the spotted owl (Blakesley *et al.* 2004), but it is unknown how the virus will ultimately affect spotted owl populations. Susceptibility to infection and the mortality rates of infected individuals vary among bird species (Blakesley *et al.* 2004), but most owls appear to be quite susceptible. For example, eastern screech-owls breeding in Ohio that were exposed to WNV experienced 100 percent mortality (T. Grubb pers. comm. in Blakesley *et al.* 2004). Barred owls, in contrast, showed lower susceptibility (B. Hunter pers. comm. in Blakesley *et al.* 2004). Wild birds may develop resistance to WNV through immune responses (Deubel *et al.* 2001).

Blakesley *et al.* (2004) offer competing scenarios for the likely outcome of spotted owl populations being infected by WNV. One scenario is that spotted owls can tolerate severe, short-term population reductions caused by the virus because spotted owl populations are widely distributed and number in the several thousands. An alternative scenario is that the virus will cause unsustainable mortality because of the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the spotted owl's current range.

Ishak *et al.* (2008) document Plasmodium spp. in a spotted owl. They also found 10 spotted owls with multiple infections (Ishak *et al.* 2008). It is unclear, however, if this rate of infection is significant and if it might affect the recovery of the species.

Inadequacy of Regulatory Mechanisms

The original listing document (USFWS 1990b), Franklin and Courtney (2004), and the 5-year review (USFWS 2004b) noted some inadequacies in existing regulatory mechanisms. The 1990 listing rule concluded that current State regulations and policies did not provide adequate protection for spotted owls; less than 1 percent of the non-federal lands provided long-term protection for spotted owls (USFWS 1990b). The listing rule stated that the rate of harvest on Federal lands, the limited amount of permanently reserved habitat, and the management of spotted owls based on a network of individually protected sites did not provide adequate protection for the spotted owl. If continued, these management practices would result in an estimated 60 percent decline in the remaining spotted owl habitat, and the resulting amount of habitat might not be sufficient to ensure long-term viability of the spotted owl.

When it was adopted in 1994, the NWFP significantly altered management of Federal lands (USDA and USDI 1994a, b, Noon and Blakesley 2006, Thomas *et al.* 2006). The substantial increase in reserved areas and associated reduced harvest (ranging from approximately 1 percent per year to 0.24 percent per year) has substantially lowered the timber-harvest threat to spotted owls. However, the NWFP allows some loss of habitat and assumed some unspecified level of continued decline in spotted owls. Franklin and Courtney (2004) noted that many, but not all, of the scientific building blocks of the NWFP have been confirmed or validated in the decade since the plan was adopted. One major limitation appears to be the inability of the conservation network presented in the plan to deal with invasive species. However, this deficiency does not diminish the important contribution of the relevant LRMPs to spotted owl conservation (Franklin and Courtney 2004).

As the Federal agencies develop new LRMPs, they will consider the conservation needs of the spotted owl and the goals and objectives of this Revised Recovery Plan. If needed, actions to implement Federal land use plans will be accompanied with either plan or project level consultations to assure management actions align with recovery goals.

Barred Owls

Barred owls expanded their range from eastern to western North America during the past century. They were first documented in British Columbia in 1943 (Rand 1944, Munro and McTaggart-Cowan 1947), Washington in 1965 (Rogers 1966), Oregon in 1972 (E. Forsman in Livezey 2009a), California in 1976 (B. Marcot in Livezey 2009a). This range expansion may have been facilitated by increases in distribution of trees in the Great Plains due to exclusion of fires historically set by Native Americans, fire suppression, tree planting , extirpation of bison and beaver, and other factors (Dark *et al.* 1998, R. Gutiérrez in Levy 1999, 2004, Mazur and James 2000, USFWS 2003, Livezey 2009b). The range of the barred owl now completely overlaps that of its slightly smaller congener, the spotted owl (Gutiérrez *et al.* 1995).

Barred owls have been observed physically attacking spotted owls (pers. comms. in Pearson and Livezey 2003) and circumstantial evidence suggests that a barred owl killed a spotted owl (Leskiw and Gutiérrez 1998). Based on early studies conducted on the west slope of the Washington Cascades (Hamer 1988, Iverson 1993), barred owls were thought by some to be more closely associated with early successional forests than spotted owls are, though even then they were known to use old-growth. Recent studies in the Pacific Northwest (Herter and Hicks 2000, Pearson and Livezey 2003, Gremel 2005, Schmidt 2006, Hamer *et al.* 2007, Singleton *et al.* 2010) show that barred owls also use, and in some cases, appear to prefer old-growth forest and older forest. Diets of spotted and barred owls in the western Washington Cascades overlap by approximately 76 percent (Hamer *et al.* 2001). Barred owl diets are more diverse than those of spotted owls (Forsman *et al.* 2004) and include more species associated with riparian and other moist habitats, along with more terrestrial and diurnal species (Hamer *et al.* 2001). The more-diverse food habits of barred owls appears to be the reason that barred owls have much smaller home-ranges than spotted owls do (Hamer *et al.* 2007).

Barred owls reportedly have reduced probability of detection (response behavior), site occupancy, reproduction, and survival of spotted owls. The probability of detecting spotted owls during surveys in Washington, Oregon, and California was significantly reduced by the presence of barred owls (Olson *et al.* 2005, Crozier *et al.* 2006). In the eastern Cascades of Washington, probabilities of detecting any spotted owl or a pair of spotted owls were significantly lower when barred owls were detected during surveys than when no barred owls were detected (Kroll *et al.* 2010). In addition, studies in Oregon showed that detection of both species was negatively influenced by presence of the other (Bailey *et al.* 2009) and barred owls frequently were not detected during surveys for spotted owls (Bailey *et al.* 2009).

Forsman *et al.* (2011) and Anthony *et al.* (2006) have documented increasing barred owl numbers across Washington, Oregon, and California from 1990-2008. While barred owls have expanded into California more recently (Kelly *et al.* 2003), Forsman *et al.* (2011) provides strong evidence of increasing barred owl populations in this region. Occupancy of territories by spotted owls in study areas in Washington and Oregon was significantly lower after barred owls were detected within 0.5 miles of the territory center but was “only marginally lower” if barred owls were located more than 0.5 miles from the spotted owl territory center (Kelly *et al.* 2003:51). In the Gifford Pinchot National Forest, there were significantly more barred owl site-centers in unoccupied spotted owl circles than in occupied spotted owl circles with radii of 0.5 miles, 1 mile, and 1.8 miles centered on spotted owl sites (Pearson and Livezey 2003). In the eastern Washington Cascades, barred owls had a significant negative effect on site occupancy by any spotted owl (both single and pair spotted owl detections combined); however, barred owls did not have a negative effect on site occupancy by spotted owl pairs (Kroll *et al.* 2010). Spotted owl simple extinction probabilities (probability that a site center changed from occupied to unoccupied) were significantly higher in the eastern Washington Cascades when barred owls were detected in a site center during the year (Kroll *et al.* 2010). In Olympic National Park, spotted owl pair occupancy declined significantly at sites where barred owls had been detected, whereas pair occupancy remained stable at spotted owl sites without barred owls (Gremel 2005). Annual probability that a spotted owl territory would be occupied by a pair of spotted owls after barred owls were detected at the site declined by five percent in the HJ Andrews study area, 12 percent in the Coast Range study area, and 15 percent in the Tyee study area (Olson *et al.* 2005).

Barred owls evidently are appropriating spotted owl sites in flatter, lower-elevation forests in some areas (Pearson and Livezey 2003, Gremel 2005, Hamer *et al.* 2007). Apparently in response to barred owls, some marked spotted owl site centers have moved higher up slopes (Gremel 2005). According to one study, “the trade-off for living in high elevation forests could be reduced survival or fecundity in years with severe winters (Hamer *et al.* 2007:764).” It is unknown whether this slope/elevation tendency found in Washington is prevalent throughout the range of the spotted owl, how long spotted owls can persist where they are relegated to only steep, higher-elevation areas, and whether barred owls will continue to move upslope and eventually supplant the remaining spotted owls in these areas.

Reproduction of spotted owls in the Roseburg study area, Oregon, was negatively affected by the presence of barred owls (Olson *et al.* 2004). Apparent survival of spotted owls was negatively affected by barred owls in two (Olympic and Wenatchee) of 14 study areas throughout the range of the spotted owl (Anthony *et al.* 2006). The researchers attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate. It is likely that this study underestimated the effects of barred owls on the reproduction of spotted owls because spotted owls often cannot be relocated after they are displaced by barred owls (E. Forsman pers. comm. 2006).

Only 47 spotted owl/barred owl hybrids were detected in an analysis of more than 9,000 banded spotted owls throughout their range (Kelly and Forsman 2004). Consequently, hybridization with the barred owl is considered to be “an interesting biological phenomenon that is probably inconsequential, compared with the real threat—direct competition between the two species for food and space" (Kelly and Forsman 2004:808).

Data indicating negative effects of barred owls on spotted owls are largely correlational and are almost exclusively gathered incidentally to data collected on spotted owls (Gutiérrez *et al.* 2004, Livezey and Fleming 2007). Competition theory predicts that barred owls will compete with spotted owls because they are similar in size and have overlapping diet and habitat requirements (Hamer *et al.* 2001, 2007, Gutiérrez *et al.* 2007). Limited experimental evidence (Crozier *et al.* 2006), preliminary response by spotted owls to a scientific collection of barred owls (L. Diller pers. comm. 2010), correlational studies (Kelly *et al.* 2003, Pearson and Livezey 2003, Gremel 2005, Olson *et al.* 2005, Hamer *et al.* 2007, Dugger *et al.* in press), and anecdotal information (Leskiw and Gutiérrez 1998, Gutiérrez *et al.* 2004) suggest that barred owls are negatively affecting spotted owls through exploitive and interference competition. The preponderance of evidence suggests barred owls are contributing to the population decline of spotted owls, especially in Washington, portions of Oregon, and the northern coast of California (Gutiérrez *et al.* 2004, Olson *et al.* 2005) which may explain the sharper decline in the spotted owl population trend in the northern portion of the spotted owl's range compared to those in the southern portion of the range.

Loss of Genetic Variation

One possible threat to spotted owls is a loss of genetic variation from population bottlenecks which could lead to increased inbreeding depression and decreased adaptive potential. Funk *et al.* (2010) found evidence of recent genetic bottlenecks in the spotted owl population, estimating these have occurred within the last few decades. They found the strongest evidence for recent bottlenecks in the Washington Cascades, which they correlate with data on significant population declines in the same area. However, they did not find strong evidence of bottlenecks in other areas that showed population declines. While they could not determine "whether inbreeding is contributing to vital rate reductions" (pg. 7), they do caution that "future efforts to conserve northern spotted owl populations will require greater consideration of genetic threats to persistence" (pg. 7).

SEI (2008) reviewed a presentation and two unpublished manuscripts, provided by Dr. Susan Haig, on the evidence for genetic bottlenecks in spotted owl populations. Using microsatellite markers and a computer program called "Bottleneck," Haig provided evidence of recent genetic bottlenecks at several spatial scales (individual "populations" [demographic study areas], regions, and subspecies). Haig explicitly stated she could not conclude these bottlenecks were the cause for, nor were they necessarily related to, the recently documented declines in spotted owl populations. However, she did present a "cross-walk" of her results with a table depicting the status of spotted owl populations from Anthony *et al.* (2006).

SEI (2008) concluded Haig's observed bottlenecks are likely the result of population declines and not the cause of it; they are signatures of something that occurred in the past. SEI (2008) advises the population dynamics of the spotted owl likely will be more important to its short-term survival than will be its genetic makeup, regardless of the evidence for bottlenecks having occurred in the past (Barrowclough and Coats 1985).

Appendix C. Development of a Modeling Framework to Support Recovery Implementation and Habitat Conservation Planning

Introduction by U.S. Fish and Wildlife Service

The Service believes a spatially explicit demographic model would greatly improve recovery planning and implementation for the spotted owl. Peer reviewers were critical of the 2008 Recovery Plan's habitat conservation network strategy and the general lack of updated habitat modeling capacity. The Service considered this criticism and concluded that a spatially explicit demographic model would greatly improve recovery implementation for the spotted owl, as well as other land use management decisions.

For this Revised Recovery Plan, the Service appointed a team of experts to develop and test a modeling framework that can be used in numerous spotted owl management decisions. This spatially-explicit approach is designed to allow for a more in-depth evaluation of various factors that affect spotted owl distribution and populations**.** This approach also allows for a unique opportunity to integrate new data sets, such as information from the NWFP 15-year Monitoring Report (Davis and Dugger in press) and the recent spotted owl population meta-analysis (Forsman *et al.* 2011).

The Service expects this modeling framework will be applied by Federal, State, and private scientists to make better informed decisions concerning what areas should be conserved or managed to achieve spotted owl recovery. Specifically, the modeling framework can be applied to various spotted owl management challenges, such as to:

1) Inform evaluations of meeting population goals and Recovery Criteria.
2) Develop reliable analysis and modeling tools to enable evaluation of the influence of habitat suitability and barred owls on spotted owl demographics.
3) Support future implementation and evaluation of the efficacy of spotted owl conservation measures described in various recovery actions.
4) Provide a framework for landscape-scale planning by both Federal and non-federal land managers that enables evaluation of potential demographic responses to various habitat conservation scenarios, including information that could be used in developing a proposed critical habitat rule.

These and other potential applications of the modeling framework described herein represent a significant advancement in spotted owl recovery planning. Although the completed model framework will be included in the Revised Recovery Plan, the Service hopes that future application of this modeling approach will lead to refinement and improvements, such as incorporation of population connectivity and source-sink dynamics, over time as experience and new scientific insights are realized.

To meet these objectives, the Service established the Spotted Owl Modeling Team (hereafter the "modeling team") to develop and apply modeling tools for the Service's use in designing and evaluating various conservation options for achieving spotted owl recovery. The modeling team was informally organized along lines of function and level of participation. Jeffrey Dunk (Humboldt State University), Brian Woodbridge (USFWS), Bruce Marcot (USFS, Pacific Northwest Research Station), Nathan Schumaker (USEPA), and Dave LaPlante (a contractor with Natural Resource Geospatial) composed the primary group which was responsible for conducting the data analyses and modeling. They were assisted by spotted owl researchers, agency staff and modeling specialists who individually provided data sets and advice on particular issues within their areas of expertise, and reviewed modeling processes and outputs. These experts were: Robert Anthony (Oregon State University), Katie Dugger (Oregon State University), Marty Raphael (USFS, Pacific Northwest Research Station), Jim Thrailkill (USFWS), Ray Davis (USFS, Northwest Forest Plan Monitoring Group), Eric Greenquist (BLM), and Brendan White (USFWS). Additionally, technical specialists—Craig Ducey (BLM), Karen West (USFWS) and Dan Hansen and M.J. Mazurek (contractors with Humboldt State University Foundation) conducted literature reviews and assisted with data collection and analyses.

To ensure that the modeling effort was based on the most current information, scientific knowledge and opinion, the modeling team also sought the assistance of numerous individual scientists and habitat managers from government, industry and a non-profit conservation organization (listed in acknowledgements) in development of habitat descriptions, modeling regions and many other aspects of spotted owl and forest ecology. To facilitate this effort, the Service held a series of meetings with spotted owl experts (habitat expert panels) to obtain additional information, data sets, and expertise regarding spotted owl habitats.

Representatives of the modeling team have prepared this Appendix to provide a thorough description of the modeling framework developed by the team, the results of model development and testing, and examples of how the modeling process can be used to evaluate habitat conservation scenarios and their relative contribution to recovery.

While this framework represents state-of-the-art science, it is not intended to represent absolute spotted owl population numbers or be a perfect reflection of reality. Instead, it provides a comparison of the relative spotted owl responses to a variety of potential conservation measures and habitat conservation networks. The implementation of spotted owl recovery actions should consider the results of the modeling framework as one of numerous sources of information to be incorporated into the decision-making process.

General Approach

The spotted owl modeling team (hereafter "modeling team" or "we") employed state-of–the-art modeling tools in a multi-step analysis similar to that proposed by Heinrichs *et al.* (2010) and Reed *et al.* (2006) for designing habitat conservation networks and evaluating their contributions to spotted owl recovery. In addition to this objective, the modeling tools in this framework, individually or in combination, are designed to enable evaluation of the efficacy of spotted owl conservation measures such as Recovery Action 10 and management of barred owls**.**

Our conservation planning framework integrates a spotted owl habitat model, a habitat conservation planning model, and a population simulation model. Collectively, these modeling tools allow comparison of estimated spotted owl population performance among alternative habitat conservation network scenarios under a variety of potential conditions. This will enable the Service and other interested managers to use relative population viability (timing and probability of population recovery) as a criterion for evaluating habitat conservation network scenarios and other conservation measures for the spotted owl.

The evaluation approach the modeling team developed consists of three main steps (Figure C1):

> **Step 1** – Create a map of spotted owl habitat suitability throughout the species' U.S. range, based on a statistical model of spotted owl habitat associations.
>
> **Step 2** – Develop a spotted owl conservation planning model, based on the habitat suitability model developed in Step 1, and use it to design an array of habitat conservation network scenarios.
>
> **Step 3** – Develop a spatially explicit spotted owl population model that reliably predicts relative responses of spotted owls to environmental conditions, and use it to test the effectiveness of habitat conservation network scenarios designed in step 2 in recovering the spotted owl. The simulations from this spotted owl population model are not meant to be estimates of what will occur in the future, but provide information on trends predicted to occur under differing habitat conservation scenarios.

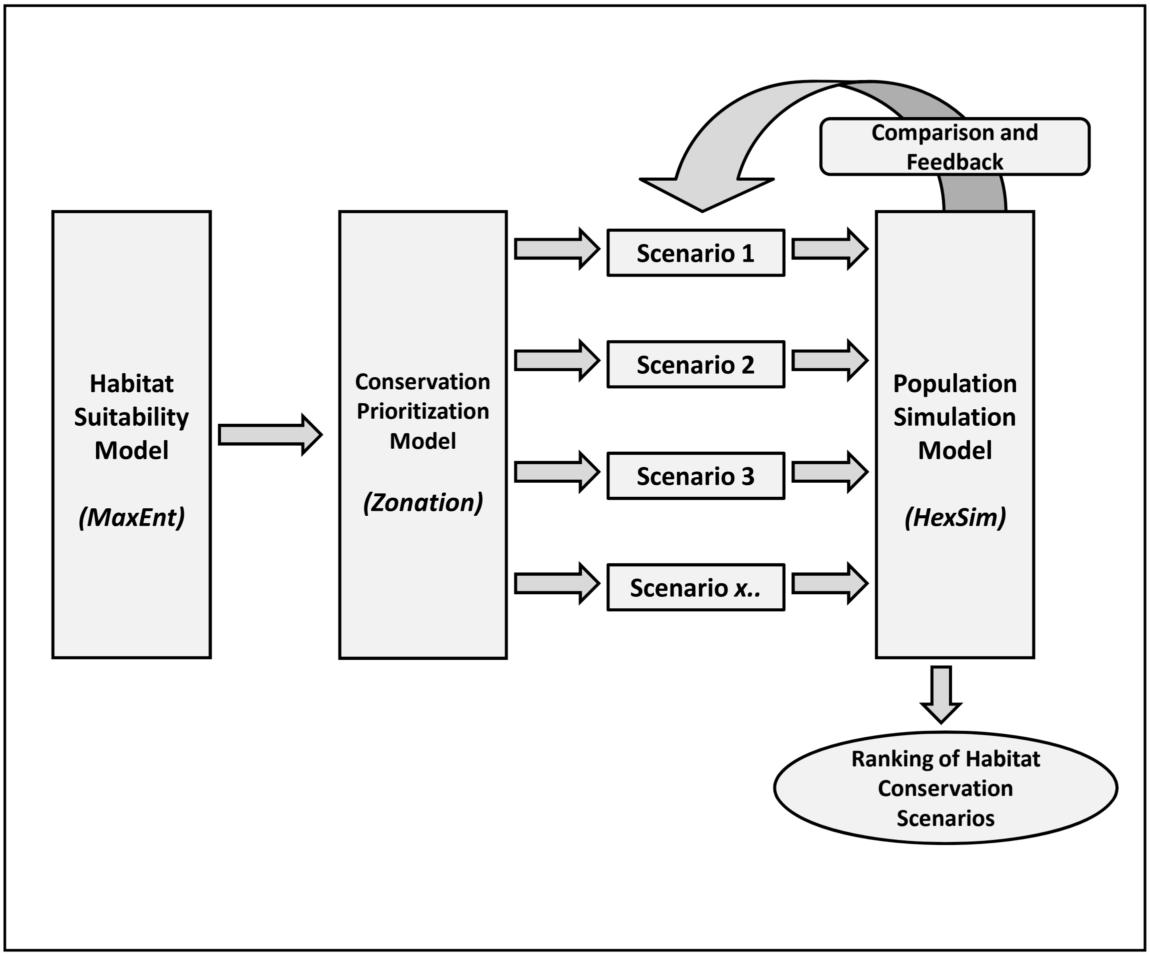
The Service or other practitioners can use the population simulation model developed in Step 3 to test the degree to which various recovery actions and habitat conservation network scenarios contribute to recovery of the spotted owl. For example, it can be used to evaluate relative population size and trend, as well as distribution and connectivity of modeled spotted owl populations through time.

Each of the steps noted above involved statistical and/or mathematical modeling and is not meant to be exact predictions of what currently exists or what will occur in the future, but represent our best estimates of current conditions and relationships. These models allow the use of powerful, up-to-date scientific tools in a repeatable and scientifically accepted manner to develop and evaluate habitat conservation networks and other conservation measures to recover the spotted owl. We view the benefit and utility of such models in the same way that Johnson (2001) articulated, "*A model has value if it provides better insight, predictions, or control than would be available without the model*." The modeling tools described herein meet this standard.

The overall framework and evaluations outlined in Figure C1 are somewhat similar to Raphael *et al.* (1998). Our modeling process differs fundamentally from the conservation planning approach used by the ISC (Thomas *et al*. 1990), 1992 Draft Recovery Plan (USFWS 1992b), FEMAT (1993), and the 2008 Recovery plan (USFWS 2008b), which were based on *a priori* rule sets derived from best expert judgment regarding the size of reserves or habitat conservation blocks, target number of spotted owl pairs per reserve or block, and targeted spacing between reserves or blocks. The new modeling framework we developed instead uses a series of spatially explicit modeling processes to develop habitat conservation networks (or "reserves") based on the distribution of habitat value. Issues of habitat connectivity and population isolation are identified within the population simulation model outputs.

The spotted owl modeling team has completed the development and evaluation of the overall modeling framework described in Steps 1 through 3 above. The *use* of the modeling framework, for example, to inform design and evaluation of various habitat conservation network scenarios (including potential effects of barred owl management), other conservation measures described in recovery actions, and evaluate potential effects of climate change will be completed as a part of recovery plan implementation or other analytical and regulatory processes.

Figure C-1. **Diagram of stepwise modeling process for developing and evaluating habitat conservation scenarios for the spotted owl.**



Modeling Process Step 1 – Create a spotted owl habitat suitability map covering the U.S. range of the subspecies based on a statistical model of spotted owl habitat associations.

Habitat modeling objective and overall approach:

A variety of methods are available for modeling species-habitat relationships (Morrison *et al*. 1992, Elith *et al.* 2006), with divergent assumptions and underlying statistical bases (Breiman 2001). The selection of a modeling tool is influenced foremost by the objectives of the modeling exercise, and by the characteristics of data available for modeling. The primary objective of our recovery plan modeling was to develop a map that reliably predicts relative habitat suitability for the spotted owl. Our primary goals were to develop predictive models that: 1) had good discriminatory ability, 2) were well calibrated, 3) were robust, and 4) had good generality. Our modeling was not an attempt to quantify or refine our understanding of the spotted owl's niche; but instead focused on predictions. Because we were primarily focused on obtaining reliable predictions, we were less concerned about covariates and their associated parameter estimates, or the relative importance of each habitat variable. This objective enabled us to consider newer algorithmic modeling approaches that emphasize prediction (Breiman 2001).

The nature of the spotted owl data available to us also influenced our choice of a modeling approach. We gathered several datasets which resulted in a large number of spotted owl locations, but only a relatively small subset of those data sets also had survey effort information (that could be used for occupancy modeling) and absence data (locations that were adequately sampled and where spotted owls were not detected). Because the majority of spotted owl data available was best characterized as 'presence-only' data, we elected not to employ occupancy modeling approaches.

Our objectives and the nature of the data available to us lead us to choose the species distribution model MaxEnt (Phillips *et al*. 2006, Phillips and Dudik 2008) to model spotted owl relative habitat suitability. MaxEnt is specifically designed for presence-only data. Moreover, MaxEnt has been thoroughly evaluated on a number of taxa, geographic regions, and sample sizes and has been found to perform extremely well (Elith *et al.* 2006, Wisz *et al*. 2008).

Distributional Models and the Spotted Owl:

Species distributional models are used to evaluate species-habitat relationships, evaluate an area's suitability for the species, and to predict a species' presence (Elith and Leathwick 2009). These models, also called environmental (or ecological) niche models, correlate environmental conditions with species distribution and thereby predict the relative suitability of habitat within some geographic area (Warren and Seifert 2011). When translated into maps depicting the spatial distribution of predicted habitat suitability, these models have great utility for evaluating conservation reserve design and function (Zabel *et al.* 2002, Zabel *et al*. 2003, Carroll and Johnson 2008, Carroll *et al.* 2010). Because the spotted owl is one of the most studied raptors in the world; we had available hundreds of peer-reviewed papers on various aspects of the species' ecology, including habitat use and selection (see reviews by Gutiérrez *et al.* 1995, Blakesley 2004). Only a few range-wide (in the U.S.) evaluations of habitat association (Carroll and Johnson 2008) or habitat distribution (Davis and Lint 2005, Davis and Dugger in press) have been conducted. While we capitalized on this large body of literature and other information to build models for conservation planning purposes, we were primarily interested in using such models to map relative habitat suitability rather than to provide new ecological understanding of spotted owl habitat associations.

Meetings with spotted owl habitat experts and review of literature and data sets:

Because the spotted owl is among the most-studied birds in the world, there is a wealth of information on its ecology and habitat associations. To ensure that the modeling effort was based on this scientific foundation, our first step was to conduct an extensive review of published and unpublished information on the species. Concurrent with this effort, team members travelled throughout the spotted owl's range and met with researchers and biologists with extensive experience studying spotted owls. Some of these meetings were one-on-one, and at other times we held meetings with several experts at one time to seek their individual advice. We have sometimes referred to these meetings as "expert panels." At these meetings, biologists were each asked to identify (1) the environmental factors to which spotted owls respond within particular physiographic provinces (*e.g.* Klamath Mountains of southern Oregon and northern California, Olympic Peninsula, Redwood Coast), and (2) regions believed to be distinct where spotted owls may be responding to conditions uniquely. In order to identify distinct modeling areas and definitions of spotted owl habitat (see below), we used both empirical findings (*i.e.*, published information) and the professional judgment of spotted owl experts.

Modeling regions - Partitioning the species' range:

Several authors have noted that spotted owls exhibit different habitat associations in different portions of their range, which is often attributed to regional differences in forest environments and factors such as important prey species (Carey *et al.* 1992, Franklin *et al.* 2000, Noon and Franklin 2002, Zabel *et al.* 2003), or presence of Douglas-fir dwarf mistletoe (expert panels). The distribution of these features is likely influenced by relatively large east-west and north-south gradients in ecological conditions (*e.g.*, temperature, precipitation, net primary productivity) and subsequent variation in forest environments. Hence, we developed and evaluated region-specific habitat suitability models under the assumption that spotted owls *within* a modeling region respond to habitat conditions more similarly than do spotted owls *between* modeling regions where conditions differ.

For monitoring, management and regulatory purposes, the spotted owl's range has historically been divided into 12 physiographic provinces (USDI 1992, Davis and Lint 2005) based largely on the regional distribution of major forest types and state boundaries. Based on differences and similarities in spotted owl habitat, we combined some provinces (California and Oregon Klamath provinces), retained others, and divided some provinces into smaller modeling regions (see Figure C2). We did not establish modeling regions or develop models for the Puget Lowlands, Southwestern Washington, and Willamette Valley, where spotted owls are almost completely absent and sample sizes were too small to support for model development. Instead, we projected the models developed for the closest adjacent area to those areas. This decision had the influence of allowing those regions to have at least some potential value to simulated spotted owls as opposed to assuming zero value.

The predictive ability and accuracy of habitat suitability models are influenced by the range of environmental conditions that are incorporated into the training data used in model development. Models developed from data sets encompassing broad environmental gradients tend to be overly general; conversely, models developed with data representing a small subset of conditions have limited applicability across the species' larger distribution. The practice of partitioning a species' range into "modeling regions" that encompass relatively dissimilar subsets of species-habitat relationships and developing models specific to each region was used to reduce this source of variability. The challenge is balancing the high degree of variability within large regions against the tendency to create many small modeling regions (with potentially small sample sizes) based on locally unique environmental conditions.

We queried experts to suggest potential modeling region boundaries, and they provided input on broad-scale patterns in climate, topography, forest communities, spotted owl habitat relationships, and prey-base that supported delineation of the draft spotted owl modeling regions (Figure C2). Franklin and Dyrness (1973), Kuchler (1977) and other published sources of information on the distribution of major ecological boundaries were also consulted. Using information provided through our discussions with the expert panels and existing ecological section and subsection boundaries (McNab and Avers 1994), we delineated 11 spotted owl modeling regions (Figure C2).

In general, the spotted owl modeling regions varied in terms of these ecological features:

1) Degree of similarity between structural characteristics of habitats used by spotted owls primarily for nesting/roosting and habitats used for foraging and other nocturnal activities. This similarity is largely influenced by habitat characteristics of the spotted owl's dominant prey (proportion of flying squirrels versus woodrats).

2) Latitudinal patterns of topography and climate. For example, in the WA Cascades, spotted owls are rarely found at elevations above 1,219-1,372 m, whereas in southern Oregon and the Klamath province spotted owls commonly reside up to 1,830 m.

3) Regional patterns of topography, climate, and forest communities.

4) Geographic distributions of habitat elements that influence the range of conditions occupied by spotted owls. For example, several panelists pointed out that the distribution of dwarf mistletoe influences the range of stand structural values associated with spotted owl use. Other examples include the geographic distribution of elements such as evergreen hardwoods, Oregon white oak woodlands, and ponderosa pine-dominated forests.

Modeling Region Descriptions:

North Coast Ranges and Olympic Peninsula (NCO): This region consists of the Oregon and Washington Coast Ranges Section M242A (McNab and Avers 1994). This region is characterized by high rainfall, cool to moderate temperatures, and generally low topography (448 to 750 m). High elevations and cold temperatures occur in the interior portions of the Olympic Peninsula, but spotted owls in this area are limited to the lower elevations (<900 m.). Forests in the NCO are dominated by western hemlock, Sitka spruce, Douglas-fir, and western red cedar. Hardwoods are limited in species diversity (consist mostly of bigleaf maple and red alder) and distribution within this region, and typically occur in riparian zones. Root pathogens like laminated root rot (*Phellinus weirii*) are important gap formers, and vine maple, among others, fills these gaps. Because Douglas-fir dwarf mistletoe is unusual in this region, spotted owl nesting habitat consists of stands providing very large trees with cavities or deformities. A few nests are associated with western hemlock dwarf mistletoe. Spotted owl diets are dominated by species associated with mature to late-successional forests (flying squirrels, red tree voles), resulting in similar definitions of habitats used for nesting/roosting and foraging by spotted owls. This region contains the Olympic Demographic Study Area (DSA).

Oregon Coast Ranges (OCR): This region consists of the southern 1/3 of the Oregon and Washington Coast Ranges Section M242A (McNab and Avers 1994). We split the section in the vicinity of Otter Rock, OR, based on gradients of increased temperature and decreased moisture that result in different patterns of vegetation to the south. Generally this region is characterized by high rainfall, cool to moderate temperatures, and generally low topography (300 to 750 m.). Forests in this region are dominated by western hemlock, Sitka spruce, and Douglas-fir; hardwoods are limited in species diversity (largely bigleaf maple and red alder) and distribution, and are typically limited to riparian zones. Douglas-fir and hardwood species associated with the California Floristic Province (tanoak, Pacific madrone, black oak, giant chinquapin) increase toward the southern end of the OCR. On the eastern side of the Coast Ranges crest, habitats tend to be drier and dominated by Douglas-fir. Root pathogens like laminated root rot (*P. weirii*) are important gap formers, and vine maple among others fills these gaps. Because Douglas-fir dwarf mistletoe is unusual in this region, spotted owl nesting habitat tends to be limited to stands providing very large trees with cavities or deformities. A few nests are associated with western hemlock dwarf mistletoe. Spotted owl diets are dominated by species associated with mature to late-successional forests (flying squirrels, red tree voles), resulting in similar definitions of habitats used for nesting/roosting and foraging by spotted owls. One significant difference between OCR and NCO is that woodrats comprise an increasing proportion of the diet in the southern portion of the modeling region. This region contains the Tyee and Oregon Coast Range DSAs.

Redwood Coast (RDC): This region consists of the Northern California Coast Ecological Section 263 (McNab and Avers 1994). This region is characterized by low-lying terrain (0 to 900 m.) with a maritime climate; generally mesic conditions and moderate temperatures. Climatic conditions are rarely limiting to spotted owls at all elevations. Forest communities are dominated by redwood, Douglas-fir-tanoak forest, coast liveoak, and tanoak series. The vast majority of the region is in private ownership, dominated by a few large industrial timberland holdings. The results of numerous studies of spotted owl habitat relationships suggest stump-sprouting and rapid growth rates of redwoods, combined with high availability of woodrats in patchy, intensively-managed forests, enables spotted owls to maintain high densities in a wide range of habitat conditions within the Redwood zone. This modeling region contains the Green Diamond and Marin DSAs.

Western Cascades North (WCN): This region generally coincides with the northern Western Cascades Section M242B (McNab and Avers 1994), combined with western portion of M242D (Northern Cascades Section), extending from the U.S. - Canadian border south to Snoqualmie Pass in central Washington. It is similar to the Northern Cascades Province of Franklin and Dyrness (1974). This region is characterized by high mountainous terrain with extensive areas of glaciers and snowfields at higher elevation. The marine climate brings high precipitation (both annual and summer) but is modified by high elevations and low temperatures over much of this modeling region. The resulting distribution of forest vegetation is dominated by subalpine species, mountain hemlock and silver fir; the western hemlock and Douglas-fir forests typically used by spotted owls are more limited to lower elevations and river valleys (spotted owls are rarely found at elevations greater than 1,280 m. in this region) grading into the mesic Puget lowland to the west. Root pathogens like laminated root rot (*P. weirii*) are important gap formers, and vine maple, among others, fills these gaps. Because Douglas-fir dwarf mistletoe occurs rarely in this region, spotted owl nests sites are limited to defects in large trees, and occasionally nests of other raptors. Diets of spotted owls in this northern region contain higher proportions of red-backed voles and deer mice than in the region to the south, where flying squirrels are dominant (expert panels). There are no Demographic Study Areas in this modeling region.

Western Cascades Central (WCC): This region consists of the midsection of the Western Cascades Section M242B (McNab and Avers 1994), extending from Snoqualmie Pass in central Washington south to the Columbia River. It is similar to the Southern Washington Cascades Province of Franklin and Dyrness (1974). We separated this region from the northern section based on differences is spotted owl habitat due to relatively milder temperatures, lower elevations, and greater proportion of western hemlock/Douglas-fir forest and occurrence of noble fir to the south of Snoqualmie Pass. Because Douglas-fir dwarf mistletoe occurs rarely in this region, spotted owl nest sites are largely limited to defects in large trees, and occasionally nests of other raptors. This region contains the Rainier DSA and small portions of the Wenatchee and Cle Elum DSAs.

Western Cascades South (WCS): This region consists of the southern portion of the Western Cascades Section M242B (McNab and Avers 1994) and extends from the Columbia River south to the North Umpqua River. We separated this region from the northern section due to its relatively milder temperatures, reduced summer precipitation due to the influence of the Willamette Valley to the west, lower elevations, and greater proportion of western hemlock/Douglas-fir forest. The southern portion of this region exhibits a gradient between Douglas-fir/western hemlock and increasing Klamath-like vegetation (mixed conifer/evergreen hardwoods) which continues across the Umpqua divide area. The southern boundary of this region is novel and reflects a transition to mixed conifer sensu Franklin and Dyrness (1974). The importance of Douglas-fir dwarf mistletoe increases to the south in this region, but most spotted owl nest sites in defective large trees, and occasionally nests of other raptors. The HJ Andrews DSA occurs within this modeling region.

Eastern Cascades North (ECN): This region consists of the eastern slopes of the Cascade range, extending from the Canadian border south to the Deschutes National Forest near Bend, OR. Terrain in portions of this region is glaciated and steeply dissected. This region is characterized by a continental climate (cold, snowy winters and dry summers) and a high-frequency/low-mixed severity fire regime. Increased precipitation from marine air passing east through Snoqualmie Pass and the Columbia River results in extensions of moist forest conditions into this region (Hessburg *et al.* 2000b). Forest composition, particularly the presence of grand fir and western larch, distinguishes this modeling region from the southern section of the eastern Cascades. While ponderosa pine forest dominates lower and middle elevations in both this and the southern section, the northern section supports grand fir and Douglas fir habitat at middle elevations. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, small trees. This modeling region contains the Wenatchee and Cle Elum DSAs.

Eastern Cascades South (ECS): This region incorporates the Southern Cascades Ecological Section M261D (McNab and Avers 1994) and the eastern slopes of the Cascades from the Crescent Ranger District of the Deschutes National Forest south to the Shasta area. Topography is gentler and less dissected than the glaciated northern section of the eastern Cascades. A large expanse of recent volcanic soils (pumice region: Franklin and Dyrness 1974), large areas of lodgepole pine, and increasing presence of red fir and white fir (and decreasing grand fir) along a south-trending gradient further supported separation of this region from the northern portion of the eastern Cascades. This region is characterized by a continental climate (cold, snowy winters and dry summers) and a high-frequency/low-mixed severity fire regime. Ponderosa pine is a dominant forest type at mid-to lower elevations, with a narrow band of Douglas-fir and white fir at middle elevations providing the majority of spotted owl habitat. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, smaller trees.

The Warm Springs DSA and eastern half of the South Cascades DSA occur in this modeling region.

Western Klamath Region (KLW): This region consists of the western portion of the Klamath Mountains Ecological Section M261A (McNab and Avers 1994). A long north-south trending system of mountains (particularly South Fork Mountain) creates a rainshadow effect that separates this region from more mesic conditions to the west. This region is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and the influence of marine air (relatively high potential precipitation). These conditions support a highly diverse mix of mesic forest communities such as Pacific Douglas-fir, Douglas-fir tanoak, and mixed evergreen forest interspersed with more xeric forest types. Overall, the distribution of tanoak is a dominant factor distinguishing the Western Klamath Region. Douglas-fir dwarf mistletoe is uncommon and seldom used for nesting platforms by spotted owls. The prey base of spotted owls within the Western Klamath is diverse, but dominated by woodrats and flying squirrels. This region contains the Willow Creek, Hoopa, and the western half of the Oregon Klamath DSAs.

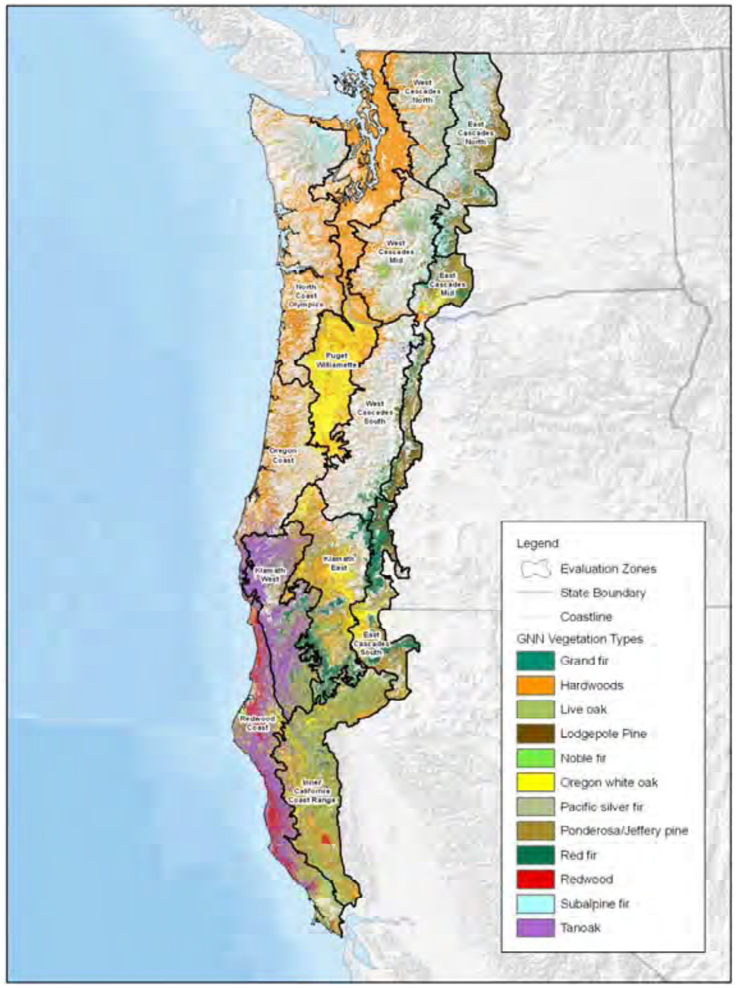
Eastern Klamath Region (KLE): This composite region consists of the eastern portion of the Klamath Mountains Ecological Section M261A (McNab and Avers 1994) and portions of the Southern Cascades Ecological Section M261D in Oregon. This region is characterized by a Mediterranean climate, greatly reduced influence of marine air, and steep, dissected terrain. Franklin and Dyrness (1974) differentiate the mixed conifer forest occurring on the "Cascade side of the Klamath from the more mesic mixed evergreen forests on the western portion (Siskiyou Mountains), and Kuchler (1977) separates out the eastern Klamath based on increased occurrence of ponderosa pine. The mixed conifer/evergreen hardwood forest types typical of the Klamath region extend into the southern Cascades in the vicinity of Roseburg and the North Umpqua River, where they grade into the western hemlock forest typical of the Cascades. High summer temperatures and a mosaic of open forest conditions and Oregon white oak woodlands act to influence spotted owl distribution in this region. Spotted owls occur at elevations up to 1,768 m. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, small trees. The western half of the South Cascades DSA and the eastern half of the Klamath DSA are located within this modeling region.

Northern California Interior Coast Ranges Region (ICC): This region consists of the Northern California Coast Ranges ecological Section M261B (McNab and Avers 1994), and differs markedly from the adjacent redwood coast region. Marine air moderates winter climate, but precipitation is limited by rainshadow effects from steep elevational gradients (100 to 2,400 m.) along a series of north-south trending mountain ridges. Due to the influence of the adjacent Central Valley, summer temperatures in the interior portions of this region are among the highest within the spotted owl's range. Forest communities tend to be relatively dry mixed conifer, blue and Oregon white oak, and the Douglas-fir-tanoak series. Spotted owl habitat within this region is poorly known; there are no DSAs and few studies have been conducted here. Spotted owl habitat data obtained during this project suggests that some spotted owls occupy steep canyons dominated by liveoak and Douglas-fir; the distribution of dense conifer habitats is limited to higher-elevations on the Mendocino National Forest.

Figure C-2. Modeling regions used in development of relative habitat suitability models for the spotted owl.

Modeling Regions

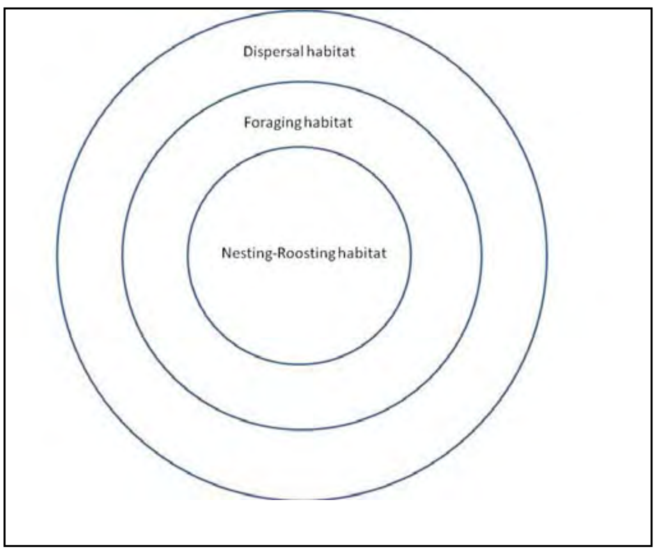
CODE	Description
NCO	North Coast and Olympic
OCR	Oregon Coast
RDC	Redwood Coast
WCN	Western Cascades - North
WCC	Western Cascades - Central
WCS	Western Cascades - South
ECN	Eastern Cascades - North
ECS	Eastern Cascades - South
KLW	Klamath-Siskiyou - West
KLE	Klamath-Siskiyou - East
ICC	Interior California Coast



Habitat Modeling Process

Because spotted owl habitat use is influenced by factors occurring at different spatial scales, we developed habitat suitability models in two stages. In the first stage we used information from our literature review and experts to develop a series of alternative models of forest conditions corresponding to nesting-roosting habitat and foraging habitat within each modeling region. We used statistical modeling to test the effectiveness of these models and identify the forest structural models that best predicted the relative likelihood of a spotted owl territory being present. Spotted owl habitat is often subdivided into distinct components including: nesting habitat, roosting habitat, foraging habitat, and dispersal habitat. Habitats used for nesting and roosting are very similar, and so we combined them into nesting-roosting. Such areas are used for nesting, roosting, foraging, and dispersal by spotted owls, and are usually forests with more late-seral forest characteristics than "foraging" or "dispersal" habitat. Foraging habitat is thought to be largely used for foraging and other nocturnal activities, but also for dispersal (USFWS 1992; see Figure C3). Dispersal habitat is thought to largely have value for dispersal, to lack nest/roost sites and to provide few foraging opportunities. These categories are not absolutes, but instead represent generalizations (*e.g.*, one should not infer that spotted owls never roost in "foraging" habitat). That said, it is important to understand that

Figure C-3. Venn diagram of relationships among spotted owl nesting-roosting, foraging, and dispersal habitats.



nesting-roosting habitat is generally considered to provide all or most habitat requirements, whereas foraging and dispersal habitats are considered to provide only a subset of the spotted owl's habitat requirements. For this effort, we attempted to accurately model the suitability of breeding habitat for spotted owls. Thus, we evaluated and modeled nesting-roosting and foraging habitat, but not dispersal habitat. While we recognized that dispersal plays an important role in population performance, we elected not to formally model dispersal habitat. This is because relatively little is known about habitat selection during dispersal and, more importantly, the likely influences of habitat conditions on dispersal success. The influence of habitat on dispersal and population performance is treated within the HexSim portion of the modeling framework (see Overview of HexSim Spotted Owl Scenario, page C-56).

Spatial scale for developing and evaluating models:

To determine the spatial scale at which to develop habitat models, the modeling team sought a uniform analysis area size that generally corresponded to large differences between use and availability. Spotted owls have been found to respond to habitats at a variety of spatial scales (Solis and Gutiérrez 1990, Meyer *et al.* 1998, Franklin *et al*. 2000, Swindle *et al.* 1999, Thome *et al*. 1999, Zabel *et al.* 2003). Spotted owls do not build their own nests, but primarily utilize broken-top snags, tree cavities, dwarf mistletoe witch's brooms, or nests made by other species (Gutiérrez *et al.* 1995). Spotted owl habitat selection in the immediate vicinity of the nest (tens of meters around the nest tree) has been found to be strongly non-random, and largely associated with late-seral forest characteristics (Solis and Gutiérrez 1990, Meyer *et al.* 1998, Swindle *et al.* 1999). Areas at this small spatial scale are necessary, but often not sufficient to be selected by spotted owls because areas at larger spatial scales around the nest-site must contain attributes that also contribute to their survival and reproductive success (*e.g.*, Franklin *et al*. 2000, Olson *et al.* 2004, Dugger *et al.* 2005).

Ripple *et al.* (1991), Carey *et al.* (1992), Hunter *et al.* (1995), Thome *et al.* (1999), Meyer *et al*. (1998), and Zabel *et al.* (2003) all evaluated spotted owl habitat selection at a variety of spatial scales beyond the nest site itself. Spatial scales evaluated in these studies were based on the distribution of radio telemetry locations, presumed territorial behavior (nearest-neighbor distances), or various 'nested rings'. All studies found differences between spotted owl-centered (nest or activity center) locations and random or unoccupied locations across the range of spatial scales examined. However, the largest differences were often found in areas approximately the size of what Bingham and Noon (1997) defined as "core areas" (areas of the home range that received disproportionately more use than would be expected). An area of 158 to 200-ha has been used to describe/define spotted owl 'territory core areas', in western Oregon and the Klamath region (Hunter *et al.* 1995, Meyer *et al.* 1998, Franklin *et al*. 2000, Zabel *et al*. 2003, Olson *et al.* 2004, and Dugger *et al.* 2005). In northwestern Oregon, Glenn *et al.* (2005) found mean cumulative core areas to be 94 ha (SE = 14.9; n = 24). For the northern portion of the range we found little information directly comparable to the abovementioned studies, but estimated home range and core areas sizes and nearest-neighbor distances are larger in the extreme northern portion of the spotted owl's range (Forsman *et al*. 2005, Hamer *et al.* 2007, Davis and Dugger in press). Based on this review, we felt a 200-ha analysis area represented an area that is disproportionately used (more than expected) surrounding nest sites. We deal explicitly with geographic variation in home range size in HexSim (see below).

Data Used for Model Development and Testing

Vegetation data – the GNN-LT Database:

To develop rangewide models of relative habitat suitability for spotted owls, we required maps of forest composition and structure of sufficient accuracy to allow discrimination of attributes used for nesting, roosting and foraging by spotted owls. Past efforts to model, map and quantify habitat selection by spotted owls at regional scales have often suffered from lack of important vegetation variables, inadequate spatial coverage, and/or coarse resolution of available vegetation databases (Davis and Lint 2005). However, recent development of vegetation mapping products for the NWFP's Effectiveness Monitoring program (Hemstrom *et al*. 1998, Lint *et al.* 1999) provided detailed maps of forest composition and structural attributes for all lands within the NWFP area (coextensive with the range of the spotted owl). These maps were developed using Gradient Nearest Neighbor (GNN) imputation (Ohmann and Gregory 2002) and LandTrendr algorithms (Kennedy *et al.* 2007, 2010) and were available for two "bookend" dates (1996 and 2006 in Oregon and Washington, 1994 and 2007 in California).

The GNN approach is a method for predictive vegetation mapping that uses direct gradient analysis and nearest-neighbor imputation to ascribe detailed attributes of vegetation to each pixel in a digital landscape map (Ohmann and Gregory 2002). Forest attributes from inventory plots (Forest Inventory and Analysis, Current Vegetation Surveys, etc.) are imputed to map pixels based on modeled relationships between plots and predictor variables from Landsat thematic mapper imagery, climatic variables, topographic variables, and soil parent materials. The assumption behind GNN methods is that two locations with similar combined spatial "signatures" should also have similar forest structure and composition. The GNN models were developed for habitat modeling regions used for the NWFP northern spotted owl effectiveness monitoring modeling (Davis and Dugger in press). For the NWFP Effectiveness Monitoring program, GNN maps were created for the two bookend time periods mentioned above to 'frame' their analysis period for habitat status and trends. This novel bookend mapping approach presents challenges associated with spectral differences due to different satellite image dates, which might produce false vegetation changes. To minimize the potential for this, the bookend models were based on Landsat imagery that was geometrically rectified and radiometrically normalized using the LandTrendr process (Kennedy *et al.* 2007, 2010).

The large list of forest species composition and structure variables provided by GNN vegetation maps constitute an improvement in vegetation data for modeling and evaluating spotted owl habitat. For our modeling, we selected from a set of 163 variables, including basal area and tree density by size class and species, canopy cover of conifers and/or hardwoods, stand height, age, mean diameter and quadratic mean diameter by dominance class, stand density index, and measures of snags and coarse woody debris. Additional variables pertaining to stand structural diversity and variability proved particularly useful for modeling spotted owl habitat.

The reliability or accuracy of vegetation databases poses a primary concern for wildlife habitat evaluation and modeling. The GNN maps come with a large suite of diagnostics detailing map quality and accuracy; these are contained in model region-specific accuracy assessment reports available at the LEMMA website (http://www.fsl.orst.edu/lemma/). For developing *a priori* models of spotted owl nesting/roosting habitat and foraging habitat, we generally selected GNN structural variables with plot correlation coefficients > 0.5 for an individual modeling region (42% were >0.7). On a few occasions when expert opinion or research results suggested a particular variable might be important, we used variables with plot correlations from 0.31 to 0.5 (Table C-1). For species composition variables, we attempted to use only variables with Kappas > 0.3. However, because we combined species variables into groups that expert opinion and research results suggested may represent influential community types, we occasionally accepted variables with Kappas > 0.2 and < 0.3 for individual variables within a group (Table C-2).

The GNN vegetation database was specifically developed for mid- to large-scale spatial analysis (Ohmann and Gregory 2002), suggesting that accuracies at the 30-m pixel scale may be less influential to results obtained at larger scales. Because we were interested in the utility of GNN at our analysis area (200 ha) spatial scale, we conducted less formal assessments where we compared the distribution of GNN variable values at a large sample of actual locations (known spotted owl nest sites and foraging sites) to published estimates of those variables at the same scale. In addition, we received comparisons of GNN maps to a number of local plot-based vegetation maps prepared by various field personnel. Based on these informal evaluations, we determined that GNN represents a dramatic improvement over past vegetation databases used for modeling and evaluating spotted owl habitat, and used the GNN-LandTrendr maps as the vegetation data for our habitat modeling.

Table C-1. Pearson correlation coefficients for GNN structural variables used in modeling relative habitat suitability models for spotted owls.

Variable	Modeling region											
	ECN	ECS	ICC	KLE	KLW	NCO	ORC	RDC	WCC	WCN	WCS	AVG	STD
BAA_75_100			0.42									0.49	0.09
BAA_GE_100			0.37									0.46	0.12
BAA_GE_3	0.75					0.71			0.71	0.71		0.70	0.06
BAC_50_75								0.46				0.45	0.06
BAC_75_100								0.31				0.50	0.09
BAC_GE_100								0.57				0.47	0.12
BAC_GE_3					0.65							0.73	0.06
BAH_3_25			0.50									0.50	0.07
BAH_PROP					0.67							0.66	0.03
CANCOV	0.76	0.80	0.71	0.71	0.71			0.70	0.74	0.74	0.80	0.74	0.04
CANCOV_CON				0.67			0.73					0.74	0.07
DDI	0.65	0.73	0.65	0.65	0.65	0.77	0.74		0.77	0.77	0.73	0.69	0.08
QMDC_DOM	0.44	0.64	0.52	0.52	0.52						0.64	0.59	0.11
TPH_50_75				0.35			0.52		0.44	0.44		0.42	0.06
TPH_75_100		0.52		0.41		0.56	0.58		0.56	0.56	0.52	0.48	0.09
TPH_GE_100		0.48		0.45		0.57	0.63		0.57	0.57	0.48	0.49	0.10
TPHC_GE_100									0.57	0.57		0.50	0.10

Table C-2. Local scale accuracy assessments (kappa coefficients) for individual species variables within stand species composition variable groupings used in applicable modeling regions. N/A = variable not in best models for modeling region.

	GNN DOM SPP	Common Name	East Cascades North	East Cascades South	Inner California Coast Ranges	Klamath East	Klamath West	North Coast Olympics	Oregon Coast	Redwood Coast	West Cascades Central	West Cascades North	West Cascades South	Average Kappa
Evergreen hardwoods	ARME	Pacific madrone	n/a	n/a	0.43	n/a	0.43	n/a	0.49	n/a	n/a	n/a	n/a	0.45
	LIDE3	tanoak	n/a	n/a	0.58	n/a	0.58	n/a	0.72	n/a	n/a	n/a	n/a	0.63
	QUCH2	canyon live oak	n/a	n/a	0.35	n/a	0.35	n/a	0.46	n/a	n/a	n/a	n/a	0.39
	UMCA	California laurel	n/a	n/a	0.29	n/a	0.29	n/a	0.43	n/a	n/a	n/a	n/a	0.34
Northern Hardwoods	ACMA3	bigleaf maple	n/a	n/a	n/a	n/a	n/a	0.41	0.30	n/a	0.41	0.41	n/a	0.38
	ALRU2	red alder	n/a	n/a	n/a	n/a	n/a	0.44	0.33	n/a	0.44	0.44	n/a	0.41
Oak woodlands	QUDO	blue oak	n/a	n/a	0.68	0.68	0.68	n/a	n/a	0.41	n/a	n/a	n/a	0.62
	QUGA4	Oregon white oak	n/a	n/a	0.35	0.35	0.35	n/a	n/a	0.34	n/a	n/a	0.52	0.38
Pines	PICO	lodgepole pine	0.26	0.57	0.28	0.28	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.35
	PIJE	Jeffrey pine	n/a	0.27	0.28	0.28	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.28
	PIMU	Bishop pine	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	PIPO	ponderosa pine	0.62	0.58	0.34	0.34	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.47
Douglas-fir	PSME	Douglas-fir	0.47	0.65	n/a	0.31	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.48
Subalpine	ABAM	Pacific silver fir	0.66	0.59	n/a	n/a	n/a	0.53	n/a	n/a	0.53	0.53	0.59	0.57
	ABLA	subalpine fir	0.58	0.39	n/a	n/a	n/a	0.48	n/a	n/a	0.48	0.48	0.39	0.47
	ABMA	California red fir	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	ABPR	noble fir	0.29	n/a	n/a	n/a	n/a	0.32	n/a	n/a	0.32	0.32	n/a	0.31
	ABSH	Shasta red fir	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	CHNO	Alaska cedar	0.29	0.19	n/a	n/a	n/a	0.28	n/a	n/a	0.28	0.28	0.19	0.25
Redwood	SESE3	redwood	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.59	n/a	n/a	n/a	0.59

Spotted owl location data:

Spotted owl data used in model development consisted of site center locations documented within three years (plus or minus) of the date of the GNN vegetation data. Site centers are the location of spotted owl nests or daytime roosts containing paired spotted owls. Site center data for the habitat suitability modeling was made available through the cooperation of a variety of sources throughout the spotted owl's range. Data come from long-term demographic studies as well as locations from other research projects, public, private, and tribal sources.

Substantial effort was expended on verification of both the spatial accuracy and territory status of each site center in the data set. We specifically requested and received very high-quality data from spotted owl demography study areas (DSAs). For areas outside of DSAs, we obtained a large set of additional locations from NWFP Effectiveness Monitoring program (Davis and Dugger in press); the majority of these site centers had been evaluated for spatial accuracy. We also obtained and verified data sets from private timber companies, USFS Region 5 NRIS database and a number of research and monitoring projects across the species' range.

Because of the spatial extent of our analysis area (>23 million ha), we do not have the luxury of having equal survey effort throughout the region. Instead we have data from research studies, monitoring of demographic rates, management efforts, and other sources. While spotted owl demographic study areas have been intensively and extensively studied for long periods of time (see Anthony *et al.* 2006 and Forsman *et al.* 2011) and provide the highest- quality data sets, they comprise ~12% of the spotted owl's geographic range (based on our masked modeling regions). As importantly, for some modeling regions the proportion of total area and/or spotted owl locations within DSAs is very low. Given the DSAs represent nearly the only areas within the spotted owl's range that have consistently been surveyed over long periods of time and that they represent a smaller portion of the species' geographic range, the data from them (at the scale of a modeling region) is generally spatially aggregated. Spotted owl site location data from the DSAs represent a much smaller portion of the spotted owl's range than the full data set we used (Table C-3), and the larger data set represents more fully the spectrum or gradient of biotic and abiotic features that spotted owls select for nesting and roosting. For example, the total number of spotted owl site locations inside DSAs was 1,199, and when thinned by 3 km was 755. In contrast, the total number of site locations outside of DSAs was 2,591, and when thinned was 2,110. With our 200-ha analysis area, if we would have sampled from only the DSAs we would have sampled ~151,000 ha around thinned DSA sites versus the 573,000 ha sampled around all thinned sites.

Table C-3. Comparison of area and spotted owl location data within modeling regions and demographic study areas (DSAs).

Modeling Region	Acronym	Percentage of Region in DSA	Number of NSO Sites in DSA	Number of NSO Sites Outside DSA
ALL MODELING REGIONS	ALL	12.34%	1199	2591
North Coast Olympics	NCO	7.29%	166	79
Oregon Coast	ORC	30.88%	352	102
East Cascades South	ECS	20.49%	78	45
East Cascades North	ECN	23.45%	132	84
West Cascades North	WCN	0.92%	3	77
West Cascades Central	WCC	19.21%	57	157
West Cascades South	WCS	6.58%	57	435
Klamath East	KLE	10.31%	98	374
Klamath West	KLW	15.24%	127	335
Inner California Coast Ranges	ICC	0.75%	8	300
Redwood Coast	RDC	10.23%	121	603

Outside of DSAs, the quantity and density of site center data varies widely. While we have attempted to compile a large sample of site centers that is broadly representative of the entire distribution of spotted owls, the overall distribution of sample sites is somewhat clumped. Areas with few nest locations are a result of: 1) few surveys being conducted, 2) the absence of spotted owls, or 3) data being unavailable. We did not want the modeling results to be a function of the intensity of spotted owl sampling throughout the region, but to be as close of an approximation as possible of spotted owl-habitat relationships. Phillips *et al*. (2009) noted that spatially biased survey data present major challenges to distributional modeling by over-weighting areas where intensive sampling has occurred. Therefore, within each modeling region we "thinned" the spotted owl nest locations such that the minimum distance between nest locations would be 3.0 km (thinning with a 3 km distance resulted in removing ~25% of the locations available to us). Carroll *et al.* (2010) used a similar approach in their modeling of other species whereby clusters of records were identified and one record from the cluster was randomly selected from the set. Using a 3 km thinning distance retained 75% of the total data, and did not have a large effect on those modeling regions with small initial sample sizes (<100) of site center locations (Table C4).

Table C-4. Sample size of spotted owl site center locations (1993-1999) by modeling region and the impact of various thinning distances (minimum allowable distance between site centers) on sample size.

		Thinning Distance					
Modeling Region	**Total Sites**	**1 km**	**1.5 km**	**2 km**	**2.5 km**	**3 km**	**4 KM**
NCO	241	236	229	221	209	196	162
OCR	454	430	414	371	325	281	202
RDC	724	716	670	547	461	392	284
WCN	80	80	79	78	77	77	74
WCC	214	211	205	195	182	173	144
WCS	489	489	487	482	477	470	342
ECN	216	215	209	203	195	184	155
ECS	123	122	119	112	104	93	67
KLW	462	460	454	440	414	358	275
KLE	472	468	463	455	434	381	285
ICC	308	308	307	300	286	253	199
Total	**3783**	**3735**	**3636**	**3404**	**3164**	**2858**	**2189**
Percentage of total	**100**	**98.7**	**96.1**	**90.0**	**83.6**	**75.5**	**57.9**

Due to the increased influence of the barred owl on spotted owls, we followed, in part, the modeling approach used by Davis and Dugger (in press) to reduce the influence of barred owls on apparent habitat associations of spotted owls. For our effort, we wanted our models to identify areas with more or less nesting suitability for spotted owls. Because barred owls have apparently displaced many spotted owls from previously-occupied nesting areas, sometimes into habitat types/conditions that spotted owls only rarely used prior to the barred owl's invasion (Gremel 2005, Gutiérrez *et al.* 2007), we did not want to evaluate their "displaced habitat use", but instead their use of habitat without the larger, current impact of barred owls. Although barred owls were known to be widely distributed in the northern portion of the spotted owl's range in 1996, Gremel (pers. comm. 2010) suggested barred owl densities were substantially lower in 1996 than in 2006. Pearson and Livezey (2003) reported that barred owls had increased by an average of 8.6% per year between 1982 and 2000 on parts of the Gifford Pinchot National Forest (GPNF), Washington. Subsequently, Livezey *et al.* (2007) reported that the 98 known barred owl sites on the GPNF in 2001 had increased to 143 sites in 2006. Thus, in an attempt to reduce the influence of barred owls on spotted owl habitat use, we developed and tested models using GNN vegetation data from 1996 (assumed to be the period with lower barred owl influence) along with spotted owl location information plus or minus three years from 1996. Those models were then projected to the most current (2006) GNN layer to predict contemporary relative habitat suitability (RHS). Each region's model was then tested by comparing with RHS values at independent sites from the 2006 spotted owl locations (only those that did not overlap with the 1996 locations).

Developing Habitat Definitions:

Nesting and roosting habitat

Prior to developing models, we attempted to synthesize both the literature and information from experts. From the literature, we emphasized studies evaluating habitat selection over those that described habitat features (associations) around spotted owl locations, but did not evaluate selection. This synthesis resulted in the development of a series of definitions of spotted owl nesting-roosting and foraging habitat. For example, several published studies concluded that nesting spotted owls strongly select for areas with canopy cover >70% and many large trees nearby and strongly select against areas with lower amounts of canopy cover and few or no large trees nearby. We therefore created definition “NR_1” (nesting-roosting definition number 1) based on canopy cover and density of large trees (*e.g.*, trees >75 cm dbh). Because experts and/or other published studies typically supported several (i) alternative NR definitions, we created roughly ten alternative NR habitat definitions (NR_2, NR_3, NR_i, etc.) per modeling region. We used an identical process to develop a series of foraging (F) habitat definitions for each modeling region (Tables C5 and C6 provide an example of this process). It is important to recognize that these habitat definitions are binary for each pixel; either the pixel contained each of the features in the definition (and was therefore considered habitat), or it did not (it was considered non-habitat).

Table C-5. Spotted owl nesting-roosting habitat variables for the northern Coast Ranges and Olympic Peninsula.

Habitat characteristics from expert panel, literature	GNN Variable expression
Canopy cover of conifers is ≥ than 80%	CANCOV_CON_GE_80
Mean stand diameter is ≥ than 50cm	MNDBHBA_CON_GE_50
Structure should include ≥ 70 medium trees/ha	TPH_GE_50_GE_70
Structure should include ≥ 20 larger trees/ha	TPH_GE_75_GE_20
Very large remnant trees are important (≥5/ha)	TPH_GE_100_GE_5
Canopy layering/diversity is important	DDI_GE_6 *

*DDI = Diameter Diversity Index (ranges from 1-10)

Table C-6. Sample definitions of spotted owl nesting-roosting habitat based on variables and values from Table 5.

	Candidate nesting/roosting habitat definitions
NR_1	CANCOV_CON_GE_80 + MNDBHBA_CON_GE_50 + DDI_GE6
NR_2	CANCOV_CON_GE_80 + MNDBHBA_CON_GE_50 + TPH_GE_75_GE_20 + TPH_GE_100_GE_5 + DDI_GE_6
NR_3	CANCOV_CON_GE_80 + TPH_GE_50_GE_70 + TPH_GE_75_GE_20 + TPH_GE_100_GE_5 + DDI_GE_6
NR_4	CANCOV_CON_GE_70 + MNDBHBA_CON_GE_50 + TPH_GE_75_GE_20 + DDI_GE_5

Foraging habitat

Foraging habitat definitions were informed by published and unpublished literature and input from experts. In this process, foraging habitat was, by definition, different than nesting-roosting habitat. This is not to suggest that spotted owls do not forage in nesting-roosting habitat, but for the sake of being explicit in this process, foraging habitat was distinct from nesting-roosting habitat. In general, foraging habitat definitions had lower thresholds of canopy cover, tree size, and canopy layering than nesting-roosting definitions (Tables C7 and C8 provide an example of this process).

Table C-7. Spotted owl foraging habitat variables for the northern Coast Ranges and Olympic Peninsula.

Habitat characteristics from expert panel, literature	**GNN Variable expression**
Canopy cover of conifers is ≥ than 70%	CANCOV_CON_GE_70
Mean stand diameter is ≥ than 40 cm	MNDBHBA_CON_GE_40
Structure should include ≥ 50 medium trees/ha	TPH_GE_50_GE_50
Structure should include ≥ 8 larger trees/ha	TPH_GE_75_GE_8
Canopy layering/diversity is important	DDI_GE_4 *

*DDI = Diameter Diversity Index (ranges from 1-10)

Table C-8. Sample definitions of spotted owl foraging habitat based on variables and values from Table C7.

	Candidate nesting/roosting habitat definitions
F_1	CANCOV_CON_GE_70 + MNDBHBA_CON_GE_40 + DDI_GE_4
F_2	CANCOV_CON_GE_70 + MNDBHBA_CON_GE_40 + TPH_GE_75_GE_8 + DDI_GE_6
F_3	CANCOV_CON_GE_70 + TPH_GE_50_GE_50 + TPH_GE_75_GE_8 + DDI_GE_4
F_4	CANCOV_CON_GE_60 + MNDBHBA_CON_GE_40 + TPH_GE_75_GE_8 + DDI_GE_4

Because attributes of habitat such as amount of edge and core area have been shown to influence both habitat selection and fitness (Franklin *et al.* 2000) of spotted owls, we also included NR "core" and "edge" metrics.

Abiotic variables

Because published literature and information from experts suggested that abiotic features might be important in determining spotted owl habitat use and selection, we evaluated a series of abiotic features known or suspected to influence spotted owl habitat selection and use (Table C9). Numerous studies have shown that local geographic features such as slope position, aspect, distance to water, and elevation have been found to influence spotted owl site selection (Stalberg *et al.* 2009, Clark 2007). Several authors (Blakesley *et al.* 1992, Hershey *et al.* 1998, LaHaye and Gutiérrez 1999) have noted the absence of spotted owls above particular elevational limits (whether this limit is due to forest structure, prey, competitors, parasites, diseases, and/or extremes of temperature or precipitation is not known). At broader scales, temporal variation in climate has been shown to be related to fitness (Franklin *et al.* 2000, Olson *et al.* 2004, Dugger *et al.* 2005, Glenn *et al.* 2010), suggesting that spatial variation in climate may also influence habitat suitability for spotted owls. Ganey *et al.* (1993) found that Mexican spotted owls (*S. o. lucida*) have a narrow thermal neutral zone and others (*e.g.*, Franklin *et al*. 2000) have assumed the northern spotted owl to be similar in this regard. Furthermore, the spotted owl's selection for areas with older-forest characteristics has been hypothesized to, in part, be related to its needing cooler areas in summer to avoid heat stress (Barrows and Barrows 1978). Temperature extremes (winter low and summer high) as well as potential breeding-season specific stressors (spring low temperature and high spring precipitation) are also considered potentially useful predictor variables for our purposes (Carroll 2010, Glenn *et al.* 2010). By including climate variables as candidate variables in our habitat suitability modeling, we evaluated whether climate effects on spotted owl fitness are translated into patterns of the species' distribution.

Developing models:

MaxEnt compares the characteristics (variables included in the models) of the training data sites to a random selection of ~10,000 random "background" (available) locations. We only used the linear, quadratic, and threshold features within MaxEnt (*i.e.,* hinge and product features were not used).

We used the following model-building and evaluation process within each modeling region

1) Each nesting-roosting habitat definition is a single-variable model. Thus, if we developed 10 nesting-roosting habitat definitions for a region, we compared 10 nesting-roosting habitat models for that region. We used MaxEnt to determine the best nesting-roosting habitat definition within each region (see model evaluation, below).
2) Within each modeling region that has foraging habitat definitions, we combined the best nesting-roosting habitat definition(s) with each foraging habitat definition to evaluate whether the addition of foraging habitat improved model performance. Models were considered to have been improved if the addition of foraging habitat increases the ranking of the model. If the addition of foraging habitat improved the model's performance, we used the nesting-roosting + foraging habitat model for step 3 (below). If not, we used the best nesting-roosting model(s) for step 3.
3) For abiotic variables, we developed univariate or multivariate models using the variables in Table C9. Carroll (2010) found that mean January precipitation, mean July precipitation, mean January temperature, and mean July temperature were the variables in the best, of 30, climate models he evaluated. He found the two precipitation metrics were the most influential of the four. Franklin *et al.* (2000) also found climate variables to influence spotted owl survival and reproduction. We included three climate models: 1) the four variables Carroll (2010) reported, 2) mean January precipitation and mean July precipitation, 3) mean January precipitation and mean January temperature. We "challenged" the best model(s) after step 2 by adding each abiotic model to it (*sensu* Dunk *et al.* 2004), in an attempt to improve its predictive ability. The abiotic models were not compared to each other, but were compared in order to see if their addition to the best biotic (nesting-roosting or nesting-roosting + foraging) model resulted in an improved model (see step 2). If the biotic plus abiotic model was an improvement over the biotic-only model, we used the combination model, otherwise we used the biotic-only model. The reason abiotic-only models were not evaluated is that it is illogical to suggest that spotted owls (a species that nests in trees) might only respond to abiotic factors when selecting nesting areas. In contrast, we could develop a logical biological argument that spotted owls might respond only to biotic features when selecting nesting areas. We could also develop logical biological arguments

articulating how a combination of biotic and abiotic factors might influence the selection of nesting areas.

Model-building hierarchy

The spatial distribution of spotted owl territories is influenced by a wide variety of environmental gradients operating at different spatial scales. At the smallest scale we evaluated, features such as the amount of nesting-roosting and/or foraging habitat within a core area, the amount of edge between spotted owl habitat and non-habitat, or amount of "core habitat" (*sensu* Franklin *et al*. 2000) have all be shown to influence spotted owl distribution, abundance, or fitness. Each of those variables, however, is a structural variable. That is, they are based on habitats comprised of various structural elements (*e.g*., large trees, high canopy cover). However important and influential these variables are to spotted owls, other variables such as plant species composition (broadly speaking), topographic position, climate, and/or elevation are also likely to influence their distribution, abundance, and perhaps fitness (Franklin *et al.* 2000, Olson *et al*. 2004, Dugger *et al.* 2005, Glenn 2009).

In part, the partitioning of the spotted owl's geographic range into 11 modeling regions should act to reduce the influence of broad patterns in plant species composition, climate and/or elevation on the species. Nonetheless, we were interested in evaluating whether habitat suitability is influenced by local variation in these non-structural variables.

Stand structure and the spatial arrangement of forest patches have been found to influence spotted owl fitness (Franklin *et al*. 2000, Olson *et al*. 2004, Dugger *et al*. 2005). Edge between nesting-roosting habitat and other habitat types is thought to afford foraging spotted owl opportunities when habitats, but which are rarely used, are juxtaposed closely with habitats spotted owls use. "Core" habitat includes those areas of spotted owl nesting habitat not subjected to edge-effects. Franklin *et al*. (2000) estimated core habitat by buffering all spotted owl habitat (largely mature forest areas) by 100 m and estimating the size of the habitat excluding the 100 m buffer.

Spotted owl experts noted that mid-scale or landscape level patterns such as tree species composition and topography may also influence the local distribution and density of spotted owls. For example, within many of the modeling regions, there exists variation in tree species composition, but forests with different species compositions may still have similar structural attributes (*e.g*., high canopy cover, multi-storied, large trees). Some forest types (regardless of their structural attributes) are rarely, if ever, used by spotted owls, so we attempted to account for this variation by evaluating models that include some compositional variables.

Many of our 11 modeling regions contain high-elevation areas above the elevational extremes normally used by spotted owls. In some higher elevation areas there exist structurally complex, multi-storied forests with large trees – areas with similar structural characteristics to those used by spotted owls.

However, spotted owls rarely if ever use such areas. Our intention was to attempt to account for this in our modeling.

We recognize the hierarchical nature of these environmental factors and their possible influence on spotted owl distribution. Our model building approach took this into consideration, by starting at the smallest scale and sequentially "challenging" models with variables from larger spatial scales. In order to focus on environmental features most directly linked to territory location, habitat selection, and individual fitness of spotted owls, we employed a bottom-up approach to building models (Table C9).

Table C-9. Categories of candidate variables, variable names, and order of the entry of variables into modeling process.

Category	Variable	Order
Best climate/elevation model	Mean July Precipitation	
	Mean July Temperature	
	Mean July Precipitation	
	Mean July Temperature	
	Mean Elevation	
Topographic position	Curvature	
	Insolation	
	Slope Position	
Compositional variables (percent of basal area)	Redwood	
	Oak Woodland	
	Pine-dominated	
	Northern Deciduous Hardwoods	
	Evergreen Hardwoods	
	Douglas-fir	
	Subalpine forest	
Habitat pattern	Core of NR habitat	
	Edge of NR habitat	
Habitat structure	Foraging Habitat Amount	
	Nesting/Roosting Habitat	

Goals of MaxEnt Modeling:

Our goals for the relative habitat suitability models were to find models that: 1) had good discriminatory ability, 2) were well calibrated, 3) were robust, and 4) had good generality. We sought models that were not over-fit, the consequences of which would be to have models that fit the developmental data very closely, but which would not have worked well on data that were not used in their development. That is we sought models with good generality (*i.e.*, models that worked well in the modeling regions in general, not simply at classifying the developmental/training data). MaxEnt attempts to balance model fit and complexity through the use of regularization (see Elith *et al.* 2011). Elith *et al.* (2011) noted that MaxEnt fits a penalized maximum likelihood model, closely related to other penalties for complexity such as Akaike's Information Criterion (AIC, Akaike 1974). In order to evaluate whether any model region's model was over-fit we conducted rigorous cross-validation on each model (see below), and, when available we evaluated how well models classified independent data (see below).

Model discrimination

Once the best model was found for each region, we conducted a cross-validation of each model to evaluate how robust the model was. Each of 10 times we removed a random subset of 25% of the spotted owl locations, developed the model with the remaining 75% and classified using the withheld 25%. The area under the receiver operating characteristic curve (AUC) was evaluated for both training and test data within each region. AUC is a measure of a model's discrimination ability; in our case discrimination between spotted owl-presence locations and available locations (not discrimination of presence versus absence locations). AUC values, theoretically, range between 0 and 1.0, with values less than 0.5 having worse discriminatory ability than expected by chance, values closer to 0.5 suggesting no to poor discriminatory ability, and values closer to 1.0 suggesting excellent discriminatory ability.

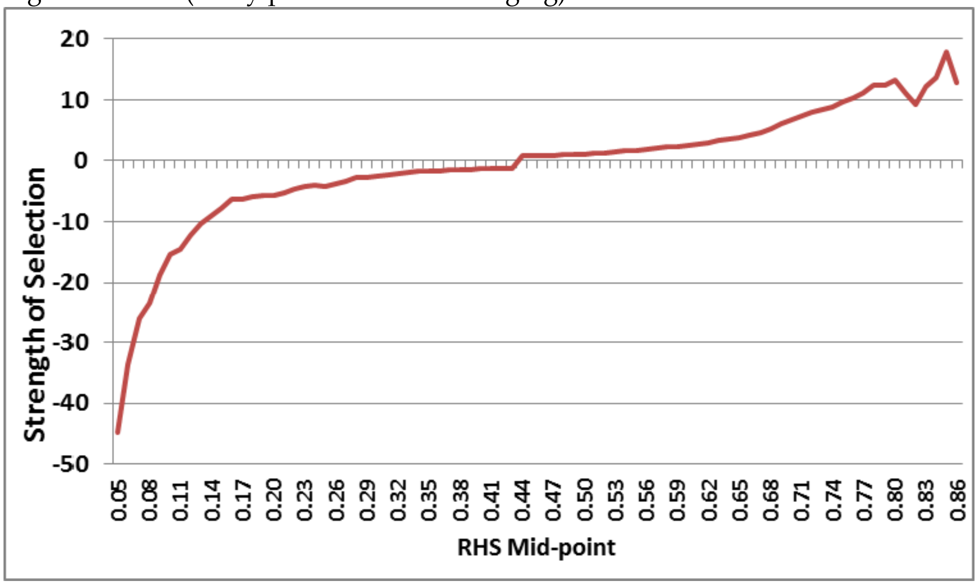
For these analyses, AUC values essentially describe the proportion of times one could expect a random selection of an actual spotted owl nest site location to have a larger relative habitat suitability value than a random selection from available locations. It is therefore a threshold-independent measure of model discriminatory ability. Because our evaluation represents use versus availability and not use versus non-use, AUC values have an upper limit somewhat less than 1.0 (because some of the available locations are actually used by spotted owls). Even for good (well-discriminating) models, AUC values should be lower in areas where the background areas contain larger amounts of suitable habitat. Two contrasting examples are provided to make this point: 1) a model estimating a riparian-dependent bird species' distribution in the Great Basin may have a very high AUC value because there is large contrast between riparian vegetation where the bird nests and the vast majority of background locations in sage-steppe, vs. 2) a model estimating the distribution of a generalist omnivore (like a black-bear) in a national forest may have a lower AUC because so much of the background habitat is suitable for the species. The point is that AUC is a measure of discrimination, but that a use-versus-availability model's ability to discriminate is a function of both the animal's habitat specificity and the abundance of the animal's habitat in the region of interest. To evaluate the degree to which AUC values from each modeling region's MaxEnt model were related to the abundance of suitable habitat we regressed AUC values against the proportion of each modeling region comprised of RHS values >30, >40, and >50 (the SOS values for all modeling regions showed selection for areas within this range – see Figure C-5 below). If the abundance of suitable habitat is high in areas with lower AUC values, and lower in areas with higher AUC values, the interpretation would be that the abundance of suitable habitat, not model discrimination ability, best explains this relationship.

In order to evaluate the degree to which AUC values were a function of the amount of suitable habitat in modeling regions, and thus help us interpret whether somewhat lower AUC values represented poor models versus a larger amount of suitable habitat in the modeling region, we evaluated the correlation between AUC values and the percentage of each modeling region with RHS scores above various thresholds corresponding to RHS values showing higher use than expected (see Model Calibration section below).

Model Calibration

To assess model calibration we evaluated the agreement between RHS and observed proportions of sites occupied. Phillips and Elith (2010) noted that model discrimination and model calibration are independent measures. Model calibration refers to the agreement between predicted probabilities of occurrence (habitat suitability for our study) and observed proportions of sites occupied (Pearce and Ferrier 2000, Phillips and Elith 2010). Phillips and Elith (2010) note that model discrimination and model calibration are independent measures. Hirzel *et al.* (2006) (whose work Phillips and Elith [2010] expand upon), developed "strength of selection" metrics for species distribution models using a moving-window approach. Strength of selection (SOS) evaluations allow for an understanding of the use that areas with various habitat suitability values receive (by nesting spotted owls in our case) relative to the abundance of such areas in the study area (see Figure C4 below). Essentially, a well-calibrated model will show the species to use higher suitability areas disproportionately more and lower suitability areas disproportionately less. The shape of the relationship provides insights into the degree to which the species avoids or is attracted to areas with particular habitat suitability values.

Figure C-4. This *example* of the strength of selection (SOS) evaluation shows a well-calibrated model. Areas with a mid-point RHS (*i.e.*, relative habitat suitability value) of 0.05 (the moving window size here was 0.1) were used ~45-times *less* than would be expected based on its extent in the study area. Similarly, areas with a mid-point RHS of 0.8 (window of 0.75-0.85) were used ~12-times *more* than expected based on its extent in the study area. This figure was developed from a model trained on >3,000 spotted owl night locations (many presumed to be foraging).



Habitat Modeling Results:

The following section provides summary descriptions of the final "best" models for each modeling region; including information on the relative contribution of each covariate to the model, model evaluation metrics, and the results of validation against independent data sets conducted to date. Because the primary objective of this habitat modeling step was to provide accurate prediction of relative habitat suitability and subsequent likelihood of spotted owl occupancy, we focus on presenting evaluation of model performance, rather than description of spotted owl habitat associations. Tables and table series C10 to C17 provide descriptions of the best nesting-roosting habitat model, foraging habitat model, and full model for each modeling region, as well as model evaluation metrics (AUC and Gain) and the relative contribution of each variable to the full model (a heuristic estimate provided in the standard output from MaxEnt). AUC values were highly correlated with the percentage of each modeling region comprised of RHS values >30, >40, and >50 (r^2 = 0.9685, 0.9649, 0.9574, respectively). Hence, variation in AUC values among modeling regions (which ranged from 0.76 – 0.93) has less to do with model discrimination ability (*i.e.*, the quality of the model) and more to do with the quantity of suitably habitat in each modeling region.

See Table C18 for codes and descriptions of variables used in the models.

Table Series C-10. Highest-ranking (best) Nesting/Roosting habitat (NR), foraging habitat (F), and full models for coastal Washington, Oregon and California modeling regions.

North Coast and Olympics Modeling Region (N= 196 training sites):

Model		AUC	GAIN
NR06	DDI (≥6) + TPH ≥ (>25/ha) + BAA GE3 (≥ 55 m²/ha)	0.8365	0.7667
F04	MNDBHBA_CON (≥40); TPH_GE75 (≥10)	0.8619	0.8817
Full Model	NR06 + NR06EDGE + F04 + SLOPE POSITION+ ELEVATION + CURVATURE + SUBALPINE FOREST+JULY MAX TEMP+JANUARY PRECIP + JULY PRECP + INSOLATION + JANUARY MIN TEMP + NORTHERN HARDWOODS	0.8989	1.057

Oregon Coast Ranges Modeling Region (N = 281training sites)

Model		AUC	GAIN
NR08	CANCOV_CON (≥55) + DDI (≥6) + TPH_GE75 (≥20)	0.7683	0.4498
F04	DDI (≥4) + TPH_GE50 (≥30)	0.7787	0.467
Full Model	NR08 + NR08 EDGE + SLOPE POSITION + JULY MAX TEMP + JANUARY MIN TEMP + F04 + CURVATURE + INSOLATION + JULY PRECIP + JANUARY PRECIP + ELEVATION + NR08 CORE + NORTHERN HARDWOODS + EVERGREEN HARDWOODS	0.864	0.811

Redwood Coast Modeling Region (N = 389 training sites)

Model		AUC	GAIN
NR03	CANCOV (≥70) + MNDBHBA_CON (≥44)	0.5928	0.0509
F05	CANCOV (≥65) + BAC_GE50 (≥3)	0.6256	0.0785
Full Model	SLOPE POSITION + CURVATURE + NR03 EDGE + F05 + NR03 + REDWOOD + ELEVATION + JANUARY PRECIP + OAK WOODLAND + JULY MAX TEMP + INSOLATION + JANUARY MIN TEMP + NR03 CORE + JULY PRECIP	0.760	0.335

Table C-11. Individual covariates and their contribution to full model.

North Coast / Olympics		Oregon Coast Ranges		Redwood Coast	
Full Model	**%**	**Full Model**	**%**	**Full Model**	**%**
NR 06	42.4	NR 08	29.4	Slope Position	48.2
NR06Edge	21.5	NR08 Edge	24.2	Curvature	11.2
NR06+F04	20.1	Slope position	11.9	NR03 Edge	10.3
Slope position	6.0	July Max Temp	10.1	NR03 + F05	6.1
Elevation	3.6	Jan Min Temp	8	NR 03	5.7
Curvature	1.8	NR08 + F04	5.5	Redwood (%BA)	4.8
Subalpine	1.1	Curvature	4.1	Elevation	4.1
July Max Temp.	0.9	Insolation	3.1	January Precip	3.2
Jan Precip.	0.9	July Precip	1.5	Oak Woodland	2.6
July Precip.	0.8	Jan Precip	1.3	July Max Temp	1.3
Insolation	0.6	Elevation	0.4	Insolation	0.9
Jan Min Temp	0.3	NR08 Core	0.2	Jan Min Temp	0.7
Northern Hdwd	0.1	Northern Hdwd	0.2	NR03 Core	0.7
		Evergreen Hdwd	0.1	July precip	0.4

Table Series C-12. Nesting/Roosting habitat, foraging habitat, and full models for Western Cascades modeling regions.

Western Cascades Modeling Region (Northern Section) (N = 76 training sites)

Model		AUC	GAIN
NR05	CANCOV (≥80) + MNDBHBA_CON (≥60) + TPHC_GE100 (≥7)	0.8377	0.7555
F01	CANCOV (≥70); DDI (≥5); TPH_GE50 (≥42); BAA_GE3 (≥40)	0.8417	0.7698
Full Model	NR05 EDGE + NR05 + SLOPE POSITION + CURVATURE + ELEVATION + JANUARY PRECIP + NORTHERN HARDWOODS + JULY MAX TEMP + SUBALPINE FOREST + INSOLATION + JULY PRECIP + F01 + JANUARY MIN TEMP + NR05 CORE	0.931	1.393

Western Cascades Modeling Region (Central Section) (N = 171 training sites)

Model		AUC	GAIN
NR09	TPH_GE50 (≥ 64) + TPH_GE75 (≥ 16) + TPHC_GE100 (≥ 4)	0.7965	0.5825
F01	CANCOV (≥70) + DDI (≥4) + TPH_GE50 (≥37) + BAA_GE3 (≥ 37)	0.816	0.6575
Full Model	NR09 EDGE + F01 + CURVATURE + ELEVATION + NORTHERN HARDWOODS + SUBALPINE + SLOPE POSITION + JANUARY MIN TEMP + NR09 + JULY PRECIP + JULY MAX TEMP + INSOLATION + NR09 CORE + JANUARY PRECIP	0.892	1.024

Western Cascades Modeling Region (Southern Section) (N = 470 training sites)

Model		AUC	GAIN
NR02	CANCOV (≥ 70) + MNDBHBA_CON (≥ 50) + TPH_GE75 (≥ 22)	**0.6877**	**0.2343**
F01	CANCOV (≥ 60) + DDI (≥ 4) + QMDC_DOM (≥ 37)	**0.6931**	**0.2385**
Full Model	NR02 + SLOPE POSITION + CURVATURE + F01 + JANUARY MIN TEMP + NORTHERN HARDWOODS + INSOLATION + JULY PRECIP + JANUARY PRECIP + JULY MAX TEMP + ELEVATION	**0.762**	**0.355**

Table C-13. Individual covariates and their contribution to full model.

Western Cascades North		Western Cascades Mid		Western Cascades South	
Full Model	%	**Full Model**	%	**Full Model**	%
NR05 Edge	34.4	NR09 Edge	44.8	NR 02	62.9
NR 05	17.2	NR09 + F01	13.9	Slope Position	17.8
Slope Position	13.0	Curvature	8.5	Curvature	4.7
Curvature	12.6	Elevation	7.6	NR02 + F01	3.9
Elevation	8.0	Northern Hdwd	7.4	Jan Min Temp	3.9
Jan Precip	4.3	Subalpine	4.2	Northern Hdwd	1.9
Northern Hdwd	3.7	Slope Position	4.1	Insolation	1.5
July Max Temp	2.2	Jan Min Temp	2.4	July Precip	1.5
Subalpine	1.4	NR 09	1.8	January Precip	0.9
Insolation	0.9	July Precip	1.5	July Max Temp	0.5
July Precip	0.9	July Max Temp	1.4	Elevation	0.5
NR05 + F01	0.8	Insolation	1.0		
Jan Min Temp	0.5	NR09 Core	0.7		
NR05 Core	0.2	Jan Precip	0.7		
NR05 Edge	34.4				

Table Series C-14: Nesting/Roosting habitat, foraging habitat, and full models for Eastern Cascades modeling regions.

Eastern Cascades Modeling Region (Northern Section) (n = 182 training sites)

Model		AUC	GAIN
NR06	CANCOV (≥ 70) + DDI (≥ 5) + MNDBHBA_CON (≥ 42)	0.685	0.2263
F03	CANCOV (≥52) + QMDC_DOM (≥30) + BAA_GE3 (≥23)	0.7347	0.3114
Full Model	NR06 + SLOPE POSITION + DOUGLAS-FIR + JANUARY MIN TEMP + ELEVATION + F03 + NR06 EDGE + JULY MAX TEMP + SUBALPINE FOREST + JANUARY PRECIP + CURVATURE + INSOLATION + JULY PRECIP + PINE	0.879	0.843

Eastern Cascades Modeling Region (Southern Section) (N = training sites)

Model		AUC	GAIN
NR07	CANCOV (≥ 70) + MNDBHBA_CON (≥ 45) + TPH_GE75 (≥ 9)	0.7263	0.2912
F03	MNDBHBA_CON(≥ 38) + DDI(≥ 4) + QMDC_DOM(≥ 32)	0.7868	0.4797
Full Model	(F03 + NR07) + NR07 + NR07 EDGE + PINE + DOUGLAS-FIR + JANUARY MIN TEMP + ELEVATION + SLOPE POSITION + NR07 CORE + JULY MAX TEMP + INSOLATION + JANUARY PRECIP + CURVATURE + SUBALPINE FOREST + JULY PRECIP	0.889	0.957

Table C-15. Individual covariates and their contribution to full model.

Eastern Cascades South		Eastern Cascades North	
Full Model	**%**	**Full Model**	**%**
NR07 + F03	18.4	NR06	20
NR 07	13.9	Slope Position	14.6
NR07 Edge	11.7	Douglas-fir	13.6
Pine	10.7	Jan Min Temp	10.6
Douglas-fir	10.7	Elevation	8.3
Jan Min Temp	9.5	NR06 + F03	6.8
Elevation	5.4	NR06 Edge	5.7
Slope Position	4.6	July Max Temp	4.1
NR07 Core	4.5	Subalpine	4.0
July Max Temp	3.3	January Precip	3.3
Insolation	3.2	Curvature	2.9
January Precip	1.6	Insolation	2.7
Curvature	1.5	July Precip	2.1
Subalpine	0.6	Pine	1.5
July Precip	0.4		

Table Series C-16. Nesting/Roosting habitat, foraging habitat, and full models for Klamath-Siskiyou Mountains and Interior California modeling regions.

Western Klamath Mountains (N = 357 training sites)

Model		AUC	GAIN
NR01	CANCOV (≥75) + DDI (≥6) + QMDC_DOM (≥50)	0.6608	0.1677
F03	DDI (≥4) + BAH_PROP (0.25 - 0.70) + BAC_GE3 (≥18)	0.6751	0.1886
Full Model	SLOPE POSITION + NR01 EDGE + NR01 + CURVATURE + JANUARY PRECIP + JULY PRECIP + NR01 CORE + JANUARY MIN TEMP + ELEVATION + INSOLATION + JULY MAX TEMP + F03 + OAK WOODLAND + EVERGREEN HARDWOODS	0.769	0.396

Eastern Klamath Mountains Modeling Region (N = 378 training sites)

Model		**AUC**	**GAIN**
NR01	CANCOV (≥65) + DDI (≥5.5) + QMDC_DOM (≥42)	0.7052	0.2601
F05	CANCOV_CON (≥45) + TPH_GE50 (≥23) + QMDC_DOM (≥30)	0.7075	0.2613
Full Model	NR01 + SLOPE POSITION+ DOUGLAS-FIR+ ELEVATION + NR01 EDGE + INSOLATION + JAN PRECIP+ F05 + CURVATURE + JULY MAX TEMP+ JAN MIN TEMP+ NR01 CORE + OAK WOODLAND+ PINE + SUBALPINE	0.830	0.605

Interior California Coast Ranges (N = 251 training sites)

Model		**AUC**	**GAIN**
NR02	CANCOV (≥65) + MNDBHBA_CON (≥46) + BAA_GE ≥75)	0.7136	0.2975
F04	DDI (≥3.5) + QMDC_DOM (≥30) + BAH_3_25 (≥5)	0.7296	0.3286
Full Model	NR02 + NR02 EDGE + SLOPE POSITION + JULY MAX TEMP + CURVATURE + F04 + NR02 CORE + JULY PRECIP + JAN PRECIP + INSOLATION + JAN MIN TEMP + EVERGRN HDWD + PINE +OAK WOODLAND + ELEVATION	0.820	0.540

Table C-17. Individual covariates and their contribution to full model.

Western Klamath		**Eastern Klamath**		**Interior CA Coast Ranges**	
Full Model	%	**Full Model**	%	**Full Model**	%
Slope Position	33.0	NR01	28.3	NR02	29.9
NR01 Edge	32.2	Slope Position	24.6	NR02 Edge	19.8
NR01	10.9	Douglas-fir	12.1	Slope Position	12.4
Curvature	6.6	Elevation	9.2	July Max Temp	11.1
January Precip	6.1	NR01 Edge	6.8	Curvature	5.6
July Precip	4.4	Insolation	5.4	NR02 + F04	4.9
NR01 Core	1.6	Jan Precip	4.9	NR02 Core	3.3
Jan Min Temp	1.3	NR01 + F05	3.3	July Precip	2.6
Elevation	1.1	Curvature	2.2	Jan. Precip	2.4
Insolation	1.0	July Max Temp	1.2	Insolation	2.0
July Max Temp	0.8	Jan Min Temp	0.8	Jan. Min Temp	1.8
NR01 + F03	0.5	NR01 Core	0.5	Evergrn Hdwd	1.7
Oak Woodland	0.2	Oak Woodland	0.2	Pine	1.3
Evergrn Hrdwd	0.2	Pine	0.2	Oak Woodland	0.7
		Subalpine	0.1	Elevation	0.5

Table C-18. Codes and descriptions of stand structural variables from GNN and compositional variables used in relative habitat suitability models.

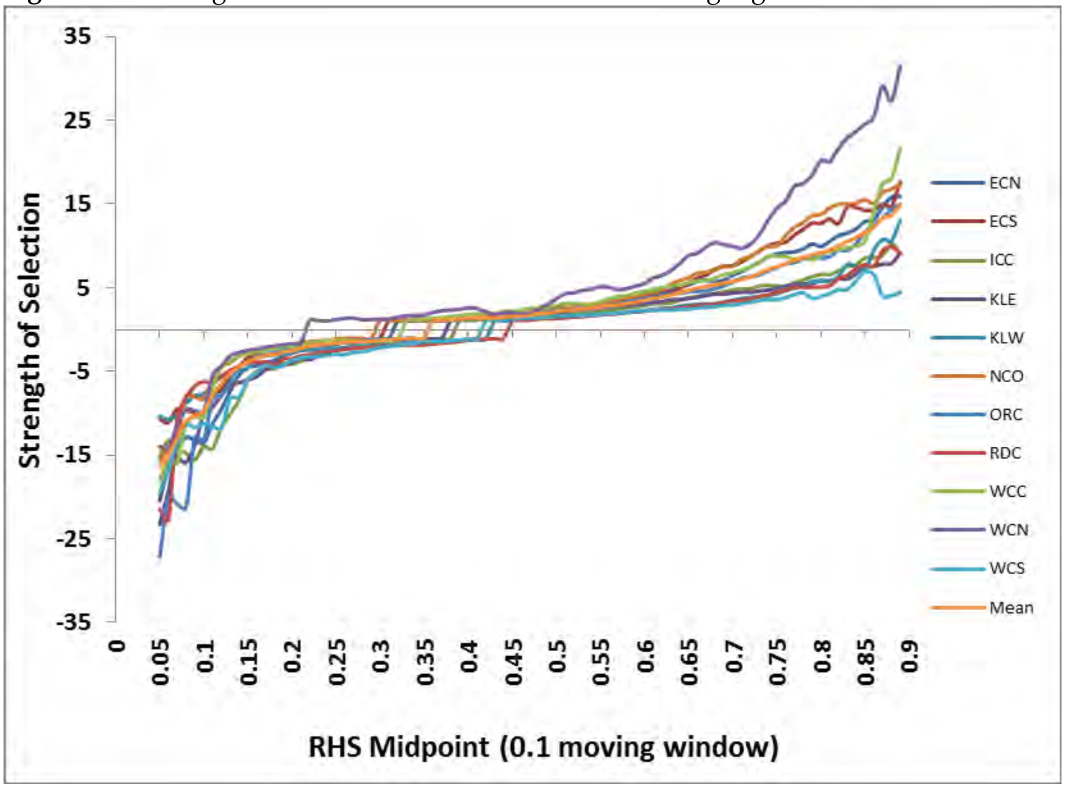
Variable	Definition
CANCOV	Canopy cover of all live trees
CANCOV_CON	Canopy cover of all conifers
DDI	Diameter diversity index (structural diversity within a stand, based on tree densities within different DBH classes)
SDDBH	Standard deviation of DBH of all live trees
MNDBHBA_CON	Basal area weighted mean diameter of all live conifers
TPH_GE_50	Live trees per hectare greater than or equal to 50 cm DBH
TPHC_GE_50	Conifers per hectare greater than or equal to 50 cm DBH
TPH_GE_75	Live trees per hectare greater than or equal to 75 cm DBH
TPHC_GE_75	Conifers per hectare greater than or equal to 75 cm DBH
TPHC_GE_100	Conifers per hectare greater than or equal to 100 cm DBH
QMDC_DOM	Quadratic mean diameter of all dominant and co-dominant conifers
BAA_GE_3	Basal area of all live trees greater than or equal to 2.5 cm DBH
BAA_3_25	Basal area of all live trees 2.5 to 25 cm DBH
BAA_GE_75	Basal area of all live trees greater than or equal to 75 cm DBH
BAC_GE_3	Basal area of conifers greater than or equal to 2.5 cm DBH
BAC_GE_50	Basal area of conifers greater than or equal to 50 cm DBH
BAH_PROP	Proportion of BAA_GE_3 that is hardwood
BAH_3_25	Basal area of all live hardwoods 2.5 to 25 cm DBH
Compositional Variables	
Evergreen Hardwoods	Basal area of tanoak, canyon, coast and interior live oaks, giant chinquapin, California bay and Pacific madrone
Subalpine	Basal area of silver fir, mountain hemlock, subalpine fir, red fir, Englemann spruce,
Pine	Basal area of ponderosa pine, Jeffrey pine, lodgepole pine, and Bishop pine
Northern Hardwoods	Basal area of red alder and bigleaf maple
Oak Woodland	Oregon white oak and blue oak

Results of Model Evaluation and Testing:

Strength of selection results

We plotted the observed use that areas with various RHS values receive (by nesting spotted owls in our case) relative to the abundance of such areas in each modeling region. Figure C5 shows the SOS curves for all 11 modeling regions. Although the degree of calibration varies among modeling regions, the RHS models are generally well-calibrated, with strong selection for areas of RHS > 0.6 to 0.7, and avoidance of RHS <0.15 to 0.25.

Figure C-5. Strength of Selection evaluation for all modeling regions.



Results of Model Cross-Validation

Overall, each modeling region's model proved to be fairly robust, and thus gave us confidence in the model's generality. When we evaluated the differences in the percentages of spotted owl sites classified among 10 equally-sized RHS bins between the full model (using all of the spotted owl locations – thinned by 3 km) and the cross-validated (CV) models (*i.e.*, the 25% of observations that were withheld from the developmental model, each of 10-times for each modeling region) there were generally very small differences (Table C19). The maximum percentage point difference (percentage of observations from the full model minus percentage of observations CV model) was 11.1 (see Table C19). The mean difference of the absolute values among modeling regions ranged from 1.6 (for the Klamath West) to 4.5 (for the West Cascades North). Absolute values were used for calculating means because without doing so, the positive and negative values within a modeling region will always have a mean of 0, and thus don't accurately represent overall differences between full and cross-validated models. There was an inverse (negative logarithmic) relationship between sample size of spotted owl sites and mean difference in absolute value ($r^2 = 0.537$, $P = 0.01$). Nonetheless, the magnitude of differences was generally quite low. For example, 39% of the differences were <2.0, 81% of the differences were <5.0, and only 7% of the differences were >7.0 (absolute value in each case). These findings suggest that none of the modeling region's full models were over-fit, and that all full models have good generality.

Table C-19. Results from cross-validation tests, showing absolute values of differences (% classified by full model - % classified in cross-validated model) among modeling regions.

	Absolute value of differences										
Po Bin	**ECN**	**ECS**	**ICC**	**KLE**	**KLW**	**NCO**	**ORC**	**RDC**	**WCC**	**WCN**	**WCS**
0-0.099	5.2	4.8	3.9	3.0	0.9	5.2	3.3	1.9	7.9	11.1	1.7
0.1-0.199	4.4	4.6	6.1	1.1	5.0	0.2	3.3	3.1	1.9	4.2	1.7
0.2-0.299	3.3	1.0	3.1	4.6	1.4	1.1	0.2	1.4	4.0	3.4	2.6
0.3-0.399	2.8	4.5	0.9	3.7	2.8	0.5	3.0	3.5	0.9	1.3	2.6
0.4-0.499	2.8	7.9	2.5	2.4	0.0	4.5	0.7	5.2	3.7	1.3	0.8
0.5-0.599	3.1	1.0	3.6	4.4	0.8	0.1	6.2	6.1	4.4	4.5	5.5
0.6-0.699	5.2	3.1	7.0	7.3	0.3	1.4	1.9	3.3	9.9	5.3	8.1
0.7-0.799	3.5	9.7	3.4	0.6	4.0	10.2	3.4	6.8	1.7	5.8	2.9
0.8-0.899	1.5	2.5	2.1	1.0	1.1	0.2	2.0	2.2	4.0	6.8	1.2
0.9-1.0	0.3	2.4	0.4	0.3	0.1	0.8	0.4	0.5	1.0	1.1	0.1
Mean	**3.2**	**4.1**	**3.3**	**2.8**	**1.6**	**2.4**	**2.4**	**3.4**	**3.9**	**4.5**	**2.7**

Results of comparisons with independent data sets

To further evaluate the reliability of the models' predictions, we obtained independent (*i.e.* not used in model development) samples of spotted owl territory locations that represented the period 1993 to 1999 (Test96) and 2003 to 2009 (Test06) and compared their associated RHS values to corresponding values for spotted owl sites used in model development. All test sites were greater than 0.8 km from a training site. Because the RHS models were developed using spotted owl territories from the 1996 time period, comparison with Test96 most directly addresses model accuracy. Comparison with independent spotted owl locations from 2006, however, enabled us to evaluate accuracy of the models when projected to a new time period (model transferability), and to investigate systematic shifts in RHS at spotted owl sites. These shifts may occur, for example, in areas where densities of barred owls have increased during the 1996 to 2006 period, and are displacing spotted owls from favorable habitat. If this is the case (as has been hypothesized), we might expect to see reduced use of RHS area at 2006 spotted owl sites, relative to 1996 values (see Methods: Spotted owl location data).

We obtained adequate (N ≥ 100) test samples for 2006 in four modeling regions. As data for additional modeling regions and Test96 become available, further evaluation of model accuracy should be conducted. Table C20 shows the proportions of spotted owl sites in each of five RHS "bins" for the training data (Train), and Test06. Because they allow comparison of RHS values across a gradient of relative habitat suitability, these comparisons are more informative than binary "correct classification" analyses.

Table C-20. Comparison of percentage of 1996 training sites versus test samples of 2006 spotted owl locations in 5 categories of Relative Habitat Suitability.

	Oregon Coast		Western Klamath		Eastern Klamath		Redwood Coast		Rangewide	
	Train	**Test**	**Train**	**Test**	**Train**	**Test**	**Train**	**Test**	**Train**	**Test**
N	247	169	358	136	375	108	392	284	2742	916
RHS bin										
0 – 0.2	7.3	7.1	8.7	2.2	6.1	4.6	4.8	3.2	6.1	4.6
0.2 – 0.4	19.0	23.1	18.2	19.8	14.1	20.4	13.8	12.7	16.5	17.8
0.4 – 0.6	35.6	35.5	38.5	46.3	38.4	39.8	42.1	44.7	36.7	41.8
0.6 – 0.8	32.8	30.2	33.5	30.8	38.7	35.2	37.2	37.7	36.7	33.8
0.8 – 1.0	5.3	4.1	1.1	0.74	2.7	0	2.0	1.8	4.0	1.2

Model evaluation summary:

All modeling regions' models were well calibrated and showed a quite similar pattern in terms of strength of selection (see Figure C5). Cross-validation results by modeling region showed that all models were relatively robust to the 25% iterative reduction in sample size (see Table C19). Lastly, comparison of model results with independent test data showed the models had good ability to predict spotted owl locations (Table C20), and performed well when projected to 2006 vegetation conditions. Overall, these evaluations suggest that our RHS models were robust and have good generality. Subsequently, we used the full dataset models.

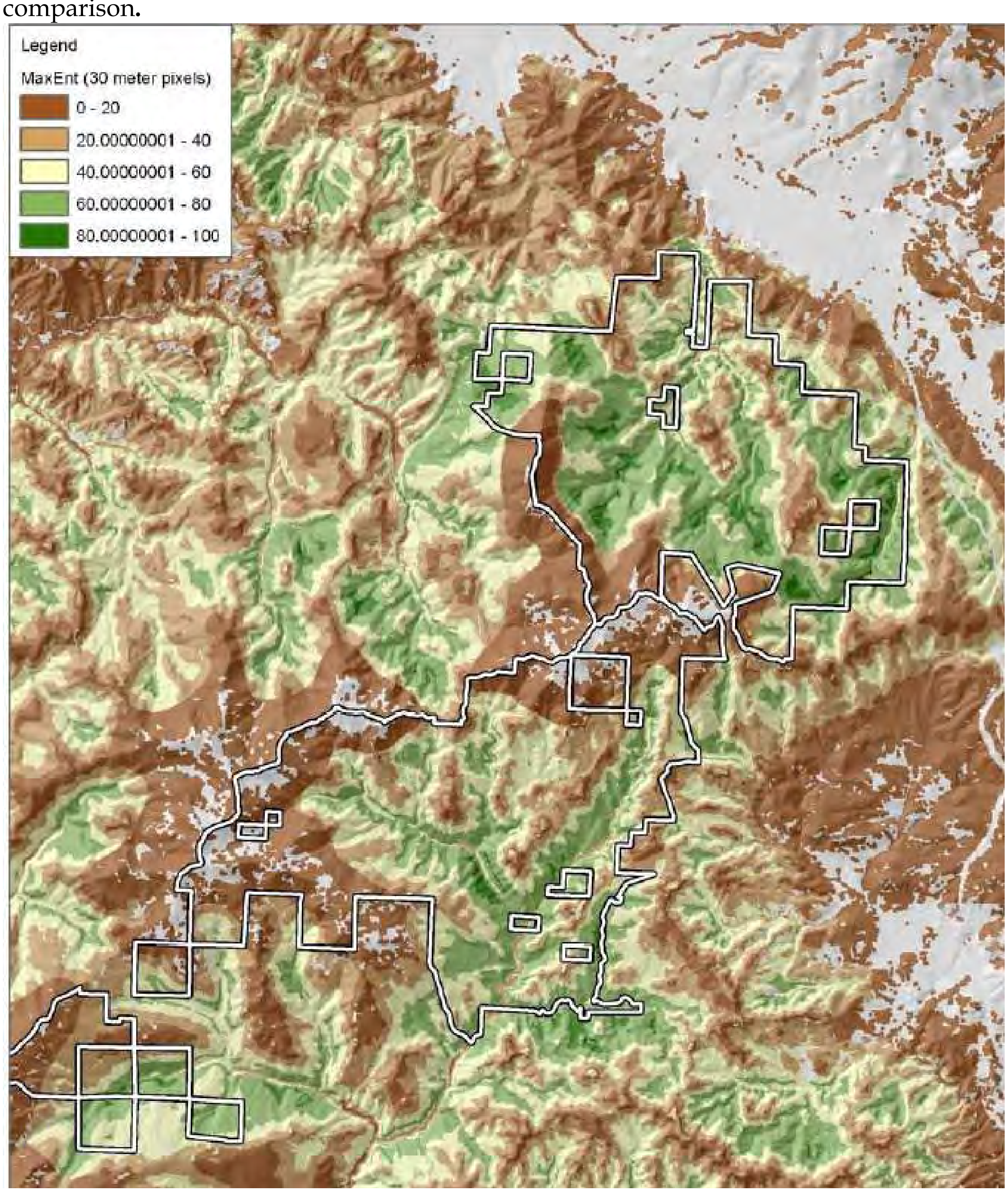
Interpretation of model output:

Elith *et al.* (2011) state that the MaxEnt logistic output is an attempt to estimate the probability that a species is present, given the environment (*i.e.*, the environmental conditions). For our purposes, we have taken a more conservative interpretation of the MaxEnt logistic output and interpret it to represent the relative habitat suitability (RHS) for nesting spotted owls within each modeling region. The map below (Figure C6) is the result of running each modeling region's best RHS model on each 30-m pixel within the region. That is, MaxEnt estimates a RHS value for each pixel based on the biotic and abiotic features within the 200-ha (~800 m radius) area around it (*i.e.*, based only on the variables in the best MaxEnt model for that modeling region). It is important to understand that a high RHS value is possible for a pixel that has little inherent value (*e.g.*, there are no trees in the 30x30 m focal pixel). It may, however, be that the surrounding 200-ha has many of the attributes associated with high RHS. Similarly, a focal pixel could have many of the positive characteristics that spotted owls generally select for, but it receives a low RHS value owing to the surrounding 200-ha having few or none of the attributes associated with high RHS values.

As noted above the RHS map is designed to facilitate and enable a wide variety of processes, discussions and analyses, including section 7 consultation, implementation and evaluation of the efficacy of spotted owl conservation measures such as Recovery Action 10 and management of barred owls. This model likely has utility for a wider variety of uses and processes than we currently envision, and it can be refined by future advances in the understanding of spotted owl habitat associations.

Maps depicting the RHS model outputs for the range of the spotted owl are available at:
http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner. The RHS values are the base layer on this map.

Figure C-6. Map depicting Relative Habitat Suitability from MaxEnt model. Higher suitability habitat conditions are indicated by darker green areas; brown colors denote lower suitability. Outline of the Mount Ashland Late-successional Reserve is shown for comparison**.**



Modeling Process Step 2 – Develop a spotted owl conservation planning model, based on the habitat suitability model developed in Step 1, and use it to design an array of habitat conservation network scenarios.

Because the RHS maps from Step 1 consisted of finely-distributed patterns of habitat suitability across the spotted owl's geographic range, we also wanted to provide a rigorous, repeatable method for aggregating habitat value into habitat conservation networks. We used the conservation planning model "Zonation" (Moilanen and Kujala 2008) to develop a spotted owl conservation planning model which can be used to design an array of habitat conservation network scenarios. To test this model we mapped a series of alternative spotted owl conservation network scenarios based on a series of rule-sets (*e.g.*, varying land ownership categories, the inclusion of existing reserves, identifying a specific amount of "habitat value" to include). The primary output of a Zonation analysis of the landscape is a "hierarchical ranking" of conservation priority of all cells or pixels in the landscape. Zonation allows analysts to incorporate species-specific factors such as dispersal capabilities and response to habitat fragmentation into the ranking of cells, and also allows the inclusion of factors such as land ownership and status into various evaluations. It is important to recognize that the maps produced by Zonation represent user-defined scenarios that were evaluated and compared in subsequent population modeling to test this modeling process; they do not represent decisions about the size or distribution of habitat conservation areas. While Zonation uses the term "reserve" to describe the conservation areas it identifies, this term does not dictate the types of management actions that could occur in those areas.

Zonation produces a hierarchical prioritization of the landscape based on the conservation value or "habitat value" of cells. A cell's habitat value is a function of its "base" value (*i.e.*, its RHS value) as well as the value of cells surrounding it. Thus, two cells of identical RHS may have different habitat value depending on how many other high, medium, and low value cells are nearby. The term habitat value therefore incorporates a larger spatial context than does RHS. Hierarchical, in this case, means that the most valuable five percent is also within the most valuable 10 percent; the top two percent is within the top five percent, and so on. Zonation uses minimization of marginal loss as the criterion to decide which cell is removed, and iteratively removes the least valuable cells from the landscape until no cells remain. The order of cell removal and its proportion of the total habitat value are recorded and can later be used to select any top fraction of cells or habitat value, the best 10 percent of cells or the top 10 percent of habitat value, for example, of the landscape.

To ensure that spotted owls and their habitat would be well-distributed throughout their range (one of the goals for recovery), Zonation analyses were conducted separately for each modeling region. This modeling region decision also had the impact of ensuring that conservation areas would be better distributed across the range of the species.

Zonation allows analysts to identify specific areas of the landscape that represent a particular percentage of the total estimated habitat value to the species. An important attribute of the Zonation algorithm is that it attempts to produce "efficient" solutions. That is, it prioritizes cells into units that maximize the habitat value per unit area within the solution (Figure C7). For example, in one Zonation scenario, 70% of the habitat value existed on ~40% of the landscape.

Figure C-7. *Hypothetical* relationship between total size of habitat conservation system (x-axis) and percentage of habitat value "captured" (y-axis). Theoretically, the only way to capture 100% of the habitat value is to have the entire area to be considered reserve (or all areas with value >0). For this example, the entire area is ~ 19 million ha. In this example, a reserve system that is ~4 million ha "captures" ~50% of the habitat value, one that is ~9 million ha captures ~75% of the habitat value, etc.

Because Zonation is spatially explicit, in a GIS environment the user can control several aspects of how the program evaluates the distribution of habitat value. This enables the program to emulate important aspects of the species' life history, landscape pattern of habitat, and desired attributes of a habitat conservation network.

Zonation's **Distribution Smoothing** function is a species-specific aggregation method that retains high-value areas (pixels) that are better-connected to others, resulting in a more compact solution. The user specifies the area or "smoothing kernel" within which Zonation averages or smooths habitat values, based on a two-dimensional habitat density calculation, in accordance with attributes of an organism's movement patterns or abilities, such as home range area. We compared kernel sizes corresponding to the core use area (800 m radius), median home range (2100 m), and median dispersal distance (27.7 km; Forsman *et al.* 2002). The main difference in the resulting solutions from these three different settings is that the results from the kernel estimated from dispersal distance or home range were less fine-grained than the results from the kernel value estimated from a core area. Given that we are estimating habitat conservation network scenarios at relatively large scales, the coarser-grained (home range-derived kernel values) maps provided more discrete areas as estimated networks, and thus we used the home range scale kernel size.

Zonation's **Cell Removal Method** function allows users to control the spatial pattern or "grain" of priority areas by specifying whether cell removal begins around the edges of the analysis area or at cells scattered across the analysis area. The idea behind the "Edge Removal" setting is that it is more likely to result in connectivity of higher-value areas within the more central areas of the landscape. However, because cell removal is limited to the perimeters of large landscapes, the Edge Removal option can result in large blocks containing extensive areas of unsuitable habitat such as interior valleys and high mountain peaks. The "Edge Removal with Add Edge Points" option allows the user to randomly distribute a specified number of edge points where cell removal occurs within large landscapes. This setting allows more flexibility than edge removal and provides a greater chance that interior areas of poor-suitability habitat will be removed from the solution, and results in more finely-grained pattern of priority areas. The "No Edge Removal" option does not predispose Zonation to start cell removal from any particular area or region, but removes the lowest value cells in the landscape first, then the next lowest, and so on. This results in very finely-grained prioritized areas (and very long computer run times). We conducted side-by-side comparisons and found that Add Edge Points and No Edge Removal end up with nearly identical solutions (~95% overlap in identifying the top 25% habitat value areas in the landscape). To develop a series of alternative habitat conservation networks, we selected Add Edge Points, distributing 2,000 edge points into each modeling region.

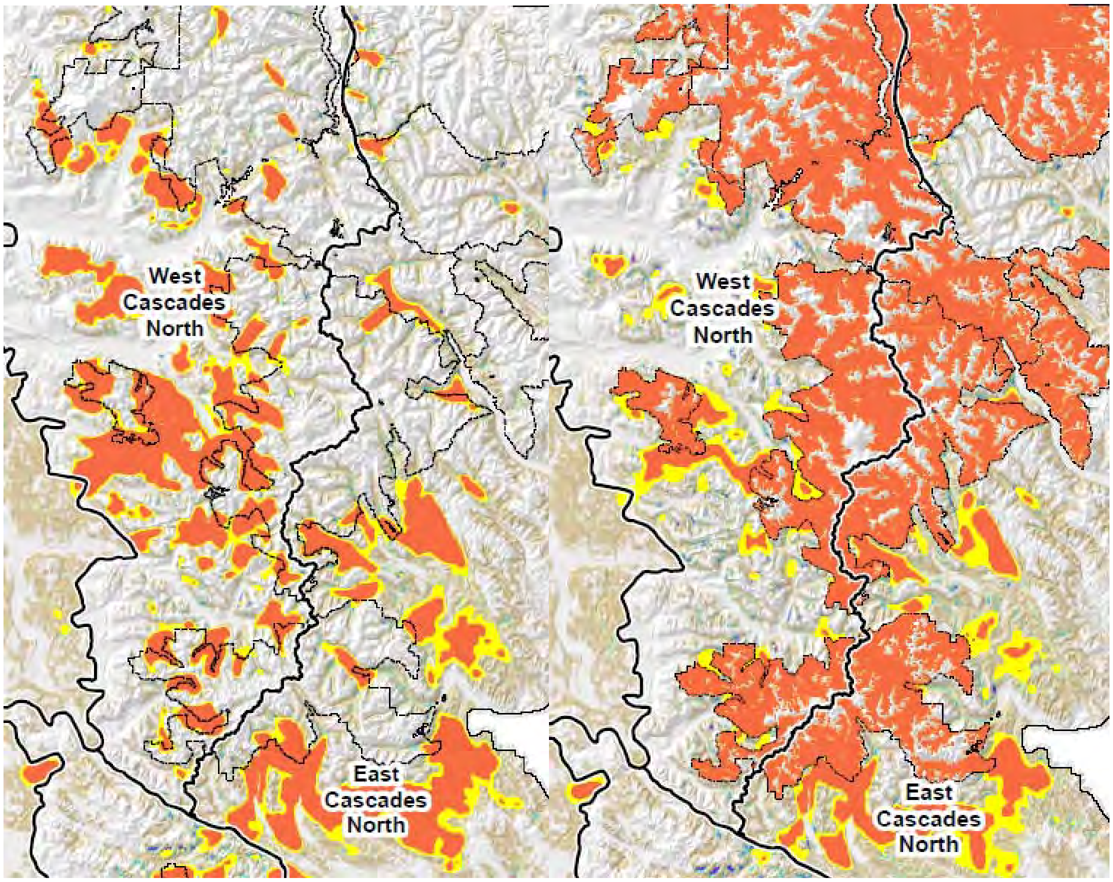
Exclusion Areas are areas that were excluded from the habitat suitability base maps prior to running Zonation. Examples are areas such as high elevation alpine areas as well as generally low elevation valley areas (*e.g.*, the Willamette Valley) that are considered incapable of supporting spotted owls. Including these areas in Zonation runs would give a false impression of habitat conservation block efficiency. That is, the algorithm would be able to remove large amounts of area (high elevation and valley areas) with no impact on the loss of spotted owl habitat value. Thus, we believed these areas should be masked out from the start. The GIS layer used to represent exclusion areas is the same one (mask) developed for the NWFP Monitoring Group (Davis and Dugger in press) and used in our MaxEnt modeling.

Selection of values for conservation value ranking: Zonation enables the user to specify the proportion of habitat value to display as maps of habitat conservation networks. Selection of the quantity of habitat value has a large influence on the size and distribution of habitat conservation networks. Because there is a near-infinite number of values that could be selected for evaluation, we compared results across a broad gradient of habitat values (20%, 30% 40%, 50%, 60%, 70%, and 80%), with the objective of identifying a smaller subset of reasonably diverse habitat conservation network scenarios for testing with the population model (see below). In addition, we compared habitat conservation networks from the above habitat values to the habitat values contained in existing networks such as spotted owl critical habitat (1992 and 2008) and the NWFP reserve network.

Precedence Masking allows the analyst to identify areas that must be or must not be included in the habitat conservation network. For example, existing protected areas such as Wilderness Areas and National Parks can be "forced" into the priority areas, regardless of their habitat value. Similarly, various land ownership categories can be "forced" out of priority areas. To accomplish this, the user identifies zones (land ownership, existing reserves, etc.) and ranks them by conservation priority (Zone 1, Zone 2, and so on) into a 'precedence mask'. In processing, Zonation removes the lowest value cells in Zone 1 first, , and continues by removing the next lowest value cell until all cells are removed in Zone 1 before moving on to Zone 2 and any potentially subsequent zones. Because the cells in Zone 2 are assigned a higher ranking, in terms of removal order, than those in Zone 1, they are disproportionately included in the solution. This process is repeated until all zones defined by the precedence mask have been fully evaluated. Zonation does not re-calculate or otherwise change the habitat value of a cell according to which zone it is in. Instead, identifying zones identifies discrete areas of the landscape that are to be given higher or lower priority of consideration for reasons other than the cells' habitat value.

The basis for precedence masking in Zonation is to allow factors such as land status to be incorporated into the landscape prioritization. For example, forcing existing National Parks and Wilderness Areas into habitat conservation networks would recognize that these areas exist as protected areas, and thus should be included in a habitat conservation networks regardless of their value to spotted owls. However, because we used Zonation to *help identify* areas estimated to provide the most conservation value for the spotted owl, we proceeded by first conducting an evaluation based purely on habitat value (unforced), and *then* evaluated how much overlap the resulting habitat conservation networks had with existing protected areas and other land designations or ownerships. Forcing existing reserves into priority areas will likely predispose Zonation to not find optimal solutions (*i.e.*, because some non-optimal areas are forced into the solution). For example, in areas such as the northern Cascades where high-value spotted owl habitat is relatively sparsely distributed, forcing Congressionally Reserved land allocations into priority areas resulted in an extremely inefficient network design (Figure C8).

Figure C-8. Comparison of Zonation 40% (orange) and 50% (yellow) solutions on all land ownerships (left) and with Congressional Reserves prioritized (right). Outlines of habitat conservation network solutions in the right frame correspond largely to National Park and National Forest boundaries.



After evaluating Zonation results employing a range of values for distributional smoothing, cell removal methods, ranking values, and land status and ownership prioritization, we selected habitat conservation network scenarios comprised of 30 percent, 50 percent, and 70 percent of habitat value as reference points. These scenarios sample along a gradient from somewhat smaller than the current habitat conservation network (NWFP) to a habitat conservation network approximately twice as large as the LSR network (Table C21). We recognize that the results of population modeling may indicate other Zonation scenarios that should or could be developed and tested (feedback loop in Figure C1). ***Also, it is important to recognize these scenarios are not recommendations for the specific size or location of habitat conservation blocks – they are only scenarios for the purpose of comparing to other scenarios to evaluate how they influence spotted owl population performance in the population simulation model.***

Settings and Values Used in Zonation

Distribution Smoothing: Home range area (2100 m radius)
Cell Removal Method: Add Edge points (2000 points/modeling region)
Exclusion Areas: Used NWFP non-capable habitat mask from NWFP Monitoring
Ranking Values: Used 30%, 50%, and 70% of habitat value
Precedence Masking: Land ownership scenarios evaluated include:

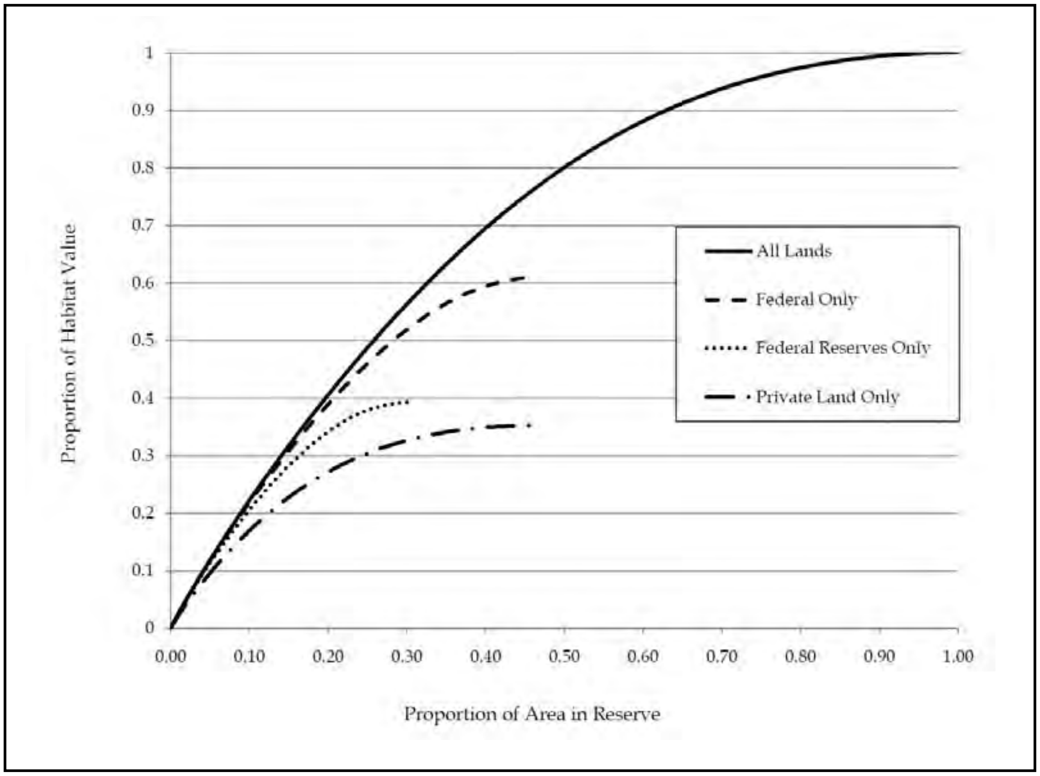
1) **No limit on inclusion** – No hierarchical masking - all land ownerships were allowed to be included and existing reserves were not forced into the priority areas. This scenario was chosen to represent the potential of the entire area to provide for spotted owls.

2) **Public lands only** – precedence masking was done such that non-public lands were removed first, and public lands were removed last. This had the effect of emphasizing reserves on public lands, but if the total amount of habitat value specified (*e.g.*, 50% or 70%) could not be acquired from cells in public lands, other lands could be included in the solution.

Maps depicting all of the initial Zonation scenarios are available at:
http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner.

Zonation outputs can be used to compare the contributions of different land classes (ownership, reserve status, etc.) based on the area and proportion of habitat value of each land class. Figure C9 depicts the relationship between area (proportion of the spotted owl's range) that could, hypothetically, be included in a habitat conservation network and the amount of spotted owl habitat value that various habitat conservation networks would contain among four categories: 1) all lands, which represents no limits on ownerships in the habitat conservation network; 2) Federal lands only, with no priority for currently existing reserves; 3) Federal reserves only, this scenario includes only NWFP reserves (Congressional Reserves and LSRs); and 4) private lands only; no reserves on Federal lands. These depictions are for demonstrative purposes only, not recommendations. They are essentially asking what would be the conservation value to spotted owls if habitat conservation areas were restricted to various land ownership categories. For example, private lands constitute about 45 percent of the spotted owl's range and provide roughly 35 percent of the rangewide habitat value (RHS), whereas the NWFP reserve network provides 40 percent of rangewide habitat value on 30 percent of the area (Figure C9).

Figure C-9. Relationship between proportion of various land ownerships/categories (no restriction, Federal lands only, Federal reserves only, or private lands only) included in a habitat conservation network and proportion of spotted owl habitat value included in the habitat conservation network.



While Zonation outputs do not evaluate or predict potential spotted owl population sizes associated with different habitat conservation network scenarios, they nonetheless permit comparison of the sizes of existing reserve or conservation networks to possible habitat conservation areas, and enable additional comparisons to be made in a GIS environment. For example, Table C21 shows a comparison of network size, percent of spotted owl training locations from the habitat modeling that falls within various habitat conservation network scenarios, and percent of the top two Zonation habitat value ranks among 10 habitat conservation network scenarios. Table C22 shows the relationship the proportion of RHS bins within each of 20 Zonation and 4 non-Zonation habitat conservation network scenarios. The results show the efficiency with which Zonation selects high RHS areas.

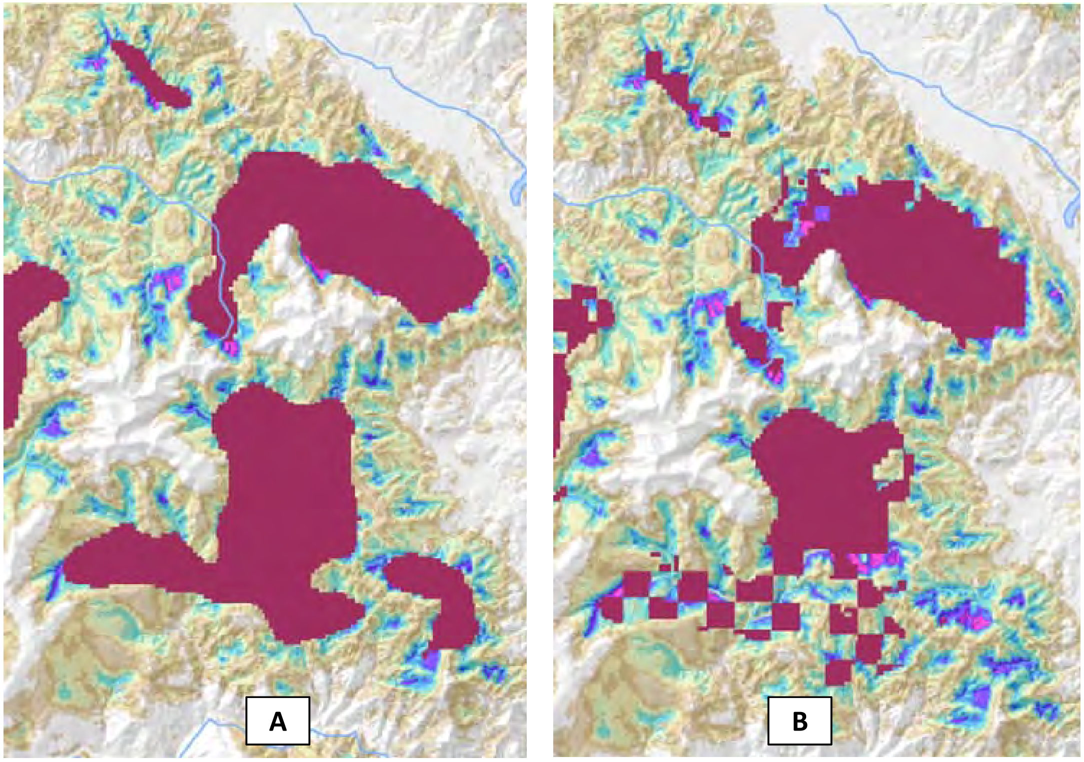
Table C-21. Comparison of area, percent of 1996 spotted owl sites used in model development, and percent of top 10% and 20% Zonation ranked habitat value for 10 spotted owl reserve scenarios.

Network scenario	Network scenario size (million hectares)	Percent of 1996 spotted owl sites	Percent of top 10% Zonation-ranked	Percent of top 25% Zonation-ranked
NWFP	6.63	46	56.7	55.2
MOCA	4.77	33	46.3	43.8
1992 Critical Habitat	5.75	44	57.3	55.4
2008 Critical Habitat	5.17	37	49.6	47.7
Z30 All lands	5.61	50	100	100
Z50 All lands	7.80	71	100	100
Z70 All lands	10.55	87	100	100
Z30 Public lands	5.57	51	94.9	91.3
Z50 Public lands	7.82	73	95.0	93.0
Z70 Public lands	11.24	88	98.9	98.0

Table C-22. Proportion of relative habitat suitability (RHS) bins represented among various habitat conservation network scenarios. Many more Zonation (Zall and Zpub) scenarios are presented in this table than in the remainder of the document. Zall = all lands available; public = Zpub lands prioritized in Zonation.

	Relative Habitat Suitability Bin									
Habitat Conservation Network Scenario	**0 - 10**	**10 - 20**	**20 - 30**	**30 - 40**	**40 - 50**	**50 - 60**	**60 - 70**	**70 - 80**	**80 - 90**	**90 - 100**
NWFP	0.22	0.26	0.31	0.36	0.41	0.46	0.51	0.57	0.63	0.58
MOCA	0.16	0.18	0.22	0.25	0.30	0.34	0.40	0.46	0.49	0.31
1992 Critical Habitat	0.17	0.22	0.28	0.33	0.38	0.44	0.50	0.57	0.66	0.57
2008 Critical Habitat	0.16	0.20	0.24	0.28	0.32	0.37	0.43	0.51	0.60	0.51
Z10all	0.00	0.00	0.02	0.03	0.07	0.16	0.33	0.54	0.70	0.89
Z10pub	0.00	0.01	0.02	0.04	0.08	0.16	0.30	0.51	0.68	0.83
Z20all	0.00	0.02	0.05	0.10	0.19	0.35	0.57	0.77	0.89	0.99
Z20pub	0.00	0.03	0.06	0.11	0.20	0.34	0.54	0.73	0.85	0.90
Z30all	0.01	0.05	0.11	0.20	0.33	0.53	0.74	0.89	0.95	1.00
Z30pub	0.01	0.06	0.13	0.21	0.34	0.51	0.70	0.83	0.90	0.91
Z40all	0.01	0.09	0.19	0.32	0.49	0.69	0.85	0.94	0.98	1.00
Z40pub	0.02	0.11	0.22	0.34	0.48	0.66	0.80	0.88	0.92	0.91
Z50all	0.02	0.15	0.30	0.46	0.63	0.81	0.92	0.98	0.99	1.00
Z50pub	0.04	0.21	0.35	0.47	0.61	0.75	0.85	0.90	0.92	0.91
Z60all	0.04	0.24	0.43	0.61	0.77	0.90	0.96	0.99	1.00	1.00
Z60pub	0.12	0.37	0.48	0.58	0.70	0.82	0.89	0.92	0.93	0.92
Z70all	0.08	0.38	0.59	0.75	0.87	0.95	0.99	1.00	1.00	1.00
Z70pub	0.25	0.47	0.59	0.70	0.81	0.90	0.94	0.97	0.98	1.00
Z80all	0.15	0.57	0.75	0.87	0.95	0.99	1.00	1.00	1.00	1.00
Z80pub	0.32	0.61	0.73	0.83	0.91	0.96	0.98	0.99	1.00	1.00
Z90all	0.31	0.80	0.91	0.97	0.99	1.00	1.00	1.00	1.00	1.00
Z90pub	0.47	0.79	0.88	0.95	0.98	1.00	1.00	1.00	1.00	1.00
Z100all	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Z100pub	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Figure C-10. Example Zonation output map of the Mount Ashland, OR, area, depicting 30 percent of habitat value in red on all lands (A) and on Federal lands only (B).



Modeling Process Step 3 - Develop a spatially explicit spotted owl population model that reliably predicts relative responses of spotted owls to environmental conditions, and use it to test the effectiveness of habitat conservation network scenarios designed in step 2 in recovering the spotted owl. The simulations from this spotted owl population model are not meant to be precise estimates of what will occur in the future, but provide information on comparative trends predicted to occur under differing habitat conservation scenarios.

To meet this objective, the modeling team elected to use a spatially explicit, individual-based modeling approach. While other approaches such as population level population viability analysis (PVA) and metapopulation models have been used for evaluating spotted owl populations, we required an approach that enabled comparison of a wide range of spatially explicit conditions such as variation in habitat conservation networks. Dunning *et al.* (1995) wrote the following regarding spatially explicit population models:

> *"Spatial models, structured and parameterized according to a species' life history, allow one to explore the efficiency of various reserve designs. The models can be*

> *used to estimate the potential effects on a species' persistence by systematically varying factors such as the percentage of the landscape that is suitable habitat, and the size, shape, and spacing of habitat patches. The addition of marginal (i.e., sink) habitat to a reserve can be assessed for negative effects on a managed population (Pulliam and Danielson 1991). These exercises can be done on artificial landscape maps to explore general reserve design principles (Lamberson et al. 1992, 1994) or on GIS-based maps that incorporate land-use and ownership constraints (Murphy and Noon 1992, Noon and McKelvey 1992)."*

Individual-based models (IBMs) allow for the representation of ecological systems in a manner consistent with the way ecologists view such systems as operating. That is, emergent properties such as population increases or declines are the result of a series of effects and interactions operating at the scale of individuals. Individuals select habitat based on what is available to them, disperse as a function of their individual circumstance (age), compete for resources, etc.

Grimm and Railsback (2005) noted that IBMs need to be simple enough to be practical, but have enough resolution to capture essential structures and processes. The spotted owl is perhaps the most studied raptor in the world, and thus there exists a tremendous quantity and quality of data (*e.g.*, vital rates are evaluated in a meta-analysis for several long-term demographic study areas every 5 years; *e.g.*, Anthony *et al.* 2006, Forsman *et al.* (2011)); habitat selection (see review by Blakesley 2004) has been thoroughly evaluated; large numbers of individuals have been followed during dispersal (Forsman *et al.* 2002); among many other aspects of the species' ecology. The spotted owl is therefore ideally suited for spatially explicit IBM. Bart (1995), however, noted that the question "Does the model improve our ability to make decisions?" needs to be explicitly considered. The modeling team believes that the spatially explicit IBM HexSim, which is parameterized largely with empirically-derived values from spotted owl studies, improves our ability to make land management decisions, and therefore we have decided to use this approach.

The HexSim Model:

HexSim (Schumaker 2011) was designed to simulate a population's response to changing on-the-ground conditions by considering how those conditions influence an organism's survival, reproduction, and ability to move around a landscape. The modeling team developed a HexSim spotted owl scenario based on the most up-to-date demographic data available on spotted owls (Forsman *et al.* 2011), published information on spotted owl dispersal, and home range size as well as on parameters for which less empirical information was available (see below). Initially, the HexSim spotted owl model allows users to evaluate the efficacy of existing conservation strategies, under currently-estimated barred owl impacts and with currently-estimated habitat conditions, to meet recovery goals. Subsequently, the model serves as a consistent framework into which variation in spatial data layers (*e.g.*, reserve or conservation block boundaries, different assumptions about habitat conditions (RHS) inside and outside of reserves or blocks, different assumptions about RHS change on public versus private lands, and different assumptions about the impact of barred owls among modeling regions) can be introduced. Comparison of estimates of simulated spotted owl population performance estimates across the range of scenarios incorporating variation in habitat conservation network sizes, habitat trends, and barred owl influence, can inform evaluations of habitat conservation networks and other conservation measures designed to lead to spotted owl recovery.

In very general terms, we tried to design the model to answer the following questions: (1) Given current circumstances (reserves, habitat, barred owls, spotted owl demographic rates, etc.), is recovery of the spotted owl likely in the foreseeable future?; (2) Given current estimates of habitat, barred owls, and spotted owl demographics, is recovery of the spotted owl likely in the foreseeable future under different habitat conservation network scenarios?; and (3) To what degree would management of habitat and barred owls contribute to or detract from reaching spotted owl recovery goals under a range of habitat conservation networks and management scenarios? Evaluation and ranking of the population simulation results from the model obtained across a range of habitat conditions, barred owl effects, and conservation network scenarios, and comparison with established recovery criteria, should provide important insight into these questions. **The HexSim model is available at: www.epa.gov/hexsim.**

HexSim Overview:

HexSim is a spatially explicit, individual-based computer model designed for simulating terrestrial wildlife population dynamics and interactions. HexSim is a generic life history simulator; it is not specifically a spotted owl model. HexSim was designed to quantify the cumulative impacts to wildlife populations of multiple interacting stressors.

HexSim simulations are built around a user-defined life cycle. This life cycle is the principal mechanism driving all other model processing and data needs. Users develop the life cycle when initially setting up a simulation. The life cycle consists of a sequence of life history events that are selected from a list. This event list includes survival, reproduction, movement, resource acquisition, species interactions, and many other actions. Users can impose yearly, seasonal, daily, or other time cycles on the simulated population. Each event can work with all, or just a segment of a population, and events can be linked to static or dynamic spatial data layers. Each life cycle event has its own data requirements. Simple scenarios may use few events with minimal parameterization and little spatial data. When more complexity is warranted, HexSim allows a great deal of data and behavior to be added to its simulations.

HexSim scenarios include descriptions of one or more populations, spatial data needs, life cycle definitions, event data, and basic simulation criteria such as the number of replicates and time steps. Each population is composed of individuals, and individuals have traits that can change probabilistically, or based on age, resource availability, disturbance, competition, etc. HexSim also includes optional genetics and heritable traits (though these were not used for the spotted owl model). The use of traits allows members of the simulated population to have unique properties that change in time and space. Traits also allow populations to be segregated into classes, such as males and females, fitness categories, disease categories, etc. Combinations of trait values can be used to stratify events such as survival, reproduction, movement, etc.

Traits are a fundamental part of HexSim scenarios. Traits can be used to control most life cycle events because events can be stratified by trait combinations. For example, a movement event might be set up to operate only on a fledgling stage class. Or a survival event might assign mortalities based on the values of a trait that reflects resource acquisition. In addition, one trait's values can also be influenced by multiple other traits, which makes it possible to set up stressor interactions and complex feedback loops. Traits can also be used to capture interactions such as parasitism, competition, mutualism, breeding, etc.

Overview of the Spotted Owl Scenario

Because females are the most influential sex in terms of population dynamics, the HexSim spotted owl scenario is a females-only model. The life cycle is simple except that the acquisition of resources by individual spotted owls is spatially stratified, and thus somewhat complex. The scenario depends on two static spatial data layers; one representing the distribution and relative suitability of habitat, and an "exclusion layer" to prevent spotted owls from moving out into the Pacific Ocean, or into areas outside of their geographic range .

An additional layer comprised of the boundaries of both the modeling regions and demographic study areas (DSAs were used to generate HexSim reports (*i.e.*, we extracted information about spotted owls in DSAs as well as within modeling regions and for all modeling regions overall), had no effect on the simulated population. All spatial data layers are converted to grids consisting of 86.6- ha hexagons. To the extent possible, simulation parameter values were estimated based on published empirical data.

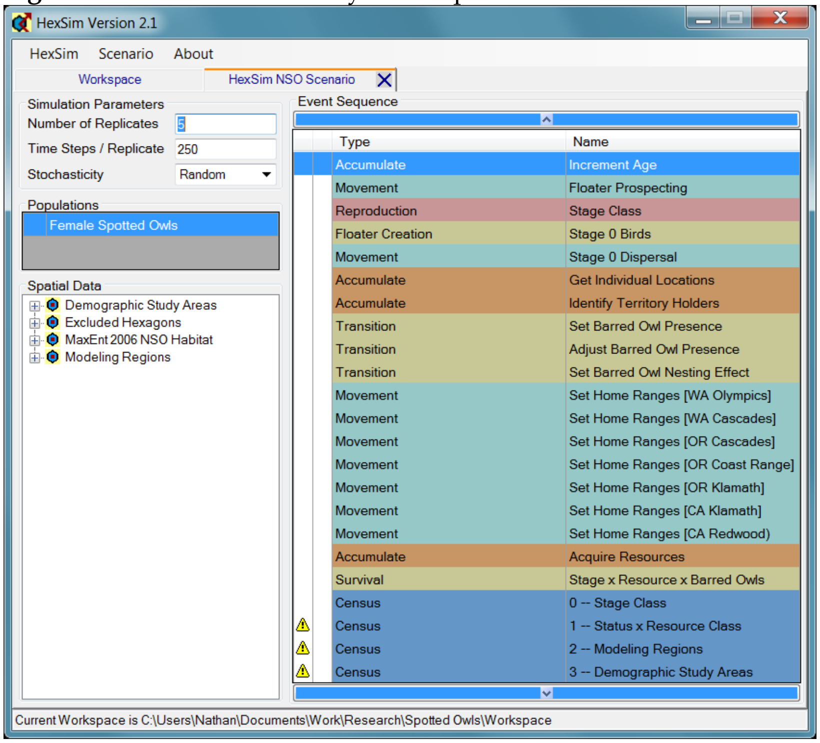
The HexSim simulations began with 10,000 spotted owls being virtually introduced into the study landscape. The initial population's ages were randomly distributed, and they were placed preferentially into areas of high RHS. Once initialization was complete, individual spotted owls were subjected to the event cycle shown in Figure C11. The year begins with each individual becoming a year older. Next, floaters (spotted owls without a territory) prospect for a territory. This is followed by reproduction and fledgling dispersal. Dispersing fledglings do not prospect for a territory.

We assumed that the RHS map developed in MaxEnt was a proxy for the amount of resources available to spotted owls within each hexagon. Because nesting spotted owls showed relatively strong selection for some RHS categories and against others (see Figure C5), we reasoned that this selection was based on a combination of factors (including, but not limited to, those we included as covariates in our models) that influence spotted owl natural selection. That is, spotted owls select some areas and avoid other areas in order to maximize their survival and reproductive success. Spatially-explicit data on competitors, prey, predators and other factors influencing spotted owls were unavailable, and thus we were unable to incorporate more direct measures of resource quantity and quality.

In the HexSim Spotted Owl Scenario, a primary influence of RHS on simulated spotted owl populations occurs in territory acquisition (occupancy). To the extent that some areas aren't selected by spotted owls (or disproportionately selected against), habitat suitability acts to limit survival and reproduction (*i.e.*, spotted owls don't survive or reproduce in areas that they don't occupy). Subsequent to territory establishment, resource acquisition (RHS values) determines the resource class a spotted owl is placed in, which influences survival rates. Reproduction was not influenced by resource acquisition, and thus was not influenced by habitat quality. Individual studies (*e.g.*, Franklin *et al*. 2000) and meta-analyses have reported influences of habitat on survival and in some cases fecundity (see Forsman *et al*. 2011).

We recognized the importance of dispersal and habitats used by dispersing spotted owls in developing habitat conservation planning models. However, relatively little is known about the characteristics of areas used by dispersing spotted owls. In the spotted owl modeling effort, the modeling team therefore elected not to define or attempt to model dispersal habitat, but instead to rely on reasonable assumptions about the influence of relative habitat suitability (for nesting) on successful dispersal. Success (survival) of spotted owls dispersing through variable landscapes may be influenced by factors similar to those affecting territorial spotted owls (*e.g.* availability of prey, cover from predation, thermal stress) albeit at a different scale. Because the RHS values generated by MaxEnt retain the full gradient of habitat suitability (*i.e.* not 'thresholded' or categorized), it is reasonable to assume that relative habitat suitability is correlated with relative success of dispersal occurring in those areas (pixels). In HexSim, dispersing spotted owls are allowed to disperse through the full range of RHS values, with some degree of repulsion to the lowest RHS values.

Figure C-11. HexSim event cycle for spotted owls.



After floater spotted owls finish prospecting for territories, the modeling region they are in is recorded. Then the determination of whether each territorial spotted owl is in the presence of a barred owl is made probabilistically, with the probability of being in the presence of a barred owl dependent on the modeling region (Table C25). The region-specific probabilities for spotted owl exposure to barred owls were based on the proportion of spotted owl territories where barred owls were detected each year on the 11 DSAs (see Appendix B; Forsman *et al*. 2011). This decision is only made once per "bird-territory" (*i.e.*, once the decision is made for an individual spotted owl at a territory, the barred owl presence/absence is fixed for that territory until another spotted owl takes over the territory). All non-territorial spotted owls are placed in an 'undetermined status' category until they obtain a territory. A newly territorial spotted owl that has this undetermined status is assigned a "barred owl present" or "barred owl absent" status, based on the barred owl encounter probability for that modeling region.

Next, spotted owls that have the "barred owl present" status are placed in either a "*nesting normal*" or "*nesting halted*" class. At present, every spotted owl is placed into the *nesting normal* class. If spotted owls were assigned to the *nesting halted* class, they would not reproduce. Unlike the barred owl presence/absence trait described above, the *nesting normal* vs. *nesting halted* decision could be revisited every year, for every territorial spotted owl. Spotted owl floaters do not reproduce, so although they are always assigned to the *nesting normal* category, this has no impact on the simulation results. We mention these features (even when they aren't used) that were built into the HexSim Spotted Owl Scenario model to show how the model can adapt to and incorporate new information when it becomes available.

In the HexSim simulation, barred owls affect spotted owls through survival only. However, the simulation has been developed to facilitate a barred owl impact on spotted owl reproduction. This feature has not yet been used. It would also be possible to have barred owls impact habitat selection by spotted owls, or site fidelity. Neither of these processes has been implemented. Reproductive rates were obtained from Table 3 of Forsman *et al*. (2011). Those estimates were for time periods as long as 1985 to 2008 and as short as 1992 to 2008. It is generally agreed that barred owl populations have increased in most areas of the spotted owl's range over that time. Thus, to the degree that barred owls have an influence on fecundity, that influence is incorporated into these estimates.

Spotted owl reproduction is stratified by both stage class and nesting status (see above). Spotted owls that are in the *nesting halted* class have 100% probability of producing a clutch of size 0. Otherwise, the reproductive rates vary by stage class.

Spotted owl survival is stratified by barred owl presence, stage class, and resource class. Spotted owls in the barred owl present class have lower survival rates. Those in the barred owl absent, or undetermined classes, have higher survival rates.

At present, barred owls are not explicitly simulated, but are instead captured probabilistically. Accounting for barred owl impacts on spotted owl habitat selection or site fidelity would require that barred owls be actually located on the simulated landscape, and possibly even fully simulated within HexSim. The modeling team felt that sufficient data did not exist range-wide to permit either option to be incorporated into the current simulations. When such data become available, they can be integrated into the framework we have developed.

Next, each spotted owl establishes a home range. The simulated spotted owls have small defended territories, but large overlapping home ranges. Home range size varies with modeling region. The spotted owls extract resources from their home ranges, and thus they experience competition for resources from conspecifics. Finally, resource acquisition and survival are simulated. Survival varies based on stage class, resource acquisition class, and exposure to barred owls.

Home range sizes were set to the mean of the available regional-specific estimates (see summary in Schilling 2009). Spotted owl survival rates were based on study area-specific estimates from Forsman *et al*. (2011), with adjustment for the impact of barred owls across all study areas as calculated from the survival meta-analysis model containing an additive barred owl effect, also from Forsman *et al.* (2011).

The Population Parameters

Three distinct component groups were involved in the specification of the HexSim spotted owl population. These involved a set of basic properties, the definition of several different population traits, and finally the establishment of rules for the spotted owl's use of space and resource needs. The basic properties were used to establish an initial population size of 10,000 spotted owls, and to define an exclusion layer. Individuals were initially placed into the best hexagons in the simulation landscape, but only one spotted owl was allowed per hexagon.

Seven traits were created as part of the spotted owl population definition. These traits track stage class, location (modeling region and possibly DSA), resource class, territory status (territorial vs. floater), exposure to barred owls, and barred owl impacts on spotted owl nesting. Table C23 shows each possible trait value.

The simulated spotted owls produced each year begin life at age zero, and stage class zero. Each year they transition into the next stage class. At age 3 they reach stage class three, which is the terminal stage class. The spotted owls always belong to one of three resource classes, depending on the amount of resources they are able to acquire from their home range. Resources are a function of the mean RHS of hexagons, derived from the MaxEnt models (see above). Spotted owls that acquire 2/3 or more of their resource target are placed in the high resource class. Those that attain less than 1/3 of their resource target are placed into the low resource class. All other spotted owls are placed into the medium resource class. Resource targets vary by modeling region, and are described below.

The territory status trait is used to record whether individual spotted owls own a territory, or are floaters. The barred owl presence trait categorizes individual spotted owls as being exposed, or unexposed, to a barred owl. This decision is made once for each territorial spotted owl. The barred owl nesting effect trait is used to assign a probability that exposure to a barred owl will cause a spotted owl to avoid nesting. This evaluation is repeated every year for every spotted owl.

Table C-23. Spotted owl scenario traits and value categories.

Trait	Values
Stage Class	Stage 0
	Stage 1
	Stage 2
	Stage 3
Resource Class	Low
	Medium
	High
Territory Status	Floater
	Territorial
Barred Owl Presence	Pending
	Absent
	Present
Barred Owl Nesting Effect	Normal
	Halted

Trait	Values
Modeling Region	North Coast Olympics
	Oregon Coast
	East Cascades South
	East Cascades North
	West Cascades North
	West Cascades Central
	West Cascades South
	Klamath East
	Klamath West
	Inner-California Coast Range
	Redwood Coast

Trait	Values
DSA	Cle Elum
	Coast Ranges
	HJ Andrews
	Klamath
	Olympic
	Rainier
	South Cascades
	Tyee
	Warm Springs
	Wenatchee
	Hoopa
	Marin
	NW California
	Simpson

The modeling region and demographic study area traits are used to track individual spotted owl locations. The 11 modeling regions are space-filling and non-overlapping. Each individual spotted owl occupies one modeling region at any one time. If a spotted owl territory spanned multiple modeling regions, it was assigned to the region in which the majority of its territory hexagons fell. The demographic study areas (DSAs) take up just a fraction of the landscape. So at any moment most spotted owls will not be in a DSA. Resource targets (explained below) and home range size vary by modeling region.

The population parameters also control individual's use of space. The simulated spotted owls had territory sizes of no more than three 86.6-hectare hexagons. This territory size represents a reasonable approximation of a spotted owl core area (see discussion of spatial scale above). Hexagons had to have at least a score of 35 (out of 90 possible) to be usable in forming a territory. We decided on a minimum score of 35 after evaluating the scores of hexagons overlaid on 3,790 spotted owl nest sites. We evaluated the score for the focal hexagon (the one in which the nest resided), the second, and third closest hexagons, as well as the mean scores of the first, second, and third hexagons. More than 75% of the nest sites were in hexagons with scores >35. Similarly, 73% of the spotted owl sites had a mean score >35 for the focal, second, and third closest hexagons. Although other scores might be reasonable, we reasoned that increasing the score would unreasonably inhibit settlement on suitable areas, whereas decreasing the score would result in unrealistic densities in areas with relatively low RHS. Territory size had little significance for the simulated population dynamics, as the spotted owls derive resources from their home ranges. The territories served as a core area around which home ranges could be constructed. Territories, in the HexSim simulations, were exclusively used areas, whereas the remainder of the home range area could overlap with that of neighboring spotted owls.

Each simulated spotted owl has a resource target, which controlled how much resource it must have access to in order to be placed into the highest resource class. The resource targets vary by modeling region. Spotted owls that acquire 2/3 or more of their resource target are placed into the high resource acquisition class. Those that attain less than 1/3 of their resource acquisition target are placed into the low resource acquisition class. All other spotted owls end up in the medium resource acquisition class. The resource targets are listed in Table C24.

Table C-24. Estimated resource targets based on RHS values at 3,790 spotted owl locations.

Modeling Region	Home Range Size ha (# hexagons)	Resource Target
North Coast Olympics	11,052 (128)	1250
East Cascades North	7,258 (84)	1000
West Cascades North	7,258 (84)	1250
West Cascades Central	7,258 (84)	1250
Oregon Coast	4,123 (48)	375
West Cascades South	3,949 (46)	375
Inner CA Coast Range	3,165 (37)	375
East Cascades South	3,033 (35)	750
Klamath East	3,033 (35)	375
Klamath West	3,033 (35)	375
Redwood Coast	1,173 (14)	250

The Event Sequence

There are 23 events in the HexSim spotted owl scenario. Not all of these events modify the population, and some have similar or related functions. These events are described in turn below. Each event is listed by type (*e.g.,* movement) and specific name (in square brackets).

Accumulate [Increment Age]

This event makes each individual one year older. As a result, stage 0 individuals will move into stage 1, stage 1 individuals will move into stage 2, and stage 2 individuals will move into stage 3.

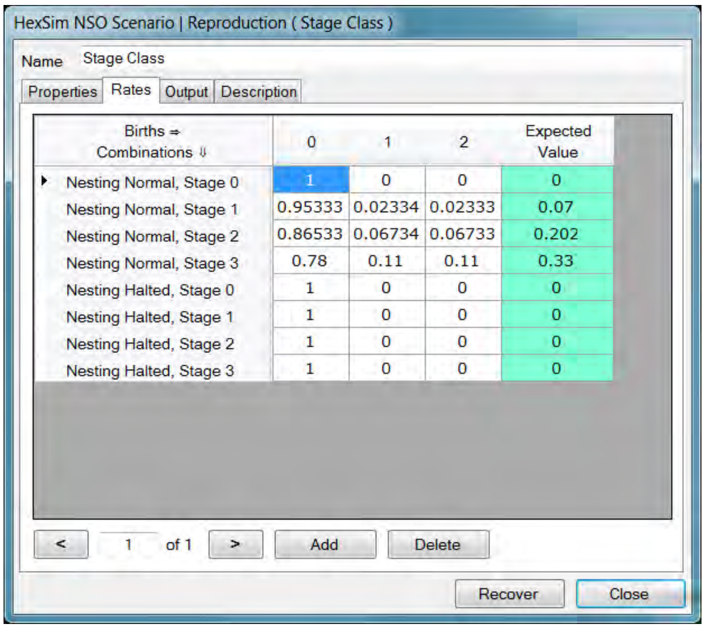
Movement [Floater Prospecting]

HexSim's movement event controls dispersal and prospecting behavior. But any one event may do either or both. This event only performs prospecting, but it does so for all spotted owls that are floaters (*i.e.,* those who do not own a territory). Individual floaters are allowed to search an area of up to 500 86.6 - hectare hexagons in search of a vacant area from which a territory could be constructed. The search strategy is imperfectly informed by resource availability. That is, spotted owls tended to construct home ranges from high RHS hexagons, but they did not select the best sites with certainty.

Reproduction [Stage Class]

HexSim's reproduction module is parameterized by assigning probabilities to each possible clutch size. Reproduction is also stratified by traits. In this case, the maximum clutch size was set to 2, and reproduction rates were varied by stage class, and based on the Barred Owl Nesting Effect trait values. The reproductive rates used in the event are shown in Figure C12. The unperturbed (by barred owls) reproductive rates were obtained from Table 3 of Forsman *et al.* (2011).

Figure C-12. Estimated spotted owl reproductive rates by stage class.



Births ⇒ Combinations ⇓	0	1	2	Expected Value
Nesting Normal, Stage 0	1	0	0	0
Nesting Normal, Stage 1	0.95333	0.02334	0.02333	0.07
Nesting Normal, Stage 2	0.86533	0.06734	0.06733	0.202
Nesting Normal, Stage 3	0.78	0.11	0.11	0.33
Nesting Halted, Stage 0	1	0	0	0
Nesting Halted, Stage 1	1	0	0	0
Nesting Halted, Stage 2	1	0	0	0
Nesting Halted, Stage 3	1	0	0	0

The column headings in Figure C12 correspond to clutch sizes. The rows contain all of the permutations of the two trait values. The right-most column shows the expected values, which, in a females-only model, equal fecundities. Individuals whose nesting has been halted by a barred owl are assigned a 100% probability of having a clutch size of zero. The same is true for stage class 0 individuals. Otherwise, the probabilities of having clutches of size 1 and 2 were set as equal as possible, to whatever value was necessary to produce the fecundity values reported in Forsman *et al.* (2011). Finally, the probability of having a clutch of size zero was set so that each row summed to exactly 1.0.

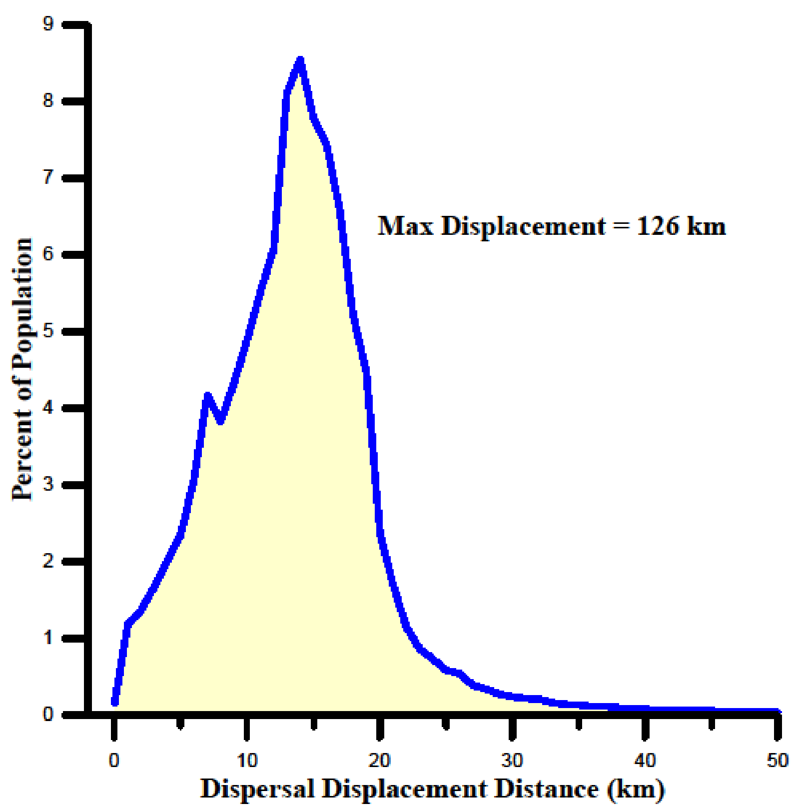
Floater Creation [Stage 0 Birds]

In HexSim, recruits become a co-owner of their mother's territory. They will disperse from their natal territory when forced to by a floater creation event at the end of Year 1. This floater creation event removes all stage 0 birds from their natal groups. These animals disperse in the next event.

Movement [Stage 0 Dispersal]

HexSim's movement event controls dispersal and prospecting behavior. Any one movement event may do either or both. This event strictly performs dispersal for stage class 0 spotted owls. The dispersing birds move with moderate auto-correlation until they encounter enough resource that a territory may be constructed (see above). Territory construction does not actually take place at this time. The dispersers are limited to moving 250 km total distance. The birds have a slight repulsion to lower RHS areas of the landscape, but are not prevented from moving into zero-valued hexagons. Figure C13 shows an example of the distribution of simulated dispersal displacement distances produced by this movement event. These data were gathered from five replicate simulations, for years 100-250. The total number of dispersal events in this period was approximately 852,000. The shape of this frequency distribution will change if either the rules for stopping (3 territory-quality hexagons encountered in succession) or the degree of autocorrelation (50%) are modified.

Figure C-13. Distribution of 852,000 simulated Year 1 dispersal distances.



Accumulate [Get Individual Locations]

This event records which modeling region each spotted owl is in. If an individual falls within a demographic study area then this event will captures that information, as well.

Accumulate [Identify Territory Holders]

This event updates a trait that segregates into two classes: floaters and territory-holders.

Transition [Set Barred Owl Presence]

This transition event assigns values to the Barred Owl Presence trait. Each modeling region was assigned a separate barred owl encounter probability, based on field data illustrating the proportion of spotted owl territories on DSAs where a barred owl was documented each year (Appendix B; Forsman *et al.* 2011). Using these probabilities, this event places each territorial spotted owl into one of two classes. The classes indicate whether the spotted owl is exposed to a barred owl or not. Once this determination is made for a specific spotted owl, it is not changed until that spotted owl dies or otherwise leaves the territory. The probabilities that were used are shown in Table C25.

Table C-25. Barred owl encounter probabilities estimated from Forsman *et al.* (2011).

Region	Encounter Probability
North Coast Olympics	0.505
East Cascades North	0.296
West Cascades North	0.320
West Cascades Central	0.320
Oregon Coast	0.710
West Cascades South	0.364
Inner CA Coast Range	0.213
East Cascades South	0.180
Klamath East	0.245
Klamath West	0.315
Redwood Coast	0.205

Transition [Adjust Barred Owl Presence]

This transition event simply removes the barred owl presence designation from floater spotted owls. This way, if a spotted owl was to give up its territory and leave, it would not retain its barred owl presence / absence designation. In the present scenario territorial spotted owls have perfect site fidelity, so this event has no impact.

Transition [Set Barred Owl Nesting Effect]

This transition event uses the barred owl presence trait to set the value of a barred owl nesting effect trait. This allows spotted owls that are exposed to a barred owl to be placed into a non-nesting category with some probability. As this probability increases from zero, barred owls have an increasingly strong influence over spotted owl nesting rates, and hence reproductive output. In these simulations, the barred owl effect on spotted owl nesting was set to zero.

Movement [Set Home Ranges]

Eight different movement events are used to set home range sizes differently based on modeling region. These movement events only establish home ranges for territorial spotted owls. The home range sizes used are listed in Table C26. Spotted owls acquire resources from their home ranges, and the home ranges for different birds may overlap; territories however, cannot overlap. This results in competition among spotted owls for resources. Spotted owl home ranges were always contiguous, but their shapes were not constrained. The home range sizes used were developed from the published results of many field studies, and were compiled by the modeling team.

Table C-26. Spotted owl home range sizes used in population modeling.

Region	Home Range Size (in hexagons)
North Coast Olympics	128
East Cascades North	84
West Cascades North	84
West Cascades Central	84
Oregon Coast	48
West Cascades South	46
Inner CA Coast Range	37
East Cascades South	35
Klamath East	35
Klamath West	35
Redwood Coast	14

Accumulate [Acquire Resources]

This "accumulate event" assigns individual spotted owls to a resource class, based on how much resource they acquire from their home ranges. Habitat suitability and quantity, plus competition with conspecifics will dictate what resource class individual spotted owls end up in.

Survival [Stage x Resource x Barred Owls]

The survival event is stratified by stage class, resource class, and exposure to barred owls (which is binary). The survival rates that were used are shown in Table C27. The derivation of these values is discussed in a separate section below.

Census [x 4]

Four census events are used to track the number of spotted owls by stage class, resource class, modeling region, and demographic study area.

Table C-27. Estimated survival rates of spotted owl based on stage class, resource class, and barred owl effect.

Without Barred Owls			With Barred Owls		
Stage Class	**Resource Class**	**Survival Rate**	**Stage Class**	**Resource Class**	**Survival Rate**
Stage 0	Low	0.366	Stage 0	Low	0.28
	Medium	0.499		Medium	0.413
	High	0.632		High	0.546
Stage 1	Low	0.544	Stage 1	Low	0.458
	Medium	0.718		Medium	0.632
	High	0.795		High	0.709
Stage 2	Low	0.676	Stage 2	Low	0.590
	Medium	0.811		Medium	0.725
	High	0.866		High	0.780
Stage 3	Low	0.819	Stage 3	Low	0.733
	Medium	0.849		Medium	0.763
	High	0.865		High	0.779

Spatial Data

The Baseline HexSim spotted owl scenario uses four different map files. All four maps are static (they do not change with time), and each is made up from 538,395 hexagons arranged in 1430 rows and 377 columns. Individual hexagons are 1000 meters in diameter, and 86.6 hectares in area. The spatial data were developed by sampling raster imagery, using a tool that is built into the HexSim model. The sampling process involves intersecting a grid of hexagonal cells with a raster image, and then computing a per-hexagon mean from a series of weights assigned to the land cover classes present in the raster data.

The habitat map (*MaxEnt 2006 NSO Habitat)* depicts spotted owl RHS values developed using MaxEnt in Step 1 (see above). In HexSim, each pixel was assigned a weight equal to its RHS score. Pixel scores ranged between zero and 97. Thus when the HexSim RHS map was constructed from this raster file, the largest possible hexagon score was 97.00; this upper limit was never realized because each hexagon's value represented an average of the pixels underneath it. The hexagons in the HexSim RHS map vary between 0.00 and 90.37. Hexagon scores were assumed to be proxies for the value of resources available to NSOs within the hexagon.

The habitat map (*MaxEnt 2006 NSO Habitat)* captures spotted owl resource quality, and was derived from RHS values developed using MaxEnt in Step 1 (see above). In HexSim, each land cover class was assigned a weight equal to its category ID. The category IDs ranged between zero and 97. Thus when the HexSim resource quality map was constructed from this raster file, the best possible hexagon score was 97.00; this upper limit was never realized because each hexagon's value represented an average of the pixels underneath it. The hexagons in the HexSim resource quality map vary between 0.00 and 90.37.

A map delineating the study area (*Excluded Hexagons)* was binary, with ones being assigned to each hexagon within the range of the spotted owl, and zeros elsewhere. Simulated spotted owls were not allowed to move into hexagons that were zero-valued in this map. This map included boundaries to the study area, such as the Pacific Ocean and other areas outside of spotted owl's range, or outside our area of inquiry (*e.g.*, the spotted owl's range in British Columbia).

The final two maps depict the locations of the modeling regions and DSAs. The map called *Modeling Regions* breaks the range of the spotted owl up into 11 different regions. This map was used to identify which region individual spotted owls occupied, because each modeling region had different resource requirements and home range sizes. Similarly, a map called D*emographic Study Areas* indicates the locations of 14 different DSAs.

Survival Rates

The survival event is stratified by stage class, resource class, and exposure to barred owls. To begin with, 9 survival rates (estimated apparent survival) were derived from Table 12 in Forsman *et al.* (2011). Because true adult survival is unknown we made the assumption that apparent adult survival is equal to, or a reliable surrogate for, true adult survival. These rates corresponded to the three oldest stage classes x 3 resource classes. Forsman *et al.* (2011) provided stage class-specific survival estimates for each of 11 DSAs. For each study area and stage class, mean apparent survival values for males and females were provided. We computed the mean of each pair and identified the smallest and largest of these mean values. For any given stage class, the smallest mean value was assigned to individuals in the low resource class. Likewise, the largest stage-specific mean value was assigned to individuals in the high resource class. The stage-specific survival rates for individuals in the medium resource class were set equal to the mean taken over all of the survival estimates present in Table 12 of Forsman *et. al* (2011) for that stage class. Through this process survival rates were obtained for stage 1-3 spotted owls in all three resource classes.

Stage class 0 survival estimates were taken from Franklin *et al.* (1999: 27-28). This is the final report titled "Range-wide status and trends in northern spotted owl populations" that was written after a major workshop held in Corvallis, Oregon, in 1999 to estimate demographic rates of the subspecies. The estimates of juvenile survival rates for three study areas from banding studies were adjusted to compensate for emigration rates, based on radio telemetry studies conducted by Eric Forsman (unpublished data). Mean, minimum and maximum juvenile survival rates were taken from this reference and used in the model. The mean value for Stage class zero was set to the midpoint between the minimum and maximum value.

Finally, survival rates were varied based on the presence or absence of barred owls, and the magnitude of their effect was based on the best meta-analysis model for survival with an additive barred owl covariate across all DSAs from Forsman *et al.* (2011). These values were stratified by both stage class and resource class.

Evaluation of Model Calibration

The HexSim model simulated a females-only population of spotted owls throughout their range. The principal metric used to evaluate the model was the simulated population size. The numbers of female spotted owls were tracked range-wide, per modeling region, and also per DSA. The model's performance was assessed by comparing all three measures of simulated population size to field data. We compared simulation year 50 HexSim estimates to field data for 8 DSAs. For this comparison, we used the HexSim simulations during which barred owl impacts were inserted during year (or time-step) 40. After barred owl impacts were incorporated at time-step 40, they remained constant for the remaining 210 time-steps. For these simulations we did not attempt to back-cast barred owl "invasion" dynamics. Our "scenario", therefore, predisposed barred owl impacts to occur all at once, not incremented. We determined by inspection that simulation year 50 most closely represented the present day.

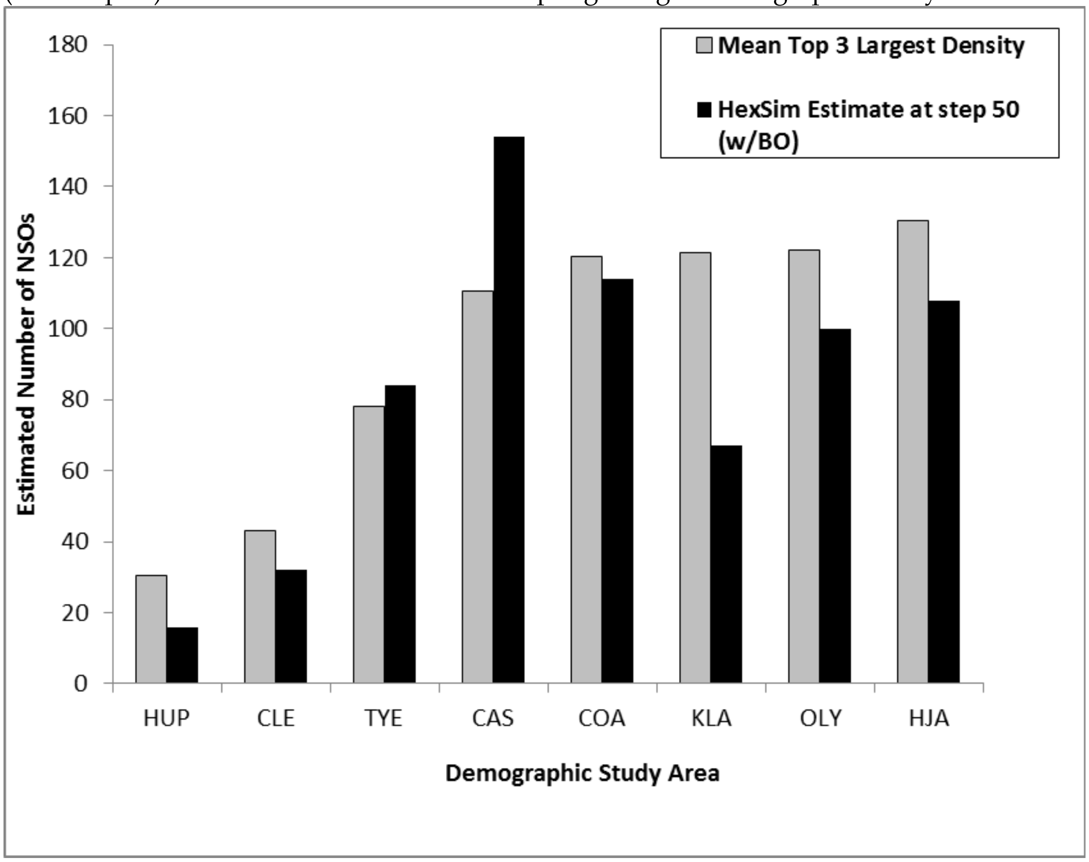
HexSim simulations are stochastic, and to quantify population size, the mean was taken from 5 replicate simulations. Each simulation was 250 time-steps (years) in duration. This does not suggest that spotted owl population sizes were forecasted 250 years into the future. Doing so would at minimum require performing the simulations with a series of maps illustrating habitat changes through time. In contrast, these initial simulations were performed with static data from year 0 to year 40, then (if changes were introduced) changes in barred owl or RHS were introduced and remained static until year 250. The length of the simulations (250 years) simply allowed a steady-state population size and trend to be estimated.

Most, but not all DSAs had data that could be used to approximate density of female spotted owls. Additionally, not all DSAs functioned as "density study areas", and they did not always sample spotted owls identically, nor present data consistently (among DSAs at least). Nonetheless, most DSA annual reports contained tables of historic data which revealed trends. For calibration purposes data from the following DSAs were used: Cle-Elum, Olympic, Oregon Coast, HJ Andrews, Tyee, Klamath, Cascades, and Hoopa. Several calibration iterations were performed by varying resource requirements one modeling region at a time.

Discrepancies in the fit between simulated and observed population size were addressed by varying the resource targets (described above). The resource targets were specified on a modeling-region basis, and they indicated how much resource an individual spotted owl living in a specific region would attempt to acquire. The resource targets were a proxy for resource availability, which varied from region to region and was not fully captured in the RHS maps. As the resource targets increased, individual spotted owl's needs for resources increased. An inability to acquire sufficient resources could cause spotted owls to drop into the lower resource acquisition classes, which would then lower their survival rates.

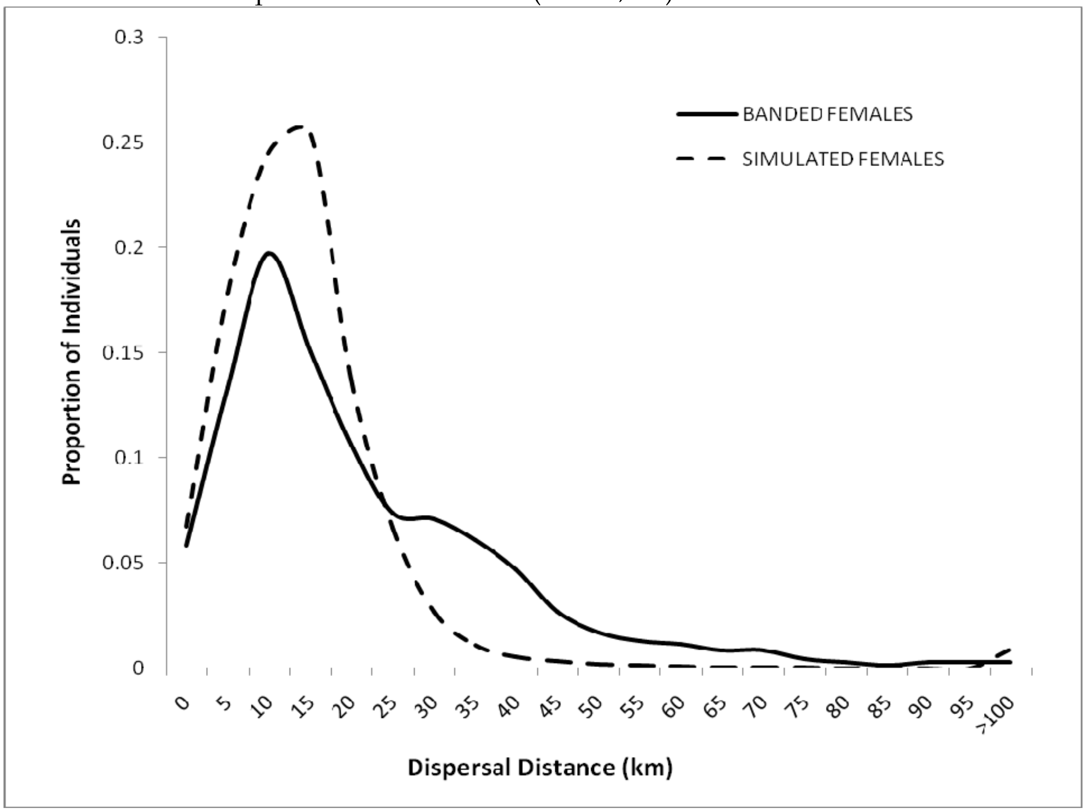
The Baseline HexSim simulations, in which barred owl impacts were introduced at time-step 40, then held static, produced an estimated total female spotted owl population size within the eight DSAs of 675. From field sampling, the total estimated female spotted owls in those DSAs based on the largest number recorded between 1996 and 2006 was 778. The average of the three highest density years from the annual reports (using only data from 1996-2006) for total estimated spotted owl females was 756. The mean of the highest three years (1996-2006) was selected instead of the highest single year in order to reduce the chance that a single year was uncharacteristic of the DSA (Figure C14). Differences in number of female spotted owls on the eight DSAs between those estimated from field sampling and those estimated from our HexSim runs ranged from 5% to 47%, with a mean absolute percentage difference of 26%. Subsequent changes to HexSim did not eliminate these differences.

Figure C-14. Model calibration: Comparison of simulated spotted owl population size (time step 50) to estimates based on field sampling in eight Demographic Study Areas.



Dispersal is a critical process through which landscape structure impacts spotted owl population size and meta-population structure, and is a primary concern in habitat conservation network design (Murphy and Noon 1992). Of particular importance is natal dispersal; the movements of juvenile spotted owls between their natal site and the site where they eventually establish breeding territories. We evaluated the performance of HexSim relative to natal dispersal by comparing graphs of simulated versus observed natal dispersal displacement distances (Figure C15). HexSim generates reports of annual dispersal events by non-territorial (juvenile and floater) spotted owls. The dispersal behavior of the simulated spotted owls was affected principally by landscape structure, the dispersal stopping criteria, and the amount of autocorrelation (both discussed above). Observed natal dispersal distances were estimated from movements of banded spotted owls (Forsman *et al.* 2002).

Figure C-15. Model calibration: Comparison of natal dispersal distances of banded female spotted owls (N= 328) from Forsman *et al.* (2002) to simulated natal dispersal distances for female spotted owls in HexSim (N=850,000).



Because our HexSim spotted owl scenario consists solely of females, we limited the comparison to banded female spotted owls. The distributions of natal dispersal distances for 328 banded female spotted owls were generally similar to 850,000 natal dispersal events recorded during a 250 time-step (years) HexSim simulation. The majority of both observed and simulated dispersal distances were between one and 25 km, however, about 10 % fewer simulated dispersal distances were greater than 10 km and 20% fewer were greater than 25 km.

Uncertainties and Limitations

An important goal of the spatial population modeling effort is to provide a tool to evaluate and compare the suitability of suites of habitat conservation network scenarios. Each scenario represents a unique ensemble of conditions that could affect future spotted owl population size and trends. The overall amounts of spotted owl habitat, the arrangement of habitat conservation networks, and barred owl influences will vary from scenario to scenario.

Several conclusions about each scenario could be drawn from the HexSim spotted owl simulations. Very specific results, such as estimates of absolute population size, will be the most sensitive to parameter uncertainties. Less specific conclusions, such as the relative differences between scenarios, will be increasingly robust. The HexSim simulations provide, at a minimum, a repeatable methodology for qualitatively ranking the efficacy of the habitat conservation scenarios. This analysis might also extend further, to include a quantification of individual reserve or block carrying capacities, and attendant probabilities of extinction. The conclusions that are drawn from a simulation model must balance concern over uncertainties with the desire to preserve a threatened species.

The HexSim spotted owl simulation model resulted from an attempt to construct the simplest model that could do a credible job of ranking habitat conservation network scenarios. HexSim makes adding realism relatively simple. But more life history detail does not automatically translate into more accurate forecasts. Realism comes at a cost since complex models have larger numbers of parameters, and thus greater data requirements.

There are many details that could be added to the existing HexSim simulation model. Examples include environmental stochasticity, the explicit modeling of spotted owl males (including mate-finding and pairing) and barred owl populations, genetics, disturbance regimes such as fire, etc. Some of these "enhancements" might provide more accurate forecasts of future spotted owl population sizes and probabilities of extinction, and decisions whether to incorporate some of them can be made in the future by model users depending on their specific needs. These enhancements, however, are not necessary in order to reliably rank habitat conservation network scenarios based on their likelihood of facilitating recovery of the spotted owl.

The modeling team considered several enhancements that could be added to the current HexSim spotted owl model. Some enhancements that might be made to the HexSim model are listed below.

Environmental Stochasticity

Incorporation of environmental stochasticity into HexSim scenarios will be necessary when estimates of population size or extinction probability need to be made. However, the addition of environmental stochasticity is unlikely to change the order in which habitat conservation network scenarios rank (*i.e.*, from least to most likely to recover the spotted owl). Developing a modeling process to determine the rank-ordering of scenarios was the modeling team's primary goal, and environmental stochasticity was left out of these simulations in order to limit the computational burden associated with that analysis. Environmental stochasticity should be added to the HexSim model before it is used to estimate population sizes or extinction rates. At that time, the more variable model could be used to test a subset of the rank-ordering results obtained without environmental stochasticity. Recent research into the effects of variability in climate on spotted owl demographic rates (Glenn *et al.* 2010) suggested adding realistic variation in annual temperature and precipitation would provide an important element of environmental stochasticity into HexSim simulations.

Effect of relative habitat suitability on reproductive rates

The HexSim spotted owl model links habitat to survival rates through resource acquisition. Individual spotted owls acquire resources from their simulated home ranges, and home ranges with higher RHS values provide greater resources. But home ranges overlap, and competition between spotted owls will lower resource availability. Resource acquisition, because it links landscape structure and intra-specific competition, is a more realistic driver of survival rates than habitat would be on its own. Resource acquisition could easily influence reproduction in exactly the same way that it influences survival. Unfortunately, the most recent meta-analysis (Forsman *et al.* 2011) was inconclusive regarding the role that habitat played in determining reproductive rates. For this reason, the modeling team elected to not vary spotted owl reproductive rates as a function of resource acquisition.

Effect of barred owls on reproductive rates

The HexSim spotted owl model includes the machinery necessary for barred owl influences to include a lowering of spotted owl reproductive rates. This is done by setting a probability that a spotted owl in the presence of a barred owl will nest. Each year, every affected territorial spotted owl will make an independent nesting decision, based on this probability. However, in the current model, the probability that a spotted owl in the presence of a barred owl will forgo nesting entirely is set to zero.

Modeling team members determined that range-wide empirical estimates were not sufficient to assign region-by-region probabilities for barred owl impacts on spotted owl reproduction. Such impacts could come in several forms. For example, the presence of a barred owl could cause a spotted owl to abandon its territory, to keep the territory but forgo nesting (or calling for a mate), or a barred owl could lower effective spotted owl reproductive rates by interfering with nest-tending or preying on spotted owl offspring.

In order to simulate territory abandonment, it would be necessary to explicitly model barred owl locations across the landscape. But sufficient data on barred owl locations and habitat associations were not available range-wide to permit doing more than setting region-by-region probabilities of barred owl occurrence. Simulating barred owl predation on spotted owl offspring runs the risk of double-counting this impact, since barred owl presence does lower survival rates in the HexSim spotted owl model. As described above, the model is able to simulate a lowering of spotted owl nesting rates (when in the presence of a barred owl). But sufficient data was not available range-wide to do more than speculate on the associated parameter values.

Interaction between habitat and barred owl effect

By incorporating the barred owl into the spotted owl scenario as a dynamic spatially explicit stressor, the influence of habitat on barred owl presence and barred owls effects to spotted owl occupancy (extinction rates), recruitment and survival could be more realistically simulated. While there is new information suggesting that habitat and barred owl effects may interact, the data necessary to develop reliable models of barred owl habitat suitability (and subsequently, distribution) are not available. For this reason, the modeling team elected not to attempt this. Moreover, outcomes of modeling region-specific simulations suggest that the current barred owl parameterization is realistic; low to intermediate barred owl encounter probabilities act to depress spotted owl populations but do not result in extinction.

Sensitivity analyses

When the HexSim spotted owl model is used to make estimates of population size, or probabilities of extinction, it will be necessary to also conduct a sensitivity analysis. The modeling team has conducted some work on a traditional sensitivity analysis. Whereas a traditional sensitivity analysis is focused on making small changes to individual parameter values, it would be instructive to complement this work with an assessment of the consequences of varying elements of the model structure itself. Examples of model design elements that might be varied include the lack of direct effects of resource acquisition on reproductive rates, the number of resource acquisition levels being simulated, and some of the behavioral features associated with dispersal and prospecting.

The most important parameters in any model of the spotted owl are going to be the survival and reproductive rates. The rates used in the HexSim survival and reproduction events have been derived from the most recent compendium of spotted owl field data (Forsman *et al.* 2011). Still, some uncertainty is introduced when these survival data are used to assign rates to spotted owls in three different resource acquisition classes, as that process involves extrapolation. We therefore elected not to use a larger number of resource acquisition classes. Likewise, the impact of barred owls on spotted owl reproduction is not perfectly understood, and certainly varies from region to region (as we represent in the HexSim scenarios).

One element of realism that the modeling team deemed necessary for this analysis was ensuring that the simulated spotted owls' home ranges and resource requirements varied by modeling region. The variation in home range size is supported by much published information (see review in Schilling 2009). The variation in resource requirements was used to account for regional differences in resource availability that were not captured in the MaxEnt resource map. In areas where the resource availability was known to be lower, spotted owls were assigned a higher resource requirement. The resource requirements were used as a fitting parameter that made it possible to adjust regional population sizes independently.

The HexSim spotted owl model described here is simple, but not overly so. It is likely the most realistic spatially-explicit individual-based spotted owl simulation that has been developed to-date. Its design and complexity mirror what is being asked of it. Additional complexity may be added at a future time as needed to meet the goals that accompany other planning exercises.

Testing Modeling Process Applications – Using the HexSim Spotted Owl Scenario model to compare the demographic effectiveness of various habitat conservation network scenarios and other recovery strategies:

For the Revised Recovery Plan, the modeling team's objective was to develop and test a modeling framework (Steps 1-3) that would support a wide variety of recovery actions, including evaluation of habitat conservation network scenarios. To facilitate the implementation of recovery actions contained in the Revised Recovery Plan, the modeling team established a process for developing scenarios and conducted preliminary population simulations to compare a sample of habitat conservation network scenarios in order to test the modeling framework's reliability. The results from these preliminary comparisons were necessary in order to obtain feedback on the overall framework and provided the basis for revisions to the HexSim model. This objective was completed as part of the recovery planning process. The following evaluation consists of the actual comparison of simulated spotted owl population responses among many alternative scenarios representing various recovery strategies and habitat conservation networks.

Development of Scenarios for Evaluation and Comparison in HexSim

An important use of the modeling framework is to simulate spotted owl population performance relative to three primary sources of variation: size (area) and distribution of habitat conservation networks; trends in habitat conditions inside and outside of the habitat conservation networks; and trends in the influence of barred owls. Considering the many possible variations in network designs, land ownership limitations, future habitat trends, and barred owl effects that could be evaluated, it is clear the number of scenarios needed to evaluate all of the possibilities could increase rapidly and become unfeasible. Instead, the modeling team developed an iterative process for evaluation of scenarios; establishing broad sideboards in earlier comparisons, then testing the models' sensitivity to habitat conditions and barred owl effects. The HexSim spotted owl model can also be used to evaluate the response of spotted owl populations to future climate scenarios.

To test the modeling framework's ability to evaluate the influence of habitat conservation network size (area) and spatial distribution on spotted owl population performance, we analyzed a subset of 10 habitat conservation network scenarios from Step 2 representing a wide range of sizes (proportions of "habitat value"), as well as existing habitat conservation networks (Table C28).

Table C-28. Initial set of habitat conservation networks evaluated in population modeling Rounds 1-3.

Network **scenario**	**Code**
Northwest Forest Plan Reserve Network	**NWFP**
Managed Owl Conservation Areas	**MOCA**
1992 Critical Habitat	**1992CH**
2008 Critical Habitat	**2008CH**
30% Zonation (All Lands Available)	**Z30all**
50% Zonation (All Lands Available)	**Z50all**
70% Zonation (All Lands Available)	**Z70all**
30% Zonation (Public Lands Only)	**Z30pub**
50% Zonation (Public Lands Only)	**Z50pub**
70% Zonation (Public Lands Only)	**Z70pub**

Maps depicting each of the network scenarios listed above are available at: http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner.

The habitat conservation networks listed in Table C28 form the basis for a series of comparisons in the population modeling environment (called Rounds) wherein different environmental conditions such as barred owl effects and habitat conditions are manipulated both spatially and temporally (scenarios). Each habitat conservation network that is subjected to different conditions is termed a habitat conservation network scenario. Rounds simply articulate the specific modifications that are made. The following paragraphs provide descriptions of the scenarios developed by the modeling team, and the results of HexSim runs for the scenarios in Rounds 1-3.

Interpreting HexSim results:

Each HexSim simulation run provides estimates of population size at any chosen time period as well as population trend over any range of time steps. Estimates are reported at both range-wide and regional scales. It is important to recognize that the results are intended to allow comparison of *relative population performance* among alternative habitat conservation network scenarios, not predictions of actual population size or trend in the future.

When a HexSim simulation starts, the number of individuals, age class distribution, spatial arrangement of territories, and other population attributes will have values that reflect the model's initial conditions. It takes many years for these artifacts to subside, and thus for the population's stable-state dynamics to become evident. Simulations were started with 10,000 female spotted owls, thus this initial period of transitory dynamics involved a period of rapid (apparent) population decline for the first 25 or 30 time-steps; typically subsiding by approximately time step 50. It is important not to confuse this decline with an observed or predicted loss in spotted owl numbers that has resulted from changing environmental conditions. We could have chosen to begin simulations with many fewer spotted owls than are known to currently exist in the landscape (say 250), and waited many time-steps for them to increase and reach some sort of equilibrium with their simulated landscape. That would have resulted in a rapid (apparent) population *increase*, but again would simply be the transitory dynamics involved with the starting population conditions. The point is that the first 25-30 time steps are not meant to be interpreted, but can be thought of as a "burn-in" period for the simulation whereby the simulated spotted owls equilibrate with the simulated environment.

Round 1: Baseline (2006) conditions

This was the simple "Baseline" scenario that was used to evaluate parameterization of the HexSim spotted owl scenario. This scenario assumes no change in habitat through time (2006 RHS map); therefore the 10 habitat conservation networks listed above are not compared (because nothing different happens inside and outside of habitat blocks in this scenario). Also, barred owl effects remain constant over time (either at zero or constant at their currently-estimated impacts, beginning at time step 40).

Figures C16 through C18 highlight differences in the relative influence of barred owls among modeling regions. Rangewide, barred owls act to depress spotted owl populations to roughly 50 percent of potential population size without barred owls (Figure C16). However, spotted owl populations in modeling regions with high barred owl encounter rates such as the Oregon Coast Ranges (P_{BO} = 0.710; figure C17) decline rapidly in comparison to modeling regions with low to intermediate barred owl encounter rates such as the Western Klamath (P_{BO} = 0.315; figure C18).

Figure C-16. Results of HexSim Round 1 model runs with five replicates each for "Without STVA" (barred owl) impacts and "With STVA" impacts for the spotted owl's entire geographic range in the U.S. The apparent within-year variation that appears in the figure is a function of an "even-odd" year effect on reproduction that was included in this version of the HexSim model.

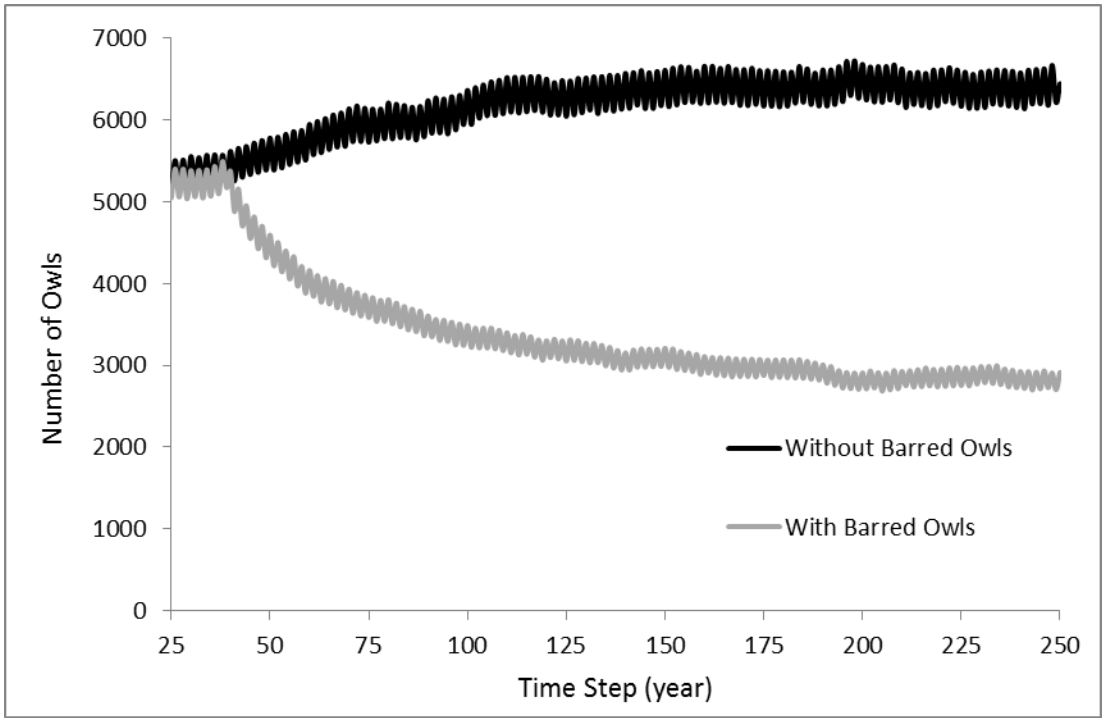


Figure C-17. Simulated Round 1 spotted owl population sizes in the Oregon Coast Ranges modeling region showing 1) current barred owl influence and 2) barred owl influence removed.

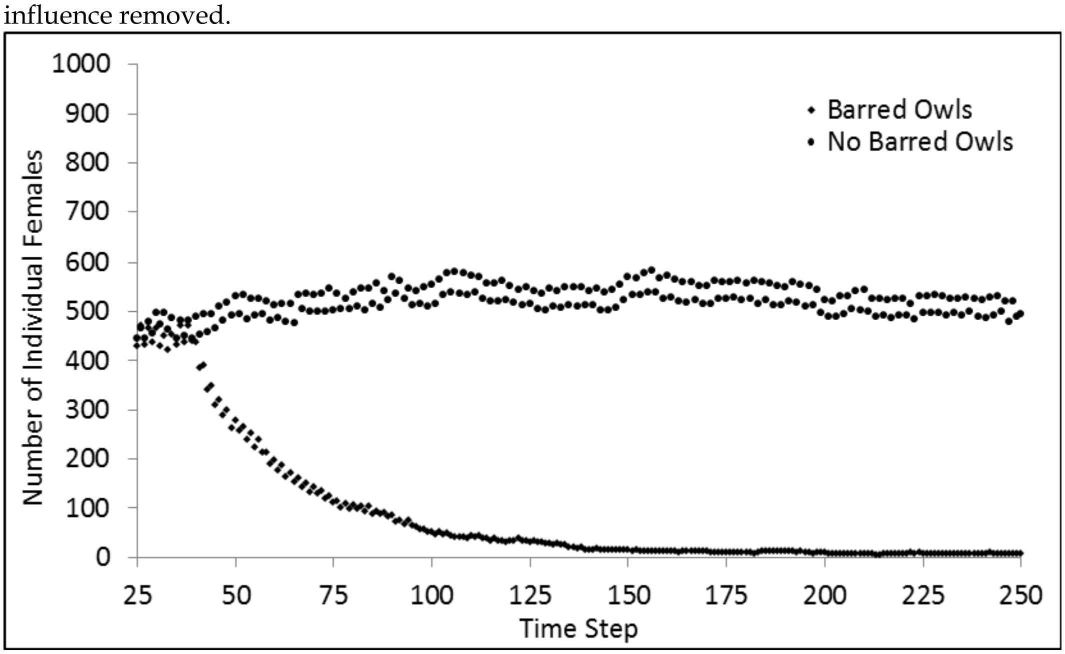
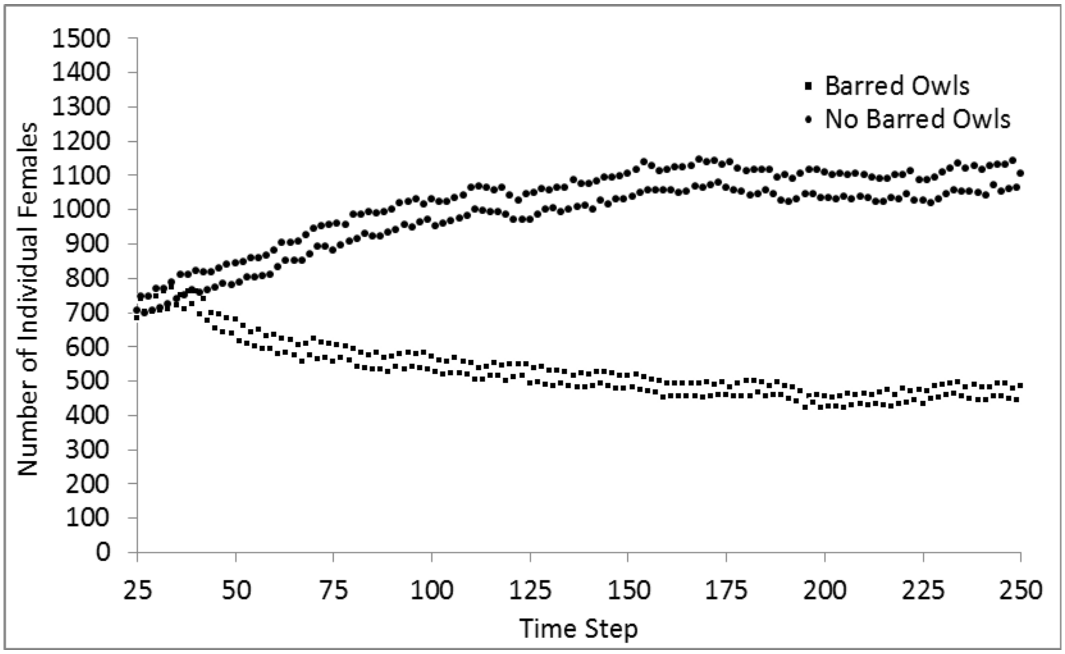


Figure C-18. Simulated Round 1 spotted owl population sizes in the Western Klamath modeling region showing 1) current barred owl influence, and 2) barred owl influence removed.



Round 2: Simulating a high degree of reliance on habitat conservation networks

Because the primary objective in this evaluation is to compare estimated spotted owl population performance across a range of habitat conservation network, the goal of Round 2 was to "isolate" the habitat conservation networks by devaluing non-network habitat suitability and holding habitat in networks at its 2006 estimated level throughout the simulation. In this scenario, we reduced relative habitat suitability (RHS) *outside* of habitat conservation networks to 34 (RHS=0.34); *just below* that needed for territory establishment; RHS within networks remained unchanged. The influence of barred owls was held to the currently-estimated encounter rates calculated from Forsman *et al.* (2011); the barred owl influence was slotted in at year 40. We repeated Round 2 with *No barred owl effect*, to evaluate the relative contribution of habitat and barred owl effects on simulated spotted owl population performance. The results of the Round 2 simulations allow for an evaluation of the relative influence of habitat conservation network size and distribution (relying primarily on public versus both public and private lands) and barred owls on spotted owl population performance – when the habitat conservation network provides nearly all nesting and roosting habitat.

Round 3: Simulating RA10 - retention of high-value habitat outside of habitat blocks

The goal of Round 3 was to evaluate the relative contribution of habitat conditions ***outside*** of habitat conservation networks to spotted owl populations; Scenarios R3S1 through R3S10 are intended to emulate the management approach of maintaining occupied spotted owl territories outside of network areas . RHS within habitat conservation networks was held constant, and areas of high RHS (>50) *outside* of networks (on public lands) were retained through time. Areas of RHS between 35 and 49 (outside of networks) were decremented to RHS 34. Scenarios R3S11 through R3S20 were similar but apply to *all* non-network lands (public and private). We repeated Round 3 with *No barred owl effect*, to evaluate the relative contribution of habitat and barred owl effects on simulated spotted owl population performance.

Figures C19 and C20 provide examples of different metrics that can be used to compare estimated spotted owl population outcomes among habitat conservation network scenarios, in this case Rounds 2 and 3 described above. Initial results using a wide range of population metrics can provide insights for meeting the recovery criteria established in the Revised Recovery Plan. Comparison of these estimates of spotted owl population performance across the range of scenarios can inform evaluation of habitat conservation networks designed to lead to spotted owl recovery.

Figure C19 provides results for the entire range of the spotted owl, but as described in Round 1 and evidenced in Figure C20, it is important to recognize that population outcomes may differ markedly among modeling regions.

Figure C-19. Comparison of percent population change (rangewide) between year 25 and year 250 under the scenarios in Rounds 2 and 3, with and without barred owl influence. MOCAs and critical habitat were not compared for Round 3.

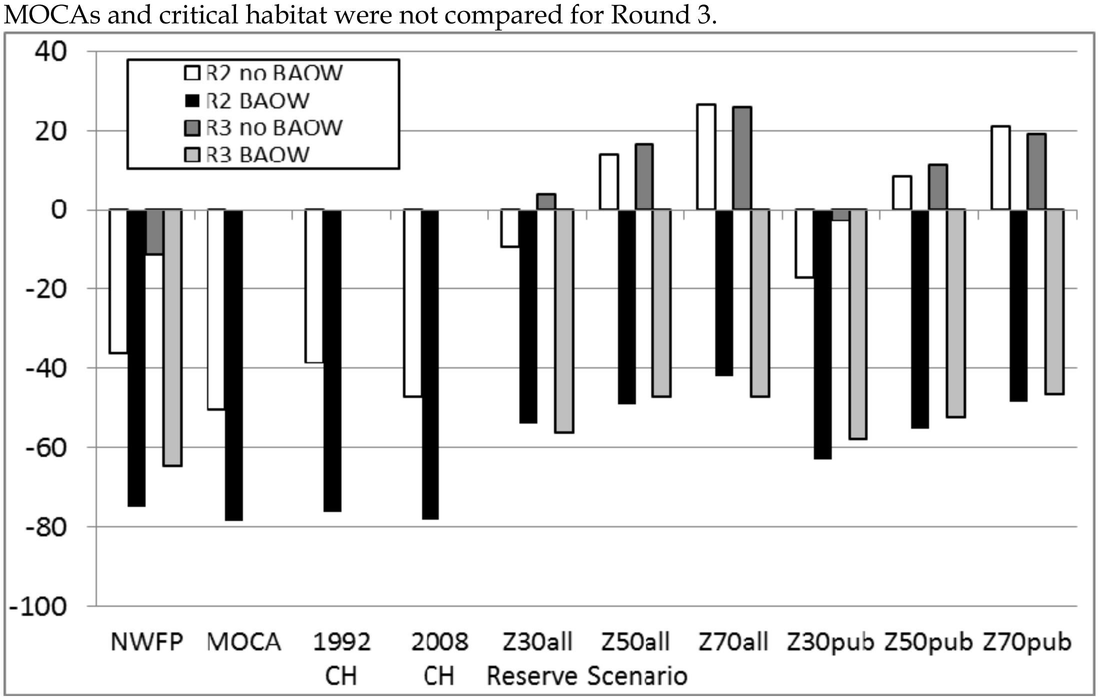
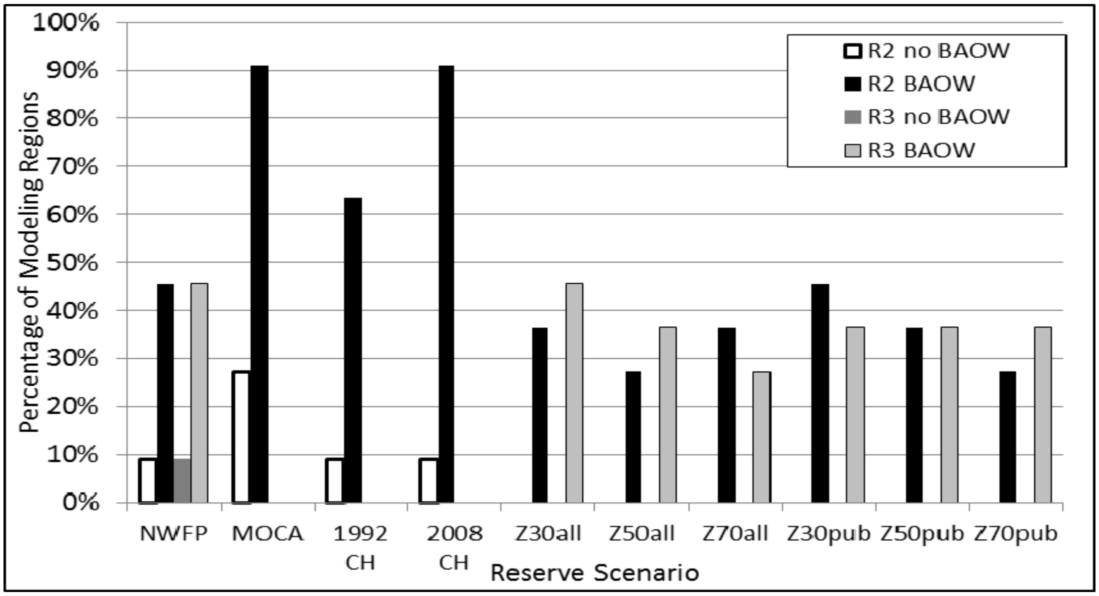


Figure C-20. Percentage of modeling regions whose simulated populations declined by more than 75% between years 25 and 250 (indication of extinction risk) under the scenarios in Rounds 2 and 3, with and without barred owl influence.



The interaction of network size with other conservation measures is highlighted in Figures C19 and C20. In Round 3 (simulated RA10 - retention of likely occupied, high-value habitat with RHS>50 in non-network areas), the amount of habitat "retained" is inversely proportional to the size of area within habitat conservation networks Subsequently, RA 10's benefit to simulated spotted owl populations is relatively less for larger habitat conservation network scenarios such as Z50 and Z70.

Conclusions:

The analysis presented in this appendix is intended to demonstrate how the three-part modeling framework can be used to evaluate spotted owl population response to a variety of environmental conditions such as habitat variation and barred owls. Although this initial analysis is intended to evaluate the modeling framework, it provides insight into factors influencing spotted owl populations and conservation planning for recovery of the spotted owl.

HexSim population simulations can be completed for the entire range of the spotted owl as well as for subsets of the species' range, such as individual modeling regions or DSAs. This capability enables evaluation of varying environmental conditions and subsequent population effects occurring in different parts of the species' range. For example, the relative effect of barred owls on spotted owl survival and subsequent population size varies among modeling regions, in accordance with different barred owl encounter rates (Table C29). Comparison of the relative differences between simulated spotted owl populations without barred owls and those resulting from different barred owl encounter rates among modeling regions (Figures C17 and C18) suggests there may be barred owl population levels (encounter rates) below which spotted owl populations remain stable (albeit at lower population sizes). Further evaluation of these relationships may inform planning of barred owl management scenarios.

Table C-29. Barred owl encounter probabilities estimated from Forsman *et al.* (2011).

Region	Encounter Probability
North Coast Olympics	0.505
East Cascades North	0.296
West Cascades North	0.320
West Cascades Central	0.320
Oregon Coast	0.710
West Cascades South	0.364
Inner CA Coast Range	0.213
East Cascades South	0.180
Klamath East	0.245
Klamath West	0.315
Redwood Coast	0.205

As shown in Figure C1, the modeling framework contains feedback loops that facilitate an iterative process, with each iteration informed by the results of previous scenarios and simulated population outcomes. This process enables an adaptive approach to developing and testing conservation measures. As new information from monitoring or other research becomes available, its influence on spotted owl conservation can be incorporated into subsequent evaluations in a consistent manner.

In sum, our goal was to develop a modeling framework that can be applied by interested parties to make better informed decisions concerning spotted owl management and recovery. The analyses described in this appendix represent a small subset of possible scenarios and are presented to test the framework and to give potential users of this approach some preliminary exposure to the models' potential utility. Future conservation planning for spotted owls will require development and evaluation of additional scenarios that are relevant to the management questions of particular interest to various stakeholders. These future planning efforts will likely address temporal factors such as changing barred owl populations, climate change, and future habitat change. They might also apply to private land managers who are evaluating different options within a Habitat Conservation Planning scenario, or Federal land managers who are considering recommendations for amending long-term forest management plans. Whatever the use to which this framework is applied, our goal was to provide managers with tools that will ultimately result in better informed decisions for spotted owl conservation.

Appendix D. References Cited

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Appendix E. Comments and Responses to Comments on the Draft Revised Recovery Plan

A complete list of the comments on the draft Revised Recovery Plan and the responses to those comments can be found at the following web site:

http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Plan/

Appendix F. Scientific Names for Common Names Used in the Text

Following is a list of scientific names for common names of plants and animals used in the text.

Trees

White fir	*Abies concolor*
Grand fir	*Abies grandis*
Shasta red fir	*Abies magnifica shastensis*
Western larch	*Larix occidentalis*
Tanoak	*Lithocarpus densiflorus*
Pinyon pine	*Pinus edulis*
Ponderosa pine	*Pinus ponderosa*
Sugar pine	*Pinus lambertiana*
Bishop pine	*Pinus muricata*
Lodgepole pine	*Pinus contorta*
Douglas-fir	*Pseudotsuga menziesii*
Coast redwood	*Sequoia sempervirens*
Western redcedar	*Thuja plicata*
Western hemlock	*Tsuga heterophylla*
Mountain hemlock	*Tsuga mertensiana*

Mammals

Tree voles	*Arborimus longicaudus, A. pomo*
Red-backed voles	*Clethrionomys* spp.
Northern flying squirrel	*Glaucomys sabrinus*
Snowshoe hare	*Lepus americanus*
Dusky-footed wood rat	*Neotoma fuscipes*
Bushy-tailed wood rat	*Neotoma cinerea*
Gophers	*Thomomys* spp.

Birds

Northern goshawk	*Accipiter gentilis*
Red-tailed hawk	*Buteo jamaicensis*
Great horned owl	*Bubo virginianus*
Eastern screech-owl	*Otus asio*
Northern spotted owl	*Strix occidentalis caurina*
California spotted owl	*Strix occidentalis occidentalis*
Mexican spotted owl	*Strix occidentalis lucida*
Barred owl	*Strix varia*

Other species

Bark beetle	*Dendroctonus* spp.
Mountain pine beetle	*Dendroctonus ponderosae*

Spruce beetle	*Dendroctonus rufipennis*
Western spruce budworm	*Choristoneura occidentalis*
West Nile virus	*Flavivirus*
Avian influenza	*Orthomyxoviridae*
Swiss needle cast	*Phaeocryptopus gaeumannii*
Sudden oak death	*Phytopthora ramorum*
Avian malaria	*Plasmodium* spp.
Truffles	*Tuber* spp.

Appendix G. Glossary of Terms

Many of these terms have a long history and various meanings in regard to spotted owl biology and management. This glossary defines the context in which they are used in this document.

Activity Center: Spotted owls have been characterized as central-place foragers, where individuals forage over a wide area and subsequently return to a nest or roost location that is often centrally-located within the home range (Rosenberg and McKelvey 1999). Activity centers are location or point within the core use area that represent this central location. Nest sites are typically used to identify activity centers, or in cases where nests have not been identified, breeding season roost sites or areas of concentrated nighttime detections may be used to identify activity centers.

Adaptive Management: Adaptive management is a systematic approach for improving resource management by learning from the results of explicit management policies and practices and applying that learning to future management decisions.

Conserve: To preserve to use, or manage wisely.

Core Use Area: An area of concentrated use within a home range that receives disproportionally high use (Bingham and Noon 1993), and commonly includes nest sites, roost sites, and foraging areas close to the activity center. Core use areas vary geographically, and in relation to habitat conditions. This is a biological definition of core use area and is not the same as a 70-acre core as defined by the Oregon Forest Practices Act nor is it equivalent to the 100-acre LSRs referred to as northern spotted owl cores on Federal lands.

Dispersal Habitat: Juvenile spotted owls often must disperse through a range of forest types prior to finding NRF habitat on which to establish a territory. These forest types include nesting, roosting, and foraging habitat in addition to forest that meets the definition of dispersal habitat. The Interagency Scientific Committee (ISC) defined dispersal habitat as forest stands with average tree diameters ≥11 inches and conifer overstory trees with closed canopies (>40 percent canopy closure in moist forests and >30 in dry forests) and with open space beneath the canopy to allow spotted owls to fly can provide the minimum conditions needed for successful dispersal (Thomas *et al.* 1990:310). We acknowledge that this definition primarily applies to moist forests in Oregon and Washington and may not capture the full range of dispersal habitat conditions in Northern California or drier forests across the range of the spotted owl.

Early-seral Forest: Stage of forest development that includes seedling, sapling, and pole-sized trees.

Foraging Habitat: Foraging habitat is defined as lands that provide foraging opportunities for spotted owls, but without the structure to support nesting and roosting (USFWS 1992b). Spotted owls often forage in forest conditions that meet the definition of nesting/roosting habitat, but also use a broader range of forest types for foraging. This definition identifies habitat that functions as foraging habitat, but does not meet requirements for nesting or roosting.

Habitat-capable Area: Forests below the elevation limits of occupancy by territorial spotted owls that are capable of growing and sustaining structural (Davis and Lint 2005) and ecological conditions of spotted owl habitat.

High-Quality Habitat: Older, multi-layered structurally complex forests that are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees. This is a subset of spotted owl habitat and specific characteristics may vary due to climatic gradients and abiotic factors across the range.

High-Value Habitat: Habitat that is important for maintaining spotted owls on landscapes. Includes areas meeting definition of high-quality habitat, but also areas with current and historic use by spotted owls that may not meet the definition of high-quality habitat.

Historical Site: Sites that contained spotted owls in the past. These may be currently unoccupied or sites where spotted owls were detected in the past, but not surveyed more recently.

Home Range: The area in which a spotted owl conducts its activities during a defined period of time (USFWS 1992b) that provides important habitat elements for nesting, roosting, and foraging. Home range sizes vary generally increase from south to north and vary in relation to habitat conditions and prey availability and composition.

Known Spotted Owl Site: An occupied spotted owl site or a spotted owl site where spotted owls were documented to be present in the past.

Late-seral Forest: Stage in forest development that includes mature and old-growth forest (USDA *et al.* 1993). The appearance and structure of these forests will vary across the range of the spotted owl, particularly in the dry forest provinces.

Long-term: For the purposes of planning and managing the spotted owl and its forest habitat, a time frame estimated to be greater than 30 years at a minimum and usually referring to time periods ranging from 50 years to several centuries. Use of this term can be context dependent and relative, for example, when referring to gradual demographic changes in a spotted owl population or the development of late-successional habitat conditions.

Manage: To make and act upon decisions about which actions to take, if any, regarding a particular issue, area of land, etc. This may include a decision to take no action.

Mature Forest: Forests where the annual net rate of growth has peaked. Stand age, diameter of dominant trees, and stand structure at maturity vary by forest types and local site conditions. Mature stands generally contain trees with a smaller average diameter, less age-class variation and less structural complexity than old growth stands of the same forest type (USDA *et al.* 1993). The appearance and structure of these forests will vary across the range of the spotted owl, particularly in the dry forest provinces. Mature stages of some forests provide NRF habitat for spotted owls. However, mature forests are not always spotted owl habitat, and spotted owl habitat is not always mature forest.

Mid-seral Forest: Intermediate stages of tree growth between early-seral and late-seral. The appearance and structure of these forests will vary across the range of the spotted owl, particularly in the dry forest provinces.

Nesting and Roosting Habitat: Habitat that provides nesting and roosting opportunities for spotted owls. Important stand elements may include high canopy closure, a multi-layered, multi-species canopy with larger overstory trees and a presence of broken-topped trees or other nesting platforms (*e.g.,* mistletoe clumps (USFWS 1992b). The appearance and structure of these forests will vary across the range of the spotted owl, particularly in the dry forest provinces.

Occupied Site: Any location where territorial spotted owls are known to be present.

Old-growth Forest: Old-growth forests are forests that have accumulated specific characteristics related to tree size, canopy structure, snags and woody debris and plant associations. Ecological characteristics of old-growth forests emerge through the processes of succession. Certain features - presence of large, old trees, multilayered canopies, forest gaps, snags, woody debris, and a particular set of species that occur primarily in old-growth forests - do not appear simultaneously, nor at a fixed time in stand development. Old-growth forests support assemblages of plants and animals, environmental conditions, and ecological processes that are not found in younger forests (younger than 150-250 years) or in small patches of large, old trees. Specific attributes of old-growth forests develop through forest succession until the collective properties of an older forest are evident.

Protect: Guard or shield from loss.

Provincial: This is a qualifying term used with home range and core use area to reflect the fact that both vary in size according to latitude, amount of available habitat, prey availability, and forest structure and composition. Typically, home range and core use area sizes increase from south to north, and decrease as amount of high-quality habitat available to spotted owls increases.

Restoration: The recovery of vegetative structure, species composition, and self-regulating ecological processes at multiple spatial and temporal scales with the intent to provide for long-term ecological sustainability and ecological integrity.

Resilience: Resilience refers to the capacity of an ecosystem to not only accommodate gradual changes but to return toward a prior condition after disturbances including fire, extreme weather events, and climate change.

Retain: To keep.

Short-term: For the purposes of planning and managing the spotted owl and its forest habitat, a time frame estimated to be less than a few decades and usually between one to ten years. Use of this term can be context dependent and relative, for example, when referring to immediate changes in a forest stand due to a wildfire or vegetation treatment, or the behavioral response of individual spotted owls to habitat alteration or the removal of barred owls from a spotted owl territory.

Snag: Any standing dead or partially dead tree. A hard snag is composed primarily of sound (merchantable) wood while a soft snag is composed of wood in advanced stages of decay and deterioration, and is not generally merchantable.

Spotted Owl Site: Any location where territorial spotted owls are known to be present, were historically present, or may be present in unsurveyed habitat. Spotted owl sites can be identified through surveys where spotted owls were detected (USFWS 2010). In cases where survey data are unavailable, spotted owl sites can be identified by 1) conducting surveys, or 2) using a modeling approach that uses habitat and landscape characteristics to identify areas with a high probability of being occupied by spotted owls.

Uncharacteristic Wildfire – Fires that threaten the loss of key ecological attributes and functions, due primarily to the diminishment of natural landscape resilience mechanisms.

Unoccupied Site: Site where spotted owls were detected in the past, but more recent surveys have not detected owls. Surveys are required to establish unoccupied status, and criteria for determining unoccupied status are presented in the 2010 (2011) Northern Spotted Owl Survey Protocol (USFWS 2011).

Viable Population - a self-sustaining population with a high probability of survival despite the foreseeable effects of demographic, environmental and genetic stochasticity and of natural catastrophes.

Appendix H. Contributors To The 2008 Recovery Plan

A Recovery Plan for the Northern Spotted Owl (2008 Recovery Plan) was prepared with the assistance of a Recovery Team representing Federal agencies, State governments, and other affected and interested parties, as well as the assistance of a contractor (Sustainable Ecosystems Institute or SEI) and published May 14, 2008. The Recovery Team members served as independent advisors to the Service for the development of the 2007 Draft Recovery Plan. The 2008 Recovery Plan did not necessarily represent the view or official position of any individual or organization—other than that of the Service—involved in its development. Additional valuable support was provided by three work groups of Federal and State agency scientists and academic researchers.

The Service gratefully acknowledges the effort and commitment of the many individuals involved in the conservation and recovery of the northern spotted owl who participated in the preparation of the 2008 Recovery Plan. Without their individual expertise and support, this Revised Recovery Plan would not have been possible as it is the culmination of many years of labor.

The Service began preparing a recovery plan for the spotted owl in April 2006. To advise the Service, a Recovery Team was initially appointed which was supported by an Interagency Support Team (IST) and led by a Recovery Plan Project Manager. During the development of the 2007 Draft Recovery Plan, the Recovery Team convened several panels of experts to advise them and provide information on scientific and land management issues (noted as Scientist and Implementer Panelists below). The Service is indebted to all of the individuals for the guidance provided during the preparation of the 2007 Draft Plan. Their names, affiliations, and roles are listed below.

Recovery Team Members for 2007 Draft Recovery Plan

Tim Cullinan, National Audubon Society, Washington State Office
Dominick DellaSala, National Center for Conservation Science and Policy
Lowell Diller, Green Diamond Resource Company
Scott Gremel, National Park Service
Mike Haske, Bureau of Land Management
Cal Joyner, U.S. Forest Service
John Mankowski, Washington Office of the Governor/Lenny Young, Washington Department of Natural Resources
Ed Murphy, Sierra Pacific Industries
Jim Paul, Oregon Department of Forestry (April 2006 to November 2006)/ Mike Cafferata, Oregon Department of Forestry (November 2006 to November 2007)
John Siperek, California Department of Fish and Game
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Interagency Support Team Leader and Recovery Plan Project Manager for 2007 Draft Plan and 2008 Final Plan

Paul Phifer, U.S. Fish and Wildlife Service

Interagency Support Team Members for 2007 Draft Plan and 2008 Recovery Plan

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Kent Livezey, U.S. Fish and Wildlife Service
Elaine Rybak, U.S. Forest Service
Brendan White, U.S. Fish and Wildlife Service

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Contributors for 2007 Draft Plan and 2008 Recovery Plan

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Karl Halupka, U.S. Fish and Wildlife Service
Jim Hines, U.S. Geological Survey
Matt How, U.S. Fish and Wildlife Service
Jim Nichols, U.S. Geological Survey

The 2007 Draft Recovery Plan generated more than 75,800 public comments. To evaluate scientific and management issues highlighted during the comment period, the Service contracted with an independent consultant (SEI) to provide assistance. In addition, the Service appointed three scientific work groups to evaluate comments and provide guidance on the best science concerning the three major areas of concern raised during the comment period: spotted owl habitat, fire, and barred owls. Based on this input, and comments from the public, the Service finalized the 2008 Recovery Plan. We thank all of these individuals; they are listed below.

Contractor (Sustainable Ecosystems Institute) for 2008 Final Plan

Steven Courtney
Kate Engel
Katie Fehring
Lisa Sztukowski

Panel Members for Contractor for 2008 Final Plan

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Andy Carey, Pacific Northwest Research Station (retired)
Martin Cody, University of California, Los Angeles
Keith Crandall, Bringham Young University
Jerry Franklin, University of Washington
Mark Fuller, U.S. Geological Survey
Rocky Gutiérrez, University of Minnesota
Miles Hemstrom, Pacific Northwest Research Station
Paul Hessburg, Pacific Northwest Research Station
John Lehmkuhl, Pacific Northwest Research Station
Jim Nichols, Patuxent Wildlife Research Center
Ken Pollock, North Carolina State University
Scott Stephens, University of California, Berkeley
Robert Zink, University of Minnesota

Liaison between Work Groups and the Service for 2008 Final Plan

Lenny Young, Washington Department of Natural Resources

Habitat Work Group Members for 2008 Final Plan

Robert Anthony, U.S. Geological Survey
Joe Buchanan, Washington Department of Fish and Wildlife
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Jeff Dunk, Humboldt State University
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Fire Work Group Members for 2008 Final Plan

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Tom Spies, Pacific Northwest Research Station
Tom Sensenig, Pacific Northwest Research Station
Carl Skinner, Pacific Southwest Research Station

Barred Owl Work Group Members for 2008 Final Plan

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June 2011

From: Rob DiPerna <rob@wildcalifornia.org>
Sent: Thursday, May 01, 2014 2:48 PM
To: Wildlife Management
Subject: Attn: Neil Clipperton--Northern Spotted Owl supporting documentation
Attachments: USFWS 2012 (BOs and COs re FGS MSHCP).pdf

Please see attached.

Thank you.

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
Yreka Fish & Wildlife Office
1829 South Oregon Street, Yreka, California 96097
(530) 842-5763, FAX (530) 842-4517

In Reply Refer To: 81333-2011-F-0018

Memorandum

To: Assistant Regional Director, Ecological Services
Sacramento, California
Attention: Michael Fris

From: Project Leader, Yreka Fish and Wildlife Office
Yreka, California

Subject: Biological and Conference Opinions for the Issuance of a Section 10(a)(1)(B) Incidental Take Permit to the Fruit Growers Supply Company for its Multi-Species Habitat Conservation Plan (FWS Reference: 81333-2011-F-0018)

This document constitutes the U.S. Fish and Wildlife Service's (Service) biological and conference opinions (BO) regarding the proposed issuance of an incidental take permit (ITP) to Fruit Growers Supply Company (FGS) for the implementation of its Habitat Conservation Plan (HCP) on 152,178 acres of commercial timberland in Siskiyou County, California, and its effects on the federally threatened northern spotted owl (*Strix occidentalis caurina*) and federal candidate West Coast Distinct Population Segment (DPS) of fisher (*Martes pennanti*), hereafter "fisher." Issuance of an incidental take permit is pursuant to section 10(a)(1)(B) and section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.; ESA).

Fruit Growers Supply Company is requesting 50-year coverage of incidental take for the northern spotted owl that may arise from timber management operations on its ownership. The proposed FGS HCP will not involve activities that would adversely affect the primary constituent elements of critical habitat for the northern spotted owl because the activities would not take place within critical habitat or directly or indirectly affect the primary constituent elements. This BO will address affects to northern spotted owls occupying critical habitat resulting from activities conducted by FGS on its own lands. Fruit Growers Supply Company did not request coverage for the fisher; however, since this species is a federal candidate and it is the Service's policy to treat candidate species as if they were proposed species, the Service conducted a conference opinion pursuant to section 7(a)(4) of the ESA.

Although take of plant species is not prohibited under the ESA, and therefore cannot be authorized under an ITP, the endangered Yreka phlox (*Phlox hirsuta*) would also be included on the permit in recognition of the conservation benefits provided to the species under the FGS HCP. The Service finds that the proposed action is not likely to adversely affect Yreka phlox because although suitable habitat for this species exists on FGS's ownership, currently there are no known populations on their property. Additionally, Yreka phlox will benefit from the conservation measures described in section 5.3.2 of the HCP, which include survey and monitoring efforts on FGS property, and equipment exclusion zones to avoid direct adverse impacts to the plants. Therefore, Yreka phlox will not be addressed further in this BO.

Fruit Growers Supply Company is also requesting an ITP from the National Marine Fisheries Service (NMFS) for take authorization of one federally listed species, the Southern Oregon/Northern California Coast coho salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit (ESU), and two non-listed species, the Klamath Mountains Province steelhead (*Oncorhynchus mykiss*) ESU and the Upper Klamath and Trinity Rivers Chinook salmon (*Oncorhynchus tshawytscha*) ESU should they become listed within the term of the ITP. Assurances provided under the "No Surprises" rule at 50 C.F.R. 17.3, 17.22(b)(5) and 17.32(b)(5) would extend to all Covered Species. The HCP is a requirement of FGS's application to the Service and NMFS for ITPs pursuant to the Federal ESA, as amended.

These Opinions are based primarily on information provided in the Environmental Impact Statement (EIS; USDI FWS and USDC NMFS 2009), and Implementing Agreement (IA) and HCP (FGS 2009), which are incorporated by reference, and the sources cited herein. A complete administrative record of this consultation is on file at the Service's Yreka Fish and Wildlife Office.

Attachments

Endangered Species Act – Section 7 Formal Consultation

Biological and Conference Opinions

Fruit Growers Supply Company
Multi-Species Habitat Conservation Plan

(Service Reference Number: 81333-2011-F-0018)

Agency:

U.S. Fish and Wildlife Service
Region 8
Sacramento, CA

Draft Biological Opinion Written by:

U.S. Fish and Wildlife Service
Red Bluff Fish and Wildlife Office
Red Bluff, CA

Conference Opinion Written and Biological Opinion Finalized by:

U.S. Fish and Wildlife Service
Yreka Fish and Wildlife Office
Yreka, CA

April 20, 2012

Erin Williams

Erin Williams, Project Leader
Yreka Fish and Wildlife Service

CONTENTS

Consultation History

In late 2007, the Red Bluff Fish and Wildlife Office (RBFWO) was asked to conduct Intra-Service consultation with the Yreka Fish and Wildlife Office (YFWO) on the FGS HCP in regards to the northern spotted owl once that document and supporting documents (e.g., EIS, IA) were prepared. In February 2008, draft documents were sent to the RBFWO for initial review. On March 11, 2008, Keith Paul of the RBFWO attended a public scoping meeting on the FGS HCP and EIS in Yreka, CA. Over the next year and a half, draft chapters of the HCP, EIS, and IA were sent to the RBFWO for review and comment. Minor comments were made on the draft documents and sent to YFWO and FGS for inclusion into the final draft. A Notice of Availability (NOA) of the HCP and Draft EIS was published in the Federal Register on November 13, 2009. On December 2, 2009, Keith attended a second public meeting in Yreka, CA shortly after the release of the NOA to allow the public to comment on the proposed HCP and Draft EIS. On May 5, 2011, due to staffing changes at the RBFWO, the BO was sent to YFWO for finalization. The conference opinion for fisher was developed by YFWO and incorporated into the BO.

BIOLOGICAL OPINION

1. DESCRIPTION OF THE PROPOSED ACTION

1.1 Introduction

The Service proposes to issue a 50-year ITP under the authority of section 10(a)(1)(B) of the ESA to FGS to cover the incidental take of the northern spotted owl that may result through implementation of the FGS HCP. Although take of plant species is not prohibited under the ESA and therefore cannot be authorized under an ITP, the Yreka phlox would also be a Covered Species in recognition of the conservation benefits provided to the species under the FGS HCP. Separately, FGS is also requesting an ITP from NMFS for coverage of three evolutionarily significant units of anadromous salmonids.

Fruit Growers Supply Company has been managing a portion of its ownership, the Hilt/Siskiyou forest, since the early 1900s. The Hilt/Siskiyou forest lies within the geographic range of the northern spotted owl. The Service regards the harvest of suitable habitat in areas occupied by northern spotted owls as having the potential for take in violation of the ESA. California Board of Forestry (CBF) regulations restrict timber harvest operations in suitable habitat within occupied owl territories in order to prevent the take of northern spotted owls. Surveys[1] of FGS lands and adjoining Federal and private lands have shown that many northern spotted owl activity centers[2] are located on or have a home range[3] that extends onto the FGS ownership.

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[1] The California Department of Fish and Game (CDFG) Northern Spotted Owl Database contains the most comprehensive compilation of northern spotted owl detections in California, including results of protocol-level surveys of FGS lands and adjacent private and public lands. The database contains records beginning in 1987. For the HCP, owl records are used through 2007.

[2] For the purposes of the HCP, "activity center" is defined as the area of concentrated activity of either a pair of owls or a territorial single (USDI FWS 1992b).

[3] "Home range" is defined as the area to which an animal usually confines its daily activities. The home range of

Consequently, FGS's forest management activities in much of the Hilt/Siskiyou forest are restricted by CBF regulations. FGS indicates that the restrictions, in conjunction with the large number of owl territories that are located on or overlap FGS lands, have substantially reduced FGS's management and operational flexibility since the owl was listed in 1990 and resulted in FGS operating more intensively in other portions of its ownership in order to generate the timber volume necessary to remain economically viable.

Since November 2003, the Service has provided technical assistance to FGS in the development of an HCP covering company lands. In requesting the Service's approval of the HCP, FGS seeks to gain the management and operational flexibility necessary to administer its forest resources in a manner that will ensure the long-term sustainable production of timber (see section 2.1.4.5).

1.2 HCP Area Definitions

The HCP covers FGS's Hilt/Siskiyou ownership located in Siskiyou County, northern California. The ownership consists of three management units defined by FGS: Klamath River, Scott Valley and Grass Lake, covering 65,340, 39,153, and 47,685 acres, respectively, for a total of 152,178 acres. FGS's Klamath River and Scott Valley management units are located west of Interstate 5, adjacent to and intermixed with Klamath National Forest (KNF) lands. FGS's Grass Lake management unit (also adjacent to the KNF) lies east of Interstate 5 and predominantly north of State Highway 97.

It is recognized that FGS may buy, sell, or exchange timberlands in the general area covered by the HCP during the 50-year term of the ITP. To reflect this aspect of FGS's business practices, the HCP is designed to allow some flexibility in the application of the HCP and ITP since the ownership may adjust over time. The HCP and this BO use a number of defined terms to describe the area in which FGS's activities will be covered under the HCP, the area in which impacts of FGS's activities are analyzed, and the extent to which adjustments may occur to the area in which the HCP will be implemented. Those terms and their definitions are set forth as follows:

- "Plan Area" means all privately owned commercial timberlands that, over the term of the HCP, are either included within the Initial Plan Area (defined below) or are eligible for coverage by the HCP as provided in the IA (see "Adjustment Area" below). This represents the entire acreage analyzed in the HCP and the EIS prepared pursuant to the National Environmental Policy Act (NEPA) to support the HCP's provisions, allowing for additions and deletions of lands from the Plan Area over the term of the HCP and ITP. Lands within the Adjustment Area may be added to the HCP over the term of the ITP without amendment, given the proper analysis and approval by the Service and NMFS, and subject to the limitation that no more than 15,218 acres (an area equal to 10 percent of the Initial Plan Area) can be added over the term of the Permit.

- "Initial Plan Area" means FGS's land ownership as of the effective date of the ITP (152,178 acres in three management units as described above).

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northern spotted owls in the California Klamath and Cascades provinces is considered to be approximately 3,400 acres, the equivalent of a circle with a 1.3 mile radius (the provincial radius) (USDI FWS 1992b).

- “Adjustment Area” means commercial timberlands that were not within the Initial Plan Area, but are eligible for addition to the Plan Area through acquisition, subject to the terms and conditions imposed by the IA.

- “Action Area” is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate areas involved in the action (50 CFR 402.02). Action Area in regards to northern spotted owl means all acreage within a 1.3-mile radius around the FGS ownership. This 1.3-mile radius around the FGS ownership has been termed Action Area for the purposes of characterizing environmental baseline conditions and describing the direct and indirect effects of the Covered Activities on the northern spotted owl. The 1.3-mile distance criterion is based on the average home range size of the northern spotted owl within the California Klamath and California Cascades Provinces. The Action Area for fishers consists of FGS ownership with a surrounding 1.6-mile buffer that was based on the radius of an estimated circular home range (i.e., 7.7 $mile^2$) for female fishers in the Klamath Province (see Appendix E of the FGS HCP). The Action Area includes the portion of the fisher population that could be directly or indirectly affected by the HCP.

1.3 Plan Area Adjustments over Time

During the term of the HCP and ITP, FGS may elect to add commercial timberlands to the Plan Area within any of the identified drainages by submitting to the Service and NMFS a description of the lands within the Adjustment Area that it intends to add, along with a summary of relevant biological and physical characteristics in the area proposed for addition. Lands within the “Initial Plan Area” are similar in characteristics and conservation value to lands in adjacent areas that could be brought into the Plan Area via land purchase. Fruit Growers Supply Company estimates that there are approximately 338,900 acres of other privately held commercial timberlands in the drainages that could be added to the Plan Area if acquired by FGS in the future. However, expansion of the Plan Area under this process is limited to10 percent of the Initial Plan Area (15,218 acres). Addition of lands to the Plan Area (i.e., to be covered by the HCP) in excess of the 10 percent limit or outside of the identified Adjustment Area would require an amendment to the HCP and ITP.

Further, through a notification to the Service and NMFS, and subject to their review, lands covered by the HCP and ITP may be disposed of without limitation provided that the lands remain subject to the terms and conditions of the IA and HCP. The extent to which lands may be disposed of without adhering to the terms and conditions of the IA is limited to 10 percent of the Initial Plan Area (15,218 acres), and the remaining Plan Area must provide benefits and effectiveness equal to those intended in the HCP and ITP.

1.4 Plan Implementation

The primary administrator for implementation of this HCP is FGS. FGS will be responsible for the conduct of all conservation, mitigation, monitoring, and reporting activities specified in the

HCP; however, some of the activities may be delegated to and carried out by contractors, partners, or volunteers.

Although significant technical expertise and local knowledge of Covered Species and their habitats are held by the agency staff that advised FGS personnel and consultants that prepared this plan, FGS may seek to consult with outside scientists and other technical experts who can provide technical advice on implementation of the conservation and monitoring programs. In developing the conservation program for northern spotted owls, FGS, in consultation with the Service, consulted with noted authorities on northern spotted owl biology and behavior. These experts provided input on the analysis of impacts to northern spotted owls and development of an evaluation matrix used to establish the relative conservation value of northern spotted owl activity centers (see section 3.2.4). In the event of changed or unforeseen circumstances (described below) that substantially alter habitat for northern spotted owls in the Conservation Support Areas (CSAs) established on the FGS ownership, outside experts may be consulted to provide input on actions needed to ensure that FGS is meeting its mitigation obligations for take of northern spotted owl. However, the Service is responsible for monitoring and enforcing the terms of the HCP and ITP.

1.4.1 Covered Activities

This section describes FGS' activities that are covered under the HCP and associated ITP, which include forest practices and related land management activities on FGS's Hilt/Siskiyou forest (the Plan Area), and those activities necessary to carry out all mitigation and conservation measures identified in the HCP and/or the ITP. Timber management is the primary activity in the Plan Area, occurring on 152,178 acres. Covered Activities include activities associated with timber harvest, road construction and maintenance, silviculture, stand regeneration, harvest of minor forest products, and fire prevention. Collectively, these are referred to as Covered Activities. In addition to the ESA and California Endangered Species Act (CESA), the Covered Activities occurring on FGS's ownership are subject to numerous other State and Federal environmental and public safety laws. All Covered Activities will be implemented in accordance with the HCP and ITP, the California Forest Practice Rules (CFPRs), and other applicable Federal and State regulations.

1.4.1.1 Timber Harvest

Timber harvest includes activities necessary to the logging and transport of timber products [primarily ponderosa pine (*Pinus ponderosa*), sugar pine (*Pinus lambertiana*), Douglas-fir (*Pseudotsuga menziessii*), and white fir (*Abies concolor*)]: felling and bucking of timber, yarding timber, salvage and transport of timber products.

Felling and Bucking of Timber

The cutting of trees (felling) is the first step in any timber harvest operation, and bucking is cutting the felled tree in predetermined log lengths. Felling and bucking are generally done with chain saws by crews working in pairs. On gentle terrain, mechanical felling machines (feller-bunchers) can be used to fell the trees and place them in a pile for moving to the log landing.

Ground-based Yarding

Ground-based yarding usually involves the use of tracked or rubber-tired tractors (skidders) to move logs to the landing. The skidders are usually equipped with mechanical grapple attachments or wind lines to grasp the logs, and they follow constructed "skid trails" on all but the mildest terrain. Skidding is generally done in a downhill direction, and occasionally is used for uphill yarding where it is limited to short distances. If logs will be moved only a short distance, a shovel or a hydraulic boom log loader may be used. A shovel is a tracked excavator that has been fitted with a grapple for grasping logs. The shovel may move a short distance off the truck road to pick up felled logs and pass them back to the truck road using the boom structure. Construction of skid trails is not necessary when using the boom loader. Ground-based yarding is typically conducted on slopes less than 55 percent.

Cable Yarding

Cable yarding generally involves the use of steel cables to skid logs to a truck road or log landing using a yarder that is set up on the truck road or landing. A yarder has a vertical tower that is held in place by a number of guylines. The skidding cables, which are operated using powered drums, are used to haul or skid the logs to the landing. The tower is used to elevate and lift the cables, hence providing lift to logs as they are yarded to the landing. High-lead systems are designed to lift only the lead end of logs so that the logs do not dig into the soil surface as they are yarded. This system is typically used for short yarding distances. Skyline systems involve the use of a skyline cable that runs from the top of the tower to an anchor located at some elevated point beyond the harvest area. Logs are attached to a carriage that rides on the skyline cable, providing increased lift to suspend logs above the ground surface. Logs are generally yarded uphill with cable systems, but occasionally these systems are used for downhill yarding. Cable yarding is typically conducted on slopes greater than 55 percent.

Aerial Yarding

Aerial yarding by helicopter is used where roads cannot be constructed to provide access to a harvest unit for conventional (ground-based or cable) yarding systems. Aerial logging suspends logs from long cables and transports them to the landing with virtually no ground disturbance. In general, it is not necessary for the helicopter to land in the loading area. However, a separate service landing is needed that provides a clean, rocked, debris- and dust-free area to protect the helicopter's engine(s) from damage. This yarding technique is usually reserved for steep (greater than 65 percent) and/or unstable terrain, although lack of a road right-of-way may trigger its use.

Loading and Landing Operations

After logs are yarded to a landing or roadside, there may be additional saw work to remove limbs, buck long pieces into shorter segments, or to remove broken sections. These operations are conducted either with hand labor (chain saws) or a mechanical delimber. Logs are then loaded onto log trucks using a shovel or front-end loader (a wheeled bucket loader equipped with log forks instead of a bucket). Some log trucks have their own loading system (self-loaders).

Salvage of Timber Products

Dead, dying, and downed trees are periodically salvaged. Salvage is primarily related to road maintenance, fire damage, insect damage, or storm damage. Generally the economics and logistics involved in the potential harvest determine the feasibility of salvage operations. Salvage operations are feasible when damaged or weakened trees occur adjacent to ongoing logging operations, or are in heavy enough concentrations over a large enough area to justify sending in a salvage logger. It is typically not feasible to harvest individual occurrences of one or two trees, or trees that have been dead for more than 2 years. Salvage operations typically occur in isolated locations throughout the Plan Area, and consist of harvesting dead and dying conifers as individuals or in small groups.

Transport of Timber Products

Timber products are most commonly transported along roads via truck and trailer. Maintenance activities on these haul roads are described below.

1.4.1.2 Road Construction and Maintenance

Activities for maintenance, improvement, construction, and closure of roads and landings include the following:

- Construction of new roads in connection with timber management, including clearing vegetation from road rights-of-way, removing trees, grubbing (removing stumps and surface organics), grading, and compaction

- Extraction of rock, sand, and gravel from small borrow pits for use in road construction and maintenance

- Drainage facility repair and/or upgrade, and erosion control

- Construction of stream crossing (bridges, culverts, fords, and a variety of temporary crossings)

- Maintenance or reconstruction of surfaced roads, seasonal roads, culverts, bridges, fords, cuts, and fillslopes

- Closure of roads, temporarily (abandoned) or permanently (decommissioned)

- Dust abatement activities, such as treating road surfaces with materials commonly used for dust abatement, including but not limited to lignin, calcium chloride, magnesium chloride, and water

- Construction and maintenance of water holes used for water drafting (a short-duration, small-pump operation that withdraws water from streams or impoundments to fill conventional tank trucks or trailers)

- Water drafting for dust abatement, road construction, and routine maintenance

1.4.1.3 Silviculture

Silviculture is the culture and management of forest trees. FGS's silvicultural practices are designed to maintain and enhance the productivity of its timberlands by promoting prompt regeneration of harvested areas and rapid forest growth. Silvicultural treatments vary by stand age, stand condition, site class, and species composition. Not all treatments are applied to every site.

FGS forest inventory serves as the foundation for long-term planning by identifying stands of generally homogeneous site, stocking, and silvicultural potential. Forest conditions are currently estimated at the landscape level by a Maximum Sustainable Production (MSP) analysis (a sustained yield planning framework is required under the CFPRs [14 CCR 933.11a]). For planning purposes, stands of similar condition are combined and a range of feasible silviculture is modeled for each of these units with yields reported at the mid-point of each decade. Once a given silviculture treatment is applied, it limits the range of future opportunities for a given stand. The current MSP analysis is intentionally non-spatial so that silviculture can be developed at the landscape level and applied at the stand level on the basis of need. Each stand is part of a modeling unit in which a range of silvicultural practices are designated by acres by decade. The forester applies silviculture within these limits and within other spatial constraints, such as for areas protected for other resources.

Forest Management Regimes

The general categories of silviculture include even-aged regeneration, even-aged thinning, and uneven-aged treatments. Even-aged regeneration occurs on a 50- to 80-year rotation and produces stands that will remain in young seral stages for 20 to 50 years depending on site potential and stocking retained. These units are generally small, from 10 to 30 acres, and scattered on the landscape. In most cases, even-aged regeneration targets marginally stocked and/or deteriorating stands to improve their long-term productivity. Harvest methods include seed tree, shelterwood, and clearcutting methods. Regeneration occurs artificially through planting nursery-grown seedlings, or naturally by seed trees retained within harvest units. Seed trees are retained to propagate certain species or characteristics (for example, rust resistance). Even-aged thinning units are intermediate treatments of mid-seral even-aged stands designed to accelerate growth of trees. Uneven-aged harvests are generally designed to maintain a distribution of tree sizes at a stocking level that maximizes board foot growth at the stand level. Site potential determines the desired stocking level. Uneven-aged silviculture is used to harvest trees individually or in small groups with the goal of developing or maintaining a variety of age classes within a stand. Typically, sites are restocked through natural regeneration and, where necessary, supplemented by planting seedlings obtained from a nursery.

Silvicultural Methods

The types of silvicultural methods commonly employed by FGS throughout its ownership and its application in the development of the MSP analysis are consistent with the methods defined and regulated in the CFPRs.

Clearcutting

The clearcutting regeneration method involves the removal of a stand in one harvest. Under the CFPR's, regeneration after harvesting shall be obtained by direct seeding, planting, sprouting, or natural seed fall[4]. When practical, clearcuts shall be irregularly shaped and variable in size to mimic natural patterns and features found in landscapes. Even-aged regeneration harvests have been allocated to portions of most merchantable-sized timber types on the Hilt/Siskiyou Forest. Actual clearcut unit locations are determined during Timber Harvest Plan (THP) layout by the area foresters.

Commercial Thin

Commercial thinning is the removal of trees in a young-growth stand to maintain or increase the average diameter of the remaining trees, promote timber growth, and/or improve forest health. Commercial thinning is used as a tool to extend the "life" of some stands before using a regeneration harvest to better balance age class distributions across the forest. Commercial thinning is used to improve stand health and growth in relatively healthy, well-stocked stands of trees large enough to be harvested for lumber [> 10 inches diameter at breast height (dbh)] that exceed target stocking requirements.

Biomass Thin

This intermediate treatment is used to thin younger, overstocked, submerchantable-sized stands to improve stand health and growth. It is predominantly used in young ponderosa pine stands and in mixed conifer stands with a heavy pine component. Although some saw logs are harvested, the main product is hog fuel (an unprocessed mix of barks and wood fiber) or paper chips from trees ranging from 4 to 10 inches dbh. Biomass thinning has been periodically used in the Grass Lake management unit to improve stand condition. It is also a valuable tool to reduce wildfire potential.

Seedtree/Shelterwood Removal (Even-aged)

This silvicultural method is used where a two-tiered structure of healthy, well-stocked understory with a scattered overstory exists. Future harvests will be even-aged (one or two commercial thins followed by regeneration harvests). The benefits of using this method are improved stand health, increased growth of trees in the understory, and promoting a more regular structure. This silvicultural method is widely used in all of the management units on FGS ownership.

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[4] Age and acreage limitations for clearcuts are regulated by the California Forest Practice Rules (14 CCR 913.1)

Selection/Group Selection (Uneven-aged)

This silvicultural method is used in heavily stocked, relatively healthy stands that have an uneven-aged structure. Merchantable trees are harvested from all size classes present. The intent is to maintain an uneven-aged structure, maintain stand health, and generate a harvest return. Harvest entries occur every 10 to 20 years. Selection harvest has also been applied to other stands throughout FGS ownership on the Hilt/Siskiyou forest, including those in watercourse protection zones and on potentially unstable slopes, including inner gorges and shallow, unstable soils.

Alternative Prescriptions

A number of alternative prescriptions are commonly used by FGS in its silvicultural management. All alternative prescriptions are analyzed and approved during the THP review process. In most cases where alternative prescriptions are employed, past management and timber harvest have created an irregular condition in stand structure and/or stocking. Standard silvicultural prescriptions as specified in the rules are difficult to apply in these irregular stands. FGS's management scheme is to maintain stand health and generate a periodic and economical harvest in these stands through the use of alternative prescriptions over the first 1 to 4 years, gradually building up inventory to a point when standard silvicultural prescriptions can be applied. These alternative prescriptions include, but are not limited to:

- Seedtree/shelterwood removal (uneven-aged)
- Modified selection
- Combination shelterwood removal/biomass thin
- Modified commercial thin
- Combination shelterwood removal/commercial thin

1.4.1.4 Stand Regeneration and Improvement

Timber stand regeneration and improvement includes activities necessary to establish, grow, and achieve the desired species composition, spacing, and rate of growth of forest stands on the ownership:

- Site preparation, prescribed burning, and slash treatment
- Tree planting
- Vegetation management
- Silvicultural thinning (includes biomass, pre-commercial, and commercial thinning)

Silvicultural thinning is described previously under silvicultural methods.

Site Preparation, Prescribed Burning, and Slash Treatment

Site preparation activities for even-aged regeneration involve the removal of logging residue and/or unwanted shrub and tree species. This is typically accomplished by using tractors to pile logging residue for burning, broadcast burning, or, less commonly, by mechanical methods. By removing fuels, this treatment has the additional benefit of reducing the potential for wildfire to ignite or spread. As needed, fuel breaks may be constructed to protect resources. The need and location of fuel breaks is determined by the area forester [in consultation with California Department of Forestry and Fire Protection (CAL FIRE) as needed]. Occasionally, site preparation also requires soil scarification for planting. This treatment applies only to regeneration harvest units where it may be necessary to ensure successful regeneration.

Tree Planting

Artificial regeneration is commonly used to ensure that sites are adequately stocked as per the stocking requirements specified in the CFPRs. The usual practice is to plant seedlings in those areas that have been either clearcut or burned by wildfire. Seedlings are grown at commercial nurseries from seed collected within the appropriate seed zones typically by FGS on its property, and/or purchased for the environmental conditions of each site where they will be planted.

Vegetation Management

Occasionally, sites may require one or more vegetation management treatments to reduce the impacts of unwanted competing vegetation on the growth of seedlings. Such treatments commonly involve the mechanical removal of competing brush species using tractors or hand crews. Brush is typically piled and burned, or may be chipped. FGS is not seeking coverage for herbicide use under the ITP.

1.4.1.5 Minor Forest Products

Minor forest products are occasionally harvested from the Plan Area and transported over private and public roads. These products include, but are not limited to, Christmas trees and bows, mistletoe, firewood, fence posts, poles, yew bark, stumps, root wads, and mushrooms. These are all very minor components of this forest and are regulated by contract. The management of Christmas trees includes pruning and growth control in scattered locations throughout the Plan Area. The harvest of Christmas trees is small enough to be considered a minor forest product.

1.4.1.6 Fire Prevention and Suppression

Wildfire prevention involves vegetation management and the construction of fuel breaks strategically located throughout the Plan Area. These activities are designed and implemented by the area forester on a local basis, and are therefore generally very limited in scale. The prescription typically includes thinning for shaded fuel breaks along property lines or between watersheds where FGS deems it beneficial. Wildfire suppression is typically under the authority of local, State, or Federal agencies. In cases of escaped prescribed burns where local, State, or Federal agencies are not involved, or for initial responses until responsible agencies have arrived, FGS employs emergency fire suppression activities, such as construction of fuel breaks by hand or bulldozer, lighting backfires, applying aerial fire suppressants, falling trees or snags, and water drafting for fire suppression.

1.4.1.7 Other Activities

In addition to FGS's forest management activities, this HCP and associated ITP will cover certain other activities undertaken by FGS and third parties pursuant to FGS obligations (for example, easements) or authorization (leases and licenses) in the future. Generally, such activities include those consistent with the zoning of FGS's lands as Timber Production Zone (TPZ). Under California's Timberland Productivity Act (CTPA), a TPZ is for growing and harvesting of timber and other designated "compatible uses." Examples of compatible uses are watershed management; fish and wildlife habitat improvement; and use of roads, landings, and log decks. Grazing is considered a compatible use, but will not be a Covered Activity under this HCP.

With regard to road use, the HCP and ITP will cover general road use, construction, and maintenance activities carried out on road segments owned by and under control of FGS. Construction and maintenance activities pursuant to cooperative road use and maintenance agreements between FGS and the United States Forest Service (USFS) would not be covered under this HCP. The USFS is developing a road use and maintenance plan through consultation with NMFS to cover roads on lands in the KNF. Rock quarrying activities would be covered under this HCP. FGS quarries rock from a number of locations on its ownership for the purpose of obtaining material for road surfacing. FGS has four primary rock quarries on the ownership that are each less than 2 acres in size. These quarries are used solely by FGS to provide rock products used on its ownership and in road construction and maintenance activities on roads governed by cooperative agreements with the USFS. Typically up to five or more local rock sources, commonly referred to as "borrow pits," are developed as needed for road upgrades associated with THPs. Each local rock source is rarely larger than 0.5 acre in size and is most often located in the upper portion of watersheds.

1.4.2 Conservation Measures

1.4.2.1 Overview of the Terrestrial Species Conservation Program

Biological Goals

The overall biological goal for northern spotted owl is to contribute to the sustainable maintenance of the local and regional populations of owls through both species and habitat objectives.

Northern Spotted Owl Biological Objectives

As described below, five specific objectives were developed to meet the biological goal for the northern spotted owl.

Objective 1: Demographic Support. Consistent with Service expectations for private lands as stated in the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b), a biological objective of the HCP is to contribute to northern spotted owl conservation and recovery by providing demographic support to owl populations on nearby federal lands. This objective to support the federal conservation strategy will be accomplished through conservation of suitable habitat within 1.3-miles of selected high conservation value activity centers located near FGS's ownership, thus providing compensatory mitigation for incidental take of owls associated with other low conservation value activity centers that may occur over the term of the HCP.

Conservation Support Areas (CSAs) will be established on FGS's ownership within the 0.5-mile radius core around high conservation value activity centers, coinciding with the area of highest likelihood of owl use. Selected nesting/roosting and foraging habitat in these areas will be maintained, and strategic locations with the potential to grow into suitable habitat will be managed to promote use by northern spotted owls in the future. FGS will provide reasonable extensions of the CSAs into the 1.3-mile-radius home range around selected activity centers to maintain connectivity with nesting/roosting habitat, and to provide foraging opportunities for owls. Extensions into the 1.3-mile radius home range will be focused primarily along riparian zones, which generally provide greater prey abundance and diversity due to increased understory vegetation and moisture.

Objective 2: Riparian Management. The biological objective of the HCP for riparian management is to provide foraging and dispersal opportunities for the northern spotted owl across the landscape by establishing Watershed and Lake Protection Zones (WLPZs) that promote growth in stands toward a more mature state with a high level of overstory canopy coverage and legacy structures, such as old large trees, snags, and downed wood.

Objective 3: Dispersal Habitat. The biological objective of the HCP for dispersal habitat is to contribute to a general trend of increased quality and quantity of northern spotted owl dispersal habitat across the ownership over the term of the ITP.

Objective 4: Incidental Take Minimization. The biological objective of the HCP for take minimization is to avoid direct take of northern spotted owls resulting from authorized timber harvesting operations. This objective will be accomplished through a combination of: (1) seasonal timing restrictions; (2) pre-harvest surveys; and (3) on-site monitoring by a qualified biologist.

Objective 5: Threat Management. The biological objective of the HCP is to manage, to the maximum extent practicable, known threats to the northern spotted owl. Significant threats to the northern spotted owl within the Plan Area include the barred owl and catastrophic wildfire. This objective will be accomplished through actions that: (1) control barred owls through management actions within the Plan Area; and (2) reduce the potential for catastrophic wildfire on the FGS ownership that could diminish the quality and amount of owl nesting/roosting, foraging, and dispersal habitat both on and off the FGS ownership.

1.4.2.2 Terrestrial Species Conservation Program

Based on the stated biological goals and objectives, FGS developed a comprehensive conservation program with a number of specific conservation measures to provide protection for the northern spotted owl. Collectively these measures are termed the "Terrestrial Species Conservation Program," and they reflect the binding, enforceable commitments FGS will make to satisfy the requirements of section 10(a) of the ESA. The Terrestrial Species Conservation Program is incorporated by reference in the section of the IA that describes all FGS's conservation planning commitments that must be made and carried out to qualify for and comply with the ITP that FGS is seeking.

The following subsections describe the specific measures associated with each of the biological objectives for northern spotted owls.

Objective 1: Demographic Support

The following measures are associated with the demographic support objective:

- FGS will establish 24 CSAs on its ownership to provide demographic support to northern spotted owls associated with strategic activity centers located within 1.3 miles of the FGS ownership (Action Area), and whose home ranges overlap with Critical Habitat Units (CHUs).

- FGS will promote and maintain the following general conditions and habitat features on its ownership within the CSAs:

  - A multi-layered mature forest to provide a more stable and moderate microclimate

  - Areas composed of tree species associated with use by northern spotted owls (i.e., Douglas-fir with mistletoe infections to provide nesting platforms, hardwoods to provide food and shelter for prey)

  - Variable and increasing average tree diameter

  - A large tree component (trees greater than 26 inches dbh)

  - Variable tree densities

- FGS will ensure that specific habitat standards for both nesting/roosting and foraging habitat are met within the entire CSA (which includes lands owned by others) before harvest can occur on its ownership in a CSA (see below).

- Harvest on the FGS ownership within CSAs will be restricted, and any harvest on the FGS ownership within the CSAs will require evaluation for compliance with the HCP provisions, and written approval by the Service.

- FGS will prioritize conservation efforts on lower elevation, northern-facing slopes near the northern spotted owl nest sites. FGS will prioritize management of owl habitat on its ownership within the lower third of mesic slopes near riparian zones, including designated WLPZs.

- Existing large hardwoods on the FGS ownership within CSAs will be retained to provide nesting structures for owls and food for prey species.

- Large down woody material on the FGS ownership within CSAs will be retained to provide nesting and foraging habitat for northern spotted owl prey species.

- Existing snags on the FGS ownership within CSAs will be retained. Snags that are judged to be a safety hazard may be felled and left onsite.

Conditions for allowable harvest within the 500-acre core area: If there are more than 250 acres of nesting/roosting habitat and more than 150 acres of foraging habitat within the overall 500-acre core area (regardless of ownership) of mitigation sites, then harvest can occur on lands owned by FGS in the core area. Any harvest allowed must maintain more than 250 acres of nesting/roosting habitat and more than 150 acres of foraging habitat within the core area post-harvest. All existing substrate for northern spotted owl nest structures (tree deformities, mistletoe brooms, tree cavities) will be maintained within the 500-acre core area where it does not create a hazard for public safety.

Nesting/roosting habitat is defined as having the following attributes:

- ≥150 ft^2/acre of basal area
- ≥ 60 percent canopy closure
- ≥ 15 inches average quadratic mean diameter (qmd)
- ≥ 8 trees/acre (or ≥ 30 ft^2/acre basal area) of large conifers ≥ 26 inches dbh
- Multi-layered canopy, nesting substrates, snags, down woody material, decadent trees

Of the 250 acres of nesting/roosting habitat in the core area of the CSA (regardless of ownership), at least 100 acres must be high quality habitat with greater than or equal to 210 ft^2/acre of basal area, and at least 100 acres must be of at least moderate quality with 180 to 210 ft^2/acre of basal area for harvest to occur on lands owned by FGS in the CSA.

Foraging habitat is defined as having the following attributes:

- 80 to 180 ft^2/acre of basal area
- ≥ 40 percent canopy closure
- ≥ 13 inches average qmd
- ≥ 5 trees/acre (≥ 20 ft^2/acre basal area) of large conifers ≥ 26 inches dbh

Of the 150 acres of foraging habitat, at least 60 acres must be high-quality foraging habitat with 150 to 180 ft^2/acre of basal area and greater than or equal to 60 percent canopy closure. At least 40 acres can be of moderate-quality, with 120 to 150 ft^2/acre of basal area and greater than or equal to 40 percent canopy closure.

As part of the CSA selection process, specific areas on the FGS ownership with the potential to develop into suitable owl habitat over the term of the ITP were identified to support mitigation sites that currently contain less than 250 acres of nesting/roosting habitat and/or less than 150 acres of foraging habitat within the overall 500-acre core area. See Appendix D in the HCP for detailed maps. Harvest in these areas will be restricted until the habitat thresholds are exceeded. High priority for conservation was given to areas at low elevations, and on north-facing slopes near riparian zones that are relatively contiguous with the activity center.

These harvest restrictions, which are based on habitat targets for the mitigation sites as a whole (regardless of ownership), were established to promote a high probability of occupancy by northern spotted owl nesting pairs at known activity centers with high conservation value to the federal conservation strategy outlined in the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b). The habitat targets guide management and stand development on FGS land within the core area. Harvest will be restricted on the entire FGS ownership within the CSAs because any harvest conducted by FGS within the CSAs will require evaluation and written approval by the Service. Overall, 78 percent of the total FGS ownership in the core areas of the mitigation sites will be managed to provide suitable owl habitat in support of the federal conservation strategy. The remaining portion of the FGS ownership in the core areas of the mitigation sites was either identified as non-habitat, could not be reasonably expected to provide habitat over the term of the ITP, or was of low priority given the amount and quality of habitat elsewhere in the core area. FGS's habitat commitments associated with the core area and home range of each mitigation site are summarized in Table 1.

Table 1. FGS Habitat Commitments in CSAs Supporting Mitigation Sites (acres).

Activity Center ID	Habitat Type	Suitable Northern Spotted Owl Habitat within the 502-Acre Core Area (0.5-mile radius around activity center)	Suitable Northern Spotted Owl Habitat within the 2,894-Acre Outer Ring Home Range (0.5 to 1.3-mile radius around activity center)	Suitable Northern Spotted Owl Habitat within the 3,396-Acre Home Range (1.3-mile radius around activity center)
SK002	Foraging	210	719	929
	Nesting/Roosting	0	6	6
SK028	Foraging	33	283	316
	Nesting/Roosting	0	0	0
SK040	Foraging	9	372	381
	Nesting/Roosting	0	0	0
SK044	Foraging	27	545	572
	Nesting/Roosting	0	1	1
SK061	Foraging	0	158	158
	Nesting/Roosting	0	0	0
SK063	Foraging	2	199	201
	Nesting/Roosting	0	0	0
SK097	Foraging	34	286	320
	Nesting/Roosting	0	0	0
SK099	Foraging	1	304	305
	Nesting/Roosting	0	1	1
SK100	Foraging	80	86	166

Activity Center ID	Habitat Type	Suitable Northern Spotted Owl Habitat within the 502-Acre Core Area (0.5-mile radius around activity center)	Suitable Northern Spotted Owl Habitat within the 2,894-Acre Outer Ring Home Range (0.5 to 1.3-mile radius around activity center)	Suitable Northern Spotted Owl Habitat within the 3,396-Acre Home Range (1.3-mile radius around activity center)
	Nesting/Roosting	38	5	43
SK153	Foraging	168	643	811
	Nesting/Roosting	0	0	0
SK238	Foraging	0	53	53
	Nesting/Roosting	0	15	15
SK262B	Foraging	140	297	437
	Nesting/Roosting	12	27	39
SK284	Foraging	124	522	646
	Nesting/Roosting	6	0	6
SK291	Foraging	11	72	83
	Nesting/Roosting	4	3	7
SK352	Foraging	58	622	680
	Nesting/Roosting	0	1	1
SK378	Foraging	33	29	62
	Nesting/Roosting	0	0	0
SK428	Foraging	16	311	327
	Nesting/Roosting	0	0	0
SK446	Foraging	43	350	393
	Nesting/Roosting	5	38	43
SK462	Foraging	110	593	703
	Nesting/Roosting	0	0	0
SK503	Foraging	38	445	483
	Nesting/Roosting	0	0	0
SK512	Foraging	15	121	136
	Nesting/Roosting	0	0	0
SK530	Foraging	28	293	321
	Nesting/Roosting	0	0	0
SK531	Foraging	108	947	1055
	Nesting/Roosting	0	1	1
SK548	Foraging	4	273	277
	Nesting/Roosting	0	1	1

* The acreage listed in this table represents the amount of habitat that will be maintained on FGS property only. The remainder of the 500-acre core and 3,396-acre home range include FGS lands that were not designated for conservation in the CSAs (e.g., non-habitat, suitable habitat not prioritized for conservation), are located on lands that are owned by others (private, Federal and State) and may include overlap with adjacent CSAs.

While silvicultural practices will be tailored to individual activity centers, FGS will manage its lands within the CSAs to develop and maintain northern spotted owl habitat as described above to promote heterogeneous habitat conditions within the 500-acre core area around an activity center (i.e., promote variable basal areas and canopy closures). The habitat commitments in Table 1 will be incorporated into FGS's management of its land within the 500-acre core area in CSAs around the strategic activity centers. As stands develop over the term of the ITPs, the actual areas of suitable habitat may shift spatially due to natural events or silvicultural activities. If an area identified for conservation as foraging habitat grows into nesting/roosting habitat, then FGS can harvest this or other nesting/roosting habitat in the CSA down to the high quality foraging habitat standards, provided that their commitments for nesting/roosting and foraging habitat are met and at least 250 acres of nesting/roosting habitat and 150 acres of foraging habitat is maintained within the overall 500-acre core area, regardless of ownership.

Upon evaluation and written concurrence by the Service, exceptions may be made on a case-by-case basis for mitigation sites that lack the acreage or site potential to meet this requirement. Timber harvest on the FGS ownership in a CSA would not be allowed if such harvest would result in FGS being unable to meet its habitat commitment (Table 1) post-harvest. Any harvest conducted by FGS within the CSAs will require evaluation and written approval by the Service for compliance with the HCP provisions.

Conditions for Allowable Harvest within the Home Range: If there are more than 600 acres of nesting/roosting habitat (as defined above for the core area) and more than 1,050 acres of foraging habitat (with at least 730 acres of high- and moderate-quality foraging habitat, as defined above for the core area) within the 3,396-acre home range, then harvest can occur outside of these habitat retention areas. By definition, the home range includes the 500-acre core area around the activity center, and the acreage identified above for the core area must be maintained. Any harvest allowed must maintain more than 600 acres of nesting/roosting habitat and more than 1,050 of foraging habitat, including at least 730 acres of high and moderate quality foraging habitat, within the home range post-harvest. As part of the CSA selection process, specific areas on FGS's ownership with the potential to develop into suitable owl habitat over the term of the permits were identified to support mitigation sites that currently contain less than 600 acres of nesting/roosting habitat and/or less than 1,050 acres of foraging habitat within the entire 3,396-acre home range. Maps with these specified areas can be seen in Appendix D of the HCP. Harvest in these areas will be restricted until the habitat thresholds are exceeded. High priority for conservation was given to areas that provide connectivity with nesting/roosting habitat in the 500-acre core area and with other owl activity centers, and with a high likelihood of use by northern spotted owls (lower third of mesic slopes near riparian zones, including designated WLPZs) to provide additional foraging opportunities for owls.

These harvest restrictions are based on habitat targets, for the mitigation sites as a whole (regardless of ownership), established to promote a high probability of occupancy by northern spotted owl nesting pairs at known activity centers with high conservation value to the Federal conservation strategy. The habitat targets guide management and stand development on FGS land within the home range and any harvest conducted by FGS within the CSAs will require evaluation and written approval by the Service. Overall, 41 percent of the total FGS ownership in the home ranges of the mitigation sites will be managed to provide suitable owl habitat in support of the Federal conservation strategy. The remaining portion of the FGS ownership in the home ranges of the mitigation sites was either identified as non-habitat, could not be reasonably expected to provide habitat over the term of the Permit, or was of low priority given the amount and quality of habitat elsewhere in the home range. FGS's habitat commitments associated with the home range of each mitigation site are summarized in Table 1.

While silvicultural practices will be tailored to individual activity centers, the habitat commitments in Table 1 will be incorporated into the management of CSAs within the 1.3-mile radius home range around each mitigation site. The amount and location of nesting/roosting and foraging habitat will change through time as stands age and grow. If an area in the CSA identified for conservation as foraging habitat grows into nesting/roosting habitat, then FGS can harvest this or other nesting/roosting habitat in the CSA down to the high quality foraging habitat standards, provided that their commitments for nesting/roosting and foraging habitat in the home range are met and at least 600 acres of nesting/roosting habitat and 1,050 acres of foraging habitat is maintained within the entire 3,396-acre home range area, regardless of ownership.

Upon evaluation and written concurrence by the Service, exceptions may be made on a case-by-case basis for mitigation sites that lack the acreage or site potential to meet this requirement. Timber harvest on the FGS ownership in a CSA would not be allowed if such harvest would result in FGS being unable to meet its habitat commitment (see Table 1) post-harvest. Any harvest conducted by FGS within the CSAs will require evaluation and written approval by the Service for compliance with the HCP provisions.

Objective 2: Riparian Management Objective

The following measure is associated with the riparian management objective:

- FGS will establish WLPZs or Equipment Exclusion Zones (EEZs) along all stream classes, and implement the management prescriptions described in the Aquatic Species Conservation Program over the term of the Permit. The WLPZs will provide foraging habitat and dispersal corridors for the northern spotted owl. No additional riparian management measures are included in the Terrestrial Species Conservation Strategy.

Objective 3: Dispersal Habitat Objective

The following measure is associated with the dispersal habitat objective:

- Consistent with the Service's expectations for conservation efforts on private lands, as stated in the "Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*)" (USDI FWS 2011b), FGS will promote forest management practices that develop and maintain dispersal habitat across its ownership to provide connectivity between the CSAs and nearby Federal lands.

Dispersal habitat is essential to the dispersal of juvenile, non-territorial, or displaced northern spotted owls (USFWS 2008a). Dispersal habitat can occur in intervening areas between larger blocks of nesting, roosting, and foraging habitat or within blocks of nesting, roosting, and foraging habitat. Dispersal habitat is essential to maintaining stable populations by filling territorial vacancies when resident northern spotted owls die or leave their territories, and to providing adequate gene flow across the range of the species. Dispersal habitat is composed of two types of habitat; habitat that supports the transience phase of dispersal and habitat that supports the colonization phase of dispersal (USFWS 2008b). Habitat supporting the transience phase of dispersal contains stands with adequate tree size and canopy closure to provide protection from avian predators and minimal foraging opportunities. This may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the movement phase. Habitat supporting the colonization phase of dispersal is generally equivalent to roosting and foraging habitat, although it may be in smaller amounts than that needed to support nesting pairs. One or both of these habitat components are essential the dispersal of northern spotted owls.

Objective 4: Take Minimization Objective

The following measures are associated with the take minimization objective:

- FGS will not conduct timber operations or create a noise disturbance in conducting Covered Activities within 0.25 mile of active northern spotted owl nest sites during the breeding season beginning February 1 and ending August 31. "Active northern spotted owl nest site" is defined as the nest tree of a pair of nesting northern spotted owls. Road use and maintenance within 0.25 mile of an active northern spotted owl nest site may occur during the breeding season, but will require evaluation by the Service. Other timber operations and other Covered Activities on FGS land within 0.25 mile of an active northern spotted owl nest site may commence without restriction after August 31 for activity centers authorized for take.

- To help ensure protection of active northern spotted owl nest sites on FGS lands and on adjacent land within 0.25-mile of a FGS THP boundary or Covered Activities during the active breeding season, FGS will conduct protocol surveys each year of operation at known activity centers and within unsurveyed suitable habitat to determine site occupancy and reproduction status. Survey results will be reviewed and approved by the Service prior to operations to ensure compliance with the current Service approved protocol.

- To help assure that all active northern spotted owl nest sites on FGS lands and on adjacent lands within 0.25-mile of a THP boundary established by FGS are identified, FGS will use the most recent information on northern spotted owl locations from DFG, the Service, and private timber companies with adjacent land, during the preparation of each THP. FGS will also provide training on northern spotted owl identification and signs of northern spotted owl presence for field personnel that will be conducting THP preparation and timber operations to increase the probability that previously unknown owl sites within or adjacent to THPs are identified. All new northern spotted owl activity centers located through surveys or incidentally will become "known" activity centers, and will be subject to the survey and avoidance provisions above. If there is no response from an historic activity center during three consecutive years of protocol-level northern spotted owl surveys, the Service will evaluate that activity center to determine its occupancy status. Recent analysis conducted on northern spotted owl site occupancy indicates that three years of surveys are not sufficient to conclude that a site will not become occupied (Dugger et al. 2009), thus other factors should be evaluated when making these determinations. Determinations regarding the likelihood of occupancy and the potential for re-occupancy of activity centers must consider the history and quality of northern spotted owl surveys, in combination with current habitat conditions and history of management activities. The Service is expected to provide additional guidance to address these situations later in 2011.

Objective 5: Threat Management Objective

The following measures are associated with the threat management objective and apply to CSAs established on the FGS ownership:

- FGS will implement the following barred owl control measures:

  - FGS will conduct barred owl monitoring using current Service-approved survey protocols every 4 years within the CSAs as long as deemed necessary by the Service. Barred owl monitoring will be conducted in coordination with protocol-level northern spotted owl surveys as described in the monitoring section of the HCP. Within the 4-year interval, FGS will conduct a barred owl survey for two consecutive years to determine if barred owls are present. Survey results will be compiled and a status report provided to the Service every 4 years.

  - If a barred owl is detected in the Plan Area, FGS will locate and monitor the barred owl and notify the Service within 10 days of detection.

  - As part of the ITP issuance, FGS will apply for a Federal Depredation Permit for barred owls as needed. FGS will help to facilitate (e.g., through providing access to and across its ownership) implementation of barred owl control measures deemed appropriate by the Service.

- Consistent with its fuels management guidelines for the Plan Area, FGS will implement the following stocking control and fuel maintenance measures within the CSAs:

  - Plantation and naturally regenerated stands will be maintained at or below stocking levels considered “normal” as defined in standard yield tables where feasible.

  - Fine fuels (slash, brush, and trees less than 3 inches in diameter) will not be permitted to accumulate to levels greater than 10 tons/acre. Thinning of suitable habitat in CSAs would require pre-approval by the Service.

- FGS will implement the following measures to prevent and/or control the spread of forest disease and insect outbreaks in the CSAs:

- Salvage of trees that are weakened or killed by disease or insects, or that are damaged by wildfire or climatic events. Except where human safety is a factor, or in instances where snags have the potential to promote wildfires, salvage is not allowed in WLPZs or in designated suitable habitat within the CSAs. Salvage operations in CSAs would require pre-approval by the Service.

1.4.3 Monitoring

1.4.3.1 Compliance Monitoring for the Northern Spotted Owl

Compliance monitoring for the northern spotted owl consists of documenting compliance with the measures set forth in the Terrestrial Species Habitat Conservation Strategy. Compliance monitoring for measures associated with each biological objective are described below.

Compliance Monitoring Associated with Objective 1 – Demographic Support.

Compensatory mitigation for incidental take of owls over the term of the ITP will be provided through establishment of CSAs on FGS's ownership to provide demographic support to activity centers with high conservation priority. FGS may harvest in CSAs only if general habitat conditions within the home range and core area of the activity center(s) set forth in section 5.3.1.1 of the HCP are met, and specific habitat targets within the CSA (see Table 1) will be maintained post-harvest. Harvest within a CSA will require written approval from the Service. Compliance monitoring for this objective consists of: 1) documenting that FGS has not conducted harvest activities within the CSAs unless the required general habitat conditions are met; and 2) if FGS conducts timber operations in the CSAs, verifying that the specific habitat targets are met following these activities.

To verify that no timber operations have occurred in CSAs without prior approval from Service, FGS will provide the Service with a list of the locations of active THPs on an annual basis (see "Reporting" section below).

If FGS proposes to conduct timber operations in a CSA, prior to conducting these activities, FGS will provide map(s) of the CSA showing suitable northern spotted owl habitat in the home range and core areas of the supported activity center to the Service. As part of the THP process, FGS will inventory areas proposed for harvest to verify that the specific targets for northern spotted owl habitat within the CSA pre-harvest can be met following harvest. FGS will provide the Service with a copy of the proposed THP encompassing the CSA, and obtain written approval for harvest in the CSA. Following completion of timber operations in a CSA, FGS will inventory harvested stands to document post-harvest stand conditions and submit a post-harvest report to the Service. The post-harvest report will quantify the amount of nesting, roosting, and foraging habitat in the harvested area, and characterize stand conditions in sufficient detail to verify compliance with the minimum habitat requirements for the CSA. FGS will submit the post-harvest report to Service within 6 months of completing timber operations.

Monitoring Type:	Compliance monitoring.
Sites:	CSAs with proposed timber operations.
Objective:	Demonstrate compliance with habitat commitments for the CSA within the core and home range of the activity center.
Methods:	Forest stand inventories documenting stand basal area, canopy cover, QMD, and number of large trees to identify suitable habitat for northern spotted owls.
Reporting:	Within 6 months following completion of timber operations in a CSA.

Compliance Monitoring Associated with Objective 2 – Riparian Management.

The Aquatic Species Habitat Conservation Strategy provides for protection of riparian zones through establishment of WLPZs with restrictions on harvest and other activities within the WLPZ. No additional riparian management measures for northern spotted owls are included in the Terrestrial Species Habitat Conservation Strategy. Compliance with the WLPZ measures will be documented through reporting and post-harvest WLPZ inspections as described in section 7.2.1 of the HCP.

Compliance Monitoring Associated with Objective 3 – Dispersal Habitat.

Dispersal habitat is composed of two types of habitat; habitat that supports the transience phase of dispersal and habitat that supports the colonization phase of dispersal (USFWS 2008b). Habitat supporting the transience phase of dispersal contains stands with adequate tree size and canopy closure to provide protection from avian predators and minimal foraging opportunities. This may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding during the movement phase. Habitat supporting the colonization phase of dispersal is generally equivalent to roosting and foraging habitat, although it may be in smaller amounts than that needed to support nesting pairs. One or both of these habitat components are essential the dispersal of northern spotted owls. Because FGS will maintain a forested landscape on its ownership, it is anticipated that the biological objective for dispersal habitat will be met. No compliance monitoring or additional reporting is required to document compliance with this measure. However, at 10-year intervals throughout the term of the ITP, FGS will provide a summary of acres in each California Wildlife Habitat Relationships (CWHR) diameter and canopy cover class in the Plan Area as part of the annual report for that year.

Compliance Monitoring Associated with Objective 4 – Incidental Take Avoidance and Minimization.

Incidental take avoidance and minimization will be accomplished through a combination of pre-harvest surveys and seasonal timing restrictions. In addition, FGS will provide formal training on owl identification and signs of northern spotted owl presence to field personnel that will be conducting THP preparation and timber operations. As described in section 5.3.1.4 of the HCP, FGS will conduct protocol surveys each year of operation at known activity centers if necessary to determine site occupancy and reproductive status and survey suitable habitat within 0.25-mile of Covered Activities planned for operations during the active breeding season. Survey plans and results must be reviewed and approved by the Service prior to operations to ensure compliance with the most current Service approved protocol. Compliance monitoring for this objective consists of documenting that pre-harvest surveys have been conducted, seasonal restrictions have been implemented as necessary, and personnel have been trained.

To demonstrate compliance with the incidental take avoidance and minimization measures, FGS will submit an annual report to the Service. The report will include the locations, dates, and results of the surveys conducted in association with THPs. Upon request, FGS will provide copies of the THPs in which take avoidance and minimization measures were implemented. FGS will document which employees have undergone northern spotted owl training and, upon request, provide the materials used in training employees to the Service.

Compliance Monitoring Associated with Objective 5 – Threat Management.

Threat management focuses on the CSAs and includes surveys for barred owl, measures for wildfire prevention in CSAs, and measures to control disease and insect outbreaks in CSAs. To demonstrate compliance with the barred owl control measures, FGS will submit an annual report to the Service of the results of any barred owl surveys conducted. The report will include the protocol followed, locations, dates, and results of the surveys. As described in section 5.3.1.5 of the HCP, FGS will monitor any barred owl detections in a CSA and notify the Service within 10 days of detection. FGS will work closely with the Service to implement barred owl control measures deemed appropriate by the Service at the time of detection. The annual report will also describe any control measures for barred owls that are implemented and the results of the control actions.

FGS may conduct fuel management or salvage in CSAs only if general habitat conditions within the home range and core area of the supported activity center(s) set forth in section 5.3.1.1 of the HCP are met and specific habitat commitments within the CSA (see Table 1) will be maintained post-harvest. Fuels management and salvage in CSAs will require prior written approval by the Service. If FGS proposes to conduct fuel management or salvage in a CSA, prior to conducting these activities, FGS will provide the Service with a copy of the proposed fuels management or salvage plan for the CSA and provide the agency an opportunity for pre-activity review of the proposed management activity. Following completion of management or salvage operations in a CSA, FGS will inventory harvested stands to document post-harvest stand conditions and submit the results of the post-harvest inventory to the Service. The post-harvest inventory will quantify the amount of nesting, roosting, and foraging habitat in the harvested area and characterize stand conditions in sufficient detail to verify compliance with the minimum habitat requirements for the CSA. FGS will submit the results of the post-harvest inventory to the Service as part of the annual report prepared for the year in which the inventory is completed.

1.4.3.2 Effectiveness Monitoring for the Northern Spotted Owl

Monitoring the effectiveness of the northern spotted owl conservation measures is necessary to evaluate whether the biological goals and objectives established in the HCP for the species are being met, and whether the effects of HCP implementation on northern spotted owls and their habitats are exceeding the levels anticipated by the Service in their BO.

FGS's effectiveness monitoring program for northern spotted owls focuses on monitoring habitat conditions and northern spotted owl occupancy of the CSAs.

Effectiveness Monitoring of Northern Spotted Owl Habitat in CSAs.

Under the HCP, timber harvest will be restricted in CSAs unless general habitat conditions within the home range and core areas of the supported activity center(s) are present and specific habitat targets within the CSA will be maintained post-harvest. Thus, the amount and quality of northern spotted owl habitat in the CSAs is expected to be maintained or to increase over the term of the ITP. To assess the effectiveness of the HCP in maintaining or improving habitat in the CSAs, habitat conditions for northern spotted owls within the core and home range of each activity center supported by a CSA on the FGS ownership will be monitored and compared to the habitat standards described in section 5.3.1.1 of the HCP.

Monitoring Type:	Effectiveness monitoring.
Sites:	All CSAs established on the FGS ownership.
Sampling Frequency:	Stand inventories within all CSAs will be completed within 2 years of issuance of the ITP and repeated every 10 years during the permit period.
Objectives:	Demonstrate that FGS's management activities in CSAs promote development of stand conditions that provide suitable owl habitat within the CSAs over the term of the ITP.
Methods:	Stand level inventories of areas in the CSAs identified as suitable northern spotted owl habitat or potential northern spotted owl habitat (see FGS HCP Appendix D – Maps of CSA habitat areas).
Reporting:	Baseline report following initial inventory of CSAs and periodic reports following repeat inventories at 10-year intervals.

***Monitoring for Northern Spotted Owl Use in CSAs*.**

The biological goal of establishing the CSAs and specifying habitat requirements within the CSAs is to enhance the likelihood that activity centers supported by CSAs will remain or become occupied by northern spotted owls, and thereby provide demographic support to the Federal conservation strategy. Occupancy of an area by northern spotted owls is influenced by many factors, of which habitat condition is only one. Also, home ranges for owls supported by CSAs encompass land managed by many different entities (e.g., USFS, other private timber companies) in addition to FGS. As a result of these circumstances, habitat conditions on FGS lands is only one factor affecting the presence or absence of northern spotted owls in these activity centers, and the absence of owls in an activity center cannot be used as a definitive measure of the HCP's effectiveness. Nonetheless, it is desirable to monitor occupancy of the activity centers supported by CSAs on the FGS ownership as one component for assessing the effectiveness of the HCP.

Fruit Growers Supply Company will conduct protocol surveys to detect the presence of northern spotted owls in activity centers supported by CSAs. Survey results will be reviewed and approved by the Service to ensure compliance with the "Protocol for surveying proposed management activities that may impact northern spotted owls" (USDI FWS, 2011a), or current northern spotted owl survey protocols approved by the Service. Fruit Growers Supply Company will conduct protocol surveys during two consecutive years, unless a northern spotted owl or owl pair is detected during the first year. If a northern spotted owl or owl pair is detected during the first year of surveys, and resident status is determined, this will indicate occupancy of the activity center, and no follow-up survey is required the second year. The surveys will be repeated at 4-year intervals for the duration of the permit to document and identify trends in occupancy and reproductive status of activity centers supported by CSAs on the FGS ownership. If there are no detections for two consecutive years at more than 40 percent of the CSAs (nine CSAs) within a 4-year period, then FGS will notify the Service and California Department of Fish and Game (CDFG), and enter into a discussion about why the sites are unoccupied and whether any alternative actions within the HCP commitments could promote occupancy. Alternatives such as delayed harvest in nearby activity centers where take is authorized, or establishment of an alternative CSA with similar conservation value could be proposed. If an alternative CSA is identified and approved through written concurrence by the Service, then FGS may conduct timber harvest operations within the unoccupied CSA without further restriction, other than as specified in other sections of this HCP (i.e., the CSA will no longer be considered a conservation or mitigation area).

Monitoring Type:	Effectiveness monitoring.
Sites:	All CSAs established on the FGS ownership.
Sampling Frequency:	Protocol surveys during breeding period for two consecutive years at 4-year intervals.

Objectives:	Determine northern spotted owl occupancy and reproductive status at activity centers supported by CSAs on the FGS ownership.
Methods:	Protocol surveys during the breeding period for northern spotted owl.
Reporting:	Annual reporting of results of any surveys conducted in the preceding year.

Monitoring for Barred Owls in CSAs.

The objective of threat management measures for barred owls is to prevent barred owls from displacing northern spotted owls and becoming established. Detections of barred owls could reflect a range expansion and increased risk of barred owls becoming established. Under the HCP, FGS will survey activity centers supported by the CSAs for barred owls. If barred owls are detected, FGS will work closely with the Service to implement appropriate barred owl control measures as necessary. Following implementation of any control measures, another individual could quickly move into the area. To monitor the effectiveness of the control strategy and minimize the potential for additional barred owls to become established following control actions FGS will, upon request by the Service, conduct annual surveys for barred owls within 1 mile of the detection site. Annual surveys will continue until no barred owls are detected for 3 consecutive years, or until the Service no longer requests additional surveys, after which the survey frequency will revert to the standard protocol of 2 consecutive years every 4 years.

Monitoring Type:	Effectiveness monitoring.
Sites:	Activity centers supported by CSAs on the FGS ownership in which barred owls have been detected and control measures have been implemented.
Sampling Frequency:	Annual protocol surveys during breeding period until no detections for 3 consecutive years or the Service determines that surveys are no longer necessary.
Objectives:	(1) Determine occurrence of barred owls in CSAs.
	(2) Demonstrate effectiveness of any barred owl control actions.
Methods:	Service-approved protocol surveys for barred owls.
Reporting:	Annual reporting of results of any surveys conducted in the preceding year.

1.4.3.3 Northern Spotted Owl Monitoring Adaptability

The monitoring outlined in the previous sections uses monitoring protocols that represent current, peer-reviewed, and accepted methods at the time of HCP development. It is possible that other monitoring methods may be developed during the term of the HCP, which would provide for better or more cost-effective assessment of compliance with and effectiveness of the conservation measures. FGS and the Service may mutually agree to modify the monitoring protocols listed in this HCP to better monitor the effectiveness of the conservation measures and ensure compliance with the terms of the conservation program at any time.

1.4.4 Reporting Requirements

FGS will regularly submit reports to the Service and CDFG to document its compliance with the terms of the HCP and report the results of effectiveness monitoring. FGS reporting obligations can be separated into three categories:

1. Annual reports
2. Periodic analyses
3. Event-driven analyses

1.4.4.1 Annual Reports

FGS will submit an annual report to the Service and CDFG on HCP activities occurring in the preceding year. At a minimum, the annual report will include:

- Any incidental take of northern spotted owls;
- List of the active THPs and their locations, and identification of THPs in which take minimization and avoidance measures for northern spotted owls were implemented;
- The amount of suitable habitat within the core area and home range of each activity center on the ‘take’ list that has been harvested or otherwise converted to nonhabitat;
- Dates, locations, and results of northern spotted owl surveys conducted in association with THPs;
- Dates, locations, and results of northern spotted owl surveys in CSAs in that year and preceding years; and
- Dates, locations, and results of barred owl surveys in that year and preceding years.

FGS will submit each year’s annual report by March 31 of the following year.

1.4.4.2 Periodic Analysis

FGS will periodically analyze northern spotted owl habitat in the CSAs. As part of the effectiveness monitoring program, FGS will conduct a baseline stand inventory of its lands within CSAs within 2 years of permit issuance and every 10 years thereafter. The inventory results will include:

- Maps of locations of stands that were inventoried;
- For each CSA, the amount and location of suitable northern spotted owl habitat in accordance with the definitions used in this HCP; and
- Estimates of snag, downed woody debris, and hardwood densities.

Results of the inventories and analysis of habitat for northern spotted owl will be included in the annual report for the year in which the inventories are completed.

1.4.4.3 Event-driven Analysis

During the term of the ITP, FGS will not conduct timber operations on its lands in CSAs unless specific habitat requirements are exceeded. If FGS proposes to conduct timber operations in a CSA, including wildfire management and salvage operations, FGS will inventory areas proposed for harvest to document pre-harvest stand conditions (including amount of hardwoods, downed woody debris, and snags) during THP preparation and obtain Service approval prior to operations in the CSA. Following completion of timber operations in a CSA, FGS will analyze habitat conditions for northern spotted owl in CSAs where timber operations have occurred. The post-harvest analysis will include:

- The amount and location of nesting, roosting and foraging habitat within the CSA prior to timber operations;
- The amount and location of nesting, roosting and foraging habitat within the CSA following timber operations;
- Results of stand level inventories of harvested stands in CSAs before and after timber operations; and
- Densities of snags, downed woody debris, and hardwoods in harvested CSAs before and after timber operations.

Results of the post-harvest analyses will be included in the annual report for the year in which the analyses are completed.

1.4.5 Changed and Unforeseen Circumstances

Section 10 regulations (as codified in [50 CFR, Sections 17.22(b)(2) and 17.32(b)(2)]) require that an HCP specify the procedures to be used for dealing with changed and unforeseen circumstances that may arise during the implementation of the HCP. In addition, the No Surprises Rule ([63 Federal Register 8859, February 23, 1998 as codified in 50 CFR 17.22 (b)(5), 17.32 (b)(5), and 222.307(g)]) describes the obligations of the permittee and the Services. The purpose of the No Surprises Rule is to provide assurance to the non-Federal landowners participating in habitat conservation planning under the ESA that no additional land restrictions or financial compensation will be required for species adequately covered by a properly implemented HCP, in light of unforeseen circumstances, without the consent of the permittee.

1.4.5.1 Changed Circumstances

Changed circumstances are defined in 50 CFR 17.3 and 222.102 as changes in circumstances affecting a species or geographic area covered by an HCP that can reasonably be anticipated by plan developers and the Service, and for which contingency plans can be prepared (e.g., the new listing of species, a fire, or other natural catastrophic event in areas prone to such event). If additional conservation and mitigation measures are deemed necessary to respond to changed circumstances, and these additional measures were already provided for in the plan's operating conservation program (e.g., the conservation management activities or mitigation measures expressly agreed to in the HCP or IA), then the permittee will implement those measures as specified in the plan. However, if such measures were not provided for in the plan's operating conservation program, the Service will not require these additional measures without the consent of the permittee, provided that the HCP is being "properly implemented" (properly implemented means the commitments and the provisions of the HCP and the IA have been or are being fully implemented). At no time does the ITP authorize Covered Activities to put a species in jeopardy.

For the purposes of this HCP, changed circumstances are those changes affecting a species or geographic area covered by the HCP that can reasonably be anticipated and planned for by FGS and the Service at the time of the HCP's preparation. In discussions with the Service, NMFS, and CDFG, FGS identified several reasonably foreseeable circumstances under which changes could occur during the term of the ITP that could result in a substantial and adverse change in the status of a species covered by the HCP. Foreseeable conditions that could result in "changed circumstances" as defined in applicable Federal regulations and policies that may affect terrestrial covered species are identified below.

- Global climate change, resulting in increased fire risk, flooding, drought, incidence of pests or pathogens, increase in the number or density of invasive species, or restriction in the range of Covered Species at a regional or local scale. These issues are individually addressed in the sections below as they would pertain to changed circumstances in the Plan Area.

- Listing of species that are currently unlisted but occur within the HCP Plan Area.

- A change in the listing status (including de-listing) of a Covered Species through a formal status review by the Service and NMFS.

- Designation or revision of critical habitat for covered species or species listed after the start of the term of the ITP that may be affected by a Covered Activity.

- Stand replacing fire that (alone or in combination with other events such as blow-down) downgrades suitable habitat within the core area or home range of an activity center supported by a CSA on the FGS ownership to non-habitat, such that the CSA no longer provides demographic support to the Federal conservation strategy or meets the biological objectives of the HCP.

- Blow-down that (alone or in combination with other events such as fire) downgrades suitable habitat within the core area or home range of an activity center supported by a CSA on the FGS ownership to non-habitat, such that the CSA no longer provides demographic support to the Federal conservation strategy or meets the biological objectives of the HCP.

- Stand modification (e.g., changes in average diameter or canopy coverage) due to pests or pathogens, or their control, that (alone or in combination with other events such as fire and blow-down) downgrades suitable habitat within the core area or home range of an activity center supported by a CSA on the FGS ownership to non-habitat, such that the CSA no longer provides demographic support to the Federal conservation strategy or meets the biological objectives of the HCP.

- Introduction or invasion by exotic plant or animal species (e.g., barred owl) that affect Covered Species or their habitat.

The potential for each of these circumstances is reasonably foreseeable. As described in this subsection, FGS also has considered the potential for earthquakes to have effects that could constitute "changed circumstances." FGS's strategy for addressing each of these changed circumstances is described in the following. If changed circumstances occur, FGS will implement the supplemental prescriptions set forth in the HCP and summarized below.

Global Climate Change

According to the Service (USDI FWS 2008a), the potential effects of increasing atmospheric concentrations of carbon dioxide and other "greenhouse gases," and the observed increase in the average temperature of the Earth's atmosphere and oceans, have been the subject of considerable technical analysis and political debate. There is growing consensus that climate change is occurring and additional change is predicted. Global climate change has the potential to influence fire risk and the incidence of exotic species, flooding, drought, and disease at a regional and local scale. The impacts of these proximal events (e.g., fire, flood) due to global climate change are addressed in the following subsections as they would pertain to changed circumstances in the Plan Area.

There is considerable uncertainty associated with projecting future climate change. This is partly due to uncertainties about future emissions of greenhouse gases and to differences among climate models and simulations (Stainforth et al. 2005, Duffy et al. 2006). There are no known climate change simulations for the Klamath-Siskiyou region, but the results of numerous climate change simulations for California and the Pacific Northwest have been published. Together, these simulations describe a range of plausible outcomes from increased emissions of greenhouse gases.

The projected effects of climate change on local and regional temperatures, precipitation, vegetation, and fire are described below. Much of the following discussion was taken from the 12-Month Finding on a Petition to List the Siskiyou Mountains Salamander (*Plethodon stormi*) and Scott Bar Salamander (*Plethodon asupak*) as Threatened or Endangered (73 FR 4380; January 24, 2008). The 12-month finding on this petition is particularly relevant to the FGS HCP because the range of both of these species overlaps the Plan Area; thus, the analysis represents the best available information on the effects of global climate change in the Plan Area.

All of the studies that were reviewed predicted continued increases in average surface temperatures in California and the Pacific Northwest in response to increased emissions of greenhouse gases (Leung and Ghan 1999, Snyder et al. 2002, Electric Power Research Institute [EPRI] 2003, Hayhoe et al. 2004, Cayan et al. 2006, Duffy et al. 2006, Maurer 2007, Salathé et al. submitted). The magnitude of projected increases in annual average temperature varied widely among studies, depending on the models and emissions scenarios used, from 3 to 10.4°F, by the year 2100 (EPRI 2003, Hayhoe et al. 2004, Cayan et al. 2006, Maurer 2007). Simulations consistently project more pronounced temperature increases in California during the summer months than during other times of the year, 3.9 to 14.9 °F by 2100 (Hayhoe et al. 2004, Cayan et al. 2006, Maurer 2007). Some simulations projected more rapid temperature increases at higher elevations than at lower ones (Leung and Ghan 1999, Salathé et al. submitted). Most researchers attributed this difference to a snow albedo feedback effect; this occurs when increased surface temperatures cause earlier and faster snow melt, which, in turn, allows more absorption of heat by the ground and further increases in surface temperatures.

Reviews of a large number and variety of climate change simulations found that projected changes to precipitation in California were highly variable but clustered around no change or a slight increase in annual precipitation (Cayan et al. 2006, Maurer 2007). Warming temperatures are consistently projected to increase the proportion of precipitation that falls as rain rather than as snow in California and the Pacific Northwest (Leung and Ghan 1999, Snyder et al. 2002, Hayhoe et al. 2004, Cayan et al. 2006, Maurer 2007). Earlier and more rapid snowmelt and decreases in the proportion of precipitation that falls as snow are expected to cause declines in spring snowpacks (Hayhoe et al. 2004, Cayan et al. 2006, Maurer 2007). Declines in spring snowpacks have already occurred in some areas and are correlated with global warming trends (Mote 2003). However, despite regional warming over the past half century, the glaciers of Mount Shasta have continued to expand following a contraction during a prolonged drought in the early twentieth century (Howat et al. 2007). Some areas will experience increased cloud cover as surface temperatures continue to increase (Croke et al. 1999).

Vegetation modeling by Lenihan et al. (2003a, 2003b) projected that increased emissions of greenhouse gases will cause large-scale replacement of evergreen conifer forest (e.g., Douglas fir-white fir) with mixed evergreen forest (e.g., Douglas-fir-tanoak) in the Klamath- Siskiyou region. This redistribution of vegetation types is predicted to occur under conditions created by two contrasting climate change models (Lenihan et al. 2003a).

Loarie et al. (2008) projected that up to 66 percent of California's endemic flora would experience >80 percent reductions in range size as a result of anticipated climate changes. While this is a worst-case scenario based on high levels of CO_2 emissions in the future, a global climate model with high sensitivity to atmospheric greenhouse gas levels, and no dispersal component, the models ignore several factors that would exacerbate the projected impacts of climate change, including specialization to restricted soil types and the spread of invasive species. Because Yreka phlox is restricted to ultramafic soil types and has limited dispersal capabilities, global climate change could result in a reduction in the range of this species. However, it is difficult to speculate as to the extent of range reduction that could occur within the Plan Area and the complete loss of local populations is not anticipated. The conservation strategy for Yreka phlox addresses this potential for a range reduction by allowing seeds to be collected on FGS lands for long-term storage and development of techniques to reestablish populations, consistent with the Federal recovery strategy.

Despite variability in climate change simulations, consistent projections for warmer summers, reduced spring snowpacks, and earlier and more rapid snowmelt suggest that forests in California and the Pacific Northwest will experience longer fire seasons and more frequent, extensive, and severe fires in the future (Flannigan et al. 2000, Lenihan et al. 2003a, Whitlock et al. 2003, McKenzie et al. 2004). Whether or not these fire predictions will occur is unknown due to inconsistent predictions for precipitation, including increased cloud cover and rainfall. However, the planned response to changed circumstances related to wildfire is described below in the Fire and Wind section.

Listing of Species that are Currently Unlisted

The preamble to the No Surprises rule states that the listing of a species as endangered or threatened could constitute a changed circumstance.

If a species that is not a Covered Species under the HCP ("Non-Covered Species") is listed the Federal ESA subsequent to the effective date of the ITP, and the Non-Covered Species is affected by the Covered Activities, such listing will constitute a changed circumstance. If a Non-Covered Species that may be affected by a Covered Activity is listed under the Federal ESA during the term of the ITP, the Section 10 Permits will be reevaluated by the Service. The HCP Covered Activities may be modified, as necessary, to ensure that the activities covered under the HCP are not likely to jeopardize or result in the take of Non-Covered Species. FGS shall implement the modifications to the HCP Covered Activities determined by the Service in consultation with FGS to avoid the likelihood of jeopardy to or take of the Non-Covered Species. FGS shall continue to implement such modifications until such time as they apply for and the Service approves an Amendment of the Section 10 Permit, in accordance with applicable statutory and regulatory requirements, to cover the Non-Covered Species or until the Service notifies FGS in writing that the modifications to the HCP Covered Activities are no longer required to avoid the likelihood of jeopardy of Non-Covered Species.

Change in the Listing Status of Covered Species

It is conceivable that the listing status of a Covered Species could be changed (i.e., from Threatened to Endangered) through a formal status review during the term of the ITP. Because conservation measures for these species are included in this HCP and these species are "Covered" by the ITP being issued, a change in the listing status of these species would not be considered a changed circumstance and will not have the effect of causing additional land, mitigation, restrictions, or compensation to be required of FGS if this HCP is being implemented in compliance with the take authorization conditions for that species. Notwithstanding the above, the ITP may be suspended or revoked if continuation of the ITP would result in jeopardy.

If the listing status of a Covered Species is downgraded (i.e., from Endangered to Threatened) or the species is de-listed during the term of the ITP through a formal status review, then the HCP may be modified, as appropriate, to reduce or eliminate required measures for that species, if the Service concludes that such measures did not contribute, in whole or in part, to the decision to de-list the species and that modification of such measures is not likely to lead to or contribute to re-listing of the species. FGS will continue to implement the HCP in accordance with all applicable provisions until such time the company applies for and the Service approves an Amendment of the ITP.

Designation or Revision of Critical Habitat for Covered or Non-Covered Species

Critical habitat has been designated for some of the federally listed species covered by this HCP. If in the future, critical habitat that is currently designated for a Covered Species is revised, or critical habitat is newly designated for a Covered Species, and such designated or revised critical habitat may be affected by one or more Covered Activities, or if critical habitat is designated or revised for a Non-covered species and such designated or revised critical habitat may be affected by one or more Covered Activities, such revision or designation of critical habitat would constitute a changed circumstance, and the Section 10 permit will be reevaluated by the affected Service in consultation with FGS. If the affected Service concludes that one or more Covered Activities would adversely modify designated or revised critical habitat, the Covered Activity(ies) shall be modified to the extent necessary to avoid adverse modification. The affected Service shall work with FGS and with the other Service to limit any modifications to the Covered Activities to those that necessary to avoid adverse modification of critical habitat and are the least disruptive to FGS's on-going timber operations. FGS shall either implement the modifications to the Covered Activities identified by affected Service until the affected Service notifies FGS in writing that the modifications to the Covered Activities are no longer required to avoid adverse modification of critical habitat, or FGS may relinquish the Permits in accordance with applicable Service regulations. Notwithstanding the above, the ITPs may be suspended or revoked if continuation of the Permits would result in adverse modification of any newly designated or revised critical habitat.

Fire and Wind

Fire frequency, intensity, and size within the Plan Area have changed since the fire-suppression era (1950 to present) (Fry and Stephens, 2006). Prior to the fire-suppression era, fires occurred frequently; and in most of the vegetation assemblages covering large portions of the Klamath Mountains, they were of generally low to moderate and mixed severity (Skinner et al., 2006). Fires occurring in the fire-suppression era are less frequent and have greater intensity, resulting in a more homogeneous effect on the habitat by damaging and removing all vegetation (Fry and Stephens, 2006). These are often considered "stand-replacing" fires. Stand-replacing fires can cause immediate long-term changes that affect watershed processes, terrestrial and aquatic species and their habitats, and timber. Fire suppression is not a covered activity. The strategy for responding to and suppressing forest fires is generally established by CAL FIRE and USFS. FGS has little ability to influence such strategy.

A blow-down event in a CSA that downgrades suitable habitat for northern spotted owls to non-habitat could have adverse effects on this species, although, in some cases, trees blown down by wind can benefit northern spotted owls by providing habitat for their prey base.

Alteration of forest stands in the CSAs due to fire and wind (alone or in combination with other factors such as pest damage), can adversely affect habitat quantity and quality for northern spotted owls, reducing the effectiveness of the CSAs in meeting the biological objectives of the HCP. Because fire and wind have similar effects (i.e., tree removal and subsequent alteration of terrestrial habitats), they are considered as a group in terms of defining what may constitute a changed circumstance.

For northern spotted owls, it is important that enough suitable habitat is maintained within the CSAs to provide demographic support to the Federal conservation strategy and meet the objectives of the HCP. For this reason, the conditions for allowable harvest in a CSA (see section 5.3.1.1 of the HCP) are used to identify when the CSA may no longer provide demographic support of the Federal conservation strategy and could constitute a changed circumstance.

Changed Circumstances with Respect to Protection of the Northern Spotted Owl

The terrestrial species conservation program for northern spotted owl (see section 5.3.1.1 of the HCP) includes specific conditions under which harvest activities can be conducted in CSAs. The harvest restrictions are based on habitat targets for the CSA as a whole (regardless of ownership, established to promote a high probability of occupancy by northern spotted owl nesting pairs at these known activity centers with high conservation value to the Federal conservation strategy. If a stand replacing fire or damage due to wind results in a downgrade of suitable habitat within the core area or home range of an activity center supported by a CSA on the FGS ownership to non-habitat, such that the conditions for allowable harvest in the CSA (see section 5.3.1.1 of the HCP) can no longer be met over the term of the ITP, this will indicate that the CSA may no longer meet the objectives of the HCP and may constitute a changed circumstance. In the event that fire or wind affects a CSA by alteration of suitable northern spotted owl habitat, FGS will provide the Service with information regarding the habitat alteration due to fire or wind within

30 days of detection. FGS, in consultation with the Service, will determine if a changed circumstance has occurred, based on the quantity and quality of habitat for northern spotted owls that remains in the CSA or could develop over the term of the ITP. Based on the fire history database maintained by the USFS, it is reasonably foreseeable that up to four CSAs could be adversely affected by stand replacing fires during the term of the ITP, potentially resulting in a changed circumstance. The frequency of adverse effects due to wind cannot be estimated, but is anticipated to be less than the incidence of stand-replacing fires. If a changed circumstance affecting a CSA due to fire or wind occurs, FGS will apply the following supplemental prescriptions within affected CSAs.

1. Trees damaged or killed outright by fire or wind, including those in WLPZs or Stream Management Zones (SMZs), will be considered by FGS for salvage.

2. Salvage of trees downed or dead by fire or wind within CSAs must comply with State law, other terms of this HCP (i.e., on unstable areas), and be approved by the Service prior to removal.

3. Reforestation of any CSA affected by the fire or wind will be implemented as soon as reasonably possible. Equipment Exclusion Zones will be avoided during any reforestation activities associated with fire or wind.

4. FGS will enter into discussions with the Service regarding alternatives that would maintain the approximate conservation value provided by the affected CSA(s) under the original conservation strategy. Alternatives could include, but are not limited to, delayed harvest around nearby activity centers where take is authorized, or establishment of an alternative CSA with similar conservation value. If an alternative CSA is identified and approved through written concurrence by the Service, then FGS may conduct timber harvest operations within the fire or wind damaged CSA without further restriction, other than as specified in other sections of the HCP (i.e., the CSA will no longer be considered a conservation or mitigation area).

Pest or Pathogen Infestation

Insects and diseases can usually be kept under control through careful forest management and proper treatments. Natural control of insects can take place through climatic conditions, parasites, or predators via biological control. Defoliators, borers, bark beetles, and various terminal and root feeders, along with sucking insects, are common types of insects in California forests. However, large outbreaks of insects or pathogens are uncommon in the Plan Area.

Introduced pathogens can also lead to the decline of native tree species. One example is Sudden Oak Death (SOD) caused by *Phytophthora ramorum*. In 14 coastal California counties and Curry County, Oregon, *P. ramorum* has caused outbreaks of SOD, killing more than 1 million native oak and tanoak trees (California Oak Mortality Task Force [COMTF], 2008). Under a worst case circumstance, as infected trees die, the niche they occupied becomes colonized by other forest tree species. Because there are no known incidences of SOD within the Plan Area, and the Plan Area is in an area considered to have a very low risk of establishment and spread of

SOD (COMTF, 2008), the disease is not expected to have a measurable adverse effect on the Covered Species or on the functional attributes of the HCP.

Site quality and nutrient availability play a key role in forest health and vigor and susceptibility to insect or pathogen damage. Since much of the Plan Area is of moderate site quality, infestations are less likely to occur within the healthy forests that occupy these sites. Criteria for changed circumstances apply only to pest and pathogen damage that occurs in CSAs established around northern spotted owl activity centers.

The conservation measures identified in section 5.3.1.1 of the HCP provide protection against most pest or pathogen invasions by promoting forest health. However, prolonged drought as a result of global climate change could alter the resistance of native forests to various pests or pathogens. If stand modification due to pests or pathogens, or their control, (alone or in combination with other factors such as fire and wind) downgrades suitable habitat within the core area or home range of an activity center supported by a CSA on the FGS ownership to non-habitat, such that the conditions for allowable harvest in the CSA can no longer be met over the term of the ITP, this will indicate that the CSA may no longer meet the objectives of the HCP and may constitute a changed circumstance. FGS will provide the Service with information regarding the damage within 30 days of detection and, in consultation with the Service, will determine if a changed circumstance has occurred, based on the quantity and quality of habitat for northern spotted owls that remains in the CSA or could develop over the term of the ITP. If a changed circumstance affecting a CSA due to pests or pathogens occurs, FGS will apply the following supplemental prescriptions within affected CSAs.

1. Trees damaged or killed outright by pests or pathogens in a CSA, including those in WLPZs and SMZs, will be considered by FGS for salvage.

2. Salvage of trees damaged or killed by pests or pathogens within CSAs must comply with State law and be approved by the Service prior to removal.

3. Reforestation of any CSA affected by pests or pathogens, or their control, will be implemented as soon as reasonably possible. Equipment Exclusion Zones will be avoided during any reforestation activities associated with pests or pathogens.

4. FGS will enter into discussions with the Service regarding alternatives that would maintain the approximate conservation value provided by the affected CSA(s) under the original conservation strategy. Alternatives could include, but are not limited to, delayed harvest around nearby activity centers where take is authorized, or establishment of an alternative CSA with similar conservation value. If an alternative CSA is identified and approved through written concurrence by the Service, then FGS may conduct timber harvest operations within the pest or pathogen damaged CSA without further restriction, other than as specified in other sections of the HCP (i.e., the CSA will no longer be considered a conservation or mitigation area).

Invasive Species

The Service anticipates that barred owls will colonize suitable habitat within the Plan Area within the term of the ITP. Because barred owls select habitat similar to that occupied by northern spotted owls, it is likely that newly established barred owl territories will overlap and may displace northern spotted owls within some of the known activity centers. The function of CSAs in providing conservation support to high value activity centers will be compromised in direct proportion to the number of barred owls that colonize the CSAs. Displacement of northern spotted owls from a CSA is considered a changed circumstance and may require implementation of barred owl control measures. This low threshold for triggering barred owl management is necessary because offspring produced at established barred owl territories, regardless of location within CSAs or not, will increase the threat to northern spotted owl territories supported by CSAs.

To maintain the functionality of the Terrestrial Species Conservation Program, FGS will monitor the CSAs and other activity centers on its ownership for barred owl presence. If barred owls are detected in any CSA or activity center on the FGS ownership, FGS will notify the Service within 10 days of detection. FGS will enter into discussions with the Service regarding alternative management actions for barred owls. Such actions could include, but are not limited to, control of barred owls through removal and study of barred owl/northern spotted owl interactions. As part of the ITP issuance, FGS will apply for a Federal Depredation Permit for barred owls as needed. FGS will help to facilitate (e.g., through providing access to and across its ownership) implementation of barred owl control measures deemed appropriate by the Service at the time of detection.

Earthquakes

The Plan Area is located in an area that is not known for earthquakes. Earthquakes are quite uncommon and are generally of a relatively insignificant magnitude, typically 2 to 3 on the Richter scale. Occasionally, greater magnitude events occur, but they are impossible to predict. In the forest environment, earthquakes of magnitude 6 or less on the Richter scale produce little, if any, visible change, and apparently have little impact on wildlife or fishery habitat.

While it may be speculated that localized landslides or other earth movements resulted from these earthquakes, there are no data to document that this occurred within the Plan Area.

An earthquake of such magnitude (greater than magnitude 6 on the Richter scale) that may substantially alter habitat status or require additional conservation or mitigation measures in excess of those already included in the Plan is not reasonably foreseeable during the life of the Plan, and would be considered an “unforeseen circumstance.”

1.4.5.2 Unforeseen Circumstances

Unforeseen circumstances are changes in circumstances affecting a species or geographic area covered by the HCP that could not reasonably have been anticipated by FGS and the Service at the time the HCP was developed and negotiated, and that result in a substantial and adverse change in the status of a Covered Species (50 CFR 17.3 and 222.102). The Service bears the burden of demonstrating that unforeseen circumstances exist, using the best scientific and commercial data available. All changes not described above as "changed circumstances" that would result in a substantial and adverse change in the status of a Covered Species are considered unforeseen circumstances.

In case of an unforeseen event, FGS will immediately notify the Service. In determining whether such an event constitutes an unforeseen circumstance, the Service shall consider, but not be limited to, the following factors: size of the current range of the affected species; percentage of range adversely affected by the HCP; percentage of range conserved by the HCP; ecological significance of that portion of the range affected by the HCP; level of knowledge about the affected species and the degree of specificity of the species' conservation program under the HCP; and whether failure to adopt additional conservation measures would appreciably reduce the likelihood of survival and recovery of the affected species in the wild.

If the Service determines that additional conservation and mitigation measures are necessary to respond to the unforeseen circumstances, and the HCP is being properly implemented, the additional measures required will be, to the maximum extent practicable, as close as possible to the terms of the original HCP, and must be limited to modifications within any conserved habitat area or to adjustments within lands or waters that already are set-aside in the HCP's operating conservation program. Additional conservation and mitigation measures shall not involve the commitment of additional land or financial compensation, or restrictions on the use of land or other natural resources otherwise available for development or use under the original terms of the HCP without the consent of the permit holder.

1.4.6 Funding

FGS has been a business entity since 1907 and has an established track record as a forest products company. In general, FGS will finance the HCP with revenues from its ongoing timber harvest operations. Accordingly, as harvesting is planned and carried out, it will provide the funds needed to carry out the HCP's measures to mitigate the impacts of take.

As described throughout the HCP, and as warranted in the IA, FGS has committed to expend the necessary funds to fulfill its obligations under the plan. After the issuance of the ITP by the Service, FGS will post a security deposit as an additional form of assurance that adequate funding will be provided for the HCP.

Further, by January 1st of each calendar year during the term of the ITP, and following the adoption of FGS company budget by its Board of Directors (which normally occurs by the end of November of the prior year), FGS will provide the Service with a Yearly Expenditure Report (YER). The YER will, when appropriate, identify the HCP tasks undertaken the prior year, and the funds expended to implement those tasks. The YER will also identify: (1) HCP tasks FGS intends to implement in the upcoming calendar year (e.g., monitoring, surveying), (2) out-of-pocket expenditures related to those tasks (e.g., hiring of outside specialists), (3) funds budgeted for those purposes, and (4) whether the budgeted funds are THP-related or not. FGS must provide this information to the Service for their review and concurrence before any activity authorized by the HCP may commence.

1.4.7 Modifications and Amendments

There are two types of changes that may be made to the HCP and/or the HCP Permits and/or its associated documents:

- Minor Modifications
- Amendments

Minor Modifications and Amendments shall be processed in accordance with the provisions of the IA and all applicable legal requirements, including but not limited to the ESA, NEPA, and any applicable Federal regulations.

1.4.7.1 Minor Modifications

Minor Modifications to the HCP are changes provided for under the operating conservation program. Minor Modifications do not (1) modify the scope or nature of activities or actions covered by the Section 10(a)(1)(B) permit; (2) result in operations under the HCP that are significantly different from those contemplated or analyzed in connection with the Plan as approved; (3) result in adverse impacts on the environment that are new or significantly different from those analyzed in connection with the Plan as approved; or (4) result in additional take not analyzed in connection with the HCP as approved. As noted above, Minor Modifications shall be processed in accordance with the provisions of the IA and all applicable legal requirements, including but not limited to the ESA, NEPA, and any applicable Federal regulations.

Minor Modifications to the HCP may include, but are not limited to, the following:

1. Correcting any maps or exhibits in mapping or boundary lines.

2. Modifying existing or establishing new avoidance or minimization measures that incorporate new nomenclature or technology. Any new or modified measures will not be substantially different in nature from existing measures and will achieve equivalent or greater protection for Covered Species.

3. Making minor changes to monitoring or reporting protocols.

4. Revising mitigation area enhancement and management techniques.

5. Making minor modifications to the HCP that are consistent with the biological goals and objectives of the HCP, and that the Service has analyzed and agreed to.

It is anticipated that FGS may, over the term of the ITP, sell or acquire additional timberlands in drainages where they currently have ownership. Sales and acquisitions of lands to be covered by the HCP shall be subject to the provisions of the IA and all applicable legal requirements, including but not limited to the ESA, NEPA, and any applicable Federal regulations.

1.4.7.2 Amendments to the HCP

Amendments to the HCP include, but are not limited to changes that affect the scope of the HCP and conservation strategy, increase the amount of take, add new species, or change significantly the boundaries of the HCP. Amendments to the HCP require an amendment to the Section 10(a)(1)(B) permits and to the Service decision documents, including NEPA documents, biological opinions, and findings and recommendations documents. Amendments will also require additional public review and comment. As noted above, Amendments shall be processed in accordance with the provisions of the IA and all applicable legal requirements, including but not limited to the ESA, NEPA, and any applicable Federal regulations.

The following describes several types of changes that would require an Amendment to the HCP.

1. The listing under the ESA of a new species within the Plan Area that is not an HCP Covered Species but may be affected by HCP Covered Activities, and for which the permittee seeks coverage under the HCP and Section 10(a)(1)(B) permit.

2. Significant changes to the HCP including, but not limited to the following:

    a. Changes to the method for calculating compensation for incidental take, which would increase the levels of incidental take permitted for the HCP.

    b. A material change in the level of funding except as otherwise provided for in the HCP to account for all adjustments for inflation and changed circumstances.

3. Changes to the Covered Activities that were not addressed in the HCP as originally adopted, and which otherwise do not meet the provisions for Minor Modifications above.

4. Extending the term of the ITP past the 50-year term.

5. Changes in the Plan Area through acquisition of properties that exceed the limit of 10 percent of the Initial Plan Area (15,218 acres).

6. Changes in the Plan Area through the sale of properties that provide suitable habitat for any of the Covered Species or mitigation for impacts to these species on the remaining ownership and the new owner(s) do not wish to assume the obligations of the ITP through the process identified below in section 1.4.7.6.

1.4.7.3 Amendments to the Section 10(a)(1)(B) Permits

Amendments to the HCP will require an amendment to the Section 10(a)(1)(B) permit. Amendments to the Section 10(a)(1)(B) permit shall be processed in accordance with the provisions of the IA and all applicable legal requirements, including but not limited to the ESA, NEPA, and any applicable Federal regulations.

1.4.7.4 Permit Transfer

All or a portion of the ITP may be transferred to a third party in accordance with the current statutory and regulatory requirements governing such transfers. Currently, regulations governing ITP transfers are codified at 50 C.F.R. 13.25(b). If the sale or transfer of a single or multiple parcels over the term of the ITP cumulatively involves more than 10 percent of the Initial Plan Area (15,218 acres) and the new owner(s) do not wish to accept transfer of the ITP, then FGS must apply for an Amendment to the HCP and ITP (see section 1.4.7.2). For the "No Surprises" assurances for Yreka phlox to be extended to the new owner(s), the new owner(s) must continue to implement the conservation measures specified in the HCP.

If the sale or transfer involves land committed as mitigation under the HCP (i.e., CSAs) and the new owner(s) do not wish to transfer the ITP, then FGS must provide mitigation on the remainder of its ownership that is equivalent in value to the mitigation areas being sold or transferred. In consultation with the Service, FGS will select and maintain CSAs around activity centers that provide an equivalent level of mitigation based on total conservation value. FGS will adhere to the Plan measures (meeting the biological goals and objectives) on the remaining Plan Area for the original term of the ITP (50 years from issuance).

If the sale or transfer involves land where incidental take of owls is authorized under the HCP (i.e., 'take' sites) and the new owner(s) do not wish to transfer the ITP, then FGS must provide mitigation for the take of owls at the 3:1 mitigation ratio provided for in the Terrestrial Species Conservation Strategy. In consultation with the Service, FGS will select and maintain CSAs around activity centers on the remaining ownership that meet the 3:1 mitigation ratio based on total conservation value. FGS's mitigation commitment does not relieve the new owner's obligation under the Federal ESA.

FGS, however, will not be required to establish additional CSAs for mitigation on its ownership if the new owner(s) apply for and receive authorization for transfer of the ITP or if the land sold or transferred is mitigation for the take sites (i.e., at a 3:1 ratio based on conservation value). FGS will adhere to the Plan measures (meeting the biological goals and objectives) on the remaining Plan Area for the original term of the ITP (50 years from issuance).

1.4.7.5 Early Termination

In the event of early termination of the HCP and ITP, FGS will carry out all outstanding mitigation obligations as follows:

- FGS will mitigate any incidental take that has occurred as a result of habitat modification by maintaining one or more CSAs that provide an overall conservation value equal to at least three (3) times the conservation value of the activity centers where take has occurred for the original term of the ITP.

Under the HCP, incidental take through habitat modification is authorized at 43 known activity centers that provide 18 percent of the total conservation value of known activity centers in the Action Area. The impacts of this taking are mitigated by the development, protection, and enhancement of suitable northern spotted owl habitat on the FGS ownership within 24 CSAs that provide 55 percent of the total conservation value of known activity centers in the Action Area (a 3:1 ratio). This same mitigation ratio (3:1) will be used in the event of early termination to identify the appropriate level of mitigation for incidental take that has occurred prior to termination of the HCP and ITP.

The level of incidental take that has occurred prior to termination of the HCP will be based on the amount (acreage) and location of suitable northern spotted owl habitat within the core and home range of known activity centers within the Action Area that are rendered unsuitable. In the event of early termination of the HCP and ITP, FGS will field verify the extent of habitat conversion for activity centers where incidental take is authorized to determine, in consultation with the Service, the level of take that has occurred prior to termination of the HCP and ITP. The sum of the conservation value of those activity centers where incidental take due to habitat modification has occurred is the level of impact that must be mitigated at a 3:1 ratio. In consultation with the Service, FGS will select an adequate number of CSAs from those established in the Plan to meet the 3:1 mitigation ratio based on total conservation value. FGS will adhere to the Plan measures (harvest restrictions and habitat commitments) (see Table 1) in the selected CSAs for the original term of the ITP (50 years from issuance).

2.0 STATUS OF THE SPECIES

2.1 Northern Spotted Owl

2.1.1 Legal Status

The northern spotted owl was listed as threatened on June 26, 1990 due to widespread loss and adverse modification of suitable habitat across the owl’s entire range and the inadequacy of existing regulatory mechanisms to conserve the owl (USDI FWS 1990a). The U.S. Fish and Wildlife Service recovery priority number for the northern spotted owl is 6C, on a scale of 1C (highest) to 18 (lowest) (USDI FWS 1983a, 1983b, 2004a). This number reflects a high degree of threat, a low potential for recovery, and the owl’s taxonomic status as a subspecies. The “C” reflects conflict with development, construction, or other economic activity. The northern spotted owl was originally listed with a recovery priority number of 3C, but that number was changed to 6C in 2004 during the 5-year review of the species (USDI FWS 2004a).

2.1.2 Life History

2.1.2.1 Taxonomy

The northern spotted owl is one of three subspecies of spotted owls currently recognized by the American Ornithologists’ Union. The taxonomic separation of these three subspecies is supported by genetic (Barrowclough and Gutiérrez 1990, Barrowclough et al. 1999, Haig et al. 2004), morphological (Gutiérrez et al. 1995), and biogeographic information (Barrowclough and

Gutiérrez 1990). The distribution of the Mexican subspecies (*S. o. lucida*) is separate from those of the northern and California (*S. o. occidentalis*) subspecies (Gutiérrez et al. 1995). Recent studies analyzing mitochondrial DNA sequences (Haig et al. 2004, Chi et al. 2004, Barrowclough et al. 2005) and microsatellites (Henke et al., unpubl. data) confirmed the validity of the current subspecies designations for northern and California spotted owls. The narrow hybrid zone between these two subspecies, which is located in the southern Cascades and northern Sierra Nevadas, appears to be stable (Barrowclough et al. 2005).

2.1.2.2 Physical Description

The northern spotted owl is a medium-sized owl and is the largest of the three subspecies of spotted owls (Gutiérrez et al. 1995). It is approximately 18 inches to 19 inches long and the sexes are dimorphic, with males averaging about 13 percent smaller than females. The mean mass of 971 males taken during 1,108 captures was 1.28 pounds (out of a range of 0.95 pound to 1.52 pounds), and the mean mass of 874 females taken during 1,016 captures was 1.46 pounds (out of a range of 1.1 pounds to 1.95 pounds) (P. Loschl and E. Forsman, pers. comm. cited in USDI FWS 2008a). The northern spotted owl is dark brown with a barred tail and white spots on its head and breast, and it has dark brown eyes surrounded by prominent facial disks. Four age classes can be distinguished on the basis of plumage characteristics (Forsman 1981, Moen et al. 1991). The northern spotted owl superficially resembles the barred owl, a species with which it occasionally hybridizes (Kelly and Forsman 2004). Hybrids exhibit physical and vocal characteristics of both species (Hamer et al. 1994).

2.1.2.3 Current and Historical Range

The current range of the northern spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USDI FWS 1990a). The range of the northern spotted owl contacts the range of the range of the California spotted owl in northern California near the southern end of the Cascade Range (Thomas et al. 1990, USDI FWS 1992b, Barrowclough et al. 1999, Haig et al. 2001). The range of the northern spotted owl is partitioned into 12 physiographic provinces (see Figure 1) based on recognized landscape subdivisions exhibiting different physical and environmental features (Thomas et al. 1993). These provinces are distributed across the species' range as follows:

- Four provinces in Washington: Eastern Washington Cascades, Olympic Peninsula, Western Washington Cascades, Western Washington Lowlands

- Five provinces in Oregon: Oregon Coast Range, Willamette Valley, Western Oregon Cascades, Eastern Oregon Cascades, Oregon Klamath

- Three provinces in California: California Coast, California Klamath, California Cascades

The northern spotted owl is extirpated or uncommon in certain areas such as southwestern Washington and British Columbia. Timber harvest activities have eliminated, reduced or fragmented northern spotted owl habitat sufficiently to decrease overall population densities across its range, particularly within the coastal provinces where habitat reduction has been concentrated (Thomas and Raphael 1993).

2.1.2.4 Behavior

Locomotion

Northern spotted owls spend virtually their entire lives beneath the forest canopy (Courtney et al. 2004). It is adapted to maneuverability beneath the forest canopy rather than strong, sustained flight, and mostly makes numerous short flights during the day (Gutiérrez et al. 1995). Foraging is accomplished by moving from perch to perch through the forest, perching and waiting for prey activity and then pouncing on prey once it is located by sight or sound (Forsman 1976, 1980; Forsman et al. 1984; Gutiérrez et al. 1995).

Roosting and Thermoregulation

Northern spotted owls seek sheltered roosts to avoid inclement weather, summer heat, and predation (Forsman 1976, 1980; Barrows and Barrows 1978; Barrows 1981; Forsman et al. 1984; Ting 1998). During warm weather, northern spotted owls seek roosts in shady recesses of understory trees and occasionally will even roost on the ground (Barrows and Barrows 1978; Barrows 1981; Forsman et al. 1984; Gutiérrez et al. 1995). In winter, they roost relatively high near the bole of canopy trees with overhanging branches to shelter themselves from precipitation, or when sunny, will seek roosts with sun exposure (Sisco 1984). Both adults and juveniles have been observed drinking water, primarily during the summer, and is thought to be associated with thermoregulation (Gutiérrez et al. 1995).

Daily Activity Pattern

Northern spotted owls are primarily noctural (Forsman et al. 1984). They forage between dawn and dusk and sleep during the day with peak activity occurring during the two hours after sunset and the two hours prior to sunrise (Forsman et al. 1984, Gutiérrez et al. 1995, Delaney et al. 1999). They will sometimes take advantage of vulnerable prey near their roosts during the day (Laymon 1991, Sovern et al. 1994).

Agonistic Behavior and Territoriality

Northern spotted owls are territorial. They become alert when roosting whenever large birds fly over the canopy or when potential predators enter their nesting or roosting stands (Forsman 1976, Gutiérrez et al. 1995). They will actively defend their nests and young from predators (Forsman 1976, Gutiérrez et al. 1995). Northern spotted owls will regularly confront other northern spotted owls with aggressive vocal displays (Forsman 1976, 1980, Forsman et al. 1984, Gutiérrez et al. 1995, Franklin et al. 1996). Territorial defense is primarily effected by hooting, barking and whistle type calls. However, home ranges of adjacent pairs overlap (Forsman et al. 1984, Solis and Gutiérrez 1990) suggesting that the area defended is smaller than the area used for foraging. It appears that they learn to recognize their neighbor's voices and respond to them much less vigorously (Fitton 1991, Waldo 2002). Some northern spotted owls are not territorial but either remain as residents within the territory of a pair or move among territories (Gutiérrez 1996). These birds are referred to as “floaters.” Floaters have special significance in northern spotted owl populations because they may buffer the territorial population from decline (Franklin 1992). Little is known about floaters other than that they exist and typically do not respond to calls as vigorously as territorial birds (Gutiérrez 1996).

Pair Behavior

Northern spotted owls are monogamous and usually form long-term pair bonds. “Divorces” occur but are relatively uncommon. There are no known examples of polygyny in this owl, although associations of three or more birds have been reported (Gutiérrez et al. 1995).

2.1.2.5 Habitat Relationships

Home Range

Home-range sizes vary geographically, generally increasing from south to north, which is likely a response to differences in habitat quality (USDI FWS 1990a). Estimates of median size of their annual home range (the area traversed by an individual or pair during their normal activities (Thomas and Raphael 1993) vary by province and range from 2,955 acres in the Oregon Cascades (Thomas et al. 1990) to 14,211 acres on the Olympic Peninsula (USDI FWS 1994a). Zabel et al. (1995) showed that these provincial home ranges are larger where flying squirrels (*Glaucomys sabrinus*) are the predominant prey and smaller where wood rats (*Neotoma* spp.) are the predominant prey. Home ranges of adjacent pairs overlap (Forsman et al. 1984, Solis and Gutiérrez 1990), suggesting that the defended area is smaller than the area used for foraging. Within the home range there is a smaller area of concentrated use during the breeding season (~20% of the home range), often referred to as the core area (Bingham and Noon 1997). Northern spotted owl core areas vary in size geographically and provide habitat elements that are important for the reproductive efficacy of the territory, such as the nest tree, roost sites and foraging areas (Bingham and Noon 1997). Northern spotted owls use smaller home ranges during the breeding season and often dramatically increase their home range size during fall and winter (Forsman et al. 1984, Sisco 1990).

Although differences exist in natural stand characteristics that influence home range size, habitat loss and forest fragmentation effectively reduce habitat quality in the home range. A reduction in the amount of suitable habitat reduces northern spotted owl abundance and nesting success (Bart and Forsman 1992, Bart 1995).

Habitat Use and Selection

Forest types that support the northern spotted owl across its geographic range include Douglas-fir, western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), white fir, Pacific silver fir (*Abies amabilis*), Shasta red fir (*Abies magnifica shastensis*), Sitka spruce (*Picea sitchensis*), mixed evergreen, mixed conifer hardwood (Klamath montane), redwood (*Sequoia sempervirens*) in coastal California and southwestern Oregon, and the moist end of the ponderosa pine coniferous forests zones at elevations up to approximately 3,000 feet near the northern edge of the range and up to approximately 6,000 feet at the southern edge (Forsman et al. 1984, Franklin and Dyrness 1988, Thomas et al. 1990, Davis and Lint 2005). The upper elevation limit at which northern spotted owls occur corresponds to the transition to subalpine forest, which is characterized by relatively simple structure and severe winter weather (Forsman 1976, Forsman et al. 1984).

Northern spotted owls generally rely on older forested habitats because such forests contain the structures and characteristics required for nesting, roosting, and foraging. Features that support nesting and roosting typically include a moderate to high canopy closure (60 to 90 percent); a multi-layered, multi-species canopy with large overstory trees (generally greater than 30 inches dbh); a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe infections, and other platforms); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for northern spotted owls to fly (Thomas et al. 1990). Nesting and roosting northern spotted owls consistently occupy stands with a high degree of canopy closure that may provide thermoregulatory benefits (Weathers et al. 2001), and protection from predators and adverse weather conditions. Patches of nesting habitat, in combination with roosting habitat, must be sufficiently large and contiguous to maintain northern spotted owl core areas and home ranges, and must be proximate to foraging habitat.

Northern spotted owls nest almost exclusively in trees. Like roosts, nest sites are found in forests having complex structure dominated by large diameter trees (Forsman et al. 1984, Hershey et al. 1998). Even in forests that have been previously logged, northern spotted owls select forests having a structure (i.e., larger trees, greater canopy closure) different than forests generally available to them (Folliard 1993, Buchanan et al. 1995, Hershey et al. 1998). Nesting habitat can also function as roosting, foraging, and dispersal habitat.

Roosting habitat differs from nesting habitat in that it need not contain those specific structural features used for nesting, such as cavities, broken tops, and mistletoe platforms. Roost sites selected by northern spotted owls have more complex vegetation structure than forests generally available to them (Barrows and Barrows 1978, Forsman et al. 1984, Solis and Gutiérrez 1990). These habitats are usually multi-layered forests having high canopy closure and large diameter trees in the overstory. Roosting habitat will also function as foraging and dispersal habitat, but not as nesting habitat due to lack of nesting structures.

Foraging habitat for northern spotted owls provides a food supply for survival and reproduction. Foraging habitat is the most variable of all habitats used by territorial northern spotted owls (USDI FWS 1992b). Descriptions of foraging habitat have ranged from complex structure (Solis and Gutiérrez 1990) to forests with lower canopy closure and smaller trees than forests containing nests or roosts (Gutiérrez 1996). Foraging activity is positively associated with tree height diversity (North et al. 1999), canopy closure (Irwin et al. 2000, Courtney et al. 2004), snag volume, density of snags greater than 20 in dbh (North et al. 1999, Irwin et al. 2000, Courtney et al. 2004), density of trees greater than or equal to 31 in dbh (North et al. 1999), volume of woody debris (Irwin et al. 2000), and young forests with some structural characteristics of old forests (Carey et al.1992, Irwin et al. 2000). Northern spotted owls select old forests for foraging in greater proportion than their availability at the landscape scale (Carey et al. 1992, Carey and

Peeler 1995, Forsman et al. 2004), but will forage in younger stands with high prey densities and access to prey (Carey et al. 1992, Rosenberg and Anthony 1992, Thome et al. 1999). Foraging habitat contains some roosting habitat attributes but can consist of more open and fragmented forests or, especially in the southern portion of the range, some younger stands may have high prey abundance and structural attributes similar to those of older forests (e.g., moderate tree density, subcanopy perches at multiple levels, multi-layered vegetation, residual older trees). Foraging habitat can also function as dispersal habitat.

Dispersal habitat is essential to maintaining stable populations by filling territorial vacancies when resident northern spotted owls die or leave their territories, and for providing adequate gene flow across the range of the species. Dispersal habitat includes forest types that support either the transience phase of dispersal or the colonization phase of dispersal. Habitat supporting the transience phase of dispersal consists, at a minimum, of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities. Dispersal habitat may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding for dispersing juveniles (USDI FWS 1992a). Habitat supporting the colonization phase of dispersal is generally equivalent to roosting and foraging habitat, although it may be in smaller amounts than that needed to support nesting pairs. Forsman et al. (2002) found that northern spotted owls could disperse through highly fragmented forest landscapes. However, the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004).

Northern spotted owls may be found in younger forest stands that have the structural characteristics of older forests or retained structural elements from the previous forest. In redwood forests and mixed conifer-hardwood forests along the coast of northwestern California, considerable numbers of northern spotted owls also occur in younger forest stands, particularly in areas where hardwoods provide a multi-layered structure at an early age (Thomas et al. 1990; Diller and Thome 1999). In mixed conifer forests in the eastern Cascades in Washington, 27 percent of nest sites were in old-growth forests, 57 percent were in the understory reinitiation phase of stand development, and 17 percent were in the stem exclusion phase (Buchanan et al. 1995). In the western Cascades of Oregon, 50 percent of northern spotted owl nests were in late-seral/old-growth stands (greater than 80 years old), and none were found in stands less than 40 years old (Irwin et al. 2000).

In the Western Washington Cascades, northern spotted owls roosted in mature forests dominated by trees greater than 19.7 inches dbh with greater than 60 percent canopy closure more often than expected during the non-breeding season. Northern spotted owls also used young forest (trees of 7.9 inches to 19.7 inches dbh with greater than 60 percent canopy closure) less often than expected based on the availability of this habitat (Herter et al. 2002).

In the Coast Ranges, Western Oregon Cascades and the Olympic Peninsula, radio-marked northern spotted owls selected old-growth and mature forests for foraging and roosting and used young forests less than predicted based on availability (Forsman et al. 1984, Carey et al. 1990, Forsman et al. 2005). Glenn et al. (2002) studied northern spotted owls in young forests in western Oregon and found little preference among age classes of young forest.

Habitat use is influenced by prey availability. Ward (1990) found that northern spotted owls foraged in areas with lower variance in prey densities (that is, where the occurrence of prey was more predictable) within older forests and near ecotones of old forest and brush seral stages. Zabel et al. (1995) showed that northern spotted owl home ranges are larger where flying squirrels are the predominant prey and smaller where wood rats are the predominant prey.

Recent landscape-level analyses in portions of the Oregon Coast and California Klamath provinces suggest that a mosaic of late-successional habitat interspersed with other seral conditions may benefit northern spotted owls more than large, homogeneous expanses of older forests (Meyer et al. 1998, Franklin et al. 2000, Zabel et al. 2003). In the Oregon Klamath and Western Oregon Cascade provinces, Dugger et al. (2005) found that apparent survival and reproduction was positively associated with the proportion of older forest near the territory center (within 2,395 feet). Survival decreased dramatically when the amount of non-habitat (e.g., non-forest areas, sapling stands) exceeded approximately 50 percent of the home range (Dugger et al. 2005). The authors concluded that they found no support for either a positive or negative direct effect of intermediate-aged forest (i.e., forest stages between sapling and mature, with total canopy cover greater than 40 percent) on either the survival or reproduction of northern spotted owls. It is unknown how these results were affected by the low habitat fitness potential in their study area, which Dugger et al. (2005) stated was generally much lower than those in Franklin et al. (2000) and Olson et al. (2004), and the low reproductive rate and survival in their study area, which they reported were generally lower than those studied by Anthony et al. (2006). Olson et al. (2004) found that reproductive rates fluctuated biennially and were positively related to the amount of edge between late-seral and mid-seral forests and other habitat classes in the central Oregon Coast Range. Olson et al. (2004) concluded that their results indicate that while mid-seral and late-seral forests are important to northern spotted owls, a mixture of these forest types with younger forest and non-forest may be best for northern spotted owl survival and reproduction in their study area.

2.1.2.6 Reproductive Biology

The northern spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman et al. 1984, Gutiérrez et al. 1995). Northern spotted owls are sexually mature at 1 year of age, but rarely breed until they are 2 to 5 years of age (Miller et al. 1985, Franklin 1992, Forsman et al. 2002). Breeding females lay one to four eggs per clutch, with the average clutch size being two eggs; however, most northern spotted owl pairs do not nest every year, nor are nesting pairs successful every year (Forsman et al. 1984, USDI FWS 1990b, Anthony et al. 2006), and renesting after a failed nesting attempt is rare (Gutiérrez 1996). The small clutch size, temporal variability in nesting success, and delayed onset of breeding all contribute to the relatively low fecundity of this species (Gutiérrez 1996).

Courtship behavior usually begins in February or March, and females typically lay eggs in late March or April. The timing of nesting and fledging varies with latitude and elevation (Forsman et al. 1984). After they leave the nest in late May or June, juvenile northern spotted owls depend on their parents until they are able to fly and hunt on their own. Parental care continues after fledging into September (Forsman et al. 1984, USDI FWS 1990a). During the first few weeks after the young leave the nest, the adults often roost with them during the day. By late summer, the adults are rarely found roosting with their young and usually only visit the juveniles to feed them at night (Forsman et al. 1984). Telemetry and genetic studies indicate that close inbreeding between siblings or parents and their offspring is rare (Haig et al. 2001, Forsman et al. 2002). Hybridization of northern spotted owls with California spotted owls and barred owls has been confirmed through genetic research (Hamer et al. 1994, Gutiérrez et al. 1995, Dark et al. 1998, Kelly 2001, Funk et al. 2008).

2.1.2.7 Dispersal Biology

Natal dispersal of northern spotted owls typically occurs in September and October with a few individuals dispersing in November and December (Miller et al. 1997, Forsman et al. 2002). Natal dispersal occurs in stages, with juveniles settling in temporary home ranges between bouts of dispersal (Miller et al. 1997, Forsman et al. 2002). The median natal dispersal distance is about 10 miles for males and 15.5 miles for females (Forsman et al. 2002). Dispersing juvenile northern spotted owls experience high mortality rates, exceeding 70 percent in some studies (Miller 1989, USDI FWS 1990a). Known or suspected causes of mortality during dispersal include starvation, predation, and accidents (Miller 1989, USDI FWS 1990a, Forsman et al. 2002). Parasitic infection may contribute to these causes of mortality, but the relationship between parasite loads and survival is poorly understood (Hoberg et al. 1989, Gutiérrez 1989, Forsman et al. 2002). Successful dispersal of juvenile northern spotted owls may depend on their ability to locate unoccupied suitable habitat in close proximity to other occupied sites (LaHaye et al. 2001).

There is little evidence that small openings in forest habitat influence the dispersal of northern spotted owls, but large, non-forested valleys such as the Willamette Valley apparently are barriers to both natal and breeding dispersal (Forsman et al. 2002). The degree to which water bodies, such as the Columbia River and Puget Sound, function as barriers to dispersal is unclear, although radio telemetry data indicate that northern spotted owls move around large water bodies rather than cross them (Forsman et al. 2002). Analysis of the genetic structure of northern spotted owl populations suggests that gene flow may have been adequate between the Olympic Mountains and the Washington Cascades, and between the Olympic Mountains and the Oregon Coast Range (Haig et al. 2001).

Breeding dispersal occurs among a small proportion of adult northern spotted owls; these movements were more frequent among females and unmated individuals (Forsman et al. 2002). Breeding dispersal distances were shorter than natal dispersal distances and also are apparently random in direction (Forsman et al. 2002). In California spotted owls, a similar subspecies, the probability for dispersal was higher in younger owls, single owls, paired owls that lost mates, owls at low quality sites, and owls that failed to reproduce in the preceeding year (Blakesley et al. 2006). Both males and females dispersed at near equal proportions and distances (Blakesley et al. 2006). Dispersal resulted in improved territory quality in 72 percent of cases (Blakesley et al. 2006).

2.1.2.8 Food Habits

Northern spotted owls are mostly nocturnal, although they also forage opportunistically during the day (Forsman et al. 1984, Sovern et al. 1994). The composition of the northern spotted owl's diet varies geographically and by forest type. Generally, flying squirrels are the most prominent prey for northern spotted owls in Douglas-fir and western hemlock forests (Forsman et al. 1984) in Washington and Oregon, while dusky-footed wood rats (*Neotoma fuscipes*) are a major part of the diet in the Oregon Klamath, California Klamath, and California Coastal provinces (Forsman et al. 1984, 2001, 2004, Ward et al. 1998, Hamer et al. 2001). Depending on location, other important prey include deer mice (*Peromyscus maniculatus*), tree voles (*Arborimus longicaudus, A. pomo*), red-backed voles (*Clethrionomys* gapperi), gophers (*Thomomys* spp.), snowshoe hare (*Lepus americanus*), bushy-tailed wood rats (*Neotoma cinerea*), birds, and insects, although these species comprise a small portion of the northern spotted owl diet (Forsman et al. 1984, 2004, Ward et al. 1998, Hamer et al. 2001).

Other prey species such as the red tree vole (*Arborimus longicaudus)*, red-backed voles, mice, rabbits and hares, birds, and insects may be seasonally or locally important (reviewed by Courtney et al. 2004). For example, Rosenberg et al. (2003) showed a strong correlation between annual reproductive success of northern spotted owls (number of young per territory) and abundance of deer mice ($r^2 = 0.68$), despite the fact they only made up 1.6±0.5 percent of the biomass consumed. However, it is unclear if the causative factor behind this correlation was prey abundance or a synergistic response to weather (Rosenberg et al. 2003). Ward (1990) also noted that mice were more abundant in areas selected for foraging by owls. Nonetheless, northern spotted owls deliver larger prey to the nest and eat smaller food items to reduce foraging energy costs; therefore, the importance of smaller prey items, like *Peromyscus*, in the northern spotted owl diet should not be underestimated (Forsman et al. 1984, 2001, 2004).

2.1.2.9 Population Dynamics

The northern spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman et al. 1984, Gutiérrez et al. 1995). The northern spotted owl's long reproductive life span allows for some eventual recruitment of offspring, even if recruitment does not occur each year (Franklin et al. 2000).

Annual variation in population parameters for northern spotted owls has been linked to environmental influences at various life history stages (Franklin et al. 2000). In coniferous forests, mean fledgling production of the California spotted owl, a closely related subspecies, was higher when minimum spring temperatures were higher (North et al. 2000), a relationship that may be a function of increased prey availability. Across their range, northern spotted owls have previously shown an unexplained pattern of alternating years of high and low reproduction, with highest reproduction occurring during even-numbered years (e.g., Franklin et al. 1999). Annual variation in breeding may be related to weather (i.e., temperature and precipitation; Wagner et al. 1996 and Zabel et al. 1996 *In*: Forsman et al. 1996) and fluctuation in prey abundance (Zabel et al. 1996).

A variety of factors may regulate northern spotted owl population levels. These factors may be density-dependent (e.g., habitat quality, habitat abundance) or density-independent (e.g., climate). Interactions may occur among factors. For example, as habitat quality decreases, density-independent factors may have more influence on survival and reproduction, which tends to increase variation in the rate of growth (Franklin et al. 2000). Specifically, weather could have increased negative effects on northern spotted owl fitness for those owls occurring in relatively lower quality habitat (Franklin et al. 2000). A consequence of this pattern is that at some point, lower habitat quality may cause the population to be unregulated (have negative growth) and decline to extinction (Franklin et al. 2000).

Olson et al. (2005) used open population modeling of site occupancy that incorporated imperfect and variable detectability of northern spotted owls and allowed modeling of temporal variation in site occupancy, extinction, and colonization probabilities (at the site scale). The authors found that visit detection probabilities average less than 0.70 and were highly variable among study years and among their three study areas in Oregon. Pair site occupancy probabilities declined greatly on one study area and slightly on the other two areas. However, for all owls, including singles and pairs, site occupancy was mostly stable through time. Barred owl presence had a negative effect on these parameters (see barred owl discussion in the New Threats section below). However, there was enough temporal and spatial variability in detection rates to indicate that more visits would be needed in some years and in some areas, especially if establishing pair occupancy was the primary goal.

2.1.3 Threats

2.1.3.1 Reasons for Listing

The northern spotted owl was listed as threatened throughout its range "due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USDI FWS 1990a). More specifically, threats to the northern spotted owl included low populations, declining populations, limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of provinces, predation and competition, lack of coordinated conservation measures, and vulnerability to natural disturbance (USDI FWS 1992a). These threats were characterized for each of the 12 provinces within the range of the northern spotted owl as severe, moderate, low or unknown (USDI FWS 1992a; see Figure 1). Declining habitat was recognized as a severe or moderate threat to the northern spotted owl throughout its range, isolation of populations was identified as a severe or moderate threat in 11 provinces, and a decline in population was a severe or moderate threat in 10 provinces. Together, these three factors represented the greatest concerns about range-wide conservation of the northern spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces, and low populations were a severe or moderate concern in eight provinces, suggesting that these factors were also a concern throughout the majority of the northern spotted owl's range. Vulnerability to natural disturbances was rated as low in five provinces.

The degree to which predation and competition might pose a threat to the northern spotted owl was unknown in more provinces than any of the other threats, indicating a need for additional information. Few empirical studies exist to confirm that habitat fragmentation contributes to increased levels of predation on northern spotted owls (Courtney et al. 2004). However, great horned owls (*Bubo virginianus*), an effective predator on northern spotted owls, are closely associated with fragmented forests, openings, and clearcuts (Johnson 1992, Laidig and Dobkin 1995). As mature forests are harvested, great horned owls may colonize fragmented forests, thereby increasing northern spotted owl vulnerability to predation.

2.1.3.2 New Threats

The Service conducted a 5-year review of the northern spotted owl in 2004 (USDI FWS 2004a), for which the Service prepared a scientific evaluation of the status of the northern spotted owl (Courtney et al. 2004). An analysis was conducted assessing how the threats described in 1990 might have changed by 2004. Some of the key threats identified in 2004 are:

- "Although we are certain that current harvest effects are reduced, and that past harvest is also probably having a reduced effect now as compared to 1990, we are still unable to fully evaluate the current levels of threat posed by harvest because of the potential for lag effects…In their questionnaire responses…6 of 8 panel member identified past habitat loss due to timber harvest as a current threat, but only 4 viewed current harvest as a present threat." (Courtney and Gutiérrez 2004)

- "Currently the primary source of habitat loss is catastrophic wildfire, although the total amount of habitat affected by wildfires has been small (a total of 2.3% of the range-wide habitat base over a 10-year period)." (Courtney and Gutiérrez 2004)

- "Although the panel had strong differences of opinion on the conclusiveness of some of the evidence suggesting [barred owl] displacement of [northern spotted owls], and the mechanisms by which this might be occurring, there was no disagreement that [barred owls] represented an operational threat. In the questionnaire, all 8 panel members identified [barred owls] as a current threat, and also expressed concern about future trends in [barred owl] populations." (Courtney and Gutiérrez 2004)

Barred Owls (Strix varia)

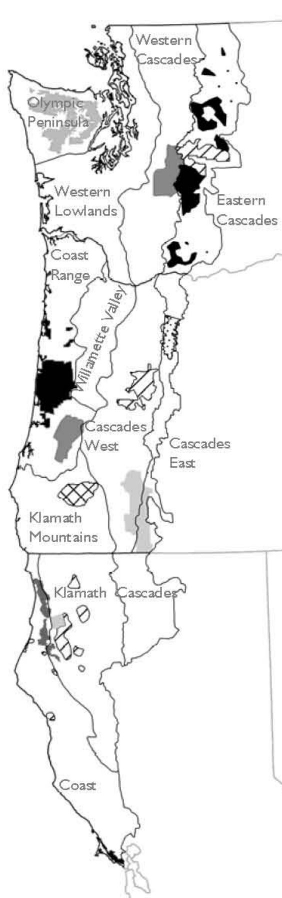
With its recent expansion to as far south as Marin County, California along the Coast Range and Kings Canyon National Park in the southern Sierra Nevada (Gutiérrez et al. 2004), the barred owl's range now completely overlaps that of the northern spotted owl. Barred owls may be affecting northern spotted owls through competition for resources, direct harm through aggressive behavior, and hybridization. Barred owls may be competing with northern spotted owls for prey (Hamer et al. 2001) or habitat (Hamer et al. 1989, Dunbar et al. 1991, Herter and Hicks 2000, Pearson and Livezey 2003). In addition, barred owls physically attack northern spotted owls (Pearson and Livezey 2003), and in at least one situation, a barred owl may have killed a northern spotted owl (Leskiw and Gutiérrez 1998). Evidence that barred owls are causing negative effects on northern spotted owls is largely indirect, based primarily on retrospective examination of long-term data collected on northern spotted owls (Kelly et al. 2003, Pearson and Livezey 2003, Olson et al. 2005). Recent research has shown that the two species of owls share similar habitats and are likely competing for food resources (Hamer et al. 2001, 2007; Singleton et al. 2010). Research on barred owls and their interactions with northern spotted owls is lacking, but necessary to determine the specific effects barred owls may have on northern spotted owls and their habitat. Because the effects of barred owls on northern spotted owls have been realized while solely conducting research and monitoring of northern spotted owls, the effects of barred owls are likely underestimated. Because there has been no research to quantitatively evaluate the strength of different types of competitive interactions, such as resource partitioning and competitive interference, the particular mechanism by which the two owl species may be competing is unknown.

Barred owls, though they are generalists, likely compete with northern spotted owls for prey resources (Hamer et al. 2001, 2007; Gutiérrez et al. 2007; Livezey and Fleming 2007). The only study comparing northern spotted owl and barred owl food habits in the Pacific Northwest indicated that barred owl diets overlap strongly (76 percent) with northern spotted owl diets (Hamer et al. 2001, 2007). Barred owl diets are more diverse than northern spotted owl diets and include species associated with riparian and other moist habitats (e.g. fish, invertebrates, frogs, and crayfish), along with more terrestrial and diurnal species (Smith et al. 1983; Mazur and James 2000; Hamer et al. 2001, 2007; Gronau 2005). Because barred owls took a much lower proportion of the four primary prey species taken by northern spotted owls (Hamer et al. 2001, 2007), barred owls may only be opportunistically taking northern spotted owl prey and not necessarily selecting for the same prey species (Gutiérrez et al. 2007). Even though barred owls may be taking northern spotted owls' primary prey only as a generalist, northern spotted owls may be affected by a sufficient reduction in the density of these prey items due to barred owls, leading to a depletion of prey to the extent that the northern spotted owl cannot find an adequate amount of food to sustain maintenance or reproduction (Gutiérrez et al. 2007, Livezey and Fleming 2007).

Barred owls were initially thought to be more closely associated with early successional forests than northern spotted owls, based on studies conducted on the west slope of the Cascades in Washington (Hamer 1988, Iverson 1993). However, recent studies conducted in the Pacific Northwest show that barred owls frequently use mature and old-growth forests (Pearson and Livezey 2003, Gremel 2005, Schmidt 2006). In the fire prone forests of eastern Washington, a telemetry study conducted on barred owls showed that barred owl home ranges were located on lower slopes or valley bottoms, in closed canopy, mature, Douglas-fir forest, while northern spotted owl sites were located on mid-elevation areas with southern or western exposure, characterized by closed canopy, mature, ponderosa pine or Douglas-fir forest (Singleton et al. 2005). More recently, Singleton et al. (2010) found that barred owls preferred multispecies, structurally diverse forests with high canopy closure dominated by large overstory trees similar to northern spotted owls, however, barred owls also showed a preference for lower topographical areas and gentler slopes not usually preferred by northern spotted owls. Additionally, the two species use the same types of nests (Devereux and Mosher 1984, Forsman et al. 1984, Hamer 1988, Postupalsky et al. 1997). Although there are no estimates for home range sizes of barred owls in Oregon or California (Gutiérrez et al. 2007), northern spotted owl home ranges in Washington can be up to eight times larger than those of barred owls (Singleton et al. 2010).

The presence of barred owls has been reported to reduce northern spotted owl site occupancy, reproduction, and survival. The occupancy of historical territories by northern spotted owls in Washington and Oregon was significantly lower ($p < 0.001$) after barred owls were detected within 0.5 miles of the territory center but was "only marginally lower" ($p = 0.06$) if barred owls were located more than 0.5 miles from the northern spotted owl territory center (Kelly et al. 2003). Pearson and Livezey (2003) found that there were significantly more barred owl site-centers in unoccupied northern spotted owl circles than occupied northern spotted owl circles (centered on historical northern spotted owl site-centers) with radii of 0.5 miles ($p = 0.001$), 1 mile ($p = 0.049$), and 1.8 miles ($p = 0.005$) in Gifford Pinchot National Forest. In Olympic National Park, Gremel (2005) found a significant decline ($p = 0.01$) in northern spotted owl pair occupancy at sites where barred owls had been detected, while pair occupancy remained stable at northern spotted owl sites without barred owls. Olson et al. (2005) found that the annual probability that a northern spotted owl territory would be occupied by a pair of northern spotted owls after barred owls were detected at the site declined by 5 percent in the HJ Andrews study area, 12 percent in the Coast Range study area, and 15 percent in the Tyee study area. Contrastingly, Bailey et al. (2009), when using a two-species occupancy model, showed no evidence that barred owls excluded northern spotted owls from territories in Oregon. Most recently, preliminary results from a barred owl and northern spotted owl radio-telemetry study in Washington reported two northern spotted owls fleeing their territories and traveling six and 15 miles, believed to be as a result of frequent direct encounters with barred owls (Irwin et al. 2010). Both northern spotted owls were subsequently found dead (Irwin et al. 2010).

Olson et al. (2004) found that the presence of barred owls had a significant negative effect on the reproduction of northern spotted owls in the central Coast Range of Oregon (in the Roseburg study area). The conclusion that barred owls had no significant effect on the reproduction of northern spotted owls in one study (Iverson 2004) was unfounded because of small sample sizes (Livezey 2005). It is likely that all of the above analyses underestimated the effects of barred owls on the reproduction of northern spotted owls because northern spotted owls often cannot be relocated after they are displaced by barred owls (E. Forsman, pers. comm., cited in USDI FWS 2008a). Anthony et al. (2006) found significant evidence for negative effects of barred owls on apparent survival of northern spotted owls in two of 14 study areas (Olympic and Wenatchee). They attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate. When examining current literature, Gutiérrez et al. (2007) found that productivity of barred owls and northern spotted owls are similar where their ranges do not overlap, leading to the assumption that barred owls likely produce more young overall than northern spotted owls, or have a higher success rate. Barred owls in a 3-year study in western Washington (Hamer 1988) produced more young than a sympatric group of northern spotted owls.



Demographic Study Area	Land Ownership	# Owls Banded	Fecundity	Apparent Survival	λ_{RJS}	Population Trend Based on $\Delta\lambda$
Washington						
Wenatchee (WEN)	Private	1,200	Stable	Declining	0.917	Declining
Rainer (RAI)	USFS	217	Stable	Declining	0.896	Declining
Olympic (OLY)	NPS & USFS	985	Stable	Declining	0.956	Declining
Cle Elum (CLE)	USFS	724	Declining[1]	Declining?[2]	0.938	Declining
Oregon						
Oregon Coast Range (COA)	USFS & BLM	1,025	Declining?[1]	Stable	0.968	Declining
Tyee (TYE)	BLM & Private	1,032	Increasing	Stable	1.005	Stationary
South Oregon Cascades (CAS)	USFS & BLM	881	Declining	Stable	0.974	Stationary
H.J. Andrews (HJA)	USFS	1,095	Stable?[3]	Stable	0.978	Declining
Klamath (KLA)	BLM & Private	1,147	Stable	Stable	0.997	Stationary
Warm Springs (WSR)	Tribal	381	Stable	Stable	0.908	Declining
California						
Marin (MAR)	NPS	96	Stable	Stable	NA	NA
Simpson (SIM)	Private	1,344	Declining[1]	Stable	0.970	Declining
Hoopa (HUP)	Tribal	279	Increasing	Stable	0.980	Stationary
NW California (NWC)	USFS	1,026	Declining	Declining	0.985	Declining?[4]

[1] Best model included age and even-odd year effects, but a competing model had a negative time effect on productivity.
[2] Variable among years, but with a declining trend.
[3] Decreasing in early years, increase in last 5 years, stable overall.
[4] Gradual declines in fecundity and apparent survival, plus estimates of realized population change suggest a decline in last 8 years.

Figure 1. Physiographic provinces, northern spotted owl demographic study areas, and demographic trends (Anthony et al. 2006).

Barred owls and northern spotted owls occasionally hybridize and produce fertile young (Hamer et al. 1994, Kelly and Forsman 2004), although it is relatively uncommon (Gutiérrez et al. 2007). In a recent analysis of more than 9,000 banded northern spotted owls throughout their range, 47 hybrids were detected (Kelly and Forsman 2004). Hybridization with the barred owl is considered to be "an interesting biological phenomenon that is probably inconsequential, compared with the real threat—direct competition between the two species for food and space" (Kelly and Forsman 2004). However, because hybridization is often more prevalent when one species is rare or limiting or when one species is a recent invader of new habitat (Randler 2002), the likelihood of barred owls mating with northern spotted owls may become more likely, especially as barred owls become more common (Gutiérrez et al. 2007).

Monitoring and management of northern spotted owls has become more complicated due to their possible reduced detectability when barred owls are present (Kelly et al. 2003, Courtney et al. 2004, Olson et al. 2005, Crozier et al. 2006). Olson et al. (2005) found that the presence of barred owls had a significant negative effect on the detectability of northern spotted owls, and that the magnitude of this effect did not vary among years. In a study simulating presence of barred owls, Crozier et al. (2006) determined that the presence of barred owls might negatively affect responsiveness of northern spotted owls. Both northern spotted owls and California spotted owls responded less frequently in areas having high numbers of barred owls (Crozier et al. 2006). Lower response and calling of northern spotted owls could interfere with their ability to establish and defend territories. Evidence that northern spotted owls were responding less frequently during surveys led the Service and its many research partners to update the northern spotted owl survey protocol, with the updated draft protocol being released in February 2010. The changes were based on the probability of detecting northern spotted owls when barred owls are present (USDI FWS 2010a). No systematic surveys for barred owls have been conducted within the range of the northern spotted owl (Gutiérrez et al. 2007), but should be considered to determine the rate and extent of expansion and overlap with the northern spotted owl, and the interaction between the two species to aid in management (Livezey and Fleming 2007).

In areas where population sizes are extremely small, barred owls may pose an even larger threat. In British Columbia, Canada, relocation of barred owls has proven unsuccessful when one barred owl that was relocated 62 miles across three mountain ranges returned to the same location in which it was captured within one year (Pynn 2010). Biologists eventually lethally controlled 12 barred owls that represented competition to the remaining six northern spotted owls occurring in the wild after these relocation efforts were unsuccessful (Pynn 2010).

Evidence suggests that barred owls are exacerbating the northern spotted owl population decline, particularly in Washington, portions of Oregon, and the northern coast of California (Dark et al. 1998; Gutiérrez et al. 2004, 2007; Courtney et al. 2004; Olson et al. 2005). There is no evidence that the increasing trend in barred owls has stabilized in any portion of the northern spotted owl's range in the western United States, and "there are no grounds for optimistic views suggesting that barred owl impacts on northern spotted owls have been already fully realized" (Gutiérrez et al. 2004).

Wildfire

Studies indicate that the effects of wildfire on northern spotted owls and their habitat are variable, depending on fire intensity, severity and size. Within the fire-adapted forests of the northern spotted owl's range, northern spotted owls likely have adapted to withstand fires of variable sizes and severities. However, fire is often considered a primary threat to northern spotted owls because of its potential to rapidly alter habitat (Bond et al. 2009) and is a major cause of habitat loss on Federal lands (Courtney et al. 2004). Bond et al. (2002) examined the demography of the three spotted owl subspecies after wildfires, in which wildfire burned through spotted owl nest and roost sites in varying degrees of severity. Post-fire demography parameters for the three subspecies were similar or better than long-term demographic parameters for each of the three subspecies in those same areas (Bond et al. 2002). In a study of fire effects of seven radiomarked California spotted owls in the southern Sierra Nevada of California, Bond et al. (2009) found that most owls foraged in high-severity burned forest more than all other burn categories, and actually avoided unburned forest within one kilometer of the center of their foraging areas. In a preliminary study conducted by Anthony and Andrews (2004) in the Oregon Klamath Province, their sample of northern spotted owls appeared to be using a variety of habitats within the area of the Timbered Rock fire, including areas where burning had been moderate.

At the time of listing there was recognition that large-scale wildfire posed a threat to the northern spotted owl and its habitat (USDI FWS 1990b, 1992b). New information suggests fire may be more of a threat than previously thought. It has been estimated that the rate of habitat loss due to stand-replacing fire within Federal lands managed under the Northwest Forest Plan (NWFP; USDA FS and USDI BLM 1994b) was almost 140,000 acres between 1993-2004 (Moeur et al. 2005). Up until 2005, the overall total amount of habitat loss from wildfires was relatively small, estimated at approximately 1.2 percent on Federal lands (Lint 2005), but this estimation does not take into account habitat lost during the more recent large fires (i.e. 2007, 2008).

During the 2008 fire season, greater than one million acres burned in northern and central California. More than 2,700 individual fires were ignited, mostly due to lightning from a storm that passed through the state in mid-June. These fires encompassed 203,320 acres of the neighboring STNF in Trinity County, affecting approximately 100 northern spotted owl activity centers (USDI FWS unpubl. data). Within the Mendocino National Forest (MNF), nearly 100,000 acres burned in the Yolla Bolly Complex during the 2008 fire season. The MNF estimates that approximately 59,354 acres of the Yolla Bolly Wilderness adjacent to the project area burned, mostly at low intensity, but also included isolated patches of stand replacing fires, the two largest being 1,900 and 550 acres. Also within the MNF, the Soda Complex burned 9,100 acres during the 2008 fire season.

Several large fires burned in the eastern Cascade Range during the 1994 fire season, negatively affecting multiple northern spotted owl territories (Bevis et al. 1997, Gaines et al. 1997). In 1994, the Hatchery Complex fire burned 43,498 acres in the Wenatchee National Forest in Washington's eastern Cascades, affecting six northern spotted owl activity centers (Gaines et al. 1997). Northern spotted owl habitat within a 1.8-mile radius of the activity centers was reduced by eight to 45 percent (mean = 31 percent) as a result of the direct effects of the fire and by 10 to

85 percent (mean = 55 percent) as a result of delayed mortality of fire-damaged trees and insects. Direct mortality of northern spotted owls was assumed to have occurred at one site, and northern spotted owls were present at only one of the six sites one year after the fire. In 1994, two wildfires burned in the Yakama Indian Reservation in Washington's eastern Cascades, affecting the home ranges of two radio-tagged northern spotted owls (King et al. 1998). Although the amount of home ranges burned was not quantified, northern spotted owls were observed using areas that burned at low and medium intensities. No direct mortality of northern spotted owls was observed, even though thick smoke covered several northern spotted owl site-centers for a week. It appears that, at least in the short term, northern spotted owls may be resilient to the effects of wildfire—a process with which they have evolved. Hanson et al. (2009) believes northern spotted owls are actually suffering adverse consequences from a deficit of fire, which creates habitat necessary for an abundance of their key prey species. More research is needed to further understand the relationship between fire and northern spotted owl habitat use. In a recent paper, Hanson et al. (2009) propose that the fire risk was overestimated in the Recovery Plan, and the effects of fire and silvicultural treatment tools should be further researched.

West Nile Virus

West Nile virus (WNV), caused by a virus in the family Flaviviridae, has killed millions of wild birds in North America since it arrived in 1999 (Caffrey and Peterson 2003, Marra et al. 2004). Mosquitoes are the primary carriers (vectors) of the virus that causes encephalitis in humans, horses, and birds. Mammalian prey may also play a role in spreading WNV among predators, like northern spotted owls. WNV has caused high levels of mortality in North American hawks and owls (Hull et al. 2010). Owls and other predators of mice can contract the disease by eating infected prey (Garmendia et al. 2000, Komar et al. 2003), and possibly through feces (Kipp et al. 2006). One captive northern spotted owl in Ontario, Canada, is known to have contracted WNV and died (Gancz et al. 2004), but there are no documented cases of the virus in wild northern spotted owls. During a four year study to detect antibody response of California spotted owls, northern goshawk (*Accipter gentilis*), and great gray owl (*Strix nebulosa*) in the Sierra Nevada mountains, no antibody response to WNV was found even though 10-60% of the species' populations were sampled (Hull et al. 2010). This finding is attributed to either low exposure of WNV to these species in the study area or high mortality rates of the species to WNV (Hull et al. 2010).

Health officials expect that WNV eventually will spread throughout the entire range of the northern spotted owl (Blakesley et al. 2004), but it is unknown how the virus will ultimately affect northern spotted owl populations. Susceptibility to infection and the mortality rates of infected individuals vary among bird species (Blakesley et al. 2004), but most owls appear to be quite susceptible. For example, eastern screech-owls (*Otus asio*) breeding in Ohio that were exposed to WNV experienced 100 percent mortality (T. Grubb pers. comm. in Blakesley et al. 2004). In California, 23.1% of western screech owls (*Otus kennicottii*) randomly collected dead by the public, tested positive for WNV, while 12.5% of great horned owls tested positive for WNV (Wheeler et al. 2009). Barred owls, in contrast, showed lower susceptibility (B. Hunter pers. comm. in Blakesley et al. 2004).

Blakesley et al. (2004) offer two possible scenarios for the likely outcome of northern spotted owl populations being infected by WNV. One scenario is that a range-wide reduction in northern spotted owl population viability is unlikely because the risk of contracting WNV varies between regions. An alternative scenario is that WNV will cause unsustainable mortality, due to the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the northern spotted owl's current range. WNV remains a potential threat of uncertain magnitude and effect (Blakesley et al. 2004).

Sudden Oak Death

Sudden oak death was recently identified as a potential threat to the northern spotted owl (Courtney et al. 2004). This disease is caused by the fungus-like pathogen, *Phytopthora ramorum* that was recently introduced from Europe and is rapidly spreading. The disease is now known to extend over 404 miles from south of Big Sur, California to Curry County, Oregon (Rizzo and Garbelotto 2003), and has reached epidemic proportions in oak (*Quercus* spp.) and tanoak (*Lithocarpus densiflorus*) forests along approximately 186 miles of the central and northern California coast (Rizzo et al. 2002). It has also been found near Brookings, Oregon, killing tanoak and causing dieback of closely associated wild rhododendron (*Rhododendron* spp.) and evergreen huckleberry (*Vaccinium ovatum*) (Goheen et al. 2002). It has been found in several different forest types and at elevations from sea level to over 2,625 feet. Sudden oak death poses a threat of uncertain proportion because of its potential impact on forest dynamics and alteration of key prey and northern spotted owl habitat components (e.g., hardwood trees, canopy closure and nest tree mortality), especially in the southern portion of the northern spotted owl's range (Courtney et al. 2004). During a study completed between 2001 and 2003 in California, one-third to one-half of the hikers present in the study area carried infected soil on their shoes (Davidson et al. 2005), creating the potential for rapid spread of the disease.

Inbreeding Depression, Genetic Isolation, and Reduced Genetic Diversity

Inbreeding and other genetic problems due to small population sizes were not considered an imminent threat to the northern spotted owl at the time of listing. Recent studies show no indication of reduced genetic variation and past bottlenecks in Washington, Oregon, or California (Barrowclough et al. 1999, Haig et al. 2004, Henke et al. unpublished data). However, in Canada in 2004, the breeding population was estimated to be less than 33 pairs and annual population decline as high as 35 percent (Harestad et al. 2004). Currently only six northern spotted owls are known to exist in the wild in British Columbia, where captive raising of young and captive breeding is currently being practiced to ensure the owl's survival (Pynn 2010). Canadian populations may be more adversely affected by issues related to small population size including inbreeding depression, genetic isolation, and reduced genetic diversity (Courtney et al. 2004). Low and persistently declining populations throughout the northern portion of the species range (see "Population Trends" below) may be at increased risk of losing genetic diversity.

Hybridization of northern spotted owls with California spotted owls and barred owls has been confirmed through genetic research (Hamer et al. 1994, Gutiérrez et al. 1995, Dark et al. 1998, Kelly 2001, Funk et al. 2008).

Climate change

The International Panel on Climate Change (IPCC), a scientific intergovernmental body established by the World Meteorological Organization and the United Nations Environment Programme to assess scientific information and consequences of climate change, concluded that climate change is occurring and is caused by human activities (Forster et al. 2007). The global average temperature has risen approximately 1.08 degrees Fahrenheit (°F) during the 20th Century (IPCC 2001). Within this time, the Pacific Northwest has seen annual average temperature increases of 1.08 to 3.06 °F (Parson et al. 2000). Snow-season length and depth of snowpack are very likely to decrease in most of North America (Christenson et al. 2007), and has already been shown in several studies (Mote et al. 2005 and Regonda et al. 2005 cited in Vicuna and Dracup 2007, Trenberth et al. 2007). Snowmelt-driven runoff is predicted to occur as much as two months earlier in the western United States (Rauscher et al. 2008).

California, in particular, will suffer significant consequences as a result of climate change [California Climate Action Team (CCAT) 2006]. Climate change is already affecting wildlife throughout California (Parmesan and Galbraith 2004), and its effects will continue to increase. Depending on the model and assumptions, scientists project the average annual temperature in California to rise between 4 and 10.5 °F above the current average temperature by the end of the century (Schneider and Kuntz-Duriseti 2002, Turman 2002, Hayhoe et al. 2004). The Grinnell Resurvey Project in Yosemite National Park and surrounding areas have already recorded a substantial increase in monthly minimum temperatures of more than 5.4 °F over 100 years, which is much greater than the average for the state of California (Moritz 2007). This temperature increase is also reflected in tree ring data and analyses of vegetation change (Millar et al. 2004). Seventeen species monitored in the Grinnell Resurvey Project showed range contractions (Moritz 2007). Most of these range contractions involved mid to high elevation taxa (Moritz 2007), coupled with the upward elevation movement of formerly low-elevation species (Moritz et al. 2008).

Climate change, a potential additional threat to northern spotted owl populations, is not explicitly addressed in the NWFP. Climate change could have direct and indirect effects on northern spotted owls and their prey. Based upon a global meta-analysis, Parmesan and Yohe (2003) discussed several potential implications of global climate change to biological systems, including terrestrial flora and fauna. Results indicated that 62 percent of species exhibited trends indicative of advancement of spring conditions. In bird species, trends were manifested in earlier nesting activities. Because the northern spotted owl exhibits a limited tolerance to heat relative to other bird species (Weathers et al. 2001), subtle changes in climate have the potential for significant negative effects. However, the direct effects of climate change to the species are unknown.

Climate change is expected to make unpredictable changes to many species' habitat. Changes in water availability to plants may affect tree growth and distribution of flora (Skinner 2007). Added stress, such as drought, to tree species and changes in the distribution of diseases and insects may make them more vulnerable, and may compound the susceptibility to high severity fire (Skinner 2007). The recent expansion of the mountain pine beetle (*Dendroctonus ponderosae Hopkins*) is an example of range expansion of insects that are affecting large amounts of North American forests (Skinner 2007). The dramatic increase in tree mortality due to these insects increases the potential for intense fires (Skinner 2007). Changes in the fire regime are expected to occur due to warmer temperatures increasing the probability of severe fire and length of fire season (Skinner 2007). Westerling et al. (2006) showed that large wildfire activity has increased suddenly since mid-1980's, with higher large-wildfire frequency, longer wildfire durations, and longer wildfire seasons. A greater number of fires with more fires escaping initial attack suppression are expected (Fried et al. 2004). However, Hanson et al. (2009) believe northern spotted owls are actually suffering adverse consequences from a deficit of fire, which creates habitat necessary for an abundance of their key prey species. Of all burn severity categories, Bond et al. (2009) found that California spotted owls mostly foraged in high-severity burned forest, actually avoiding unburned forest within one kilometer of the center of their foraging areas.

As shown by paleoecological record, dramatic changes in species distributions can take place over only a few decades to a century during periods of rapid climate variation (Peteet 2000, Davis and Shaw 2001). Current communities of plants are likely to dissolve and create new associations as species ranges adjust (Davis 1986, Whitlock 1992). The current assemblages are managed for favorable conditions for the northern spotted owl; however, the influence of a warming climate may make it more difficult to sustain appropriate habitat without considering climate (Skinner 2007). Winter precipitation was the most important climate variable based on northern spotted owl distribution models used by Carroll (in press), further suggesting that negative effects on survival and recruitment may occur due to climate change. Range shifts due to climate change may affect the effectiveness of reserves for northern spotted owls, increasing the importance of higher elevation reserves that were created before the NWFP (Carroll, in press).

Disturbance-Related Effects

The effects of noise on northern spotted owls are largely unknown, and whether noise is a concern has been a controversial issue. The effect of noise on birds is extremely difficult to determine due to the inability of most studies to quantify one or more of the following variables: 1) timing of the disturbance in relation to nesting chronology; 2) type, frequency, and proximity of human disturbance; 3) clutch size; 4) health of individual birds; 5) food supply; and 6) outcome of previous interactions between birds and humans (Knight and Skagan 1988). Additional factors that confound the issue of disturbance include the individual bird's tolerance level, ambient sound levels, physical parameters of sound and how it reacts with topographic characteristics and vegetation, and differences in how species perceive noise.

Although information specific to behavioral responses of northern spotted owls to disturbance is limited, research indicates that recreational activity can cause Mexican spotted owls to vacate otherwise suitable habitat (Swarthout and Steidl 2001) and helicopter overflights can reduce prey delivery rates to nests (Delaney et al. 1999). Additional effects from disturbance, including altered foraging behavior and decreases in nest attendance and reproductive success, have been reported for other raptors (White and Thurow 1985, Anderson et al. 1989, McGarigal et al. 1991).

Northern spotted owls may also respond physiologically to a disturbance without exhibiting a significant behavioral response. In response to environmental stressors, vertebrates secrete stress hormones called corticosteroids (Campbell 1990). Although these hormones are essential for survival, extended periods with elevated stress hormone levels may have negative effects on reproductive function, disease resistance, or physical condition (Carsia and Harvey 2000, Saplosky et al. 2000). In avian species, the secretion of corticosterone is the primary non-specific stress response (Carsia and Harvey 2000). The quantity of this hormone in feces can be used as a measure of physiological stress (Wasser et al. 1997). Recent studies of fecal corticosterone levels of northern spotted owls indicate that low intensity noise of short duration and minimal repetition does not elicit a physiological stress response (Tempel and Gutiérrez 2003, 2004). However, prolonged activities, such as those associated with timber harvest, may increase fecal corticosterone levels depending on their proximity to northern spotted owl core areas (Wasser et al. 1997, Tempel and Gutiérrez 2004).

Post-harvest fuels treatments may also create above-ambient smoke or heat. Although it has not been conclusively demonstrated, it is anticipated that nesting northern spotted owls may be disturbed by heat and smoke intrusion into the nest grove.

2.1.4 Conservation Needs of the Northern Spotted Owl

Based on the above assessment of threats, the northern spotted owl has the following habitat-specific and habitat-independent conservation (i.e., survival and recovery) needs:

2.1.4.1 Habitat-specific Needs

1. Large blocks of suitable habitat to support clusters or local population centers of northern spotted owls (i.e., 15 to 20 breeding pairs) throughout the owl's range;

2. Suitable habitat conditions and spacing between local northern spotted owl populations throughout its range to facilitate survival and movement;

3. Suitable habitat distributed across a variety of ecological conditions within the northern spotted owl's range to reduce risk of local or widespread extirpation;

4. A coordinated, adaptive management effort to reduce the loss of habitat due to catastrophic wildfire throughout the northern spotted owl's range, and a monitoring program to clarify whether these risk reduction methods are effective and to determine how owls use habitat treated to reduce fuels; and

5. In areas of significant population decline, sustain the full range of survival and recovery options for this species in light of significant uncertainty.

2.1.4.2 Habitat-independent Needs

1. A coordinated research and adaptive management effort to better understand and manage competitive interactions between spotted and barred owls; and

2. Monitoring to better understand the risk that WNV and sudden oak death pose to northern spotted owls and, for WNV, research into methods that may reduce the likelihood or severity of outbreaks in northern spotted owl populations.

2.1.4.3 Conservation Strategy

Since 1990, various efforts have addressed the conservation needs of the northern spotted owl and attempted to formulate conservation strategies based upon these needs. These efforts began with the Interagency Scientific Committee's (ISC's) Conservation Strategy (Thomas et al. 1990); they continued with the designation of critical habitat (USDI FWS 1992a), the Draft Recovery Plan (USDI FWS 1992b), and the Scientific Analysis Team report (Thomas et al. 1993), report of the Forest Ecosystem Management Assessment Team (Thomas and Raphael 1993); and they culminated with the NWFP (USDA FS and USDI BLM 1994a). Each conservation strategy was based upon the reserve design principles first articulated in the ISC's report, which are summarized as follows:

- Species that are well distributed across their range are less prone to extinction than species confined to small portions of their range.

- Large blocks of habitat, containing multiple pairs of the species, are superior to small blocks of habitat with only one to a few pairs.

- Blocks of habitat that are close together are better than blocks far apart.

- Habitat that occurs in contiguous blocks is better than habitat that is more fragmented.

- Habitat between blocks is more effective as dispersal habitat if it resembles suitable habitat.

2.1.4.4 Federal Contribution to Recovery

Since it was signed on April 13, 1994, the NWFP has guided the management of Federal forest lands within the range of the northern spotted owl (USDA FS and USDI BLM 1994a, 1994b). The NWFP was designed to protect large blocks of old growth forest and provide habitat for species that depend on those forests including the northern spotted owl, as well as to produce a predictable and sustainable level of timber sales. The NWFP included land use allocations which would provide for population clusters of northern spotted owls (i.e., demographic support) and maintain connectivity between population clusters. Certain land use allocations in the plan contribute to supporting population clusters: Late-Successional Reserves (LSRs), Managed Late-successional Areas (MLSAs), and Congressionally Reserved Areas (CRAs). Riparian Reserves (RRs), Adaptive Management Areas (AMAs) and Administratively Withdrawn Areas (AWAs) can provide both demographic support and connectivity/dispersal between the larger blocks, but were not necessarily designed for that purpose. Matrix areas were to support timber production while also retaining biological legacy components important to old-growth obligate species (i.e., 100-acre owl cores, 15 percent late-successional provision; USDA FS and USDI BLM 1994a, USDI FWS 1994b) which would persist into future managed timber stands.

The NWFP with its rangewide system of LSRs was based on work completed by three previous studies (Thomas et al. 2006): the 1990 ISC Report (Thomas et al. 1990), the 1991 report for the Conservation of Late-successional Forests and Aquatic Ecosystems (Johnson et. al. 1991), and the 1993 report of the Scientific Assessment Team (Thomas et al. 1993). In addition, the 1992 Draft Recovery Plan for the Northern Spotted Owl (USDI FWS 1992b) was based on the ISC report.

The Forest Ecosystem Management Assessment Team predicted, based on expert opinion, the northern spotted owl population would decline in the Matrix land use allocation over time, while the population would stabilize and eventually increase within LSRs as habitat conditions improved over the next 50 to 100 years (Thomas and Raphael 1993; USDA FS and USDI BLM 1994a, 1994b). Based on the results of the first decade of monitoring, Lint (2005) could not determine whether implementation of the NWFP would reverse the northern spotted owl's declining population trend because not enough time had passed to provide the necessary measure of certainty. However, the results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described in the NWFP (Lint 2005, Noon and Blakesley 2006). Bigley and Franklin (2004) suggested that more fuels treatments are needed in east-side forests to preclude large-scale losses of habitat to stand-replacing wildfires. Other stressors that occur in suitable habitat, such as the range expansion of the barred owl (already in action) and infection with WNV (which may or may not occur) may complicate the conservation of the northern spotted owl. Recent reports about the status of the northern spotted owl offer few management recommendations to deal with these emerging threats. The arrangement, distribution, and resilience of the NWFP land use allocation system may prove to be the most appropriate strategy in responding to these unexpected challenges (Bigley and Franklin 2004).

Under the NWFP, the agencies anticipated a decline of northern spotted owl populations during the first decade of implementation. Recent reports (Courtney et al. 2004, Anthony et al. 2006) identified greater than expected northern spotted owl declines in Washington and northern portions of Oregon, and more stationary populations in southern Oregon and northern California. The reports did not find a direct correlation between habitat conditions and changes in vital rates of northern spotted owls at the meta-population scale. However, at the territory scale, there is evidence of negative effects to northern spotted owl fitness due to reduced habitat quantity and quality. Also, there is no evidence to suggest that dispersal habitat is currently limiting (Courtney et al. 2004, Lint 2005). Even with the population decline, Courtney et al (2004) noted that there is little reason to doubt the effectiveness of the core principles underpinning the NWFP conservation strategy.

The current scientific information, including information showing northern spotted owl population declines, indicates that the northern spotted owl continues to meet the definition of a threatened species (USDI FWS 2004a). That is, populations are still relatively numerous over most of its historic range, which suggests that the threat of extinction is not imminent, and that the subspecies is not endangered, even though, in the northern part of its range population trend estimates are showing a decline.

In May, 2008, the Service published the 2008 Final Recovery Plan for the Northern Spotted Owl (USDI FWS 2008a). The recovery plan identified that competition with barred owls, ongoing loss of suitable habitat as a result of timber harvest and catastrophic fire, and loss of amount and distribution of suitable habitat as a result of past activities and disturbances are the most important range-wide threats to the northern spotted owl (USDI FWS 2008a). To address these threats, the recovery strategy had the following three essential elements: barred owl control, dry-forest landscape management strategy, and managed owl conservation areas (MOCAs) (USDI FWS 2008a). The recovery plan listed recovery actions that address research of the competition between spotted and barred owls, experimental control of barred owls to better understand the impact the species is having on northern spotted owls, and, if recommended by research, management of barred owls (USDI FWS 2008a). In addition, the recovery plan recommended a research and monitoring program be implemented to track progress toward recovery, inform changes in recovery strategy by a process of adaptive management, and ultimately determine when delisting is appropriate (USDI FWS 2008a). The three primary elements of this program included 1) the monitoring of northern spotted owl population trends, 2) an inventory of northern spotted owl distribution, and 3) a comprehensive program of barred owl research and monitoring (USDI FWS 2008a). The recovery plan estimated that recovery of the northern spotted owl could be achieved in approximately 30 years (USDI FWS 2008a).

In 2011, the Service published the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b). The 2011 Revised Recovery Plan, like the 2008 Recovery Plan, identifies barred owls and habitat loss due to timber harvest and wildfire as major threats to the northern spotted owl. To address these threats, the present recovery strategy has the following four essential elements: completion and application of rangewide habitat modeling, habitat conservation and active forest management, barred owl management, and research and monitoring (USDI FWS 2011b). The revised recovery plan lists 34 recovery actions that address overall recovery through maintenance and restoration of suitable habitat for northern spotted owls, monitoring of avian diseases, development and implementation of a delisting monitoring plan, and management of the barred owl (USDI FWS 2011b). Implementation of the full suite of recovery actions will involve participation from the States, Federal agencies, non-Federal landowners, and the public. Recovery Actions 10 and 20 are especially reliant on the participation of private landowners and pertain to the FGS HCP. The intent of Recovery Action 10 is to conserve spotted owl sites and high value spotted owl habitat, regardless of land ownership. Recovery Action 20 requests the cooperation of CAL FIRE and individual stakeholders to evaluate the potential recovery role of spotted owl sites and high-quality habitat on nonfederal lands in California, and to evaluate and implement appropriate conservation tools, such as HCPs, to assist with supporting spotted owl recovery actions outlined in the recovery plan.

2.1.4.5 Conservation Efforts on Non-Federal Lands

In the report from the Interagency Scientific Committee (Thomas et al. 1990), the draft recovery plan (USDI FWS 1992b), and the report from the Forest Ecosystem Management Assessment Team (Thomas and Raphael 1993), it was noted that limited Federal ownership in some areas constrained the ability to form a network of old-forest reserves to meet the conservation needs of the northern spotted owl. In these areas in particular, non-Federal lands would be important to the range-wide goal of achieving conservation and recovery of the northern spotted owl. The Service's primary expectations for private lands are for their contributions to demographic support (pair or cluster protection) to Federal lands, or their connectivity with Federal lands. In addition, timber harvest within each state is governed by rules that provide protection of northern spotted owls or their habitat to varying degrees.

There are 17 current or completed HCPs that have incidental take permits issued for northern spotted owls—eight in Washington, three in Oregon, and four in California. The HCPs range in size from 40 acres to more than 1.6 million acres, although not all acres are included in the mitigation for northern spotted owls. In total, the HCPs cover approximately 2.9 million acres (9.1 percent) of the 32 million acres of non-Federal forest lands in the range of the northern spotted owl. The period of time that the HCPs will be in place ranges from 5 to 100 years; however, most of the HCPs are of fairly long duration. While each HCP is unique, there are several general approaches to mitigation of incidental take:

- Reserves of various sizes, some associated with adjacent Federal reserves
- Forest harvest that maintains or develops suitable habitat
- Forest management that maintains or develops dispersal habitat
- Deferral of harvest near specific sites

Washington. In 1996, the State Forest Practices Board adopted rules (Washington Forest Practices Board 1996) that would contribute to conserving the northern spotted owl and its habitat on non-Federal lands. In Spotted Owl Special Emphasis Areas, suitable owl habitat inside management circles established for territorial spotted owls is regulated under the default component of the Forest Practices Rules. Outside the Spotted Owl Special Emphasis Areas, the best 70 acres of habitat around the site center is protected from harvest during the nesting season. Outside the nesting season there are no owl-related protections that constrain harvest of suitable habitat in spotted owl management circles. Adoption of the rules was based in part on recommendations from a Science Advisory Group that identified important non-Federal lands and recommended roles for those lands in northern spotted owl conservation (Hanson et al. 1993, Buchanan et al. 1994). The 1996 rule package was developed by a stakeholder policy group and then reviewed and approved by the Forest Practices Board (Buchanan and Swedeen 2005). Northern spotted owl-related HCPs in Washington generally were intended to provide demographic or connectivity support (USDI FWS 1992b).

Oregon. The Oregon Forest Practices Act provides for protection of 70-acre core areas around sites occupied by an adult pair of northern spotted owls capable of breeding (as determined by recent protocol surveys), but it does not provide for protection of northern spotted owl habitat beyond these areas (Oregon Department of Forestry 2007). In general, no large-scale northern spotted owl habitat protection strategy or mechanism currently exists for non-Federal lands in Oregon. The three northern spotted owl-related HCPs currently in effect cover more than

300,000 acres of non-Federal lands. These HCPs are intended to provide some nesting habitat and connectivity over the next few decades.

California. The California Forest Practice Rules (CFPRs,) which govern timber harvest on private lands, require surveys for northern spotted owls in suitable habitat and provide protection around activity centers (CALFIRE 2007). Under the CFPRs, no timber harvest plan can be approved if it is likely to result in incidental take of federally listed species, unless the take is authorized by a Federal incidental take permit (CALFIRE 2007). The CDFG initially reviewed all THPs to ensure that take was not likely to occur. The Service took over that review function in 2000. In 2008, the Service handed over the THP review process to CALFIRE. Upon request, the Service may provide technical assistance to CALFIRE if deemed necessary.

The CFPRs requires private landowners to maintain 500 acres and 1,336 acres of suitable (nesting, roosting and foraging) northern spotted owl habitat within an activity center's 0.7- mile core and 1.3-mile home range, respectively. Additionally, within 500 feet of the active nest site or pair activity center, the characteristics of functional nesting habitat must be maintained. Harvest of suitable habitat is allowed if more than 500 acres and 1,336 acres within the 0.7-mile core and 1.3-mile home range, respectively, are currently present. Additionally, under the current CFPRs, if an activity center is determined to be unoccupied all habitat within the home range can be removed without compensatory mitigation.

There are several short-comings of the current CFPRs. The CFPRs define suitable northern spotted owl habitat based on CWHR classification system, which could lead to retention of relatively low quality habitat. For example, 4D is considered suitable nesting/roosting habitat, but encompasses a broad range of tree diameters (11 to 24 inches dbh) and canopy cover (60 to 100 percent). The CFPRs do not specify how much of the total northern spotted owl habitat within the core and home range should be maintained as nesting, roosting and foraging. Conceivably, most of the northern spotted owl habitat within the core and home range could be low quality foraging habitat and harvest could be allowed under the CFPRs. Furthermore, the CFPRs follow the guidance in the 1992 Protocol for Surveying Management Activities that May Impact Northern Spotted Owls for determining unoccupied status. According to that protocol, an historic activity center may be considered unoccupied if no responses have been obtained after three years of surveys. New research information available on northern spotted owl site occupancy indicates that sites may be unoccupied (or northern spotted owls fail to respond due to the presence of barred owls) for more than three years and then subsequently are utilized by nesting northern spotted owls.

The Service's experience with interior California THP review from 2000 to 2009 indicates that the CFPRs regulating timber harvest during the 1990s did not necessarily prevent significant effects to activity centers resulting from the continued reduction of habitat quality within northern spotted owl home ranges overlapping THPs. Extensive review has suggested that in many cases, the cumulative effects of repeated entries within northern spotted owl home ranges reduces habitat quality and leads to reduced occupancy rates and apparent site abandonment. In a large proportion of the Service's technical assistance letters to CALFIRE and industrial timberland owners during the past five years, the Service has noted the lack of northern spotted owl responses at historic territories and habitat conditions considered inadequate to support continued occupancy and reproduction following repeated entries within northern spotted owl home ranges under the CFPRs.

In 2008, the YFWO developed take avoidance guidance for CALFIRE which included documentation of the criteria and habitat thresholds currently used by the Service in making take evaluations for northern spotted owls on private lands in the interior region (USDI FWS 2008c). In 2009, in order to document the scientific rationale behind the Service guidelines, the YFWO issued a science support document titled "Regulatory and Scientific Basis for the U.S. Fish and Wildlife Service Guidance for Evaluation of Take for Northern Spotted Owls on Private Timberlands in California's Northern Interior Region." Generally, the guidelines describe the range of conditions associated with occupied northern spotted owl activity centers. The Service recommends maintenance of 250 acres of nesting/roosting and 150 acres of foraging habitat within the northern spotted owl territory (i.e., core area). The northern spotted owl territory is established by placing a 0.5 mile radius circle around a nest site, which equates to 502 acres. Additionally, maintenance of 935 acres of foraging habitat is recommended within the northern spotted owl outer ring of the home range (i.e., 0.5 to 1.3-mile radius around the nest site). The northern spotted owl home range is established by placing a 1.3 mile radius circle around a nest site which equates to 3,396 acres. The habitat thresholds and definitions in the Service guidance provide the quantity and quality of habitat associated with occupancy and reproduction at northern spotted owl cores. Although these new guidelines were developed by the Service and based upon the best scientific information available at the time, CALFIRE cannot mandate the use of a different standard than those described in the CFPRs.

Several large industrial owners operate under northern spotted owl management plans that have been reviewed by the Service and that specify basic measures for northern spotted owl protection. Four HCPs authorizing take of northern spotted owls have been approved; these HCPs cover more than 669,000 acres of non-Federal lands in California. Implementation of these plans is intended to provide for northern spotted owl demographic and connectivity support to NWFP lands.

2.1.5 Current Condition of the Northern Spotted Owl

The current condition of the species incorporates the effects of all past human activities and natural events that led to the present-day status of the species and its habitat (USDI FWS and USDC NMFS 1998).

2.1.5.1 Range-wide Habitat

The 1992 Draft Northern Spotted Owl Recovery Plan estimated approximately 8.3 million acres of northern spotted owl habitat remained range-wide (USDI FWS 1992b). However, reliable habitat baseline information for non-Federal lands is not available (Courtney et al. 2004). The Service has used information provided by the USFS, Bureau of Land Management, and National Park Service to update the habitat baseline conditions on Federal lands for northern spotted owls on several occasions since the northern spotted owl was listed in 1990. The estimate of 7.4 million acres used for the NWFP in 1994 (USDA FS and USDI BLM 1994a) was believed to be representative of the general amount of northern spotted owl habitat on these lands. This baseline has been used to track relative changes over time in subsequent analyses, including those presented here.

In 2005, a new map depicting suitable northern spotted owl habitat throughout the range of the northern spotted owl was produced as a result of the NWFP's effectiveness monitoring program (Lint 2005). However, the spatial resolution of this new habitat map currently makes it unsuitable for tracking habitat effects at the scale of individual projects. The Service is evaluating the map for future use in tracking habitat trends. Additionally, there continues to be no reliable estimates of northern spotted owl habitat on non-Federal lands; consequently, consulted-on acres by the Service can be tracked, but not evaluated in the context of change with respect to a reference condition on non-Federal lands. The production of the monitoring program habitat map does, however, provide an opportunity for future evaluations of trends in non-Federal habitat.

NWFP Lands Analysis 1994 – 2001

In 2001, the Service conducted an assessment of habitat baseline conditions, the first since implementation of the NWFP (USDI FWS 2001). This range-wide evaluation of habitat, compared to the Final Supplemental Environmental Impact Statement (FSEIS) (USDA FS and USDI BLM 1994b), was necessary to determine if the rate of potential change to northern spotted owl habitat was consistent with the change anticipated in the NWFP. In particular, the Service considered habitat effects that were documented through the Section 7 consultation process since 1994. In general, the analytical framework of these consultations focused on the reserve and connectivity goals established by the NWFP land-use allocations (USDA FS and USDI BLM 1994a), with effects expressed in terms of changes in suitable northern spotted owl habitat within those land-use allocations. The Service determined that actions and effects were consistent with the expectations for implementation of the NWFP from 1994 to June, 2001 (USDI FWS 2001).

Range-wide Analysis 1994 – March 30, 2011

This section updates the information considered in USDI FWS (2001), relying particularly on information in documents the Service produced pursuant to Section 7 of the ESA and information provided by NWFP agencies on habitat loss resulting from natural events (e.g., fires, windthrow, insects and disease). To track impacts to northern spotted owl habitat, the Service designed the Consultation on Effects Database which records impacts to northern spotted owls and their habitat at a variety of spatial and temporal scales. Data are entered into the Consulted on Effects Database under various categories including, land management agency, land-use allocation, physiographic province, and type of habitat affected.

In 1994, about 7.4 million acres of suitable northern spotted owl habitat were estimated to exist on Federal lands managed under the NWFP. As of March 30, 2011**,** the Service had consulted on the proposed removal/downgrading of approximately 188,971 acres (Table 2) or 2.6 percent of 7.4 million acres (Table 3) of northern spotted owl suitable habitat on Federal NWFP lands. Of the total Federal acres consulted on for removal/downgrading, approximately 160,566 acres or 2.2 percent of 7.4 million acres of northern spotted owl habitat were removed/downgraded as a result of timber harvest. These changes in suitable northern spotted owl habitat are consistent with the expectations for implementation of the NWFP (USDA FS and USDI BLM 1994a).

Habitat loss from Federal NWFP lands due to management activities has varied among the individual provinces with most of the impacts concentrated within the Non-Reserve relative to the Reserve land-use allocations (Table 3). When habitat loss is evaluated as a proportion of the affected acres range-wide, the most pronounced losses have occurred within Oregon (79%), especially within its Klamath Mountains (40%) and Cascades (East and West) (38%) Provinces (Table 3), followed by much smaller habitat losses in Washington (10%) and California (11%) (Table 3). When habitat loss is evaluated as a proportion of provincial baselines, the Oregon Klamath Mountains (20.3%), Cascades East (13%) and the California Cascades (5.5%) all have proportional losses greater than the range-wide mean (5.4%) (Table 3).

From 1994 through February 14, 2011, habitat lost due to natural events was estimated at approximately 207,262 acres range-wide (Table 3). This estimate doesn't include acres of habitat lost from the 2008 fires and a couple of 2009 fires on the Shasta-Trinity, Mendocino, and Six Rivers National Forests because emergency consultations have not been completed on these fires. About two-thirds of this loss was attributed to the Biscuit Fire that burned over 500,000 acres in southwest Oregon (Rogue River basin) and northern California in 2002. This fire resulted in a loss of approximately 113,451 acres of northern spotted owl habitat, including habitat within five LSRs (Table 3[7]). Approximately 18,630 acres of northern spotted owl habitat were lost due to the B&B Complex and Davis Fires in the East Cascades Province of Oregon in 2003 (Table 3[7]).

Because there is no comprehensive northern spotted owl habitat baseline for non-NWFP Federal lands and non-Federal lands, there is little available information regarding northern spotted owl habitat trends on these lands. Yet, we do know that Service consultations conducted since 1992, have documented the eventual loss of 472,772 acres (Table 2) of habitat on non-NWFP Federal lands and non-Federal lands. Approximately 63 percent of these losses have yet to be realized because they are part of large-scale, long-term HCPs/Safe Harbor Agreements (SHAs). Combining effects on Federal and non-Federal lands, the Service had consulted on the proposed removal of approximately 661,743 acres of northern spotted owl habitat range-wide, resulting from all management activities, as of March 30, 2011 (Table 2).

Table 2. Range-wide Aggregate of Changes to NRF[1] Habitat Acres from Activities Subject to Section 7 Consultations and Other Causes from 1994 to March 30, 2011.

Land Ownership	Consulted On Habitat Changes[2]		Other Habitat Changes[3]	
	Removed/ Downgraded	Maintained/ Improved	Removed/ Downgraded	Maintained/ Improved
NWFP (FS,BLM,NPS)	188,971	512,961	207,262	5,481
Bureau of Indian Affairs / Tribes	108,210	28,372	2,398	0
Habitat Conservation Plans/Safe Harbor Agreements	295,889	14,430	N/A	N/A
Other Federal, State, County, Private Lands	68,673	21,894	279	0
Total Changes	**661,743**	**577,657**	**209,939**	**5,481**

Notes:

1. Nesting, roosting, foraging (NRF) habitat. In California, suitable habitat is divided into two components; nesting - roosting (NR) habitat, and foraging (F) habitat. The NR component most closely resembles NRF habitat in Oregon and Washington. Due to differences in reporting methods, effects to suitable habitat compiled in this, and all subsequent tables include effects for nesting, roosting, and foraging (NRF) for 1994-6/26/2001. After 6/26/2001 suitable habitat includes NRF for Washington and Oregon but only nesting and roosting (NR) for California.
2. Includes both effects reported in USFWS 2001 and subsequent effects reported in the Northern Spotted Owl Consultation Effects Tracking System (web application and database.)
3. Includes effects to suitable NRF habitat (as generally documented through technical assistance, etc.) resulting from wildfires (not from suppression efforts), insect and disease outbreaks, and other natural causes, private timber harvest, and land exchanges not associated with consultation.

Table 3. Aggregate Results of All Adjusted, Suitable Habitat (NRF[1]) Acres Affected by Section 7 Consultation on NWFP Lands for the Northern Spotted Owl; Baseline and Summary of Effects by State, Physiographic Province and Land Use Function from 1994 to March 30, 2011.

Physiographic Province[2]		Evaluation Baseline[3]	Habitat Removed/Downgraded[4]					% Provincial Baseline Affected	% Range-wide Effects
			Land Use Allocations			Habitat Loss to Natural Events[7]	Total		
		Total	Reserves[5]	Non-Reserves[6]	Total				
WA	**Eastern Cascades**	706,849	4,522	6,392	10,914	14,307	25,221	3.57	6.37
	Olympic Peninsula	560,217	869	1,711	2,580	299	2,879	0.51	0.73
	Western Cascades	1,112,480	1,681	10,870	12,551	3	12,554	1.13	3.17
OR	**Cascades East**	443,659	2,500	14,249	16,749	40,884	57,663	12.99	14.55
	Cascades West	2,046,472	3,697	63,941	67,638	24,583	92,221	4.51	23.27
	Coast Range	516,577	527	3,844	4,371	66	4,437	0.86	1.12
	Klamath Mountains	785,589	2,631	55,200	57,831	101,676	159,507	20.3	40.26
	Willamette Valley	5,658	0	0	0	0	0	0	0
CA	**Cascades**	88,237	0	4,820	4,820	4	4,824	5.47	1.22
	Coast	51,494	464	79	543	100	643	1.25	0.16
	Klamath	1,079,866	1,546	9,428	10,974	25,340	36,314	3.36	9.16
Total		**7,397,098**	**18,437**	**170,534**	**188,971**	**207,262**	**396,233**	**5.36**	**100**

Notes:

1. Nesting, roosting, foraging (NRF) habitat. In California, suitable habitat is divided into two components; nesting - roosting (NR) habitat, and foraging (F) habitat. The NR component most closely resembles NRF habitat in Oregon and Washington. Due to differences in reporting methods, effects to suitable habitat compiled in this, and all subsequent tables include effects for nesting, roosting, and foraging (NRF) for 1994-6/26/2001. After 6/26/2001 suitable habitat includes NRF for Washington and Oregon but only nesting and roosting (NR) for California.

2. Defined by the NWFP as the 12 physiographic provinces, as presented in Figure 3&4-1 on page 3&4-16 of the FSEIS. The WA Western Lowlands and OR Willamette Valley provinces are not listed as they are not expected to contribute to recovery.
3. 1994 FSEIS baseline (USDA FS and USDI BLM 1994b).
4. Includes both effects reported in USDI FWS (2001) and subsequent effects reported in the Northern Spotted Owl Consultation Effects Tracking System (web application and database.)
5. Land-use allocations intended to provide large blocks of habitat to support clusters of breeding pairs. (LSR, MLSA, CRA)
6. Land-use allocations intended to provide habitat to support movement of spotted owls among reserves. (AWA, AMA, MX)
7. Acres for all physiographic provinces, except the Oregon Klamath Mountains, are from the Scientific Evaluation of the Status of the Northern Spotted Owl (Courtney et al. 2004) and subsequent effects entered into the Northern Spotted Owl Consultation Effects Tracking System. Acres for the Oregon Klamath Mountains province are from the biological assessment entitled: Fiscal year 2006-2008 programmatic consultation: re-initiation on activities that may affect listed species in the Rogue-River/South Coast Basin, Medford BLM, and Rogue-Siskiyou National Forest and from subsequent effects entered into the Northern Spotted Owl Consultation Effects Tracking System.

Other Habitat Trend Assessments

In 2005, the Washington Department of Wildlife released the report, "An Assessment of Northern Spotted Owl Habitat on Non-Federal Lands in Washington between 1996 and 2004" (Pierce et al. 2005). This study estimates the amount of northern spotted owl habitat in 2004 on lands affected by State and private forest practices. The study area is a subset of the total Washington forest practice lands, and statistically-based estimates of existing habitat and habitat loss due to fire and timber harvest are provided. In the 3.2-million acre study area, Pierce et al. (2005) estimated there was 816,000 acres of suitable northern spotted owl habitat in 2004, or about 25 percent of their study area. Based on their results, Pierce et al. (2005) estimated there were less than 2.8 million acres of northern spotted owl habitat in Washington on all ownerships in 2004. Most of the suitable owl habitat in 2004 (56%) occurred on Federal lands, and lesser amounts were present on State-local lands (21%), private lands (22%) and tribal lands (1%). Most of the harvested northern spotted owl habitat was on private (77%) and State-local (15%) lands. A total of 172,000 acres of timber harvest occurred in the 3.2 million-acre study area, including harvest of 56,400 acres of suitable northern spotted owl habitat. This represented a loss of about 6 percent of the owl habitat in the study area distributed across all ownerships (Pierce et al. 2005). Approximately 77 percent of the harvested habitat occurred on private lands and about 15 percent occurred on State lands. Pierce and others (2005) also evaluated suitable habitat levels in 450 northern spotted owl management circles (based on the provincial annual median northern spotted owl home range). Across their study area, they found that owl circles averaged about 26 percent suitable habitat in the circle across all landscapes. Values in the study ranged from an average of 7 percent in southwest Washington to an average of 31 percent in the east Cascades, suggesting that many owl territories in Washington are significantly below the 40 percent suitable habitat threshold used by the State as a viability indicator for northern spotted owl territories (Pierce et al. 2005).

Moeur et al. (2005) estimated an increase of approximately 1.25 to 1.5 million acres of medium and large older forest (greater than 20 inches dbh, single and multi-storied canopies) on Federal lands in the NWFP area between 1994 and 2003. The increase occurred primarily in the lower end of the diameter range for older forest. The net area in the greater than 30 inch dbh size class increased by only an estimated 102,000 to 127,000 acres. The estimates were based on change-detection layers for losses due to harvest and fire and remeasured inventory plot data for increases due to ingrowth. Transition into and out of medium and large older forest over the 10-year period was extrapolated from inventory plot data on a subpopulation of Forest Service land types and applied to all Federal lands. Because size class and general canopy layer descriptions do not necessarily account for the complex forest structure often associated with northern spotted owl habitat, the significance of these acres to northern spotted owl conservation remains unknown.

2.1.5.2 Northern spotted Owl Numbers, Distribution, and Reproduction Trends

There are no estimates of the size of the northern spotted owl population prior to settlement by Europeans. Northern spotted owls are believed to have inhabited most old-growth forests or stands throughout the Pacific Northwest, including northwestern California, prior to beginning of modern settlement in the mid-1800s (USDI FWS 1989). According to the final rule listing the northern spotted owl as threatened (USDI FWS 1990a), approximately 90 percent of the roughly 2,000 known northern spotted owl breeding pairs were located on federally managed lands, 1.4 percent on State lands, and 6.2 percent on private lands; the percent of northern spotted owls on private lands in northern California was slightly higher (Forsman et al. 1984, USDI FWS 1989, Thomas et al. 1990).

The current range of the northern spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USDI FWS 1990a). The range of the northern spotted owl is partitioned into 12 physiographic provinces (Figure 1) based on recognized landscape subdivisions exhibiting different physical and environmental features (Thomas et al. 1993). The northern spotted owl has become rare in certain areas, such as British Columbia, southwestern Washington, and the northern coastal ranges of Oregon.

There are few northern spotted owls remaining in British Columbia. Chutter et al. (2004) suggested immediate action was required to improve the likelihood of recovering the northern spotted owl population in British Columbia. As a result, in 2007, personnel in British Columbia captured and brought into captivity 16 wild northern spotted owls (USDI FWS 2008a). Prior to initiating the captive-breeding program, the population of northern spotted owls in Canada was declining by as much as 10.4 percent per year (Chutter et al. 2004). Currently, only six northern spotted owls are known to exist in the wild in British Columbia (Pynn 2010). Biologists plan to capture two of the remaining single males for their captive breeding program (Pynn 2010). The other four northern spotted owls comprise two pairs and will continue to remain in the wild, with any offspring removed for captive breeding. Provincial biologists have lethally controlled 12 barred owls that represented competition for the last remaining northern spotted owls. The amount of previous interaction between northern spotted owls in Canada and the United States is unknown.

As of July 1, 1994, there were 5,431 known site-centers of northern spotted owl pairs or resident singles: 851 sites (16 percent) in Washington, 2,893 sites (53 percent) in Oregon, and 1,687 sites (31 percent) in California (USDI FWS 1995). By June 2004, the number of territorial northern spotted owl sites recognized by Washington Department of Fish and Wildlife was 1,044 (Buchanan and Swedeen 2005). The actual number of currently occupied northern spotted owl locations across the range is unknown because many areas remain unsurveyed (USDI FWS 1992a, Thomas et al. 1993). In addition, many historical sites are no longer occupied because northern spotted owls have been displaced by barred owls, timber harvest, or severe fires, and it is possible that some new sites have been established due to reduced timber harvest on Federal lands since 1994. The totals in USDI FWS (1995) represent the cumulative number of locations recorded in the three States, not population estimates.

Because the existing survey coverage and effort are insufficient to produce reliable range-wide estimates of population size, demographic data are used to evaluate trends in northern spotted owl populations. Analysis of demographic data can provide an estimate of the finite rate of population change (λ) (lambda), which provides information on the direction and magnitude of population change. A λ of 1.0 indicates a stationary population, meaning the population is neither increasing nor decreasing. A λ of less than 1.0 indicates a decreasing population, and a λ

of greater than 1.0 indicates a growing population. Demographic data, derived from studies initiated as early as 1985, have been analyzed periodically (Anderson and Burnham 1992, Burnham et al. 1994, Forsman et al. 1996, Anthony et al. 2006) to estimate trends in the populations of the northern spotted owl.

In January 2009, two meta-analyses by Forsman et al. (2011) modeled rates of population change for up to 24 years using the re-parameterized Jolly-Seber method (λ_{RJS}). One meta-analysis modeled the 11 long-term study areas (Table 4), while the other modeled the eight study areas that are part of the effectiveness monitoring program of the NWFP (Forsman et al. 2011).

Table 4. Northern spotted owl demographic study areas (adapted from Forsman et al. 2011).

Study Area	Fecundity	Apparent Survival[1]	λ_{RJS}	Population change[2]
Cle Elum	Declining	Declining	0.937	Declining
Rainier	Increasing	Declining	0.929	Declining
Olympic	Stable	Declining	0.957	Declining
Coast Ranges	Increasing	Declining since 1998	0.966	Declining
HJ Andrews	Increasing	Declining since 1997	0.977	Declining
Tyee	Stable	Declining since 2000	0.996	Stationary
Klamath	Declining	Stable	0.990	Stationary
Southern Cascades	Declining	Declining since 2000	0.982	Stationary
NW California	Declining	Declining	0.983	Declining
Hoopa	Stable	Declining since 2004	0.989	Stationary
Green Diamond	Declining	Declining	0.972	Declining

[1]Apparent survival calculations are based on model average.
[2]Population trends are based on estimates of realized population change.

Point estimates of λ_{RJS} were all below 1.0 and ranged from 0.929 to 0.996 for the 11 long-term study areas. There was strong evidence that populations declined on seven of the 11 areas (Forsman et al. 2011), these areas included Rainier, Olympic, Cle Elum, Coast Range, HJ Andrews, Northwest California and Green Diamond. On other four areas (Tyee, Klamath, Southern Cascades, and Hoopa), populations were either stable, or the precision of the estimates was not sufficient to detect declines.

The weighted mean λ_{RJS} for all of the 11 study areas was 0.971 (standard error [SE] = 0.007, 95 percent confidence interval [CI] = 0.960 to 0.983), which indicated an average population decline of 2.9 percent per year from 1985 to 2006. This is a lower rate of decline than the 3.7 percent reported by Anthony et al. (2006), but the rates are not directly comparable because Anthony et al. (2006) examined a different series of years and because two of the study areas in their analysis were discontinued and not included in Forsman et al. (2011). Forsman et al. (2011) explains that the indication populations were declining was based on the fact that the 95 percent confidence intervals around the estimate of mean lambda did not overlap 1.0 (stable) or barely included 1.0.

The mean λ_{RJS} for the eight demographic monitoring areas (Cle Elum, Olympic, Coast Range, HJ Andrews, Tyee, Klamath, Southern Cascades and Northwest California) that are part of the effectiveness monitoring program of the NWFP was 0.972 (SE = 0.006, 95 percent CI = 0.958 to 0.985), which indicated an estimated decline of 2.8 percent per year on Federal lands with the range of the northern spotted owl (Forsman et al. 2011). The weighted mean estimate λ_{RJS} for the other three study areas (Rainier, Hoopa and Green Diamond) was 0.969 (SE = 0.016, 95 percent CI = 0.938 to 1.000), yielding an estimated average decline of 3.1 percent per year (Forsman et al. 2011). These data suggest that demographic rates for northern spotted owl populations on Federal lands were somewhat better than elsewhere; however, this comparison is confounded by the interspersion of non-Federal land in study areas and the likelihood that northern spotted owls use habitat on multiple ownerships in some demography study areas.

The number of populations that declined and the rate at which they have declined are noteworthy, particularly the precipitous declines in the Olympic, Cle Elum, and Rainier study areas in Washington and the Coast Range study area in Oregon. Estimates of population declines in these areas ranged from 40 to 60 percent during the study period through 2006 (Forsman et al. 2011). Northern spotted owl populations on the HJ Andrews, Northwest California, and Green Diamond study areas declined by 20-30 percent whereas the Tyee, Klamath, Southern Cascades, and Hoopa study areas showed declines of 5 to 15 percent.

Decreases in adult apparent survival rates were an important factor contributing to decreasing population trends. Forsman et al. (2011) found apparent survival rates were declining on 10 of the study area with the Klamath study area in Oregon being the exception. Estimated declines in adult survival were most precipitous in Washington where apparent survival rates were less than 80 percent in recent years, a rate that may not allow for sustainable populations (Forsman et al. 2011). In addition, declines in adult survival for study areas in Oregon have occurred predominately within the last five years and were not observed in the previous analysis by Anthony et al. 2006. Forsman et al. (2011) express concerns by the collective declines in adult survival across the subspecies range because northern spotted owl populations are most sensitive to changes in adult survival.

2.2 Fisher

2.2.1 Legal Status

In 2004, the U.S. Fish and Wildlife Service (Service) concluded a 12-month finding (USDI FWS 2004b) for a petition to list the West Coast (Washington, Oregon, and California) population of the fisher (*Martes pennanti*). The finding determined that West Coast fishers constitute a distinct population segment (DPS) and that their listing is warranted but precluded by higher priority listing actions.

2.2.2 Life History

2.2.2.1 Taxonomy

The fisher is a member of the order *Carnivora*, family *Mustelidae* (weasels), subfamily *Mustelinae*, genus *Martes* (martens, fishers, and sables), subgenus *Pekania* (Anderson 1994). It is the largest member of the genus *Martes* and is the only extant species in the subgenus *Pekania* (Anderson 1994). The fisher's range overlaps extensively with that of the American marten (*M. americana*), which is the only other North American member of the genus *Martes* (Anderson 1994).

Three subspecies of fisher have been recognized in the literature: *M. p. pennanti* in eastern and central North America, *M. p. columbiana* in central and western Canada and the Rocky Mountains of the United States, and *M. p. pacifica* on the West Coast of North America (Goldman 1935, Hall 1981). A morphological analysis of specimens from across the range of the fisher, however, did not support recognition of separate subspecies (Hagmeier 1959). Genetic studies have found patterns of population subdivision similar to the 3 subspecies but have not determined whether the subspecies designations are taxonomically valid (Kyle et al. 2001; Drew et al. 2003) or have rejected the subspecies designations (Knaus et al. 2011).

2.2.2.2 Physical Description

The fisher has a long body, short legs, a long bushy tail, and a pointed face with forward eyes and rounded ears (Powell and Zielinski 1994). Fishers are usually deep brown to black and the face, neck, and shoulders are often grizzled with gray, silver, or gold (Powell 1993). The chest and abdomen typically have irregular white or cream markings. Fishers often have a sleeker appearance during their fall molt than during other seasons (Powell and Zielinski 1994). The species is commonly confused with the American marten, which is smaller and lighter in color and has more pointed ears and a shorter tail relative to the length of the body (Lofroth et al. 2010).

Male fishers are approximately 20% longer and 50 to 100% heavier than females (Lofroth et al. 2010). Adult males are 35 to 47 inches long and weigh 7.7 to 12.1 pounds, while adult females are 29 to 37 inches long and weigh 3.3 to 5.5 pounds (USDI FWS 2004b). Fishers also exhibit regional variation in body mass. Fishers in western North America typically weigh less than those in the eastern United States (USDI FWS 2004b). Individuals in the northern portions of western North America are typically heavier than those in the southern portions (Aubry and Lewis 2003, Lofroth et al. 2010).

2.2.2.3 Current and Historical Range

At the time of European settlement, the fisher's range extended across the northern forests of North America and south along the Appalachian, Rocky, and Pacific Coast mountains (Powell and Zielinski 1994; Figure 2). The range of the West Coast population of fishers included the Hozameen, Okanagan, and Cascade Ranges of British Columbia; the Cascade and Coast Ranges of Washington, Oregon, and northern California; the Klamath-Siskiyou Mountains of Oregon and California; and the Sierra Nevada of California (Powell and Zielinski 1994).

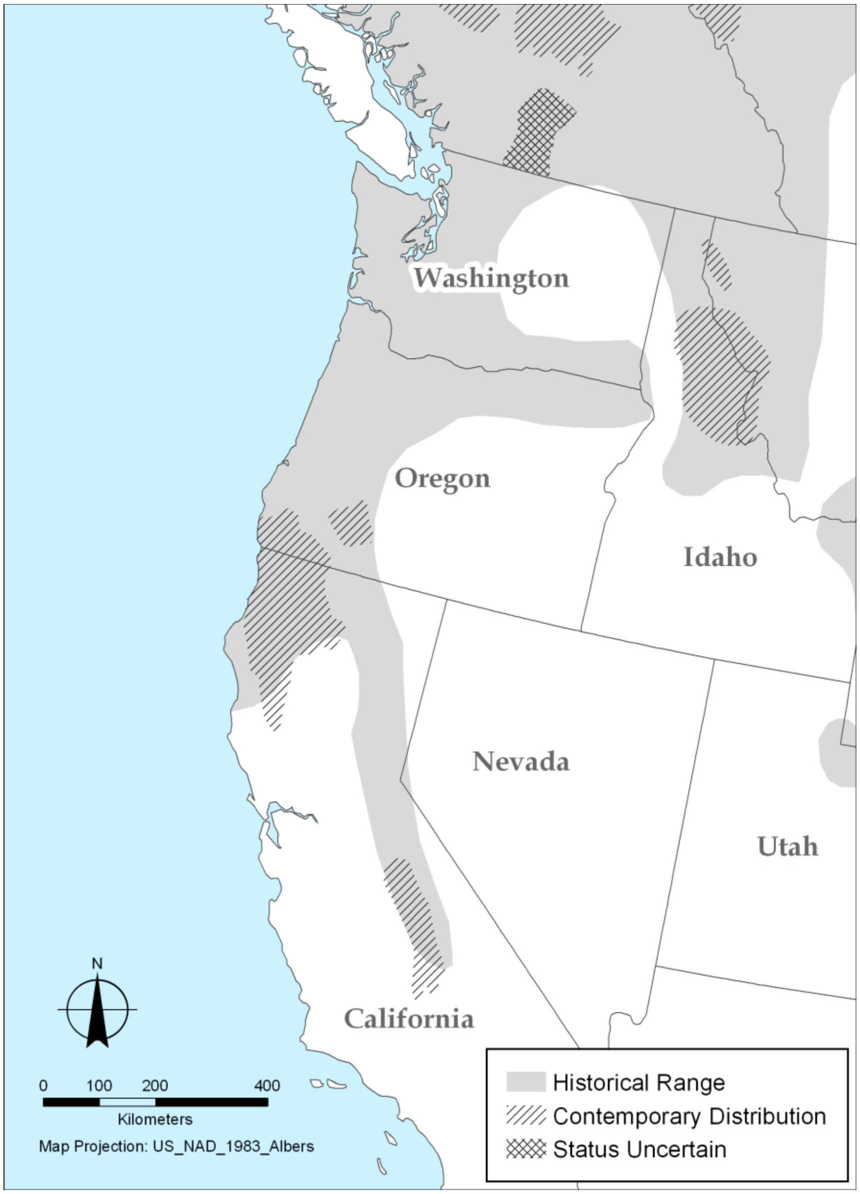


Figure 2. Contemporary distribution of fisher in the western United States and southern British Columbia compared to the historical distribution as depicted by Gibilisco (1994). Figure adapted from Lofroth et al. (2010).

Trapping, predator control, and habitat destruction during the late 1800s and early 1900s extirpated fishers from large portions of their range in the United States and eastern Canada (Douglas and Strickland 1987, Powell and Zielinski 1994). Within the Pacific Coast region, fishers were extirpated from Washington and portions of British Columbia, Oregon, and California (Lofroth et al. 2010).

Fishers are still absent from portions of their historical range (e.g., the southern Appalachian Mountains) but regrowth of forests, reduced trapping, and reintroduction programs have facilitated population recoveries in some areas (Powell and Zielinski 1994, Lofroth et al. 2010). The fisher's range and distribution in the Pacific Coast region have been substantially reduced. Fishers native to Washington are currently rare or extinct. Fishers have been reintroduced to the Olympic Peninsula but successful establishment of the population has not yet been verified (Lewis et al. 2010, Washington Department of Fish and Wildlife 2011). Oregon currently has 2 genetically isolated populations: a native population in the Siskiyou Mountains and a reintroduced population in the Cascade Range (Aubry and Lewis 2003). California has 2 disjunct native populations: one in the southern Sierra Nevada and one in the northwestern part of the State (Powell and Zielinski 1994, Zielinski et al. 1995). Fishers in southwestern Oregon and northwestern California occur as a series of interconnected local populations (USDI FWS 2010b); hereafter, these are collectively referred to as the southwestern Oregon/northwestern California population. Fishers have been translocated to the northern Sierra Nevada but successful establishment of the population has not yet been verified (CDFG 2011).

2.2.2.4 Behavior

Locomotion

Fishers have 5 toes on each of their large feet (Powell and Zielinski 1994). They walk with either their whole foot or just their toes and have an undulating, weasel-like, gait (Powell 1993). Deep snow can restrict fishers' movements and possibly influences their habitat associations, distribution, and reproduction (Powell and Zielinski 1994, Krohn et al. 2004).

The fisher's partially retractable claws and slightly specialized anatomy enable them to climb trees and descend head-first (Powell 1993, Lofroth et al. 2010). Fishers climb trees to access cavities or prey and have been observed traveling from tree to tree (Coulter 1966). However, the species is less arboreal than is commonly thought (Powell 1993, Powell and Zielinski 1994).

Daily Activity Pattern

Fishers have 1 to 3 activity periods per day (Powell 1993). They are active during daytime or nighttime, but are least active during mid-day and often have peaks in activity near sunrise and sunset (Arthur and Krohn 1991, Powell 1993). Fisher activity patterns appear to be influenced by a variety of factors beyond time of day, such as gender, breeding status, development of offspring, ambient temperature, and snow conditions (Leonard 1980, Arthur and Krohn 1991, Weir and Corbould 2007).

Fishers use snags, logs, and other structures for resting when they are not foraging or traveling (Lofroth et al. 2010). Individuals typically remain inactive at a rest site for several hours to several days at a time (Powell and Zielinski 1994).

Fishers are able to rapidly move long distances but travel an average of approximately 3 to 4 miles per day (Powell 1993). As with activity patterns, the mobility of fishers is influenced by season, offspring development, and other factors (Powell 1993).

Agonistic Behavior and Territoriality

Fishers are solitary except when mating, defending their territory, or rearing kits (Powell 1993). Fishers are territorial toward members of the same sex. Home ranges do not generally overlap for members of the same sex but the large home ranges of males often overlap those of multiple females (Powell 1993). Fishers appear to primarily maintain their territories through scent marking (Powell and Zielinski 1994). Agonism has rarely been documented for fishers (Powell and Zielinski 1994). However, kits are often aggressive toward each other at about 3 months of age and mothers often become aggressive toward their kits after they are about 4 months old (Coulter 1966, Powell 1993). Indirect evidence suggests that adult males occasionally fight during the breeding season, when many males trespass into neighboring territories to find estrous females (Leonard 1986, Powell 1993). Male fishers appear to select between 2 reproductive strategies. Some males maintain their territories during the breeding season, perhaps in order to defend access to females within them, while others abandon their territories and roam in search of estrous females (Aubry et al. 2004).

2.2.2.5 Habitat Relationships

Home Range Size

Rigorous comparisons of fisher home range estimates are not possible due to differences in sampling efforts and analytical methods among studies. General comparisons, however, may still be of interest. Mean fisher home range sizes across North America varied from 3,954 to 30,147 acres for males and from 988 to 13,096 acres for females (USDI FWS 2004b). Mean home range sizes for fishers in western North America closely resembled these (Lofroth et al. 2010). Throughout North America, the home ranges of males are, on average, nearly 3 times larger than those of females (Powell and Zielinski 1994, Lofroth et al. 2010). Mean home range sizes from 7 study areas in California ranged from 1,829 to 14,357 acres for males and from 420 to 5,807 acres for females (Lofroth et al. 2010).

Habitat Relationships

Denning and Resting Sites

Dens and rest sites likely provide fishers with protection from predators and weather, access to foraging areas, and a place to safely consume prey (Powell 1993, USDI FWS 2004b, Lofroth et al. 2010). Fishers typically use 3 dens per litter of kits (Arthur and Krohn 1991, Paragi et al. 1996, Higley and Matthews 2006) and only occasionally reuse rest sites (Powell and Zielinski 1994). Thus, a well distributed network of suitable denning and resting sites is a key feature of fisher home ranges (USDI FWS 2004b). Suitable dens and rest sites are likely more limiting than foraging habitat for fishers (Powell 1993, Powell and Zielinski 1994).

All natal dens are located in cavities in trees or snags, but platforms in trees (e.g., mistletoe brooms or rodent nests), the interiors of hollow logs, and spaces under woody debris may be used for maternal dens (Powell and Zielinski 1994, Lofroth et al. 2010). Fishers also use a variety of structures for resting, including cavities in trees or snags, large branches, hollow logs, mistletoe clumps, platform nests, rocks, holes in the ground, and slash and brush piles (Powell and Zielinski 1994, Lofroth et al. 2010). Fishers rested primarily in live trees and secondarily in snags and coarse down wood (Lofroth et al. 2010). Fishers on managed timberlands in northwestern California primarily rested on mistletoe brooms but also used large lateral branches, mammal nests, and tree cavities (Self and Kerns 2001, Simpson Resource Company 2003).

Fishers in western North America use both conifers and hardwoods for denning but appear to favor hardwoods (Lofroth et al. 2010). Black oaks (*Quercus kelloggii*) are often used for denning in California (Lofroth et al. 2010). Most (91%) hardwoods used for denning in western North America are alive, whereas live and dead conifers are used almost equally (Lofroth et al. 2010). Fishers in the southern Sierra Nevada usually rested in black oaks and other hardwoods; fishers near the northern California coast primarily used Douglas-firs; and fishers in the Klamath Mountains mostly rested in hardwoods, followed by conifers, snags, and logs (Zielinski et al. 2004b, Higley and Matthews 2006).

Trees used for denning and resting are typically large. The average diameter at breast height (dbh) of trees used for denning and resting in western North America ranged between 18 and 73 inches and 22 and 46 inches, respectively (Lofroth et al. 2010). Conifer trees used for denning and resting are usually larger than hardwoods used (Lofroth et al. 2010). In California, conifers, conifer snags, and hardwoods used for denning averaged 46, 46, and 25 inches dbh, respectively (Truex et al. 1998). The sizes of trees used for resting in California were similar to those used for denning (46, 47, and 27 inches dbh for conifers, conifer snags, and hardwoods; Zielinski et al. 2004b). The diameters of trees used for denning and resting in western North America were, on average, 1.7 to 2.8 and 1.5 to 1.7 times larger, respectively, than those of other nearby trees (Lofroth et al. 2010). Logs used for denning and resting in western North America were also generally large; ranges of means among studies were 22 to 65 inches for dens and 16 to 52 inches for resting (Lofroth et al. 2010).

Areas immediately surrounding fisher denning and resting locations in western North America are generally characterized by the presence of large trees and snags, large-diameter hardwoods, coarse woody debris, dense multi-layered canopies, and steep slopes near water (USDI FWS 2004b, Lofroth et al. 2010). Rest sites in western North America usually had denser canopies, larger trees, more large trees and snags, and a greater abundance of coarse woody debris than was generally available (Lofroth et al. 2010). Fishers in California also tended to rest at sites with more hardwoods than were generally available.

Habitats Used by Active Fishers and Prey

Habitats used for foraging, traveling, and other activities resemble denning and resting habitat but include a broader range of conditions (USDI FWS 2004b, Lofroth et al. 2010). Throughout their range, fishers generally favor areas with dense canopy cover and avoid open or sparsely-canopied areas (Powell 1993, Powell and Zielinski 1994, Lofroth et al. 2010). Fishers also occur in areas with sparse canopy cover, particularly on managed lands in northern California, but their population performance in these areas is unknown (Powell and Zielinski 1994). Rosenberg and

Raphael (1986) characterized fishers in northern California as sensitive to the sizes of forest stands. Survey stations at which fishers were detected in both northern and southern California have generally been located in more structurally complex forests than those at which fishers were not detected (Lofroth et al. 2010). Fishers in northern California were also more likely to be detected at sites with a greater component of hardwoods, greater shrub or overstory tree cover, and greater densities of snags and coarse woody debris (Lofroth et al. 2010). Fishers in the southern Sierra Nevada were usually detected in areas with greater canopy cover, a component of hardwoods and large trees (greater than about 24 inches), and close proximity to a stream (Green 2007).

Fishers have broad diets that include prey species with a wide variety of habitat associations. Nonetheless, certain habitat elements are important to many of the fisher's prey: (1) large conifers and hardwoods are the primary sources of seeds for many birds and small mammals; (2) many of the fisher's prey rely on shrubs for food, cover, or nest sites, and shrubs and other understory plants provide fruit for fishers; (3) snags and coarse woody debris are used by many birds and small mammals for cover, foraging, caching food, nesting, and other functions, and large, well-decayed logs are often important to truffles (a key food resource for many small mammals); and (4) interconnected, multi-layered canopies are important for arboreal mammals and many bird species (Lofroth et al. 2010).

Landscape Composition

Home ranges and landscapes occupied by fishers typically consist of a mosaic of vegetation types and structural stages, but with a large component of mid- to late-successional forest (Powell and Zielinski 1994, Lofroth et al. 2010). Fishers in western North America appear to generally avoid landscapes with large amounts of non-forest (Lofroth et al. 2010). The home ranges of fishers in California contained a variety of vegetation types and structural stages but were mostly composed of conifer or conifer-hardwood forest with dense canopy cover and mid- to late-successional structure (Zielinski et al. 2004a).

Abiotic Habitat Features

Studies have identified a variety of abiotic features associated with the presence or absence of fishers, including elevation, terrain ruggedness, solar insolation, slope angle or position, and proximity to streams or roads (Powell and Zielinski 1994, Lofroth et al. 2010, Zielinski et al. 2010). It is often unclear whether these features directly influence habitat use by fishers or are simply associated with other important variables, such as vegetation conditions or prey availability.

Fishers are generally found at low- to mid-elevations in the Pacific States (e.g., less than about 5,000 feet; Powell 1993, Powell and Zielinski 1994, Lofroth et al. 2010). Elevation is likely a proxy for the distribution of snow depth and suitable vegetation conditions, rather than a direct influence on fisher-habitat relationships (Powell and Zielinski 1994, Lofroth et al. 2010). Throughout its range, the fisher appears to avoid higher elevations and other areas with deep snow, which is thought to restrict the species' movements (Powell and Zielinski 1994). In areas with intermediate snow depths, fishers may partly favor densely-canopied forests for their interception of snow (Powell and Zielinski 1994, Weir 1995). Elevation also influences the distribution of vegetation composition and structure in western mountains. For example, major vegetation types in the Klamath Mountains and Sierra Nevada of California tend to occur as lateral bands distributed according to elevational controls on climate and natural disturbance regimes (Sawyer 2006, Fites-Kaufmann et al. 2007).

Numerous studies have found that fishers favor riparian areas or other areas near streams (Powell and Zielinski 1994, Lofroth et al. 2010). In areas where they differ from uplands, riparian areas provide important habitat for many birds and small mammals due to the presence of shrubs, herbs, hardwoods, and other moisture- or disturbance-associated plants and their function as corridors for movement for some species (Doyle 1990, Knopf and Samson 1994, Boyce and Payne 1997, Anthony et al. 2003). Riparian areas may also function as corridors for movements by fishers (Powell and Zielinski 1994). In some landscapes, large proportions of suitable denning and resting structures and habitat may be located in riparian areas (Lofroth et al. 2010).

2.2.2.6 Reproductive Biology

The fisher's breeding season extends from February through April but can occur as early as January and as late as May (Powell and Zielinski 1994). Fishers usually give birth between mid-March and early April, although parturition can also occur a month earlier or later than this (Powell 1993). Females become estrous for about 1 week 3 to 9 days after giving birth (Powell 1993). Males become more active early in the breeding season and often foray into other males' territories in search of estrous females (Arthur and Krohn 1991, Powell 1993). Due to delayed implantation, fishers give birth nearly 1 year after conception (Powell 1993). The average litter size for fishers is 2 to 3 kits (Powell 1993). Males do not assist females with care of the offspring and may even pose a threat to young fishers (Powell 1993).

Fishers use cavities in trees or snags to give birth (Powell 1993, Lofroth et al. 2010). Kits are born blind and have tightly closed ears and sparse hair (Coulter 1966). Mothers may move kits to multiple den locations before weaning them at approximately 10 weeks old (Arthur and Krohn 1991, Powell 1993). After weaning, mothers and kits become more mobile but often use the same den for 2 or more days at a time (Arthur and Krohn 1991, Paragi et al. 1996, Aubry and Raley 2006). Kits typically establish their own home ranges by about 1 year of age (Powell 1993).

Male fishers produce sperm at 1 year of age but do not appear to be effective breeders until after their first year (Powell 1993). Females can breed at 1 year of age but do not produce a litter until at least their second year due to delayed implantation (Powell and Zielinski 1994). Older females may breed more frequently than younger females (Weir and Corbould 2008).

2.2.2.7 Natal Dispersal

Juvenile fishers usually disperse from their natal areas during their first fall or winter (Lofroth et al. 2010). Fishers are capable of moving long distances but appear to have relatively poor dispersal abilities (Lofroth et al. 2010). The duration of dispersal by fishers is influenced by multiple factors, including gender and the availability of unoccupied, suitable habitat (Lofroth et al. 2010). Inferences about dispersal by fishers, however, are generally limited by small sample sizes.

Juvenile fishers may disperse shorter distances in areas with high mortality and a low density of other fishers (Arthur et al. 1993). In Maine, which has high trapping mortality and a low density, the mean minimum distance moved by dispersing fishers was 7 miles (Arthur et al. 1993). In contrast, fishers in a higher-density population in Massachusetts dispersed a mean minimum distance of 20 miles (York 1996).

Juvenile dispersal appears to be male-biased in western North America (Lofroth et al. 2010). For example, in the Oregon Cascades, the average dispersal distance for males (18 miles) was nearly 5 times that of females (3.7 miles) (Aubry and Raley 2006).

2.2.2.8 Food Habits

Fishers are opportunistic, generalist predators (Powell and Zielinski 1994, Lofroth et al. 2010). Fisher diets typically include birds, mammals, reptiles, insects, fruit, and carrion (Powell and Zielinski 1994, Lofroth et al. 2010). Porcupines (*Erethizon dorsatum*) and snowshoe hares (*Lepus americanus*) are key contributors to fisher diets in much of North America but appear to be absent from the diet in California (Zielinski et al. 1999, Golightly et al. 2006). Fishers in California tend to have more diverse diets than do other western fishers (Zielinski et al. 1999, Golightly et al. 2006). Small and medium size mammals, including carnivores, rodents, and insectivores, were most often present in the scats of fishers in California (Zielinski et al. 1999, Golightly et al. 2006). Birds, reptiles, insects, truffles, and ungulate carrion also appeared to be important components of fisher diets in the State (Zielinski et al. 1999, Golightly et al. 2006).

Seasonal changes in fisher diets are generally minor (Powell and Zielinski 1994), although ungulate carrion was present in substantially more scats during winter than during other seasons in the southern Sierra Nevada (Zielinski et al. 1999). Sexual differences in the diets of fishers also appear to be weak (Powell and Zielinski 1994). However, males, which are larger, may capture larger mammalian prey more frequently than do females (Lofroth et al. 2010). Perhaps due to their poorer hunting ability, juvenile fishers in the eastern United States ate more fruits than did adults (Giuliano et al. 1989).

2.2.2.9 Population Biology

Fishers have low annual reproductive capacity and reproductive rates can strongly fluctuate among years (Lofroth et al. 2010). The annual reproductive rate of adult female fishers (proportion that denned) in western North America averaged 64% and ranged between 39 and 89% (Lofroth et al. 2010). The annual reproductive rates in a study on managed timberlands in northern California were 22 and 80% during 2 breeding seasons (51% for both years combined; Reno et al. 2008). Only a portion of breeding females successfully wean kits. For example, the annual reproductive rate in a northern California study was 85% but only 68% of females successfully weaned 1 or more kits (Higley and Matthews 2006). Annual fluctuations in reproduction could be influenced by a variety of factors, including snow depths or the age structure of the population’s females (Powell and Zielinski 1994, Weir and Corbould 2008).

Trapping and other human activities are the primary causes (68%) of mortality in some eastern North American populations, whereas natural factors cause the majority (54%) of mortalities in western North America (Lofroth et al. 2010). Predation is the primary natural source of mortality in western North America (Lofroth et al. 2010); bobcats, large carnivores, and raptors are the fisher's main predators (Powell and Zielinski 1994, Higley and Matthews 2009). Starvation, choking on food, injuries received from prey or conspecifics, are also sources of natural mortality for fishers (Powell and Zielinski 1994, Lofroth et al. 2010). Anthropogenic factors that contribute to individual fisher mortality and fitness include; contaminants, pest control programs, non-target poisoning, collision with vehicles, and accidental trapping in manmade structures (Folliard 1997, Truex et al. 1998, Gabriel et al. 2011, Sweitzer et al. 2011). Diseases and parasites are thought to be uncommon in fishers (Powell 1993, Powell and Zielinski 1994, Lofroth et al. 2010). A recent study in northern California, however, found exposure by fishers to several diseases including canine distemper virus and parvovirus (Brown et al. 2008). Although the full ecology of canine distemper virus and parvovirus in fishers is not fully understood, both viruses have caused mortality and morbidity in fishers and many other susceptible mustelids (Gabriel 2010). In 2009, in an insular population of fishers in the southern Sierra Nevada Mountains in California, an epizootic of distemper virus caused four mortalities within a short period of time (Gabriel 2010). Some of the reported diseases suppress immune function in other species and thus, could act synergistically with other factors to cause mortality of fishers. For example, the protozoan *Toxoplasma gondii* has been documented as a cause of mortality as well as an immunosuppressive pathogen in fishers (Gabriel 2010).

An emerging conservation concern is how the widespread use of anticoagulant rodenticides may be affecting fishers. Prevalence of exposure to anticoagulant rodenticides in fishers from California and Washington is quite high, with 80% of 71 sampled fishers testing positive (Gabriel 2012). It is unknown at this time whether exposure to these toxicants has an additive sublethal or chronic effect on an individual fisher or population; however, four fisher mortalities from California were directly attributed to anticoagulant rodenticides toxocosis (Gabriel 2012). To date, no direct consumption of anticoagulant rodenticides has been detected in fisher stomach contents, thus suggesting that exposure to these toxicants may be from secondary poisoning from consumption of prey or carrion exposed to anticoagulant rodenticides (Gabriel 2012).

The life expectancy of fishers is approximately 10 years but individuals as old as 12 have been reported (Powell 1993, Lofroth et al. 2010). Nonetheless, only a small proportion of fishers in wild, unharvested populations are more than 6 or 7 years-old (Lofroth et al. 2010). Studies in 2 areas of northern California found that 45 and 55% of individuals were not yet of reproductive age (i.e., less than 2 years-old), 52 and 35% were 2 to 6 years-old, 3% and 10% were 7 or 8 years-old, and no individuals were older than 8 years (Brown et al. 2006, Reno et al. 2008). It is possible, however, that these studies' use of live-trapping to determine fishers' ages biased their results toward younger animals (Lofroth et al. 2010). The age structures of fisher populations likely fluctuate among years in response to a variety of factors, including age-specific survivorship, population density, and prey availability (Powell and Zielinski 1994, Lofroth et al. 2010).

Estimates of annual survivorship, sex ratios, and age structure vary across the fisher's range and are closely associated with the occurrence of commercial trapping (Powell and Zielinski 1994, Lofroth et al. 2010). Mean annual survivorship was 0.82 for males and 0.74 for females in 3 untrapped populations in western North America (Lofroth et al. 2010). In contrast, male survivorship was, on average, 34% lower than that of females in commercially trapped populations in eastern North America. Age-specific survivorship also appears to be sensitive to commercial trapping (Lofroth et al. 2010). In Maine, juvenile survivorship during the trapping period was nearly half that of the nontrapping period (38 vs. 72%; Krohn et al. 1994).

Powell and Zielinski (1994) hypothesized that populations of fishers and other mustelids are characterized by episodes of local extinction and recolonization. If true, small population sizes and geographic isolation could prevent recolonization of depopulated areas (see section 2.2.3).

2.2.3 Threats

2.2.3.1 Reasons for Legal Status

The Service's 12-month finding for a petition to list the West Coast DPS concluded that listing was warranted but precluded by pending proposals for other species with higher listing priorities (USDI FWS 2004b). The Service determined that listing was warranted due to multiple past and present threats to the DPS, including: (1) over-trapping and incidental captures; (2) loss and fragmentation of habitat; (3) other problems associated with spread of roads and other human developments, such as vehicle collisions and behavioral disturbance; (4) disease and predation; and (5) small, isolated populations. The Service considered the combined magnitude of these threats to be non-imminent but high. The remainder of this section summarizes relevant sections of the Service's 12-month finding.

Commercial trapping, particularly during the late 1800s and early 1900s, contributed to dramatic declines in the fisher's abundance, distribution, and range. Trapping continues to be a primary cause of fisher mortality in areas where it is still legal. Commercial trapping has been prohibited in California, Oregon, and Washington since the 1930s and 1940s. However, fishers are sometimes incidentally captured in traps set for other species. Incidental captures often maim or kill fishers. Even small numbers of mortalities from trapping could prevent local recovery of populations or recolonization of historically occupied areas.

Historical logging was a primary cause of the fisher's decline and harvesting continues to threaten the species in some parts of its range. Depending on how and where it occurs, logging can alter fisher habitat by fragmenting or reducing forests or by modifying forest composition and structure. Fishers are generally associated with dense canopy cover, large and deformed trees, and large snags and logs. These features, along with understory cover, are also important to the fisher's prey communities. The impacts of logging on fishers partly depend on the degree to which these structural characteristics are reduced. Habitat fragmentation and loss might also negatively affect fishers by creating barriers to dispersal and other movements.

Fire suppression, together with logging, livestock grazing, and other factors, has facilitated increased forest densities in drier, more fire-prone portions of the fisher's range. Increased canopy cover and greater abundances of dead woody materials in these forests might benefit some fishers. However, increased forest densities have substantially heightened the risk of large, stand-replacing wildfires. Large, stand-replacing fires could threaten large areas of fisher habitat.

Although not discussed in the 12-month finding, it is also important to note that increased forest densities have contributed to declines in oaks and other shade-intolerant hardwoods in some areas of California (Sugihara et al. 2006). Loss or reduction of hardwoods could negatively affect some populations by reducing denning and resting structures for fishers and mast for prey. Additionally, increased densities of small and medium size trees have accelerated declines of large conifers in some forests (Dolph et al. 1995, Smith et al. 2005, Ritchie et al. 2008).

The 12-month finding concluded that outbreaks of insects and diseases that affect trees are probably not a major threat to fisher habitat on the West Coast. However, at uncharacteristic high levels, insects and disease can cause broad-scale loss of overstory trees and vegetation diversity that may fragment or remove forested environments capable of supporting fishers. Sudden Oak Death, for example, could pose a significant future threat to fisher populations strongly associated with oaks and other hardwoods (e.g., the southwestern Oregon/northern California population).

Increases in the number and distribution of residential areas, roads, and other human developments likely strongly contributed to the fisher's extirpation from, and failure to recolonize, the central and northern Sierra Nevada. Expanding human populations are projected to result in increased land conversion in forested areas of the West Coast. Increased roads and other human developments could reduce and fragment fisher habitat, disrupt fisher movements, and bring the species into greater contact with vehicles, recreationists, and trapping. Collisions with vehicles are a major cause of fisher mortality in some areas and vehicles or recreationists may alter the behavior or distribution of fishers. Additionally, several fishers have been found dead in water storage tanks associated with human developments.

Major outbreaks of disease have not been documented for fisher populations but fishers are susceptible to diseases that have strongly impacted other mustelids. Predation appears to be a primary source of mortality for some fisher populations. Disease and predation potentially threaten West Coast fishers due to their occurrence as small, isolated populations.

West Coast fishers are at risk of extinction due to small population size and associated factors, such as isolation, low reproductive capacity, and demographic and environmental stochasticity. California and southwestern Oregon have the only known native populations of fishers on the West Coast. Native fishers are currently rare or absent in Washington and most of Oregon. Fishers were reintroduced to the southern Cascades of Oregon but the population is small and isolated. Fishers were reintroduced to the Olympic Peninsula of Washington and northern Sierra Nevada of California subsequent to the 12-month finding but their status is still being determined (Lewis et al. 2010, Washington Department of Fish and Wildlife 2011, CDFG 2011).

2.2.3.2 Additional Threats

Climate Change

Projected climate changes and their general effects are described in sections 1.4.5.1 (Changed Circumstances) and 2.1.3.2 (New Threats). Projected effects that could influence West Coast fisher populations include changes to forest composition and structure, prey communities, snow packs, and natural disturbance regimes. The effects of projected changes are difficult to predict for fishers because they would likely affect the species in complex and synergistic ways (Safford 2007). Some projected changes could benefit fishers. For example, reduced, earlier-melting snow packs might enable fishers to travel more easily or exploit higher-elevation areas. Projected increases in the abundance and distribution of oaks and other hardwoods in California's mountains could also benefit fishers by increasing denning and resting structures and mast for prey. Other projected changes could negatively affect West Coast fishers. For example, increased occurrence of catastrophic wildfires in some forests could reduce or fragment habitat for fishers. Climate change is also expected to cause the extinction of many wildlife species. Extinctions, along with species-specific responses to climate change, would likely have complex, unpredictable effects on the composition and abundance of the fisher's prey communities.

2.2.4 Conservation Needs of the Fisher

2.2.4.1 Habitat Needs

1. Large blocks of suitable habitat to support clusters of fisher (i.e., greater than 20 females) throughout the fisher's range;

2. Suitable habitat conditions and spacing between clusters of fisher populations throughout its range to facilitate survival and movement;

3. Suitable habitat distributed across a variety of ecological conditions within the fishers' range to reduce risk of local or widespread extirpation;

4. A coordinated, adaptive management effort to reduce the loss of habitat due to catastrophic wildfire throughout the fisher's range, and a monitoring program to clarify whether these risk reduction methods are effective and to determine how fishers use habitats treated to reduce fuels; and

5. Monitoring and coordinated research to better understand the risk of how uncharacteristically high levels of insect and disease (e.g., sudden oak death) affect fisher habitat.

2.2.4.2 Habitat-independent Needs

1. A coordinated adaptive management effort is needed to ameliorate threats and overcome the fundamental challenges posed by relatively, small isolated populations. These efforts will differ by geographic region because the type, number, and potential synergistic effects of threat

interactions are complex and varied;

2. A coordinated research and adaptive management effort to better understand and manage for the competitive and predatory interactions between fishers and their predators.

3. A coordinated research and monitoring effort to better understand the risk that disease and toxins pose to fishers and methods that may reduce the likelihood or severity of outbreaks and exposure in fisher populations.

2.2.4.3 Conservation Strategy

Region 8 of the Service completed an action plan for the West Coast DPS of the fisher (USDI FWS 2010c). The plan identified the following actions to maintain or improve the West Coast fisher's current status from 2010 to 2014:

1. Develop conservation strategies among Federal, State, and local agencies, as well as private land owners.

2. Develop a systematic survey and monitoring program for fishers throughout their historical range in the Pacific States and ensure that it has long-term institutional support.

3. Conduct research to assist in recovery and conservation planning.

4. Augment existing populations or reintroduce extirpated populations in suitable habitat within the species' historical range.

The Service's action plan acknowledged that 5 years was likely insufficient for demonstrating satisfactory improvements in the numbers or distribution of fishers. Large amounts of time and money from multiple Federal and State agencies will be required to demonstrate growth of existing populations and/or establishment of new populations. The Service did, however, expect to initiate the required programs during the 5-year period.

2.2.4.4 Federal Contribution to Recovery

As described above in section 2.1.4.4, the NWFP was adopted in 1994 to guide the management of 24 million acres of Federal lands in portions of western Washington and Oregon, and northwestern California (USDA Forest Service and USDI Bureau of Land Management 1994a, b). The NWFP represents a 100-year strategy for conservation of the northern spotted owl (*Strix occidentalis caurina*) and other species associated with late-successional and old-growth forests on Federal lands. The NWFP is intended to ultimately provide a network of large block reserves of late-successional habitat, connected through riparian reserves, and surrounded by a matrix of younger more intensively managed forest. As the forests mature the plan could lead to a substantial improvement in current habitat conditions for fishers on Federal lands within the reserve network. However, the assessment of NWFP implementation on fishers within the Plan Area projected only a 63% likelihood of achieving an outcome in which habitat is of sufficient quality, distribution, and abundance to allow the fisher population to stabilize and be well distributed across Federal lands (FEMAT 1V-173). Habitat modeling by Zielinski et al. (2006) suggested that areas of high predicted value for fishers poorly overlap with the current NWFP Late-Successional Reserve system; particularly in the eastern portion of the Klamath Province, where relatively little high value habitat currently occurs.

The Sierra Nevada Forest Plan Amendment (SNFPA) was adopted in 2001 and a Final Record of Decision (ROD) was issued in 2004 (USDA FS 2000a, 2001, 2004). The final ROD provides the framework guidance and policy document for managing 11 National Forests and about 11 million acres of California's National Forest lands in the Sierra Nevada and Modoc Plateau. The SNFPA includes measures expected to lead to an increase over time of late-successional forest; retention of important wildlife structures such as large-diameter snags and coarse woody debris; and management of about 40% of the Plan Area as old forest emphasis areas. The SNFPA also established a Southern Sierra Fisher Conservation Area with additional requirements intended to maintain and expand the fisher population in the southern Sierra Nevada. Conservation measures for the fisher conservation area include maintaining at least 60% of each watershed in mid-to-late successional forest (at least 11-inch mean dbh) with an average canopy cover of at least 50%. The plan also includes protections for known fisher den sites. However, this measure has limited conservation value in many areas due to the difficulty of locating fisher den sites without radio-telemetry. As part of the ROD, the USFS initiated a regional fisher monitoring program in 2002 to track population trends throughout the southern Sierra Nevada. The primary objective of the program is to use sampling to detect a 20% decline in relative abundance of the population with 80% statistical power.

The USDA Forest Service (USFS) Sensitive Species Policy and the USDI Bureau of Land Management (BLM) manual call for both National Forests and BLM districts to assist and coordinate with other Federal agencies and States to conserve species with viability concerns. The fisher has been identified as a sensitive species by the USFS Pacific Southwest and Pacific Northwest Regions (Regions 5 and 6, respectively) and the Oregon-Washington and California BLM.

Each National Forest operates under a Land and Resource Management Plan (LRMP) and each BLM district operates under a Resource Management Plan (RMP). The NWFP standards and guidelines apply to National Forests and BLM districts within the range of the northern spotted owl except when the standards and guidelines of LRMPs or RMPs are more restrictive or provide greater benefits to species associated with late-successional forest. Most individual Forest LRMPs and BLM district RMPs do not provide any additional protections to fishers or fisher habitat. Therefore, the above discussion regarding the NWFP and SNFPA summarizes the primary regulatory mechanisms in place on National Forest and BLM lands within the range of the West Coast DPS.

Land management plans for the National Parks within the range of the West Coast DPS do not contain specific measures to protect fishers. Nonetheless, areas not developed specifically for recreation or camping are managed toward natural ecosystem composition and function and are expected to maintain fisher habitat. Hunting and trapping are not allowed in the parks. Fisher habitat occurs in National Parks within the range of the West Coast DPS but many of the parks contain large areas at higher elevations than those at which fishers and their habitat generally occur. The Olympic National Park, Olympic National Forest, and the Washington Department of Fish and Wildlife are currently cooperating and implementing a reintroduction of fishers to suitable lands in the Olympic National Park (Lewis et al. 2010, Washington Department of Fish and Wildlife 2011).

2.2.4.5 Conservation Efforts on Non-Federal Lands

Washington. The State of Washington listed the fisher as endangered (WAC 232-12-297) in 1998. This status provides protection in the form of more stringent fines for poaching and a process for environmental analysis of projects that may affect the species. There are no special regulations to protect habitat for fishers or to conduct surveys for this species prior to obtaining forest activity permits.

The State Forest Practice Rules are the primary regulatory mechanism on non-Federal forest lands in Washington (Title 222 of the Washington Administrative Code). These rules apply to all commercial timber growing, harvesting, or processing activities on non-Federal lands, and give direction on how to implement the Forest Practice Act (Title 76.09 Revised Code of Washington), and Stewardship of Non-Industrial Forests and Woodlands (Title 76.13 RCW). Washington's Forest Practice Rules do not specifically address the fisher's habitat requirements but may provide limited benefit to the species through protection of important habitat elements (e.g., dead woody materials, canopy cover) in some areas.

The Washington Department of Fish and Wildlife (WDFW), in cooperation with the Olympic National Park, US Geological Survey, and others, began to reintroduce fishers onto Park Service lands on the Olympic Peninsula in Washington in January 2008 (Lewis et al. 2010). Three years of planned reintroductions were complete at the end of the 2010 trapping season with a total of 90 fishers (40 males and 50 females) relocated from British Columbia to the park. These fishers will be monitored for a number of years to determine both the extent of their distribution and success in establishing a reproducing population of fishers on the Olympic Peninsula. Successful establishment of this population will not be known for several years.

Oregon. Oregon designated the fisher a protected non-game species and a sensitive species (critical category; Oregon Department of Fish and Wildlife 2008). The Oregon Department of Fish and Wildlife does not allow 'take' (i.e., kill or obtain possession or control) of fishers, but some fishers may be injured or killed by traps set for other species. Training and testing is required of applicants for trapping licenses in order to minimize take of non-target species such as fishers.

The two management plans for Oregon's State Forests generally appear to be of little benefit to fishers. Both plans include provisions to protect some forest reserves, but these are not likely to benefit fishers because of the fragmented nature of the lands.

The Forest Practice Administrative Rules and Forest Practices Act (Oregon Department of Forestry 2000) regulates forest activities on all State, county, and private lands in Oregon. Interim procedures for protecting sensitive resource sites apply only to threatened and endangered species, and to bird species listed as "sensitive" in the rules, and currently do not apply to fishers. While Oregon's rules governing forest management on non-Federal lands do not directly protect the fisher or its habitat, they may provide some protection for habitat elements important to the species.

California. The State of California classifies the fisher as a furbearing mammal that is protected from commercial harvest. On April 8, 2009, the California Fish and Game Commission accepted a petition initiating a 12-month review of the status of fisher by the CDFG, pursuant to Fish and Game Code Section 2074.6. At its June 23, 2010 meeting, the California Fish and Game Commission determined that listing was not warranted as suggested by CDFG in the "Report to the Fish and Game Commission, A Status Review of the Fisher (*Martes pennanti*) in California", (CDFG 2010).

The California Environmental Quality Act (CEQA) provides regulatory protections for critical habitat and habitat required by federally listed species (e.g., northern spotted owls, marbled murrelets [*Brachyramphus marmoratus*], anadromous salmonids) on state and private lands in California. These protections may provide limited benefits to fishers.

Timber management activities on commercial forestlands in the State are guided by the CFPRs (California Department of Forestry and Fire Protection 2011). The Forest Practice Rules provide protections for species listed as threatened or endangered under the Endangered Species Act or CESA and for species identified by the California Board of Forestry as sensitive, but the fisher is not currently on any of these lists. The Forest Practice Rules also include intent language about reducing significant impacts to non-listed species and maintaining functional wildlife habitat. However, this language is not associated with specific enforceable measures. The CFPRs may provide limited benefit to fishers in some areas; for example, by protecting habitat elements for spotted owls and other species associated with late-successional forests.

The CDFG, in cooperation with the Service and Sierra Pacific Industries, began to translocate fishers to the northern Sierra Nevada in December, 2009. Three years of planned translocations (Callas and Figura 2008) were complete in December of 2011, with a total of 40 fishers (16 males and 24 females) relocated from northwestern California to the northern Sierra Nevada. These fishers will be monitored for seven years to determine both the extent of their distribution and success in establishing a reproducing population of fishers in the northern Sierra Nevada. Successful establishment of this population will not be known for several years.

Tribal. Tribal lands within the range of the West Coast DPS manage their forests under a variety of management plans. Some of these forest management plans (e.g., Warm Springs Reservation of the Confederated Tribes, The Coquille Tribe of Oregon, and The Confederated Tribes and Bands of the Yakama Nation) contain guidelines and habitat protection measures for spotted owls, riparian areas, and dead woody materials that will, at a minimum, provide some of the habitat components important to fishers and their prey. The forest management plan for the Hoopa Valley Indian Reservation in northwestern California includes setting aside habitat and no-harvest reserves and specifically acknowledges needs for conservation and research of fishers on the Reservation.

Habitat Conservation Plans. Some non-Federal lands are managed under Habitat Conservation Plans (HCPs) with strategies that conserve habitat for a variety of species. These HCPs may provide some incidental benefit to fishers. A few HCPs cover areas within the historical range of the fisher, particularly in western Washington and northwestern California. Although the fisher is a covered species in 7 HCPs within Washington and California, the species is currently known to be present only on lands under 2 California HCPs. In most HCPs, areas where late-successional habitat will be protected or allowed to develop are mostly in riparian buffers and smaller blocks of remnant old forest.

2.2.5 Current Condition of the West Coast DPS of the Fisher

2.2.5.1 Current Range and Distribution

The current range and distribution of West Coast fishers is described in section 2.2.2.3 (also see Lofroth et al. 2010).

2.2.5.2 Habitat Trends and Current Conditions

West Coast fishers favor areas containing mid- to late-successional conifer or conifer-hardwood forest, with relatively dense canopy cover, large-diameter trees, snags, and logs, and complex structure, including understory vegetation and down wood (USDI FWS 2004b). The current abundance of these conditions in the Pacific States is substantially lower than during historical periods. Bolsinger and Waddell (1993) found a 31% reduction of old-growth forests in evaluated portions of California, Oregon, and Washington compared to the early 20th century. The Forest Ecosystem Management Assessment Team (1993) reported that: (1) heavy logging has eliminated most late-successional and old-growth forest in the western Washington lowlands and northern Oregon Coast Range; (2) public lands in the Olympic Peninsula, southern Oregon Coast Range, and western Washington and Oregon Cascades still contain substantial amounts of late-successional or old-growth forest but much of it has been highly fragmented by logging; and (3) the Oregon and California Klamath Provinces and the California Cascades also have substantial amounts of late-successional and old-growth forest but it is highly fragmented by logging and natural factors. Franklin and Fites-Kauffman (1996) found that only about 14% of evaluated polygons (landscape units on public lands that were relatively uniform in type and distribution of vegetation patches) in the Sierra Nevada and southern Cascades of California are currently dominated by late-successional or old-growth forest structure and function.

Several recent models have used fisher detection locations and habitat associations to predict the distribution of habitat suitability for the species in California and southwestern Oregon (Carroll et al. 1999; Zielinski et al. 2006, 2010; Davis et al. 2007; Spencer et al. 2011). These models showed that large proportions of northwestern California currently consist of predicted medium- and high-suitability habitat for fishers; that is, areas in which there is a moderate or high probability of detecting the species (Carroll et al. 1999; Zielinski et al. 2006, 2010; Davis et al. 2007). The models have differed somewhat, however, in their projections of habitat suitability in the western versus eastern portions of the Klamath Province. Carroll et al. (1999) showed that most of the high-suitability fisher habitat in the Oregon and California Klamath Provinces is located relatively close to the coast. In contrast, Davis et al. (2007) projected greater amounts of high-suitability fisher habitat in the central, northern, and eastern portions of the California Klamath Province than in the western portion. Zielinski et al. (2010) did not model fisher habitat near the coast but did project greater concentrations of medium- and high-suitability fisher habitat in the western portion of the California Klamath Province than in the eastern portion. Models indicated that the southern Sierra Nevada currently contains a band of medium- and high-suitability fisher habitat on the range's western slope (Davis et al. 2007, Spencer et al. 2011). Pockets of medium- and high-suitability habitat likely also occur in rugged forested canyons in the northern Sierra Nevada but they are distant from the southern Sierra Nevada fisher population relative to fisher dispersal distances (Davis et al. 2007).

2.2.5.3 Population Densities and Abundances

Estimates of fisher densities and abundances vary among studies and geographic areas. Fisher populations are primarily influenced by the availability of habitat and prey (Powell 1993, Powell and Zielinski 1994). Population estimates for the species are often inaccurate due to large sampling errors and should be cautiously evaluated (Powell 1993, Powell and Zielinski 1994).

In British Columbia, densities of fishers in the highest-suitability habitats were estimated to be between 1.0 and 1.5 fishers per 38.6 mile^2 (Weir 2003). Estimated densities on an industrial forest in the province ranged between 0.8 and 1.3 fishers per 38.6 mile^2 (Weir and Corbould 2006). The late-winter population in British Columbia was conservatively estimated to be between 1,113 and 2,759 individuals (Weir 2003).

Native fishers are absent or rare in Washington. Ninety fishers were relocated from British Columbia to the Olympic Peninsula during 2008 through 2010 (Washington Department of Fish and Wildlife 2011). Monitoring during the coming years will determine whether or not fishers successfully establish themselves in this area.

Fishers were relocated from British Columbia and Minnesota to the southern Oregon Cascades in 1961 and from 1977 to 1981 (Aubry and Lewis 2003, Drew et al. 2003). The population has persisted but there have been no rigorous efforts to estimate its size (Lofroth et al. 2010).

Several density estimates are available for California portions of the southwestern Oregon/northern California fisher population. A density of about 5 females per 38.6 mile^2 was estimated for a study area on the Six Rivers and Shasta-Trinity National Forests (Zielinski et al. 2004a). On the Hoopa Valley Indian Reservation, densities of 52 and 14 fishers (male and female) per 38.6 mile^2 were estimated for 1998 and 2005, respectively (Matthews et al. 2011). The population was not monitored during the period between these years, so the cause of the apparent decline is unknown; however, the rebounding population appears to be stable or increasing based on lambda estimates and age structure shifts (Higley and Matthews 2009). Surveys on adjacent Green Diamond Resource Company lands during a similar period did not detect any major declines, suggesting that the decline on Hoopa lands was localized (Callas and Figura 2008). The density of fishers on Green Diamond lands was estimated to be between 7 and 11 fishers (male and female) per 38.6 mile^2) during 2002 and 2003 (Thompson 2008). Self et al. (2008) estimated that the entire southwestern Oregon/northern California population consists of 4,616 fishers. In a personal communication to the CDFG, C. Carroll estimated that the population consists of between 1,000 and 3,000 individuals (CDFG 2010).

Density and population estimates are also available for the southern Sierra Nevada. Roughly 8 females per 38.6 mile^2) were estimated to occur on the Sequoia National Forest (Zielinski et al. 2004a). Fishers on the Sierra National Forest were estimated to have a density of 9.5 to 13.4 individuals (male and female) per 38.6 mile^2) (Jordan 2007). Spencer et al. (2008) used 3 different approaches to estimate a population of between 160 and 350 fishers (55 to 120 adult females) in the southern Sierra Nevada. Using 2 approaches, Self et al. (2008) estimated that either 548 or 598 fishers occur in the southern Sierra Nevada. A third paper used expert opinion to estimate a population of between 100 and 500 fishers in the area (Lamberson et al. 2000). In 2002, the Forest Service initiated a monitoring program to track population trends in the Sierra Nevada. The population trend has not yet been analyzed but there was little change in the index of abundance during the program's first 5 years (Truex et al. 2009).

Native fishers appear to be rare or extirpated from the central and northern Sierra Nevada. A program is currently underway (2009 through 2011) to reintroduce a total of 40 fishers to the northern Sierra Nevada and southern Cascades of California (CDFG 2010). The translocated animals will be monitored for 7 years to determine the program's success (Callas and Figura 2008).

3.0 ENVIRONMENTAL BASELINE

Regulations implementing the ESA (50 CFR §402.02) define the environmental baseline as including the past and present impacts of all Federal, State, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed Federal projects in the Action Area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation process. Such activities include, but are not limited to, previous timber harvests and other land management activities.

The environmental baseline encompasses the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the Action Area. The environmental baseline is a "snapshot" of a species' health at a specified point in time.

3.1 Factors Affecting Species Environment within the Action Area

This analysis describes factors affecting the environment of the northern spotted owl and fisher in the Action Area. The baseline includes State, tribal, local, private and natural factors affecting the species or that will occur contemporaneously with the consultation in progress. Unrelated Federal actions affecting the species or critical habitat that have completed formal or informal consultation are also part of the environmental baseline, as are Federal and other actions within the Action Area that may benefit listed species or their critical habitat.

Existing conditions in the Action Area are largely the result of past management practices and natural disturbance regimes. Many factors have combined to alter the present environment from conditions that existed prior to Anglo-American settlement of the Klamath and Scott River basins. Human-induced changes related to terrestrial habitat have been the result of timber operations, mining, and grazing. Other factors that have influenced the current conditions related to terrestrial habitat within the Action Area include geology and the past fire regime. The historical vegetative condition is described briefly to provide context. Much of this information was drawn from the Beaver Creek (USDA FS 1996a), Horse Creek (USDA FS 2002), Callahan (USDA FS 1997), and Lower Scott (USDA FS 2000b) ecosystem analyses.

3.1.1 Land Management Activities

3.1.1.1 Timber Operations

Repeated timber operations, mining, grazing, and other land management activities over the past century have left the landscape deficit in late-successional and old-growth forested habitat essential to northern spotted owls for nesting and roosting, and fisher for resting and denning. Through 1971, timber harvest concentrated on old-growth stands. Requirements for logging included snag removal and stream cleaning, which removed denning and nest cavities and reduced canopy cover, thereby hampering the ability of the forest to provide a moderate microclimate for thermoregulation. Large sugar pine and ponderosa pine were the preferred logs because they were easy to mill, and mills were designed to accommodate logs more than 20 inches in diameter. During the 1950s, mills were refurbished to cut dimensional lumber and fir trees became desirable. Since passage of the Forest Practices Act in 1972, timber management has focused on younger, more productive forests. Mandatory protective measures for natural resources have been implemented, including designated stream protection zones, canopy retention standards, stream crossing standards, and other protective best management practices. Despite these protective measures, much of the landscape is still lacking suitable spotted owl and fisher habitat because forest stands have yet to develop the necessary habitat features to provide nesting and roosting sites for owls, and resting and denning sites for fisher.

3.1.1.2 Roads

Early logging operations used steam donkeys (steam powered hoists), log chutes, horses, and other less invasive methods to transport logs. Steam donkeys were eventually replaced with steam engines and railroad track, allowing logs to be transported longer distances. By the late 1930s and 1940s, railroad logging declined and railroad grades were converted to road systems for logging trucks. Extensive new road development and reconstruction of existing roads began in the late 1950s and continued to the mid-1980s by private timber companies and the USFS, primarily for timber harvest.

Throughout the drainages that contain the Plan Area, nearly 4,500 miles of roads have been identified, but only about one-third (about 1,350 miles) of these roads are on FGS lands. The remaining 3,150 miles of road are on lands controlled by the USFS, other governmental agencies, or private interests. FGS is solely responsible for maintenance of more than 1,100 miles of road in the Plan Area. About 250 miles of road on FGS lands are maintained under cooperative road agreements with USFS (co-op roads). Only the approximately 1,100 miles of road for which FGS is solely responsible for maintenance are covered under this HCP.

The density of roads in the individual drainages ranges from 0.6 to 5.9 miles per square mile (mi/mi^2). On the FGS ownership, road density generally ranges from 4 to 7 mi/mi^2 depending on the watershed. The highest road densities are in the Doggett and Lumgrey Creek watersheds in the Klamath River Management Unit, and the Mill and Pat Ford watersheds in the Scott Valley Management Unit, where road densities exceed 7 mi/mi^2. Overall road density on the FGS ownership is 5.4 mi/mi^2.

For roads solely maintained and covered under the FGS HCP, there are approximately 781 miles classified as local or secondary roads and 219 miles classified as arterial main lines. For the purposes of this BO, a local or secondary road will average 12 feet in width, while an arterial main line will average 24 feet in width. Based on this assumption, roads solely maintained by FGS have removed approximately 1,773 acres of habitat. While it cannot be determined from this estimate the quantity or quality of northern spotted owl and fisher habitat that was removed for road construction, it does provide an estimate of habitat no longer available to these species.

3.1.1.3 Mining

Gold mining within the Klamath and Scott watersheds was the primary resource for extraction from the mid-1850s through the 1930s. Hydraulic mining began in the area sometime after 1850, and operations were often concurrent with hard-rock and dredge mining. Giant “monitors” were used to wash away entire hillsides. This form of mining may have existed into the 1930s along with dredge and small-scale, depression-era placer mining. Large-scale dredge mining, however, continued in the upper reaches and tributaries of the Scott River until the 1950s (USDA FS 1997).

Hydraulic mining diverted creeks to supply water to high pressure nozzles that leveled entire hillsides and rearranged much of the riparian areas in the basin. Sluicing and hydraulic mining destroyed riparian areas. Deforestation associated with mining destabilized hillslopes, and increased erosion, flooding, and fires. Deforestation, erosion, and degradation of riparian areas caused by years of mining downgraded and removed habitat used by spotted owls, fisher and their prey species.

3.1.1.4 Grazing

Domestic livestock were brought to northern California more than 150 years ago. Miners and homesteaders raised livestock to supply food for local residents and for transportation to distant markets. As the Scott Valley area became settled and ranches were established, cattle and sheep were moved into the adjacent mountains to forage. In the early 1900s, grazing was largely unregulated, and livestock numbers were as much as five times higher than what is currently permitted on the KNF (USDA FS 1996a, 2000b, 2002). In the past, the longer grazing seasons of February through December (compared to the present April to October grazing season) allowed animals to graze plants in the more sensitive times of spring and early winter. Continued high use of the mountain rangelands created degraded conditions in some areas, and forage production was reduced, potentially reducing habitats used by some spotted owl and fisher prey species. The land affected by grazing today is a much smaller portion of the KNF (USDA FS 1996a, 2000b, 2002).

3.1.2 Vegetation

Few forested regions have experienced fires as frequently and with such high variability in severity as those in the Klamath Mountains (Taylor and Skinner 1998). The fire regime prior to European settlement (1850) within the Klamath area can be described as having frequent fires with return intervals of 1 to 25 years. Lightning and intentional burning by American Indians were the predominant causes of ignition (USDA FS 1996a, 1997, 2000b, 2002). The pre-European fire regime can be described as having mostly low- to moderate-intensity fires, with only small areas burning at high intensity. Fire return intervals were shorter on exposed sites and longer on sheltered sites. The steepness of the slopes and vegetation that had adapted to a history of frequent fires contributed to the varying intensities. Fire worked as both a thinning agent and an agent of decomposition. Although most vegetation (mixed conifers) promoted lower intensities when burned at frequent intervals, stand-replacing events occurred in some areas. Aspect, stand diameter, elevation, and topography are all factors that influence fire intensity within the Klamath region (Taylor and Skinner 1998, Fry and Stephens 2006, Alexander et al. 2006).

Prior to European settlement, much of the Action Area was maintained in an open mixed conifer forest. Ponderosa pine was the dominant conifer species found in open lower elevation stands on south and west aspects. Douglas fir was most prevalent on moister sites, especially on north and east aspects (USDA FS 1996a, 2002). Due to the historic fire regime, north and east aspects supported denser stands than south and west, but were less dense than current stands (USDA FS 1996a, 2002). True fir was found on colder sites above 5,000 feet elevation, and the mixed conifer forest blended into hardwoods on drier sites below 3,000 feet. Under the historical fire regime, brush fields within the Action Area were periodically replaced, but fire suppression has resulted in much denser and larger vegetation here as well. Depending on the level and types of human activities conducted, these vegetation communities have been altered to varying degrees.

Fire frequency, intensity, and size occurring within the Action Area have changed since the fire-suppression era (1950 to present) (Fry and Stephens 2006). Prior to the fire-suppression era, fires occurred frequently. In most of the vegetation assemblages covering large portions of the Klamath Mountains, they were of generally low to moderate and mixed severity (Skinner et al. 2006). Fires occurring in the fire-suppression era are less frequent and have greater intensity, resulting in a more homogeneous effect on the habitat by damaging and removing all vegetation (Fry and Stephens 2006). Fire suppression has allowed dense conifer stands to develop, and more litter and downed woody material accumulation than that under the historical fire regime (USDA FS 1996a, 2002). The lack of fire favors regeneration of Douglas fir and white fir over pine species. Currently, dense stands of Douglas fir and white fir are found in some areas that were historically open, pine-dominated stands. Although this shift in species composition to favor Douglas fir may be beneficial to spotted owls because they are most highly associated with this tree species, the increase in brush and stand density resulting from years of fire suppression may decrease the owl's foraging ability in some areas. Fisher hunt for a variety of prey species that occupy various forest vegetation types and successional stages, but typically avoid non-forested environments and early successional forest stands that lack dense canopy cover (Lofroth et al. 2010). More importantly, the increase in fire frequency and severity due to fire suppression has increased the risk of uncharacteristically severe wildfire, which removes habitat for both spotted owls and fishers and creates more homogenous forest conditions compared to what would occur historically in the naturally mosaic landscape.

The following vegetation characteristics (e.g., tree size [dbh], canopy coverage) within the Action Area are described using the vegetation classification system described in the CWHR system (Mayer and Laudenslayer 1988).

3.1.2.1 Upland Forest

The forest communities of FGS's Klamath River and Scott Valley Management Units are dominated by second-growth mixed evergreen forests consisting of three or more species of conifers. Conifer species of the mixed evergreen forest include Douglas-fir, incense-cedar (*Calocedrus decurrens*), white fir, ponderosa pine, and sugar pine. The proportion of these species represented in the overstory depends on site-specific conditions (such as elevation, aspect, precipitation, soils, microclimate conditions, and past management). Small stands consisting of a single species (typically Douglas-fir or ponderosa pine), are scattered throughout the predominately mixed conifer forest landscape. Hardwood species such as canyon live oak (*Quercus chrysolepis*), Pacific madrone (*Arbutus menziesii*), California black oak (*Quercus kelloggii*), and Oregon white oak (*Quercus garryana*) are common in the understory. Forested areas within the Action Area tend to be naturally fragmented due to the diverse geology, topography, and dry conditions that result in areas dominated by hardwoods or chaparral species.

Three major forest types occur in FGS's Grass Lake Management Unit: Sierran Montane Forest, Upper Montane Forest, and Northern Yellow Pine Forest (Kuchler 1988). Sierran and Upper Montane Forest types occur at higher elevations, and Northern Yellow Pine forest at lower elevations. The Northern Yellow Pine forest type, dominated by ponderosa pine and white fir, is the most common forest type in FGS's Grass Lake Management Unit. As a result of fire suppression, stands of white fir have developed in some locations previously dominated by ponderosa pine. In contrast to the forests of FGS's Klamath River and Scott Valley Management Units, hardwood species are largely absent from FGS's Grass Lake Management Unit.

Approximately 11 percent of the ownership is not considered commercial forest land, consisting of either non-stocked forest land (brush and non-commercial species) or non-forest land (bare ground, meadows, rock). The greatest percentage of non-commercial land is in the Scott Valley Management Unit (15.1 percent, primarily non-stocked forest land) followed by Grass Lake (14.3 percent) and the Klamath River (6.7 percent) Management Units.

Forests in the Action Area have been managed for commercial timber production since the early 1900s. Consequently, forests are relatively young (less than 80 years old) with only small, isolated patches of older stands. Prior to the start of large-scale commercial logging, much of the conifer forests in the Action Area and vicinity were older, on average, than current forest stands. However, because this region is fire-prone, it is likely that a mosaic of age classes, including a high percentage of late-seral stages, developed and persisted prior to the advent of commercial logging. Currently, less than 1 percent of the forested area in FGS's Klamath River, Scott Valley, and Grass Lake Management Units (65, 21, and 29 acres in each management unit, respectively) are in CWHR size class 5 (> 24 inches dbh) and may be considered late-seral stage. From 79 to 93 percent of commercial forest stands are considered mid-seral, with average tree sizes of 6 to 24 inches dbh (CWHR size classes 3 and 4).

3.1.2.2 Riparian Forest

The plant species composition and structure of riparian forest habitat currently occurring along streams in the Action Area varies in relation to factors such as stream characteristics, topography, elevation, and past management. Close to the valley floor, hardwoods (such as willows [*Salix spp.*] and cottonwoods [*Populus spp.*]) predominate. In some of the valley floor areas, the riparian zone composed of hardwoods forms a plant community that is distinct from drier upland areas that support chaparral species. At higher elevations, the riparian zone is characterized as a mix of conifer and hardwood species. The conifer component is similar to adjacent upslope areas; the hardwood component consists of red alders (*Alnus rubra*) and big leaf maple (*Acer macrophyllum*) along the immediate margins of the stream. Along many streams on FGS lands, particularly higher-gradient streams, riparian forest composition is largely indistinguishable from the adjacent upland mixed conifer forest.

Site-specific riparian inventories have not been conducted along all streams in the Plan Area. To provide a general indication of the condition of riparian stands, the FGS hydrology (stream) layer was buffered according to CDFG Coho Recovery Plan specifications (150-foot buffers along Class I streams, 75- to 125-foot buffers along Class II streams, and 25- to 50-foot buffers along Class III streams) and overlain on the FGS 2004 Forest Inventory using Geographic Information System (GIS). The range of buffer width within a given class was dependent on percent slope of adjacent hillsides. Results of this analysis are presented in Tables 4-9 through 4-11 of the HCP, which summarize the number of trees per acre in various size classes in riparian stands along Class I[5], Class II, and Class III streams, respectively.

3.1.3 Climate

The climate in FGS's Klamath River Management Unit can be characterized as temperate Mediterranean, with hot, dry summers and cool, moist winters. Precipitation in the Klamath River watershed varies greatly, from around 20 inches per year in the upper watershed to as much as 100 inches per year near the coast. FGS's Klamath River Management Unit lies near the middle of this range; precipitation increases with elevation within the unit. Precipitation in the Klamath River Management Unit ranges from an average of around 30 inches per year in the lower elevations near the Klamath River to about 75 inches per year at the highest elevations, with approximately 90 percent falling between October and May (USDA FS 1996a, 2002). Summer precipitation occurs primarily during thunderstorm activity; high-intensity, short-duration thunderstorms are common (USFS 1996a, 2002). Below 3,500 feet in elevation, most precipitation is rainfall; above 4,000 feet, winter precipitation is predominately snowfall. Higher-elevation terrain in the Klamath River watershed receives large winter and spring snowpacks, and can be associated with high amounts of runoff during warm winter storms (CETFKRB 2004).

The Scott River watershed also has hot, dry summers and cool, wet winters characteristic of Mediterranean climates. Rainfall is somewhat less than along the Klamath River. Approximately 90 percent of precipitation falls between October and May; peak precipitation occurs in December and January. Although most precipitation occurs winter through spring, there may be short periods of locally intense rainfall from summer thunderstorms (USDA FS 1997, 2000b). In the valleys, precipitation is significantly lower than in the surrounding mountains. Average annual precipitation ranges from below 20 inches at the lowest elevations along the Scott River, to more than 60 inches at the highest elevations at the western and southern extents of the watershed (North Coast RWQCB 2005). Winter precipitation is mostly rain at the lower elevations, below about 4,000 feet, with a rain-snow transition zone between about 4,000 feet and 5,000 feet. Snow typically accumulates in the rain-snow transition zone, but is frequently melted by midwinter rains. The higher elevations, especially above 6,000 feet, have short summers and relatively long winters with deep snowpacks.

The topographic characteristics of the basin make the Scott River watershed particularly susceptible to severe flooding caused by rain-on-snow events. A significant portion of the basin is between 4,500 and 5,500 feet in elevation, which is the range of elevation most susceptible to rain-on-snow events (North Coast RWQCB 2005). The largest floods on record (1861, 1955, 1964, 1974, and 1997) were associated with this type of event (USDA FS 2000b).

The Grass Lake Management Unit receives considerably less precipitation than the Klamath River and Scott Valley Management Units. In the western portions of the Action Area, annual precipitation averages about 30 to 35 inches, whereas precipitation in the eastern portions averages 20 inches or less per year (Ruffner 1978).

3.1.4 Land Ownership

FGS's Hilt/Siskiyou ownership is intermixed with Federal and other private lands. The KNF accounts for the largest proportion of adjacent Federal land; although a small portion of FGS lands are bordered by lands managed by the Bureau of Land Management (BLM). Much of FGS's Klamath River Management Unit is in "checkerboard" ownership; land in alternating sections typical of lands granted to the railroad in the nineteenth century, with USFS lands and other private landowners. FGS's Scott Valley and Grass Lake Management Units generally consist of larger, more contiguous blocks surrounded by USFS lands or private landowners. Adjoining privately owned lands are managed for commercial timber harvest in a manner similar to the FGS ownership, or are agricultural lands with rural residential use.

Federal lands of the KNF are managed for multiple uses including recreation, fish and wildlife habitat, timber harvest, and visual resources under the KNF Land and Resource Management Plan (LRMP) (USDA FS 1994). The LRMP was largely based on the NWFP (USDA FS and USDI BLM 1994a). Under the LRMP, the USFS will manage about 22 percent of the KNF as LSRs, with the objective of providing for the viability needs of late-successional species using an ecosystem-based approach. About 35 percent of the KNF is considered matrix lands that are managed for multiple-use purposes, including timber harvest, fish and wildlife resources, recreation, and visual resources. The remaining 43 percent of the KNF consists of other CRAs and AWAs. Many of these areas (such as wilderness areas, backcountry areas, RRs, cultural areas, and research natural areas) will be managed in a manner consistent with achieving late seral conditions (USDA FS 1994).

Riparian Reserves on the KNF are designated primarily along perennial and intermittent streams, lakes, ponds, seeps, springs, and wetlands. They are also designated in unstable and potentially unstable non-riparian areas that are primary contributors of sediment and wood to aquatic systems. In riparian reserves, riparian-dependent resources are of primary concern, with management standards and guidelines applied to maintain or restore riparian functions. In keeping with the ROD, riparian reserves are at least 300 feet wide along fishbearing (Class I)[5] streams, and at least 150 feet wide along perennial, non-fishbearing (Class II) streams. Along intermittent streams and around unstable or potentially unstable areas, riparian reserves are at least 100 feet wide. Timber harvest is generally prohibited in riparian reserves unless it is consistent with or necessary to achieve the Aquatic Conservation Strategy (ACS) objectives set forth in the NWFP. Other land uses, such as grazing and mineral operations, are similarly restricted in that they must be conducted in a manner compatible with the ACS objectives. Riparian reserves encompass an estimated 458,000 acres (27 percent) of KNF (USDA FS 1994).

3.2 Status of Northern Spotted Owl in the Action Area

The Action Area is defined to mean "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR §402.02)." For the purposes of this consultation, the Action Area consists of a 1.3-mile radius around the FGS ownership, reflective of the local owl population that could be directly or indirectly affected by the HCP. The 1.3-mile distance criterion is based on the average home range size of the northern spotted owl within the California Klamath and California Cascades Provinces (USDI FWS 2005). The activity center typically consists of a roost or nest site, and is considered the center of an owl's home range. The total area within the Action Area is approximately 545,030 acres. This 1.3-mile radius around the FGS ownership is termed "Area of Impact" in the FGS HCP for the purposes of characterizing environmental baseline conditions and describing effects of the covered activities on the northern spotted owl.

The northern spotted owl population in the Action Area is divided by two ecological provinces: the California Klamath Province and the California Cascades Province. The environmental baseline is described separately for these two provinces within the Action Area because they are distinct in terms of population demographics and trends, threats, and quantity and quality of northern spotted owl habitat.

The following description of owl population status and habitat both range-wide and within the Action Area is based on published and unpublished information, and stand inventories and protocol-level owl surveys within the Plan Area and adjacent Federal lands.

[5] Stream classes used in the HCP are those defined in the California Forest Practice Rules (CAL FIRE 2008)

3.2.1 Environmental Baseline in the California Klamath Province Action Area

The following section describes local environmental baseline conditions for the portion of the Action Area within the California Klamath Province, including a discussion of the northern spotted owl population, amount and quality of habitat on the FGS ownership and adjacent Federal lands, and current threats. Fruit Growers Supply's Scott Valley and Klamath River Management Units occur within the California Klamath Province.

Northern Spotted Owl Population in the Klamath Action Area

Comprehensive surveys for spotted owls were not conducted for the purposes of developing the FGS HCP. The Service relied on the CDFG Northern Spotted Owl Database to estimate the number of spotted owls occupying the Action Area using records dating from 1987 through 2007. The owl population baseline is based on a compilation of northern spotted owl sightings from the database within the Action Area, including results of incidental sightings as well as protocol-level owl surveys on FGS lands and adjacent private and public lands. Information on fecundity and survivorship in the Action Area is not available, as no mark-recapture programs for owls have been conducted on FGS's ownership in the California Klamath Province.

For the period from 1987 through 2007, the CDFG database contains records of 87 activity centers on or within 1.3-miles of FGS's ownership in the California Klamath Province. Of these, 13 sites were determined by the Service to be invalid because they did not meet the Service's criteria for designation as an activity center (i.e, inadequate number of detections for residency status) and/or were extremely lacking in amounts of suitable habitat (i.e., habitat was removed by a stand-replacing fire in a significant portion of the core) during development of the HCP. Since FGS did not conduct comprehensive surveys of all the historic activity centers to determine current occupancy status, the remaining 74 activity centers were considered occupied at their highest historic status (Table 5) for the purposes of HCP development. Using this conservative approach, a total of 143 northern spotted owls were estimated to occur within the California Klamath Province portion of the Action Area (containing FGS's Scott Valley and Klamath River Management Units); 18 of these historic activity centers are located on FGS land.

There is some uncertainty as to the exact number of currently occupied activity centers within this area because some activity centers may no longer be active. A substantial number of the remaining 74 historic activity centers are unlikely to support occupancy by spotted owls, particularly reproducing pairs. Many of the historic activity centers have not been surveyed during the past five to 10 years, others have been surveyed to varying degrees with no detections, and most of the historic activity centers have received substantial timber harvest within their core areas and home ranges. It is unlikely that there are additional undetected activity centers on FGS ownership given the low amounts of suitable habitat and extensive survey effort over time on the property.

Because the size and distribution of the spotted owl population within the Action Area was uncertain, the Service augmented the above-described survey information with results from a predictive model developed by Zabel et al. (2003). The model was used to evaluate the likelihood of additional activity centers occurring within the California Klamath Province portion of the Action Area over the permit term. The model predicts probability of occupancy based on habitat conditions within a 500-acre (0.5-mile radius) circular window; this spatial scale corresponds to 'core areas' that receive disproportionate use by nesting and foraging spotted owls in the Klamath region (Bingham and Noon 1997) and where differences between use and availability of habitat tend to be most pronounced (USDI FWS 2011b, Appendix C). The Service evaluated the broad-scale patterns of habitat suitability on and within 1.3 miles of the FGS ownership by decade and determined that establishment of additional activity centers (i.e larger population size) beyond the owl population baseline within the Klamath Action Area is unlikely over the permit term.

Table 5. Quantification of Northern Spotted Owls by Reproductive Status in the California Klamath Province Portion of the Action Area

Status (1987-2007)[a]	Sites[b]	Owls
Reproductive pair with young	50	100
Nesting pair	19	38
Territorial single	5	5
Not valid activity center	13	0
Total activity centers	87	143
Total valid activity centers	74	143

[a] Source: CDFG Northern Spotted Owl Database

[b] For the purpose of the effects analysis, each site is considered an activity center

Northern Spotted Owl Habitat in the Klamath Action Area

In addition to landscape and topographic features, vegetation and structural elements are important factors determining northern spotted owl habitat suitability (57 FR 1796). The structure and composition of coniferous vegetation within the Action Area is naturally diverse and fragmented due to variation in topography and soil type, the relatively dry climate, and stochastic events such as fire. Timber harvest and fuels management have contributed to the habitat mosaic. Because the HCP area is an industrial forest landscape, forest stands within the HCP area have experienced a long history of intensive management. Many attributes important to northern spotted owls (i.e., dense stands of large old trees, snags, logs) are lacking in most stands.

As part of the HCP development process, FGS worked with the Service to produce a GIS layer that represents current northern spotted owl habitat in the Action Area and the region. Using a combination of local data sources and models, a habitat data layer was derived for the area encompassing FGS ownership and surrounding 20-mile buffer, which includes portions of Siskiyou, Shasta, and Trinity counties in California and Jackson, Josephine, and Klamath counties in Oregon. This derived data layer represents the most current depiction of northern spotted owl habitat for this region. The habitat definitions used in the database are based on mean values and minimum standards for stand structural variables; this fact, combined with the long history of intensive timber management of FGS lands, suggests that the habitat layer likely represents an overestimate of actual habitat quality. A description of the 2005 northern spotted owl baseline habitat layer, including data sources and methods can be found in Appendix A of the FGS HCP (2009).

Based on the owl habitat layer, there are 70,034 acres of foraging habitat, 42,045 acres of nesting habitat, and 227,464 acres of unsuitable habitat within the 339,543-acre Klamath portion of the Action Area (Table 6). Table 7 shows the acreage and ownership of northern spotted owl habitat within the core and home range of each activity center within the Klamath Action Area. Habitat on Federal and private non-FGS land over the term of the ITP is represented by the owl habitat layer to avoid speculating on the types of changes that may occur on these lands over time.

Table 6. Northern Spotted Owl Habitat and Land Ownership in the California Klamath Province portion of the Action Area

	Acres of Habitat			
Owner	**Unsuitable**	**Foraging**	**Nesting/Roosting**	**Total**
Federal	78,144	26,315	26,436	130,895
FGS	65,535	30,548	8,410	104,493
Other Private	83,281	13,128	7,199	103,608
State	504	42	0	546
Total Public	78,648	26,358	26,436	131,442
Total Private	148,816	43,676	15,609	208,101

Table 7. Suitable Northern Spotted Owl Nesting/Roosting and Foraging Habitat within Northern Spotted Owl Cores and Home Ranges across Land Ownerships within the Klamath Action Area.

Klamath Action Area			**Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)**					**Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)**					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
SK002	Pair (KNF)	Foraging	**139**	139	0	0	0	**515**	315	140	0	61	0
		Nesting	**165**	3	162	0	0	**302**	6	296	0	0	0
		Total	**314**	142	162	0	0	**817**	321	436	0	61	0
SK012	Pair (KNF)	Foraging	**188**	0	177	0	11	**1570**	40	370	0	1160	0
		Nesting	**118**	0	110	0	8	**436**	1	310	0	126	0
		Total	**306**	0	287	0	19	**2006**	41	680	0	1286	0
SK020	Pair (KNF)	Foraging	**80**	5	75	0	0	**164**	119	45	0	0	0
		Nesting	**243**	26	217	0	0	**618**	160	458	0	0	0
		Total	**323**	31	292	0	0	**782**	279	503	0	0	0
SK028	Pair (KNF)	Foraging	**388**	39	257	0	92	**1540**	617	920	0	4	0
		Nesting	**48**	0	47	0	0	**300**	0	296	0	3	0
		Total	**436**	39	304	0	92	**1840**	617	1216	0	7	0
SK040	Pair (KNF)	Foraging	**152**	4	147	0	0	**1132**	266	654	0	213	0
		Nesting	**137**	0	137	0	0	**352**	174	167	0	10	0
		Total	**289**	4	284	0	0	**1484**	440	821	0	223	0
SK044	Pair (KNF)	Foraging	**40**	21	18	0	0	**748**	429	267	0	52	0
		Nesting	**393**	12	381	0	0	**1231**	58	1173	0	0	0
		Total	**433**	33	399	0	0	**1979**	487	1440	0	52	0
SK046	Pair (KNF)	Foraging	**173**	173	0	0	0	**821**	749	72	0	0	0
		Nesting	**119**	67	52	0	0	**143**	39	104	0	0	0
		Total	**292**	240	52	0	0	**964**	788	176	0	0	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
SK048	Pair (KNF)	Foraging	**213**	0	105	0	108	**1133**	0	428	0	704	0
		Nesting	**152**	0	120	0	32	**730**	7	553	0	171	0
		Total	**365**	0	225	0	140	**1863**	7	981	0	875	0
SK051	Pair (KNF)	Foraging	**74**	0	49	0	25	**582**	51	267	0	263	0
		Nesting	**153**	0	122	0	31	**429**	10	240	0	179	0
		Total	**227**	0	171	0	56	**1011**	61	507	0	442	0
SK061	Pair (OP)	Foraging	**70**	0	41	0	29	**697**	96	346	0	255	0
		Nesting	**344**	0	409	0	235	**966**	52	436	0	477	0
		Total	**414**	0	450	0	264	**1663**	148	782	0	732	0
SK063	Pair (KNF)	Foraging	**156**	11	75	0	70	**551**	131	224	0	196	0
		Nesting	**167**	0	138	0	29	**761**	32	322	0	407	0
		Total	**323**	11	213	0	99	**1312**	163	546	0	603	0
SK065	Pair (KNF)	Foraging	**82**	0	44	0	39	**286**	87	82	0	117	0
		Nesting	**118**	63	54	0	1	**832**	278	460	0	94	0
		Total	**200**	63	98	0	40	**1118**	365	542	0	211	0
SK097	Pair (KNF)	Foraging	**34**	34	0	0	0	**646**	399	247	0	0	0
		Nesting	**395**	0	395	0	0	**1235**	37	1198	0	0	0
		Total	**429**	34	395	0	0	**1881**	436	1445	0	0	0
SK099	Pair (KNF)	Foraging	**136**	1	91	0	44	**573**	79	376	0	118	0
		Nesting	**300**	0	300	0	0	**1197**	207	991	0	0	0
		Total	**436**	1	391	0	44	**1770**	286	1367	0	118	0
SK100	Pair (KNF)	Foraging	**210**	8	188	0	14	**1054**	14	755	0	285	0
		Nesting	**77**	38	26	0	13	**421**	5	360	0	56	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
		Total	**287**	46	214	0	27	**1475**	19	1115	0	341	0
SK130	Single (KNF)	Foraging	**175**	60	114	0	0	**1501**	611	540	0	349	0
		Nesting	**155**	59	96	0	0	**567**	131	406	0	30	0
		Total	**330**	119	210	0	0	**2068**	742	946	0	379	0
SK131	Pair (KNF)	Foraging	**95**	0	95	0	0	**940**	192	717	0	30	0
		Nesting	**177**	0	177	0	0	**385**	0	385	0	0	0
		Total	**272**	0	272	0	0	**1325**	192	1102	0	30	0
SK204	Pair (KNF)	Foraging	**117**	0	54	0	62	**763**	25	517	0	221	0
		Nesting	**96**	0	42	0	54	**788**	13	462	0	313	0
		Total	**213**	0	96	0	116	**1551**	38	979	0	534	0
SK205	Pair (OP)	Foraging	**216**	109	56	0	51	**678**	276	180	0	223	0
		Nesting	**87**	63	15	0	9	**277**	52	108	0	116	0
		Total	**303**	172	71	0	60	**955**	328	288	0	339	0
SK237	Pair (KNF)	Foraging	**48**	0	48	0	0	**537**	5	495	0	38	0
		Nesting	**360**	0	324	0	36	**1989**	179	1515	0	296	0
		Total	**408**	0	372	0	36	**2526**	184	2010	0	334	0
SK238	Pair (KNF)	Foraging	**103**	0	103	0	0	**886**	83	803	0	0	0
		Nesting	**339**	0	339	0	0	**1336**	104	1232	0	0	0
		Total	**442**	0	442	0	0	**2222**	187	2035	0	0	0
SK239	Pair (KNF)	Foraging	**9**	0	9	0	0	**765**	474	275	0	16	0
		Nesting	**451**	151	301	0	0	**1365**	619	721	0	25	0
		Total	**460**	151	310	0	0	**2130**	1093	996	0	41	0
SK262	Pair	Foraging	**194**	193	1	0	0	**982**	455	484	20	23	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
	(KNF)	Nesting	**79**	79	0	0	0	**306**	31	241	2	32	0
		Total	**273**	272	1	0	0	**1288**	486	725	22	55	0
SK262B	Pair (KNF)	Foraging	**225**	101	123	0	0	**1211**	523	650	0	38	0
		Nesting	**82**	0	82	0	0	**374**	196	158	0	20	0
		Total	**307**	101	205	0	0	**1585**	719	808	0	58	0
SK291	Pair (KNF)	Foraging	**281**	16	265	0	0	**1900**	641	1122	0	138	0
		Nesting	**106**	4	102	0	1	**249**	3	242	0	4	0
		Total	**387**	20	367	0	1	**2149**	644	1364	0	142	0
SK309	Pair (FGS)	Foraging	**84**	71	13	0	0	**544**	325	219	0	0	0
		Nesting	**75**	75	0	0	0	**67**	44	23	0	0	0
		Total	**159**	146	13	0	0	**611**	369	242	0	0	0
SK310	Pair (KNF)	Foraging	**59**	0	41	0	17	**286**	0	81	0	205	0
		Nesting	**232**	0	159	0	74	**564**	45	264	0	256	0
		Total	**291**	0	200	0	91	**850**	45	345	0	461	0
SK318	Pair (KNF)	Foraging	**43**	0	30	0	14	**290**	0	211	0	79	0
		Nesting	**150**	0	138	0	12	**283**	0	225	0	59	0
		Total	**193**	0	168	0	26	**573**	0	436	0	138	0
SK321	Pair (FGS)	Foraging	**313**	139	175	0	0	**1769**	970	767	2	30	0
		Nesting	**51**	12	39	0	0	**215**	148	68	0	0	0
		Total	**364**	151	214	0	0	**1984**	1118	835	2	30	0
SK322	Pair (KNF)	Foraging	**12**	4	8	0	0	**1100**	1088	5	0	5	0
		Nesting	**286**	12	274	0	0	**177**	129	48	0	0	0
		Total	**298**	16	282	0	0	**1277**	1217	53	0	5	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
SK333	Pair (FGS)	Foraging	**391**	290	101	0	0	**902**	617	270	0	15	0
		Nesting	**22**	12	10	0	0	**194**	59	135	0	0	0
		Total	**413**	302	111	0	0	**1096**	676	405	0	15	0
SK334	Pair (KNF)	Foraging	**119**	34	85	0	0	**1151**	872	279	0	0	0
		Nesting	**40**	0	40	0	0	**303**	82	220	0	0	0
		Total	**159**	34	125	0	0	**1454**	954	499	0	0	0
SK335	Pair (FGS)	Foraging	**75**	39	36	0	0	**862**	582	277	3	0	0
		Nesting	**151**	46	106	0	0	**288**	18	245	20	5	0
		Total	**226**	85	142	0	0	**1150**	600	522	23	5	0
SK336	Pair (KNF)	Foraging	**151**	151	1	0	0	**890**	725	165	0	0	0
		Nesting	**104**	70	34	0	0	**200**	68	133	0	0	0
		Total	**255**	221	35	0	0	**1090**	793	298	0	0	0
SK352	Pair (KNF)	Foraging	**9**	0	9	0	0	**482**	317	165	0	0	0
		Nesting	**320**	4	316	0	0	**816**	67	749	0	0	0
		Total	**329**	4	325	0	0	**1298**	384	914	0	0	0
SK358	Pair (FGS)	Foraging	**272**	272	0	0	0	**1546**	1546	0	0	0	0
		Nesting	**69**	69	0	0	0	**162**	162	0	0	0	0
		Total	**341**	341	0	0	0	**1708**	1708	0	0	0	0
SK359	Pair (KNF)	Foraging	**199**	0	182	0	17	**818**	96	267	0	456	0
		Nesting	**61**	0	61	0	0	**175**	15	61	0	99	0
		Total	**160**	0	243	0	17	**993**	111	328	0	555	0
SK360	Pair (FGS)	Foraging	**235**	235	0	0	0	**920**	919	0	0	1	0
		Nesting	**171**	171	0	0	0	**452**	452	0	0	1	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
		Total	**406**	406	0	0	0	**1372**	1371	0	0	2	0
SK361	Pair (FGS)	Foraging	**138**	138	0	0	0	**789**	686	98	0	5	0
		Nesting	**185**	184	0	0	0	**542**	536	2	0	3	0
		Total	**232**	322	0	0	0	**1331**	1222	100	0	8	0
SK363	Pair (FGS)	Foraging	**156**	152	0	0	3	**592**	223	44	0	325	0
		Nesting	**67**	55	12	0	0	**303**	40	67	0	197	0
		Total	**223**	207	12	0	3	**895**	263	111	0	522	0
SK364	Pair (FGS)	Foraging	**123**	116	0	0	6	**987**	924	5	0	58	0
		Nesting	**134**	130	0	0	4	**487**	214	65	0	209	0
		Total	**257**	246	0	0	10	**1474**	1138	70	0	267	0
SK365	Single (FGS)	Foraging	**164**	0	122	0	41	**950**	75	596	4	276	0
		Nesting	**63**	0	11	0	52	**0**	0	0	0	0	0
		Total	**227**	0	133	0	93	**950**	75	596	0	276	0
SK368	Pair (FGS)	Foraging	**70**	70	0	0	0	**724**	716	0	0	9	0
		Nesting	**111**	111	0	0	0	**241**	241	0	0	0	0
		Total	**181**	181	0	0	0	**965**	957	0	0	9	0
SK369	Pair (FGS)	Foraging	**370**	365	0	2	4	**590**	373	9	197	11	0
		Nesting	**76**	76	0	0	0	**282**	236	6	40	0	0
		Total	**446**	441	0	2	4	**872**	609	15	237	11	0
SK370	Pair (OP)	Foraging	**174**	130	0	45	0	**1155**	1017	30	96	13	0
		Nesting	**76**	18	0	59	0	**374**	305	6	2	61	0
		Total	**250**	148	0	104	0	**1529**	1322	36	98	74	0
SK378	Pair	Foraging	**150**	0	150	0	0	**722**	5	717	0	0	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
	(KNF)	Nesting	**308**	32	276	0	0	**1625**	167	1399	0	59	0
		Total	**458**	32	426	0	0	**2347**	172	2116	0	59	0
SK379	Pair (KNF)	Foraging	**205**	0	205	0	0	**910**	4	885	0	20	0
		Nesting	**286**	0	286	0	0	**1458**	196	1262	0	0	0
		Total	**491**	0	491	0	0	**2368**	200	2147	0	20	0
SK380	Pair (OP)	Foraging	**152**	69	77	0	6	**937**	357	464	0	117	0
		Nesting	**294**	164	116	0	14	**1326**	201	936	0	189	0
		Total	**446**	233	193	0	20	**2263**	558	1400	0	305	0
SK382	Pair (KNF)	Foraging	**152**	0	93	0	59	**398**	0	214	0	183	0
		Nesting	**55**	0	39	0	16	**734**	0	348	0	386	0
		Total	**207**	0	132	0	75	**1132**	0	562	0	569	0
SK386	Single (OP)	Foraging	**61**	0	4	0	58	**352**	0	111	0	241	0
		Nesting	**157**	0	13	0	144	**572**	0	225	0	346	0
		Total	**218**	0	17	0	202	**924**	0	336	0	587	0
SK387	Pair (KNF)	Foraging	**267**	3	264	0	0	**575**	22	462	0	92	0
		Nesting	**89**	49	40	0	0	**220**	211	10	0	0	0
		Total	**355**	52	304	0	0	**795**	233	472	0	92	0
SK388	Pair (KNF)	Foraging	**69**	7	61	0	0	**834**	353	406	0	75	0
		Nesting	**40**	40	0	0	0	**223**	115	33	0	75	0
		Total	**109**	47	61	0	0	**1057**	468	439	0	150	0
SK389	Pair (FGS)	Foraging	**113**	64	48	0	0	**291**	14	140	0	137	0
		Nesting	**81**	0	35	0	46	**590**	31	453	0	105	0
		Total	**194**	64	83	0	46	**881**	45	593	0	242	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
SK391	Pair (OP)	Foraging	**107**	20	3	0	84	**571**	92	201	4	258	17
		Nesting	**112**	49	0	0	62	**687**	298	330	0	59	0
		Total	**219**	69	3	0	146	**1258**	390	531	4	317	17
SK446	Pair (KNF)	Foraging	**212**	18	184	0	10	**890**	178	583	0	129	0
		Nesting	**209**	5	204	0	0	**308**	41	264	0	4	0
		Total	**421**	23	388	0	0	**1198**	219	847	0	133	0
SK450	Pair (KNF)	Foraging	**120**	50	53	0	17	**639**	209	36	7	378	9
		Nesting	**196**	159	34	0	4	**819**	652	51	6	111	0
		Total	**316**	209	87	0	21	**1458**	861	87	13	489	9
SK454	Pair (KNF)	Foraging	**170**	65	106	0	0	**609**	356	246	0	8	0
		Nesting	**14**	14	0	0	0	**166**	117	49	0	0	0
		Total	**184**	79	106	0	0	**775**	473	295	0	8	0
SK467	Pair (FGS)	Foraging	**204**	204	0	0	0	**550**	549	0	0	1	0
		Nesting	**15**	15	0	0	0	**234**	193	0	0	41	0
		Total	**219**	219	0	0	0	**784**	742	0	0	42	0
SK469	Pair (FGS)	Foraging	**26**	0	26	0	0	**725**	506	219	0	0	0
		Nesting	**379**	297	82	0	0	**1377**	443	934	0	0	0
		Total	**405**	297	108	0	0	**2102**	949	1153	0	0	0
SK472	Pair (KNF)	Foraging	**153**	13	141	0	0	**626**	385	241	0	0	0
		Nesting	**126**	21	105	0	0	**454**	283	171	0	0	0
		Total	**279**	34	246	0	0	**1080**	668	412	0	0	0
SK473	Single (FGS)	Foraging	**229**	226	3	0	0	**296**	191	104	0	0	0
		Nesting	**62**	0	62	0	0	**50**	3	47	0	0	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
		Total	**291**	226	65	0	0	**346**	194	151	0	0	0
SK474	Pair (KNF)	Foraging	**205**	120	85	0	0	**687**	404	284	0	0	0
		Nesting	**40**	11	29	0	0	**81**	57	24	0	0	0
		Total	**245**	131	114	0	0	**768**	461	308	0	0	0
SK475	Pair (FGS)	Foraging	**53**	51	2	0	0	**495**	403	89	0	4	0
		Nesting	**176**	159	17	0	0	**104**	42	42	0	51	0
		Total	**229**	210	19	0	0	**599**	445	131	0	55	0
SK477	Pair (KNF)	Foraging	**67**	37	30	0	0	**463**	370	93	0	0	0
		Nesting	**183**	1	182	0	0	**547**	228	319	0	0	0
		Total	**150**	38	212	0	0	**1010**	598	412	0	0	0
SK500	Pair (KNF)	Foraging	**66**	33	33	0	0	**896**	348	478	0	70	0
		Nesting	**92**	0	92	0	0	**215**	0	170	0	45	0
		Total	**158**	33	125	0	0	**1111**	348	648	0	115	0
SK503	Pair (KNF)	Foraging	**25**	0	21	0	4	**332**	0	89	0	242	0
		Nesting	**303**	0	300	0	2	**864**	120	335	0	409	0
		Total	**328**	0	321	0	6	**1196**	120	424	0	651	0
SK512	Pair (KNF)	Foraging	**24**	0	24	0	0	**743**	16	604	0	123	0
		Nesting	**205**	16	189	0	0	**940**	168	772	0	0	0
		Total	**229**	16	213	0	0	**1683**	184	1376	0	123	0
SK526	Pair (KNF)	Foraging	**37**	0	0	0	37	**525**	7	242	0	276	0
		Nesting	**285**	0	178	0	107	**635**	0	345	0	290	0
		Total	**322**	0	178	0	144	**1160**	7	587	0	566	0
SK530	Pair	Foraging	**28**	28	0	0	0	**814**	439	374	0	0	0

Klamath Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)					
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**State**
	(KNF)	Nesting	**316**	0	316	0	0	**974**	24	949	0	0	0
		Total	**344**	28	316	0	0	**1788**	463	1323	0	0	0
SK531	Pair (KNF)	Foraging	**61**	58	3	0	0	**924**	765	159	0	0	0
		Nesting	**272**	3	269	0	0	**728**	73	654	0	0	0
		Total	**333**	61	272	0	0	**1652**	838	813	0	0	0
SK533	Pair (KNF)	Foraging	**125**	81	44	0	0	**671**	206	425	0	40	0
		Nesting	**11**	11	0	0	0	**136**	103	33	0	0	0
		Total	**136**	92	44	0	0	**807**	309	458	0	40	0
SK534	Pair (FGS)	Foraging	**121**	121	0	0	0	**381**	368	0	7	5	0
		Nesting	**107**	107	0	0	0	**24**	19	0	5	0	0
		Total	**228**	228	0	0	0	**405**	387	0	12	5	0
SK537	Pair (BLM)	Foraging	**104**	0	0	44	60	**136**	84	0	0	52	0
		Nesting	**0**	0	0	0	0	**0**	0	0	0	0	0
		Total	**104**	0	0	44	60	**136**	84	0	0	52	0
SK548	Pair (OP)	Foraging	**91**	3	61	0	28	**738**	130	475	0	133	0
		Nesting	**227**	1	58	0	168	**682**	69	555	0	58	0
		Total	**318**	4	119	0	196	**1420**	199	1030	0	191	0

HRS = Highest Reproductive Status and land owner on which activity center occurs
Nesting = Nesting/Roosting
OP = Other Private

Northern Spotted Owl Critical Habitat in the Klamath Action Area

On August 13, 2008, the Service released the Final Revised Designation of Critical Habitat for the Northern Spotted Owl (USDI FWS 2008b). This rule became effective on September 12, 2008, and designated 5,312,300 acres of Federal lands in California, Oregon, and Washington as northern spotted owl critical habitat. Under regulations, the Service is required to identify the known physical and biological features [Primary Constituent Elements (PCEs)] essential to the conservation of the northern spotted owl. All areas designated as revised critical habitat for the northern spotted owl are within the geographic area occupied by the species at the time of listing and contain the appropriate forest type (PCE 1) and at least one other PCE. The Service determined that the PCEs for northern spotted owl are 1) forest types that support the northern spotted owl across its geographic range, 2) nesting, roosting, and foraging habitat, and 3) dispersal habitat. Nesting, roosting, foraging, and dispersal habitat, as well as the forest types associated with northern spotted owls, are described in section 2.1.2.5 (Habitat Relationships).

Northern spotted owl critical habitat has not been designated for private lands, and therefore, critical habitat does not occur on FGS lands. However, designated northern spotted owl critical habitat is located on Federal lands within the Action Area of the FGS HCP. The selection of FGS HCP mitigation sites was based on proximity to northern spotted owl critical habitat. The FGS HCP Conservation Strategy is designed to provide demographic support to northern spotted owls inhabiting lands in the Federal Reserve System by providing CSAs on FGS's ownership to provide habitat for activity centers that are centered on or are in close proximity to federal lands designated as northern spotted owl critical habitat. The following information characterizes the status of northern spotted owls and habitat within CHUs and LSRs within the California Klamath Province portion of the Action Area to describe the baseline condition of the Federal Reserve System upon which the FGS HCP Conservation Strategy is based.

Five CHU subunits overlap with the California Klamath Province portion of the Action Area: subunits CA-29 and OR-19 in the Klamath Intra-Province CHU; subunit OR-18 in the Southern Cascades CHU; and subunits CA-28 and CA-31 in the Scott and Salmon Mountains CHU. Four of these subunits overlap with four designated LSRs. A summary of the habitat conditions in the LSRs that overlap the CHUs is described below and is based on the KNF LSR Assessment conducted by Dix et al. (1999). Information on the status of the LSRs was used because considerably more information is available on conditions in the LSRs than for individual CHUs and subunits, and because there is an 83 percent overlap in acreage between current subunit designations and the 1994 LSRs. Northern spotted owl pair goals for the newly designated CHUs and their subunits are under development by the Service but have not been finalized. However, because the distribution and total acres of the 2008 designated subunits do not differ significantly from the 1992 critical habitat designation within the Action Area, it is reasonable to assume that pair goals will be comparable. Therefore, for the purpose of this document, the 1992 pair goals will be used as a surrogate for the 2008 designated subunits.

Seiad LSR (353)/Scott and Salmon Mountains CHU Subunits CA 28 and CA-30.
The Seiad LSR is approximately 101,200 acres in size, making it the largest LSR within the KNF. It contains approximately 26,240 acres of nesting/roosting habitat and 23,490 acres of foraging habitat, for a total of 49,730 acres of suitable northern spotted owl habitat. An

additional 24,910 acres have the potential to provide northern spotted owl habitat. The combined habitat within the Seiad LSR and the adjacent Marble Mountain Wilderness enables this area to function as a large refugium for northern spotted owls. The amount of nesting/roosting and foraging habitat is within 10 percent of the expected range of suitable northern spotted owl habitat for the Seiad LSR (Dix et al. 1999).

Twenty-five activity centers have been located within the Seiad LSR boundary (21 pairs and 4 territorial singles); however, at least 40 percent of the LSR has not been adequately surveyed. The southern portion of the Seiad LSR overlaps considerably with subunit CA-30 (which is outside of the FGS Action Area) and the northern portion of this LSR overlaps considerably with the western portion of subunit CA-28. The eastern portion of CA-28 overlaps with the Klamath portion of the Johnny O'Neil LSR. In the northern portion of the Seiad LSR that overlaps with CA-28, three pairs and 4 territorial singles have been reported. In the Klamath portion of the Johnny O'Neil LSR that overlaps with CA-28, 16 pairs and one territorial single have been reported. The total of 19 owl pairs within the portions of the Seiad and Johnny O'Neil LSRs that overlap with subunit CA-28 nearly meets the pair goal of 22 for this subunit. Overall, the Seiad LSR, in combination with the Johnny O'Neil LSR, performs all the intended functions for subunit CA-28. There are some portions of critical habitat that fall outside of the LSR boundary, but overall, the population goals of the critical habitat designation is exceeded by the LSR.

Johnny O'Neil LSR (354)/ Scott and Salmon Mountains CHU Subunit CA-28.
The Johnny O'Neil LSR is approximately 46,840 acres in size, with 27,900 acres located on the KNF and the remainder on the Rogue National Forest. This LSR contains approximately 20,420 acres of nesting/roosting habitat and 7,370 acres of foraging habitat, for a total of 27,790 acres of suitable northern spotted owl habitat. An additional 8,850 acres have the potential to provide owl habitat. There are large, continuous parcels of late-successional and old growth (LSOG) habitat throughout most portions of the Johnny O'Neil LSR, including the Horse Creek drainage in the southeast, much of the northeast portion, and a 2-mile-wide band in the northwest that runs along the Siskiyou Crest and north. The amount of nesting/roosting and foraging habitat is within the expected range of suitable northern spotted owl habitat, and the acres of LSOG forest are above the expected functioning range for the Klamath portion, but below for the Rogue portion. Overall, Johnny O'Neil was ranked at the high end of moderate for habitat connectivity, due in part to moderate amounts of mid-successional forest.

As described previously, the Klamath portion of the Johnny O'Neil LSR overlaps with the eastern portion of subunit CA-28. A total of 21 northern spotted owl activity centers have been located within the Johnny O'Neil LSR boundary, 17 of which overlap with subunit CA-28. However, approximately 20 percent of the Klamath portion has not been surveyed. Sixteen northern spotted owl pairs and one territorial single were recorded in the Klamath portion of the Johnny O'Neil LSR. The total of 19 owl pairs within the portions of the Seiad and Johnny O'Neil LSRs that overlap with subunit CA-28 nearly meets the pair goal of 22 for this subunit. There are some portions of critical habitat that fall outside of the LSR boundary, but overall, the population goals of the critical habitat designation is met by the LSR.

Collins Baldy LSR (355)/ Scott and Salmon Mountains Subunit CA-31.
The Collins Baldy LSR is approximately 14,670 acres in size, and supports approximately 4,600 acres of nesting/roosting habitat and 4,500 acres of foraging habitat, for a total of 9,100 acres of suitable northern spotted owl habitat. An additional 2,930 acres have the potential to provide northern spotted owl habitat. The habitat is fairly discontinuous because of the checkerboard ownership of private and Federal lands. Late-successional habitat is currently lacking within the Collins Baldy LSR and accounts for only 1,630 acres (13 percent) of the capable ground. Relative to other LSRs, it ranks low and moderate for the proportion of LSOG habitat and combined mid-successional/LSOG habitat, respectively.

A total of 12 northern spotted owl activity centers supporting 12 owl pairs have been located within the Collins Baldy LSR. The entire LSR has been surveyed for northern spotted owls. The Collins Baldy LSR overlaps almost entirely with subunit CA-31. The 12 known owl pairs within the Collins Baldy LSR exceed the pair goal of 5 for subunit CA-31.

Overall, the Collins Baldy LSR performs the intended function of subunit CA-31 in that it extends protected habitat east toward subunit CA-61 in the Southern Cascades Unit and exceeds the CHU pair goal.

Mt. Ashland LSR (248)/Klamath Intra-Province Subunits OR-19 and CA-29.
The Mt. Ashland LSR is approximately 51,512 acres in size and provides approximately 30,169 acres of suitable northern spotted owl habitat, or 58 percent of the total LSR land base. Late-successional habitat (greater than 24 inch dbh) accounts for 14,981 acres (29 percent) of the LSR and mostly occurs below 5,000 feet elevation. Another 29 percent is less optimal habitat (mid-successional stands from 17 to 24 inch dbh). This LSR is extensively fragmented by a checkerboard ownership pattern and past land use.

A total of 26 activity centers have been located within the Mt. Ashland LSR. Thirteen northern spotted owl pairs and two territorial singles were recorded in the northern portion of the LSR, while nine pairs and two territorial singles were located in the southern zone, for a total of 22 pairs and four resident singles. Complete protocol surveys have covered almost all suitable habitat within the LSR boundary. The home ranges of two activity centers in the northern portion of the LSR have less than 40 percent suitable habitat, and four activity centers south of the crest are below this minimum habitat threshold. The Mt. Ashland LSR overlaps with the subunits OR-19 and CA-29 of the Klamath Intra-Province CHU. The CHU objectives include maintaining a link between California and Oregon, and providing habitat for 20 northern spotted owl pairs. The 22 owl pairs in the Mt. Ashland LSR exceed the pair goals for subunits OR-19 and CA-29.

Threats to the Northern Spotted Owl in the California Klamath Province

Threats to the northern spotted owl in this region include habitat loss due to fires, Federal and private management activities, displacement by barred owls, forest health (insect outbreaks and disease), and potential for avian disease. Northern spotted owl nesting/roosting and dispersal habitat both decreased by one percent on Federal lands as a result of management activities from 1994 to 2007 in the California Klamath Province; nesting/roosting and dispersal habitat on

Federal lands was reduced by 1.05 percent and 1.03 percent, respectively, as a result of natural disturbances from 1994 to 2007 in this province (Davis, in press). The total reduction in nesting/roosting habitat was 5.2 percent and the net gain of dispersal habitat was 5.4 percent on Federal lands from land management activities and natural disturbances during this timeframe.

Fire

Fire continues to modify the quality and quantity of northern spotted owl habitat within this region. The Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b) reported a reduction of 71,600 acres from 1994 to 2007 on Federal lands in the California Klamath Province attributable to fire, and 1,600 acres lost from insects and disease during the same time period. However, Agee (2007) disputed these estimates, reporting that from 1994 through 2003, this region experienced the Dillon fire (27,000 acres), Megram/Onion (125,000 acres), Jones and Happy Camp Complex (1,670 acres and 6,800 acres, respectively), and many smaller fires. He concluded that while not all acres burned with high severity, probably 30 percent of this habitat was seriously altered or destroyed as owl habitat, resulting in a loss of 48,141 acres from 1994 through 2003. An additional 170,000 acres burned in 2006. While not all of the 2006 fires burned with high severity, using an estimate of 30 percent loss, it was estimated that an additional 51,042 acres of habitat was lost to fire in this province (Agee 2007). Although there is some uncertainty as to the extent of northern spotted owl habitat loss due to fire, both estimates clearly demonstrate that fire is a threat to owls.

Historically, lands within the California Klamath Province experienced frequent (1 to 25 years) low- to moderate-intensity surface fires, while the current regime is characterized as infrequent (25 to 100 years) high-intensity fires. The extent of the recent high-severity burns appears to be different than historic burn patterns, with more area burning at high intensity (Skinner et al. 2006). Before fire suppression, fires of higher spatial complexity created openings of variable size within a matrix of forest that was generally more open than today (Taylor and Skinner 1998, as referenced in Skinner et al. 2006). This heterogeneous pattern has been replaced by a more homogeneous pattern of smaller openings in a matrix of denser forest, thus reducing spatial complexity (Skinner 1995, as referenced in Skinner et al. 2006). Studies suggest that vegetation patterns and conditions generated by pre-fire suppression fire regimes may be advantageous for the northern spotted owl (Franklin et al. 2000). The incidence of catastrophic wildfire on Federal Reserve lands (e.g., CHUs, LSRs) may have increased from historical occurrences as a result of recent fire suppression policies, but this effect has been strongly debated by various researchers (Hanson et al. 2009).

Forest Health

Information on forest health is primarily based on the KNF LSR Assessment conducted by Dix et al. (1999). Mortality caused by insects and disease in the Seiad and Johnny O'Neil LSRs was localized to the southern portion of the LSRs. At upper elevations, the fir engraver beetle has been responsible for ponderosa pine and Douglas fir mortality. At lower elevations, the western pine beetle and pine engraver beetle have been primarily responsible for ponderosa pine and Douglas-fir mortality. The Johnny O'Neil LSR is at risk for future insect outbreaks due to early and midseral stand stocking levels.

Barred Owls

Barred owls are present within the California Klamath Province, and have recently been detected in the Action Area. Barred owls were reported in southern Jackson County, Oregon as early as 1990 (Kelly 2001), and records from the Rogue-Siskiyou National Forest and Medford BLM indicate that numerous barred owl locations have been reported in that area through 2007. Five pairs of barred owls were detected in the Oregon portion of the Mt. Ashland LSR (subunit OR-19 of the Klamath Intra-Province CHU) during 2005-2006 (USDI FWS unpublished data); however, annual surveys of subunit CA-29 of the Klamath Intra-Province CHU, and subunits CA-28, CA-31, and CA-30 of the Scott and Salmon Mountains CHU did not detect barred owls until 2006. In 2006 and 2007, barred owls were detected at six locations in and adjacent to these CHUs (USDI FWS unpublished data). Based on these reports, combined with the rate and pattern of colonization observed in the California Cascades Province, barred owls are predicted to become established in the Action Area within 5 years (USDI FWS unpublished data).

West Nile Virus

West Nile virus is the primary disease of concern for the northern spotted owl (USDI FWS 2008a). The virus has not been detected in the California Klamath Province; however, it is now within the range of the northern spotted owl in northwestern California (Courtney et al. 2004).

3.2.2 Environmental Baseline in the California Cascade Province Action Area

The following section describes environmental baseline conditions for the portion of the Action Area within the California Cascades Province, including a discussion of the northern spotted owl population, amount and quality of habitat on the FGS ownership and adjacent Federal lands, and current threats. Fruit Growers Supply's Grass Lake Management Unit occurs within the California Cascades Province.

Northern Spotted Owl Population in the Cascades Action Area

The northern spotted owl population in the California Cascades Province has been identified as providing an important link between the California spotted owl and northern spotted owl and resides in the Shasta-McCloud Area of Special Concern (Thomas et al. 1990). Unlike the California Klamath Province, the amount of northern spotted owl habitat in the California Cascades Province is limited and protocol-level owl surveys have been conducted in the last 10 years on the majority of lands within the province that could potentially support owls. Anthony et al. (2006) did not include the California Cascades Province in their demographic studies because northern spotted owl populations in this province are too low to make demographic studies of this type possible. Information on fecundity and survivorship in this portion of the Action Area is not currently available, as no mark-recapture programs for owls have been conducted on FGS's ownership in the California Cascades Province.

The Service considers the CDFG Northern Spotted Owl Database the best source for documenting the number of owls in this province. For the period from 1987 through 2007, the

CDFG database contains records of 10 activity centers within 1.3 miles of FGS's ownership in the California Cascades Province. Of these, two sites were determined by the Service to be invalid because they typically did not meet the Service's criteria for designation as an activity center (i.e, inadequate number of detections for residency status) and/or were extremely lacking in amounts of suitable habitat (i.e., habitat was removed by a stand-replacing fire in a significant portion of the core). Therefore, eight historic activity centers supporting a total of up to 15 northern spotted owls are estimated to occur within the California Cascades Province portion of the Action Area. A quantification of northern spotted owls by reproductive status in the Cascades Action Area is presented in Table 8. There is some uncertainty as to the exact number of currently occupied activity centers within this area because some activity centers may no longer be active. It is unlikely that there are additional undetected activity centers on FGS ownership given the low amounts of suitable habitat and extensive survey effort over time on the property.

Table 8. Quantification of Northern Spotted Owls by Reproductive Status in the California Cascades Province Portion of the Action Area.

Status (1987-2007)[a]	Sites[b]	Owls
Reproductive pair with young	5	10
Nesting pair	2	4
Territorial single	1	1
Total valid activity centers	8	15

[a] Source: CDFG Northern Spotted Owl Database
[b] For the purpose of the effects analysis, each site is considered an activity center

Northern Spotted Owl Habitat in the Cascades Action Area

Based on the 2005 owl habitat layer, there are 22,728 acres of suitable foraging habitat, 7,349 acres of suitable nesting habitat, and 154,865 acres of unsuitable habitat within the entire 184,942-acre Cascades Province portion of the Action Area (Table 9). Table 10 shows the acreage and ownership of northern spotted owl habitat within the core and home range of each activity center within the Cascades Action Area.

Table 9. Northern Spotted Owl Habitat and Land Ownership within the California Cascades Province Portion of the Action Area.

	Acres of Habitat			
Owner	**Unsuitable**	**Foraging**	**Nesting/Roosting**	**Total**
Federal	83,092	14,220	5,737	103,050
FGS	38,168	4,180	619	42,967
Other Private	33,464	4,328	933	38,785
State	140	0	0	140
Total Public	83,233	14,220	5,737	103,190
Total Private	71,632	8,508	1,612	81,752

Data from 2005 northern spotted owl baseline habitat layer developed by FGS and the Service

Table 10. Suitable Northern Spotted Owl Nesting/Roosting and Foraging Habitat within Northern Spotted Owl Cores and Home Ranges across Land Ownerships within the Cascades Action Area.

Cascades Action Area			**Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)**					**Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)**				
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**
SK153	Pair (KNF)	Foraging	**141**	61	79	0	1	**1036**	454	482	0	100
		Nesting	**133**	0	132	0	1	**155**	0	130	0	24
		Total	**274**	61	211	0	2	**1191**	454	612	0	124
SK153B	Pair (KNF)	Foraging	**294**	0	274	0	20	**772**	15	501	10	247
		Nesting	**3**	0	3	0	0	**419**	0	308	19	92
		Total	**297**	0	277	0	20	**1191**	15	809	29	339
SK194	Pair (KNF)	Foraging	**56**	0	56	0	0	**811**	0	782	0	29
		Nesting	**101**	0	101	0	0	**630**	0	628	0	2
		Total	**157**	0	157	0	0	**1441**	0	1410	0	31
SK284	Pair (KNF)	Foraging	**292**	12	115	0	166	**501**	96	55	0	351
		Nesting	**6**	6	0	0	0	**73**	0	17	0	56
		Total	**298**	18	115	0	166	**574**	96	72	0	407
SK428	Pair (KNF)	Foraging	**2**	0	2	0	0	**166**	0	80	0	86
		Nesting	**271**	0	270	0	1	**177**	12	131	0	35
		Total	**273**	0	272	0	1	**343**	12	211	0	121
SK442	Single (KNF)	Foraging	**123**	0	123	0	0	**847**	0	847	0	0
		Nesting	**0**	0	0	0	0	**93**	0	93	0	0
		Total	**123**	0	123	0	0	**940**	0	940	0	0
SK462	Pair (KNF)	Foraging	**395**	120	276	0	0	**1602**	639	718	0	245
		Nesting	**17**	0	17	0	0	**95**	0	86	0	8
		Total	**412**	120	293	0	0	**1697**	639	804	0	253
SK542	Pair	Foraging	**8**	0	0	0	8	**431**	44	285	0	102

Cascades Action Area			Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Core (502 acres)					Acres of Suitable Nesting/ Roosting and Foraging Habitat in NSO Outer Ring Home Range (2,894 acres)				
Activity Center	**HRS**	**Habitat**	**Total**	**FGS**	**USFS**	**BLM**	**OP**	**Total**	**FGS**	**USFS**	**BLM**	**OP**
	(OP)	Nesting	**25**	0	6	0	19	**30**	0	0	0	30
		Total	**33**	0	6	0	27	**461**	44	285	0	132

HRS = Highest Reproductive Status and land owner on which activity center occurs
Nesting = Nesting/Roosting
OP = Other Private

Northern Spotted Owl Critical Habitat in the Cascades Action Area

As described above, the Revised Designation of Critical Habitat for the Northern Spotted Owl; Final Rule (FR 73 47326, USDI FWS 2008b) revised the designation of critical habitat into larger critical habitat units (e.g., Western Klamath-Siskiyou Mountains) with designated subunits that roughly correspond with the original CHU designations. Northern spotted owl critical habitat does not occur on FGS lands; however, the following section characterizes the status of northern spotted owls and habitat within CHUs and LSRs to describe the baseline condition of the Federal Reserve System upon which the FGS HCP Conservation Strategy is based. The analysis below is based on LSR Assessment for the Goosenest LSR #RC-363 (USDA FS 1996b) but uses the revised subunit numbers for critical habitat from the revised designation. Information on the status of the LSRs was used because considerably more information is available on conditions in the LSRs than for individual CHUs and subunits, and because there is an 83 percent overlap in acreage between current subunit designations and the 1994 LSRs. Owl pair objectives for the new subunits have not been established by the Service; however, since the distribution and total acres of the newly designated subunits do not significantly differ from the 1992 critical habitat designation within the Action Area, pair objectives from the 1992 critical habitat designation were used for the evaluation below.

Two subunits (CA-61 and CA-66) in the Southern Cascades CHU are within the California Cascades portion of the Action Area. Subunit CA-61 overlaps with the Goosenest LSR. A very small portion (200 of approximately 3,000 acres) of subunit CA-66 is within the California Cascades Province portion of the Action Area.

Goosenest LSR (363)/ Southern Cascades CHU Subunits CA-61 and CA-66. The Goosenest LSR is approximately 39,770 acres in size. Habitats considered suitable for breeding and/or foraging by northern spotted owls (dense late-successional, open late-successional, and dense mid-successional) occupy 14,097 acres, or about 35 percent, of the LSR area (USDA FS 1996b). Low precipitation and temperatures, and high elevation reduce the overall potential of lands within the California Cascades Province to support dense late-successional habitat suitable for northern spotted owls (USDA FS 1996b). The majority of northern spotted owl home ranges in the Goosenest LSR are functioning poorly in terms of long-term sustainability (USDA FS 2005). Home ranges contain overly dense forest with suppressed understory dominated by white fir and lack large trees, particularly Douglas fir. The habitat in these home ranges is at moderate to high risk of insect attack, with subsequent increased wildfire hazard. At such high densities, stand development is unlikely to attain old-growth characteristics in the absence of fire or active management.

A total of 14 northern spotted owl activity centers have been located within the Goosenest LSR. The Goosenest LSR overlaps considerably with subunit CA-61. The 14 known activity centers (12 pairs and 2 territorial singles) within the Goosenest LSR exceed the recovery pair goal of 6 for subunit CA-61 (USDA FS 1996b).

Threats to the Northern Spotted Owl in the California Cascades Province

Threats to the northern spotted owl in this region include habitat loss due to Federal and private management activities, forest health issues (including overstocking, insect infestations, and forest disease), fire, and displacement by barred owls. Northern spotted owl nesting/roosting and dispersal habitat decreased by 1.03 percent and 1.02 percent, respectively, on Federal lands as a result of management activities from 1994 to 2007 in the California Cascades Province; nesting/roosting and dispersal habitat both decreased by 1.01 percent on Federal lands as a result of natural disturbances from 1994 to 2007 in this province (Davis, in press). Bigley and Franklin (2004) reported a 5.77 percent reduction in northern spotted owl habitat on Federal lands as a result of management activities from 1994 to 2003 in the California Cascades Province. Habitat was unchanged by natural disturbances from 1994 to 2002 in the California Cascade Province (USDI FWS 2008a). The total reduction in nesting/roosting habitat was 4.0 percent and the net gain of dispersal habitat was 8.1 percent on Federal lands from land management activities and natural disturbances during this timeframe.

Barred owls currently pose a significant threat to northern spotted owls in the California Cascades Province. While numerous detections of barred owls were reported in the southern Oregon Cascades during the early 1990s, this species was not detected in the California Cascades Province until 1996. From 1996 to 2003, single barred owls were detected at two locations within subunit CA-61 of the Southern Cascades CHU. Surveys in 2004 detected barred owl pairs at three locations, all within northern spotted owl territories. Single barred owls were detected at three additional locations in and adjacent to CHU CA-61, and two locations were reported on the McCloud Ranger District of the STNF, immediately to the south of subunit CA-61. Between 2004 and 2007, the numbers of barred owls detected in the California Cascades Province has increased steadily (USDI FWS unpublished data). As of 2007, barred owls have been detected at 11 locations, and three of 12 northern spotted owl territories (within subunit CA-61) have been displaced by barred owls.

West Nile virus is the primary disease of concern for the northern spotted owl (USDI FWS 2008a). The virus has not been detected in the California Cascades Province; however, it is within the range of the northern spotted owl in northwestern California (Alan Franklin, John Marzluff, pers. comm., as reported in Courtney et al. 2004).

3.3 Status of Fishers in the Action Area

For the purposes of this consultation, the Service is analyzing the environmental baseline for fisher populations and habitat within the California Klamath Province and California Cascades Province portions of the Action Area. The environmental baseline is described separately for these two provinces because they are distinct in terms of their ecology, the availability and quality of information for fishers, and the apparent abundances of fishers and their habitat. The Action Area for fishers consists of FGS ownership with a surrounding 1.6-mile buffer (Figure 3). The 1.6-mile buffer was based on the radius of an estimated circular home range for female fishers in the Klamath Province (7.7 $mile^2$: Appendix E of the HCP). Female fisher home range size was used because females are considered the reproductive unit and presumably establish their home ranges based on the availability of resources. Male fisher home ranges are larger and may in part establish their home ranges based on the location of female home ranges. The Action Area includes the portion of the fisher population that could be directly or indirectly affected by the proposed HCP and ITP.

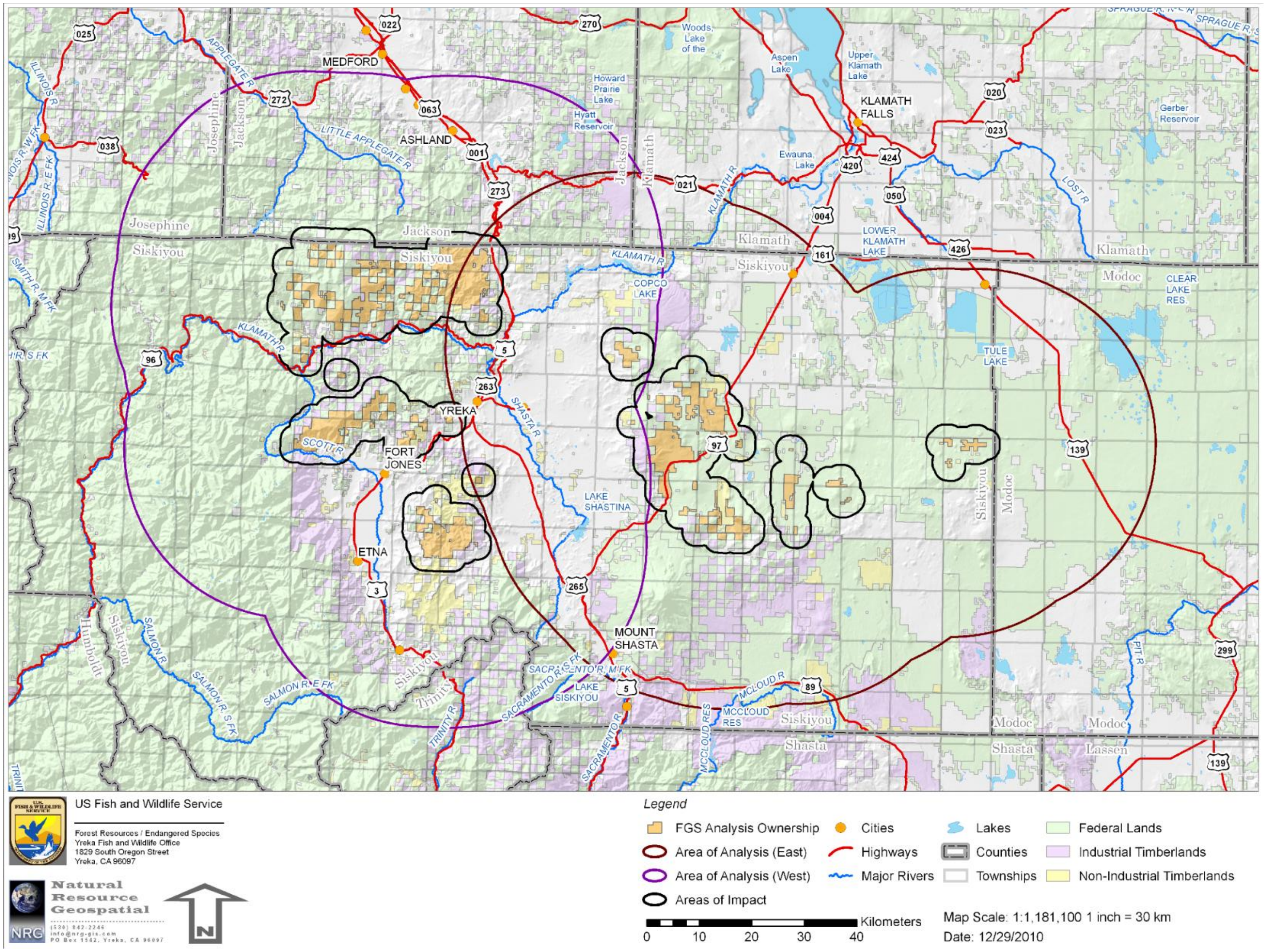


Figure 3. California Klamath and California Cascades regional “Area of Analysis” and local “Area of Impact” within a 20-mile and 1.6-mile radius, respectively, of Fruit Growers Supply Company’s ownership.

3.3.1 Environmental Baseline in the California Klamath Province Action Area

The California Klamath Province portion of the Action Area for fishers contains approximately 350,800 acres. About 29% of this area is owned by FGS, 38% is federally owned, 33% is held by other private land owners, and less than 1% is owned by the State of California.

Fisher Habitat in the Klamath Action Area

Zielinski et al. (2010) used survey data to develop a model that predicts the probability of detecting fishers throughout the California Klamath Region. The final model included the following variables (see Zielinski et al. 2010 for definitions): amount of dense forest, percent hardwood, medium and large trees, structurally complex forest, elevation, solar insolation, and predicted abundance of mammalian prey. Other biotic and abiotic habitat variables may also be important to fishers and were included in candidate models. However, the final model (a composite of the 4 best candidate models) better classified fisher detection locations in the region than did any of the candidate models. The model correctly classified fisher detection and non-detection locations 84% and 70% of the time, respectively.

The Service modified the Zielinski et al. (2010) model by using FGS forest inventory data in place of the original model's vegetation data for FGS lands to provide an estimate of the current amount of modeled habitat for fishers in the California Klamath Province portion of the Action Area. The model predicts the probability of detection of fishers across the landscape, and assumes that areas with a higher probability of detection fulfill a greater number of, or higher quality of, life-requisite needs for fishers (e.g., food, shelter). The probability of detecting fishers may be used as an index of relative habitat suitability for fishers. The Service selected modeled values greater than or equal to 0.41 as a threshold to represent preferred habitat (hereafter 'suitable habitat') using the FGS fisher model (see "Fisher Spatial Analysis" in Appendix E of the HCP for more details on the modeling process used for the Klamath Action Area). To represent the minimum area for supporting a hypothetical female home range, the Service excluded from some calculations isolated patches of modeled habitat smaller than 7.7 mi^2 (20 km^2). This provided a conservative approach to quantifying areas that have a greater likelihood of providing sufficient habitat for the species to meet its life history needs and a spatially explicit method for analyzing how changes in the amount and spatial configuration of habitat may impact fishers under the Proposed Action.

The California Klamath Province portion of the Action Area for fishers consists of approximately 350,800 acres. As predicted by the FGS model, 39% of this area (137,163 acres) currently consists of suitable fisher habitat, with 36% (125,937 acres) existing in large (greater than 7.7 mi^2) patches that contain the minimum area to support a hypothetical female fisher home range (Figure 4). Federal and private (e.g., FGS, other private industrial timberland owners, some non-capable agriculture and urban land) lands account for similar proportions of suitable habitat that occurs in large patches (Figure 4). However, relative to their total acreage within this portion of the Action Area, Federal lands disproportionately contribute to the total amount of suitable fisher habitat that occurs in large patches compared to private lands (Figure 4). State lands account for a negligible (0.4%) proportion of the Klamath Action Area, and do not contain suitable habitat for fisher. Of the FGS ownership within the Klamath Action Area, approximately 34% currently consists of suitable habitat for fishers, mostly (31%) in large blocks. Fruit Growers Supply Company contributes about 10% of the suitable habitat and about 9% of the suitable habitat that occurs in large blocks; therefore, FGS's potential impact on fisher habitat within the Klamath Action Area is limited (Figure 4).

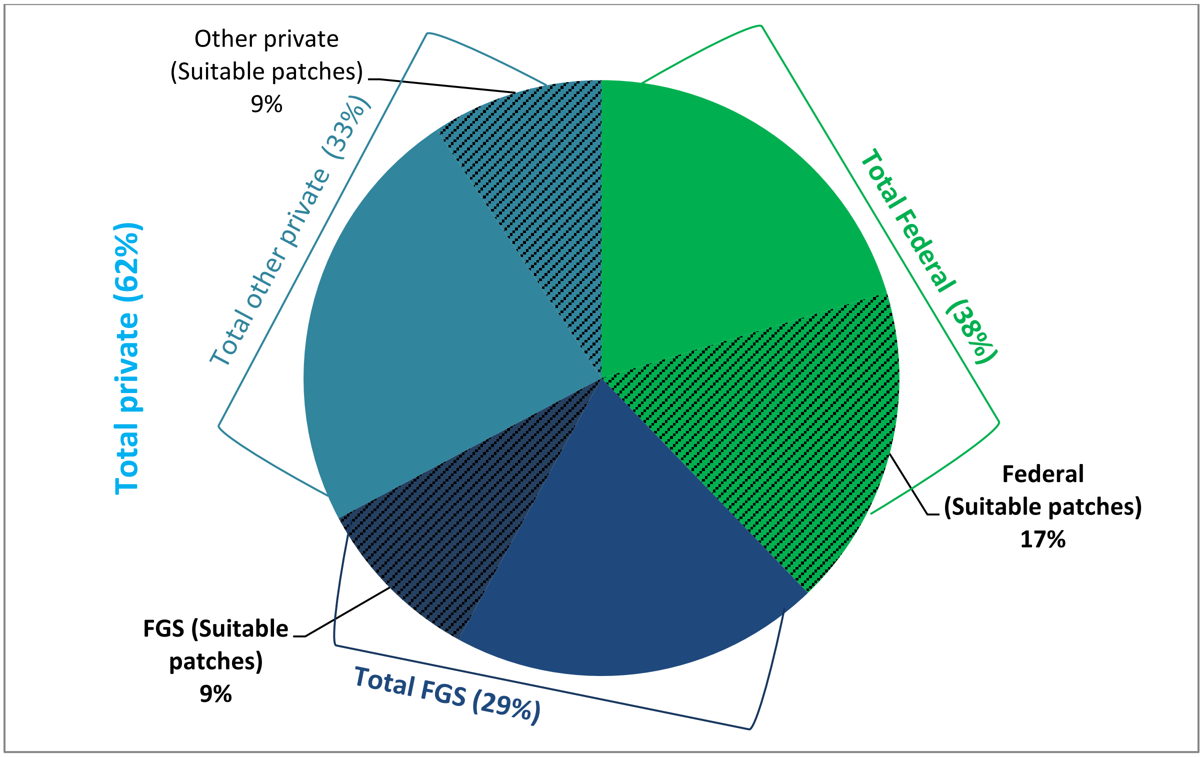


Figure 4. Percentage of total ownership and large patches (>7.7 mi^2) of fisher habitat within the California Klamath Province portion of the Action Area showing suitable habitat by ownership at baseline conditions.

Fisher Population in the Klamath Action Area

Fishers within the California Klamath Province portion of the Action Area are part of the native southwestern Oregon/northern California population, which consists of a series of interconnected local populations that extend west to the Pacific Ocean, south to Lake County, and north into southern Oregon (USDI FWS 2010b). A USFS database query conducted on January 24, 2011 reported verified fisher detections throughout much of the northern and central portions of the Klamath Action Area (Figure 5). Relatively few surveys have been conducted in the vicinity of Moffet Creek in the southernmost portion of the Klamath Action Area; however, one fisher was detected in this area in October, 2011 (Callas 2011).

Additional information on fisher numbers was available for a portion of the Klamath Action Area. In 2006, a fisher monitoring study began in the eastern Klamath Mountains of California. The northern half of this 200-mile^2 study area occurs within the Action Area, overlapping the Beaver Creek drainage of FGS's Klamath River Management Unit. This study uses DNA extracted from fisher hair samples to "mark" and "recapture" individuals. This methodology can be used to estimate population size, demographic structure, and immigration/emigration for each year. DNA samples were collected from 52 different fishers (22 females and 30 males) during 2006 through 2009. Preliminary population estimates for the study area were 25, 53, and 47 individuals during years 2007, 2008, and 2009, respectively (Swiers and Powell 2010).

Comprehensive surveys have not been conducted within the California Klamath Province portion of the Action Area to determine actual fisher population size within this area; however, the modified Zielinski et al. (2010) model indicated that current conditions could support approximately 25 hypothetical female home ranges within the Klamath Action Area (Appendix E of the HCP).

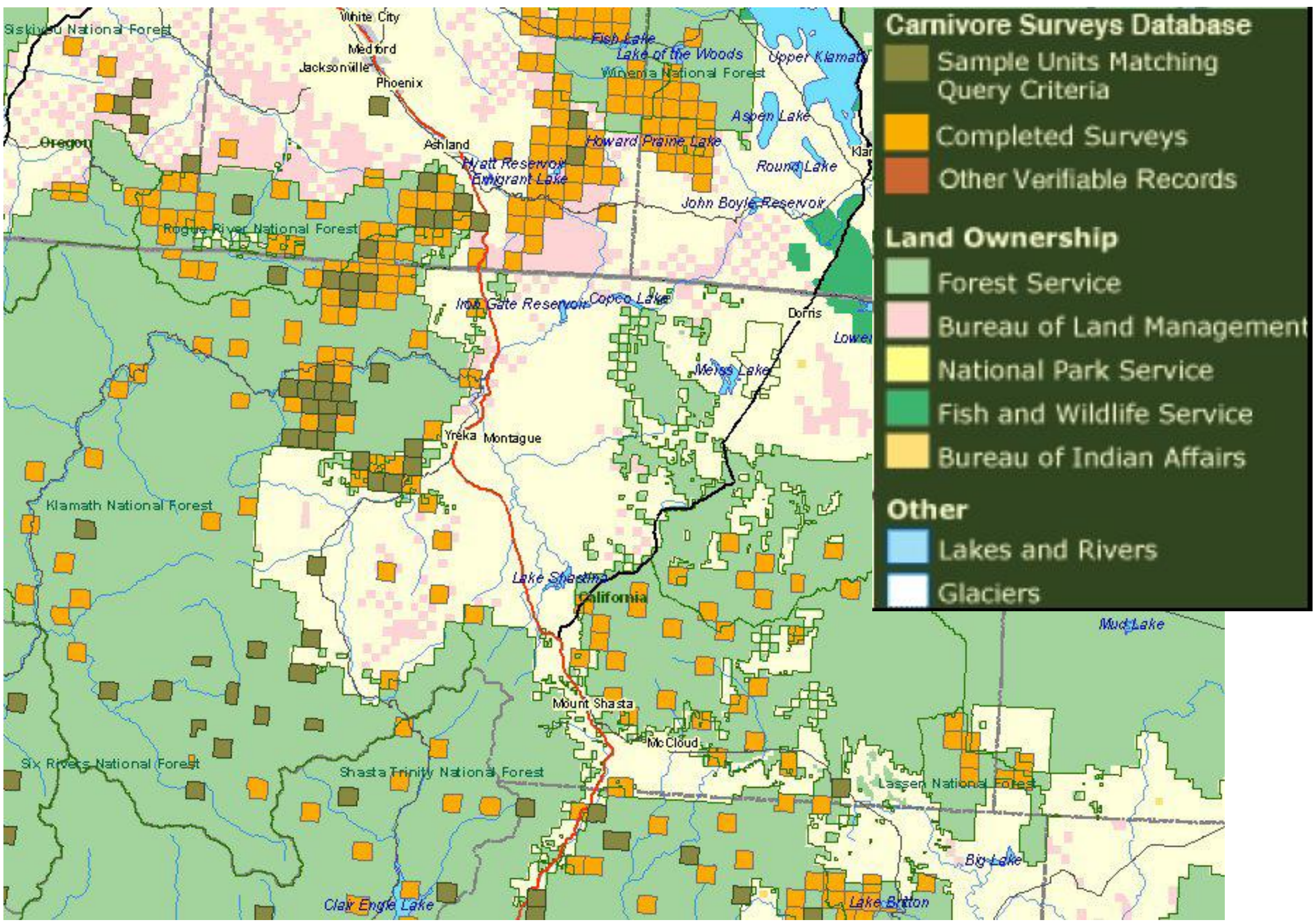


Figure 5. Graphical results of January 24, 2011 query of the USFS Forest Carnivore Surveys in the Pacific States website [http://maps.fs.fed.us/carnivore//Modules/application/home.html]. Orange squares [ ] represent completed surveys within 4-mi^2 sample units based on the Public Land Survey System. Dark green squares [ ] match query parameters that included: Carnivores: "Fisher", Range of Years from: "1995" to "2010", and detection Sources: "All Sources".

Threats to the Fisher in the California Klamath Province

Threats to fishers in the Klamath Province are similar those that threaten the West Coast DPS as a whole (see section 2.2.3). Threats in the Klamath Province include loss, deterioration, and fragmentation of habitat from past and current forest management practices and the potential for catastrophic wildfire. Disturbances that reduce canopy cover or the availability of large trees, snags, and down wood can negatively affect fishers by degrading habitat for them and their prey. Other potential threats, such as vehicle traffic, disease, or predation could work synergistically with habitat modification to further threaten fishers. See section 3.2.2 for more information on management-induced changes to natural disturbance regimes and habitat in the California Klamath Province.

3.3.2 Environmental Baseline in the California Cascades Province Action Area

The total area within the California Cascades Province portion of the Action Area for fishers is 255,100 acres. About 19% of this area is owned by FGS, 60% is federally owned, 20% is held by other private land owners, and less than 1% is owned by the State of California.

Fisher Habitat in the Cascades Action Area

The Zielinski et al. (2010) habitat model could not be applied to the California Cascades Province because it was developed specifically for the Klamath region. Furthermore, the number of fisher detections in the California Cascades Province is currently insufficient for an adequate evaluation of model performance.

Davis et al. (2007) developed and compared multiple habitat models for fishers in California. The model that was developed with detection locations from northern California (as opposed to the southern Sierra Nevada or Statewide) predicted only small, isolated areas of modeled habitat in the California Cascades portion of the Action Area.

Although some of their life history requirements differ, fishers and northern spotted owls have overlapping habitat associations. For example, both species generally gravitate toward relatively old, densely-canopied, multi-layered forests with large trees and dead woody materials. Sixteen percent of the Cascades Action Area currently consists of suitable foraging, nesting, or roosting northern spotted owl habitat on FGS ownership (Table 9). Section 3.2.3 describes the distribution of foraging, nesting, and roosting habitat for northern spotted owls by ownership within the Cascades Action Area.

Fisher Population in the Cascades Action Area

A January 24, 2011 query of the USFS Forest Carnivore Surveys in the Pacific States showed no records of fisher detections within the California Cascades Province portion of the Action Area. However, survey effort in this area is relatively low compared to the Klamath Province. One verified detection of a fisher south of Mount Shasta approximately 9 miles south-southwest of the Cascades Action Area is known to have occurred in 2003 (Lindstrand 2008). Except for the one verified location, fishers appear to be either not present or sufficiently low in numbers to avoid detection. The close proximity of this detection relative to fisher movements, combined with the relatively low survey effort in the region, suggest that fishers may occur in the Cascades Action Area.

As described above in the “Fisher Habitat in the Cascades Action Area” section, the Zielinski et al. (2010) model could not be used to model habitat within the California Cascades Province; therefore, the number of hypothetical female home ranges under current conditions within the California Cascades Province portion of the Action Area could not be estimated.

Threats to Fishers in the California Cascades Province

Threats to fishers in the California Cascades Province include habitat loss and modification due to management activities (e.g., timber harvesting, fire suppression) and the potential for catastrophic wildfire. The Forest Ecosystem Management Assessment Team (1993) described forests in the California Cascades as highly fragmented due to harvest activities and natural factors.

4.0 EFFECTS OF THE ACTION

In general, implementation of the FGS HCP Covered Activities consists of the following: timber harvest (e.g., felling and bucking of timber, yarding timber, salvage and transport of timber), silviculture (e.g., clearcutting, commercial thinning, biomass thinning, seedtree/shelterwood removal, selection/group selection, or combination of these), stand regeneration and improvement (e.g., site preparation, prescribed burning, slash treatment, tree planting, vegetation management), minor forest products (e.g., Christmas tree cutting, firewood cutting, fence post cutting), and fire prevention (e.g., vegetation management, fuel break construction) and suppression (e.g., fuel break construction, application of aerial fire suppressants, falling trees or snags, water drafting). Each of these Covered Activities has the potential to result in adverse effects to the northern spotted owl, fisher, and their habitat through a number of mechanisms (e.g., habitat modification, noise disturbance, direct injury, and mortality), which are described in detail in the following sections. This section presents an analysis of the direct and indirect effects of the FGS HCP, including interrelated and interdependent actions, on the northern spotted owl and fisher.

4.1 Northern Spotted Owl

The degree to which the Covered Activities listed above are likely to directly and indirectly affect the northern spotted owl within the Action Area are discussed below. These effects are then evaluated with consideration of the conservation needs of the owl within the larger conservation strategy established for the northern spotted owl by the NWFP and Revised Recovery Plan, including: 1) protection of large blocks of habitat to provide for clusters of breeding pairs of northern spotted owls; 2) suitable habitat distributed across a variety of ecological conditions; and, 3) reserves connected by habitat within the intervening matrix to support survival and movement across the landscape.

Forest management is the primary activity in the Plan Area, occurring on 152,178 acres. Not all forest management activities and their effects have the potential to cause 'take' of northern spotted owls. The modification of forest stand conditions through timber harvest has the greatest potential to affect (adversely or beneficially) northern spotted owls because of the immediate and long-term effects it has on habitat conditions and prey availability. Silvicultural treatments such as thinning may benefit northern spotted owls by accelerating the development of northern spotted owl habitat and dense prey populations, and reducing the risk of catastrophic wildfire. Silvicultural activities associated with stand regeneration (e.g., site prep and tree planting) are unlikely to affect habitat conditions for northern spotted owls, but have the potential to adversely affect northern spotted owls by increasing noise and activity levels. Other Covered Activities related to timber harvesting (e.g., harvesting minor forest products, fire prevention, and watershed management) could result in varying levels of habitat modification and disturbance.

4.1.1 Direct Effects

4.1.1.1 Disturbance-Related Effects

Timber harvesting, timber hauling, plantation establishment and maintenance, road management (road building, road decommissioning), and fuels work will require use of heavy equipment, power tools, chainsaws, and large vehicles, all of which introduce an increased level of sound and human activity into the environment. The effect of sight- and sound-related disturbance on northern spotted owls is not well studied. Further, the effects of noise on birds can be difficult to establish due to difficulties associated with quantifying and qualifying characteristics of disturbance (i.e., type, frequency, proximity) and appropriate response variables (i.e., behavior, reproductive success, survival). Additional factors increase the complexity of evaluating effects of disturbance such as the individual bird's tolerance level, ambient sound levels, physical parameters of sound and how it reacts with topographic characteristics and vegetation, and differences in how species perceive noise.

In spite of these challenges, research conducted on a variety of bird species does suggest that disturbance can have a negative effect on reproductive success (Tremblay and Ellison 1979, Anderson et al. 1989, Belanger and Bedard 1989, Piatt et al. 1990, Henson and Grant 1991). Such studies have shown that disturbance can affect productivity in a number of ways including: interference of courtship (Bednarz and Hayden 1988), nest abandonment (White and Thurow 1985), egg and hatchling mortality due to exposure and predation (Drent 1972, Swensen 1979), and altered parental care (Fyfe and Olendorrf 1976, Bortolotti et al. 1984). Disturbance can also have an effect prior to incubation by influencing the choice of a nesting site (Long and Ralph 1998). The few studies that have examined spotted owl responses to several types of disturbance (e.g., helicopters, small chainsaw, hikers) determined that owl behavior was disrupted by such stimuli, as demonstrated by flushing, altered prey delivery rates, and decreased prey handling behavior (Delaney et al. 1999; Delaney and Grubb 2001; Swarthout and Steidl 2001, 2003). However, whether or not the owls responded to the disturbance, and to what extent, depended on several factors, including time of year, noise level, and proximity to stimulus.

Disturbances that cause exposure of adult or juvenile northern spotted owls may increase predation risks. Causing a northern spotted owl to fly off the nest may increase the likelihood of predation or injury through the advertisement of the nest's location, advertisement of the adult and juvenile, or premature departure of a nestling from a nest. Predation is presumed the largest cause of northern spotted owl mortality, particularly of juveniles, due to raptors, other owls, and corvids (Forsman et al. 1984, Laymon 1985, Verner et al. 1992). Human presence alone appears to attract predators, such as corvids. For example, Forsman et al. (1984) recorded an incident in which ravens attempted to predate a nest after survey efforts called the female out of the nest cavity during the day.

As described under "Disturbance-Related Effects" in section 2.1.3.2 (Threats), spotted owls may have elevated stress hormone levels in response to a disturbance without exhibiting a change in behavior which, over extended periods, may have negative effects on reproductive function, disease resistance, or physical condition (Carsia and Harvey 2000, Saplosky et al. 2000). Prolonged activities, such as those associated with timber harvest, may increase stress hormone levels depending on their proximity to northern spotted owl core areas (Wasser et al. 1997, Tempel and Gutiérrez 2004). Gender differences found in fecal glucocortoid concentrations over time from owls in Washington and Oregon suggest that timber practices and other prolonged disturbances may have disproportional negative effects to female owls (Wasser et al. 1997). However, not surprisingly, these studies also indicate that owl sensitivity varies with stimulus distance, location (aerial or ground), type, and timing, as well as individual tolerance (Delaney et al. 1999; Delaney and Grubb 2001; Swarthout and Steidl 2001, 2003; Tempel and Gutiérrez 2003).

Post-harvest fuels treatments may also create above-ambient smoke or heat. Although it has not been conclusively demonstrated, it is anticipated that nesting northern spotted owls may be negatively affected by heat and smoke intrusion into the nest grove. Smoke and heat may serve as a disturbance to nesting owls or their young by causing them to avoid important foraging areas or fleeing the nest area prematurely, thereby reducing fitness.

Fruit Growers Supply's Covered Activities have the potential to cause direct disturbance to northern spotted owls when they are present within a treatment area. Noise or visual disturbance created by the use of heavy machinery, logging trucks, or other noise producing equipment used within treatment areas or along access roads to carry out FGS' Covered Activities has the potential to disrupt nesting, roosting, and foraging behaviors of northern spotted owls. Prescribed burning or burning of brush/scrap piles may also disrupt northern spotted owls nesting, roosting, and foraging behaviors. Noise, smoke, or visual disturbance can cause nesting northern spotted owls to temporarily flush from nest sites leaving eggs or hatchlings exposed to temperature changes or predation. More severe disturbances can cause the abandonment of the nest by adults or early abandonment of the nest by young. Roosting northern spotted owls exposed to noise, smoke, or visual disturbance can be subject to predation if forced off their roost site. If forced to move into an area with a less favorable microclimate and habitat, it could ultimately reduce their fitness (i.e., survival and reproduction). Additionally, owls that are forced out of their normal foraging areas may be subject to move into areas that have less prey availability or where they are less efficient in capturing prey.

While roosting and foraging northern spotted owls can be disturbed during any time of the year, noise, smoke, or visual disturbances generally have the greatest effect on them during the breeding, nesting, or rearing periods. To minimize direct disturbance to northern spotted owls during breeding, nesting, or rearing periods, FGS will implement a Limited Operating Period (LOP) from February 1 to August 31 for activities within 0.25 mile of known active nest sites. Fruit Growers Supply Company will implement protocol surveys according to the "Protocol for Surveying Proposed Management Activities that May Impact Northern Spotted Owls" (USDI FWS 2011a) or current northern spotted owl survey protocols approved by the Service prior to project implementation to determine the status of historic activity centers and determine if new activity centers have been established within 0.25 mile of any proposed treatment units.

4.1.1.2 Injury or Mortality

Forest management activities can result in direct mortality of adults, eggs, or young. Such cases are rare, but direct mortality due to tree-felling has been documented (Forsman et al. 2002). The potential for northern spotted owls to be struck and killed or injured by falling trees during harvesting or exposed to high levels of smoke during prescribed burning is confined to the area relatively close to the nest tree. During timber harvest or prescribed burning, individual adult northern spotted owls can reasonably be expected to move from the area and avoid injury. However, nesting adult northern spotted owls tending to reproductive activities such as incubation or brooding young may be reluctant to leave the area (Delaney et al. 1999), and therefore may be vulnerable to such injury. Foraging owls are not expected to be affected directly, as they will likely avoid areas with disturbance.

Young-of-the-year, whether in or out of the nest, may also be vulnerable to the effects of tree falling or smoke inhalation, or might disperse prematurely in response to the disturbance and thus be subject to predation, starvation, or injury outside of the nest or nest grove. Because young must be constantly brooded by an adult post hatching for up to two weeks, parental abandonment of the nest could lead to mortality of the young. Potential effects to eggs range from the implications of parental abandonment (Drent 1972, Swensen 1979, White and Thurow 1985) to destruction during tree falling. These types of direct effects are most likely to occur in nesting/roosting habitat during the breeding season when active breeding activities are underway.

As stated in the Take Minimization Objective in section 5.3.1.4 of the FGS HCP, FGS will not conduct timber operations or create a noise or smoke disturbance in conducting Covered Activities (minus fire suppression) within 0.25 mile of active northern spotted owl nest sites during the breeding, nesting, or rearing season beginning February 1 and ending August 31 (i.e., the LOP). "Active northern spotted owl nest site" is defined as the nest tree of a pair of nesting northern spotted owls. Road use and maintenance within 0.25 mile of an active northern spotted owl nest site may occur during the breeding season, but will require evaluation and approval by the Service. With implementation of the LOP, the likelihood of direct injury or mortality of owls is very unlikely and thus discountable.

Emergency fire suppression by FGS could potentially lead to incidental take of northern spotted owls. Since wildfire can occur during the northern spotted owl breeding season, there is a small probability that an adult owl or dependent young could be injured or killed as a result of dozer line construction, lighting backfires, applying aerial fire suppressants, and falling trees or snags. While individual adult northern spotted owls can reasonably be expected to move from an area of disturbance, nesting northern spotted owls tenaciously tending to reproductive activities such as incubation or brooding young may be reluctant to leave the area (Delaney et al. 1999), and therefore may be vulnerable to injury or death. Northern spotted owl eggs or nest dependent young have a higher probability of mortality from fire suppression activities that affect nest groves since they would be unable to move away from the disturbance.

4.1.2 Indirect Effects

4.1.2.1 Habitat Modification

The FGS HCP proposes timber harvest through different types of silviculture, road construction and maintenance, stand regeneration and improvement, minor forest product harvest, fire prevention and suppression, and other activities collectively referred to as Covered Activities. Forest management activities can alter suitable northern spotted owl habitat to varying degrees, leading to direct and indirect effects to northern spotted owls at both site-specific and landscape scales.

Site-Specific Effects

Currently, FGS has approximately 43,757 acres of suitable northern spotted owl habitat across its ownership within the entire Action Area, 9,029 acres of which are nesting/roosting and 34,728 acres of which are foraging habitat. Within the California Klamath Province Action Area there are 8,410 acres of nesting/roosting and 30,548 acres of foraging habitat. Within the California Cascades Province Action Area there are 619 acres of nesting/roosting and 4,180 acres of foraging habitat. Nearly all of the currently suitable habitat available for northern spotted owl in the Action Area could be harvested over the term of the ITP, with the exception of approximately 7,131 acres which have been identified by FGS as habitat commitments in CSAs. Of these 7,131 acres in CSAs, 115 acres are targeted for nesting/roosting, 3,721 acres for high-quality foraging, and 3,294 acres for low-quality foraging habitat. Northern spotted owls will benefit from an additional 5,648 acres that will be protected outside of the CSAs in WLPZs under the Aquatic Conservation Strategy, 5,017 acres of which will be in the California Klamath Province and 631 acres of which will be in the California Cascades Province. It is anticipated that the majority of timber harvest of currently suitable northern spotted owl habitat within the Action Area will occur in the first ten years of the HCP, accounting for modification of approximately 18,640 acres of suitable northern spotted owl habitat. Of the 18,640 acres of suitable northern spotted owl habitat that is likely to be harvested in the first decade, it is estimated that 34 percent (approximately 6,347 acres) will be reduced to non-habitat. The remaining acres will provide some level of dispersal or foraging capability.

Timber harvesting can result in the direct loss of suitable habitat important for northern spotted owl nesting, roosting or foraging. As a result, northern spotted owls may abandon a territory and seek out habitat elsewhere that may be marginal or occupied by other northern spotted owls or barred owls that compete for the same resources. Timber harvest can adversely affect northern spotted owls by reducing the total amount of suitable habitat within a northern spotted owl’s home range. The result may be that the northern spotted owls continue to persist at the territory in the short-term, but marginal habitat conditions in the territory compromise the northern spotted owls’ long-term survival and ability to successfully reproduce.

Forest management activities, whether intended to address silvicultural needs or to facilitate other actions (e.g., road construction, wildfire prevention, recreation) have the potential to reduce availability of nest and roost sites and foraging and dispersal habitat for the northern spotted owl. Northern spotted owls do not construct their own nests, but depend upon existing structures such as cavities in snags and live trees, broken tree tops, and mistletoe brooms; characteristics associated with stands in later seral stages of development. Silvicultural prescriptions (e.g. regeneration and overstory removal prescriptions) or management activities that specifically target the oldest, most decadent trees in the stand for economic purposes, or require removal of hazard trees and snags to address human safety concerns, are likely to result in loss of nesting opportunities for northern spotted owls by removing the trees that contain those structures (Blakesley et al. 1992). In studying tree dimension data from trees harvested in the 1960s, Hummel (2009) found that crown morphologies of large, young trees were not the same as their similarly sized older counterparts; therefore younger stands with old-growth characteristics may not provide as favorable nesting habitat as actual old growth. Further, prescriptions designed to reduce or remove ladder fuels or release co-dominant individuals can simplify vertical structure in the forest understory, where northern spotted owls perch for hunting or roosting (Forsman et al. 1984).

Intermediate timber harvest and fuels reduction activities can contribute to changes in structure, diversity, and habitat microclimate by reducing overall canopy closure within a stand. Northern spotted owls prefer to nest and roost in older, multi-storied forests (USDI FWS 1990a, Thomas et al. 1990, Blakesley et al. 1992, Verner et al. 1992, Andrews et al. 2005) presumably because they provide protection under most weather conditions (Forsman et al. 1984, North et al. 2000). During periods of rain, snow, or cold, Forsman et al. (1984) found northern spotted owls roosting significantly higher in the forest overstory than during hot weather when northern spotted owls were commonly found roosting low in the forest understory (Barrows and Barrows 1978). Weathers et al. (2001) documents physiological limitations that corroborate results of laboratory work and field studies which determined low heat tolerance of northern spotted owls compared to other birds.

Various forestry activities that remove large trees, snags, shrubs, and downed wood can affect prey composition and/or availability by altering characteristics of the habitat upon which prey species depend. Because the amount of standing dead (i.e., snags) and down material present on the forest floor is positively correlated with densities of some northern spotted owl prey species, removing these materials or temporarily disturbing material on the forest floor may contribute to declines in northern spotted owl prey, at least on a localized, short-term basis (Williams et al. 1992, Bevis et al. 1997). It may also be possible for prey species to be adversely affected by incidental loss of hardwoods, hazard trees, or snags during harvest.

In the southern portion of their range, where woodrats are a major component of their diet, northern spotted owls are more likely to use a variety of stands, including younger stands, brushy openings in older stands, and edges between forest types in response to higher prey density in some of these areas (Solis 1983, Sakai and Noon 1993, 1997, Carey et al. 1999, Franklin et al. 2000). Density of dusky-footed woodrats appears to be highest in sapling/bushy poletimber 15 to 40 years old and in older forests that have openings with abundant bushy understory (Raphael

1988, Sakai and Noon 1993, Hamm 1995, Carey et al. 1999, Hamm and Diller 2009). Hamm and Diller (2009) hypothesize that dusky-footed woodrats (*Neotoma fuscipes*) in northern California are likely directly tied to understory plant species diversity, vegetation density, and sites suitable for constructing houses rather than presence or absence of overstory conifer trees. Many other researchers (e.g. Carey et al. 1999, Innes et al. 2007) recognize the importance of large logs, stumps, shrubs, and materials for houses to woodrat density. Because of the importance of snags, downed logs, and mistletoe to woodrats, Lehmkuhl et al. (2006a) found that management to reduce woody fuels and restore low-intensity high frequency fire into ponderosa pine and Douglas fir forests will likely reduce bushy-tailed woodrat (*Neotoma cinerea occidentalis*) populations.

Dusky-footed woodrats prefer forested habitats with a brushy understory and suitable nest building materials. Houses are built of sticks and leaves at the base of, or in a tree, around a shrub, or at the base of a hill. Silvicultural treatments and prescribed burning could negatively affect dusky-footed woodrat habitat by destroying shrub cover and burning stick nests. However, it has been noted that opening up the canopy and having patchy openings throughout a stand may provide for the growth of shrubs, thereby increasing habitat availability to dusky-footed woodrats. Lehmkuhl et al. (2006b) determined that bushy-tailed woodrats can be abundant in dry interior forests where rock is scarce and snags, logs, and mistletoe provide cover. Large snags, mistletoe, and large logs are important cover elements that are positively correlated with bushy-tailed woodrat habitat value (Maser et al. 1984, Carey 1991, Smith 1997, Verts and Carraway 1998). Management to reduce woody fuels and restore low-intensity high-frequency fire regimes in ponderosa pine and dry Douglas-fir forest will likely reduce bushy-tailed woodrat populations (Lehmkuhl et al. 2006b). Cover provided by downed logs and mistletoe trees, whose dense brooms close to the ground torch easily in ground fires (Hessburg et al. 1994), would be mostly consumed by prescribed fire (Lehmkuhl et al. 2006b). Additionally, existing large snags with defects and old woodpecker cavities that provide woodrat nest sites (Carey 1991) also would be at risk of destruction by prescribed fire (Lehmkuhl et al. 2006b). Stand simplification, such as removal of tree height diversity or understory shrubbery, commonly resulting from timber harvest and prescribed burning, create less favorable foraging conditions for northern spotted owls. Because availability of large prey species, particularly dusky-footed woodrat and northern flying squirrels, has been shown to be important for northern spotted owl reproductive success (Barrows 1985, 1987; Zabel et al. 1995), activities that reduce prey populations could lower northern spotted owl recruitment and individual fitness, especially during breeding season.

Populations of small mammals vary widely in response to habitat availability and food resources. Silvicultural and fuel reduction treatments affect species differently depending on their life history needs. Northern flying squirrels, western red-backed voles, and bushy-tailed woodrats are usually negatively affected by silvicultural (thinning, shelterwood) and fuel reduction treatments in the short-term and may not start to recover until several years after treatments. On the other hand, many species such as ground dwelling squirrels and chipmunks increase almost immediately (1 to 2 years) after treatments. Loss of foraging habitat or silvicultural activities that lead to a short-term (1 to 5 years) reduction in prey availability may cause northern spotted owls to forage in other, less-familiar areas, leading to an increased probability of competitive interactions with barred owls or other northern spotted owls that may be in the area, as well as an increased probability of predation.

Fruit Growers Supply Company will employ various silvicultural treatments across its ownership. The most pronounced effect to suitable northern spotted owl habitat within the Plan Area will be from the use and implementation of even-aged regeneration methods. Even-aged regeneration occurs on a 50- to 80-year rotation and produces stands that will remain in young seral stages for 20 to 50 years depending on site potential and stocking retained. These units are generally small, from 10 to 30 acres, and scattered on the landscape. Additionally, based on FGS's MSP analysis and as stated on page 2-18 of the Final EIS, the HCP is expected to result in an increase in what the Service considers foraging habitat (i.e., CWHR habitat categories 4M and 4D) over time and a decrease in clearcutting and other even-aged management practices.

In most cases, even-aged regeneration targets marginally stocked and/or deteriorating stands to improve their long-term productivity. Harvest methods include seed tree, shelterwood, and clearcutting methods. Regeneration occurs artificially through planting nursery-grown seedlings, or naturally by seed trees retained within harvest units. Stands that are 50 to 80 years old generally support dispersal and foraging habitat for northern spotted owl. Harvesting by seed tree, shelterwood, and clearcutting methods will generally render the stands unsuitable to the northern spotted owl for nesting, roosting, foraging, and potentially dispersal.

Even-aged thinning units are intermediate treatments of mid-seral even-aged stands designed to accelerate growth of trees. Generally, mid-seral even-aged stands may provide dispersal and foraging opportunities for northern spotted owls, although these stands are generally dense with limited below-canopy roosting or perching opportunities. Thinning of these stands would likely improve an owl's ability to disperse through the stand by providing more space in the subcanopy to maneuver and fly through.

Uneven-aged silviculture is used to harvest trees individually or in small groups with the goal of developing or maintaining a variety of age classes within a stand. Typically, sites are restocked through natural regeneration and, where necessary, supplemented by planting seedlings obtained from a nursery. Uneven-aged silviculture will generally maintain the function of northern spotted owl habitat, although degradation of habitat components will typically occur.

Clearcutting

The clearcutting regeneration method involves the removal of a stand in one harvest. These clearcutting units are generally 20 to 30 acres, but may be up to 40 acres in size. Clearcutting occurs on FGS ownership within stands that are generally 50 to 80 years old. These stands typically provide foraging and dispersal habitat for northern spotted owls. In rare circumstances, a 70 to 80 year old stand may provide isolated patches of nesting/roosting habitat for northern spotted owls under optimum conditions (i.e., high site class mixed conifer or Douglas fir, proper elevation, aspect, slope position) which include older trees or snags that provide nesting opportunities. Clearcut timber harvest will adversely affect northern spotted owl habitat by completely removing the forest stand and rendering the harvested area unsuitable for northern spotted owl nesting, roosting, foraging, or dispersal for the life of the 50-year ITP. However, based on FGS's MSP analysis and as stated on page 2-18 of the Final EIS, the HCP is expected to result in an increase in what the Service considers foraging habitat (i.e., CWHR habitat categories 4M and 4D) over time and a decrease in clearcutting and other even-aged management practices (see section 4.1.3.2).

Commercial Thin

Commercial thinning is the removal of trees in a forest stand to maintain or increase the average diameter of the remaining trees, promote timber growth, and/or improve forest health. Commercial thinning is used as a tool to extend the "life" of some stands before using a regeneration harvest to better balance age class distributions across the forest. Commercial thinning is used to improve stand health and growth in relatively healthy, well-stocked stands of trees large enough to be harvested for lumber (> 10 inches dbh) that exceed target stocking requirements. Commercial thinning is typically conducted in northern spotted foraging or dispersal habitat. Commercial thinning reduces current canopy closure and has the potential to reduce tree height diversity when used within an uneven-aged stand of trees. Removal of forest cover increases solar radiation at the surface and in the understory, elevating daytime air temperatures (Heithecker and Halpern 2006). Rambo and North (2009) found that understory thinning units had significantly more extreme summer daily ranges of temperature and vapor pressure deficit than untreated control units. After thinning, northern spotted owls may avoid the area and move to adjacent suitable habitat areas (Forsman et al. 1984). Northern spotted owls prefer to roost in older forests due to their thermoregulatory properties, and early to middle stage forests have been shown to be used less than expected based on their availability, even in areas where old forest is scarce (Carey et al. 1990). Owls flew long distances to reach older stands, even bypassing younger and mature forests (Carey et al. 1990). Treated stands will likely be less favorable to northern spotted owls in the short-term (i.e., 30 to 50 years) for roosting due to a reduction in thermoregulatory properties, overstory canopy, and a reduction in understory perch trees that the owls use during hot summer days. Additionally, thinning treatments have the potential to damage residual trees, make residual trees more susceptible to windthrow, and allow increased wind speeds through the stand, which in turn could affect fire behavior. Therefore, while these stands will still maintain the characteristics of foraging and dispersal habitat, they may be less desirable to the northern spotted owl as a result of thinning activities.

Depending on the magnitude and severity, commercial thinning within northern spotted owl home ranges has the potential to cause site abandonment of resident owls or cause a reduction in owl fitness and recruitment. In a radiotelemetry study of northern spotted owls in hemlock/Douglas-fir forest in Oregon, timber harvest was the principal cause of site abandonment (Forsman et al. 1984), although it should be noted that sample size was small and the results were not based on an experimental design. In areas that experienced heavy thinning where canopy closure was reduced to less than 50 percent, northern spotted owls either completely disappeared or moved to adjacent unharvested old growth stands (Forsman et al. 1984).

The effects of commercial thinning on northern spotted owl in the more diverse Klamath forest types where the Action Area is located are less conclusive. The limited available literature from the Coast, West Cascades and Klamath Physiographic Provinces in Oregon appears to support the concept that spotted owl habitat can be thinned, to some degree (i.e., lightly), and retain its biological function post-treatment. Solis (1983), using radio-telemetry, found that northern spotted owl pairs infrequently used recently thinned pole/medium stands that retained 70 percent canopy closure post-thinning. Irwin et al. (1989) reported that many private forest managers in northern California observed owl pairs nesting successfully following partial harvest that retained relatively continuous forest canopies and important structures believed to influence owls and/or their prey. Kerns (1989) monitored three spotted owls during the breeding season and found that one of the owls used a thinned, relatively more open stand. King (1993) found that spotted owls used sites within selectively harvested (uneven-aged management) forests that retained higher canopy cover in the Yakama Indian Reservation. Hicks et al. (1999) documented through telemetry work on 14 northern spotted owls that the owls occasionally roosted in stands that had recently been managed, either through selective harvest or pre-commercial thinning. In both cases the owls were found in the managed stand within six months after ground operations. Irwin et al. (2005) evaluated spotted owl fidelity to home ranges following thinning and partial harvest treatments in young stands that retained at least 60 percent canopy. The authors found that no spotted owls vacated their home ranges after treatments were applied, and spotted owl use of stands pre- and post-treatment remained similar. Meiman et al. (2003) tracked the response of a single male spotted owl following relatively heavy commercial thinning in young (second-growth, 70-80 years old) Douglas-fir stands in the Oregon Coast Range. The authors recorded 13 percent of the male's locations in the thinned area prior to harvest and 3.8 percent of the locations in the thinned area following harvest. Use of the thinned stand was statistically significantly greater before than after harvest.

Thinning reduces the number of snags, downed woody material, shrubs, forbs, grasses, and fungi which provide key components of foraging and denning for northern spotted owl prey species. Shrub, down wood, and snags provide important cover from predators, so loss of these habitat elements may negatively affect some small mammals (Chambers 2002). Although small mammals seem to recolonize disturbed areas soon after disturbance, diversity and species dominance differ as succession progresses. Small mammals that prefer high canopy closure and/or woody debris may be adversely affected by thinning. Additionally, thinning has short-term negative effects on understory plants (mechanical destruction) and below-ground fungi (death of host trees and mechanical destruction) (Courtney et al. 2004). Loss of these habitat components can lead to decreased prey availability and less favorable habitat conditions (i.e., reduced snags, tree height diversity, less thermoregulatory buffering properties) resulting in possible avoidance of use by northern spotted owls and a reduction of overall fitness. Logging methods that minimize ground disturbing activities could minimize detrimental impacts to prey habitat and food resources. Variable-density thinning, as opposed to conventional thinning prescriptions holds promise for acceleration of the development of spotted owl habitat and dense prey populations (Carey 1995, 2001) especially when appropriate attention is paid to decadence (snags, cavity trees, and coarse woody debris) (Bunnell et al. 1999; Carey et al. 2002).

<u>Biomass Thin</u>

This intermediate treatment is used to thin younger, overstocked, submerchantable-sized stands to improve stand health and growth. It is predominantly used in young ponderosa pine stands and in mixed conifer stands with a heavy pine component. Although some saw logs are harvested, the main product is hog fuel (an unprocessed mix of barks and wood fiber) or paper chips from trees ranging from 4 to 10 inches dbh. Biomass thinning has been periodically used in the Grass Lake Management Unit to improve stand condition. It is also a valuable tool to reduce wildfire potential.

Biomass thinning would typically occur in northern spotted owl dispersal habitat or unsuitable habitat due to the age of the stands being thinned. Biomass stands are typically overstocked and are difficult for owls to forage or disperse through. Thinning these stands would generally improve the dispersal capability of northern spotted owls within the stands and potentially provide improved foraging capability. Although some saw logs may be removed, biomass thinning will generally improve current habitat conditions and allow the faster development of foraging and nesting/roosting habitat into the future.

<u>Seedtree</u>

The seed tree regeneration method involves the removal of a stand in one harvest except for well distributed seed trees of desired species which are left singly or in groups to restock the harvested area. The CFPRs require that retention trees are at least 18 inches dbh and that 15 ft^2/ac on site I, II and III (see Table 11; Site Classification) lands and 12 ft^2/ac on site IV and V lands per acre must be retained. The seed step is utilized to promote natural reproduction from seed and to initiate the establishment of an even-aged stand. The removal step may be utilized to remove the seed trees after a fully stocked stand of reproduction has become established.

Table 11. CFPR Site Classification (CALFIRE 2010)

	Ponderosa Pine, Jeffrey Pine, Mixed Conifer and True Fir[1]	
Site Class	**Site Index**[2] feet@100 years	**Site Index**[3] feet@300 years
I	≥114	≥163
II	93-113	138-162
III	75-92	113-137
IV	60-74	88-112
V	<60	<88

[1] Dunning 1942. Site index based on average tree height of dominant trees at age 100 and 300 years.
[2] Average total height in feet of dominant trees at 100 years of age.
[3] Average total height in feet of dominant trees at 300 years of age.

Seed tree regeneration harvest will typically occur in northern spotted owl nesting/roosting or foraging habitat. The initial harvest (seed step) will eliminate key components of northern spotted owl suitable habitat. Canopy closure and tree height diversity will be substantially reduced by the removal of the majority of trees within the stand. The removal of trees would likely include the removal of nest or potential nest trees that have various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence) as these trees are less desirable to provide a viable seed source to restock the stand. Additionally, snags may be reduced and downed woody material would be reduced to prepare the stand for natural seeding. The reduction in these key components of northern spotted owl suitable habitat would render the harvested area unsuitable for northern spotted owl nesting/roosting, foraging, or dispersal as the remaining seed trees would be incapable of providing sufficient canopy closure needed by the northern spotted owl. The retention of seed trees throughout the stand could potentially provide nest trees in the future if not harvested through the removal step; however, these trees will remain unusable until the surrounding stand provides key components of nesting/roosting or foraging habitat.

Shelterwood Removal (Even-aged)

The shelterwood regeneration method reproduces a stand via a series of harvests (preparatory, seed, and removal). The preparatory step is utilized to improve the crown development, seed production capacity and wind firmness of designated seed trees. The seed step is utilized to promote natural reproduction from seed. The removal step is utilized when a fully stocked stand of reproduction has become established, and this step includes the removal of the protective overstory trees. The shelterwood regeneration method is normally utilized when some shade canopy is considered desirable for the establishment of regeneration.

In the shelterwood preparatory step, the CFPRs require that seed trees that are at least 18 inches dbh must be retained at a minimum of 30 ft^2/ac on site I, II, and III lands and 24 ft^2/ac on site IV and V lands. Overall, at least 125 ft^2/ac on site I lands, 75 ft^2/ac on site II and III lands, and 50 ft^2/ac on site IV and V lands must be retained. In the shelterwood seed step, the CFPRs require that seed trees that are at least 18 inches dbh must be retained at a minimum of 30 ft^2/ac on site I, II, and III lands and 24 ft^2/ac on site IV and V lands. Once the minimum stocking requirements have been met, as required by the CFPRs, then the shelterwood removal step may be utilized.

Shelterwood regeneration harvest will typically occur in northern spotted owl nesting/roosting or foraging habitat. The initial harvest (preparatory step) will eliminate key components of northern spotted owl suitable habitat, although not to the extent of a seed tree regeneration harvest, since additional basal area must be maintained within the stand. Canopy closure and tree height diversity will be reduced by the removal of overstory and mid-story trees within the stand. The removal of trees would likely include the removal of nest or potential nest trees that have various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence) as these trees are less desirable to provide a viable seed source to restock the stand. Trees in the understory that provide perching opportunities for northern spotted owls and snags and downed woody material that provide shelter for northern spotted owl prey species would also be reduced. Based on the CFPRs retention standards, site I, II and III lands would likely maintain some characteristics of northern spotted owl foraging and/or dispersal habitat. Site IV lands would likely be reduced to northern spotted owl dispersal habitat. Once the shelterwood seed step was implemented, only the remaining overstory seed trees would be maintained. The remaining seed trees would be incapable of providing sufficient canopy closure needed by the northern spotted owl, thus rendering the harvested area unsuitable for northern spotted owl foraging or dispersal. The retention of seed trees throughout the stand could potentially provide nest trees in the future if not harvested through the removal step; however, these trees will remain unusable until the surrounding stand provides key components of nesting/roosting or foraging habitat.

Selection/Group Selection (Uneven-aged)

This silvicultural method is used in heavily stocked, relatively healthy stands that have an uneven-aged structure. Merchantable trees are harvested from all size classes present. The intent is to maintain an uneven-aged structure, maintain stand health, and generate a harvest return. Harvest entries occur every 10 to 20 years. Selection harvest has also been applied to other stands throughout FGS ownership on the Hilt/Siskiyou forest, including those in watercourse protection zones and on potentially unstable slopes, including inner gorges and shallow, unstable soils.

Under the selection regeneration method, the trees are removed individually or in small groups sized from 0.25 acres to 2.5 acres. The CFPRs state that stocking should not be reduced below the following standards post-harvest: on site I lands at least 100 ft^2/ac shall be retained, on site II and III lands at least 75 ft^2/ac shall be retained, and on site IV and V lands at least 50 ft^2/ac of basal area shall be retained.

Selection harvest will typically occur in northern spotted owl nesting/roosting and foraging habitat. Selection harvest, whether individual or group selection, will reduce overall canopy closure but maintain a level of tree height diversity throughout the stand. Additionally, snags and downed woody material will be reduced. Overall, current nesting/roosting habitat for the northern spotted owl would be reduced to foraging or dispersal habitat and current foraging habitat would either be maintained at foraging or reduced to dispersal habitat, depending on site class and amount of timber removed.

Alternative Prescriptions

A number of alternative prescriptions are commonly used by FGS in its silvicultural management. All alternative prescriptions are analyzed and approved during the THP review process. In most cases where alternative prescriptions are employed, past management and timber harvest have created an irregular condition in stand structure and/or stocking. Standard silvicultural prescriptions as specified in the rules are difficult to apply in these irregular stands. FGS's management scheme is to maintain stand health and generate a periodic and economical harvest in these stands through the use of alternative prescriptions over the first one to four years, gradually building up inventory to a point when standard silvicultural prescriptions can be applied. These alternative prescriptions include, but are not limited to:

- Seedtree/shelterwood removal (uneven-aged)
- Modified selection
- Combination shelterwood removal/biomass thin

- Modified commercial thin
- Combination shelterwood removal/commercial thin

Alternative prescriptions are likely to degrade, downgrade, or remove northern spotted owl habitat within stands being treated. Without a definitive THP, it is difficult to determine actual effects, but effects would be a composite of the silvicultural treatments discussed previously.

Salvage Logging

Dead, dying, and downed trees are periodically salvaged. Salvage is primarily related to road maintenance, fire damage, insect damage, or storm damage. Generally the economics and logistics involved in the potential harvest determine the feasibility of salvage operations. Salvage operations are feasible when damaged or weakened trees occur adjacent to ongoing logging operations, or are in heavy enough concentrations over a large enough area to justify sending in a salvage logger. It is typically not feasible to harvest individual occurrences of one or two trees, or trees that have been dead for more than two years. Salvage operations typically occur in isolated locations throughout the Plan Area, and consist of harvesting dead and dying conifers as individuals or in small groups.

Patches of dead, dying and downed trees typically provide high quality foraging habitat for northern spotted owls, especially when these patches are interspersed within larger areas of suitable nesting/roosting and foraging habitat. The abundance of standing snags and downed logs provide quality habitat for northern spotted owl prey species and northern spotted owls typically have high foraging success within and adjacent to these patches. In vast expanses of tree mortality, northern spotted owls may avoid foraging in the center of these areas if canopy closure is absent and the potential for predation is high. Additionally, standing dead and dying trees provide nest sites for northern spotted owls. In summary, the removal of dead, dying and downed trees may remove northern spotted nest sites or potential nest sites, foraging habitat, and prey habitat and subsequently have adverse effects to northern spotted owls.

Road Construction and Maintenance

Implementation of the HCP is expected to result in less than one mile of new road construction per year and will mainly serve as temporary spurs to access isolated patches of timber. Construction of new roads in connection with timber management, including clearing vegetation from road rights-of-way, removing trees, grubbing (removing stumps and surface organics), grading, and compaction will remove suitable northern spotted owl habitat if present. In addition, new road construction will remove habitat for northern spotted owl prey species.

Maintenance of existing roads typically will not affect northern spotted owl habitat unless snags or hazard trees that provide nesting opportunities for the owl are removed for safety concerns. Removal of snags, hazard trees, or removal of brush along existing roads will likely have some negative impact on northern spotted owl prey species, which in turn may indirectly affect northern spotted owl foraging success.

Closure of roads, temporary (abandoned) or permanently (decommissioned), will have a net positive effect on northern spotted owl as noise disturbance from vehicle traffic will be eliminated and vegetation will be allowed to reestablish and grow. Decommission of seasonal roads under the HCP is estimated to be approximately one mile per year. Over half of FGS's permanent roads (not coop) are subject to seasonal closure and many are opened only during operations (approximately 500 miles are gated, 250 miles of which are gated year-round).

Stand Regeneration and Improvement

Timber stand regeneration and improvement includes activities necessary to establish, grow, and achieve the desired species composition, spacing, and rate of growth of forest stands on the ownership. Activities may include site preparation, prescribed burning, slash treatment, tree planting, vegetation management, and silvicultural thinning (includes biomass, pre-commercial thinning, and commercial thinning). Silvicultural thinning was described previously and will not be discussed here. Site preparation, prescribed burning, slash treatment, tree planting, and vegetation management will have no effect on existing suitable northern spotted owl habitat. However, these activities are likely to negatively affect northern spotted owl prey species, which in turn may indirectly affect northern spotted owl foraging success along the edges of the stand. A LOP for noise and smoke disturbance will be implemented around known northern spotted owl nest sites to reduce disturbance during the critical nesting period.

Minor Forest Product Harvest

Minor forest products include, but are not limited to, Christmas trees and bows, mistletoe, firewood, fence posts, poles, yew bark, stumps, root wads, and mushrooms. These are all very minor components of FGS's Covered Activities and are not considered a major contribution to habitat loss for the northern spotted owl; however, firewood cutting has the potential to reduce prey habitat by removing snags or downed wood on a local scale.

Fire Prevention and Suppression

Wildfire prevention involves vegetation management and the construction of fuel breaks strategically located throughout the Plan Area. These activities are designed and implemented by the area forester on a local basis, and are therefore generally limited in scale. The prescription typically includes thinning for shaded fuel breaks along property lines or between watersheds where FGS deems it beneficial.

Fuel break construction typically involves the retention of overstory trees and the removal of understory trees and shrubs, snags, and downed woody material. As a result, overstory canopy typically remains the same or may be slightly reduced; vertical structure, shrubs, and downed wood are reduced; and snags are eliminated. Typically this type of vegetation management will degrade or downgrade suitable northern spotted owl habitat and reduce the amount of suitable habitat available to prey species. In areas of non-suitable northern spotted owl habitat, habitat manipulation that reduces brush and downed woody material may have a negative effect on the local prey population, thereby reducing northern spotted owl foraging success along edges of suitable habitat.

Wildfire suppression is typically under the authority of local, State, or Federal agencies. In cases of escaped prescribed burns where local, State, or Federal agencies are not involved, or for initial responses until responsible agencies have arrived, FGS employs emergency fire suppression activities, such as construction of fuel breaks by hand or bulldozer, lighting backfires, applying aerial fire suppressants, falling trees or snags, and water drafting for fire suppression.

Construction of fuel breaks or the falling of trees or snags during emergency fire suppression can have substantial effects to suitable northern spotted owl habitat. Hand lines are created by crews using hand tools. The focus of hand crews is to create a line at the ground level. The vegetation is either scraped or cut away with hand tools, such as shovels and chainsaws, to create a bare ground strip to prevent ground fire from spreading. Ladder fuels that are close to the line may be cut away to prevent the fire from jumping into the higher canopy. Dozer lines vary in width and can be anywhere from eight to 20 feet. Dozer lines require the total removal of all vegetation including the overstory. Lighting backfires can have a substantial effect on existing northern spotted owl habitat by burning up habitat components (e.g., understory trees, snags, downed wood) and killing larger trees.

Activities that remove large trees, snags, shrubs, and downed wood, such as fireline construction, felling of snags and trees, and lighting backfires, can affect habitat by directly removing or damaging nesting and/or roosting and perching trees, and affect prey composition and/or availability by altering characteristics of the habitat upon which prey species depend. The effects of removing standing dead and down material on northern spotted owl prey species is described above. It may also be possible for prey species to be adversely affected by incidental loss of hardwoods, hazard trees, or snags during burning, felling, or fireline construction.

Applying aerial fire suppressants is unlikely to affect suitable northern spotted owl habitat, but could potentially kill a northern spotted owl if directly hit by the suppressant. This is discussed in the direct mortality section above.

Other Activities

Other activities that may occur on FGS lands include those activities that are consistent with the zoning of FGS's lands as a Timber Production Zone. These activities may include watershed management, fish and wildlife habitat improvement, use of roads, landings, and log decks. These activities are not anticipated to affect suitable northern spotted owl habitat.

Rock quarrying activities would be covered under the HCP. Fruit Growers Supply Company quarries rocks from a number of locations on its ownership for the purpose of obtaining material for road surfacing. FGS has four primary rock quarries on the ownership that are each less than two acres in size. These existing rock quarries will not affect suitable northern spotted owl habitat and will be subject to a LOP to minimize noise disturbance during the breeding season if within 0.25-mile of an active nest site. Typically, up to five or more local rock sources commonly referred to as "borrow pits," are developed as needed for road upgrades associated with THPs. Each local rock source is rarely larger than 0.5 acres in size and is most often located in the upper portions of watersheds away from Class 1 streams. There is the possibility that these borrow pits may remove northern spotted owl habitat; however, it is anticipated that borrow pits will be located in areas with minimal vegetation.

Landscape Level Effects

Any individual or suite of site-specific effects discussed above could change the habitat function that a forested stand provides for owls. For the purpose of the following discussion, the degree of change to habitat function has been categorized using the following terms: removal, downgrade, and degrade. The term *removal* represents a complete loss of habitat function following an effect (i.e., an area that functioned as nesting/roosting, foraging, or dispersal habitat for northern spotted owls before the effect, no longer provides any habitat function for northern spotted owls after the effect). *Downgrade*, a subset of the term *removal*, refers to a reduction in the function of habitat (i.e., an area that functions as nesting/roosting habitat before an effect, provides only foraging or dispersal habitat following the effect). This term could be used also to signify a change in function from foraging to dispersal as well. *Degrade*, to be distinguished from *downgrade*, indicates a reduction in habitat quality, but not habitat function following the effect (i.e., an area that functioned as foraging habitat prior to the effect, still provides such function after the effect, but perhaps is more limited due to a temporary reduction in prey base).

Landscape-level changes in habitat availability, distribution, and configuration have implications to individual northern spotted owl survival and productivity, as well as to northern spotted owl population dynamics. For example, removal or downgrading of habitat within home ranges, and especially close to the nest site, can be expected to have negative effects on northern spotted owls. Bart (1995) reported a linear reduction in northern spotted owl productivity and survivorship as the amount of suitable habitat within a northern spotted owl home range declined. In addition, many researchers have stressed the importance of habitat availability within a 0.5-mile radius core area around the nest site (Hunter et al. 1995, Bingham and Noon 1997, Meyer et al. 1998, Wagner and Anthony 1999, Franklin et al. 2000, Zabel et al. 2003). In northwestern California, Franklin et al. (2000) found that survivorship of adult owls was higher where greater amounts of older forest were present around the activity center, but also found increased reproductive success where the amount of edge between older and younger forest was relatively high. Based on analysis of radio-telemetry data, Bingham and Noon (1997) reported that a sample of northern spotted owls in northern California focused their activities in heavily-used core areas that ranged in size from about 167 to 454 ac, with a mean of about 409 ac. These core areas, which included 60 to 70 percent of the owl telemetry locations during the breeding season, typically comprised only 20 percent of the area of the wider home range, and survivability of the owls was affected by the amount of habitat available within these core areas. Meyer et al. (1998) evaluated habitat available within a 2-mile circle around the nest site and found habitat within the 0.5-mile radius, or core, was profoundly different from that in the remainder of the home range, suggesting that owls are most strongly affected by landscape characteristics within the 0.5-mile core. These studies suggest that habitat removal within core areas could have disproportionate effects to owls.

Landscape-level, large scale timber harvest that produces relatively open stands (less than 40 percent canopy closure) or patch clear-cuts can fragment forest stands, creating more forest edge, and reducing the area of interior old forest habitat (Lehmkuhl et al. 1991). Habitat fragmentation has the potential to isolate individual owls or populations of owls by increasing distances between suitable habitat patches and reducing habitat connectivity. Such isolation decreases the likelihood of successful dispersal of juvenile owls (Miller 1989), which in turn could reduce opportunities for genetic exchange between owl populations (Barrowclough and Coats 1985).

Currently there is little empirical data confirming that habitat fragmentation contributes to increased levels of predation on northern spotted owls. However, great horned owls, an effective predator on northern spotted owls, are known to be closely associated with fragmented forest habitats (Johnson 1992). As mature forests are harvested, it is possible that great horned owls could colonize the fragmented forest and possibly increase northern spotted owl vulnerability to predation events.

Recent studies indicate that barred owls are capable of utilizing a broader range of habitat types than northern spotted owls (Hamer 1988, Kelly et al. 2003). Thus, activities that modify suitable northern spotted owl habitat could benefit barred owls. Barred owls may be negatively affecting northern spotted owls through competition for resources, direct harm through aggressive behavior, and hybridization, and may also directly attack northern spotted owls. However, it is unclear whether forest management has an effect on the outcome of interactions between barred owls and the northern spotted owl (Gutiérrez et al. 2004).

Many recent silvicultural projects focus on managing fire behavior and severity to avoid loss of timber stands to high severity fire; however, some silvicultural activities have been shown to negatively affect fire behavior and severity. Odion et al. (2004) tested for modern human effects on the fire regime and severity and found that multi-aged, closed forests burned with much lower severity than open forest and shrubby non-forest vegetation. In addition, tree plantations experienced twice as much severe fire as multi-aged forests (Odion et al. 2004). Odion et al. (2004) hypothesize that coupled with a warming climate, tree plantations that now occur on one-third of the roaded landscape within their study area in the Klamath-Siskiyou region of northern California and southwestern Oregon may increase the size and severity of future fires. On the Shasta-Trinity National Forest, evidence of increasing fire severity in plantations and adjacent stands was noted after the 2008 fires (USDI FWS 2009). Although the risk of high severity fire is expected to decrease due to the reduction in clearcutting and other even-aged management practices under the FGS HCP, tree plantations will be created and continue to pose a potential fire threat.

Landscape level changes in habitat availability, distribution, and configuration have implications to individual northern spotted owl survival and productivity as well as to northern spotted owl population dynamics. Northern spotted owls are known to disperse through many kinds of forested areas including over and around roads, clear-cuts, burned areas, and non-forested areas (Forsman et al. 2002). Dispersing juveniles have been observed using a wide variety of conifer forests ranging from harvested areas to open sapling stands to mature and old-growth stands (Miller et al. 1997). Implementation of the FGS HCP has the potential to improve the dispersal ability of northern spotted owls within the Action Area with the reduction in clearcutting, seed tree and shelterwood harvesting, and other even-aged management practices across FGS's ownership. However, dispersal patterns may be disrupted by the fragmented landscape that is typical of heavily managed forests.

Plantation establishment, as a result of clearcutting, seed tree harvest, and shelterwood harvest within the Plan Area has the potential to affect northern spotted owls by changing and/or increasing fire severity within the area and surrounding areas, potentially leading to further habitat loss and disturbance in the Action Area and on adjacent Federal, private and State lands. Tree plantations have been found to experience twice as much severe fire as multi-aged forests, and multi-aged closed forests burn with much lower severity than open forest and shrubby non-forest vegetation (Odion et al. 2004). When viewing areas within the Shasta-Trinity National Forest after the 2008 fires, it was evident in the areas visited that even-aged stands and stands adjacent to plantations also experienced higher fire severity than those that were not (USDI FWS 2009). Creation of new plantations within the fire-prone California Klamath Province is not recommended (SEI 2008). The creation of new plantations within the Plan Area could potentially change and/or increase fire severity within adjacent Federal lands, leading to habitat loss and disturbance in these areas that we assume are contributing to the conservation of the northern spotted owl. However, based on FGS's MSP analysis and as stated on page 2-18 of the Final EIS, the HCP is expected to result in an increase in what the Service considers foraging habitat (i.e., CWHR habitat categories 4M and 4D) over time and a decrease in clearcutting and other even-aged management practices. Additionally, thinning and maintenance of existing plantations within the Plan Area would help balance the effects on fire severity. The fire tolerance of existing plantations can be increased by actively manipulating species composition, reducing density, promoting spatial heterogeneity in forest structure (avoiding large areas of homogeneously fire-prone plantations), treating surface fuels, and favoring the development of large, fire tolerant trees (SEI 2008).

4.1.3 Description of Effects to Northern Spotted Owls in the Action Area

4.1.3.1 Northern Spotted Owl Activity Centers in the Action Area

The population within the Action Area includes all northern spotted owls that could be directly or indirectly affected by FGS's operations. It encompasses the known northern spotted owl activity centers within 1.3 miles of FGS ownership, which is the average radius of northern spotted owl home ranges within the California Klamath and California Cascades Provinces (USDI FWS 1992b). Eighty-two historic activity centers supporting a total of up to 158 individual northern spotted owls were estimated to occur within the Action Area during development of the HCP. As described in section 3.2.2, northern spotted owls have been detected at these historic activity centers at some point since the owl was listed; however, in most cases the current status is unknown and many home ranges contain high amounts of low quality habitat due to repeated timber harvest entries and wildfire. Based on the distribution of the current population and habitat available, there is a very low probability of additional undetected activity centers within the Action Area.

The northern spotted owl population in the Action Area is divided by two ecological provinces: the California Klamath Province and the California Cascades Province. The effects analysis is conducted separately for these two provinces within the Action Area because they are distinct in terms of population demographics and trends, threats, and quantity and quality of northern spotted owl habitat.

California Klamath Province

Seventy-four of the 82 total activity centers in the Action Area are located in the California Klamath Province (see section 3.2.2). During HCP development, the Service identified 31 of these 74 activity centers where incidental take of owls is not likely. Implementation of Covered Activities within the home ranges of 11 of these activity centers is not expected to result in incidental take of owls because FGS has limited ownership in the core and/or home range (i.e., less than ten percent) and therefore has little potential to reduce the amount and distribution of habitat to the point that take will occur. For example, out of these 11 activity centers, FGS has suitable northern spotted owl habitat within only one activity center core (SK379). The core has 0.02 acres of suitable northern spotted owl nesting/roosting habitat on FGS's lands. It is not anticipated that removal or downgrading of this habitat would impact the ability of the core to support occupancy by northern spotted owls because of the negligible amount of habitat and since the core would still be within the range of habitat conditions described in the Service Take Avoidance Guidance (USDI FWS 2008c). All other suitable habitat within this core is managed by the USFS.

At the home range scale, FGS has suitable northern spotted owl habitat in nine of the 11 outer ring home ranges. Eight of these are currently within the range of habitat conditions described in the Service guidelines to support occupancy by owls (USDI FWS 2008c). Given current restrictions on timber harvest on other ownerships, if FGS harvested all suitable habitat within these eight outer ring home ranges, the outer ring home ranges would still retain adequate amounts of habitat to support northern spotted owl occupancy. It is unlikely that FGS' removal of habitat within the outer home ranges of these activity centers will result in take of spotted owls. Fruit Growers Supply Company's activities are not likely to impact the ability of the other activity center (SK537) to support occupancy by northern spotted owls because the activity center has a low likelihood of occupancy due to an inadequate amount of suitable habitat in both the core and outer ring home range. This activity center may be deemed abandoned with the appropriate level of protocol surveys determined by the Service.

Incidental take of owls is not expected to occur at an additional 20 activity centers within the California Klamath portion of the Action Area because adequate habitat within their home ranges will be retained as CSAs on FGS's ownership throughout the 50-year permit term to support occupancy. Fruit Growers Supply Company will adhere to habitat commitments for each CSA identified in Appendix D of the FGS HCP in addition to maintaining or creating general habitat conditions and features identified in the demographic support objective of the Terrestrial Species Conservation Program in section 5.3.1.1 of the FGS HCP. While FGS may be allowed to harvest suitable habitat within CSAs not specifically identified as part of their habitat commitments, FGS must first meet its habitat commitments and, in general, the activity centers must exceed the FGS HCP habitat standards, regardless of ownership. Any Covered Activities occurring in CSAs must be approved by the Service. These conservation measures will provide demographic support to northern spotted owls associated with these 20 activity centers located within 1.3 miles of the FGS ownership and whose home ranges overlap with CHUs in the Klamath portion of the Action Area. None of the actual activity centers occur on FGS lands; 22 occur on the KNF and two occur on other private lands.

The habitat targets that must be maintained in the CSAs under the FGS HCP have a higher threshold than those used to determine take of other northern spotted owl activity centers on private lands (i.e., CFPRs or the 2008 Service Take Avoidance Guidance – Interior Region, USDI FWS 2008c). The habitat commitments in the core remain the same as the 2008 Service Take Avoidance Guidance; 250 acres of nesting/roosting and 150 acres of foraging must be maintained in the 502-acre core. Additionally, all existing substrate for northern spotted owl nest structures (tree deformities, mistletoe brooms, tree cavities) will be maintained within the 502-acre core area where it does not create a hazard for public safety. Within the outer ring home range (2,894 acres), the minimum habitat that must be maintained is 350 acres of nesting/roosting habitat and 900 acres of foraging habitat, which provides greater retention of habitat than the 2008 Service Take Avoidance Guidance (USDI FWS 2008c).

Out of the 20 mitigation activity centers in the Klamath portion of the Action Area, habitat in the core of six and in the outer ring home range of 15 are currently above the HCP habitat targets. Table 12 shows both the cumulative current acres of habitat and amount of habitat FGS has committed to grow and/or maintain on its ownership within the 20 mitigation activity center cores and outer ring home ranges over the 50-year permit term. The habitat commitments would provide a cumulative decrease of 59 acres of nesting/roosting habitat and an increase of 396 acres of foraging habitat in the core areas, and a cumulative decrease of 1,134 acres of nesting/roosting habitat and an increase of 351 acres of foraging habitat in the outer ring home ranges compared to current levels on FGS ownership over the permit term. The reduction in nesting/roosting habitat is due to 1) harvest in the core of mitigation sites that currently or will (with ingrowth of habitat) exceed the HCP habitat targets specified in section 5.3.1.1 of the FGS HCP, and 2) harvest of small patches that do not function as nesting/roosting habitat due to their size and/or distance to the core. The exceptions to these reasons are the harvest of habitat in the outer ring home range of SK040, SK262b, and SK503 because of current conditions of vegetation (i.e., low potential to grow additional high-quality habitat) and planned timber projects as negotiated with the Service.

Table 12. Cumulative Current and Target Non-Overlapping Acres of Northern Spotted Owl Habitat on Fruit Growers Supply Company Ownership within the 20 Mitigation Sites in the Klamath Province portion of the Action Area.

	Current Habitat		**Target Habitat**	
Habitat	**502-acre Core**	**2,894-acre Outer Ring**	**502-acre Core**	**2,894-acre Outer Ring**
Foraging	481	3,484	877	3,835
Nesting/Roosting	119	1,183	60	49
Total	**600**	**4,667**	**937**	**3,884**

Currently, there are only six mitigation activity centers where both the core and outer ring home range are above threshold when nesting/roosting habitat is used as a surrogate for foraging. However, none of the activity centers meet the threshold according to the conditions identified in section 5.3.1.1 of the FGS HCP. To the degree that mitigation sites are currently below the HCP habitat targets, sufficient ingrowth of habitat will need to occur before FGS can harvest suitable habitat.

Harvest by FGS within the home ranges of mitigation sites will maintain sufficient amounts and distribution of habitat to support occupancy and reproduction of owls, as determined by the Service. Any Covered Activities occurring in CSAs must be approved by the Service and are reliant upon FGS conducting protocol level surveys and implementing a LOP within 0.25-mile of active northern spotted owl nest sites where operations would not be authorized during the breeding season to avoid disturbance to nesting owls and their young. Any Covered Activities that occur within the home ranges of the 31 activity centers where incidental take of owls is not likely, or newly identified activity centers within the California Klamath Province, must undergo a review and approval process by the Service prior to any Covered Activities being implemented. Approval would be based on a rigorous evaluation of the quantity and quality of existing habitat, field reviews, and other criteria to insure that sufficient amounts and distribution of habitat to support occupancy and reproduction by owls is maintained.

The northern spotted owl conservation strategy in the FGS HCP is based on the conservative assumption that habitat at 43 historic activity centers that are not designated as mitigation or 'no take' sites would be harvested to the extent that take of up to 83 individual owls would occur as a result of FGS implementing Covered Activities under the HCP. Generally, take would occur indirectly from the loss or degradation of habitat within northern spotted owl cores and home ranges.

As described in section 3.2.2, this estimate of the potential for incidental take represents a worst-case scenario because it assumes that each of the activity centers supports northern spotted owls at their highest historical reproductive status and that modification of habitat would lead to the incidental take of all individual northern spotted owls occupying those activity centers. However, not all activity centers may be currently occupied and some activity centers are not likely to be occupied at their highest historic reproductive status.

This conservative approach is appropriate for landscape-level analysis and development of the conservation strategy in the HCP. However, in determining the amount and impact of take under section 7 of the Act, the Service must use the best scientific information available to evaluate as closely as possible the likelihood of significant impairment of feeding, breeding and sheltering behavior (take) of spotted owls. Determination of the likelihood of take is based primarily on 1) the rate, intensity, and extent of habitat modification potentially influencing the species and 2) the probability of individuals being present where habitat-modifying activities occur. In particular, because the 43 'take' sites were established based on a wide range of historical survey records, the Service conducted an evaluation of the probability of occupancy at the 43 sites where harvest would likely occur. Because updated surveys have not been conducted at the 43 sites where take could potentially occur, the Service determined the likelihood of take based on the combination of: 1) existing survey records, 2) results of habitat modeling (Zabel et al. 2003), and 3) evaluation of the amount and distribution of suitable habitat.

1) Evaluation of survey results

The amount, quality, and vintage of survey records at some of the 43 historic activity centers were not adequate to support classification of all of the sites into 'occupied' and 'not occupied' status. Because some surveys did not fully conform with the recommended Service survey protocols for the spotted owl, negative results (i.e., survey was conducted and owls were not detected) did not always result in a determination of 'unoccupied'. However, since development of the HCP, additional survey information is available because FGS has continued to survey historic activity centers associated with THPs. In cases where spotted owls were recently detected (2007-2011) or there were no detections during the past five years of protocol surveys, this information was used to determine occupancy status for the purposes of the BO. Using this information, the Service classified eight activity centers as currently occupied and 12 activity centers as likely not occupied (Table 13). The remaining activity centers have varying potential for occupancy.

Table 13. Likelihood of Occupancy for the 43 'Take' Activity Centers in the California Klamath Province portion of the Action Area.

Code	Category	Criteria	Activity Center	# Sites
1	Currently occupied	Spotted owl(s) detected during 2007-2011 surveys	SK205, SK262, SK322, SK370, SK380, SK450, SK467, SK500	8
2	Likely occupied	Spotted owl(s) detected prior to 2007, recent surveys lacking	SK020, SK046, SK065, SK130, SK310, SK359, SK454, SK469, SK472, SK477	10
3	Potentially occupied	Spotted owl(s) not detected 2007-2011, survey effort not to protocol but substantial	SK239, SK309, SK334, SK336, SK360, SK363, SK364, SK369, SK387, SK388, SK389, SK474, SK533	13
4	Likely not occupied	Spotted owl(s) not detected during >3 years protocol surveys	SK318, SK321, SK333, SK335, SK358, SK361, SK365, SK368, SK391, SK473, SK475, SK534	12

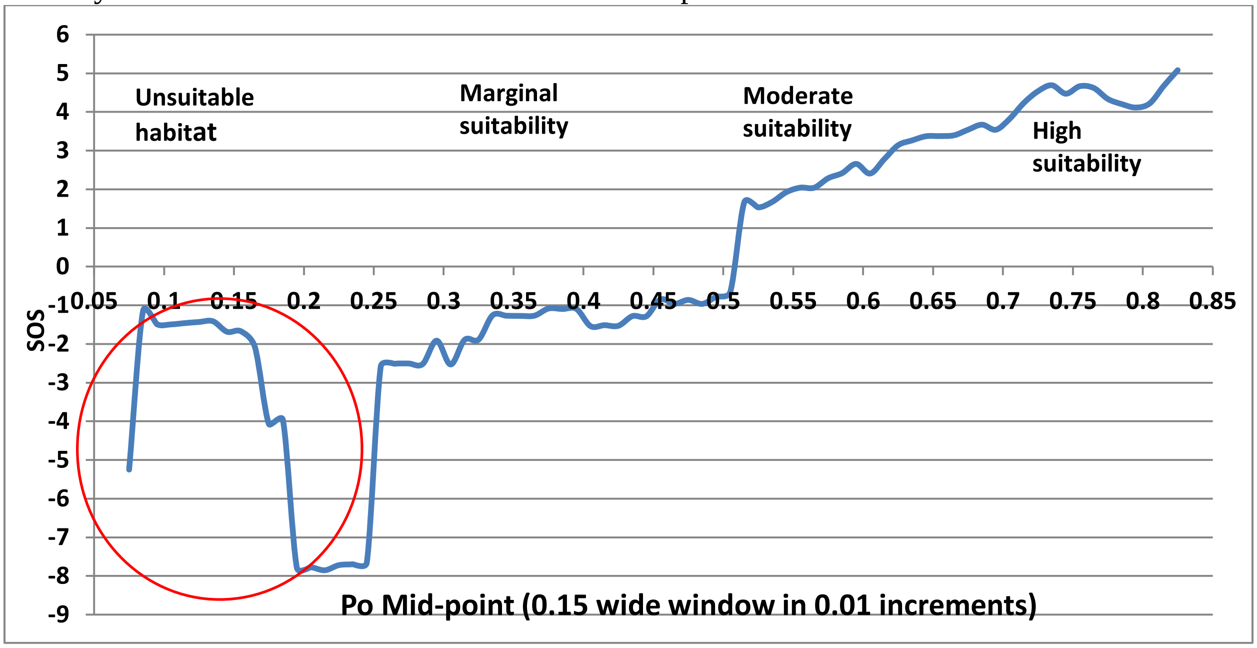
2) Relative habitat suitability modeling

Species distributional models are used to evaluate species-habitat relationships, evaluate an area's suitability for the species, and to predict a species' presence (Elith and Leathwick 2009). These models, also called environmental (or ecological) niche models, correlate environmental conditions with species distribution and thereby predict the relative suitability of habitat within some geographic area (Warren and Seifert 2011). In this context, we defined relative habitat suitability (RHS) as the relative similarity of environmental conditions (forest composition and structure) at spotted owl sites to the distribution of those conditions across the landscape. When translated into maps depicting the spatial distribution of predicted habitat suitability, these models have great utility for evaluating conservation reserve design and function (Zabel et al. 2003, Carroll and Johnson 2008, Carroll et al. 2010).

The spotted owl distribution model described by Zabel et al. (2003) was used in the development of the FGS HCP, and provided the Service with a useful method to evaluate the habitat quality at historic activity centers in the project's Action Area. As described in the Environmental Baseline section, the Zabel model predicts probability of occupancy based on habitat conditions within a 500-acre (0.5-mile radius) circular window. This spatial scale corresponds to 'core areas' that receive disproportionate use by nesting and foraging spotted owls in the Klamath region (Bingham and Noon 1997) and where differences between use and availability of habitat tend to be most pronounced (USDI FWS 2011b, Appendix C). This approach is appropriate for mapping broad-scale patterns of habitat suitability, but because spotted owls depend on a larger 'home range' area for resources, may not provide a reliable method for evaluating the quality of individual territories (Buchanan et al. 1998). To account for this, we analyzed the Zabel model results using a 'focal mean' method that incorporates a larger area (1-mile radius, or approximately 2,011 acres) into estimation of RHS at an activity center, while still emphasizing conditions within the core area. This larger area corresponds to the mean home range size (95% Fixed Kernel method) of spotted owls in the Klamath region (Irwin et al. 2007, Timber Products Company 2007).

The Service used a 'Strength of Selection' (SOS) approach to compare the distribution of RHS values at spotted owl territories to the overall landscape, and establish cutoff points for categories of habitat suitability (unsuitable, marginal suitability, moderate suitability, and high suitability). The observed use that areas with various RHS values receive (by nesting spotted owls in our case) were plotted relative to the abundance of such areas within the FGS HCP Action Area. For example, areas with a mid-point RHS less than 0.25 were used eight times less than expected based on their availability within the Action Area. Similarly, areas with RHS values greater than 0.75 were used about 4.5 times more than expected. Figure 6 shows the degree of selection by spotted owls for RHS values ranging from 0 to 100, and the four RHS categories used to inform our estimation of the likelihood of take. The portion of the curve circled in red exhibits an anomaly caused by the large proportion of the FGS Action Area occurring in the lowest RHS values and a very small sample of spotted owl records in low RHS value areas.

Figure 6. 'Strength of Selection' (SOS) and Relative Habitat Suitability for the 43 'Take' Activity Centers in the California Klamath Province portion of the Action Area.



To quantify habitat conditions and the subsequent likelihood of occupancy at each of the 43 historic spotted owl sites, we evaluated the distribution of RHS values in three categories (Table 14).

Table 14. Likelihood of Occupancy based on Relative Habitat Suitability (RHS) Values for the 43 'Take' Activity Centers in the California Klamath Province portion of the Action Area.

Code	Likelihood of Occupancy	Criteria	Activity Center	# Sites
1	High	Core and home range contain high proportions of moderate to high suitability habitat (RHS > 60%)	SK020, SK046, SK130, SK205, SK239, SK262, SK322, SK335, SK360, SK361, SK364, SK380, SK389, SK391, SK450, SK469, SK472	17
2	Moderate	Core and home range contain intermediate proportions of moderate to high suitability habitat (RHS = 51% to 60%)	SK065, SK310, SK318, SK336, SK359, SK363, SK365, SK368, SK370, SK387, SK477, SK500, SK534	13
3	Low	Core and home range contain high proportions of marginal and unsuitable habitat (RHS < 51%)	SK309, SK321, SK333, SK334, SK358, SK369, SK388, SK454, SK467, SK473, SK474, SK475, SK533	13

Evaluation of RHS at spotted owl core areas and home ranges provided a useful method for describing the likelihood of occupancy by spotted owls at the 43 historic sites. However, in a number of cases the model outputs were unreliable due to changes in habitat condition (e.g., fires, timber harvest) that occurred after the model's underlying vegetation layer was developed or other inconsistencies in the habitat typing used in the modeling. To ensure that our determinations were based on the best site-specific information available, we verified the model results at each site by assessing the amount and distribution of habitat by comparing with 2009 digital orthophoto quadrangles (DOQs; see below).

3) Amount and distribution of suitable habitat

To provide a more site-specific evaluation of the likelihood of take, we augmented the habitat modeling results with a visual assessment of the amount and distribution of spotted owl habitat within the core areas and home ranges of the 43 historic activity centers. We used DOQs and maps generated from the 2005 northern spotted owl baseline habitat layer to estimate 1) the overall amount of nesting/roosting and foraging habitat and 2) the proportion of suitable habitat occurring on lands managed by FGS (and therefore likely to be harvested under the HCP) versus habitat on adjacent USFS land.

Table 8 (section 3.2.2) shows amount and distribution of suitable spotted owl habitat by ownership at each activity center within the Klamath Province portion of the Action Area. Compared to the Service Take Avoidance Guidance thresholds of 400 acres of suitable habitat (250 acres nesting/roosting and 150 acres foraging habitat) in the 502-acre core and 935 acres suitable habitat in the 2,894-acre outer ring of the home range (USDI FWS 2008c), out of the 43 'take' activity center cores, three are currently above the habitat thresholds and the remaining 40 activity centers are currently below. Of the 40 activity centers that are below, three are above threshold in total amount of suitable habitat, but are deficit in the amount of nesting/roosting habitat. Out of the 43 'take' activity center outer ring home ranges, 28 are currently above threshold and the remaining 15 activity centers are currently below threshold. Only three activity centers (SK239, SK380, and SK469) currently have both the core and home range above threshold. Table 15 shows the results of the Service's evaluation of the likelihood of occupancy at the 43 'take' activity centers based on amounts of nesting/roosting and foraging habitat within the core and home range.

Table 15. Likelihood of Occupancy based on Amounts of Nesting/Roosting and Foraging Habitat within the Core and Home Range of the 43 'Take' Activity Centers in the California Klamath Province portion of the Action Area.

Code	Likelihood of Occupancy	Criteria	Activity Center	# Sites
1	High	Core and home range contain adequate amounts of nesting/roosting and foraging habitat	SK239, SK380, SK469	3
2	Moderate	Core or home range is deficient in nesting/roosting or foraging habitat	SK046, SK065, SK130, SK205, SK262, SK321, SK322, SK333, SK334, SK335, SK336, SK358, SK359, SK360, SK361, SK364, SK365, SK368, SK370, SK388, SK391, SK450, SK472, SK477, SK500	25
3	Low	Core and home range contain insufficient amounts of nesting/roosting and foraging habitat	SK020, SK309, SK310, SK318, SK363, SK369, SK387, SK389, SK454, SK467, SK473, SK474, SK475, SK533, SK534	15

This evaluation focuses on quantification of the amounts of nesting/roosting habitat and foraging habitat at both the core area and home range scales, but also the distribution, patch size and other features that influence the suitability of an area for spotted owls. Because forest habitats in the vicinity of many of the historic spotted owl sites have been modified by wildfires and repeated harvest entries, current vegetation databases and habitat classification maps required verification by visual examination of DOQs. In a number of cases, the quantity and quality of habitat observed on DOQs differed substantially from amounts described in step 2 above. In these cases the likelihood of occupancy was revised to reflect current conditions.

4) Evaluation of extent of impacts to spotted owl territories

The Service evaluated the potential for FGS's Covered Activities to result in take based on the proportion of existing suitable habitat located on FGS's ownership within the core and home range of the 43 'take' activity centers. The Service used the habitat amounts in the core and outer ring of the home range from Table 7 (section 3.2.2) to calculate the proportion of suitable habitat on FGS's ownership. Table 16 shows the potential impact of FGS's activities on the currently suitable habitat for each 'take' site. Fruit Grower's activities have a low likelihood of taking spotted owls, if present, at 15 sites where FGS has a "low" potential for impact. However, in a number of cases the results are unreliable due to changes in habitat condition (e.g., fires, timber harvest) that occurred after the vegetation layer was developed or other inconsistencies in the habitat typing. As described in step 3 (above) in these cases the observed quantity and quality of habitat as observed on aerial photographs was used to revise the estimation of likelihood of take.

Table 16. Potential Impact on Suitable Habitat based on Proportion of FGS's Ownership in the Core and Outer Ring of the Home Range of the 43 'Take' Activity Centers in the California Klamath Province portion of the Action Area.

Code	Potential Impact	Criteria	Activity Center	# Sites
1	Low	FGS owns < 20% suitable habitat in core and/or home range	SK020, SK310, SK318, SK359, SK365, SK387, SK388, SK389, SK391, SK454, SK469, SK474, SK477, SK500, SK533	15
2	Moderate	FGS owns 20% to 40% suitable habitat in core and/or home range	SK065, SK130, SK205, SK239, SK309, SK321, SK334, SK335, SK368, SK472, SK473, SK534	12
3	High	FGS owns > 40% suitable habitat in core and/or home range	SK046, SK262, SK322, SK333, SK336, SK358, SK360, SK361, SK363, SK364, SK369, SK370, SK380, SK450, SK467, SK475	16

Summary

In total, of the 74 activity centers within the Klamath portion of the Action Area, incidental take of owls is not likely to occur at 43 activity centers (Figure 7). Eleven activity centers are not likely to be occupied by spotted owls based on more recent protocol survey results and a rigorous evaluation of the amount and distribution of suitable habitat using 2009 digital orthophoto quadrangles (DOQs), habitat maps generated from the 2005 northern spotted owl baseline habitat layer (see 2009 FGS HCP, Appendix A), and a Relative Habitat Suitability (RHS) model (Zabel et al. 2003). Spotted owls have not been detected at these 11 activity centers during protocol surveys within the last five years, and/or the core and/or home ranges contain high proportions of marginal and unsuitable habitat (RHS < 51 percent) and amounts of nesting/roosting and foraging habitat the Service considers insufficient to support occupancy and reproduction (USDI FWS 2008c). Incidental take of owls is also not likely to occur at the 20 mitigation sites, at the 11 activity centers that have low overlap with FGS ownership, and the one activity center (SK310) where only three percent of the suitable habitat in its home range is on FGS's ownership.

Based on the evaluation of survey records, habitat suitability models, habitat mapping, and evaluation of potential impacts of FGS activities, the Service identified 31 activity centers where incidental take of owls resulting from FGS's operations could reasonably occur over the course of the 50-year permit term (Table 17). Suitable habitat with the home ranges of these 31 activity centers is scheduled to be harvested to the extent that incidental take of up to 61 individual owls could reasonably occur as a result of FGS implementing Covered Activities under the HCP. Generally, take would occur indirectly from the loss or degradation of habitat within northern spotted owl cores and home ranges. Eleven of these 31 activity centers occur on FGS lands, 17 occur on KNF, and three occur on other private lands.

Figure 7. Northern Spotted Owl Activity Centers within the California Klamath Province portion of the Action Area.

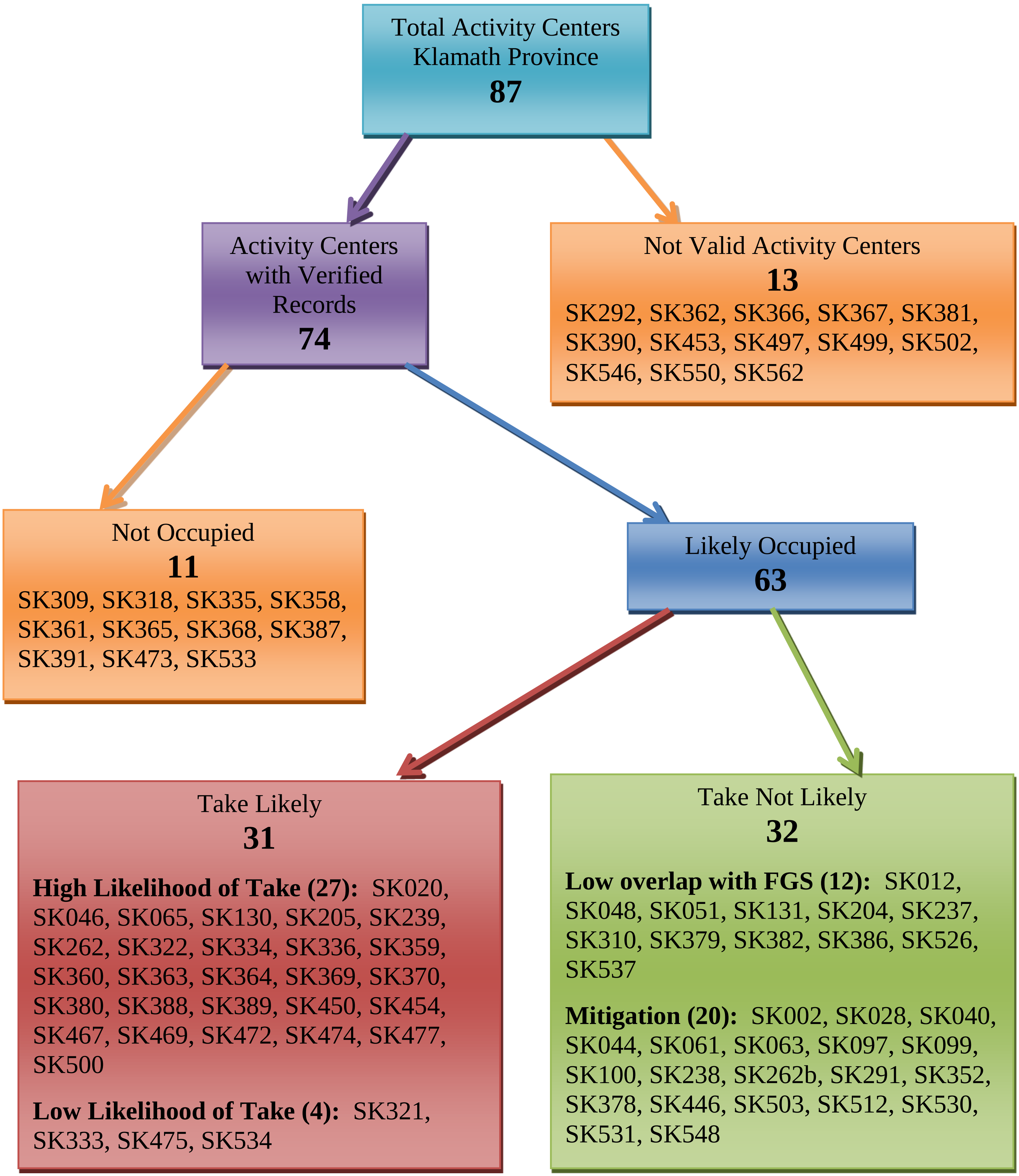


Table 17. Likelihood of Actual Take based on the Service's Evaluation for the 43 'Take' Activity Centers in the California Klamath Province Portion of the Action Area.

Code	Likelihood of Take	Criteria	Activity Center	# Sites
1	High	Detections within past 5 years, high Relative Habitat Suitability, high amounts of suitable habitat, and/or high potential impact of FGS's activities on existing suitable habitat.	SK130, SK239, SK262, SK322, SK370, SK380, SK450, SK467, SK469, SK500	10
2	Moderate/Low	Spotted owls(s) detected prior to 2007 and recent surveys lacking or inconclusive, moderate Relative Habitat Suitability, moderate amounts of suitable habitat, and/or moderate potential impact of FGS's activities on existing suitable habitat.	SK020, SK046, SK065, SK205, SK334, SK336, SK359, SK360, SK363, SK364, SK369, SK388, SK389, SK454, SK472, SK474, SK477	17
3	Very Low	Spotted owl(s) not detected during >3 years protocol surveys, low Relative Habitat Suitability, low amounts of suitable habitat, and/or low potential impact of FGS's activities on existing suitable habitat.	SK321, SK333, SK475, SK534	4
4	None	Spotted owl(s) not detected during >5 years protocol surveys, very low Relative Habitat Suitability, very low amounts of suitable habitat, and/or very low potential impact of FGS's activities on existing suitable habitat.	SK309, SK310, SK318, SK335, SK358, SK361, SK365, SK368, SK387, SK391, SK473, SK533	12

California Cascades Province

Eight of the activity centers in the Action Area are located in the California Cascades Province (see section 3.2.3). Incidental take of owls at these eight activity centers is not likely (Figure 8). Implementation of Covered Activities within the home ranges of four of these activity centers is not expected to result in incidental take of owls because FGS has limited ownership in the core and/or home range (i.e., less than ten percent) and therefore has little potential to reduce the amount and distribution of habitat to the point that take will occur. For example, FGS owns land that does not have any suitable northern spotted owl habitat available within either the core or outer ring home range of SK194 and SK442; therefore, incidental take due to FGS's activities will not occur. None of the four actual activity centers occur on FGS lands; three occur on the KNF and one occurs on other private lands.

Incidental take of owls will not occur at an additional four activity centers (SK153, SK284, SK428, SK462) within the California Cascades portion of the Action Area because habitat within their home ranges will be retained as CSAs on FGS's ownership throughout the 50-year permit term. Fruit Growers Supply Company will adhere to habitat commitments for each CSA identified in Appendix D of the FGS HCP in addition to maintaining or creating general habitat conditions and features identified in the demographic support objective of the Terrestrial Species Conservation Program in section 5.3.1.1 of the FGS HCP. While FGS will be allowed to harvest suitable habitat within CSAs not specifically identified as part of their habitat commitments, FGS must first meet its habitat commitments and, in general, the mitigation activity centers must exceed the FGS HCP habitat targets, regardless of ownership. As described below, any Covered Activities occurring in CSAs must be approved by the Service. These conservation measures will provide demographic support to northern spotted owls associated with these four activity centers located within 1.3 miles of the FGS ownership and whose home ranges overlap with CHUs in the Cascades portion of the Action Area. None of the actual activity centers occur on FGS lands; all occur on the KNF.

All four mitigation activity center cores and outer ring home ranges in the Cascades portion of the Action Area are currently below the HCP habitat targets. Table 18 shows both the cumulative current acres of habitat and amount of habitat FGS has committed to grow and/or maintain on its ownership within the four mitigation activity center cores and outer ring home ranges over the 50-year permit term. The habitat commitments would maintain the same amount of nesting/roosting habitat and provide a cumulative increase of 226 acres of foraging habitat in the core areas, and a cumulative decrease of 12 acres of nesting/roosting habitat and an increase of 883 acres of foraging habitat in the outer ring home ranges compared to current levels on FGS ownership over the permit term. The reduction in nesting/roosting habitat is due to 1) harvest in the outer ring home range of mitigation sites that currently or will (with ingrowth of habitat) exceed the HCP habitat targets specified in section 5.3.1.1 of the FGS HCP, and 2) harvest of small patches that do not function as nesting/roosting habitat due to their size and/or distance to the core. The exception to these reasons is the harvest of habitat in the outer ring home range of SK428 because of current conditions of vegetation (i.e., low potential to grow additional high-quality habitat) and planned timber projects as negotiated with the Service.

Table 18. Cumulative Current and Target Non-Overlapping Acres of Northern Spotted Owl Habitat on Fruit Growers Supply Company Ownership within the Four Mitigation Sites in the Cascades Province portion of the Action Area.

	Current Habitat		**Target Habitat**	
Habitat	**502-acre Core**	**2,894-acre Outer Ring**	**502-acre Core**	**2,894-acre Outer Ring**
Foraging	193	1,001	419	1,884
Nesting/Roosting	6	12	6	0
Total	**199**	**1,013**	**425**	**1,884**

Currently, none of the mitigation activity centers in the Cascades portion of the Action Area are above threshold in both the core and outer ring home range when nesting/roosting habitat is used as a surrogate for foraging. To the degree that mitigation sites are currently below the HCP habitat targets, sufficient ingrowth of habitat will need to occur before FGS can harvest suitable habitat.

Harvest by FGS within the home ranges of mitigation sites will maintain sufficient amounts and distribution of habitat to support occupancy and reproduction of owls, as determined by the Service. Any Covered Activities occurring in CSAs must be approved by the Service and are reliant upon FGS conducting protocol level surveys within 1.3 miles of the treatment units and implementing a LOP within 0.25-mile of active northern spotted owl nest sites where operations would not be authorized during the breeding season to avoid disturbance to nesting owls and their young. Any Covered Activities that occur within the home ranges of the eight activity centers where incidental take of owls is not likely, or newly identified activity centers within the California Cascades Province, must undergo a review and approval process by the Service prior to any Covered Activities being implemented. Approval would be based on a rigorous evaluation of the quantity and quality of existing habitat, field reviews, and other criteria to insure that sufficient amounts and distribution of habitat to support occupancy and reproduction by owls is maintained.

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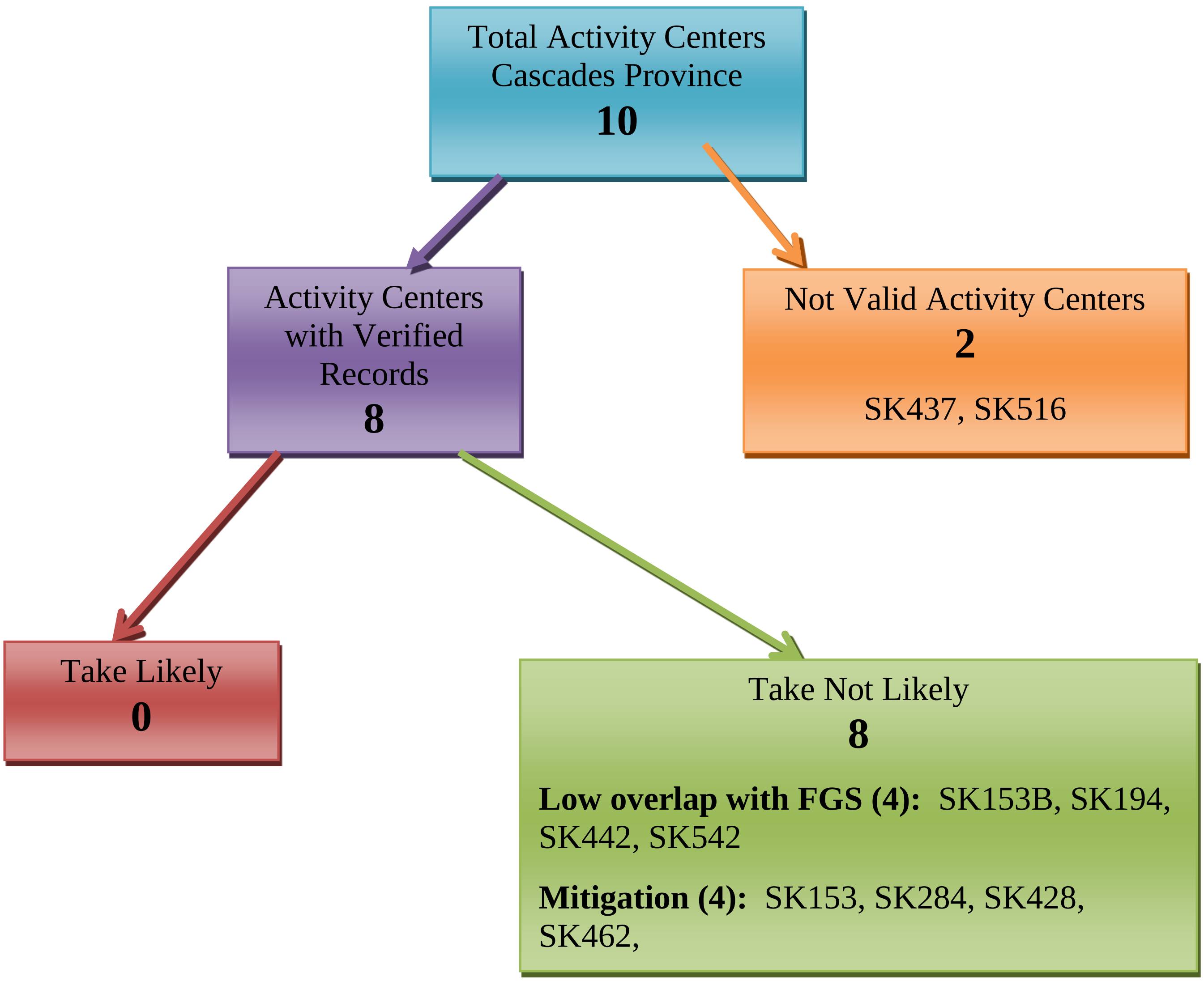
Figure 8. Northern Spotted Owl Activity Centers within the California Cascades Province portion of the Action Area.



4.1.3.2 Northern Spotted Owl Habitat in the Action Area

Based on the 2005 owl habitat layer, there are 92,762 acres of suitable foraging habitat, 49,394 acres of suitable nesting habitat, and 382,329 acres of unsuitable habitat within the entire 524,484-acre Action Area (Tables 6 and 9). Thirty-one percent of the total amount of suitable northern spotted owl habitat within the Action Area is likely to be affected by FGS's activities over the term of the ITP. Of the suitable habitat likely to be affected, it is anticipated that approximately 44 percent (19,340 acres) will be reduced to non-habitat on FGS's land at some point over the 50-year permit term. The remaining 51 percent on FGS's lands is not scheduled to be converted to plantation, and will continue to function as foraging or dispersal habitat. The quality of nesting/roosting and foraging habitat on FGS ownership has been degraded due to repeated timber harvest entries, and to a substantial degree does not support reliable occupancy or reproduction by spotted owls; higher-quality habitats are retained in CSAs. Spotted owl habitat on adjacent federally managed lands is much more likely to contain important habitat elements and support spotted owl occupancy.

An important aspect of the HCP is the ownership-wide increase in foraging and dispersal habitat that is predicted to occur due to changes in FGS's management practices. According to FGS's Maximum Sustainable Production (MSP) analysis and as stated on page 2-18 of the Final EIS, the HCP is expected to result in an increase in what the Service considers foraging habitat (i.e., CWHR habitat categories 4M and 4D) over time and a decrease in clearcutting and other even-aged management practices across the FGS ownership. Under the ITP, FGS would be allowed to harvest more of the currently suitable northern spotted owl habitat on its ownership within the home ranges of 'take' sites. Areas of suitable owl habitat generally have more and larger trees and provide more timber volume per acre than non-habitat areas. Fruit Growers Supply Company has indicated that this would reduce the amount of even-aged regeneration harvest necessary to meet financial targets. A reduction in clearcutting of moderate-complexity stands would allow these and other stands to grow into suitable northern spotted owl habitat over the duration of the permit. According to FGS's MSP analysis, it is anticipated that there would be about a 10 percent decrease in acres harvested each decade under the FGS HCP, including as much as a 25 percent decrease in even-age regeneration harvest compared to timber management under current regulations. As shown in Table 19, the amount of early- and mid-seral forest with high canopy coverage (CWHR classes 2M, 2D, 3M, and 3D) would decrease by up to 20 percent during the first three decades under the HCP compared to conditions under current regulations. The acreage of mid-to late-seral stands with low canopy coverage (CWHR classes 4S and 4P) would decrease over the 50-year permit term to levels less than 10 percent of the acreage in these stand types under current regulations as these stands are allowed to grow and increase in canopy coverage. Thus, the acreage in mid- to late-seral stands with high canopy coverage (CWHR classes 4M and 4D) would be nearly twice as high as under current regulations by the end of the permit term. The amount of late-seral forest in size class 5 would remain essentially the same as currently exists (near zero).

Table 19. Projected Acres in each CWHR Size/Canopy Cover Class Under the FGS HCP.

CWHR Class	**2007**	**Decade 1**	**2**	**3**	**4**	**5**
2S	0	0	0	0	0	0
2P	0	0	0	0	0	0
2M	221	1,688	1,132	782	0	3,145
2D	4,899	8,366	9,868	10,218	12,515	8,370
3S	7,619	2917	0	0	0	0
3P	28,634	21,820	7,140	220	27	0
3M	11,986	14,783	10,903	6,272	5,108	5,240
3D	11,844	20,315	21,737	24,053	28,011	32,021
4S	1,385	1,011	839	300	0	0
4P	36,257	16,886	31,611	16,861	14,767	4,768
4M	10,612	31,907	25,189	44,809	34,586	37,929
4D	16,318	10,064	21,086	25,759	34,761	38,301
5S	0	0	0	0	0	0
5P	0	0	269	0	0	0
5M	0	0	0	0	0	0
5D	0	16	0	0	0	0
Total	**129,774**	**129,774**	**129,774**	**129,774**	**129,774**	**129,774**

4.1.4 Relative Effects on Survival and Recovery of Northern Spotted Owl

Evaluation of the relative effects of the FGS HCP on the survival and recovery of the northern spotted owl is based on several factors, including:

- The estimated changes in number of spotted owls and their habitat that are likely to occur with implementation of the FGS HCP
- The current and future condition of the FGS landscape and its ability to support spotted owl survival and recovery
- The conservation and mitigation strategy employed in the HCP and its contribution to spotted owl recovery
- The adequacy of existing regulatory mechanisms to conserve spotted owls and habitat currently existing on FGS lands.

The importance of each of these factors, and the relative significance of effects, vary with the scale of analysis. For this consultation, the Service evaluated the relative effects at three spatial scales; the Action Area, Region (local population scale) and rangewide.

4.1.4.1 Effects to Northern Spotted Owls within Action Area

Effects to Northern Spotted Owl Population within Action Area

Fruit Growers Supply Company has requested incidental take of up to 83 owls within the Action Area. While the Service based its take evaluation (section 4.1.3.1) on potential impacts to owls at 43 activity centers within the Action Area, the analysis strongly indicates that 11 of these 43 historic activity centers (representing 20 owls) are no longer occupied because the home ranges of these 11 activity centers contain extremely low amounts of suitable habitat due to repeated timber harvest entries and wildfire, and several consecutive years of protocol surveys have not detected owls at most of these sites. Fruit Growers Supply Company is also not likely to incidentally take the two owls associated with one activity center (SK310) because the company owns only three percent of the remaining suitable habitat in the home range. Therefore, 61 owls are likely to be incidentally taken over the permit term during HCP implementation. The take authorization of the 22 additional owls, for a total of 83 owls under the proposed ITP, is based on uncertainty regarding the potential displacement and movement of owls in response to Covered Activities within the Action Area during the 50-year permit term. Based on analysis of owl activity centers and habitat suitability, the Service concludes that authorization of take of an additional 22 owls would, at most, likely have a minor impact to the species' survival and recovery because 11 of the activity centers used in the estimate of the baseline population are of low quality and are not likely to support owls now or perhaps in the future, and because FGS has very low potential to reduce the habitat quality in the home range of SK310. Habitat loss expected to occur within the home ranges of the 22 owls has already been identified and evaluated in the habitat sections of this BO.

Based on the take evaluation (section 4.1.3.1) and as described above, the Service anticipates that incidental take of up to 61 northern spotted owls resulting from FGS's Covered Activities within the Action Area could reasonably occur as a result of implementation of the FGS HCP over the 50-year permit term. This number corresponds to 44% of the individual owls the Service considers potentially occupying the Action Area. However, as described in section 3.2.2, actual take is not likely to be this high because historic activity centers may not be currently occupied or occupied by owl pairs.

The significance of the loss of 61 owls is strongly influenced by the current condition of forest habitats on FGS ownership; in particular the amount and quality of habitat within spotted owl home ranges and core areas. Spotted owl activity centers on and immediately adjacent to FGS ownership have received multiple timber harvest entries during the past 25 years, and most of these activity centers are considered deficit in nesting/roosting and foraging habitat. Repeated harvest entries have removed or reduced important habitat elements such as high canopy cover, snags and large, defective trees, resulting in degraded habitat conditions even in stands classified as nesting/roosting or foraging. These conditions, combined with the Service's review of survey records for many of the historic activity centers, were the bases for the Service's conclusion that occupancy rates at many of these sites are low and that over time the observed pattern of site abandonment will continue regardless of whether an HCP is implemented.

Given the above conditions, existing regulatory mechanisms will be unlikely to conserve activity centers that are strongly influenced by FGS ownership. Under the current CFPRs and Section 9 of the ESA, take is deemed unlikely if an activity center is determined to be abandoned; subsequently all habitat within the home range can be removed without compensatory mitigation. Because occupancy rates at many of the historic activity centers on FGS ownership are low, take of spotted owls as a result of habitat removal and degradation at these sites is expected to be low. This circumstance acts to further reduce both the extent and the effects of the potential take estimated under the HCP.

Estimation and description of the local or population-level effects of proposed take is based on the significance of the take to survival and recovery of the listed species as a whole. Northern spotted owl populations encompass large regions (physiographic provinces), and owls within the FGS Action Area constitute a very small portion of two, much larger, widespread populations in two physiographic provinces. For the northern spotted owl, the significance of impacts is most strongly influenced by losses of owl pairs occupying sites likely to support long-term occupancy and reproductive success; these sites contribute disproportionately to population stability and recovery. Low-quality sites supporting territorial singles or low rates of occupancy and reproduction by owl pairs contribute substantially less to the conservation of the species, but may provide habitat for dispersing spotted owls and occasional occupancy and even reproduction. Because some of the activity centers proposed to be lost or degraded currently support owl pairs and some reproduction, implementation of the FGS HCP is likely to result in a measurable reduction in the numbers and distribution of spotted owls within the Action Area; however, as discussed below in "Relative Effects to Northern Spotted Owl across its Range" (section 4.1.4.3), the effect of this loss on the survival and the recovery of spotted owls across the species range is minor and insignificant. Even when the impact of the anticipated take is considered within the Action Area, the significance of this impact is reduced substantially by the low occupancy and reproductive rates of many territories anticipated to be lost, and the low likelihood that these activity centers would persist through time via existing regulatory mechanisms. For this reason, the Service concludes that implementation of the FGS HCP is likely to have a measurable impact on occupancy, survival, and reproduction of individual spotted owls within the Action Area. However, as described in the following sections, this impact is insignificant at the scale of regional or provincial populations.

Relative Effects to Northern Spotted Owl Habitat within Action Area

<u>California Klamath Province</u>

Within the California Klamath Province portion of the Action Area there are 339,543 acres of land, of which FGS manages 104,493 acres (31 percent). In addition, 30 percent (103,608 acres) of the total Action Area in this province is managed by other private landowners. Thirty-nine percent (130,895 acres) is administered by Federal agencies, approximately 29,663 acres (23 percent) of which are in federally designated CHUs. Approximately 33 percent of the Klamath

Action Area (112,078 acres) is considered suitable northern spotted owl habitat; 42,045 acres of nesting/roosting and 70,033 acres of foraging habitat. Currently, 38,958 acres of the suitable northern spotted owl habitat (35 percent) is located on the FGS ownership; 8,410 acres of nesting/roosting and 30,548 acres of foraging habitat. Approximately 4,771 acres have been identified by FGS as habitat commitments in CSAs, of which 109 acres are targeted as nesting/roosting, 2,850 acres as high-quality foraging, and 1,812 acres as low-quality foraging habitat. Northern spotted owls will benefit from an additional 5,017 acres that will be protected outside of the CSAs in WLPZs under the Aquatic Species Conservation Program. The majority of suitable habitat outside of the habitat commitments made for CSAs and WLPZs on FGS's lands in this province are likely to be harvested over the term of the ITP, which equates to 34,954 acres. Of these 34,954 acres of suitable habitat planned for harvest, 7,118 acres are currently nesting/roosting and 27,836 acres are foraging habitat.

Implementation of the FGS HCP is anticipated to result in a 17 percent reduction in spotted owl nesting/roosting habitat and 31 percent reduction in foraging habitat from current levels within the California Klamath Action Area. Much of this reduction will occur within the spotted owl activity centers (described in 4.2.1.1, above) where take is anticipated. As described above, the quality of nesting/roosting and foraging habitat on FGS ownership has been degraded due to repeated timber harvest entries, and to a substantial degree does not support reliable occupancy or reproduction by spotted owls; higher-quality habitats are retained in CSAs. Spotted owl habitat on adjacent federally managed lands is much more likely to contain important habitat elements and support spotted owl occupancy. However, in the short term (five to 25 years), the FGS habitat could be used by single territorial owls, dispersing owls, and some pairs. The loss of this habitat is therefore anticipated to have a negative impact on numbers and distribution of spotted owls within the Action Area. The significance of this impact over longer time periods (>25 years) is reduced by the increase in foraging habitat expected to occur across FGS ownership, as modeled by the company's MSP analysis.

California Cascades Province

Within the California Cascades Province portion of the Action Area there are 184,942 acres of land, of which FGS manages 42,967 acres (23 percent). Currently, 21 percent (38,785 acres) of the total Action Area in this province is managed by other private landowners and 56 percent (103,190 acres) is administered by Federal agencies. Approximately 13,054 acres (13 percent) of the Federal lands are in federally designated CHUs for the northern spotted owl. Approximately 16 percent of the Cascades Action Area (30,077 acres) is considered suitable northern spotted owl habitat; 7,349 acres of nesting/roosting and 22,728 acres of foraging habitat. Currently, 4,799 acres of the suitable northern spotted owl habitat (16 percent) is located on the FGS ownership; 619 acres of nesting/roosting and 4,180 acres of foraging habitat. Approximately 2,359 acres have been identified by FGS as habitat commitments in CSAs, of which six acres are targeted as nesting/roosting, 871 acres as high-quality foraging, and 1,482 acres as low-quality foraging habitat. Northern spotted owls will benefit from an additional 631 acres that will be protected outside of the CSAs in WLPZs under the Aquatic Species Conservation Program. The majority of suitable habitat outside of the habitat commitments made for CSAs and WLPZs on FGS's lands in this province are likely to be harvested over the term of the ITP, which equates to 4,605 acres. Of these 4,605 acres of suitable habitat planned for harvest, 609 acres are currently nesting/roosting and 3,996 acres are foraging habitat.

Implementation of the FGS HCP is anticipated to result in an eight percent reduction in spotted owl nesting/roosting habitat and an 18 percent reduction in foraging habitat from current levels within the California Cascades Action Area. Because spotted owl activity centers are located primarily on federal lands adjacent to FGS ownership, and because home ranges that overlap FGS ownership are managed in CSAs, this degree of habitat loss is not anticipated to have a significant negative impact on survival and recovery of spotted owls within the California Cascades Action Area.

4.1.4.2 Relative Effects to Northern Spotted Owl within Region

Relative Effects to Northern Spotted Owl Population within Region

The Service analyzed the relative impacts of the proposed take of northern spotted owls within a 20-mile buffer surrounding FGS ownership (see section 6.2.1.3 of the FGS HCP). This area, termed the Area of Analysis, is intended to represent the regional population or subpopulation of owls. The Area of Analysis encompasses 3,304,840 acres and represents 35 percent of the 6-million acre California Klamath Province and 46 percent of the 2.5-million acre California Cascades Province. The Service evaluated relative impacts at the regional rather than provincial scale because it provides a more meaningful analysis of potential impacts of FGS's operations that are reasonably expected to affect dispersal and long-term distribution of owls over the 50-year permit term. Additionally, information about northern spotted owl population size and distribution is not available at the larger provincial scale. Even though the number of currently active owl sites is unknown at the regional scale, there is even greater uncertainty with using data at the provincial level.

The Service estimated the baseline population for the California Klamath Province Area of Analysis using a predictive model (probability of occupancy model; Zabel et al. 2003). A detailed description of this process can be found in section 4.9.1.3 of the FGS HCP (2009). Results of the modeling indicated that approximately 186 activity centers (372 owls) may be supported within the California Klamath Province Area of Analysis. The Service was unable to apply the Klamath model to the California Cascades Area of Analysis, so instead used a 2008 query of the CDFG Northern Spotted Owl Database to estimate the potential number of spotted owl activity centers there. There are records for 54 northern spotted owl activity centers (108 owls) within the California Cascades Area of Analysis. The Service estimated that there are 240 activity centers potentially supporting 480 northern spotted owls within the combined Areas of Analysis.

The Service estimates that up to 61 northern spotted owls within the Action Area may be taken as a result of implementation of the FGS HCP. This would represent a 13 percent reduction in the number of individual owls within the regional population (Area of Analysis). Incidental take authorization of the additional 22 owls requested by FGS constitutes, at most, a minor additional impact to the species' survival and recovery at the regional and provincial scales because the Service concluded that the habitat within the home ranges of these owls is of low quality and is unlikely to support owls over the permit term, and FGS has very low potential to affect the habitat quality in the home range of the additional site.

As described under the Action Area (4.2.1.1, above), the relative impact of this loss on survival and recovery of the species at the regional and provincial levels is substantially reduced by the poor quality and low occupancy rates at many of the spotted owl activity centers that could reasonably be lost or degraded during HCP operations. Because spotted owl population performance is largely driven by survival and reproduction of owls occupying high-quality territories, activity centers on federally managed lands surrounding FGS ownership contribute disproportionately to the regional population. These federal lands constitute about 60 percent of the Area of Analysis and support a large majority of the owls estimated to occur there. Spotted owl activity centers located on FGS lands constitute a very small proportion of the regional population, and due to their low quality contribute little to reproductive output and population stability.

Conservation measures within the FGS HCP act to further mitigate the negative impacts associated with take of owls. The HCP's Terrestrial Species Conservation Program takes into account the wide variation in quality and conservation value among spotted owl activity centers within the Action Area, retaining higher-value activity centers supported by CSAs. The conservation value of the 'take' versus mitigation activity centers has an important influence on the relative impact of the anticipated take at the broader population scales. As part of the HCP development process, the Service identified 24 activity centers within the HCP area that contain or can grow sufficient amounts of suitable habitat to support occupancy by breeding pairs, and are in close proximity to federally designated CHUs. These activity centers were designated mitigation sites to offset the loss of owls associated with the lower quality take activity centers and to provide demographic support to the Federal conservation strategy. Fruit Growers has committed to maintaining habitat within the home ranges of the 24 mitigation sites to support occupancy by reproductive owls throughout the 50-year permit term.

The mitigation sites have some of the highest conservation value because in general they:

- Are in close proximity to a CHU
- Contain high amounts of federal land in the core and home range
- Have consistent occupancy and productivity
- Contain relatively high quality habitat

Conservation values were derived for each activity center in the Action Area using the above four factors (section 6.2.1.3 of the FGS HCP). The 24 mitigation activity centers have some of the highest conservation values; all are generally greater than 40 on a scale of 0 to 111. Seventeen of the mitigation sites have a conservation value greater than 60, 19 have a conservation value greater than 40, and five have a conservation value less than 40. Of the 15 activity centers where take is not likely because of low overlap with FGS's ownership, eight have a relatively high conservation value of greater than 60; the remaining seven activity centers have a conservation value ranging from 0 to 37. All take activity centers have conservation values less than 42, with the majority having values less than 20 (see Figure 6-6 of the FGS HCP). Almost half of the take sites have conservation values less than 10 on a scale of 0 to 111. Therefore, the mitigation sites are those with the highest likelihood of contributing significantly to the conservation and recovery of the northern spotted owl.

If take of 83 owls were to occur across the landscape, which as discussed above, the Service considers very unlikely, there would be a corresponding reduction of 18 percent of the total conservation value of activity centers in the Action Area because most of the activity centers where incidental take is likely to occur under the HCP provide a minimal contribution to the conservation strategy outlined in the Recovery Plan. The 24 mitigation activity centers and the 15 activity centers in which incidental take is unlikely because of low overlap with FGS's ownership represent 55 percent and 27 percent of the total conservation value of activity centers in the Action Area, respectively, for a combined total of 82 percent.

The vast majority of activity centers within the Area of Analysis are located within high quality habitat on Federal lands, and the FGS ownership contains relatively poor habitat for spotted owls due to repeated timber harvest entries into owl home ranges. At many of the 'take' sites on FGS's lands, the amount and distribution of existing suitable habitat is not sufficient to support owls currently or in the long-term due to the lack of high quality habitat that is essential for nesting and roosting. The take sites that do not contain adequate amounts of suitable habitat, particularly nesting/roosting sites, provide little contribution to the overall population in the region because they are not likely to support owls, especially once they are determined to be unoccupied or abandoned. For these reasons, and because the activity centers most likely to contribute to spotted owl occupancy, survival and reproduction within the Action Area receive protection with CSAs, the relative impact resulting from implementation of the FGS HCP is expected to have a measurable but small negative impact on the survival and recovery of northern spotted owls within the Area of Analysis. Because the Klamath and Cascades provinces encompass much larger areas and owl populations, potential effects would be even less.

Relative Effects to Northern Spotted Owl Habitat within Region

California Klamath Province

The majority of the FGS HCP is located within the Klamath Province, a large expanse of federally administered land managed under the NWFP. Within the Klamath Province, there are approximately 3 million acres of high-quality (nesting/roosting) spotted owl habitat, 2.5 million acres of which are Federal. Approximately half of the acres on Federal lands are within Federal Reserves such as Wilderness and Late-successional Reserves (Davis, in press).

Within the California Klamath Province portion of the Area of Analysis (the FGS ownership plus an approximate 20-mile radius area around the ownership) there are 2,157,945 acres of land, of which FGS manages 109,370 acres (5 percent). Currently, 35 percent (748,477 acres) of the total Area of Analysis in this province is managed by other private landowners and 60 percent (1,292,400 acres) is administered by Federal agencies. Approximately 291,000 acres (22 percent) of the Federal lands are in federally designated CHUs for the northern spotted owl. Approximately 27 percent of the Area of Analysis (572,460 acres) in this province is considered suitable northern spotted owl habitat; 286,335 acres of nesting/roosting and 286,125 acres of foraging habitat. Currently, 40,443 acres of the suitable northern spotted owl habitat (7 percent) is located on the FGS ownership; 9,413 acres of nesting/roosting and 31,030 acres of foraging habitat. Of the 40,443 acres of suitable habitat, 38,958 acres are covered under the HCP; the remaining 1,485 acres are located in Oregon and are not included in the HCP. Of those lands covered under the HCP, there are a total of 8,410 acres of nesting/roosting and 30,548 acres of foraging habitat that could potentially be affected by FGS's Covered Activities.

Approximately three percent of the total nesting/roosting habitat and 11 percent of the total foraging habitat available within the Klamath Area of Analysis may potentially be affected by implementation of the FGS HCP. However, accounting for FGS habitat commitments within CSAs and WLPZs, the percentage of suitable habitat potentially affected would also be three percent for nesting/roosting habitat, but less (eight percent) for foraging habitat. As described under 4.2.1.2, above, the quality of nesting/roosting and foraging habitat on FGS ownership has been degraded due to repeated timber harvest entries, and to a substantial degree does not support reliable occupancy or reproduction by spotted owls; higher-quality habitats are retained in CSAs. Spotted owl habitat on adjacent federally managed lands is much more likely to contain important habitat elements and support spotted owl occupancy. Relative to the quantity and quality of spotted owl habitat on adjacent federally managed lands and protected within CSAs, habitat expected to be removed or downgraded on FGS lands contributes little to spotted owl survival and reproduction. The significance of this habitat loss over longer time periods (>25 years) is further reduced by the increase in foraging habitat expected to occur across FGS's ownership, as modeled by the company's MSP analysis. In addition, forest stands that are considered unsuitable or dispersal habitat, and nesting/roosting and foraging habitat that is not removed but downgraded or degraded by FGS's Covered Activities, will be allowed to grow and mature across the ownership in the Klamath Area of Analysis over the term of the ITP, thereby offsetting some of the initial approximately 17,588 acres of habitat removed during the first decade of the HCP.

Because the large majority of high-quality spotted owl habitat, particularly habitat within spotted owl sites likely to be occupied, occurs on federally managed lands within the Area of Analysis, the Service concludes that the small proportions of lower-quality nesting/roosting and foraging habitat (3 percent and 11 percent, respectively) likely to be affected by implementation of the FGS HCP does not constitute a significant effect to survival and recovery of spotted owls within the regional population.

California Cascades Province

Within the California Cascades Province portion of the Area of Analysis there are 1,146,898 acres of land, of which FGS manages 42,967 acres (4 percent). Currently, 47 percent (540,116 acres) of the total Area of Analysis in this province is managed by other private landowners and 49 percent (563,185 acres) is administered by Federal agencies. Approximately 85,948 acres (15 percent) of the Federal lands are in federally designated CHUs for the northern spotted owl. Approximately 15 percent of the Area of Analysis (168,623 acres) in this province is considered suitable northern spotted owl habitat; 50,309 acres of nesting/roosting and 118,314 acres of foraging habitat. Currently, 4,799 acres of the suitable northern spotted owl habitat (3 percent) is located on the FGS ownership; 619 acres of nesting/roosting and 4,180 acres of foraging habitat.

The total potentially affected suitable habitat accounts for one percent of the total nesting/roosting habitat and four percent of the total foraging habitat available within the Cascades Area of Analysis. However, accounting for FGS habitat commitments within CSAs and WLPZs, the percentage of suitable habitat potentially affected would also be one percent for nesting/roosting habitat, but less (one percent) for foraging habitat. As described under 4.2.1.2, above, the quality of nesting/roosting and foraging habitat on FGS ownership has been degraded due to repeated timber harvest entries, and to a substantial degree does not support reliable occupancy or reproduction by spotted owls; higher-quality habitats are retained in CSAs. Spotted owl habitat on adjacent federally managed lands is much more likely to contain important habitat elements and support spotted owl occupancy. Relative to the quantity and quality of spotted owl habitat on adjacent federally managed lands and protected within CSAs, the habitat expected to be removed or downgraded on FGS lands contributes little to spotted owl survival and reproduction. The Service concludes that the loss of small amounts of spotted owl habitat expected to result from implementation of the FGS HCP will have an insignificant effect on survival and recovery of the species in the California Cascades Area of Analysis.

4.1.4.3 Relative Effects to Northern Spotted Owl across its Range

The range of the northern spotted owl encompasses roughly 50 million acres distributed across three states and several physiographic provinces. Rangewide population estimates are unavailable, but recent population modeling suggested that roughly 5,000 to 6,000 owl sites may currently exist (USDI FWS 2011b). Against this backdrop, the significance of the estimated potential take of 61 owls and modification of 39,000 acres of low-quality habitat resulting from issuance of an ITP to FGS is considered not significant. However, additional population factors such as demographic trends and isolated populations or genetic units are evaluated below to determine whether the estimated take may have a disproportionate effect on the species.

Estimates from demographic studies suggest the rangewide population declined by three percent per year from 1985 to 2006. The most precipitous declines in northern spotted owl populations have occurred in the Olympic, Cle Elum, and Rainier study areas in Washington and the Coast Range study area in Oregon. Estimates of population declines in these areas ranged from 40 to 60 percent during the 21 year study period (Forsman et al. 2011). Northern spotted owl populations on the HJ Andrews, Northwest California, and Green Diamond study areas declined by 20-30 percent, whereas the Tyee, Klamath, Southern Cascades, and Hoopa study areas showed declines of five to 15 percent. Two of the three demographic study areas (DSAs) closest to the HCP area support stationary populations (Klamath and South Cascades DSAs) and one (Northwestern California) is marginally declining (Forsman et al. 2011).

Genetic analyses have confirmed genetic mixing between the northern and California spotted owls, especially in the eastern Klamath region. Most gene flow is directional from the California spotted owl northward into the historical range of the northern spotted owl in the Klamath region of northern California and southern Oregon (Barrowclough et al. 1999; Haig et al. 2001, 2004). Mitochondrial DNA sequence analysis by Haig et al. (2004) of 213 owls demonstrated California spotted owl gene flow into the traditional geographic range of the northern spotted owl (15 or 11.5% of 131 owls). When the analysis was limited to the Klamath region, this value went up to 12 or 20.3% of 59 birds, suggesting most of the genetic overlap is in the area surrounding the zone of contact between the two subspecies.

The FGS HCP area is located within a region which supports a fairly large, well-distributed, and genetically robust population of northern spotted owls. Demographic monitoring within the Klamath and southern Cascades regions indicates that spotted owl populations are stable or slightly decreasing. This information suggests that the estimated potential loss of 61 owls over a 50 year period will not occur within a small, isolated population area, or contribute significantly to genetic isolation or population vulnerability within a significant portion of the species' range.

As described in section 4.1.4.1, FGS has requested incidental take authorization for 22 owls in addition to the 61 owls of which FWS expects take to reasonably occur over the permit term. The Service has determined that habitat within the home ranges of 20 of these owls is unlikely to support occupancy by spotted owls. This determination is based on extremely low amounts of suitable habitat due to repeated timber harvest entries and wildfire within the home ranges of these owls, as well as several consecutive years of protocol surveys with no owl detections. At one additional site (SK310), only three percent of suitable habitat occurs on FGS ownership. Due to the fact that the habitat within the home ranges of 20 of these owls is of low quality and is unlikely to support owls over the permit term, and FGS has very low potential to reduce the habitat quality in the home range of SK310, the Service concludes that the take authorization of the additional 22 owls constitutes at most a minor, discountable impact to the species' survival and recovery across its range. Habitat loss expected to occur within the home ranges of the 22 owls has already been included in the habitat sections of this BO.

In 1994, it was estimated that there was 7,400,000 acres of suitable nesting/roosting habitat on NWFP lands within the range of the northern spotted owl. There is no range-wide estimate on the amount of suitable nesting/roosting habitat on non-NWFP lands. Additionally, there are no range-wide estimates for suitable foraging habitat on NWFP lands or non-NWFP lands since foraging habitat characteristics vary widely across the range of the northern spotted owl. The Service has tracked nesting/roosting habitat removed or downgraded since the northern spotted owl was listed through the Section 7 process and technical assistance documents. As of March 30, 2011, the Service has documented the removal or downgrading of 188,971 acres of nesting/roosting habitat as a result of management activities on NWFP lands. Additionally, the Service has documented the removal or downgrading of 472,772 acres of nesting/roosting habitat associated with Tribal lands, HCPs/SHAs, other Federal, State, county, and private lands. The Service also tracks the amount of nesting/roosting habitat removed or downgraded as a result of natural disturbances (e.g., wildfire, insect infestations, windthrow). The Service has documented the removal or downgrading of 207,262 acres of nesting/roosting habitat on NWFP lands, although this figure does not take into account the habitat lost due to the 2008 wildfires that occurred in northern California. Those figures are still being calculated through the emergency consultation process and technical assistance. The Service recognizes the need to develop a new range-wide habitat baseline for the northern spotted owl. The current (1994) habitat baseline that is being used to track changes to available suitable habitat through management actions and natural events does not take into account habitat that has developed since the baseline was established. That is to say, the Service does not know the amount of non-habitat, dispersal habitat or foraging habitat that has grown into suitable dispersal, foraging or nesting/roosting habitat since the 1994 baseline was established.

As a result of issuing an ITP to FGS, the HCP would result in the potential modification of 7,727 acres of suitable nesting/roosting habitat and 31,832 acres of foraging habitat through harvest operations. Of this, approximately 49% or 19,340 acres (4,159 acres nesting/roosting and 15,182 acres foraging habitat) are scheduled for regeneration harvests over the term of the ITP. Regeneration harvests result in plantations, which may provide dispersal and potentially foraging habitat at various stages of their rotation during the permit term, but are not expected to become nesting/roosting habitat because of the even-aged structure and density. The modification of approximately 39,559 acres of low-quality habitat is considered minor with respect to the available suitable habitat range-wide for the northern spotted owl. This relative impact is substantially reduced by 1) the generally low quality of habitat within the FGS HCP area as a result of repeated timber harvest entries and subsequent low rates of occupancy by spotted owls, and 2) predicted increases in foraging habitat across FGS's ownership, as modeled by the company's MSP analysis. Based on this analysis, the Service concludes that the loss of spotted owl habitat expected to occur with implementation of the FGS HCP will not significantly impact the species' survival and recovery across its range.

4.1.4.4 Consistency with Objectives of Northern Spotted Owl Recovery Plan

The Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b; RRP) acknowledges the important role that State, private, and Tribal lands can play toward recovering the northern spotted owl. Contributions from non-Federal lands are recognized as important to the range-wide goal of achieving conservation and recovery of the spotted owl. While the RRP recommends retention of all occupied sites and unoccupied, high quality northern spotted owl habitat on all lands to the greatest extent feasible, the Service recognized that this goal will be especially difficult to meet on non-Federal lands.

Recovery Action 14 in the RRP states: *Encourage applicants to develop Habitat Conservation Plans/Safe Harbor Agreements that are consistent with the recovery objectives.* Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) are important tools that non-Federal landowners can voluntarily use to assist in the recovery of the spotted owl. Although HCPs authorize take of listed species, the conservation measures developed to mitigate the impact of the taking must be consistent with the recovery plan objectives. Although HCPs do not require recovery standards, voluntary Recovery Actions included in an HCP can promote recovery. The Service estimates that 71 activity centers may currently be occupied within the FGS HCP Action Area; the Service has determined that take is unlikely at 40 sites because 1) FGS identified 24 activity centers where CSAs will be established to provide demographic support to the recovery of northern spotted owl under the HCP, and 2) the home ranges of 16 activity centers have low overlap with FGS's ownership or remaining suitable habitat on FGS's ownership.

The RRP suggests that spotted owl recovery will require conservation of occupied and high quality owl habitat to ameliorate impacts from barred owls and buffer potential declines in habitat due to climate change. This strategy is described in Recovery Action 10 – *Conserve spotted owl sites and high value habitat to provide additional demographic support to the spotted owl population.* This recovery action focuses on retention of high quality habitat and long-term occupancy and reproduction at spotted owl sites in order to bolster demographic rates in the larger landscape. Because the CSAs in the FGS HCP are intended to support higher-quality spotted owl activity centers that are associated with existing conservation reserve networks (Critical Habitat Units), and because the majority of activity centers where take is likely to occur exhibit low occupancy rates and poor overall habitat quality, the HCP is generally consistent with this objective.

Recovery Acton 32 is intended to reduce negative impacts of barred owls and other stressors on spotted owls by maintaining and restoring high-quality habitat that can serve as refugia where such habitat is limited. High-quality habitat is described as stands with large-diameter trees, high canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees. Because of the long history of intensive timber management on FGS lands, stands meeting this description are limited to a few spotted owl nest stands and patches of riparian habitat. Some of the existing RA32 habitat will be conserved with CSAs; whereas an unknown quantity will be harvested at the spotted owl activity centers where take is authorized. Stands meeting the RA 32 definition of habitat must be identified in the field on a case by case basis and are not mapped at a broad-scale resolution. Because RA32 stands have not been identified on FGS lands, the degree to which effective RA32 habitat may be removed by implementation of the FGS HCP is unknown.

In the RRP, the Service recognizes the threat posed by the barred owl to spotted owl recovery, and proposes nine Recovery Actions focused on better understanding and ameliorating this threat. The objectives of Recovery Action 30 – *Manage to reduce the negative effects of barred owls on spotted owls so that Recovery Criterion 1 can be met* and Recovery Action 31 – *Develop mechanisms for landowners and land managers to support barred owl management using a collaborative process* – are both addressed in the FGS HCP. In the HCP, the Company is required to survey for barred owls, report detections of barred owls to the Service, and facilitate removal of barred owls from FGS lands if and when a Migratory Bird Treaty Act Permit is obtained.

Although the bulk of conservation and recovery activities described in the RRP are focused on Federal lands, the above-listed Recovery Actions pertain to management of private timberlands and are to varying degrees incorporated into the FGS HCP. The FGS HCP does not detract from the broader objectives of the RRP; it does not result in significant losses of high-quality spotted owl sites with consistent occupancy and reproduction or high-quality habitat, it contains provisions that facilitate conservation of existing higher-quality spotted owl sites associated with Critical Habitat, and it facilitates the potential control of barred owls. The Service therefore concludes that the FGS HCP is consistent with the above-described provisions of the RRP and with recovery of the northern spotted owl.

4.2 Fisher

4.2.1 Biological Requirements of the Fisher

Section 2.2.2 describes the fisher's life history, including its home range sizes, habitat associations, food habits, and dispersal distances (also see Powell 1993, Powell and Zielinski

1994, and Lofroth et al. 2010). Relationships between these factors and the individual fitness or population performance of fishers have not been rigorously established. Nonetheless, the large body of literature concerning fishers suggests that they have the following biological requirements:

1. Home range and density estimates vary substantially among studies and geographic areas but fishers generally have large spatial requirements (100s to 10,000s of acres each).

2. Although they are capable of moving long distances, fishers appear to have limited dispersal abilities and thus, require habitat that is well connected at landscape scales.

3. Fisher home ranges often consist of a mosaic of vegetation types and structural stages but typically contain a large component of mid- to late-successional forest. Thus, suitable landscapes for fishers likewise contain a large component of mid- to late-successional forest.

4. Fishers require a well-distributed network of suitable denning and resting sites within their home ranges. Fishers favor relatively dense, old, decadent forest conditions for denning and resting. Suitable denning and resting sites often include dense, multi-layered canopies, large-diameter trees, snags, and logs, or defective trees (e.g., with cavities or mistletoe brooms). Oaks and other hardwoods are often favored for denning or resting when available.

5. Fishers use a wider variety of conditions when active than when denning or resting but still generally favor areas with relatively complex structure, dense canopy cover, large trees, snags, and logs, and a component of hardwoods.

6. Fishers are associated with several abiotic habitat features. Perhaps most important among these are lower to middle elevations at which relatively dense conifer or conifer-hardwood forests and low to moderate snowfall occur, and riparian areas, where denser forest and prey may be concentrated.

7. Fishers have broad diets that include prey with a wide variety of habitat associations. Nonetheless, many of their primary prey species are associated with structures and resources that are also favored by fishers, such as multi-layered canopies, hardwoods, and large-diameter trees, snags, and logs.

4.2.2 Potential Effects of Habitat Modification

Given that the habitat associations of fishers and northern spotted owls overlap substantially, many of the effects of the Covered Activities on northern spotted owls as described above in section 4.1 are also likely to impact fishers. Forest management is the primary activity in the Plan Area and will be conducted in a variety of ways and settings and could, therefore, have a variety of short- and long-term effects on fishers. For example, depending on the setting and prescription, forest thinning could remove structures important to fishers and their prey or could result in their accelerated development or prevent their loss to severe natural disturbances.

Timber harvest practices that clearly degrade habitat for fishers or their prey (e.g., by excessively reducing canopy cover, structural complexity, large or deformed trees, or dead woody materials) have the most obvious potential to negatively affect the species. Fishers could also be accidentally killed or injured if they are struck by vehicles associated with management operations or if their den or rest trees are felled while in use. Covered Activities other than timber harvesting include harvesting minor forest products, fire prevention, and watershed management. These activities could result in varying levels of habitat modification and disturbance for fishers.

4.2.3 Habitat Model

The Service modified the Zielinski et al. (2010) model by using FGS forest inventory data in place of the original model's vegetation data for FGS lands (section 3.3.1.1; also see "Fisher Spatial Analysis" in Appendix E of the HCP) to quantify changes to both the total amount of modeled habitat suitable for fishers and the amount of modeled habitat in large (female home range-size) blocks (7.7 $mile^2$) in the Klamath Province. The Service selected modeled values greater than or equal to 0.41 as a threshold to represent preferred habitat (hereafter 'suitable habitat') using the FGS fisher model. To quantify changes to modeled habitat suitability under the Proposed Action, the Service compared the current predicted amount of suitable habitat to amounts at five subsequent 10-year time steps. Analysis of changes to female home range-size blocks of suitable habitat provided a spatially explicit means of analyzing habitat changes over this period. This approach does not provide an absolute estimate of the size of the area's fisher population but, rather, serves as a reasonable index for changes to the number of female fishers that the area can support over time under the Proposed Action.

Appendix E of the HCP describes some limitations to the application and interpretation of the FGS fisher model. First, the Service only applied the model to the California Klamath Province. The Zielinski et al. (2010) model was developed specifically for fishers in the Klamath Province and thus, might not have accurately predicted habitat suitability in the California Cascades Province. Furthermore, few fisher detection locations were available for testing the model's validity in the California Cascades Province. Second, the FGS inventory data used to build the modified model were spatially coarse compared with those used for non-FGS ownerships (EVEG: USDA FS 2011). It is unknown whether or how this difference in vegetation data influenced the modeling results. Third, the resolution of the habitat suitability model, regardless of the vegetation data used, is too coarse to detect changes to the availability of important fine-scale habitat elements (e.g., structures and sites suitable for denning and resting).

Despite its limitations, the modeling effort used the best available science to describe fisher habitat in the Klamath Province. This model represents the most current description of fisher habitat in the Klamath Action Area and provides the best estimate of potential changes to habitat under the Proposed Action.

4.2.4 Summary of Effects to Fisher in the Action Area

The Action Area occurs in two ecological provinces: the California Klamath Province and the California Cascades Province. The Service is providing separate effects analyses for these provinces because they are distinct in terms of their ecology, the availability and quality of information for fishers, and the apparent abundances of fishers and their habitat. The Action Area encompasses the local fisher population on FGS ownership that could be directly affected by FGS's operations (FGS ownership with a 1.6-mile buffer).

Effects to Fisher in Klamath Action Area

Table 20 describes changes to the predicted amount of suitable fisher habitat in the California Klamath Province portion of the Action Area (both total and in large blocks), as well as the number of hypothetical female home ranges. The amount of suitable habitat was projected to increase by nearly 17% with large a block increase of 21% during the 50-year permit term. Projected increases in large blocks of suitable habitat and the number of hypothetical female home ranges suggest that the Proposed Action will lead to a slight increase in the number of fishers that the Klamath Action Area can support. Fishers would also benefit from the increases in habitat from the northern spotted owl and aquatic conservation measures, and increases in habitat over the ownership with the expected reduction of even-aged management practices. However, at a finer scale, timber harvest activities at northern spotted owl take sites are expected to reduce habitat suitability, forest complexity, and the availability of structures that are essential to fishers for resting and denning at these locations. Overall, the adverse and beneficial effects of the FGS HCP on fisher are expected to be less than significant.

Table 20. Changes to the amount of suitable fisher habitat (total and in blocks of at least 7.7 mile^2) and the number of hypothetical female home ranges in the Klamath Action Area under the Proposed Action.

	Total		Large Blocks		Hypothetical Female
Time Step	**Acres**	**% Change**	**Acres**	**% Change**	**Home Ranges**
Current	137,163	–	126,036	–	25.5
Decade 1	141,205	2.95%	126,468	0.34%	25.6
Decade 2	157,751	11.72%	144,032	13.89%	29.1
Decade 3	160,143	1.52%	150,798	4.70%	30.5
Decade 4	166,832	4.18%	152,545	1.16%	30.9
Decade 5	160,113	-4.03%	152,251	-0.19%	30.8

Effects to Fisher in Cascades Action Area

The Service was unable to model changes in habitat suitability for fishers in the California Cascades Province. However, given that the habitat associations of fishers and northern spotted owls overlap substantially, many of the effects of the Covered Activities on northern spotted owls (see section 4.1) are also likely to impact fishers. It is important to acknowledge, however, that protections of northern spotted owls provided by the CFPRs do not apply to fishers. Fishers may incidentally benefit from spatial or temporal restrictions on activities near northern spotted owl nests but some areas important to fishers may be unprotected.

5.0 CUMULATIVE EFFECTS

Cumulative effects are those effects of future State, tribal, and private actions that are reasonably certain to occur within the Action Area. Future Federal actions will be subject to the consultation requirements established in section 7 of the ESA and, therefore, are not considered cumulative to the Proposed Action.

Approximately 152,178 acres within the Action Area is owned by FGS. The effects of the proposed Covered Activities on northern spotted owl and fisher are evaluated elsewhere in this BO and therefore are not included in this section.

In 1990, CFPRs, which govern timber harvest on private lands, were amended to require surveys for northern spotted owls in suitable habitat and to provide protection around activity centers (CALFIRE 2001). Under the CFPRs, no timber harvest plan can be approved if it is likely to result in incidental take of federally listed species, unless the take is authorized, for example, under an HCP or Safe Harbor Agreement. The CFPRs do not contain specific provisions for fishers other than including intent language about reducing significant impacts to non-listed species and maintaining functional wildlife habitat. However, this language is not associated with specific enforceable measures. Fishers may incidentally benefit from the CFPRs' spatial and temporal restrictions on activities near northern spotted owl nests; however, some areas important to fishers may be unprotected.

Other private lands account for 142,393 acres within the Action Area. Of these lands, 116,745 acres are currently unsuitable northern spotted owl habitat; suitable habitat includes 8,192 acres of nesting/roosting habitat and 17,456 acres of foraging habitat. These adjoining other private lands are typically managed for commercial timber harvest, or are agricultural lands with rural residential use. The majority of agricultural lands are not suitable northern spotted owl or fisher habitat due to their location on the landscape (i.e., meadows, valleys, grasslands); therefore, they will not provide northern spotted owl or fisher habitat even in the absence of agricultural practices. Commercial timberlands in the Action Area have been actively managed since the early 1900s, and it can be expected that commercial timber harvest on other private lands will continue in the future.

The Service anticipates that FGS's Covered Activities will remove habitat to the extent that incidental take of up to 83 owls is likely over the 50-year permit term. The take prohibition of the CFPRs will still apply to other private landowners who want to harvest suitable habitat within the home ranges of these take sites. Before harvest of additional habitat can occur, other private landowners will be required to survey for owls at these sites. However, the Service has found that the effects of repeated entries within northern spotted owl home ranges reduces habitat quality and leads to reduced occupancy rates and apparent site abandonment. If the Service issues a letter of non-occupancy after making the determination that the activity center is no longer occupied (i.e., abandoned) and doesn't contain sufficient amounts of habitat to support owls, suitable habitat on other private lands within the home ranges of owl sites may be harvested, further reducing suitable owl and fisher habitat available within the Action Area. Because we have no information that actions on private lands will occur during the 50-year term of the permit and we have no information that the rate of non-occupancy will change, we assume that at least the present rate of apparent northern spotted owl site abandonment will continue for the 50-year term of the permit. Likewise we have no information that any other activities likely to affect fishers are reasonably certain to occur in the Action Area.

State Lands account for 686 acres within the Action Area; 644 acres which are currently unsuitable and 42 acres of foraging owl habitat. It is not anticipated that suitable owl or fisher habitat on State lands would change considerably over the term of the ITP. There are no tribal lands within the Action Area.

The Service does not have information to support analysis of the effects of specific actions that are expected to occur on state and private lands within the Action Area; however, activities reasonably certain to occur include the continued harvesting of some proportion of forest habitat suitable for fisher and northern spotted owl. After nearly a century of intensive timber management, the current condition of these forests does not contribute substantially to the survival and recovery of these species, and activity centers on private lands in the Action Area generally exhibit low occupancy rates. For these reasons, the Service concludes that the loss of habitat expected to occur with implementation of FGS HCP, in combination with activities reasonably certain to occur on other private and State lands within the Action Area, will not have a significant negative cumulative effect on the survival and recovery of the northern spotted owl or be likely to jeopardize the continued existence of the West Coast DPS of fishers.

6.0 CONCLUSION

Under Section 7(a)(2) of the ESA, Federal agencies must ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. Regulations implementing this Section of the ESA define "jeopardize the continued existence of" as: "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (FR §402.02).

6.1 Northern Spotted Owl

After reviewing the current status of the northern spotted owl, the environmental baseline, the effects of the Proposed Action, and the cumulative effects, it is the Service's biological opinion that implementation of the FGS HCP discussed herein is not likely to jeopardize the continued existence of the northern spotted owl or impede its recovery, and will not destroy or adversely modify designated critical habitat. The bases for this determination are as follows.

Relative Impacts to Populations

Action Area:

- Although the Service analyzed the potential impact of incidental take of up to 61 northern spotted owls within the Action Area as a result of implementation of the FGS HCP over the 50-year permit term, actual take is likely to be lower because historic activity centers may not be currently occupied or occupied by owl pairs. Thus the Service concludes the level of take and impact of that take is likely to be substantially lower due to the low occupancy and reproductive rates of many of the territories.

- Authorization of incidental take under the FGS HCP of an additional 22 northern spotted owls, for a total of 83 owls, as requested by FGS, constitutes at most a minor additional impact at the Action Area scale because the Service has determined that habitat within the home ranges of 20 of these owls is of low quality and not likely to support owls now or perhaps in the future, and FGS has very low potential to reduce the habitat quality in the home range of SK310.
- The Service concluded that population growth beyond the owl population baseline within the Klamath Action Area is unlikely over the permit term based on an evaluation of current conditions and habitat suitability modeled (Zabel et al. 2003) by decade.

Regional scale:

- Incidental take of up to 61 northern spotted owls represents a 13 percent reduction in the number of individual owls within the regional population, as defined by a 20-mile buffer surrounding FGS ownership (Area of Analysis). Spotted owl activity centers located on FGS lands constitute a very small proportion of the regional population and, due to their low quality, contribute little to reproductive output and population stability. In contrast, federal lands constitute about 60 percent of the Area of Analysis and support the majority of high-quality territories that contribute disproportionately to the local population. Therefore, the relative impact resulting from implementation of the FGS HCP is expected to have a measurable but small negative impact on the regional population. However, the potential adverse effects will not impede the survival and recovery of the northern spotted owl, and the establishment of CSAs on FGS's ownership to support existing higher-quality spotted owl sites associated with CHUs is consistent with the Revised Recovery Plan's strategy to conserve occupied and high quality owl habitat.

Provincial scale:

- The FGS HCP area is located within two physiographic provinces that support a fairly large, well-distributed, and genetically robust population of northern spotted owls. The estimated take of owls will not occur within a small, isolated population area, or contribute significantly to genetic isolation.

Rangewide:

- Given that recent population modeling suggests that roughly 5,000 to 6,000 owl sites may currently exist (USDI FWS 2011b) across the species range, the estimated incidental take of up to 61 owls resulting from issuance of an ITP to FGS is not likely to jeopardize the continued existence or impede recovery of the northern spotted owl across its range because it represents a less than one percent reduction in activity centers range-wide. Additionally, the majority of activity centers where take is likely to occur do not substantially contribute to the Federal conservation strategy outlined in the Revised Recovery Plan because the sites exhibit low occupancy rates, poor overall habitat quality, and/or are not in close proximity to the Federal conservation reserve network. In contrast, most of the activity centers designated as mitigation sites contribute disproportionately to overall population stability and recovery because they are more likely to support long-term occupancy and reproductive success by owl pairs, in accordance with the Revised Recovery Plan.

Relative Impact of Habitat Modification

- Implementation of the FGS HCP is anticipated to result in a 17 percent reduction in spotted owl nesting/roosting habitat and 31 percent reduction in foraging habitat from current levels within the California Klamath portion of the Action Area, and an eight percent reduction in spotted owl nesting/roosting habitat and an 18 percent reduction in foraging habitat from current levels within the California Cascades portion of the Action Area. The degree of this impact over longer time periods (>25 years) is reduced by the increase in foraging habitat expected to occur across FGS ownership, as modeled by the company's MSP analysis.
- Approximately three percent of the total nesting/roosting habitat and 11 percent of the total foraging habitat available within the Klamath portion of the Area of Analysis, and one percent of the total nesting/roosting habitat and four percent of the total foraging habitat available within the Cascades portion of the Area of Analysis may potentially be affected by implementation of the FGS HCP. Relative to the quantity and quality of spotted owl habitat on adjacent federally managed lands and protected within CSAs, habitat expected to be removed or downgraded on FGS lands contributes little in terms of quantity or quality to spotted owl survival and reproduction. The significance of this habitat loss over longer time periods (>25 years) is further reduced by the increase in foraging habitat expected to occur across FGS's ownership, as modeled by the company's MSP analysis.
- Given that the range of the northern spotted owl encompasses roughly 50 million acres distributed across three states and several physiographic provinces, the Service considers the estimated modification of 39,000 acres of lower quality habitat resulting from issuance of an ITP to FGS to be insignificant. The relative impact is substantially reduced by the generally low quality of habitat within the FGS HCP area as a result of repeated timber harvest entries and subsequent low rates of occupancy by spotted owls, and predicted increases in foraging habitat across FGS's ownership over the permit term, as modeled by the company's MSP analysis.

Conservation Planning and Mitigation

- If take of 83 owls were to occur across the landscape, there would be a corresponding reduction of 18 percent of the total conservation value of activity centers in the Action Area. Most of the activity centers where incidental take is likely to occur under the HCP provide a minimal contribution to the recovery of northern spotted owls under the federal conservation strategy outlined in the Revised Recovery Plan (USDI FWS 2011b). The 24 mitigation activity centers and the 15 activity centers in which incidental take is unlikely because of low overlap with FGS's ownership represent 55 percent and 27 percent of the total conservation value of activity centers in the Action Area, respectively, for a combined total of 82 percent.

- Existing regulatory mechanisms will be unlikely to conserve activity centers that are strongly influenced by FGS ownership, which acts to further reduce the relative impact of the estimated taking because under the current CFPRs, if an activity center is determined to be unoccupied or abandoned, all habitat within the home range can be removed without compensatory mitigation. For this reason, the HCP would provide more certainty that habitat would be conserved thru time than would existing regulatory mechanisms because habitat within CSAs would be maintained throughout the 50-year permit term, regardless of occupancy.
- The FGS HCP is consistent with the provisions of the Revised Recovery Plan (USDI FWS 2011b) because it does not result in significant losses of high-quality spotted owl sites with consistent occupancy and reproduction or high-quality habitat, it contains provisions that facilitate conservation of existing higher-quality spotted owl sites associated with Critical Habitat, and it facilitates the potential control of barred owls.

Impacts to Northern Spotted Owl Critical Habitat

- Critical habitat for the northern spotted owl has been designated on federal lands only; no direct destruction or adverse modification of critical habitat is anticipated due to implementation of the FGS HCP because modification of habitat will occur solely on FGS's private ownership.
- The Service considered whether implementation of the FGS HCP would indirectly affect critical habitat by creating fragmentation and 'edge effects' along the boundaries of FGS lands and adjacent critical habitat, potentially reducing the quality of critical habitat along those edges. Because of the long history of intensive timber management on FGS lands, there currently is a high degree of contrast between forest conditions on FGS's ownership and adjacent critical habitat on Federal lands. While Covered Activities may increase edge contrast in some limited areas, overall the Service anticipates that implementation of the FGS HCP will reduce this contrast during the 50-year permit term as stands develop as forecasted in the MSP modeling. In addition, the diversity of naturally occurring and anthropogenic habitat types in the project area, combined with the association of spotted owls with edge habitat in the Klamath Province (USDI FWS 2011b) suggest that any changes in edge characteristics will not have a significant negative effect on critical habitat. Therefore, the Service does not expect any indirect effects to critical habitat to result from implementation of the FGS HCP.

6.2 Fisher

After reviewing the current status of the fisher, the environmental baseline for the Action Area, the effects of implementing the proposed action and the cumulative effects, it is the Service's conference opinion that the FGS HCP, as proposed, is not likely to jeopardize the continued existence of the fisher within the West Coast DPS. No critical habitat has been designated for this species; therefore, none will be destroyed or adversely modified. The Service reached the non-jeopardy conclusion based on the following factors:

- Where modeled, the amount of suitable fisher habitat was estimated to increase during the 50-year permit term. Although the resolution of the fisher habitat suitability model was too coarse to detect changes to the availability of important fine-scale habitat elements (e.g., structures and sites suitable for denning and resting) and portions of FGS's lands associated with owl takes sites will likely be downgraded, the modeling results suggest an increasing trend in the amount of suitable fisher habitat at the landscape scale.
- The fisher habitat model also projected a slight increase in the number of fishers that the area can support.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement. Sections 7(b)(4) and 7(o)(2) of the ESA do not apply to listed plant species.

Amount or Extent of Take

Loss and fragmentation of habitat, together with the legacy of past harvesting on this landscape, may result in reduced resources such as prey and cover, increased predation, and exacerbate competition with barred owls and other spotted owls and therefore reduce the ability of spotted owls to survive and reproduce successfully within the Action Area. Given that many of the activity centers in the Action Area currently have less habitat than what is currently understood to be the minimum required to avoid take, the Service has determined that issuance of an ITP will create a likelihood of injury to owls by harming them to such an extent as to significantly disrupt their normal behavioral patterns such as breeding, feeding, or sheltering. The Service does not anticipate that incidental take of northern spotted owl in the form of harassment will occur because protocol surveys and restrictions on operations during the breeding season should act to avoid or adequately minimize disturbance to owls at occupied sites.

Based on review of survey records, habitat suitability models, habitat mapping, and evaluation of potential impacts of FGS activities on existing suitable habitat, the Service anticipates take, in the form of harm, of up to 61 northern spotted owls within the Action Area to occur over the course of the 50-year permit term as a result of FGS's Covered Activities (Table 16). Under the proposed ITP, the Service would authorize take of an additional 22 northern spotted owls for a total of 83 individual owls. However, the Service's evaluation (see section 3.2.2) indicates that take of this additional 22 owls is unlikely because negative survey results and/or lack of sufficient amounts of suitable habitat suggest the owls are not likely to occupy the Action Area now or throughout the permit term. The authorization of take of these 22 owls, *in addition to* the 61 owls deemed likely to be taken, reflects the total number of historic activity centers within the Action Area that could be adversely affected by timber harvest and other Covered Activities during the permit term, including activity centers that have little possibility of occupancy during the permit term due to deficient habitat conditions. However, because it is possible that owls might occupy these areas over the permit term, and because the proposed habitat conservation plan includes conservation measures to minimize and mitigate take of up to 83 owls, based on the number of historical activity centers, we have conservatively authorized take of up to 83 owls over the life of the permit. Estimating take based on impacts to historical activity centers also accounts for potential displacement of owls by Covered Activities and subsequent movement to alternate activity centers within the Action Area during the permit term.

The Service based its estimation of take on an analysis of historic activity centers, current habitat conditions, and modeled future conditions. Based on this analysis, the Service concludes that it is unlikely that there are additional undetected activity centers on FGS ownership given the low amounts of suitable habitat and extensive survey efforts that have been undertaken over time on the property. The Service also concluded that population growth beyond the current owl population baseline within the Klamath Action Area is unlikely over the permit term. However, because the future location of spotted owl habitat and activity centers within the Action Area cannot be predicted with certainty, the Service recognizes that the take of owls will occur across the Action Area over the permit term and not be based solely on the current activity centers. The Service will continue to provide technical assistance to FGS and will monitor the timing and extent of take throughout the permit term.

Effect of the Take

For the reasons stated in the analyses of the proposed project's effects, the Service determined that the anticipated incidental take of up to 61 northern spotted owls, in combination with the unlikely take of up to 22 additional individuals associated with low-quality habitat, is not likely to jeopardize the continued existence of or impede the recovery of the threatened northern spotted owl across its range. The Service has also determined that the proposed action is not likely to jeopardize the continued existence of the federal candidate West Coast DPS of fisher.

Reasonable and Prudent Measures and Terms and Conditions

The FGS HCP and accompanying documents identify anticipated adverse effects to the northern spotted owl likely to result from the proposed taking, and the specific measures and levels of species and habitat protection that are necessary and appropriate to minimize those adverse effects. All conservation measures described in the proposed HCP, together with the terms and conditions described in the associated Implementing Agreement and any section 10(a)(1)(B) permits issued with respect to the proposed HCP are hereby incorporated by reference as reasonable and prudent measures and terms and conditions within this Incidental Take Statement pursuant to 50 CFR 402.14(I). Such terms and conditions are non-discretionary and must be undertaken for the exemptions under section 10(a)(1)(B) and section 7(o)(2) of the ESA to apply. If FGS fails to adhere to these terms and conditions, the protective coverage of the section 10(a)(1)(B) permit and section 7(o)(2) may lapse. The Service finds that no further measures are necessary beyond those specified in the FGS HCP, Implementing Agreement, and any section 10(a)(1)(B) permit or permits issued with respect to the proposed HCP Because the Service will provide technical assistance to FGS throughout the term of the ITP, the Service will be in a position to monitor and influence how the HCP is implemented. In order to monitor the impact of incidental take, FGS must report the progress of the action and its impact on the species to the Service as specified below.

Reporting Requirements

As described in Chapter 7 of the HCP and Section 8 of the IA, FGS will submit periodic reports describing its activities and results of the compliance and effectiveness monitoring programs implemented by FGS during the prior calendar year. By January 1st of each calendar year during the Permit Term, and following the adoption of FGS's budget by its Board of Directors, FGS will also provide the Service with a Yearly Expenditure Report (YER). The YER will identify all HCP obligations undertaken the prior year, and the funds expended to implement those obligations. The YER will also identify: (1) all HCP-required obligations FGS will implement in the upcoming calendar year (e.g., monitoring, surveying, road work), (2) the funds budgeted for those purposes, (3) whether the budgeted funds are THP-related or not, and 4) all out-of-pocket expenditures required to carry out the obligations (e.g., hiring of outside specialists). Fruit Growers Supply Company will provide, within 30 days of being requested by the Service, any additional information in its possession or control related to implementation of the HCP that is requested by the Service for the purpose of assessing whether the terms and conditions of the permit and the HCP are being fully implemented. Fruit Growers Supply Company shall notify the Service of any transfer of ownership of real property or harvesting rights therein subject to the IA at the time of transfer of ownership, except where prior notification occurs pursuant to section 10. Such notice shall describe the lands to be transferred with particularity, identify the name and address of the transferee and include a detailed map showing the transferred lands.

Disposition of Sick, Injured, or Dead Specimens

Any dead or injured northern spotted owl must be reported to the Service's Law Enforcement Division (916-414-6660) as soon as possible, and turned over to the Law Enforcement Division or to a game warden or biologist of the CDFG for care or analysis. Care should be taken in handling sick or injured specimens to ensure effective treatment and care or handling of dead specimens to preserve biological material in the best possible state for later analysis of cause of death. In conjunction with the care of any sick or injured northern spotted owl or preservation of biological materials from a dead animal, the finder has the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not unnecessarily disturbed. The Service is to be notified in writing within three working days of the accidental death of, or injury to, a northern spotted owl, or of the finding of any dead or injured northern spotted owl during implementation of the proposed action. Notification must include the date, time, and location of the incident or discovery of a dead or injured northern spotted owl, as well as any pertinent information on circumstances surrounding the incident or discovery. The Service contact for this written information is the Field Supervisor at (530) 842-5763.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. In this case, the conservation measures of the project are sufficient to minimize take of northern spotted owl; therefore, the Service finds that no further measures are necessary beyond those specified in the FGS HCP, IA, and the conditions of the Permit.

REINITIATION-CLOSING STATEMENT

This concludes formal consultation on the issuance of the ITP to implement the FGS HCP. As provided in 50 CFR §402.16, reinitiation of consultation shall be required if: (1) the amount or extent of incidental take of northern spotted owl is exceeded; (2) new information reveals effects of the action that may affect northern spotted owl in a manner or to an extent not considered in this biological opinion or affect northern spotted owl critical habitat; (3) the action is subsequently modified in a manner that causes an effect to the species that was not considered in this biological opinion or to critical habitat; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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From:	Rob DiPerna <rob@wildcalifornia.org>
Sent:	Thursday, May 01, 2014 2:40 PM
To:	Wildlife Management
Subject:	Attn: Neil Clipperton--Northern Spotted Owl supporting evidence
Attachments:	Appendix A and B_SOS_CH.pdf

Please see attached.

Thank you.

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Appendix A. Gemmill Thin Project – Shasta-Trinity National Forest

STATUS OF THE SPECIES

1.0 STATUS OF THE NORTHERN SPOTTED OWL

1.1 Legal Status

The spotted owl was listed as threatened on June 26, 1990 due to widespread loss and adverse modification of suitable habitat across the owl's entire range and the inadequacy of existing regulatory mechanisms to conserve the owl (USDI FWS 1990a, p. 26114). The northern spotted owl was originally listed with a recovery priority number of 3C, but that number was changed to 6C in 2004 during the 5-year review of the species (USDI FWS 2004, p. 55). Priority numbers are assigned on a scale of 1C (highest) to 18 (lowest). This number reflects a high degree of threat, a low potential for recovery, and the owl's taxonomic status as a subspecies (USDI FWS 1983b, p. 51895). The "C" reflects conflict with development, construction, or other economic activity (USDI FWS 1983a, p. 43104). The most recent five year status review was completed on September 29, 2011, and did not propose changes to the listing status or introduce any new threats (USDI FWS 2011a).

1.2 Life History

1.2.1 Taxonomy

The northern spotted owl is one of three subspecies of spotted owls currently recognized by the American Ornithologists' Union. The taxonomic separation of these three subspecies is supported by genetic (Barrowclough and Gutiérrez 1990, pp.741-742; Barrowclough et al. 1999, p. 928; Haig et al. 2004, p. 1354), morphological (Gutiérrez et al. 1995, p. 2), and biogeographic information (Barrowclough and Gutiérrez 1990, p.741-742). The distribution of the Mexican subspecies (*S. o. lucida*) is separate from those of the northern and California (*S. o. occidentalis*) subspecies (Gutiérrez et al. 1995, p.2). Recent studies analyzing mitochondrial DNA sequences (Haig et al. 2004, p. 1354; Chi et al. 2004, p. 3; Barrowclough et al. 2005, p. 1117) and microsatellites (Henke et al., unpubl. data, p. 15) confirmed the validity of the current subspecies designations for northern and California spotted owls. The narrow hybrid zone between these two subspecies, which is located in the southern Cascades and northern Sierra Nevada, appears to be stable (Barrowclough et al. 2005, p. 1116).

Funk et al. (2008, pp. 1-11) tested the validity of the three current recognized subspecies of spotted owls and found them to be valid. During this genetics study, bi-directional hybridization and dispersal between northern spotted owls and California spotted owls centered in southern Oregon and northern California was discovered. In addition, a discovery of intro-regression of

Mexican spotted owls into the northernmost parts of the northern spotted owl populations in Washington was made, indicating long-distance dispersal of Mexican spotted owls into the northern spotted owl range (Funk et al. 2008, pp. 1-11). Some hybridization of northern spotted owls with barred owls has been recorded (Hamer et al. 1994, pp. 487-491; Dark et al. 1998, pp. 50-56; Kelly 2001, pp. 33, 38).

1.2.2 Physical Description

The northern spotted owl is a medium-sized owl and is the largest of the three subspecies of spotted owls (Gutiérrez et al. 1995, p. 2). It is approximately 46 to 48 centimeters (18 inches to 19 inches) long and the sexes are dimorphic, with males averaging about 13 percent smaller than females. The mean mass of 971 males taken during 1,108 captures was 580.4 grams (1.28 pounds) (out of a range 430.0 to 690.0 grams) (0.95 pound to 1.52 pounds), and the mean mass of 874 females taken during 1,016 captures was 664.5 grams (1.46 pounds) (out of a range 490.0 to 885.0 grams) (1.1 pounds to 1.95 pounds) (P. Loschl and E. Forsman, pers. comm. cited in USDI FWS 2011b, p. A-1). The northern spotted owl is dark brown with a barred tail and white spots on its head and breast, and it has dark brown eyes surrounded by prominent facial disks. Four age classes can be distinguished on the basis of plumage characteristics (Forsman 1981; Moen et al. 1991, p. 493). The northern spotted owl superficially resembles the barred owl, a species with which it occasionally hybridizes (Kelly and Forsman 2004, p. 807). Hybrids exhibit physical and vocal characteristics of both species (Hamer et al. 1994, p. 488).

1.2.3 Current and Historical Range

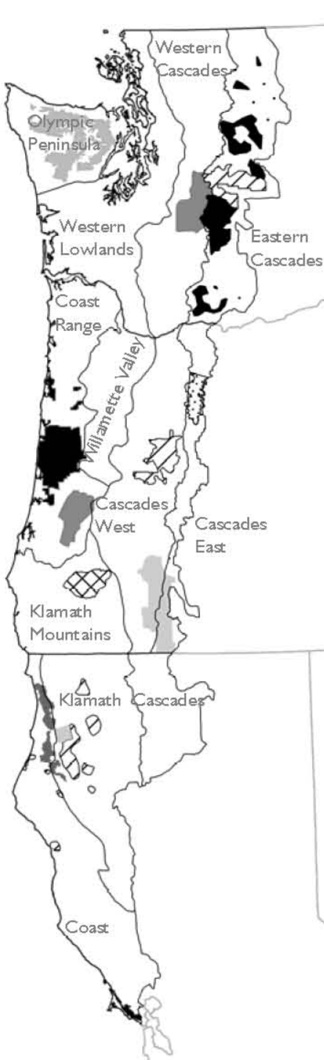
The current range of the spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USDI FWS 1990a, p. 26115). The range of the spotted owl is partitioned into 12 physiographic provinces (see Figure 1) based on recognized landscape subdivisions exhibiting different physical and environmental features (USDI FWS 2011b, p. III-1; Thomas et al. 1993). These provinces are distributed across the species' range as follows:

- Four provinces in Washington: Eastern Washington Cascades, Olympic Peninsula, Western Washington Cascades, Western Washington Lowlands

- Five provinces in Oregon: Oregon Coast Range, Willamette Valley, Western Oregon Cascades, Eastern Oregon Cascades, Oregon Klamath

- Three provinces in California: California Coast, California Klamath, California Cascades

The spotted owl is extirpated or uncommon in certain areas such as southwestern Washington and British Columbia. Timber harvest activities have eliminated, reduced or fragmented spotted owl habitat sufficiently to decrease overall population densities across its range, particularly within the coastal provinces where habitat reduction has been concentrated (USDI FWS 2011b, pp. B-1 to B-4; Thomas and Raphael 1993).



	Demographic Study Area	Land Ownership	# Owls Banded	Fecundity	Apparent Survival	λ_{RJS}	Population Trend Based on $\Delta\lambda$
	Washington						
	Wenatchee (WEN)	Private	1,200	Stable	Declining	0.917	Declining
	Rainer (RAI)	USFS	217	Stable	Declining	0.896	Declining
	Olympic (OLY)	NPS & USFS	985	Stable	Declining	0.956	Declining
	Cle Elum (CLE)	USFS	724	Declining[1]	Declining?[2]	0.938	Declining
	Oregon						
	Oregon Coast Range (COA)	USFS & BLM	1,025	Declining?[1]	Stable	0.968	Declining
	Tyee (TYE)	BLM & Private	1,032	Increasing	Stable	1.005	Stationary
	South Oregon Cascades (CAS)	USFS & BLM	881	Declining	Stable	0.974	Stationary
	H.J. Andrews (HJA)	USFS	1,095	Stable?[3]	Stable	0.978	Declining
	Klamath (KLA)	BLM & Private	1,147	Stable	Stable	0.997	Stationary
	Warm Springs (WSR)	Tribal	381	Stable	Stable	0.908	Declining
	California						
	Marin (MAR)	NPS	96	Stable	Stable	NA	NA
	Simpson (SIM)	Private	1,344	Declining[1]	Stable	0.970	Declining
	Hoopa (HUP)	Tribal	279	Increasing	Stable	0.980	Stationary
	NW California (NWC)	USFS	1,026	Declining	Declining	0.985	Declining?[4]

[1] Best model included age and even-odd year effects, but a competing model had a negative time effect on productivity.
[2] Variable among years, but with a declining trend.
[3] Decreasing in early years, increase in last 5 years, stable overall.
[4] Gradual declines in fecundity and apparent survival, plus estimates of realized population change suggest a decline in last 8 years.

Figure 1. Physiographic provinces, northern spotted owl demographic study areas, and demographic trends (Anthony et al. 2006).

1.2.4 Behavior

Northern spotted owls are primarily nocturnal (Forsman et al. 1984, pp. 51-52) and spend virtually their entire lives beneath the forest canopy (Courtney et al. 2004, p. 2-5). They are adapted to maneuverability beneath the forest canopy rather than strong, sustained flight (Gutiérrez et al. 1995, p. 9). They forage between dusk and dawn and sleep during the day with peak activity occurring during the two hours after sunset and the two hours prior to sunrise (Gutiérrez et al. 1995, p. 5; Delaney et al. 1999a, p. 44). They will sometimes take advantage of vulnerable prey near their roosts during the day (Layman 1991, pp. 138-140; Sovern et al. 1994, p. 202).

Northern spotted owls seek sheltered roosts to avoid inclement weather, summer heat, and predation (Forsman 1975, pp. 105-106; Barrows and Barrows 1978; Barrows 1981; Forsman et al. 1984, pp. 29-30). Northern spotted owls become stressed at temperatures above 28°C, but there is no evidence to indicate that they have been directly killed by temperature because of their ability to thermoregulate by seeking out shady roosts in the forest understory on hot days (Barrows and Barrows 1978; Forsman et al. 1984, pp. 29-30, 54; Weathers et al. 2001, pp. 678, 684). During warm weather, spotted owls seek roosts in shady recesses of understory trees and occasionally will even roost on the ground (Barrows and Barrows 1978, pp. 3, 7-8; Barrows 1981, pp. 302-306, 308; Forsman et al. 1984, pp. 29-30, 54; Gutiérrez et al. 1995, p. 7). Glenn et al. (2010, p. 2549) found that population growth was negatively associated with hot summer temperatures at their southernmost study area in the southern Oregon Cascades, indicating that warm temperatures may still have an effect on the species. Both adults and juveniles have been observed drinking water, primarily during the summer, which is thought to be associated with thermoregulation (Gutiérrez et al. 1995, p. 7).

Spotted owls are territorial; however, home ranges of adjacent pairs overlap (Forsman et al. 1984, p. 22; Solis and Gutiérrez 1990, p. 746) suggesting that the area defended is smaller than the area used for foraging. They will actively defend their nests and young from predators (Forsman 1975, p. 15; Gutiérrez et al. 1995, p. 11). Territorial defense is primarily effected by hooting, barking and whistle type calls. Some spotted owls are not territorial but either remain as residents within the territory of a pair or move among territories (Gutiérrez 1996, p. 4). These birds are referred to as “floaters.” Floaters have special significance in spotted owl populations because they may buffer the territorial population from decline (Franklin 1992, p. 822). Little is known about floaters other than that they exist and typically do not respond to calls as vigorously as territorial birds (Gutiérrez 1996, p. 4).

Spotted owls are monogamous and usually form long-term pair bonds. “Divorces” occur but are relatively uncommon. There are no known examples of polygyny in this owl, although associations of three or more birds have been reported (Gutiérrez et al. 1995, p. 10).

1.2.5 Habitat Relationships

<u>1.2.5.1 Home Range</u>

Home-range sizes vary geographically, generally increasing from south to north, which is likely a response to differences in habitat quality (USDI FWS 1990a, p. 26117). Estimates of median size of their annual home range (the area traversed by an individual or pair during their normal activities (Thomas and Raphael 1993, pp. IX-15)) vary by province and range from 2,955 acres in the Oregon Cascades (Thomas et al. 1990, p. 194) to 14,211 acres on the Olympic Peninsula (USDI FWS 1994a, p. 3). Zabel et al. (1995, p. 436) showed that these provincial home ranges are larger where flying squirrels are the predominant prey and smaller where wood rats are the predominant prey. Home ranges of adjacent pairs overlap (Forsman et al. 1984, p. 22; Solis and Gutiérrez 1990, p. 746), suggesting that the defended area is smaller than the area used for foraging. Within the home range there is a smaller area of concentrated use during the breeding season (approximately 20 percent of the home range), often referred to as the core area (Bingham and Noon 1997, pp. 133-135). Spotted owl core areas vary in size geographically and provide habitat elements that are important for the reproductive efficacy of the territory, such as the nest tree, roost sites and foraging areas (Bingham and Noon 1997, p. 134). Spotted owls use smaller home ranges during the breeding season and often dramatically increase their home range size during fall and winter (Forsman et al. 1984, pp. 21-22; Sisco 1990, p. iii).

Although differences exist in natural stand characteristics that influence home range size, habitat loss and forest fragmentation effectively reduce habitat quality in the home range. A reduction in the amount of suitable habitat reduces spotted owl abundance and nesting success (Bart and Forsman 1992, pp. 98-99; Bart 1995, p. 944).

1.2.5.2 Habitat Use and Selection

Forsman et al. (1984, pp.15-16) reported that spotted owls have been observed in the following forest types: Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), white fir (*Abies concolor*), ponderosa pine (*Pinus ponderosa*), Shasta red fir (*Abies magnifica shastensis*), mixed evergreen, mixed conifer hardwood (Klamath montane), and redwood (*Sequoia sempervirens*). The upper elevation limit at which spotted owls occur corresponds to the transition to subalpine forest, which is characterized by relatively simple structure and severe winter weather (Forsman 1975, p. 27; Forsman et al. 1984, pp. 15-16).

Spotted owls generally rely on older forested habitats because such forests contain the structures and characteristics required for nesting, roosting, and foraging. Features that support nesting and roosting typically include a moderate to high canopy closure (60 to 90 percent); a multi-layered, multi-species canopy with large overstory trees (with diameter at breast height [dbh] of greater than 30 inches); a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for spotted owls to fly (Thomas et al. 1990, p. 19). Forested stands with high canopy closure also provide thermal cover (Weathers et al. 2001, p. 686) and protection from predators (Franklin et al. 2000, p. 578).

Spotted owls nest almost exclusively in trees. Like roosts, nest sites are found in forests having complex structure dominated by large diameter trees (Forsman et al. 1984, p. 30; Hershey et al. 1998, p. 1402). Even in forests that have been previously logged, spotted owls select forests having a structure (i.e., larger trees, greater canopy closure) different than forests generally available to them (Folliard 1993, p. 40; Buchanan et al. 1995, p. 1402; Hershey et al. 1998, p. 1404).

Roost sites selected by spotted owls have more complex vegetation structure than forests generally available to them (Barrows and Barrows 1978, p. 3; Forsman et al. 1984, pp. 29-30; Solis and Gutiérrez 1990, pp. 742-743). These habitats are usually multi-layered forests having high canopy closure and large diameter trees in the overstory.

Foraging habitat is the most variable of all habitats used by territorial spotted owls (Thomas et al. 1990; USDI FWS 2011b, p. G-2). Descriptions of foraging habitat have ranged from complex structure (Solis and Gutiérrez 1990, pp. 742-744) to forests with lower canopy closure and smaller trees than forests containing nests or roosts (Gutiérrez 1996, p. 5). Foraging habitat for northern spotted owls provides a food supply for survival and reproduction. Foraging activity is positively associated with tree height diversity (North et al. 1999, p. 524), canopy closure (Irwin et al. 2000, p. 180; Courtney et al. 2004, pp. 5-15), snag volume, density of snags greater than 20 in (50 cm) dbh (North et al. 1999, p. 524; Irwin et al. 2000, pp. 179-180; Courtney et al. 2004, pp. 5-15), density of trees greater than or equal to 31 in (80 cm) dbh (North et al. 1999, p. 524), volume of woody debris (Irwin et al. 2000, pp. 179-180), and young forests with some structural characteristics of old forests (Carey et al.1992, pp. 245-247; Irwin et al. 2000, pp. 178-179). Northern spotted owls select old forests for foraging in greater proportion than their availability at the landscape scale (Carey et al. 1992, pp. 236-237; Carey and Peeler 1995, p. 235; Forsman et al. 2004, pp. 372-373), but will forage in younger stands with high prey densities and access to prey (Carey et al. 1992, p. 247; Rosenberg and Anthony 1992, p. 165; Thome et al. 1999, pp. 56-57).

Dispersal habitat is essential to maintaining stable populations by filling territorial vacancies when resident northern spotted owls die or leave their territories, and to providing adequate gene flow across the range of the species. Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities (USDI FWS 2011b, p. G-1). Dispersal habitat may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding for dispersing juveniles (USDI FWS 2011b, p. G-1). Forsman et al. (2002, p. 22) found that spotted owls could disperse through highly fragmented forest landscapes. However, the stand-level and landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004, p. 1341).

Spotted owls may be found in younger forest stands that have the structural characteristics of older forests or retained structural elements from the previous forest. In redwood forests and mixed conifer-hardwood forests along the coast of northwestern California, considerable numbers of spotted owls also occur in younger forest stands, particularly in areas where hardwoods provide a multi-layered structure at an early age (Thomas et al. 1990, p. 158; Diller and Thome 1999, p. 275). In mixed conifer forests in the eastern Cascades in Washington, 27 percent of nest sites were in old-growth forests, 57 percent were in the understory reinitiation phase of stand development, and 17 percent were in the stem exclusion phase (Buchanan et al.

1995, p. 304). In the western Cascades of Oregon, 50 percent of spotted owl nests were in late-seral/old-growth stands (greater than 80 years old), and none were found in stands of less than 40 years old (Irwin et al. 2000, p. 41).

In the Western Washington Cascades, spotted owls roosted in mature forests dominated by trees greater than 50 centimeters (19.7 inches) dbh with greater than 60 percent canopy closure more often than expected for roosting during the non-breeding season. Spotted owls also used young forest (trees of 20 to 50 centimeters (7.9 inches to 19.7 inches) dbh with greater than 60 percent canopy closure) less often than expected based on this habitat's availability (Herter et al. 2002, p. 437).

In the Coast Ranges, Western Oregon Cascades and the Olympic Peninsula, radio-marked spotted owls selected for old-growth and mature forests for foraging and roosting and used young forests less than predicted based on availability (Forsman et al. 1984, pp. 24-25; Carey et al. 1990, pp. 14-15; Thomas et al. 1990; Forsman et al. 2005, pp. 372-373). Glenn et al. (2004, pp. 46-47) studied spotted owls in young forests in western Oregon and found little preference among age classes of young forest.

Habitat use is influenced by prey availability. Ward (1990, p. 62) found that spotted owls foraged in areas with lower variance in prey densities (that is, where the occurrence of prey was more predictable) within older forests and near ecotones of old forest and brush seral stages. Zabel et al. (1995, p. 436) showed that spotted owl home ranges are larger where flying squirrels (*Glaucomys sabrinus*) are the predominant prey and smaller where wood rats (*Neotoma* spp.) are the predominant prey.

Recent landscape-level analyses in portions of Oregon Coast and California Klamath provinces suggest that a mosaic of late-successional habitat interspersed with other seral conditions may benefit spotted owls more than large, homogeneous expanses of older forests (Zabel et al. 2003, p. 1038; Franklin et al. 2000, pp. 573-579; Meyer et al. 1998, p. 43). In Oregon Klamath and Western Oregon Cascade provinces, Dugger et al. (2005, p. 876) found that apparent survival and reproduction was positively associated with the proportion of older forest near the territory center (within 730 meters) (2,395 feet). Survival decreased dramatically when the amount of non-habitat (non-forest areas, sapling stands, etc.) exceeded approximately 50 percent of the home range (Dugger et al. 2005, pp. 873-874). The authors concluded that they found no support for either a positive or negative direct effect of intermediate-aged forest—that is, all forest stages between sapling and mature, with total canopy cover greater than 40 percent—on either the survival or reproduction of spotted owls. It is unknown how these results were affected by the low habitat fitness potential in their study area, which Dugger et al. (2005, p. 876) stated was generally much lower than those in Franklin et al. (2000) and Olson et al. (2004), and the low reproductive rate and survival in their study area, which they reported were generally lower than those studied by Anthony et al. (2006). Olson et al. (2004, pp. 1050-1051) found that reproductive rates fluctuated biennially and were positively related to the amount of edge between late-seral and mid-seral forests and other habitat classes in the central Oregon Coast Range. Olson et al. (2004, pp. 1049-1050) concluded that their results indicate that while mid-seral and late-seral forests are important to spotted owls, a mixture of these forest types with younger forest and non-forest may be best for spotted owl survival and reproduction in their study area. In a large-scale demography modeling study, Forsman et al. (2011, pp. 1-2) found a positive correlation between the amount of suitable habitat and recruitment of young.

1.2.6 Reproductive Biology

The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman et al. 1984; Gutiérrez et al. 1995, p. 5). Spotted owls are sexually mature at 1 year of age, but rarely breed until they are 2 to 5 years of age (Miller et al. 1985, p. 93; Franklin 1992, p. 821; Forsman et al. 2002, p. 17). Breeding females lay one to four eggs per clutch, with the average clutch size being two eggs; however, most spotted owl pairs do not nest every year, nor are nesting pairs successful every year (USDI FWS 1990b; Forsman et al. 1984, pp. 32-34; Anthony et al. 2006, p. 28), and renesting after a failed nesting attempt is rare (Gutiérrez 1996, p. 4). The small clutch size, temporal variability in nesting success, and delayed onset of breeding all contribute to the relatively low fecundity of this species (Gutiérrez 1996, p. 4).

Courtship behavior usually begins in February or March, and females typically lay eggs in late March or April. The timing of nesting and fledging varies with latitude and elevation (Forsman et al. 1984, p. 32). After they leave the nest in late May or June, juvenile spotted owls depend on their parents until they are able to fly and hunt on their own. Parental care continues after fledging into September (USDI FWS 1990a; Forsman et al. 1984, p. 38). During the first few weeks after the young leave the nest, the adults often roost with them during the day. By late summer, the adults are rarely found roosting with their young and usually only visit the juveniles to feed them at night (Forsman et al. 1984, p. 38). Telemetry and genetic studies indicate that close inbreeding between siblings or parents and their offspring is rare (Haig et al. 2001, p. 35; Forsman et al. 2002, p. 18). Hybridization of northern spotted owls with California spotted owls and barred owls has been confirmed through genetic research (Hamer et al. 1994, pp. 487-492; Gutiérrez et al. 1995, pp. 2-3; Dark et al. 1998, p. 52; Kelly 2001, pp. 33-35; Funk et al. 2008, pp. 161-171).

1.2.7 Dispersal Biology

Natal dispersal of spotted owls typically occurs in September and October with a few individuals dispersing in November and December (Miller et al. 1997; Forsman et al. 2002, p. 13). Natal dispersal occurs in stages, with juveniles settling in temporary home ranges between bouts of dispersal (Forsman et al. 2002, pp. 13-14; Miller et al. 1997, p. 143). The median natal dispersal distance is about 10 miles for males and 15.5 miles for females (Forsman et al. 2002, p. 16). Dispersing juvenile spotted owls experience high mortality rates, exceeding 70 percent in some studies (USDI FWS 1990a; Miller 1989, pp. 32-41). Known or suspected causes of mortality during dispersal include starvation, predation, and accidents (Miller 1989, pp. 41-44; USDI FWS 1990a; Forsman et al. 2002, pp. 18-19). Parasitic infection may contribute to these causes of mortality, but the relationship between parasite loads and survival is poorly understood (Hoberg et al. 1989, p. 247; Gutiérrez 1989, pp. 616-617; Forsman et al. 2002, pp. 18-19). Successful dispersal of juvenile spotted owls may depend on their ability to locate unoccupied suitable habitat in close proximity to other occupied sites (LaHaye et al. 2001, pp. 697-698).

There is little evidence that small openings in forest habitat influence the dispersal of spotted owls, but large, non-forested valleys such as the Willamette Valley apparently are barriers to both natal and breeding dispersal (Forsman et al. 2002, p. 22). The degree to which water bodies, such as the Columbia River and Puget Sound, function as barriers to dispersal is unclear, although radio telemetry data indicate that spotted owls move around large water bodies rather than cross them (Forsman et al. 2002, p. 22). Analysis of the genetic structure of spotted owl populations suggests that gene flow may have been adequate between the Olympic Mountains and the Washington Cascades, and between the Olympic Mountains and the Oregon Coast Range (Haig et al. 2001, p. 35).

Breeding dispersal occurs among a small proportion of adult spotted owls; these movements were more frequent among females and unmated individuals (Forsman et al. 2002, pp. 20-21). Breeding dispersal distances were shorter than natal dispersal distances and also are apparently random in direction (Forsman et al. 2002, pp. 21-22). In California spotted owls, a similar subspecies, the probability for dispersal was higher in younger owls, single owls, paired owls that lost mates, owls at low quality sites, and owls that failed to reproduce in the preceding year (Blakesley et al. 2006, p.77). Both males and females dispersed at near equal distances (Blakesley et al. 2006, p. 76). In 72 percent of observed cases of dispersal, dispersal resulted in increased habitat quality (Blakesley et al. 2006, p. 77).

Dispersal can also be described as having two phases: transience and colonization (Courtney et al 2004, p. 5-13). Fragmented forest landscapes are more likely to be used by owls in the transience phase as a means to move rapidly between denser forest areas (Courtney et al 2004, p. 5-13; USDI FWS 2012, p. 14086). Movements through mature and old growth forests occur during the colonization phase when birds are looking to become established in an area (Miller et al 1997, p. 144; Courtney et al 2004, p. 5-13). Transient dispersers use a wider variety of forest conditions for movements than colonizing dispersers, who require habitats resembling nesting/roosting/foraging habitats used by breeding birds (USDI FWS 2012, p. 14086). Dispersal success is likely highest in mature and old growth forest stands where there is more likely to be adequate cover and food supply (USDI FWS 2012, p. 14086).

1.2.8 Food Habits

Spotted owls are mostly nocturnal, although they also forage opportunistically during the day (Forsman et al. 1984, p. 51; 2004, pp. 222-223; Sovern et al. 1994, p. 202). The composition of the spotted owl's diet varies geographically and by forest type. Generally, flying squirrels (*Glaucomys sabrinus*) are the most prominent prey for spotted owls in Douglas-fir and western hemlock (*Tsuga heterophylla*) forests (Forsman et al. 1984, pp. 40-41) in Washington and Oregon, while dusky-footed wood rats (*Neotoma fuscipes*) are a major part of the diet in the Oregon Klamath, California Klamath, and California Coastal provinces (Forsman et al. 1984, pp. 40-42; 2004, p. 218; Ward et al. 1998, p. 84; Hamer et al. 2001, p. 224). Depending on location, other important prey include deer mice (*Peromyscus maniculatus*), tree voles (*Arborimus longicaudus, A. pomo*), red-backed voles (*Clethrionomys* spp.), gophers (*Thomomys* spp.), snowshoe hare (*Lepus americanus*), bushy-tailed wood rats (*Neotoma cinerea*), birds, and insects, although these species comprise a small portion of the spotted owl diet (Forsman et al. 1984, pp. 40-43; 2004, p. 218; Ward et al. 1998; p. 84; Hamer et al. 2001, p.224).

Other prey species such as the red tree vole (*Arborimus longicaudus)*, red-backed voles (*Clethrionomys gapperi)*, mice, rabbits and hares, birds, and insects) may be seasonally or locally important (reviewed by Courtney et al. 2004, pp. 4-27). For example, Rosenberg et al. (2003, p. 1720) showed a strong correlation between annual reproductive success of spotted owls (number of young per territory) and abundance of deer mice (*Peromyscus maniculatus*) (r2 = 0.68), despite the fact they only made up 1.6±0.5 percent of the biomass consumed. However, it is unclear if the causative factor behind this correlation was prey abundance or a synergistic response to weather (Rosenberg et al. 2003, p. 1723). Ward (1990, p. 55) also noted that mice were more abundant in areas selected for foraging by owls. Nonetheless, spotted owls deliver larger prey to the nest and eat smaller food items to reduce foraging energy costs; therefore, the importance of smaller prey items, like *Peromyscus*, in the spotted owl diet should not be underestimated (Forsman et al. 2001, p. 148; 2004, pp. 218-219). In the southern portion of their range, where woodrats are a major component of their diet, northern spotted owls are more likely to use a variety of stands, including younger stands, brushy openings in older stands, and edges between forest types in response to higher prey density in some of these areas (Forsman et al. 1984, pp. 24-29).

1.2.9 Population Dynamics

The spotted owl is relatively long-lived, has a long reproductive life span, invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman et al. 1984; Gutiérrez et al. 1995, p. 5). The spotted owl's long reproductive life span allows for some eventual recruitment of offspring, even if recruitment does not occur each year (Franklin et al. 2000, p. 576).

Annual variation in population parameters for spotted owls has been linked to environmental influences at various life history stages (Franklin et al. 2000, p. 581). In coniferous forests, mean fledgling production of the California spotted owl (*Strix occidentalis occidentalis*), a closely related subspecies, was higher when minimum spring temperatures were higher (North et al. 2000, p. 805), a relationship that may be a function of increased prey availability. Across their range, spotted owls have previously shown an unexplained pattern of alternating years of high and low reproduction, with highest reproduction occurring during even-numbered years (e.g., Franklin et al. 1999, p. 1). Annual variation in breeding may be related to weather (i.e., temperature and precipitation) (Wagner et al. 1996, p. 74; Zabel et al. 1996, p.81 *In*: Forsman et al. 1996) and fluctuation in prey abundance (Zabel et al. 1996, pp.437-438).

A variety of factors may regulate spotted owl population levels. These factors may be density-dependent (e.g., habitat quality, habitat abundance) or density-independent (e.g., climate). Interactions may occur among factors. For example, as habitat quality decreases, density-independent factors may have more influence on survival and reproduction, which tends to increase variation in the rate of growth (Franklin et al. 2000, pp. 581-582). Specifically, weather could have increased negative effects on spotted owl fitness for those owls occurring in relatively lower quality habitat (Franklin et al. 2000, pp. 581-582). A consequence of this pattern is that at some point, lower habitat quality may cause the population to be unregulated (have negative growth) and decline to extinction (Franklin et al. 2000, p. 583).

Olson et al. (2005, pp. 930-931) used open population modeling of site occupancy that incorporated imperfect and variable detectability of spotted owls and allowed modeling of temporal variation in site occupancy, extinction, and colonization probabilities (at the site scale). The authors found that visit detection probabilities average less than 0.70 and were highly variable among study years and among their three study areas in Oregon. Pair site occupancy probabilities declined greatly on one study area and slightly on the other two areas. However, for all owls, including singles and pairs, site occupancy was mostly stable through time. Barred owl presence had a negative effect on these parameters (see barred owl discussion in the New Threats section below). However, there was enough temporal and spatial variability in detection rates to indicate that more visits would be needed in some years and in some areas, especially if establishing pair occupancy was the primary goal.

1.3 Threats

1.3.1 Reasons for Listing

The spotted owl was listed as threatened throughout its range "due to loss and adverse modification of suitable habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (USDI FWS 1990a, p. 26114). More specifically, threats to the spotted owl included low populations, declining populations, limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of provinces, predation and competition, lack of coordinated conservation measures, and vulnerability to natural disturbance (USDI FWS 1992a, pp. 33-41). These threats were characterized for each province as severe, moderate, low, or unknown (USDI FWS 1992a, pp. 33-41). Declining habitat was recognized as a severe or moderate threat to the spotted owl throughout its range, isolation of populations was identified as a severe or moderate threat in 11 provinces, and a decline in population was a severe or moderate threat in 10 provinces. Together, these three factors represented the greatest concerns about range-wide conservation of the spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces, and low populations were a severe or moderate concern in eight provinces, suggesting that these factors were also a concern throughout the majority of the spotted owl's range. Vulnerability to natural disturbances was rated as low in five provinces.

The degree to which predation and competition might pose a threat to the spotted owl was unknown in more provinces than any of the other threats, indicating a need for additional information. Few empirical studies exist to confirm that habitat fragmentation contributes to increased levels of predation on spotted owls (Courtney et al. 2004, pp. 11-8 to 11-9). However, great horned owls (*Bubo virginianus*), an effective predator on spotted owls, are closely associated with fragmented forests, openings, and clearcuts (Johnson 1992, p. 84; Laidig and Dobkin 1995, p. 155). As mature forests are harvested, great horned owls may colonize fragmented forests, thereby increasing spotted owl vulnerability to predation.

1.3.2 New Threats

The Service conducted a 5-year review of the spotted owl in 1994 (USDI FWS 2004), for which the Service prepared a scientific evaluation of the status of the spotted owl (Courtney et al.

2004). An analysis was conducted assessing how the threats described in 1990 might have changed by 2004. Some of the key threats identified in 2004 are:

- "Although we are certain that current harvest effects are reduced, and that past harvest is also probably having a reduced effect now as compared to 1990, we are still unable to fully evaluate the current levels of threat posed by harvest because of the potential for lag effects…In their questionnaire responses…6 of 8 panel member identified past habitat loss due to timber harvest as a current threat, but only 4 viewed current harvest as a present threat" (Courtney and Gutiérrez 2004, pp.11-7).

- "Currently the primary source of habitat loss is catastrophic wildfire, although the total amount of habitat affected by wildfires has been small (a total of 2.3 percent of the range-wide habitat base over a 10-year period)" (Courtney and Gutiérrez 2004, pp.11-8).

- "Although the panel had strong differences of opinion on the conclusiveness of some of the evidence suggesting [barred owl] displacement of [spotted owls], and the mechanisms by which this might be occurring, there was no disagreement that [barred owls] represented an operational threat. In the questionnaire, all 8 panel members identified [barred owls] as a current threat, and also expressed concern about future trends in [barred owl] populations" (Courtney and Gutiérrez 2004, pp. 11-8).

Threats, as identified in the 2011 Revised Recovery Plan for the Northern Spotted Owl, continue to emphasize that habitat loss and barred owls are the main threats to northern spotted owl recovery (USDI FWS 2011b, Appendix B).

1.3.2.1 Barred Owls (*Strix varia*)

With its recent expansion to as far south as Marin County, California (Gutiérrez et al. 2004, pp. 7-12 to 7-13; Steger et al. 2006, p.226), the barred owl's range now completely overlaps that of the northern spotted owl. Barred owls may be competing with spotted owls for prey (Hamer et al. 2001, p.226) or habitat (Hamer et al. 1989, p.55; Dunbar et al. 1991, p. 467; Herter and Hicks 2000, p. 285; Pearson and Livezey 2003, p. 274). In addition, barred owls physically attack spotted owls (Pearson and Livezey 2003, p. 274), and circumstantial evidence strongly indicated that a barred owl killed a spotted owl (Leskiw and Gutiérrez 1998, p. 226). Evidence that barred owls are causing negative effects on spotted owls is largely indirect, based primarily on retrospective examination of long-term data collected on spotted owls (Kelly et al. 2003, p. 46; Pearson and Livezey 2003, p. 267; Olson et al. 2005, p. 921). Recent research has shown that the two species of owls share similar habitats and are likely competing for food resources (Hamer et al. 2001, p. 226). Research on barred owls and their interactions with northern spotted owls is lacking, but necessary to determine the specific effects barred owls may have on northern spotted owls and their habitat. Forsman et al. (2011, pp. 69-70) found that the presence of barred owls led to a decrease in fecundity, apparent survival, and caused a decline in populations in most of the demography study areas included in their large scale modeling effort. However, given that the presence of barred owls has been identified as a negative effect while using methods designed to detect a different species (spotted owls), it seems safe to presume that the effects are stronger than estimated. Because there has been no research to evaluate quantitatively the strength of different types of competitive interactions, such as resource partitioning and competitive interference, the particular mechanism by which the two owl species may be competing is unknown.

Barred owls, though they are generalists, likely compete with northern spotted owls for prey resources (Hamer et al. 2001, p. 226; Gutiérrez et al. 2007, p. 187; Livezey and Fleming 2007, p. 319). The only study comparing northern spotted owl and barred owl food habits in the Pacific Northwest indicated that barred owl diets overlap strongly (76 percent) with northern spotted owl diets (Hamer et al. 2001, pp. 221, 226). Barred owl diets are more diverse than northern spotted owl diets and include species associated with riparian and other moist habitats (e.g. fish, invertebrates, frogs, and crayfish), along with more terrestrial and diurnal species (Smith et al. 1983; Hamer et al. 2001; Gronau 2005). Even though barred owls may be taking northern spotted owls' primary prey only as a generalist, northern spotted owls may be affected by a sufficient reduction in the density of these prey items due to barred owls, leading to a depletion of prey to the extent that the northern spotted owl cannot find an adequate amount of food to sustain maintenance or reproduction (Gutiérrez et al. 2007, p. 187; Livezey and Fleming 2007, p. 319).

Barred owls were initially thought to be more closely associated with early successional forests than spotted owls, based on studies conducted on the west slope of the Cascades in Washington (Hamer et al 1989, p. 34; Iverson 1993, p.39). However, recent studies conducted in the Pacific Northwest show that barred owls frequently use mature and old-growth forests (Pearson and Livezey 2003, p. 270; Gremel 2005, Schmidt 2006, p. 1; Singleton et al. 2010, pp. 290-292). In the fire prone forests of eastern Washington, a telemetry study conducted on barred owls showed that barred owl home ranges were located on lower slopes or valley bottoms, in closed canopy, mature, Douglas-fir forest, while spotted owl sites were located on mid-elevation areas with southern or western exposure, characterized by closed canopy, mature, ponderosa pine or Douglas-fir forest (Singleton et al. 2005, p. 1).

The presence of barred owls has been reported to reduce spotted owl detectability, site occupancy, reproduction, and survival. Olson et al. (2005, p. 924) found that the presence of barred owls had a significant negative effect on the detectability of spotted owls, and that the magnitude of this effect did not vary among years. The occupancy of historical territories by spotted owls in Washington and Oregon was significantly lower ($p < 0.001$) after barred owls were detected within 0.8 kilometer (0.5 miles) of the territory center but was "only marginally lower" ($p = 0.06$) if barred owls were located more than 0.8 kilometer (0.5 miles) from the spotted owl territory center (Kelly et al. 2003, p. 51). Pearson and Livezey (2003, p. 271) found that there were significantly more barred owl site-centers in unoccupied spotted owl circles than occupied spotted owl circles (centered on historical spotted owl site-centers) with radii of 0.8 kilometer (0.5 miles) ($p = 0.001$), 1.6 kilometer (1 mile) ($p = 0.049$), and 2.9 kilometer (1.8 miles) ($p = 0.005$) in Gifford Pinchot National Forest. In Olympic National Park, Gremel (2005, p. 11) found a significant decline ($p = 0.01$) in spotted owl pair occupancy at sites where barred owls had been detected, while pair occupancy remained stable at spotted owl sites without barred owls. Olson et al. (2005, p. 928) found that the annual probability that a spotted owl territory would be occupied by a pair of spotted owls after barred owls were detected at the site declined by 5 percent in the HJ Andrews study area, 12 percent in the Coast Range study area, and 15 percent in the Tyee study area. In contrast, Bailey et al. (2009, p. 2983), when using a two-species occupancy model, showed no evidence that barred owls excluded northern spotted owls from territories in Oregon. Most recently, preliminary results from a barred owl and northern spotted owl radio-telemetry study in Washington reported two northern spotted owls fleeing their territories and traveling six and 15 miles, believed to be as a result of frequent direct encounters with barred owls (Irwin et al. 2010, pp. 3-4). Both northern spotted owls were subsequently found dead (Irwin et al. 2010, p. 4).

Olson et al. (2004, p. 1048) found that the presence of barred owls had a significant negative effect on the reproduction of spotted owls in the central Coast Range of Oregon (in the Roseburg study area). The conclusion that barred owls had no significant effect on the reproduction of spotted owls in one study (Iverson 2004, p. 89) was unfounded because of small sample sizes (Livezey 2005, p. 102). It is likely that all of the above analyses underestimated the effects of barred owls on the reproduction of spotted owls because spotted owls often cannot be relocated after they are displaced by barred owls (E. Forsman, pers. comm., cited in USDI FWS 2011b, p. B-11). Anthony et al. (2006, p. 32) found significant evidence for negative effects of barred owls on apparent survival of spotted owls in two of 14 study areas (Olympic and Wenatchee). They attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate. Dugger et al. (2011, pp. 2463-2467) confirmed the synergistic effects of barred owls and territory habitat characteristics on extinction and colonization rates of territories by northern spotted owls. Extinction rates of northern spotted owl territories nearly tripled when barred owls were detected (Dugger et al. 2011, p. 2464).

Monitoring and management of northern spotted owls has become more complicated due to their possible reduced detectability when barred owls are present (Kelly et al. 2003, pp. 51-52; Courtney et al. 2004, p. 7-16 ; Olson et al. 2005, p. 929; Crozier et al. 2006, p.766-767). Evidence that northern spotted owls were responding less frequently during surveys led the Service and its many research partners to update the northern spotted owl survey protocol. The recent changes to the northern spotted owl survey protocol were based on the probability of detecting northern spotted owls when barred owls are present (See USDI FWS Memorandum dated February 7, 2011, "2011 Northern Spotted Owl Survey Protocol" and attached "Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls" for guidance and methodology).

In a recent analysis of more than 9,000 banded spotted owls throughout their range, only 47 hybrids were detected (Kelly and Forsman 2004, p. 807). Consequently, hybridization with the barred owl is considered to be "an interesting biological phenomenon that is probably inconsequential, compared with the real threat—direct competition between the two species for food and space" (Kelly and Forsman 2004, p. 808).

Evidence suggests that barred owls are exacerbating the spotted owl population decline, particularly in Washington, portions of Oregon, and the northern coast of California (Gutiérrez et al. 2004, pp. 739-740; Olson et al. 2005, pp. 930-931). There is no evidence that the increasing trend in barred owls has stabilized in any portion of the spotted owl's range in the western United States, and "there are no grounds for optimistic views suggesting that barred owl impacts on northern spotted owls have been already fully realized" (Gutiérrez et al. 2004, pp. 7-38). In Oregon, Dugger et al. (2011, p. 2466) reported that some northern spotted owl pairs retained their territories and continued to survive and successfully reproduce during their study even when barred owls were present, but that the effects of reduced old growth forest in the core habitat areas were compounded when barred owls were present.

1.3.2.2 Wildfire

Studies indicate that the effects of wildfire on spotted owls and their habitat are variable, depending on fire intensity, severity, and size. Within the fire-adapted forests of the spotted owl's range, spotted owls likely have adapted to withstand fires of variable sizes and severities. However, fire is often considered a primary threat to spotted owls because of its potential to alter habitat rapidly (Bond et al. 2009, p. 1116) and is a major cause of habitat loss on Federal lands (Courtney et al. 2004, executive summary). Bond et al. (2002, p. 1025) examined the demography of the three spotted owl subspecies after wildfires, in which wildfire burned through spotted owl nest and roost sites in varying degrees of severity. Post-fire demography parameters for the three subspecies were similar or better than long-term demographic parameters for each of the three subspecies in those same areas (Bond et al. 2002, p. 1026). In a preliminary study conducted by Anthony and Andrews (2004, p. 8) in the Oregon Klamath Province, their sample of spotted owls appeared to be using a variety of habitats within the area of the Timbered Rock fire, including areas where burning had been moderate.

In 1994, the Hatchery Complex fire burned 17,603 hectares in the Wenatchee National Forest in Washington's eastern Cascades, affecting six spotted owl activity centers (Gaines et al. 1997, p. 125). Spotted owl habitat within a 2.9-kilometer (1.8-mile) radius of the activity centers was reduced by 8 to 45 percent (mean = 31 percent) as a result of the direct effects of the fire and by 10 to 85 percent (mean = 55 percent) as a result of delayed mortality of fire-damaged trees and insects. Direct mortality of spotted owls was assumed to have occurred at one site, and spotted owls were present at only one of the six sites 1 year after the fire (Gaines et al. 1997, p. 126). In 1994, two wildfires burned in the Yakama Indian Reservation in Washington's eastern Cascades, affecting the home ranges of two radio-tagged spotted owls (King et al. 1998, pp. 2-3). Although the amount of home ranges burned was not quantified, spotted owls were observed using areas that burned at low and medium intensities. No direct mortality of spotted owls was observed, even though thick smoke covered several spotted owl site-centers for a week. It appears that, at least in the short term, spotted owls may be resilient to the effects of wildfire—a process with which they have evolved. More research is needed to understand further the relationship between fire and spotted owl habitat use. Overall, we can conclude that fires are a change agent for northern spotted owl habitat, but there are still many unknowns regarding how much fire benefits or adversely affects northern spotted owl habitat (USDI FWS 2011b, p. III-31).

At the time of listing there was recognition that large-scale wildfire posed a threat to the spotted owl and its habitat (USDI FWS 1990a, p. 26183). New information suggests fire may be more of a threat than previously thought. In particular, the rate of habitat loss in the relatively dry East Cascades and Klamath provinces has been greater than expected (see "Habitat Trends" below). Moeur et al. (2005, p. 110) suggested that 12 percent of late-successional forest rangewide would likely be negatively impacted by wildfire during the first 5 decades of the Northwest Forest Plan.

Currently, the overall total amount of habitat affected by wildfires has been relatively small (Lint 2005, p. v). It may be possible to influence through silvicultural management how fire prone forests will burn and the extent of the fire when it occurs. Silvicultural management of forest fuels are currently being implemented throughout the spotted owl's range, in an attempt to reduce the levels of fuels that have accumulated during nearly 100 years of effective fire suppression. However, our ability to protect spotted owl habitat and viable populations of spotted owls from large fires through risk-reduction endeavors is uncertain (Courtney et al. 2004, pp. 12-11). The NWFP recognized wildfire as an inherent part of managing spotted owl habitat in certain portions of the range. The distribution and size of reserve blocks as part of the NWFP design may help mitigate the risks associated with large-scale fire (Lint 2005, p. 77).

1.3.2.4 West Nile Virus

West Nile virus (WNV), caused by a virus in the family Flaviviridae, has killed millions of wild birds in North America since it arrived in 1999 (McLean et al. 2001; Caffrey 2003; Caffrey and Peterson 2003, pp. 7-8; Marra et al. 2004, p. 393). Mosquitoes are the primary carriers (vectors) of the virus that causes encephalitis in humans, horses, and birds. Mammalian prey may also play a role in spreading WNV among predators, like spotted owls. Owls and other predators of mice can contract the disease by eating infected prey (Garmendia et al. 2000, p. 3111; Komar et al. 2001). One captive spotted owl in Ontario, Canada, is known to have contracted WNV and died.

Health officials expect that WNV will eventually spread throughout the range of the spotted owl (Courtney et al. 2004; Blakesley et al. 2004, pp. 8-31), but it is unknown how WNV will ultimately affect spotted owl populations. Susceptibility to infection and the mortality rates of infected individuals vary among bird species (Blakesley et al. 2004, pp. 8-33), but most owls appear to be quite susceptible. For example, breeding Eastern screech owls (*Megascops asio*) in Ohio experienced 100 percent mortality (T. Grubb pers. comm. in Blakesley et al. 2004, pp. 8-33). Barred owls, in contrast, showed lower susceptibility (B. Hunter pers. comm. in Blakesley et al. 2004, pp. 8-34). Some level of innate resistance may occur (Fitzgerald et al. 2003), which could explain observations in several species of markedly lower mortality in the second year of exposure to WNV (Caffrey and Peterson 2003). Wild birds also develop resistance to WNV through immune responses (Deubel et al. 2001). The effects of WNV on bird populations at a regional scale have not been large, even for susceptible species (Caffrey and Peterson 2003), perhaps due to the short-term and patchy distribution of mortality (K. McGowan, pers. comm., cited in Courtney et al. 2004) or annual changes in vector abundance and distribution.

Blakesley et al. (2004, pp. 8-35) offer competing propositions for the likely outcome of spotted owl populations being infected by WNV. One scenario is that spotted owls can tolerate severe, short-term population reductions due to WNV, because spotted owl populations are widely distributed and number in the several hundreds to thousands. An alternative scenario is that WNV will cause unsustainable mortality, due to the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the spotted owl's current range. Thus far, no mortality in wild, northern spotted owls has been recorded; however, WNV is a potential threat of uncertain magnitude and effect (Blakesley et al. 2004, pp. 8-34).

1.3.2.5 Sudden Oak Death

Sudden oak death was recently identified as a potential threat to the spotted owl (Courtney et al. 2004). This disease is caused by the fungus-like pathogen, *Phytopthora ramorum* that was recently introduced from Europe and is rapidly spreading. The disease is now known to extend over 650 km from south of Big Sur, California to Curry County, Oregon (Rizzo and Garbelotto 2003, p. 198), and has reached epidemic proportions in oak (Quercus spp.) and tanoak (*Lithocarpus densiflorus*) forests along approximately 300 kilometers of the central and northern California coast (Rizzo et al. 2002, p. 733). At the present time, sudden oak death is found in natural stands from Monterey to Humboldt Counties, California, and has reached epidemic proportions in oak (*Quercus* spp.) and tanoak (*Lithocarpus densiflorus*) forests along approximately 300 km of the central and northern California coast (Rizzo et al. 2002, p. 733). It has also been found near Brookings, Oregon, killing tanoak and causing dieback of closely associated wild rhododendron (*Rhododendron* spp.) and evergreen huckleberry (*Vaccinium ovatum*) (Goheen et al. 2002, p. 441). It has been found in several different forest types and at elevations from sea level to over 800 m. During a study completed between 2001 and 2003 in California, one-third to one-half of the hiker's present in the study area carried infected soil on their shoes (Davidson et al. 2005, p. 587), creating the potential for rapid spread of the disease. Sudden oak death poses a threat of uncertain proportion because of its potential impact on forest dynamics and alteration of key prey and spotted owl habitat components (e.g., hardwood trees - canopy closure and nest tree mortality); especially in the southern portion of the spotted owl's range (Courtney et al. 2004, pp. 11-8).

1.3.2.6 Inbreeding Depression, Genetic Isolation, and Reduced Genetic Diversity

Inbreeding and other genetic problems due to small population sizes were not considered an imminent threat to the spotted owl at the time of listing. Recent studies show no indication of reduced genetic variation and past bottlenecks in Washington, Oregon, or California (Barrowclough et al. 1999, p. 922; Haig et al. 2004, p. 36). Canadian populations may be more adversely affected by issues related to small population size including inbreeding depression, genetic isolation, and reduced genetic diversity (Courtney et al. 2004, pp. 11-9). A 2004 study (Harestad et al. 2004, p. 13) indicates that the Canadian breeding population was estimated to be less than 33 pairs and annual population decline may be as high as 35 percent. In 2007, a recommendation was made by the Spotted Owl Population Enhancement Team to remove northern spotted owls from the wild in British Columbia (USDI FWS 2012, p. 14078). This recommendation resulted in the eventual capture of the remaining 16 wild northern spotted owls in British Columbia for a captive breeding program (USDI FWS 2012, p. 14078). Low and persistently declining populations throughout the northern portion of the species range (see "Population Trends" below) may be at increased risk of losing genetic diversity. Hybridization of northern spotted owls with California spotted owls, Mexican spotted owls, and barred owls has been confirmed through genetic research (Funk et al. 2008, p. 1; Hamer et al. 1994, p. 487; Gutiérrez et al. 1995, p. 3; Dark et al. 1998, p. 50; Kelly 2001, pp. 33-35).

1.3.2.7 Climate Change

Climate change, combined with effects from past management practices is influencing current forest ecosystem processes and dynamics by increasing the frequency and magnitude of wildfires, insect outbreaks, drought, and disease (USFWS 2011b, pp. III-5 - III-11). In the

Pacific Northwest, mean annual temperatures rose 0.8° C (1.5° F) in the 20th century and are expected to continue to warm from 0.1° to 0.6° C (0.2° to 1° F) per decade (Mote and Salathe 2010, p. 29). Climate change models generally predict warmer, wetter winters and hotter, drier summers and increased frequency of extreme weather events in the Pacific Northwest (Salathe et al. 2010, pp. 72-73).

Predicted climate changes in the Pacific Northwest have implications for forest disturbances that affect the quality and distribution of spotted owl habitat. Both the frequency and intensity of wildfires and insect outbreaks are expected to increase over the next century in the Pacific Northwest (Littell et al. 2010, p. 130). One of the largest projected effects on Pacific Northwest forests is likely to come from an increase in fire frequency, duration, and severity. Westerling et al. (2006, pp. 940-941) analyzed wildfires and found that since the mid-1980s, wildfire frequency in western forests has nearly quadrupled compared to the average of the period from 1970-1986. The total area burned is more than 6.5 times the previous level and the average length of the fire season during 1987-2003 was 78 days longer compared to 1978-1986 (Westerling et al. 2006, p. 941). The area burned annually by wildfires in the Pacific Northwest is expected to double or triple by the 2080s (Littell et al. 2010, p. 140). Wildfires are now the primary cause of spotted owl habitat loss on Federal lands, with over 236,000 acres of habitat loss attributed to wildfires from 1994 to 2007 (Davis et al. 2011, p. 123).

Potential changes in temperature and precipitation have important implications for spotted owl reproduction and survival. Wet, cold weather during the winter or nesting season, particularly the early nesting season, has been shown to negatively affect spotted owl reproduction (Olson et al. 2004, p. 1039, Dugger et al. 2005, p. 863), survival (Franklin et al. 2000 pp. 576-577, Olson et al. 2004, p. 1039, Glenn et al. 2011, p. 1279), and recruitment (Glenn et al. 2010, pp.2446-2547). Cold, wet weather may reduce reproduction and/or survival during the breeding season due to declines or decreased activity in small mammal populations so that less food is available during reproduction when metabolic demands are high (Glenn et al. 2011, pp. 1288-1289). Cold, wet nesting seasons may increase the mortality of nestlings due to chilling and reduce the number of young fledged per pair per year (Franklin et al. 2000, p.557, Glenn et al. 2011, p. 1286).

Drought or hot temperatures during the summer have also been linked to reduced spotted owl recruitment (Glenn et al. 2010, p. 2549). Drier, warmer summers and drought conditions during the growing season strongly influence primary production in forests, food availability, and the population sizes of small mammals that spotted owls prey upon (Glenn et al. 2010, p. 2549).

In summary, climate change is likely to exacerbate some existing threats to the spotted owl such as the projected potential for increased habitat loss from drought-related fire, tree mortality, insects and disease, as well as affecting reproduction and survival during years of extreme weather.

1.3.2.8 Disturbance

Northern spotted owls may also respond physiologically to a disturbance without exhibiting a significant behavioral response. In response to environmental stressors, vertebrates secrete stress hormones called corticosteroids (Campbell 1990, p. 925). Although these hormones are essential for survival, extended periods with elevated stress hormone levels may have negative effects on reproductive function, disease resistance, or physical condition (Carsia and Harvey 2000, pp. 517-518; Saplosky et al. 2000, p. 1). In avian species, the secretion of corticosterone is the primary non-specific stress response (Carsia and Harvey 2000, p. 517). The quantity of this hormone in feces can be used as a measure of physiological stress (Wasser et al. 1997, p. 1019). Recent studies of fecal corticosterone levels of northern spotted owls indicate that low intensity noise of short duration and minimal repetition does not elicit a physiological stress response (Tempel and Gutiérrez 2003, p. 698; Tempel and Gutiérrez 2004, p. 538). However, prolonged activities, such as those associated with timber harvest, may increase fecal corticosterone levels depending on their proximity to northern spotted owl core areas (Wasser et al. 1997, p.1021; Tempel and Gutiérrez 2004, p. 544).

The effects of noise on spotted owls are largely unknown, and whether noise is a concern has been a controversial issue. The effect of noise on birds is extremely difficult to determine due to the inability of most studies to quantify one or more of the following variables: 1) timing of the disturbance in relation to nesting chronology; 2) type, frequency, and proximity of human disturbance; 3) clutch size; 4) health of individual birds; 5) food supply; and 6) outcome of previous interactions between birds and humans (Knight and Skagan 1988, pp. 355-358). Additional factors that confound the issue of disturbance include the individual bird's tolerance level, ambient sound levels, physical parameters of sound, and how it reacts with topographic characteristics and vegetation, and differences in how species perceive noise.

Information specific to behavioral responses of spotted owls to disturbance is limited, research indicates that recreational activity can cause Mexican spotted owls (*S. o. lucida*) to vacate otherwise suitable habitat (Swarthout and Steidl 2001, p. 314) and helicopter overflights can reduce prey delivery rates to nests (Delaney et al. 1999, p. 70). Additional effects from disturbance, including altered foraging behavior and decreases in nest attendance and reproductive success, have been reported for other raptors (White and Thurow 1985, p. 14; Andersen et al. 1989, p. 296; McGarigal et al. 1991, p. 5).

Although it has not been conclusively demonstrated, it is anticipated that nesting spotted owls may be disturbed by heat and smoke as a result of burning activities during the breeding season.

1.4 Conservation Needs of the Spotted Owl

Based on the above assessment of threats, the spotted owl has the following habitat-specific and habitat-independent conservation (i.e., survival and recovery) needs:

1.4.1 Habitat-specific Needs

1. Large blocks of habitat capable of supporting clusters or local population centers of spotted owls (e.g., 15 to 20 breeding pairs) throughout the owl's range;

2. Suitable habitat conditions and spacing between local spotted owl populations throughout its range that facilitate survival and movement;

3. Suitable habitat distributed across a variety of ecological conditions within the northern spotted owl's range to reduce risk of local or widespread extirpation;

4. A coordinated, adaptive management effort to reduce the loss of habitat due to catastrophic wildfire throughout the spotted owl's range, and a monitoring program to clarify whether these risk reduction methods are effective and to determine how owls use habitat treated to reduce fuels; and

5. In areas of significant population decline, sustain the full range of survival and recovery options for this species in light of significant uncertainty.

1.4.2 Habitat-independent Needs

1. A coordinated research and adaptive management effort to better understand and manage competitive interactions between spotted and barred owls; and

2. Monitoring to understand better the risk that WNV and sudden oak death pose to spotted owls and, for WNV, research into methods that may reduce the likelihood or severity of outbreaks in spotted owl populations.

1.4.3 Conservation Strategy

Since 1990, various efforts have addressed the conservation needs of the spotted owl and attempted to formulate conservation strategies based upon these needs. These efforts began with the ISC's Conservation Strategy (Thomas et al. 1990); they continued with the designation of critical habitat (USDI FWS 1992a), the Draft Recovery Plan (USDI FWS 1992b), and the Scientific Analysis Team report (Thomas et al. 1993), report of the Forest Ecosystem Management Assessment Team (Thomas and Raphael 1993); and they culminated with the NWFP (USDA FS and USDI BLM 1994a). Each conservation strategy was based upon the reserve design principles first articulated in the ISC's report, which are summarized as follows:

- Species that are well distributed across their range are less prone to extinction than species confined to small portions of their range.

- Large blocks of habitat, containing multiple pairs of the species, are superior to small blocks of habitat with only one to a few pairs.

- Blocks of habitat that are close together are better than blocks far apart.

- Habitat that occurs in contiguous blocks is better than habitat that is more fragmented.

- Habitat between blocks is more effective as dispersal habitat if it resembles suitable habitat.

1.4.4 Federal Contribution to Recovery

Since it was signed on April 13, 1994, the NWFP has guided the management of Federal forest lands within the range of the spotted owl (USDA FS and USDI BLM 1994a, 1994b). The NWFP was designed to protect large blocks of old growth forest and provide habitat for species that depend on those forests including the spotted owl, as well as to produce a predictable and sustainable level of timber sales. The NWFP included land use allocations which would provide for population clusters of northern spotted owls (i.e., demographic support) and maintain connectivity between population clusters. Certain land use allocations in the plan contribute to supporting population clusters: LSRs, Managed Late-successional Areas, and Congressionally Reserved areas. Riparian Reserves, Adaptive Management Areas, and Administratively Withdrawn areas can provide both demographic support and connectivity/dispersal between the larger blocks, but were not necessarily designed for that purpose. Matrix areas were to support timber production while also retaining biological legacy components important to old-growth obligate species (in 100-acre owl cores, 15 percent late-successional provision, etc. (USDA FS and USDI BLM 1994a, USDI FWS 1994b) which would persist into future managed timber stands.

The NWFP with its rangewide system of LSRs was based on work completed by three previous studies (Thomas et. al. 2006): the 1990 Interagency Scientific Committee (ISC) Report (Thomas et. al. 1990), the 1991 report for the Conservation of Late-successional Forests and Aquatic Ecosystems (Johnson et. al. 1991), and the 1993 report of the Scientific Assessment Team (Thomas et. al. 1993). In addition, the 1992 Draft Recovery Plan for the Northern Spotted Owl (USDI FWS 1992b) was based on the ISC report.

The Forest Ecosystem Management Assessment Team predicted, based on expert opinion, the spotted owl population would decline in the Matrix land use allocation over time, while the population would stabilize and eventually increase within LSRs as habitat conditions improved over the next 50 to 100 years (Thomas and Raphael 1993, p. II-31; USDA FS and USDI BLM 1994a, 1994b, p. 3&4-229). Based on the results of the first decade of monitoring, Lint (2005, p. 18) could not determine whether implementation of the NWFP would reverse the spotted owl's declining population trend because not enough time had passed to provide the necessary measure of certainty. However, the results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described in the NWFP (Lint 2005, p. 18; Noon and Blakesley 2006, p. 288). Bigley and Franklin (2004, pp. 6-34) suggested that more fuels treatments are needed in east-side forests to preclude large-scale losses of habitat to stand-replacing wildfires. Other stressors that occur in suitable habitat, such as the range expansion of the barred owl (already in action) and infection with WNV (which may or may not occur) may complicate the conservation of the spotted owl. Recent reports about the status of the spotted owl offer few management recommendations to deal with these emerging threats. The arrangement, distribution, and resilience of the NWFP land use allocation system may prove to be the most appropriate strategy in responding to these unexpected challenges (Bigley and Franklin 2004, p. 6-34). The Revised Recovery Plan builds on the NWFP and recommends continued implementation of the NWFP and its standards and guides (USDI FWS 2011b, p. I-1).

Under the NWFP, the agencies anticipated a decline of spotted owl populations during the first decade of implementation. Recent reports (Courtney et al. 2004; Anthony et al. 2006, pp. 33-34) identified greater than expected spotted owl declines in Washington and northern portions of Oregon, and more stationary populations in southern Oregon and northern California. The reports did not find a direct correlation between habitat conditions and changes in vital rates of spotted owls at the meta-population scale. However, at the territory scale, there is evidence of negative effects to spotted owl fitness due to reduced habitat quantity and quality. Also, there is no evidence to suggest that dispersal habitat is currently limiting (Courtney et al. 2004, p. 9-12; Lint 2005, p. 87). Even with the population decline, Courtney et al (2004, p. 9-15) noted that there is little reason to doubt the effectiveness of the core principles underpinning the NWFP conservation strategy.

The current scientific information, including information showing northern spotted owl population declines, indicates that the spotted owl continues to meet the definition of a threatened species (USDI FWS 2004, p. 54). That is, populations are still relatively numerous over most of its historic range, which suggests that the threat of extinction is not imminent, and that the subspecies is not endangered; even though, in the northern part of its range population trend estimates are showing a decline.

On June 28, 2011 the Service published the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b). The recovery plan identifies threats from competition with barred owls, ongoing loss of northern spotted owl habitat as a result of timber harvest, loss or modification of northern spotted owl habitat from uncharacteristic wildfire, and loss of amount and distribution of northern spotted owl habitat as a result of past activities and disturbances (USDI FWS 2011b, p. II-2 and Appendix B). To address these threats, the current recovery strategy identifies five main steps: 1) development of a range-wide habitat modeling framework; 2) barred owl management; 3) monitoring and research; 4) adaptive management; and 5) habitat conservation and active forest restoration (USDI FWS 2011b, p. II-2). The recovery plan lists recovery actions that address each of these items, some of which were retained from the 2008 recovery plan. The Managed Owl Conservation Areas and Conservation Support Areas recommended in the 2008 recovery plan are not a part of the recovery strategy outlined in the revised recovery plan. The Service completed a range-wide, multi-step habitat modeling process to help evaluate and inform management decisions and critical habitat development (USDI FWS 2011b, Appendix C).

The final recovery plan (USDI FWS 2011b) recommended implementing a robust monitoring and research program for the spotted owl. The recovery plan encourages these efforts by laying out the following primary elements to evaluate progress toward meeting recovery criteria: monitoring spotted owl population trends, comprehensive barred owl research and monitoring, continued habitat monitoring; inventory of spotted owl distribution, and; explicit consideration for climate change mitigation goals consistent with recovery actions (USDI FWS 2011b, p. II-5). The revised recovery plan also strongly encourages land managers to be aggressive in the implementation of recovery actions. In other words, land managers should not be so conservative that, to avoid risk, they forego actions that are necessary to conserve the forest ecosystems that are necessary to the long-term conservation of the spotted owl. But they should also not be so aggressive that they subject spotted owls and their habitat to treatments where the long-term benefits do not clearly outweigh the short-term risks. Finding the appropriate balance to this dichotomy will remain an ongoing challenge for all who are engaged in spotted owl conservation (USDI FWS 2011b, p. II-12). The revised recovery plan estimates that recovery of the spotted owl could be achieved in approximately 30 years (USDI FWS 2011b, p. II-3).

1.4.5 Conservation Efforts on Non-Federal Lands

In the report from the Interagency Scientific Committee (Thomas et al. 1990, p. 3, p. 272), the draft recovery plan (USDI FWS 1992b), and the report from the Forest Ecosystem Management Assessment Team (Thomas and Raphael 1993, p. IV-189), it was noted that limited Federal ownership in some areas constrained the ability to form a network of old-forest reserves to meet the conservation needs of the spotted owl. In these areas in particular, non-Federal lands would be important to the range-wide goal of achieving conservation and recovery of the spotted owl. The U.S. Fish and Wildlife Service's primary expectations for private lands are for their contributions to demographic support (pair or cluster protection) to Federal lands, or their connectivity with Federal lands. In addition, timber harvest within each state is governed by rules that provide protection of spotted owls or their habitat to varying degrees.

There are 17 current and ongoing conservation plans (CPs) including Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) that have incidental take permits issued for northern spotted owls—eight in Washington, three in Oregon, and six in California (USDI FWS 2011b, p. A-15). The CPs range in size from 76 acres to more than 1.8 million acres, although not all acres are included in the mitigation for northern spotted owls. In total, the CPs cover approximately 3 million acres (9.4 percent) of the 32 million acres of non-Federal forest lands in the range of the northern spotted owl. The period of time that the HCPs will be in place ranges from 20 to 100 years. While each CP is unique, there are several general approaches to mitigation of incidental take:

- Reserves of various sizes, some associated with adjacent Federal reserves
- Forest harvest that maintains or develops nesting habitat
- Forest harvest that maintains or develops foraging habitat
- Forest management that maintains or develops dispersal habitat
- Deferral of harvest near specific sites

Washington. In 1996, the State Forest Practices Board adopted rules (Washington Forest Practices Board 1996) that would contribute to conserving the spotted owl and its habitat on non-Federal lands. Adoption of the rules was based in part on recommendations from a Science Advisory Group that identified important non-Federal lands and recommended roles for those lands in spotted owl conservation (Hanson et al. 1993, pp. 11-15; Buchanan et al. 1994, p. ii). The 1996 rule package was developed by a stakeholder policy group and then reviewed and approved by the Forest Practices Board (Buchanan and Swedeen 2005, p. 9). Spotted owl-related HCPs in Washington generally were intended to provide demographic or connectivity support (USDI FWS 1992b, p. 272). There are over 2.1 million acres of land in six HCPs and two SHAs (USDI FWS 2011b, p. A-15). Some of these CPs focus on providing nesting/roosting habitat throughout the area or in strategic locations; while others focus on providing connectivity through foraging habitat and/or dispersal habitat. In addition, there is a long term habitat management agreement covering 13,000 acres in which authorization of take was provided through an incidental take statement (section 7) associated with a Federal land exchange (USDI FWS 2011b, p. A-15).

Oregon. The Oregon Forest Practices Act provides for protection of 70-acre core areas around sites occupied by an adult pair of spotted owls capable of breeding (as determined by recent protocol surveys), but it does not provide for protection of spotted owl habitat beyond these areas (Oregon Department of Forestry 2007, p. 64). In general, no large-scale spotted owl habitat protection strategy or mechanism currently exists for non-Federal lands in Oregon. The three spotted owl-related HCPs currently in effect cover more than 300,000 acres of non-Federal lands. These HCPs are intended to provide some nesting habitat and connectivity over the next few decades (USDI FWS 2011b, p. A-16). On July 27, 2010, the Service completed a programmatic SHA with the Oregon Department of Forestry that will enroll up to 50,000 acres of non-federal lands within the State over 50 years. The primary intent of this programmatic SHA is to increase time between harvests and to lightly to moderately thin younger forest stands that are currently not habitat to increase tree diameter and stand diversity (USDI FWS 2011b, p. A-16).

California. The California State Forest Practice Rules, which govern timber harvest on private lands, require surveys for spotted owls in suitable habitat and to provide protection around activity centers (California Department of Forestry and Fire Protection 2007, pp. 85-87). Under the Forest Practice Rules, no timber harvest plan can be approved if it is likely to result in incidental take of federally listed species, unless the take is authorized by a Federal incidental take permit (California Department of Forestry and Fire Protection 2007, pp. 85-87). The California Department of Fish and Game initially reviewed all timber harvest plans to ensure that take was not likely to occur; the U.S. Fish and Wildlife Service took over that review function in 2000. Several large industrial owners operate under spotted owl management plans that have been reviewed by the U.S. Fish and Wildlife Service and that specify basic measures for spotted owl protection. Four HCPs and two SHAs authorizing take of spotted owls have been approved; these HCPs cover more than 622,000 acres of non-Federal lands. Implementation of these plans is intended to provide for spotted owl demographic and connectivity support to NWFP lands (USDI FWS 2011b, p. A-16).

1.5 Current Condition of the Spotted Owl

The current condition of the species incorporates the effects of all past human activities and natural events that led to the present-day status of the species and its habitat (USDI FWS and USDC NMFS 1998, pp. 4-19).

1.5.1 Range-wide Habitat and Population Trends

1.5.1.1 Range-wide Habitat Baseline

The Service has used information provided by the USFS, BLM, and National Park Service to update the habitat baseline conditions by tracking relative habitat changes over time on Federal lands for northern spotted owls on several occasions, since the northern spotted owl was listed in 1990 (USDA and USDI 1994b, USDI 2001, Lint 2005, Davis et al. 2011). The estimate of 7.4 million acres used for the NWFP in 1994 (USDA and USDI 1994b) was believed to be representative of the general amount of northern spotted owl habitat on NWFP lands at that time. The most recent mapping effort (Davis et al. 2011, Appendix D, Table D) indicates approximately 8.85 million acres of spotted owl nesting/roosting habitat existed on Federal lands and 4.19 million acres existed on non-federal lands at the beginning of the NWFP in 1994/1996. Davis et al. (2011, pp. 28-30) further evaluated changes in spotted owl nesting/roosting habitat using data from California that covered 14 years from 1994 to 2007, and data from Oregon and Washington that covered 10 years from 1996 to 2006. Although the spatial resolution of this new habitat map currently makes it unsuitable for tracking habitat effects at the scale of individual projects, the Service has evaluated the map for use in tracking provincial and range-wide habitat trends and now considers these data as the best available information on the distribution and abundance of extant spotted owl habitat within its range as of 2006 for Oregon and Washington, and 2007 for California, when the base imagery was collected.

Periodic range-wide evaluations of habitat, as compared to the Final Supplemental Environmental Impact Statement (FSEIS; USDA and USDI 1994b), are necessary to determine if the rate of potential change to northern spotted owl habitat is consistent with the change anticipated in the NWFP: a reduction in suitable habitat of approximately 2.5 percent per decade (USDA and USDI 1994a, p. 46). In particular, the Service considers habitat effects that are documented through the section 7 consultation process since 1994. In general, the analytical framework of these consultations focuses on the reserve and connectivity goals established by the NWFP land-use allocations (USDA and USDI 1994a), with effects expressed in terms of changes in suitable northern spotted owl habitat within those land-use allocations.

In 2001, the Service conducted the first assessment of habitat baseline conditions since implementation of the NWFP (USDI 2001). The Service determined that actions and effects were consistent with the expectations for implementation of the NWFP from 1994 to June 2001 (USDI 2001). April 13, 2004, marked the start of the second decade of the NWFP. Decade-specific baselines and summaries of effects by State, physiographic province and land use function from proposed management activities and natural events are not provided here, but are consistent with expected habitat changes under the NWFP.

In February 2013, the Service adopted the 2006/07 satellite imagery data on spotted owl habitat as the new range-wide habitat baseline for Federal lands which effectively resets the timeframe for establishing changes in the distribution and abundance of spotted owl habitat. On that basis, the assessment of local, provincial and range-wide spotted owl habitat status in this and future Opinions as well as Biological Assessments will rely on these 2006/07 habitat data to characterize changes in the status of spotted owl habitat.

1.5.1.2 Service's Consultation Database

To update information considered in 2001 (USDI 2001), the Service designed the Consultation Effects Tracking System database in 2002, which recorded impacts to northern spotted owls and their habitat at different spatial and temporal scales. In 2011, the Service replaced the Consultation Effects Tracking System with the Consulted on Effects Database located in the Service's Environmental Conservation Online System (ECOS). The ECOS Database corrected technical issues with the Consultation Effects Tracking System. Data are currently entered into the ECOS Database under various categories including; land management agency, land-use allocation, physiographic province, and type of habitat affected.

1.5.1.3 Range-wide Consultation Effects: 1994 to October 24, 2013

Between 1994 and October 24, 2013, the Service has consulted on the proposed removal/downgrade of approximately 708,155 acres (Table A1) or eight percent of the 8.854 million acres of northern spotted owl nesting/roosting habitat estimated by Davis et al. (2011) to have occurred on Federal lands (Table A1). These changes in suitable northern spotted owl habitat are consistent with the expectations for implementation of the NWFP, which anticipated a rate of habitat harvested at 2.5 percent per decade (USFS and BLM 1994a).

The Service tracks habitat changes on non-NWFP lands through consultations for long-term Habitat Conservation Plans, Safe Harbor Agreements, or Tribal Forest Management Plans. Service consultations conducted since 1992 have documented the eventual loss of over 507,169 acres habitat on non-NWFP lands. Most of these losses have yet to be realized because they are part of large-scale, long-term Habitat Conservation Plans. However, the NWFP 15 year monitoring report documented habitat losses on non-federal lands associated with timber harvest continues to occur at a rate of approximately 2 percent per year in Oregon and Washington, and at a lesser rate in California (Davis et al. 2011, pp. 123-124).

Table A1. NWFP Timeframe - Consulted on actions by land ownership

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Land Ownership	Consulted On Habitat Changes[2]		Other Habitat Changes[3]	
	Removed/ Downgraded	Maintained/ Improved	Removed/ Downgraded	Maintained/ Improved
NWFP (FS,BLM,NPS)	200,986	542,456	246,112	39,720
Bureau of Indian Affairs / Tribes	111,627	28,372	2,398	0
Habitat Conservation Plans/Safe Harbor Agreements	326,868	27,208	N/A	N/A
Other Federal, State, County, Private Lands	68,674	28,433	2,392	0
Total Changes	**708,155**	**626,469**	**250,902**	**39,720**

Notes:

1. Nesting, roosting, foraging (NRF) habitat. In California, suitable habitat is divided into two components; nesting - roosting (NR) habitat, and foraging (F) habitat. The NR component most closely resembles NRF

habitat in Oregon and Washington. Due to differences in reporting methods, effects to suitable habitat compiled in this, and all subsequent tables include effects for nesting, roosting, and foraging (NRF) for 1994-6/26/2001. After 6/26/2001 suitable habitat includes NRF for Washington and Oregon but only nesting and roosting (NR) for California.

2. Includes both effects reported in USFWS 2001 and subsequent effects reported in the Northern Spotted Owl Consultation Effects Tracking System (web application and database.). Note consulted on effects to NSO habitat (NR and F) for Fruit Growers' HCP is included in these totals, but has not yet been entered into the web application database.
3. Includes effects to suitable NRF habitat (as generally documented through technical assistance, etc.) resulting from wildfires (not from suppression efforts), insect and disease outbreaks, and other natural causes, private timber harvest, and land exchanges not associated with consultation.

1.5.1.4 Range-wide Consultation Effects: 2006/2007 to October 24, 2013

The Service updated the ECOS Database to reflect the 2006/2007 habitat baseline developed for the NWFP 15-year monitoring report (Davis et al. 2011, Appendix D, Table D). This mapping effort accounted for habitat loss due to wildfire, harvest, insects and disease, and indicates approximately 8.555 million acres of spotted owl nesting/roosting habitat existed on Federal lands in 2006/2007. Because the data developed for the NWFP monitoring program is only current through 2006/2007, the Service continues to rely on information compiled in the spotted owl consultation database to summarize current owl habitat trends at provincial and range-wide scales.

Table A2 summarizes the habitat impacts on Federal lands that have occurred since 2006/2007 through October 24, 2013. The effects from 2013 fires were not available for the preparation of this biological opinion. To date, an estimated 100,700 acres of nesting, roosting, and foraging habitat has been lost from Federal lands since 2006/2007 due to land management activities and natural events. When overall habitat loss is evaluated as a proportion of provincial baselines, the Oregon Cascades and the California Klamath provinces have proportional losses greater than the loss of habitat across all provinces. Effects have varied among the individual provinces; most of the impacts are due to management-related actions and are concentrated within the 'Non-Reserves' land-use allocations. When habitat loss is evaluated as a proportion of the affected acres range-wide, the most pronounced losses have occurred from management activities within Oregon (85 percent of total habitat removed range-wide; especially within its Cascades West and Cascades East provinces). Wildland fires have resulted in considerable loss of NRF habitat within the California Klamath Province (about 40 percent of total lost habitat range-wide).).

Table A2. Summary of northern spotted owl suitable habitat (NRF[1]) acres removed or downgraded as documented through Section 7 consultations on all Federal Lands within the Northwest Forest Plan area. Environmental baseline and summary of effects by State, Physiographic Province, and Land Use Function from 2006 to present.

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State	Physiographic Province[2]	Evaluation Baseline (2006/2007)[3]			Habitat Removed/Downgraded[4]							% Provincial Baseline Affected	% Range-wide Effects
					Land Management Effects			Habitat Loss from Natural Events			Total NRF removed/ downgraded		
		Nesting/ Roosting Acres in Reserves	Nesting/ Roosting Acres in Non-Reserves	Total Nesting Roosting Acres	Reserves[5]	Non-Reserves	Total	Reserves	Non-Reserves	Total			
WA	Eastern Cascades	462,400	181,100	643,500	2,700	2,238	4,938	1,559	132	1,691	6,629	1.03	6.58
	Olympic Peninsula	729,000	33,400	762,400	6	0	6	0	1	1	7	0	0.01
	Western Cascades	1,031,600	246,600	1,278,200	529	831	1,360	3	0	3	1,363	0.11	1.35
	Western Lowlands	24,300	0	24,300	0	0	0	0	0	0	0	0	0
OR	Cascades East	248,500	128,400	376,900	2,748	6,875	9,623	7,639	1,981	9,620	19,243	5.11	19.1
	Cascades West	1,275,200	939,600	2,214,800	1,126	22,820	23,946	0	0	0	23,946	1.08	23.77
	Coast Range	494,400	113,400	607,800	183	838	1,021	0	0	0	1,021	0.17	1.01
	Klamath Mountains	549,400	334,900	884,300	2,617	4,910	7,527	0	0	0	7,527	0.85	7.47
	Willamette Valley	700	2,600	3,300	0	0	0	0	0	0	0	0	0
CA	Cascades	101,700	102,900	204,600	10	1	11	325	0	325	336	0.16	0.33
	Coast	132,900	10,100	143,000	274	1	275	0	175	175	450	0.31	0.45
	Klamath	910,900	501,200	1,412,100	75	646	721	19,072	20,409	39,481	40,202	2.85	39.91
Total		**5,961,000**	**2,594,200**	**8,555,200**	**10,268**	**39,160**	**49,428**	**28,598**	**22,698**	**51,296**	**100,724**	**1.18**	**100**

Notes:

1. Nesting, roosting, foraging (NRF) habitat. In WA/OR, the values for Nesting/Roosting habitat generally represent the distribution of suitable owl habitat, including foraging habitat. In CA, foraging habitat occurs in a much broader range of forest types than what is represented by nesting/roosting habitat. Baseline information for foraging habitat as a separate category in CA is currently not available at a provincial scale.
2. Defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as Recovery Units as depicted on page A-3.
3. Spotted owl nesting and roosting habitat on all Federal lands (includes USFS, BLM, NPS, DoD, USFWS, etc.) as reported by Davis et al. 2011 for the the Northwest Forest Plan 15-Year Monitoring Report (PNW-GTR-80, Appendix D). NR habitat acres are approximate values based on 2006 (OR/WA) and 2007 (CA) satellite imagery.

4. Estimated NRF habitat removed or downgraded from land management (timber sales) or natural events (wildfires) as documented through section 7 consultation or technical assistance. Effects reported here include all acres removed or downgraded from 2006 to present. Effects in California reported here only include effects to Nesting/Roosting habitat. Foraging habitat removed or downgraded in California is not summarized in this table. 2013 fire effects have not been reported at the date of this biological opinion.
5. Reserve land use allocations under the NWFP intended to provide demographic support for spotted owls include LSR, MLSA, and CRA. Non-reserve allocations under the NWFP intended to provide dispersal connectivity between reserves include AWA, AMA, and MX.

Table A3: Summary of northern spotted owl suitable habitat (NRF)[1] acres removed or downgraded on Federal lands within the Northwest Forest Plan area through timber harvest, natural disturbance, or other management actions as documented through section 7 consultation and technical assistance. Range-wide changes by land-use function from 2006 to present. Fri Oct 25 18:25:20 MDT 2013

Suitable Habitat (NRF) Effects	Reserves (LSR, MLSA, CRA)[3]	Non-reserves (AWA, AMA, Matrix)[3]	Totals
Evaluation Baseline (2006/2007)[2]	5,961,000	2,594,200	8,555,200
Removed/Downgraded (timber harvest only)[4]	8,011	37,214	45,225
Removed/Downgraded (other management activities)[5]	2,257	1,946	4,203
Subtotal	10,268	39,160	49,428
Removed/Downgraded (natural disturbance)[6]	28,598	22,698	51,296
Total Net Change	38,866	61,858	100,724
Baseline Balance	**5,922,134**	**2,532,342**	**8,454,476**
Habitat Maintained[7]	36,955	58,498	95,453

Notes:

1. Nesting, roosting, foraging (NRF) habitat. In WA/OR, the values for Nesting/Roosting habitat generally represent the distribution of suitable owl habitat, including foraging habitat. In CA, foraging habitat occurs in a much broader range of forest types than what is represented by nesting/roosting habitat. Baseline information for foraging habitat as a separate category in CA is currently not available at a provincial scale. Effects to spotted owl habitat in California reported here include effects to Nesting/Roosting habitat only. Foraging habitat removed or downgraded in California is not summarized in this table.
2. Spotted owl nesting and roosting habitat on all Federal lands (includes USFS, BLM, NPS, DoD, USFWS, etc.) as reported by Davis et al. 2011 for the the Northwest Forest Plan 15-Year Monitoring Report (PNW-GTR-80, Appendix D). NR habitat acres are approximate values based on 2006 (OR/WA) and 2007 (CA) imagery.
3. Reserve land use allocations under the NWFP intended to provide demographic support for spotted owls include LSR, MLSA, and CRA. Non-reserve allocations under the NWFP intended to provide dispersal connectivity between reserves include AWA, AMA, and MX.
4. NRF habitat removed or downgraded from timber harvest on Federal lands.
5. NRF habitat removed or downgraded from recreation, roads, minerals, or other non-timber programs.
6. NRF habitat losses resulting from wildfires, insect and disease, windthrow or other natural causes.
7. Habitat maintained means that stands have been modified by management, but the habitat function remains the same.

1.5.1.5 Other Habitat Trend Assessments

In 2005, the Washington Department of Wildlife released the report, "An Assessment of Spotted Owl Habitat on Non-Federal Lands in Washington between 1996 and 2004" (Pierce et al. 2005). This study estimates the amount of spotted owl habitat in 2004 on lands affected by state and private forest practices. The study area is a subset of the total Washington forest practice lands, and statistically-based estimates of existing habitat and habitat loss due to fire and timber harvest are provided. In the 3.2-million acre study area, Pierce et al. (2005) estimated there was 816,000 acres of suitable spotted owl habitat in 2004, or about 25 percent of their study area. Based on their results, Pierce et al. (2005) estimated there were less than 2.8 million acres of spotted owl habitat in Washington on all ownerships in 2004. Most of the suitable owl habitat in 2004 (56%) occurred on Federal lands, and lesser amounts were present on state-local lands (21%), private lands (22%) and tribal lands (1%). Most of the harvested spotted owl habitat was on private (77%) and state-local (15%) lands. A total of 172,000 acres of timber harvest occurred in the 3.2 million-acre study area, including harvest of 56,400 acres of suitable spotted owl habitat. This represented a loss of about 6 percent of the owl habitat in the study area distributed across all ownerships (Pierce et al. 2005). Approximately 77 percent of the harvested habitat occurred on private lands and about 15 percent occurred on State lands. Pierce and others (2005) also evaluated suitable habitat levels in 450 spotted owl management circles (based on the provincial annual median spotted owl home range). Across their study area, they found that owl circles averaged about 26 percent suitable habitat in the circle across all landscapes. Values in the study ranged from an average of 7 percent in southwest Washington to an average of 31 percent in the east Cascades, suggesting that many owl territories in Washington are significantly below the 40 percent suitable habitat threshold used by the State as a viability indicator for spotted owl territories (Pierce et al. 2005).

Moeur et al. 2005 estimated an increase of approximately 1.25 to 1.5 million acres of medium and large older forest (greater than 20 inches dbh, single and multi-storied canopies) on Federal lands in the NWFP area between 1994 and 2003. The increase occurred primarily in the lower end of the diameter range for older forest. In the greater than 30 inch dbh size class, the net area increased by only an estimated 102,000 to 127,000 acres (Moeur et al. 2005). The estimates were based on change-detection layers for losses due to harvest and fire and re-measured inventory plot data for increases due to ingrowth. Transition into and out of medium and large older forest over the 10-year period was extrapolated from inventory plot data on a subpopulation of Forest Service land types and applied to all Federal lands. Because size class and general canopy layer descriptions do not necessarily account for the complex forest structure often associated with northern spotted owl habitat, the significance of these acres to northern spotted owl conservation remains unknown.

In 2011, Davis *et al.* produced the second in a series of monitoring reports on northern spotted owl population and habitat trends on Northwest Forest Plan administered lands. They summarized demographic analyses from Forsman *et al.* (2011) discussed below under trends in numbers, distribution and reproduction, and reported on a new effort using remotely sensed data from 1994 to 2007 to develop "habitat suitability" models, and ultimately suitable habitat maps for the entire range of the northern spotted owl for each of these time periods. They also created change-detection maps and reported on the cause of habitat change during this time period. The authors suggest that because of improvements in remotely sensed vegetation, and change-detection mapping, their habitat maps represent the best available information and should replace the baseline versions used for the first monitoring report. Davis *et al*. (2011) estimated 8.9 million acres of suitable habitat for the 1994 baseline map, as compared to 7.4 million acres estimated by FEMAT in 1994, and 10.3 million acres estimated by Davis and Lint (2005) for the 10-year report.

Davis *et al*. (2011) were not able to report on gains in nesting/roosting habitat suitability due to issues with current technology, and the need for additional time to capture the slow process of forest succession. However, they were able to report on gains in recruitment of younger forests or dispersal habitat. They estimated a gain of about 1.26 million ac of dispersal habitat, with the greatest increases in nonreserves than reserves. The largest increase in dispersal habitat was in the Oregon Coast Range province.

Davis *et al*. (2011) estimated that nesting/roosting habitat declined by 3.4 percent (298,600 ac) rangewide on federal lands since 1994, which is less than the anticipated rate of habitat loss under the NWFP of 5 percent per decade. Most of the loss (79 percent) occurred within reserves and was the result of wildfires. Wildfires also were responsible for about half of the loss in nonreserves. Timber harvest accounted for about 45 percent (37,400 ac) in nonreserves, and 7 percent (16,000 ac) in reserves. The Oregon Klamath province lost the most nesting/roosting habitat (93,730 ac) due to the Biscuit Fire in 2002. They estimated a rangewide loss of about 417,000 ac of dispersal habitat, but like nesting/roosting habitat, most of the loss of dispersal habitat was due to wildfire.

Davis *et al*. (2011) created a wildfire suitability (likelihood) map for large fires throughout the range of the northern spotted owl. Their goal was to identify landscape-scale areas where large wildfires are more probable. They report that the California Klamath province has the most owl habitat in fire-prone landscapes, followed by the Oregon Western Cascades and Oregon Klamath provinces.

1.5.2 Spotted Owl Population Trends and Distribution

There are no estimates of the historical population size and distribution of spotted owls, although they are believed to have inhabited most old-growth forests throughout the Pacific Northwest prior to modern settlement (mid-1800s), including northwestern California (USFWS 1989, pp. 2-17).

The current range of the spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USDI FWS 1990a, p. 26114). The range of the spotted owl is partitioned into 12 physiographic provinces (Figure 1) based on recognized landscape subdivisions exhibiting different physical and environmental features (USFWS 1992a, p. 31). The spotted owl has become rare in certain areas, such as British Columbia, southwestern Washington, and the northern coastal ranges of Oregon.

As of July 1, 1994, there were 5,431 known site-centers of spotted owl pairs or resident singles: 851 sites (16 percent) in Washington, 2,893 sites (53 percent) in Oregon, and 1,687 sites (31 percent) in California (USDI FWS 1995, p. 9495). The actual number of currently occupied spotted owl locations across the range is unknown because many areas remain unsurveyed (USFWS 2011b, p. A-2). In addition, many historical sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or severe fires, and it is possible that some new sites have been established due to reduced timber harvest on Federal lands since 1994. The totals above represent the cumulative number of locations recorded in the three states, not population estimates.

Because the existing survey coverage and effort are insufficient to produce reliable range-wide estimates of population size, demographic data are used to evaluate trends in spotted owl populations. Analysis of demographic data can provide an estimate of the finite rate of population change (λ), which provides information on the direction and magnitude of population change. A λ of 1.0 indicates a stationary population, meaning the population is neither increasing nor decreasing. A λ of less than 1.0 indicates a decreasing population, and a λ of greater than 1.0 indicates a growing population. Demographic data, derived from studies initiated as early as 1985, have been analyzed periodically (Anderson and Burnham 1992; Anthony et al. 2006; Burnham et al. 1994; Forsman et al. 2011; Forsman et al. 1996) to estimate trends in the populations of the spotted owl.

In January 2009, two meta-analyses modeled rates of population change for up to 24 years using the re-parameterized Jolly-Seber method (λ_{RJS}). One meta-analysis modeled the 11 long-term study areas (Table 4), while the other modeled the eight study areas that are part of the effectiveness monitoring program of the NWFP (Forsman et al. 2011, pp. 65-67).

Table A4. Summary of spotted owl population trends from in demographic study areas (Forsman et al. 2011, p. 65).

Study Area	Fecundity	Apparent Survival[1]	λ_{RJS}	Population change[2]
Cle Elum	Declining	Declining	0.937	Declining
Rainier	Increasing	Declining	0.929	Declining
Olympic	Stable	Declining	0.957	Declining
Coast Ranges	Increasing	Declining since 1998	0.966	Declining
HJ Andrews	Increasing	Declining since 1997	0.977	Declining
Tyee	Stable	Declining since 2000	0.996	Stationary
Klamath	Declining	Stable	0.990	Stationary
Southern Cascades	Declining	Declining since 2000	0.982	Stationary
NW California	Declining	Declining	0.983	Declining
Hoopa	Stable	Declining since 2004	0.989	Stationary
Green Diamond	Declining	Declining	0.972	Declining

[1]Apparent survival calculations are based on model average.
[2]Population trends are based on estimates of realized population change.

Point estimates of λRJS were all below 1.0 and ranged from 0.929 to 0.996 for the 11 long-term study areas. There was strong evidence that populations declined on 7 of the 11 areas (Forsman et al. 2011, p. 65), these areas included Rainier, Olympic, Cle Elum, Coast Range, HJ Andrews, Northwest California and Green Diamond. On other four areas (Tyee, Klamath, Southern Cascades, and Hoopa), populations were either stable, or the precision of the estimates was not sufficient to detect declines.

The weighted mean λRJS for all of the 11 study areas was 0.971 (standard error [SE] = 0.007, 95 percent confidence interval [CI] = 0.960 to 0.983), which indicated an average population decline of 2.9 percent per year from 1985 to 2006. This is a lower rate of decline than the 3.7 percent reported by Anthony et al. (2006, p. 23), but the rates are not directly comparable because Anthony et al. (2006) examined a different series of years and because two of the study areas in their analysis were discontinued and not included in Forsman et al. (2011, p. 65). Forsman et al. (2011, p. 65) explains that the indication populations were declining was based on the fact that the 95 percent confidence intervals around the estimate of mean lambda did not overlap 1.0 (stable) or barely included 1.0.

The mean λRJS for the eight demographic monitoring areas (Cle Elum, Olympic, Coast Range, HJ Andrews, Tyee, Klamath, Southern Cascades and Northwest California) that are part of the effectiveness monitoring program of the NWFP was 0.972 (SE = 0.006, 95 percent CI = 0.958 to 0.985), which indicated an estimated decline of 2.8 percent per year on Federal lands with the range of the spotted owl (Forsman et al. 2011, p. 67). The weighted mean estimate λRJS for the other three study areas (Rainier, Hoopa and Green Diamond) was 0.969 (SE = 0.016, 95 percent CI = 0.938 to 1.000), yielding an estimated average decline of 3.1 percent per year. These data suggest that demographic rates for spotted owl populations on Federal lands were somewhat better than elsewhere; however, this comparison is confounded by the interspersion of non-Federal land in study areas and the likelihood that spotted owls use habitat on multiple ownerships in some demography study areas.

The number of populations that declined and the rate at which they have declined are noteworthy, particularly the precipitous declines in the Olympic, Cle Elum, and Rainier study areas in Washington and the Coast Range study area in Oregon. Estimates of population declines in these areas ranged from 40 to 60 percent during the study period through 2006 (Forsman et al. 2011, p. 66). Spotted owl populations on the HJ Andrews, Northwest California, and Green Diamond study areas declined by 20-30 percent whereas the Tyee, Klamath, Southern Cascades, and Hoopa study areas showed declines of 5 to 15 percent (Forsman et al. 2011, p. 66).

Decreases in adult apparent survival rates were an important factor contributing to decreasing population trends. Forsman et al. (2011, pp. 65-66) found apparent survival rates were declining on 10 of the study area with the Klamath study area in Oregon being the exception. Estimated declines in adult survival were most precipitous in Washington where apparent survival rates were less than 80 percent in recent years, a rate that may not allow for sustainable populations (Forsman et al. 2011, p. 66). In addition, declines in adult survival for study areas in Oregon have occurred predominately within the last five years and were not observed in the previous analysis by Anthony et al. (2006). Forsman et al. (2011, p. 64) express concern for the decline in adult survival rates across the subspecies range because spotted owl populations are most sensitive to changes in adult survival.

There are few spotted owls remaining in British Columbia. Chutter et al. (2004, p. v) suggested immediate action was required to improve the likelihood of recovering the spotted owl population in British Columbia. In 2007, personnel in British Columbia captured and brought into captivity the remaining 16 known wild spotted owls (USFWS 2011b, p. A-6). Prior to initiating the captive-breeding program, the population of spotted owls in Canada was declining by as much as 10.4 percent per year (Chutter et al. 2004, p. v). The amount of previous interaction between spotted owls in Canada and the United States is unknown.

1.5.3 Spotted Owl Recovery Units

The 2011 Final Revised Recovery Plan for the Northern Spotted Owl determined that the 12 existing physiographic provinces meet the criteria for use as recovery units (USDI FWS 2011b, p. III 1-2). The proposed project is within the Eastern Oregon Cascades Physiographic Province. Recovery criteria, as described in the 2011 Final Revised Recovery Plan (p. 11-3), are measurable and achievable goals that are believed to result through implementation of the recovery actions described in the recovery plan. Achievement of the recovery criteria will take time and are intended to be measured over the life of the plan, not on a short-term basis. The criteria are the same for all 12 identified recovery units. The four recovery criterion are: 1) stable population trend, 2) adequate population distribution, 3) continued maintenance and recruitment of northern spotted owl habitat, and 4) post-delisting monitoring (USDI FWS 2011b, p III-3).

As discussed in the Section 3.5.1, demographic data are used to evaluate trends in northern spotted owl populations. The Southern Oregon Cascades Demographic Study Area, which overlaps a portion of the Eastern Oregon Cascades Physiographic Province, is one of five demographic study areas in Oregon that are part of the Effectiveness Monitoring Program for Spotted Owls in the Northwest Forest Plan. A workshop was conducted to analyze range-wide demographic data of northern spotted owls in January 2004 and fecundity, apparent survival, and population trend were estimated for the Southern Oregon Cascades Study Area during the workshop for a period of 1985 to 2003 (Anthony et al. 2008, pp.23-24). Anthony et al. (2008, p. 24) found that apparent survival estimated from the model that "best fit" the data indicated that there were no sex related differences but that subadult (first and second year combined) survival differed from adult owls. Anthony et al. (2006) also found that the "best fit" model of fecundity incorporated a three-age-class effect, an odd-even year effect, and linear time trend. The model indicated that fecundity for the southern Cascades was possibly decreasing for the period of study. Results from this study also suggest that the population was stationary (neither increasing nor decreasing) during the period of the study. Similarly, Forsman et al. (2011) indicate that fecundity (young produced) within the Southern Oregon Cascades Study Area is declining. At the population scale, Forsman et al. (2011) indicate that the population in the Southern Oregon Cascades Study Area may be stable (Table 4); however, the precision of the estimates (95 percent confidence interval) may not be sufficient to detect declines in this population (Forsman et al. 2011).

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Gemmill Thin Project

APPENDIX B

NORTHERN SPOTTED OWL CRITICAL HABITAT

Conservation Role of Critical Habitat

Critical habitat contains those areas that are essential to the conservation of the species. The expectation of critical habitat is to ameliorate habitat-based threats. The recovery of the northern spotted owl requires habitat conservation in concert with the implementation of recovery actions that address other, non-habitat-based threats to the species, including the barred owl (USFWS 2012, p. 71879). The conservation role of northern spotted owl critical habitat is to "adequately support the life-history needs of the species to the extent that well-distributed and inter-connected northern spotted owl nesting populations are likely to persist within properly functioning ecosystems at the critical habitat unit and range-wide scales" (USDI FWS 2012, p. 71938). The specific conservation role of the subunit included in the action area is described in the Environmental Baseline in the document.

Physical or Biological Features and Primary Constituent Elements

When designating critical habitat, the Service considers "the physical or biological features [PBFs] essential to the conservation of the species and which may require special management considerations or protection" (50 CFR §424.12; USDI FWS 2012, p. 71897). "These include, but are not limited to: (1) space for individual and population growth and for normal behavior; (2) food, water, air, light, minerals, or other nutritional or physiological requirements; (3) cover or shelter; (4) sites for breeding, reproduction, or rearing (or development) of offspring; and (5) habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species" (USDI FWS 2012, p. 71897). The final critical habitat rule states that "for the northern spotted owl, the physical or biological features essential to the conservation of the species are forested areas that are used or likely to be used for nesting, roosting, foraging, or dispersing" (USDI FWS 2012, p. 71897). The final critical habitat rule for the northern spotted owl provides an in-depth discussion of the PBFs, which may be referenced for further detail (USDI FWS 2012, pp. 71897-71906).

The primary constituent elements (PCEs) are the specific elements of the PBFs that are considered essential to the conservation of the northern spotted owl and are those elements that make areas suitable as nesting, roosting, foraging, and dispersal habitat (USDI FWS 2012, p. 71904). The PCEs should be arranged spatially such that it is favorable to the persistence of populations, survival, and reproductive success of resident pairs, and survival of dispersing individuals until they are able to recruit into a breeding population (USDI FWS 2012, p. 71904).

Within areas essential for the conservation and recovery of the northern spotted owl, the Service has determined that the PCEs are:

1) Forest types that may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographic range;
2) Habitat that provides for nesting and roosting;
3) Habitat that provides for foraging;
4) Habitat to support the transience and colonization phases of dispersal, which in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCEs 2 or 3), but which may also be composed of other forest types that occur between larger blocks of nesting, roosting, or foraging habitat (USDI FWS 2012, pp. 72051-72052).

Some critical habitat subunits may contain all of the above PCEs and support multiple life history requirements of the northern spotted owl, while some subunits may contain only those PCEs necessary to support the species particular use of that habitat. All of the areas designated as critical habitat, however, do contain PCE 1, forest type. Therefore, PCE 1 always occurs in concert with at least one other PCE (PCE 2, 3, or 4; USDI FWS 2012, p. 72051). Northern spotted owl critical habitat does not include meadows, grasslands, oak woodlands, aspen woodlands, or manmade structures and the land upon which they are located (USDI FWS 2012, p. 71918).

PCE 1: Forest Types

The primary forest types that support the northern spotted owl are: Sitka spruce, western hemlock, mixed conifer, mixed evergreen, grand fir, Pacific silver fir, Douglas-fir, white fir, Shasta red fir, redwood/Douglas-fir, and moister ponderosa pine (USDI FWS 2012, p. 72051). Specific to the California Klamath Province, the western portions of this zone support a diverse mix of mesic forest communities interspersed with drier forest types. Forests of mixed conifers and evergreen hardwoods are typical of the zone. Eastern portions of this zone have a Mediterranean climate with increased occurrence of ponderosa pine.

PCE 2: Nesting and Roosting Habitat (California Klamath Emphasis)

Nesting and roosting habitat for northern spotted owl provides structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risk for adults and young. In many cases, the same habitat may also provide for foraging. Nesting and roosting habitats must provide: sufficient habitat for foraging by territorial pairs, moderate to high canopy closure (60 to over 80 percent), multilayered and multispecies canopies with large overstory trees (20 to 30 inches dbh), basal area greater than 240 square feet per acre, high diversity of tree diameters, high incidence of large live trees with various deformities (e.g., large cavities, broken tops, mistletoe infections, and other evidence of decadence), large snags and large accumulations of woody debris on the ground, and sufficient open space beneath the canopy for flight (USDI FWS 2012, p. 72051).

PCE 3: Foraging Habitat (California Klamath Emphasis)

Across the range of the northern spotted owl, nesting and roosting habitats also provide foraging opportunities; however, northern spotted owls may use other habitat types for foraging as well. The components of PCE 3 for northern spotted owl foraging habitat in the East Cascades are: stands of nesting and roosting habitat including stands composed of Douglas-fir and white fir/Douglas-fir, quadratic mean diameter of trees greater than 16.5 inches, higher densities of large trees (greater than 26 inches dbh) and higher basal areas leading to increased foraging habitat quality, large accumulations of fallen trees and other down woody debris, and sufficient open space beneath the canopy for flight (USDI FWS 2012, p. 72051).

PCE 4: Dispersal habitat

Northern spotted owl dispersal habitat is habitat that supports the transience and colonization phases of owl dispersal, and in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCE 2 or 3), but which may also be composed of other forest types that occur between larger blocks of northern spotted owl nesting, roosting, or foraging habitat. In cases where nesting, roosting, or foraging habitats are insufficient to provide for dispersing or nonbreeding owls, the specific dispersal PCEs are: habitat supporting transience phase of dispersal (protection from avian predators, minimal foraging opportunities, younger and less diverse forests that provide some roosting structures and foraging opportunities) and habitat supporting the colonization phase of dispersal (nesting, roosting, and foraging habitat but in smaller amounts than needed to support a nesting pair) (USDI FWS 2012, p. 72052).

Current Condition of Northern Spotted Owl Critical Habitat

The current condition of critical habitat incorporates the effects of all past human activities and natural events that led to the present-day status of the habitat (USDI and USDC 1998, pg. 4-19). With the revision of spotted owl critical habitat, the range-wide condition has been “reset” as of December 4, 2012.

Range-Wide Critical Habitat Baseline

The Service updated the ECOS Database to reflect the 2006/2007 habitat baseline developed for the NWFP 15-year monitoring report (Davis et al. 2011, Appendix D, Table D). This mapping effort indicates that approximately 9.577 million acres of spotted owl critical habitat existed in 2006/2007 (Table 1). As of July 18, 2013 the database reports 10,927acres have been removed or downgraded from critical habitat range-wide. The majority of these impacts originated in the Oregon Coast Range and Oregon Cascades (east and west) Physiographic Provinces, and less than half (3,207 acres) occurred in land use allocations under the NWFP that were intended to emphasize maintenance of spotted owl habitat values (i.e., late-successional reserves).

Thu Oct 24 14:46:58 MDT 2013

Physiographic Province[2]		Evaluation Baseline		Habitat Removed/Downgraded					% Provincial Baseline Affected	% Range-wide Effects
				Land Use Allocations[5]			Habitat Loss to Natural Events	Total		
		Total Designated Critical Habitat Acres[3]	Nesting/Roosting Acres[4]	Reserves	Non-Reserves	Total				
WA	Eastern Cascades	1,022,960	416,069	265	0	265	0	265	0.06	2.34
	Olympic Peninsula	507,165	238,390	6	0	6	0	6	0.00	0.05
	Western Cascades	1,387,567	667,173	18	0	18	0	18	0.00	0.16
OR	Cascades East	529,652	181,065	887	1,262	2,149	0	2,149	1.19	18.97
	Cascades West	1,965,407	1,161,780	223	2,701	2,924	0	2,924	0.25	25.81
	Coast Range	1,151,874	535,602	516	3,714	4,230	0	4,230	0.79	37.33
	Klamath Mountains	911,681	481,577	1,292	446	1,738	0	1,738	0.36	15.34
CA	Cascades	243,205	98,243	0	0	0	0	0	0.00	0.00
	Coast	149,044	58,278	0	0	0	0	0	0.00	0.00
	Klamath	1,708,787	752,131	0	0	0	0	0	0.00	0.00
Total		**9,577,342**	**4,590,308**	**3,207**	**8,123**	**11,330**	**0**	**11,330**	**0.12%**	**100%**

Notes:

1. Nesting, roosting, foraging (NRF) habitat. In California, suitable habitat is divided into two components; nesting - roosting (NR) habitat, and foraging (F) habitat. The NR component in CA most closely resembles NRF habitat in Oregon and Washington.

2. Defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as Recovery Units as depicted on page A-3.
3. Northern spotted owl critical habitat as designated December 4, 2012 (77 FR 71876). Total designated critical habitat acres listed here (9,577,342 acres) are derived from GIS data, and vary slightly from the total acres (9,577,969 acres) listed in the Federal Register (-627 acres).
4. Calculated from GIS data for spotted owl Nesting/Roosting habitat generated by Davis et al. 2011 for the Northwest Forest Plan 15-year Monitoring Report (PNW-GTR-850). NR habitat acres are approximate values based on 2006 (OR/WA) and 2007 (CA) satellite imagery.
5. Reserve land use allocations under the NWFP intended to provide demographic support for spotted owls include LSR, MLSA, and CRA. Non-reserve allocations under the NWFP intended to provide dispersal connectivity between reserves include AWA, AMA, and MX.

Zones *of Habitat Associations used by Northern Spotted Owls*

Differences in patterns of habitat associations used by the northern spotted owl across its range suggest four different broad zones of habitat use, which we characterize as the (1) West Cascades/Coast Ranges of Oregon and Washington, (2) East Cascades, (3) Klamath and Northern California Interior Coast Ranges, and (4) Redwood Coast (Figure 3.1). We configured these zones based on a qualitative assessment of similarity among ecological conditions and habitat associations within the 11 different regions analyzed during the critical habitat designation process (see USDI FWS 2012). These four zones capture the range in variation of some of the PBFs essential to the conservation of the northern spotted owl. Summarized below are the PBFs for each of these four zones, emphasizing zone-specific features that are distinctive within the context of general patterns that apply across the entire range of the northern spotted owl.

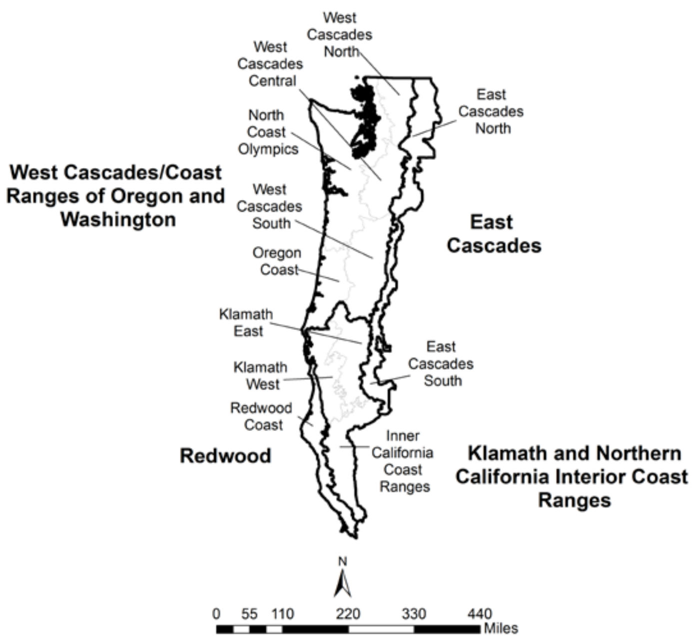

Figure 1. Eleven regions and four zones of habitat associations used by northern spotted owls in Washington, Oregon, and California.

West Cascade/Coast Ranges of Oregon and Washington

This zone includes five regions west of the Cascade crest in Washington and Oregon (Western Cascades North, Central and South; North Coast Ranges and Olympic Peninsula; and Oregon Coast Ranges; USDI FWS 2011, p. C–13). Climate in this zone is characterized by high rainfall and cool to moderate temperatures. Variation in elevation between valley bottoms and ridges is relatively low in the Coast Ranges, creating conditions favorable for development of contiguous forests. In contrast, the Olympic and Cascade ranges have greater topographic variation with many high-elevation areas supporting permanent snowfields and glaciers. Douglas-fir and western hemlock dominate forests used by northern spotted owls in this zone. Root diseases and wind-throw are important natural disturbance mechanisms that form gaps in forested areas. Flying squirrels (*Glaucomys sabrinus*) are the dominant prey, with voles and mice also representing important items in the northern spotted owl's diet.

Our habitat modeling indicates that vegetation structure has a dominant influence on owl population performance, with habitat pattern and topography also contributing. High canopy cover, high density of large trees, high numbers of sub-canopy vegetation layers, and low to moderate slope positions are all important features.

Nesting habitat in this zone is mostly limited to areas with large trees with defects such as mistletoe brooms, cavities, or broken tops. The subset of foraging habitat that is not nesting/roosting habitat generally had slightly lower values than nesting habitat for canopy cover, tree size and density, and canopy layering. Prey species (primarily the northern flying squirrel) in this zone are associated with mature to late-successional forests, resulting in small differences between nesting, roosting, and foraging habitats.

East Cascades

This zone includes the Eastern Cascades North and Eastern Cascades South regions (USDI FWS 2011, p. C–13). This zone is characterized by a continental climate (cold, snowy winters and dry summers) and a high frequency of natural disturbance due to fires and outbreaks of forest insects and pathogens. Flying squirrels are the dominant prey species, but the diet of northern spotted owls in this zone also includes relatively large proportions of bushy-tailed woodrats (*Neotoma cinerea*), snowshoe hare (*Lepus americanus*), pika (*Ochotona princeps*), and mice (*Microtus spp*. (Forsman et al. 2001, pp. 144–145).

Our modeling indicates that habitat associations in this zone do not show a pattern of dominant influence by one or a few variables (USDI FWS 2011, Appendix C). Instead, habitat association models for this zone included a large number of variables, each making a relatively modest contribution (20 percent or less) to the predictive ability of the model. The features that were most useful in predicting northern spotted owl habitat quality were vegetation structure and composition, and topography, especially slope position in the north. Other efforts to model habitat associations in this zone have yielded similar results (e.g., Gaines et al. 2010, pp. 2048–2050; Loehle et al. 2011, pp. 25–28).

Relative to other portions of the northern spotted owls' range, nesting and roosting habitat in this zone includes relatively younger and smaller trees, likely reflecting the common usage of dwarf mistletoe (*Arceuthobium douglasii*) brooms (dense growths) as nesting platforms (especially in the north). Forest composition that includes high proportions of Douglas-fir is also associated with this nesting structure. Additional foraging habitat in this zone generally resembles nesting and roosting habitat, with reduced canopy cover and tree size, and reduced canopy layering. High prey diversity suggests relatively diverse foraging habitats are used. Topographic position was an important variable, particularly in the north, possibly reflecting competition from barred owls (Singleton et al. 2010, pp. 289, 292). Barred owls, which have been present for over 30 years in the northern portions of this zone, preferentially occupy valley-bottom habitats, possibly compelling northern spotted owls to establish territories on less productive, mid-slope locations (Singleton et al. 2010, pp. 289, 292).

Klamath and Northern California Interior Coast Ranges

This zone includes the Klamath West, Klamath East, and Interior California Coast regions (USDI FWS 2011, p. C–13). This region in southwestern Oregon and northwestern California is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and large differences in moisture from west to east. Summer temperatures are high, and northern spotted owls occur at elevations up to 5,800 feet. The western portions of this zone support a diverse mix of mesic forest communities interspersed with drier forest types. Forests of mixed conifers and evergreen hardwoods are typical of the zone. The eastern portions of this zone have a Mediterranean climate with increased occurrence of the ponderosa pine. Douglas-fir/dwarf mistletoe is rarely used for nesting platforms in the western part of the northern spotted owl's range, but is commonly used in the east.

The prey base for northern spotted owls in this zone is correspondingly diverse, but dominated by dusky-footed woodrats, bushy-tailed woodrats, and flying squirrels. Northern spotted owls have been well studied in the western Klamath portion of this zone (Forsman et al. 2004, p. 217), but relatively little is known about northern spotted owl habitat use in the eastern portion and the California Interior Coast Range portion of the zone.

Our habitat association models for this zone suggest that vegetation structure and topographic features are nearly equally important in influencing owl population performance, particularly in the Klamath. High canopy cover, high levels of canopy layering, and the presence of very large dominant trees were all important features of nesting and roosting habitat. Compared to other zones, additional foraging habitat for this zone showed greater divergence from nesting habitat, with much lower canopy cover and tree size. Low to intermediate slope positions were strongly favored. In the eastern Klamath, the presence of Douglas-fir was an important compositional variable in our habitat model (USDI FWS 2011, Appendix C).

Redwood Zone

This zone is confined to the northern California coast, and is represented by the Redwood Coast region (USDI FWS 2011, p. C–13). It is characterized by a maritime climate with moderate temperatures and generally mesic conditions. Near the coast, frequent fog delivers consistent moisture during the summer. Terrain is typically low-lying (0 to 3,000 feet). Forest communities are dominated by redwood, Douglas-fir–tanoak (*Lithocarpus densiflorus*) forest, coast live oak (*Quercus agrifolia*), and tanoak series. Dusky footed woodrats are the dominant prey items for northern spotted owls in this zone.

Habitat association models for this zone diverged strongly from models for other zones. Topographic variables (slope position and curvature) had a dominant influence with vegetation structure having a secondary role. Low position on slopes was strongly favored, along with concave landforms.

Several studies of northern spotted owl habitat relationships suggest that stump-sprouting and rapid growth of redwood trees, combined with high availability of woodrats in patchy, intensively managed forests, enables northern spotted owls to occupy a wide range of vegetation conditions within the redwood zone. Rapid growth rates enable young stands to develop structural characteristics typical of older stands in other regions. Thus, relatively small patches of large remnant trees can also provide nesting habitat structure in this zone.

Climate Change and Range-wide Spotted Owl Critical Habitat

There is growing evidence that recent climate change has impacted a wide range of ecological systems (Stenseth et al. 2002, entire; Walther et al. 2002, entire; Ådahl et al. 2006, entire; Karl et al. 2009, entire; Moritz et al. 2012, entire; Westerling et al. 2011, p. S459; Marlon et al. 2012, p. E541). Climate change, combined with effects from past management practices, is exacerbating changes in forest ecosystem processes and dynamics to a greater degree than originally anticipated under the NWFP. Environmental variation affects all wildlife populations; however, climate change presents new challenges as systems may change beyond historical ranges of variability. In some areas, changes in weather and climate may result in major shifts in vegetation communities that can persist in particular regions.

Climate change will present unique challenges to the future of northern spotted owl populations and their habitats. Northern spotted owl distributions (Carroll 2010, entire) and population dynamics (Franklin et al. 2000, entire; Glenn et al. 2010, entire; Glenn et al. 2011a, entire; Glenn et al. 2011b, entire) may be directly influenced by changes in temperature and precipitation. In addition, changes in forest composition and structure as well as prey species distributions and abundance resulting from climate change may impact availability of habitat across the historical range of the subspecies. The *2011 Northern Spotted Owl Revised Recovery Plan* provides a detailed discussion of the possible environmental impacts to the habitat of the northern spotted owl from the projected effects of climate change (USDI FWS 2011, pp. III-5 to III-11).

Because both northern spotted owl population dynamics and forest conditions are likely to be influenced by large-scale changes in climate in the future, we have attempted to account for these influences in our designation of critical habitat by recognizing that forest composition may change beyond the range of historical variation, and that climate changes may have unpredictable consequences for both Pacific Northwest forests and northern spotted owls. Our critical habitat designation also recognizes that forest management practices that promote ecosystem health under changing climate conditions will be important for northern spotted owl conservation.

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From: Rob DiPerna <rob@wildcalifornia.org>
Sent: Thursday, May 01, 2014 2:14 PM
To: Wildlife Management
Subject: Attn: Neil Clipperton--Northern Spotted Owl supporting materials
Attachments: GainesEtAl1997.pdf; Keane 2010 (PLS CSO 2010 Report).pdf

Please see attached.

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From: Dan Hansen [mailto:danhansen03@gmail.com]
Sent: Thursday, May 01, 2014 1:43 PM
To: Rob DiPerna
Subject: Re: Fire discussion for comment letter

Do you need all of them--even the ones that you cited in your original draft? Here are the new ones that I added (one of the three is a webinar, for which I provided a link at the bottom of the draft).

Dan

On Thu, May 1, 2014 at 1:38 PM, Rob DiPerna <rob@wildcalifornia.org> wrote:

Thanks, Dan.

If you have them, can you send me the papers that are cited here? I don't have them and really don't have time to look them up at this point.

Thanks for all your efforts! See you in June!

Rob DiPerna

California Forest and Wildlife Advocate

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From: Dan Hansen [mailto:danhansen03@gmail.com]
Sent: Thursday, May 01, 2014 1:34 PM
To: Rob DiPerna
Subject: Fire discussion for comment letter

Hi Rob,

Great to see you and Gary today! Here's my very quickly written version of the fire section. Feel free to use all, part, or none of it as you see fit. FYI, for the status review, we will look at quite a bit more information than is discussed here--this is just to get CDFW on the right track.

Have a great vacation!

Dan

Proceedings — Fire Effects on Rare and Endangered Species and Habitats Conference, Nov. 13-16, 1995. Coeur d'Alene, Idaho.

Effects of the Hatchery Complex Fires on Northern Spotted Owls in the Eastern Washington Cascades

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Abstract. During the summer of 1994 the Hatchery Complex fires burned 17,603 ha in the east Cascades of Washington. These fires affected three habitat reserves and six activity centers for the northern spotted owl (*Strix occidentalis* caurina). The availability of spotted owl habitat within a 2.9 km radius of these activity centers was reduced by the direct effects of the fire, (average habitat loss=31%, range 8%-45%) but was also significantly reduced by delayed tree mortality and insect caused mortality (average habitat loss=55%, range 10%-85%). Fewer spotted owls occuppied and reproduced at these sites than in previous years. Spotted owl habitat located in riparian areas or on a bench was somewhat more likely to remain as fire refugia than habitat located on mid-upper slopes. This was especially true on south aspects. The availability of spotted owl habitat under current and inherent fire regimes was very dynamic across the east Cascades landscape. Appropriate management strategies may include strategically located low density fuel areas created to protect adjacent spotted owl habitat.

Introduction

Fires are a natural event within the eastside Cascades ecosystems (Agee 1994), however, fire suppression and logging have contributed to higher fuel loadings that can lead to higher fire intensity than would have inherently occurred (Agee and Edmunds 1992). The fires of 1994 were a dramatic example of this. Areas in which the inherent disturbance regime would have been low to moderate intensity and high frequency fires, burned as moderate to high intensity stand replacement fires. Several of these fires were part of the Hatchery Complex that included the Rat, Hatchery, Eightmile, Blackjack I and Blackjack II fires. In total these fires burned about 17,603 ha.

These fires burned within three areas that have been identified as Late-Succesional Reserves (USFS 1994 and 1995). These areas have management objectives to provide habitat for late- successional associated species, including the Threatened northern spotted owl (*Strix occidentalis* caurina). Agee and Edmunds (1992) stated that: "There is a very low probability that any (spotted owl habitat reserve) created in the East Cascades subregion will avoid catastrophic wildfire over a significant portion of its landscape over the next century." Thus the management dilema, while fire suppression may have increased the amount of suitable spotted owl habitat across the lanscape, it has also resulted in a greater risk of habitat loss due to catastrophic fires (Agee and Edmunds 1992, Buchanan et al. 1995). Management of these landscapes must consider the short-term habitat needs of the spotted owl and the risk associated with stand replacement fires.

Important in the management of these landscapes is understanding how fire affects spotted owls and their habitat. Our objectives were to quantify, as much as possible, the effects of the Hatchery Complex fires on spotted owl habitat, occupancy rates, and reproduction. In addition, the future risk to additional owl sites and possible management strategies will be presented.

Study Area

This study was conducted on the Leavenworth Ranger District, Wenatchee National Forest, located on the east side of the Cascades of Washington state (Figure 1). Elevations range from 650 meters to 1300 meters. The study area is composed of ponderosa pine (*Pinus ponderosa*) plant associations at lower elevations, and Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) plant associations at the mid-elevations.

Disturbances, such as fire, have been shown to have a significant influence on the vegetation patterns and processes of east Cascade landscapes (Gast et al. 1991, Agee 1994, Johnson et al. 1994, Harrod et al. 1996). Prior to fire suppression, fire occurred at relatively frequent intervals within east Cascade forests (Agee and Edmunds 1992). For example, within the ponderosa pine and dry Douglas fir plant series fire occurred at intervals of 10 to 25 years resulting in a forest structure largely composed of open park-like ponderosa pine forests (Agee 1991 and 1994). Fires in these forests were usually of low to moderate intensity.

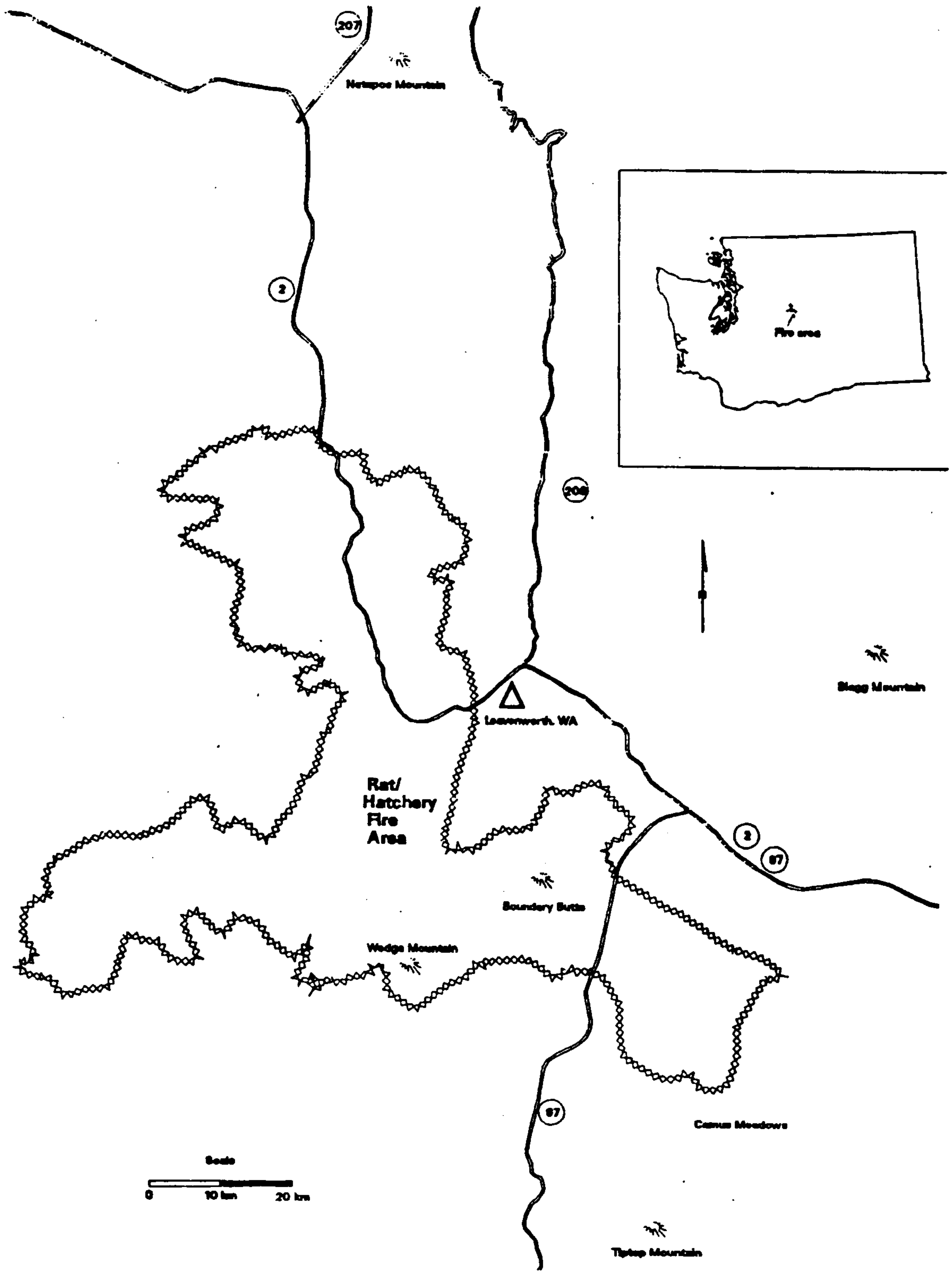

Figure 1. Vicinity map of the Rat and Hatchery Fires.

Fire suppression and logging have signficantly altered these forests. With the advent of effective fire supression technologies, fire frequency within these forests was significantly reduced (Agee and Edmunds 1992). In addition, logging practices until about 1950 often focused on removing the most fire tolerant species, the large ponderosa pine (Wellner 1984). The end result is that eastside forests are now composed of more shade tolerant tree species, are less fire tolerant, are at higher densities, and are more prone to large scale high intensity fires (Agee and Edmunds 1992, Camp 1995).

Methods

Habitat Inventory

Inventories of spotted owl habitat were completed from aerial photo-interpretation followed by field verification. These data were then loaded into MOSS geographic information system for habitat analyses. Habitat inventories were completed prior to the fire, immediately post-fire, and one year after the fires occurred in order to measure habitat changes over time. Suitable habitat was defined as having at least a 60% canopy closure presence of numerous snags and several down logs, and two or more canopy layers. The habitat mapping resolution was 0.8 ha.

Once habitat maps were developed an additional analysis was conducted to describe landscape features for habitat that was within the fire perimeter but remained suitable following the fire. This analysis was completed for all habitat within a 2.9 km radius around three of the six fire affected activity centers. A spotted owl activity center is the location in which there was a resident single, pair or nest site (USFS 1991). These three spotted owl activity centers were selected because they were distributed across the burned landscape, they were the most extensively affected, and there was no overlap in habitat within the 2.9 km radius. This information was developed to determine if habitat at particular landscape locations burned at proportions equal to, greater than or less than was available within the three activity centers. Habitat was classified into one of the following categories: north aspect (>270 to 89 degrees), south aspect (>90 to 270 degrees), riparian, valley (>300m wide), bench (<10% slope and >6 ha), and mid-upper slope.

Spotted Owl Inventories

The Region 6 spotted owl survey protocol was followed (USFS 1991). During 1995, spotted owl activity centers were surveyed regardless of how extensive the habitat was changed as a result of the fires. Sites were monitored to determine if spotted owls were present, and if so, their status: single, pair, or reproductive pair. If spotted owls were determined to be reproductive, additional monitoring was conducted to determine the number of young. Surveys and site monitoring were accomplished through a cooperative effort between the U.S. Forest Service, National Council on Air and Stream Improvement, and Natapoc Resources.

Data Analysis

A linear correlation analysis (Zar 1984) was completed to determine if there was a relationship between site status and the degree to which habitat was affected by the fires within a 0.8 km and 2.9 km radius. A Chi-Square Goodness of Fit test (Zar 1984) was used to determine if there was a significant difference between habitat burned vs habitat available at several locations on the burned landscape.

Persistence of Spotted Owl Nest Sites

Camp (1995) presents a probability model for the development of late-successional fire refugia under an inherent disturbance regime for the eastern Cascade mountains. Because spotted owl nesting habitat has been shown to be associated with these late- successional conditions (Buchanan et al. 1993, Buchanan et al. 1995) this model was used to show the potential for a fire under an inherent disturbance regime, at the 28 known nest sites on the Leavenworth Ranger District.

Results and Discussion

Habitat Availability

The availability of suitable spotted owl habitat within a 2.9 km radius of the six affected activity centers prior to the fire, immediately following the fire and one year post-fire are shown in Table 1. The average amount of habitat loss that occurred within a 2.9 km radius was 31% and ranged from 8% to 45%. The average amount of habitat lost within a 2.9 km radius as of one year after the fire was 55% and ranged from 10% to 85%.

These data show that a considerable reduction in habitat occurred as a result of the direct effects of the fire, however, additional habitat reductions occurred well after the fires were out. This occurred because trees damaged but not directly killed by the fires eventually died.

Table 1. Habitat availability pre-fire, post-fire, and one year post-fire within a 2.9 km radius of spotted owl activity centers (n=6), Hatchery Complex Fires.

Site No.	Pre-fire (ha)	Post-fire (ha)	1 Yr Post-fire (ha)
1	691	463	342
2	493	454	446
3	512	399	114
4	604	344	92
5	618	420	324
6	377	208	171

In addition, some trees that survived the fires have been killed by increased insect activity. It is expected that this trend will continue as insect populations increase, however the extent is not yet known.

The results of the analysis to determine if suitable habitat at various locations on the landscape burned in proportion to its availability are shown in Figures 2 and 3. Habitat located on north aspects and within riparian areas burned less than available, though not statistically different ($p>0.05$). Habitat on north slopes located on a bench burned at proportions equal to it's availability. Habitat on north slopes on the mid-upper part of the slope burned at levels slightly greater than available, but not statistically different than expected ($p>0.05$). On south slopes habitat located on a bench burned at levels that were significantly less than expected ($p<0.05$). Habitat located on south slopes and on the mid-upper portion of the slope burned at proportions greater than available, but not at levels significantly different than expected ($p>0.05$).

Site Status

The results of the spotted owl surveys at the six fire affected activity centers are shown in Table 2. Four of the six sites were not occupied during 1995. At one of these sites the fire overtook the activity center very rapidly and at extremely high intensity. It is likely that these owls did not survive the fire, and their activity center is likely no longer capable of supporting an owl pair. Habitat at an additional site was reduced to levels that make it unlikely that it could support spotted owls. This site was not occupied in 1995. Fewer of these activity centers were occupied in 1995 than at any time during the previous four years. In addition, only one site was reproductive, also the lowest level compared to the previous four years.

Site Status and Habitat Availability

There was no correlation between the habitat available within a 2.9 km radius one year post-fire and the site status ($\alpha=0.05$, $p>0.05$). There was, however, a cor-

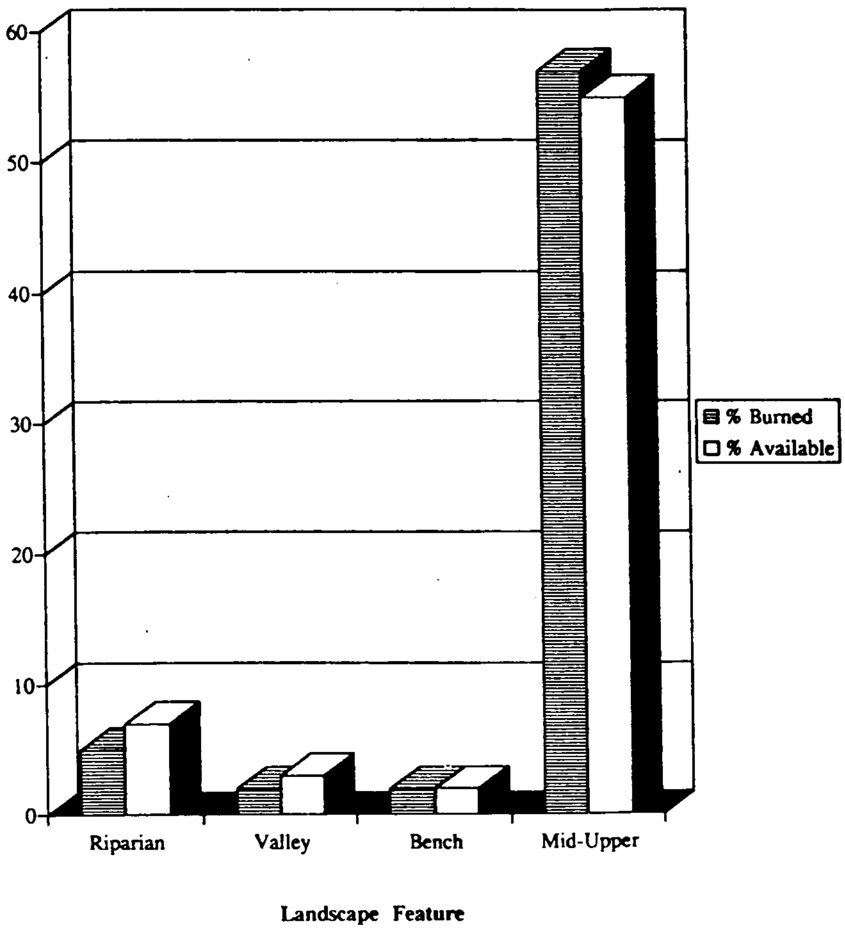

Figure 2. Proportion of spotted owl habitat that burned vs that available at various locations on north aspects, Hatchery Complex fires.

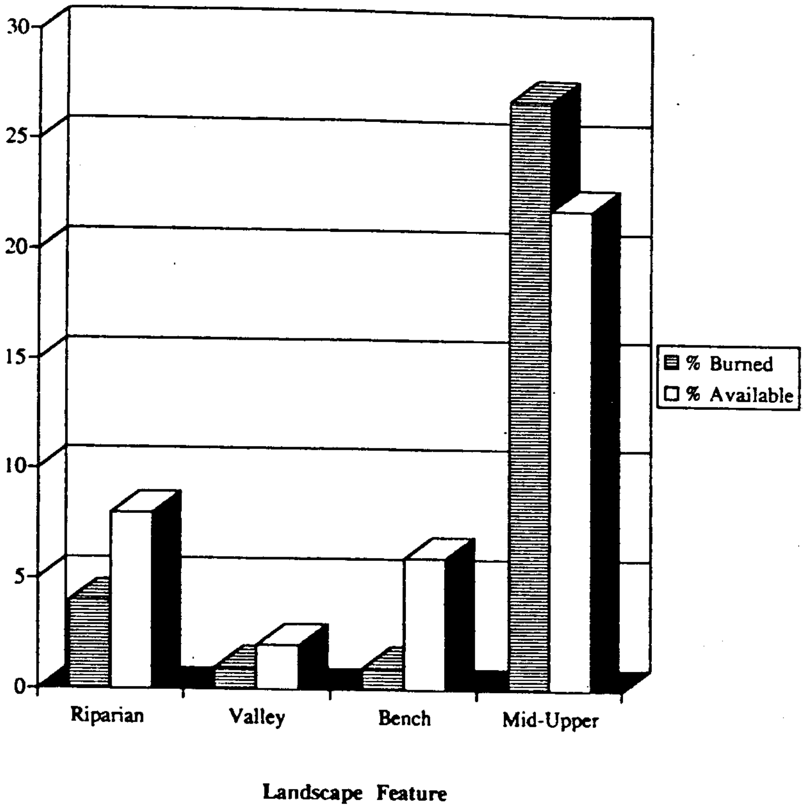

Figure 3. Proportion of spotted owl habitat that burned vs that available at various locations on south aspects, Hatchery Complex fires.

Table 2. Status of spotted owl activity centers for four years prior to the Hatchery Complex fires and one year following.

Status	1991	1992	1993	1994	1995
No Present	50%	25%	20%	17%	66%
Single		25%		33%	
Pair			20%	17%	17%
Reproductive	50%	50%	60%	33%	17%
No. sites	4	4	5	6	6

relation between site status and the amount of habitat remaining after the fire within a 0.8 mile radius (alpha=0.05, $p<0.05$). As the availability of habitat increased so did the site status (no presence being low status and reproductive pair being the highest status).

Reproduction

Data from all owl sites on the Leavenworth Ranger District were used to compare reproduction at burned vs unburned sites. These data are shown in Table 3. The 1995 season (one year post burn) was lower than any of the previous four years at the sites affected by the fires. However, reproduction during 1994 was also quite low, and as shown in Table 3, 1995 was overall a low year for reproduction. Reproduction, at least one year post-fire was not reduced much below previously reported low years.

Spotted Owl Nest Sites and Inherent Fire Regime

A total of 28 nest sites on the Leavenworth Ranger District were evaluated using the fire refugia model developed by Camp (1995). The results of this evaluation are shown in Figure 4. Two (7%) of the nest sites were in

Table 3. Comparison of # young/site at spotted owl activity centers affacted and not by the Hatchery Complex fires.

Site Data	1991	1992	1993	1994	1995
Affected by fires (# young/site)	0.6	1	0.8	0.3	0.2
No. sites	5	5	6	6	6
Not affected fy fires (# young/site)	0.9	1.3	.03	1.8	0.3
No. sites	13	15	15	14	17

locations where there was only a 2% probability of them remaining as fire refugia under an inherent fire regime. Fourteen (50%) of the sites occurred at a position on the landscape in which there was a 10% probability of them remaining as fire refugia under an inherent disturbance regime. Eleven (39%) of the nest sites occurred at locations in which there was a 19% probability, and 1 (4%) was at a location in which there was a 51% probability of them remaining as fire refugia. This assessment examplifies the dynamic nature of spotted owl habitat across a landscape in which fire played its inherent role. This is especially true on forests on the east side of the Cascades where relatively dry conditions resulted in frequent fires (Agee 1994).

Conclusions

Because data from only one season has been collected up to this point, conclusions must be mae very cautiously. Additional monitoring of these sites will occur in succeeding years and data may support the findings made in this initial evaluation or it may provide new insights. However, at this point the following observations about the effects of the Hatchery Complex fires on spotted owls and their habitat have been made.

The fires reduced the availability of spotted owl habitat around six activity centers. The initial direct reduction caused by the fire was not an accurate reflection of the total affects on habitat availability. Fire damaged trees continued to die, and increased insect activity contributed to the total reduction in spotted owl habitat within the burned landscape.

Habitat located within riparian areas and on a bench is somewhat more likely to remain as suitable following a fire vs habitat located on the mid-upper slopes, especially on south slopes. This information should be useful in the development of management plans for habitat reserves.

In the six fire affected activity centers there was a decrease in the number of reproductive pairs and an increase in the number of sites not occupied. Direct mortality likely occurred at one of the sites as a result of rapid and intense fire.

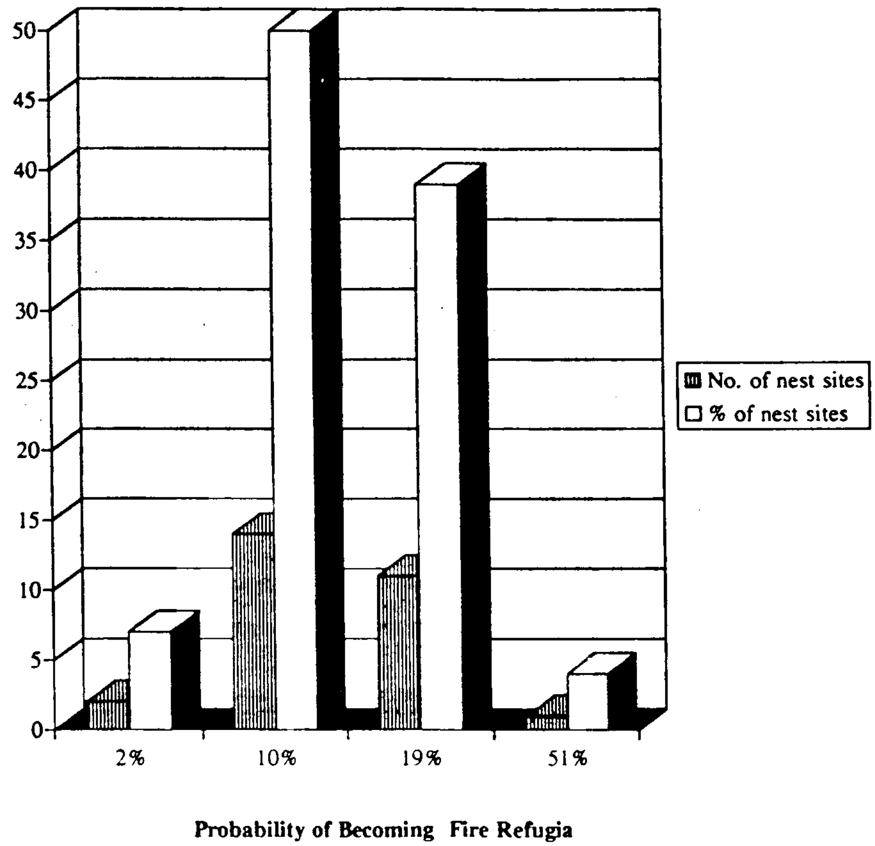

Figure 4. Persistence of spotted owl nest sites (n=28) using the Fire Refugia model (Camp 1995), Hatchery Complex fires.

The availability of spotted owl habitat across the eastern Cascades landscape appears to have been very dynamic under inherent disturbances (Camp 1995). This is an important consideration when developing management strategies for habitat reserves. The fire refugia model developed by Camp (1995) and information from this study should be useful in developing strategies that result in the highest probability of sustaining spotted owl habitat.

Management of fuel loading and tree density within habitat reserves may be neccessary to protect activity centers (Agee and Edmunds 1992). Strategically located low fuel density areas could accomplish dual objectives: protection of adjacent spotted owl habitat and restoration of fire climax ponderosa pine.

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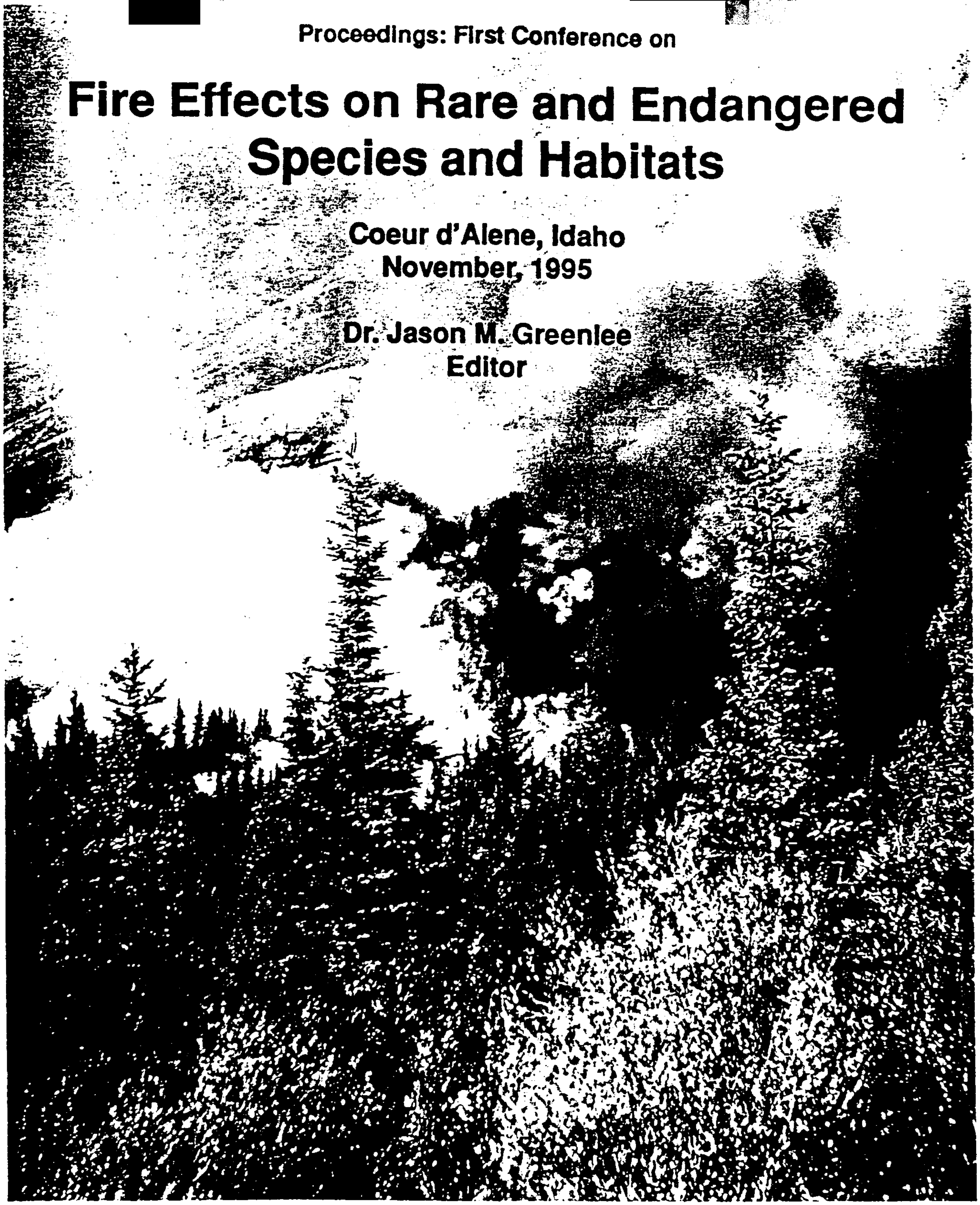

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California Spotted Owl Module: 2010 Annual Report

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Introduction

Knowledge regarding the effects of fuels and vegetation management on California spotted owls (***Strix occidentalis occidentalis;*** CSOs) and their habitat is a primary information need for addressing conservation and management objectives in Sierra Nevada forests. The specific research objectives of the California spotted owl module as identified and described in the Plumas-Lassen Study (PLS) Plan are:

1) What are the associations among landscape fuels treatments and CSO density, distribution, population trends and habitat suitability at the landscape-scale?

2) What are the associations among landscape fuels treatments and CSO reproduction, survival, and habitat fitness potential at the core area/home range scales?

3) What are the associations among landscape fuels treatments and CSO habitat use and home range configuration at the core area/home range scale?

4) What is the population trend of CSO in the northern Sierra Nevada and which factors account for variation in population trend?

5) Are barred owls increasing in the northern Sierra Nevada, what factors are associated with their distribution and abundance, and are they associated with reduced CSO territory occupancy?

6) Does West Nile Virus affect the survival, distribution and abundance of California spotted owls in the study area?

7) What are the effects of wildfire on California spotted owls and their habitat?

Our focus in 2010 was to conduct landscape inventories of CSO distribution and abundance, and continue banding to provide the required data and baseline information to meet the objectives of Research Questions 1-4 identified above. Current information on the distribution and density of CSOs across the HFQLG study area is required to provide the data necessary to build predictive habitat models and provide baseline population information against which we will assess post-treatment changes in CSO populations and habitat. Continued monitoring on the Lassen Demographic Study Area is critical for estimating CSO population trends and status. Complete landscape inventory surveys were conducted across 9 of the 11 original project survey areas in 2010 (Figure 1). Surveys were not conducted in 2 survey areas in 2006-2010 (SA-5, SA-7, Figure 1); sufficient data for determining the number and distribution of CSO sites for initial habitat modeling efforts was collected in these areas from 2004-2005. In 2010, we conducted a second year of surveys in two proposed project areas on the Lassen NF (Scotts John) and Plumas NF (Empire). We added these two new survey areas to the project in 2009 to bring our sample size of survey areas slated for treatment to four (Meadow Valley, Creeks, Scotts John, Empire).

Details on survey methods are described in the study plan. Efforts were made to monitor the pair and reproductive status of each owl, and to capture, uniquely color-mark, and collect blood samples from each individual owl across the study area. Capture and color-marking is necessary to estimate survival and population trend, and to assess exposure to West Nile Virus (WNV) (Research Question #5). We also recorded all barred and hybrid barred-spotted owls encountered in the study area and synthesized all existing barred owl records for the northern Sierra Nevada to address Research Question #6. Additionally, we completed a radio-telemetry study on CSOs within SA-4 in the Meadow Valley project area to document home range size and configuration, and to assess habitat associations relative to the recently implemented treatments. In response to a need for information on the association between CSOs and wildfire we conducted a second year of surveys to assess CSO distribution, abundance and habitat associations in the Cub Onion Complex fire area (COCFA) on the Lassen NF. The information from the COCFA complements our data from the Moonlight-Antelope Complex fire area (MACFA) collected in 2008-2009. The MACFA fires burned in 2007 and we conducted surveys in 2008 and 2009 to assess the immediate post-fire response of CSOs. The COCFA burned in 2008 and we conducted surveys in 2009 and 2010. For both study areas, we surveyed for CSOs in the first and second years immediately post-fire. Finally, we completed an analysis of the demographic data from the Lassen Demographic Study area collected through 2010 to provide the most current information on the status, demography and population trend of CSOs in the northern Sierra Nevada.

Results

CSO Numbers, Reproductive Success, Density and Population Trends:

A total of 71 territorial CSO sites were documented across the core PLS study area in 2010 (Figure 2). This total consisted of 58 confirmed pairs, 3 unconfirmed pairs (i.e., one member of pair confirmed as territorial single plus single detection of opposite sex bird), and 10 territorial single CSOs (single owl detected multiple times with no pair-mate detected). Thirty-one pairs successfully reproduced in 2010 (50.8% of confirmed/unconfirmed pairs). Of these 31 pairs, 18 were located on the Lassen Study Core Area and 13 were located on the Plumas NF. A total of 54 fledged young were documented in 2010 (1.74 young per successful nest) (Table 1). Across the last seven years of the study, CSO reproduction has been highest in 2004, 2007, 2009 and 2010 in terms of the percent of CSO pairs that successfully reproduced, and in terms of the number of young fledged per successful nest. Approximately 50% of CSO pairs successfully reproduced in 2004, 2007, 2009 and 2010 whereas the proportion of pairs successfully reproducing ranged between 14%-18% in 2005, 2006 and 2008. The number of young produced per successful nest was more similar across years, ranging between 1.47 -1.81. Our second year of surveys conducted in 2010 within two project areas yielded 4 pairs (2 pairs present in 2009) of CSOs in the Empire project area and 2 pairs (3 pairs present in 2009) in the Scotts John project area. Two pairs in the Empire project area reproduced in 2010 producing 3 fledglings, whereas neither pair reproduced in the Scotts John project area.

CSO reproduction is known to vary with spring weather: precipitation patterns were more similar in 2004 and 2007, with total precipitation relatively low during March-April of 2004 and 2007 as compared to 2005 and 2006 (Figure 3). From 2004 through 2007, CSO reproduction was high in years of low spring precipitation and low in years with high spring precipitation. However, this pattern between spring precipitation and reproduction varied during 2008-2010. In 2008 spring precipitation was low in March-April, yet CSO reproduction was also low. In contrast, during 2009 spring precipitation was high in February-March, low in April, and CSO reproduction was high on the Lassen portion of the study area and low on the Plumas portion of the study area. In 2010, precipitation was moderate and consistent over the February-May period and CSO reproduction was high. These patterns indicate that additional factors influence CSO energetics and are associated with annual variation in CSO reproduction. Potential factors include elevational variation in cold and hot temperatures, precipitation, duration of spring/summer and snowpack, in addition to annual variation in prey populations.

The Lassen Demographic Study Area (SA-1A, SA-11, SA-12, SA-13, SA-14, SA-15) and Plumas NF Survey Areas (SA-2, SA-3, SA-4, SA-5, SA-7) were fully integrated in 2005 to define the overall Plumas-Lassen Study project area and provide consistent CSO survey effort across the project area (Figures 1 & 2). We estimated the crude density of CSOs based on the number of territorial owls detected across 9 survey areas during 2010 at the Survey Area spatial scales (Tables 2 and 3). The estimated crude density across the overall study area in 2010 was 0.070 territorial owls/km^2. Overall study area crude densities are not directly comparable across years because different total areas were surveyed in each year. However, crude density estimates within individual Survey Areas indicate similar densities and number of territorial sites (pair sites plus territorial single sites) between 2004-2010 for the survey areas on the Plumas NF (SA-2, SA-3, SA-4). while numbers have declined somewhat on the Lassen survey areas (SA-1A, SA-11, SA-12, SA-13, SA-14, SA-15) between 2005-2007 and then stabilized or slightly increased between 2008-2010 (Tables 2 and 3).

We conducted a 5-year update and re-analyzed the demographic data through 2010 following the methods described in Blakesley et al. (2010). These data continue to provide the best estimates of CSO population trends. The Lassen Demographic Study Area is contained within the overall PLS study area and consists of survey areas SA-1A, SA-11, SA-12, SA-13, SA-14 and SA-15 in Figure 1. The estimated mean lambda for the Lassen Demographic Study between 1990-2010 was 0.979 (SE = 0.0097), with 95% confidence limits ranging from 0.959-0.999 (Scherer et al 2010). There was no evidence of linear, quadratic or pseudo-threshold trends in lambda, rather the means model was strongly supported by the data. These results suggest a decline in the CSO population within the Lassen study area over the 20-year study period. Annual lambda estimates from the best model ranged between 0.87-1.13. Estimates of realized population change based on the time series of lambda estimates generated from our modeling suggests that there have been declines in the number of territory holding CSOs within the study area (Scherer et al. 2010). These updated results are similar to the findings reported for the the 1990-2005 period reported in Blakesley et al. (2010).

Habitat Assessment – Nest/Roost Plot Scale

We documented a total of 103 CSO territorial sites between 2004-2006. We overlayed the primary nest/roost locations for each of the 103 CSO sites with the CWHR vegetation classes available within the VESTRA photo-interpreted vegetation map for the PLS to examine nest/roost-site habitat association patterns. Approximately 53% of the nest sites were located within CWHR 5M, 5D and 6 size classes (Table 4, Figure 4). An additional 37% of the sites were located within CWHR size class 4M and 4D polygons. CWHR size class 4 is defined as stands with average tree sizes of 12-24 inch diameter-at-breast-height (dbh) trees. Of the 38 sites located in size class 4 polygons, 25 (66%) were in size class 4 polygons with a large tree component (i.e., presence of >24 inch dbh trees). Overall, about 90% of the sites were located within CWHR 4M, 4D, 5M, 5D, and 6 size classes. The remaining 10 sites were located in more open, smaller-tree size polygons, with nests or roosts located within remnant, scattered larger trees (Table 4, Figure 4).

While the distribution of nest site locations relative to broad vegetation classes provides insight into patterns of nest-site habitat, we also conducted vegetation sampling at nest or primary roost sites to describe vegetation structure and composition. Vegetation plot sampling was conducted at 80 CSO territories across 2005-2007. Vegetation plots were centered on CSO nest trees, or on a primary roost tree for sites where no nest has been documented, and were measured using the national Forest and Inventory Assessment (FIA) protocol. The FIA protocol is used nationally by the USDA Forest Service for inventorying and monitoring vegetation. FIA sampling consists of measuring vegetation structural and compositional variables within a 1-ha plot centered on a CSO nest or roost tree. Only one plot was collected from each CSO territory, with the most frequently used nest tree serving as the plot center location, or the most recent nest tree used at sites where no nest tree was used more frequently than another. CSO nest sites were characterized by mean total basal areas of 260.8 ft^2/acre, 7.4 snags (>15 inch dbh)/acre, and 10.7 trees (>30 inch dbh)/acre (Table 5). Under the FIA protocol, canopy cover is modeled based on the tree inventory list. The modeled canopy cover for these plots averaged 64.1%. Shrub cover averaged 7.7%. Fuel loads averaged 0.75 tons/acre for 1-hr fuels, 4.0 tons/acre for 10-hr fuels and 4.44 tons/acre for 100-hr fuels (Table 5). Use of the FIA sampling protocol will facilitate monitoring of vegetation and development of CSO habitat models that can be used as adaptive management planning tools. Habitat models are currently being evaluated that can be used to assess projected changes in CSO nesting habitat suitability under varying fuels and vegetation treatment scenarios.

Habitat Assessment – Core Area/Home Range Scale

Core area habitat associations around 102 CSO nest and roost sites was assessed by using a Geographic Information System (GIS) and the VESTRA photo-interpreted vegetation map to determine the vegetation patterns within a 500 acre (201 ha) circle centered on each of the CSO territory sites. To compare the CSO sites with the general availability of habitat across the study area we also assessed the same vegetation patterns around 130 points determined by placing a systematic grid across the study area. For this summary we assessed vegetation using the USDA Forest Service Region 5 classification system. Overall, CSO core areas averaged 75.7% suitable habitat (classes 3N, 3G, 4N, 4G) whereas the grid points averaged 61.9% (Table 6, Figure 5). Approximately 32% of CSO core areas was composed of large tree polygons (>24inch dbh, >=40% canopy cover) compared to 19.6% of the grid points (Table 6, Figure 6).

Meadow Valley Project Area Case Study

The Meadow Valley Project Area (MVPA) is the first area within the PLS where the full implementation of HFQLG treatments has occurred. Treatments were implemented on the ground within this project area during 2001-2008, with primarily light-thinning and underburning occurring in 2001-2005, and Defensible Fuel Profile Zones and Group Selections implemented during 2005-2008. The MVPA corresponds closely with the boundaries of SA-4 of the PLS (Figure 7).

We began monitoring CSOs SA-4 in 2003 and have annually monitored the distribution, abundance and reproduction of CSOs within SA-4. Additionally, we have color-banded all individuals within this area, with the exception of one male who could not be captured. Full survey methods are described in detail in our study plan (available from field project leaders) and are consistent with USDA Forest Service R5 survey methods. Briefly, we conduct 3 nocturnal broadcast surveys during the breeding period (April-August) across a network of survey points to detect CSOs. When a CSO is detected we then conduct dusk status surveys to pinpoint roost and nest locations for each bird. Status surveys are used to determine the social status of each bird (pair or single), nesting and reproductive status (breeding, non-breeding, unknown), and to identify color-banded individual birds.

In general, in years of higher CSO reproduction, such as occurred in 2004 and 2007, it is easier to establish pair and reproductive status and to identify individual birds as they are more vocal and exhibit stronger ties to their core areas. In years of lower reproduction, such as occurred in 2005, 2006, 2008, and 2009 (reproduction was low on the Plumas NF, while high on the Lassen NF portion of the study area in 2009) it is more difficult to determine the status of birds as they tend to range more widely and are not as vocal and territorial, particularly the females. Based on our cumulative survey results, we then use accepted, standardized methods for estimating the overall number of territorial sites (confirmed pairs, unconfirmed pairs and territorial singles) for each year. Confirmed pairs consist of a reproductive pair of CSOs or, at non-reproductive sites, the detection of a male and female on more than one occasion within 1/2-mile of each other across the breeding period. Unconfirmed pairs consist of at least two sightings of one sex but only one detection of the opposite sex within 1/2-mile of each other across the breeding period. Territorial singles are considered to be individuals that are detected on at least 2 occasions within a 1/2-mile distance across the breeding period without a detection of the opposite sex. Birds detected on only a single occasion across the breeding period are not considered to be territorial.

Figure 7 illustrates treatment project areas and the cumulative number and distribution of CSO territorial sites across the seven years between 2003-2010. The number of territorial sites across SA-4 varied annually between 6-9 (Table 7, Fig. 8a&b). Overall, the numbers of territorial sites was fairly similar with 7 sites documented between 2004-2006, an increase to 9 territorial sites during the high reproductive year that occurred in 2007, decreasing to 6 territorial sites in both 2008 and 2009, with 7 sites documented in 2010.

Whereas we have not detected much change in the number of CSO territorial sites across SA-4, we have documented changes in occupancy status and spatial movements of individual sites that may be associated with treatments. The Maple Flat site, located in the NW corner of SA-4 was occupied from 2004-2007, not occupied in 2008 following treatments in autumn 2007, and was colonized by an unconfirmed pair of new CSOs who were present in the area during 2009 and 2010. Whether or not the treatments caused the site to be unoccupied in 2008 is uncertain as the male also died during the winter of 2007-2008 (determined by radio-telemetry). The female from 2007 visited the site in early 2008 then moved and summered 14.5 km (9 miles) from Maple Flat near Seneca in early June 2008. She remained in this area through October 2008 when she was recaptured and the radio-transmitter was removed. No new CSOs were detected or colonized the Maple Flat site in 2008.

We also observed movement of a site in the SW corner of SA-4 that corresponded to the timing of treatments in the nest core. This site (Miller Fork) was occupied by CSO pairs in 2003-2005, a single male in 2006 following treatments in 2005-2006, and then was not occupied between 2007-2009. However, a new CSO pair established a site (Big Creek) in 2007 about 2km to the NW of this site. This new site has been occupied by a pair from 2007-2010.

Changes in occupancy status were recorded at a third site that coincided with the timing of treatments. A pair of CSOs occupied Whitlock Ravine from 2003-2008. Treatments were implemented near the core area during 2008. The female CSO was found with a broken wing alongside a road in November 2008. In 2009, the historic male occupied the site as a single male. No CSOs occupied the site in 2010; the male was located 8.1 km (5 mi) southwest of Whitlock Ravine.

CSO pairs were present at Deer Creek from 2003-2007 and fledged triplets in 2007. The female died during the winter 2007-2008 and the site was not occupied from 2008-2010. Treatments had been conducted to the south of the core area of this pair in 2006 and the female was observed to forage in this area in 2007.

We also documented changes in occupancy at 1 site in the eastern portion of SA-4 that were outside the area of treatments. Slate Creek was occupied by a male in 2003 and a pair in 2004, yet has not been occupied since. The female from 2004 was detected on the Lassen NF, and then she was back on the Plumas in subsequent years. This female was not detected in 2009 but was again observed in 2010.

We documented the colonization of a new site (Pineleaf Creek) during and following treatments in the north portion of SA-4. A single territorial male was present in this area in 2006, with a pair of CSOs then present from 2007-2010. This pair successfully reproduced in 2009.

To date, we have not observed dramatic changes in the numbers of territorial CSO sites within SA-4 as an immediate acute response to treatments. These initial findings should be tempered by the need to assess possible chronic, or longer-term, responses by CSOs. Of importance, 2008 and 2009 were low reproductive years on the Plumas NF, with only 2 nests in 2008 and 7 nests in 2009 documented across all of the Plumas NF sites. The conditions leading to the low reproductive activity in 2008 and 2009 may have resulted in a low probability of recruitment and occupancy of sites in both years. For example, a higher number of territorial sites (9) were documented within SA-4 in the higher breeding year of 2007 as compared to the 7 territorial sites documented in the low reproductive years of 2005-2006. Also, higher CSO reproduction in 2007 may result in increased number of recruits available to colonize sites in 2009-2010. In 2010, we again documented 7 territorial sites. Thus far in our study, this landscape has supported 6-7 CSO territorial sites in each year, except for the high reproductive year in 2007 when 9 territorial sites were documented. We recommend that monitoring be continued to assess: (1) long-term occupancy, abundance and distribution of CSOs across the project area to document longer-term responses to address concerns that site fidelity in such a long-lived species may obscure possible negative effects of habitat change over the short term; and (2) to continue to monitor color-banded birds to assess longer-term associations between CSO survival, reproduction, and recruitment related to changes in habitat. Each of the pieces of above information is necessary to fully assess the potential acute and chronic responses of CSOs to landscape treatments.

Whereas we have not observed dramatic short-term changes in CSO numbers across the broader MVPA in response to treatments, we have documented some changes in the distribution and occupancy of CSO territories where treatments have occurred within SA-4 that may be associated with treatments. Accurate spatial post-treatment maps for the MVPA have been recently completed (March 1, 2010) documenting: (1) the specific locations where treatments were actually implemented on the ground; (2) the specific site-specific treatments that were implemented on a piece of ground; and (3) when the treatments were implemented on the ground (which year at minimum). Unfortunately, significant errors in the classification of canopy cover within base vegetation maps were discovered in 2010 while conducting habitat analyses and modeling exercises designed to explore the association between CSOs, their habitat, and treatments. This resulted in the need to recreate an updated landscape vegetation map for the project area. This updated vegetation map for MVPA is scheduled to be completed by March 2011. Understanding the what, where, when, and effects of treatments is the foundation on which subsequent adaptive management assessments will be constructed. This information has been difficult to obtain and is required to be able to explore the associations between treatments and CSO responses at the landscape and home range spatial scales, in addition to relating within home range habitat use through our telemetry studies.

Radio-Telemetry – Meadow Valley Project Area

Our landscape-scale research in the MVPA provides insight into CSO response at population and territory spatial scales. Within home ranges, CSOs may also respond to treatments in terms of selection of foraging habitat. To evaluate spotted owl foraging and home range characteristics in a landscape recently modified by fuels-reduction treatments, we radio-marked and tracked 9 CSOs in the MVPA area from April 2007-October 2008. Prior to this study, spotted owl foraging patterns in post-treatment landscapes had not been well-described. This telemetry study was designed to explore initial behavioral responses of California spotted owls to fuels treatments by characterizing home range configuration and foraging site selection immediately following treatment installation.

We gathered 446 owl foraging locations across 2 breeding seasons, and categorized fuels treatments into 4 types: Defensible Fuel Profile Zones (DFPZs), understory thin (removal of trees <10-inches diameter); group selection (removal of all trees <30-inches diameter in <0.8-ha patches); and understory thin followed by underburn. We estimated owl home ranges from 30-60 owl locations per home range, using a fixed kernel density estimator; only owl locations with an error ellipse <1.5 ha were used in analyses. We evaluated spotted owl home range size and composition using repeated measures analysis of variance (ANOVA) and resource selection functions. To analyze owl foraging patterns within home ranges, we evaluated a priori hypotheses using an information-theoretic approach and Akaike's Information Criterion corrected for small sample sizes.

During the 2007 season, we gathered 236 nocturnal use locations across all individuals, with 4 locations occurring within fuels treatments. In 2008, we gathered 210 nocturnal use locations, and 32 of these locations occurred within fuels treatments. Spotted owls used all treatment types for nocturnal activities on at least one occasion; 51% of within-treatment locations were accounted for by one spotted owl foraging repeatedly in underburn.

At the landscape scale, owl home ranges contained fuels treatments in proportion to their availability on the landscape. Owl home ranges contained 7-35% fuels treatments ($\bar{x}$= 16%), with home range size positively correlated with the total amount of fuels treatment within the home range (p=0.049). Spotted owls selected against DFPZs (p=0.006), but not other fuels treatments, for nocturnal activities; we hypothesize that the habitat character of DFPZs may be unfavorable for common spotted owl prey species (Figure 9). One owl strongly selected underburn treatments over untreated forest for foraging; limited availability of underburn within the study area prevents further extrapolation of this result. Spotted owls foraged much closer to their site center than expected by chance; because fuels treatments are not permitted within PACs (located at most owl site centers), the required travel distance between the site center and fuels treatments complicates result interpretation. Conclusions from this study are exploratory and are intended to provide a baseline for further research (Gallagher 2010).

Our next action, scheduled for completion in 2011, is to use a detailed landscape-scale habitat map to incorporate habitat metrics into home range and foraging analyses. The plot-scale vegetation structure and composition will also be analyzed at a subsample of CSO radio-telemetry locations. Eighty-seven vegetation plots were measured to the standard FIA protocol between August-November 2008, and forty-five additional vegetation plots were measured to the same protocol in September-October 2009.

We recommend further exploration of spotted owl use of fuels treatments, particularly underburn, across multiple time periods and at patch, home range, and landscape spatial scales. Additionally, considerations should be given to the design and implementation of rigorous experimental studies to address the effects of fuels treatments on spotted owl nesting and foraging habitat. A repeat of this study in 4-5 years, coupled with a study of spotted owl population dynamics, would provide a comprehensive assessment of owl response in the MVPA area. Evaluation of long-term effects is critical for long-lived species such as the spotted owl (Blakesley et al. 2010); effects of fuels treatments on the owl may manifest after short and long time periods, each with ramifications for ecological understanding in the Sierra Nevada.

Wildfire –California Spotted Owl Case Studies

A primary source of uncertainty regarding the effects of fuels treatments is an assessment of risk to CSOs and their habitat from treatments versus the risk from wildfire that occurs across untreated landscapes. Prior to 2008 our PLS work had focused on assessing CSO distribution, abundance and habitat associations across the untreated overall project area landscape and being in position to monitor effects as treatments are implemented within specific project areas, as illustrated by the MVPA case study described above. Beginning in 2008 we were fortunate to have the opportunity and funding support from the Plumas and Lassen National Forests to extend our work to inventory CSO distribution, abundance, and status across the Moonlight and Antelope Complex fire area (MACFA) that burned on the Plumas National Forest in 2007. In 2009 we conducted a second year of surveys in the MACFA and also conducted the first year of similar surveys in the Cub-Onion Complex fire area (COCFA) that burned on the Lassen National Forest in 2008. As described below, the MACFA was largely a high severity wildfire while the COCFA burned primarily at low-moderate severity. In 2010 we conducted a second year of surveys in the COCFA. Incorporating these two study areas which differ in wildfire severity allow us to directly assess response of CSOs to landscapes that burned with different severities.

The MACFA consists of two fires burned adjacent to each other in 2007 and both were primarily high severity fires (Fig. 10). The MACFA covers approximately 88,000 acres. The COCFA consist of two low-moderate severity fires that burned adjacent to each other during June 2008 over approximately 21,000 acres (Fig. 10). About 52% of the MACFA burned at high severity whereas only 11% of the COCFA burned at high severity (Fig. 11).

In both wildfire study areas we conducted CSO surveys during the breeding period across the entire landscape and within a 1.6 km (1 mile) unburned buffer surrounding the fire perimeter. We used our standardized survey protocol and conducted 3 nocturnal surveys across the landscape with follow-up visits to attempt to located nest/roost locations for birds detected on nocturnal surveys. These methods are described in the section above and fully in protocol described in the study plan.

The high-severity fires that burned in the MACFA resulted in significant changes to the vegetation (Fig. 12 & 13). The amount of suitable CSO habitat (CWHR classes 4M, 4D, 5M, 5D) within the 88,000 acre MACFA decreased from 70.1% of the pre-fire landscape to 5.8% of the landscape following the fires. The largest increase in the post-fire landscape occurred in the CWHR classes <= 2D which increased from 8.2% to 64.9%. The remaining forested areas across the post-fire landscape were predominantly classified as either 4P (18.5%) or 4S (7.9%).

We are still in the process of synthesizing all of the pre-fire CSO survey information for the MACFA as there is not a solid baseline of consistently collected survey information prior to the fire such as exists for our core PLS project area. Nevertheless, this synthesis may provide us with a reasonable estimate of the pre-fire distribution and abundance of

CSO sites across the MACFA. All or parts of at least 23 PACs were located within the pre-fire MACFA. Given the lack of continuous annual CSO survey effort we are uncertain what proportion of those PACs were occupied in 2007 prior to the fires.

During our 2008 surveys we documented a single confirmed pair of CSOs (non-breeding) within the MACFA, with the female from this pair being the only female we detected within the fire area (Fig. 14). We had 10 single detections of male CSOs across the burned area. In each of these ten cases we were not able to locate the birds at nests or roosts on follow-up status surveys. Each of these ten locations occurred primarily in the middle of the night when birds are out foraging and none of the detections occurred within 1/2-mile of each other as required to classify these individuals as territorial birds under currently accepted protocols. Within the unburned 1-mile buffer area surrounding the burned area we documented 5 confirmed pairs, 1 unconfirmed pair, 1 territorial male single, and 6 single detections (4 males, 2 sex unknown). Thus, in the immediate unburned buffer area we observed territorial sites whereas we only were able to document the single confirmed territorial pair within the burned area.

During our 2009 surveys within the MACFA we documented a single confirmed pair of CSOs in the same location as the pair documented in 2008 (Fig. 14). Within the 1-mile buffer area we documented 7 confirmed pairs, 0 unconfirmed pairs, 2 territorial single males, and 3 single detections. In contrast to 2008, in 2009 we did not record single detections of apparently non-territorial single birds within the fire perimeter across the MACFA landscape. Rather, we only recorded 3 detections of CSOs near the perimeter of the fire in the vicinity of confirmed pairs located within the buffer around the fire.

In our two years of work we were able to document significant changes to the vegetation and amounts and distribution of CSO habitat within the MACFA as a result of the high-severity wildfires. Our CSO survey work suggests that the immediate post-fire landscape may not support territorial CSO sites as evidenced by the single confirmed pair of owls that we documented in 2008 in 2009. In 2009 we did not document single male CSOs across the burned landscape, suggesting that the apparently non-territorial single males observed in 2008 may have been present because of previous site fidelity or were perhaps opportunistically utilizing a flush of prey in the first year following the fire. In both years, territorial CSOs were present in similar numbers and distributed at expected spacing within the buffer area surrounding the fire. Thus, our results from our 2 years of work suggest that the primarily high-severity MACFA does not support CSOs other than a single pair that is using the landscape. Further, territorial CSO sites are well-distributed within the buffer area outside of the fire perimeter. Our 3 detections of individual CSOs just within the perimeter of the burned areas suggest that some CSOs are able to exploit the edge between the burned and unburned areas for foraging.

In our first year of surveys during 2009 in the COCFA we documented 3 confirmed territorial pairs, 1 unconfirmed territorial pair, and 2 territorial single male CSOs, for a total of 6 territorial CSOs sites within the fire perimeter (Fig. 15). Additionally, we had 6 single detections (3 male, 3 unknown sex) of individual CSOs within the fire perimeter. Within the buffer area we documented 3 confirmed pairs and 3 single detections (2 male, 1 female). These results and distribution patterns suggest that CSOs were able to persist in the post-fire COCFA landscape with similar abundance and spacing as has been observed in unburned forests outside the burned areas.

In 2010 we attempted to repeat the complete landscape survey coverage of the COCFA. However, we were precluded from accessing the entire landscape area by law enforcement restrictions due to safety concerns for field crews. Extensive, illegal marijuana growing operations were distributed widely across the COCFA landscape. Due to this limitation we instead conducted focused surveys within approximately 1-2 miles surrounding each of the sites that were occupied by CSOs in 2009. Although we may have missed new sites colonized in 2010 outside our focused survey areas, our efforts allowed us to determine if the 2009 sites were still occupied in 2010. In 2010 we documented 2 confirmed territorial pairs and 1 unconfirmed territorial pair of CSOs within the fire perimeter, and 2 confirmed territorial pairs and 1 unconfirmed territorial pair within the 1-mile buffer. Overall, in 2009 there were 7 pairs (6 confirmed and 1 unconfirmed) within the fire plus the 1-mile buffer. In 2010, there were 6 pairs (4 confirmed and 2 unconfirmed) in this same area. These results suggest that CSOs are able to persist within landscapes that experience predominantly low-moderate severity wildfire.

It is important to determine both the acute and chronic responses of CSOs and their habitat to wildfire as it is unknown if CSOs can persist over both the short-term and long-term in these areas. Whether a post-fire landscape can support CSOs likely depends on the pre-fire habitat suitability and variable fire severity patterns both within individual fires and across different fires. Largely low-moderate severity fires may have positive or neutral effects on CSOs and their habitat while high severity fires may result in greater negative effects. Our results into the acute, short-term response of CSOs to wildfire from the primarily high-severity MACFA and primarily low-moderate severity COCFA support this hypothesis. Additionally, information on the pre- and post-fire vegetation, location of salvage logging, and habitat conditions are needed to fully assess the response of CSOs and their habitat to wildfire in the MACFA and COCFA wildfire landscapes.

Banding, Blood Sampling, West Nile Virus Monitoring

Sixty-three owls were captured and banded in 2010. Blood samples were collected from 11 individuals that will be screened at the University of California, Davis for West Nile Virus (WNV) antibodies. None of the 141 individual blood samples collected from the northern Sierra Nevada from 2004-2008 have tested positive for WNV antibodies (Hull et al. 2010). The 2009 and 2010 samples have not been analyzed to date.

Barred and Sparred (Spotted x Barred hybrid) Distributional Records

We detected 7 barred owl and 3 sparred owls during 2010 surveys within our PLS study area. This result represents the highest number of barred and sparred owls that we have detected in any year during our study from 2004-2010. Our synthesis and update of barred-sparred owl records through 2010 based on Forest Service and California Department of Fish and Game databases indicates that there are a minimum of 44 individual site records across the broader HFQLG Project Area and a minimum total of 57 across the Sierra Nevada (Figure 16). This includes a minimum total of 24 records that have been documented within our intensively surveyed PLS study area. The first barred owl in the region was reported in 1989. The first documented breeding in the PLS survey area was in 2007 and consisted of a sparred owl paired with a CSO. In 2010, we documented the first barred-barred owl nest record for the northern Sierra Nevada to the best of our knowledge. Despite several surveys, the outcome of this barred-barred owl nesting attempt is uncertain, as the pair was non-responsive during the fledgling period. The pattern of records suggests that barred/sparred owls have been increasing in the northern Sierra Nevada from 1989-2010 and are now present in low, stable numbers over the past 4-5 years on our study area. This pattern is consistent with that observed in other areas as barred owls have expanded their range in western North America. Initially barred owls colonize an area and persist at low population numbers, during this period they may hybridize with spotted owls. At some threshold population size or when ecological conditions allow they are then poised for, and capable of, exhibiting exponential population growth. Notably, we detected an increase in barred numbers in 2010. This situation requires further monitoring and we recommend that an inventory of barred owls be conducted using barred owl-specific survey methods to document the distribution and status of barred owls in the northern Sierra Nevada.

California Spotted Owl Diet

A single diet survey plot was established at a CSO nest or roost location at each CSO territory on the Plumas National Forest during 2003-2007. Systematic searches for pellets and prey remains were conducted in each plot during each year. A total of approximately 3398 pellets have been collected during 2003-2007 (2003 = 606; 2004 = 807; 2005 = 838; 2006 = 516; 2007 = 552). We completed sorting of all pellets and identification of all prey remains in January 2010. All prey items are identified to species, or taxonomic group when species identification could not be ascertained. A total of 8,595 prey items have been recorded from the pellets. Mammals are the dominant taxonomic group and comprise of 96.5% of the total biomass identified in the diet. Across years the highest biomass contributions were from the dusky-footed woodrat (contributed 45% of the estimated total biomass) and northern flying squirrel (10.8%). Our objective has been to sample over several years to assess temporal variation in diets and possible relationships to variation in CSO reproduction, and to sample widely over space in order to investigate potential variation in CSO diets associated with elevation and vegetation conditions. We will now be able to address these questions given completion of the sorting and prey identification from the pellet samples.

Summary 2003-2010

Our efforts from 2003-2010 have focused on monitoring CSO distribution, abundance and demographics to address our primary research objectives and provide the baseline data for assessing the effects of HFQLG implementation. In conjunction with the now fully integrated Lassen Demographic Study we have collected landscape-scale information on the distribution and abundance of CSOs across approximately 650,000 acres of land. Determining the accurate number and distribution of CSO sites requires multiple years of survey and marking of individual CSOs to delineate separate territories and identify individual birds that move among multiple sites within and across years. These baseline data are fundamental for developing empirically-based habitat models for understanding CSO habitat associations and developing adaptive management tools and models. The completion of the Meadow Valley area projects in 2007-2008 marked the first landscape series of HFQLG treatments to be implemented within the study area, providing the first opportunity to address treatment effects within a case study framework. Our baseline information on CSO distribution and habitat associations, coupled with our 2007-2008 radio-telemetry work, will allow us to assess associations between CSOs and vegetation changes. In 2009-2010 we were now able to monitor post-treatment CSO distribution and abundance in the Meadow Valley project area, providing the first empirical data from a treated landscape. Our short-term results to date suggest that CSOs are able to persist in this treated landscape, although we have observed territory-specific responses in both areas that have experienced treatments and sites where no treatments have occurred. In 2010, we also completed the analysis of the radio-telemetry work which has provided insight into how individual owls respond to treatments within the first 1-2 years following implementation.

Additionally we were able to expand our work to address the effects of wildfire and CSOs and their habitat through our 2008-2010 survey work in the Moonlight-Antelope Complex and Cub-Onion Complex fire areas. In summary, we are working towards being able to broadly address CSO management questions across a gradient of landscape conditions ranging across untreated landscapes, landscapes treated to meet desired fuels/vegetation conditions, and landscapes that have experienced wildfire in order to address primary management issues.

Dedicated monitoring of CSOs on the Lassen Demographic study continues to provide critically valuable demographic and population trend information for determining the status of CSOs. Our analyses of the demographic data through 2010 continue to suggest that the CSO population on study area declined over the 20-year study period, similar to the results through 2005 reported in Blakesley et al. (2010). These results warrant close continued monitoring of the status of CSOs within the study area, along with continued management focus on providing high-quality CSO habitat during the planning and implementation of HFQLG treatments. We lack similar long-term demographic data for the Plumas NF study areas, but our baseline information on CSO distribution and abundance suggests that numbers of territorial CSOs and sites have been fairly consistent from 2004-2010.

Our focused diet analyses have broadened and deepened our understanding of CSO diets and sources of variation in CSO diets among pairs and across environmental gradients. Monitoring of WNV exposure coupled with demographic monitoring has provided an opportunity to assess if WNV may ultimately be a factor influencing CSO viability. We have provided the first information investigating evidence for CSO exposure to West Nile Virus in the Sierra Nevada (Hull et al. 2010). To date we have not had a positive detection for WNV within CSOs. Through our research into historical and current occurrence records, in conjunction with our field surveys, we have been able to document the colonization of the northern Sierra Nevada by barred owls. Our results indicate that barred owls are increasing in the northern Sierra Nevada and may become an increasing risk factor to CSOs.

Current Research: 2011

In 2011 we will continue monitoring owl distribution, abundance, demography, and population trend across the core PLS study area, including post-treatment monitoring in the Meadow Valley Project area. Additionally, we will continue monitoring within the Creeks Project Area on the Lassen NF, as this area is projected to receive forest and fuels treatments in the near future. In 2011 we will also initiate surveys in suitable CSO habitat within the Storrie Fire footprint to collect information on CSO response to this wildfire following 10-11 years of post-fire vegetation change. These data will also be used to inform restoration efforts within the Storrie Fire landscape. Together this work will contribute to our efforts to build a more comprehensive base of knowledge regarding CSO habitat associations and the effects of treatments and wildfires.

In addition to continuing field surveys designed to address our seven research questions, we have broadened our emphasis on the development of predictive habitat relationship models as described in the module study plan. We have continued to work closely with biologists on the Plumas and Lassen National Forests, and the R5 Regional Office, to identify and define the types of analyses and tools that would best address management needs. Baseline information collected during this study forms the foundation for this phase of the research. The combination of broad-scale landscape CSO distribution data, in conjunction with detailed demographic information available from the Lassen Demographic Study, will facilitate exploration and development of predictive habitat models for use in an adaptive management framework and to directly monitor implementation of the HFQLG project. The greatest challenge and obstacle to this research has been the lack of accurate pre- and post-treatment vegetation information and accurate spatial locations of treatments. Significant progress has been made in these 2 areas over the past year. Efforts to address vegetation and treatment mapping information needs for habitat modeling are underway and accurate vegetation maps are projected to be completed in 2011. Completion of the needed vegetation maps will facilitate completion of the primary research objectives for this project.

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Table 1. California spotted owl reproduction on the Plumas and Lassen National Forests 2004-2010.

Year	Percent of confirmed/unconfirmed pairs with successful nests	Young fledged per successful nest
2004	49.4%	1.68
2005	17.7%	1.47
2006	13.8%	1.50
2007	55.4%	1.81
2008	16.4%	1.70
2009	47.6%	1.57
2010	50.8%	1.74

Table 2. Crude density of territorial California spotted owls across survey areas on the Plumas and Lassen National Forests 2004-2010. Locations of survey areas are identified in Figure 1.

		Crude Density of Territorial Owls (#/km^2)						
Survey Area	**Size (km^2)**	**2004***	**2005***	**2006***	**2007***	**2008***	**2009***	**2010***
SA-2	182.4	0.126	0.143	0.115	0.115	0.132	0.121	0.132
SA-3	214.4	0.075	0.093	0.089	0.103	0.098	0.089	0.079
SA-4	238.2	0.059	0.050	0.046	0.071	0.046	0.046	0.050
SA-5	260.2	0.069	0.069	NS****	NS****	NS****	NS****	NS****
SA-7	210.3	0.071	0.062	NS	NS	NS	NS	NS
SA-1A	190.4	NI***	0.042	0.042	0.053	0.042	0.058	0.053
SA-1B**	130.3	NI	0.023	NS	NS	NS	NS	NS
SA-11	179.4	NI	0.045	0.033	0.033	0.045	0.033	0.039
SA-12	215.8	NI	0.097	0.070	0.074	0.070	0.074	0.102
SA-13	152.9	NI	0.105	0.085	0.065	0.050*****	0.099	0.099
SA-14	318.7	NI	0.053	0.044	0.035	0.047	0.044	0.035
SA-15	196.8	NI	0.086	0.036	0.056	0.081	0.076	0.076
Total Study Area	2489.8	0.078	0.073	0.060	0.066	0.067	0.069	0.070

*Total Area surveyed each year: 2004 = 1,106 km^2; 2005 = 2,490 km^2; 2006 = 1,889 km^2; 2007 = 1,889 km^2; 2008 = 1,877 km^2; 2009 = 1,889 km^2; 2010 = 1,889 km^2

**NI = not included. Project level area surveyed only in 2005. Included for comparative purposes.

***The Lassen Demographic Study Area (SA-1A, SA-1B, SA-11 through SA-15) was incorporated into the overall study in 2005.

****Survey areas not surveyed in 2006-2010.

*****This survey area was not completely surveyed during 2008 because of wildfire activity in the area. Two CSO territories within the study area could not be surveyed.

Table 3. Number of pairs (confirmed and unconfirmed) and territorial single California spotted owls across the Plumas-Lassen Study survey areas on the Plumas and Lassen National Forests, California, 2004-2010. Locations of survey areas are identified in Figure 1.

	2004	2005	2006	2007	2008	2009	2010
Survey Area	**Pairs/ TS***	**Pairs/TS***	**Pairs/TS***	**Pairs/TS***	**Pairs/TS***	**Pairs/TS***	**Pairs/TS***
SA-2	11/1	12/2	10/1	10/1	12/0	11/0	10/2
SA-3	7/2	10/0	9/1	11/0	9/3	9/1	8/1
SA-4	7/0	5/2	4/3	8/1	5/1	5/1	5/2
SA-5	8/2	9/0	NS****	NS****	NS****	NS****	NS****
SA-7	7/1	6/1	NS	NS	NS	NS	NS
SA-1A	NI***	4/0	4/0	5/0	4/0	5/1	4/2
SA-1B**	NI	3/0	NS	NS	NS	NS	NS
SA-11	NI	4/0	3/0	3/0	3/2	3/0	3/1
SA-12	NI	10/1	1/7	8/0	7/1	8/0	10/2
SA-13	NI	8/0	6/1	5/0	3/1*****	7/0	7/0
SA-14	NI	8/1	7/0	5/1	7/1	7/0	5/1
SA-15	NI	8/1	3/1	4/3	8/0	7/1	7/1

*TS = Territorial Single.
**NI = not included. Project level area surveyed only in 2005. Included for comparative purposes.
***Lassen Demographic Study Area – incorporated into the overall study in 2005.
****Survey areas not surveyed in 2006-2010.
***** This survey area was not completely surveyed during 2008 because of wildfire activity in the area. Two CSO territories within the study area could not be surveyed.

Table 4. Distribution of California spotted owl nest/primary roost sites (n = 103) across CWHR tree size classes within the Plumas-Lassen Study on the Plumas and Lassen National Forests, 2004-2006.

CWHR Size Class*	CWHR Size Class Description	Number of Nests	Percent
Barren	Open, sparse tree coverage	1	1.0
3S	6-12 inch dbh, ,20% CC	1	1.0
3M-LT	6-12 inch dbh, 40-60% CC, large trees recorded	1	1.0
3D	6-12 inch dbh, >60% CC	4	3.9
4P	12-24 inch dbh, 20-40% CC	3	2.9
4M	12-24 inch dbh, 40-60% CC	3	2.9
4M-LT	12-24 inch dbh, 40-60% CC, large trees recorded	12	11.7
4D	12-24 inch dbh, >60% CC	10	9.7
4D-LT	12-24 inch dbh, >60% CC, large trees recorded	13	12.6
5M	>24 inch dbh, 40-60% CC	25	24.3
5D	>24 inch dbh, >60% CC	9	8.7
6	>24 inch dbh, >60% CC, multi-layer canopy	21	20.1

*defined by average tree size (dbh = diameter at breast-height) and average percent canopy cover (CC).

Table 5. Nest-site (1 ha (2.47 acres)) habitat characteristics collected using the Forest Inventory and Analysis sampling protocol at California spotted owl nest sites (n = 80) on the Plumas and Lassen National Forests, California, 2005-2006.

Variable	Mean	SE
Total Basal Area (ft^2/acre)	260.8	6.47
# Trees >= 30 inch dbh (#/acre)	10.7	0.58
Basal Area Trees >= 30 inch dbh (ft^2/acre)	96.0	5.70
# Trees >= 24 inch dbh (#/acre)	19.9	0.90
Basal Area Trees >= 24 inch dbh (ft^2/acre)	131.7	6.29
# Trees <12 inch dbh (#/acre)	383.5	26.36
Basal Area Trees , <12 inch dbh (ft^2/acre)	50.1	2.71
# Snags >=15 inch dbh (#/acre)	7.4	0.80
Mean Duff Depth (inches)	3.0	0.16
Duff (tons/acre)	67.4	3.64
Mean Litter Depth (inches)	2.3	0.18
Litter (tons/acre)	23.7	1.81
1 Hour Fuels (tons/acre)	0.75	0.03
10 Hour Fuels (tons/acre)	4.0	0.21
100 Hour Fuels (tons/acre)	4.4	0.28
Shrub Cover (%)	7.7	1.16
Canopy Cover (%)*	64.1	1.24

* estimated through Forest Vegetation Simulator modeling of plot-based tree lists.

Table 6. Distribution of USDA Region 5 vegetation classes (Mean (SE)) within 500 acre (201 ha) circles centered on California spotted owl (CSO) territories (n = 102) and systematic grid (Grid) points (n = 130) within the Plumas-Lassen Study on the Plumas and Lassen National Forests, 2004-2006.

R5 Size Class*	**R5 Size Class Description**	**CSO**	**Grid**
Non-forest	Sum of non-forest land types	4.4 (1.0)	8.4 (1.2)
Total Size 1	Sum of 1G,1N, 1P, 1S: <6 inch dbh, all %CC classes	1.7 (0.3)	1.6 (0.3)
2P & 2S	6-12 inch dbh, 10-39% CC	3.4 (0.4)	4.1 (0.5)
2N	6-12 inch dbh, 40-69% CC	3.8 (0.6)	4.4 (0.9)
2G	6-12-24 inch dbh, >=70% CC	1.6 (0.5)	0.5 (0.1)
3P&3S	12-24 inch dbh, >10-39% CC	9.2 (0.8)	16.1 (1.3)
3N	12-24 inch dbh, 40-69% CC	37.2 (2.4)	38.5 (1.8)
3G	12-24 inch dbh, >=70% CC	6.2 (1.0)	3.8 (0.7)
4P&4S	>24 inch dbh, >10-39% CC	1.0 (0.3)	2.1 (0.4)
4N	>24 inch dbh, 40-69% CC	25.8 (2.0)	17.3 (1.6)
4G	>24 inch dbh, >=70% CC	6.5 (0.1)	2.4 (0.8)
Total 4N & 4G	Sum of 4N & 4G: >24 inch dbh, >= 40% CC	32.4 (2.3)	19.6 (1.8)
Total Suitable habitat	Sum of classes 3N, 3G, 4N, 4G = >12 inch dbh, >40% CC	75.7 (2.19)	61.9 (1.75)

*defined by average tree size (dbh = diameter at breast-height) and average percent canopy cover (CC).

Table 7. Annual number of California spotted owls documented during the breeding period (April-August) in SA-4 (Meadow Valley Project Area), Plumas National Forest, California, 2003-2010.

Year	Confirmed Pairs	Unconfirmed Pairs	Territorial Singles	Total Territorial Sites
2003	7	0	1	8
2004	7	0	0	7
2005	4	1	2	7
2006	3	1	3	7
2007	8	0	1	9
2008	5	0	1	6
2009	5	0	1	6
2010	5	0	2	7

Figure 1. (A) Location of California spotted owl (CSO) Survey Areas surveyed 2004-2010. (B) Example of original survey plot consisting of multiple Cal-Planning watersheds. (C) Example of Primary Sampling Units for surveying for CSOs. See text and study plan for further details.

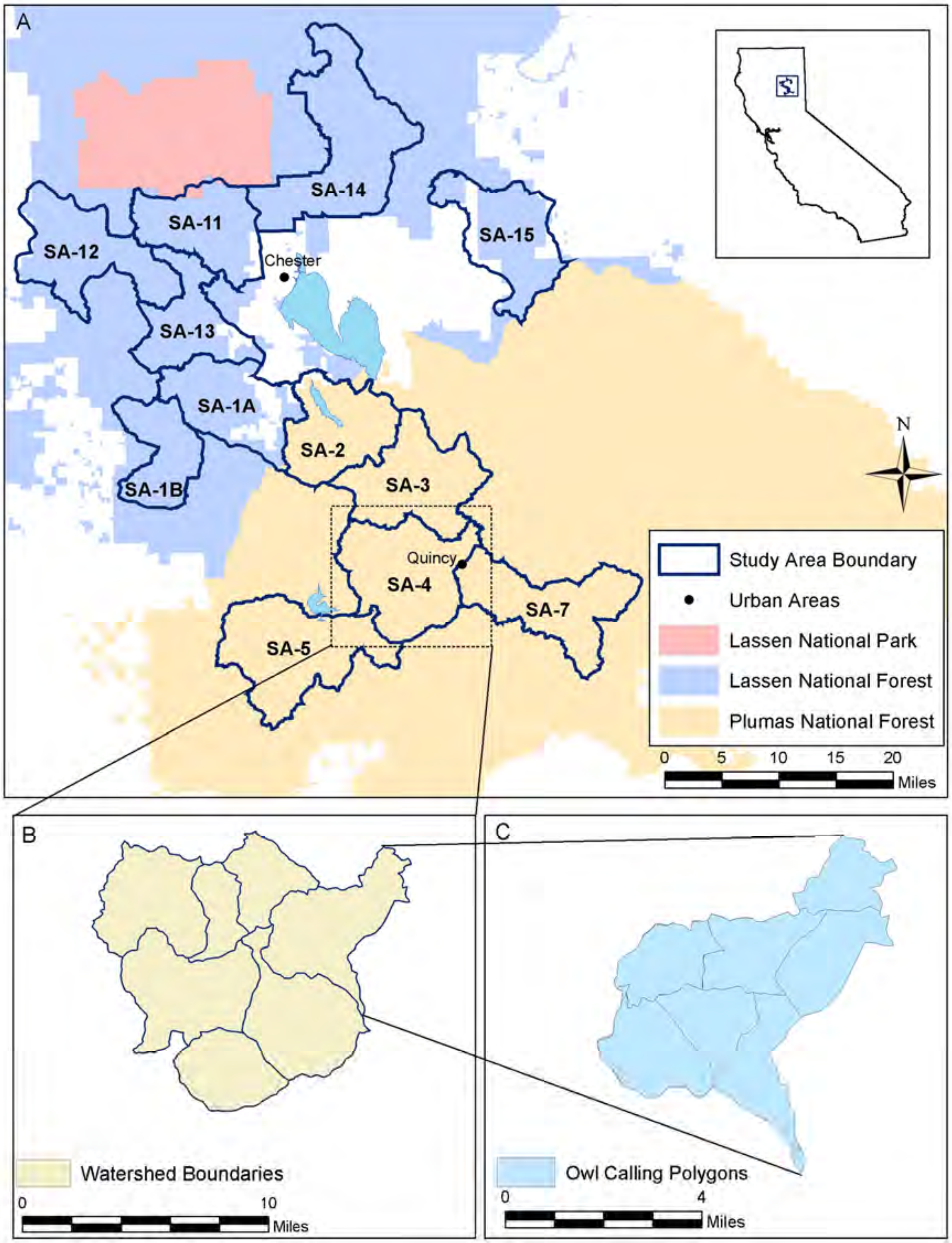


Figure 2. Distribution of California spotted owl territories within the study survey area across the Plumas and Lassen National Forests, 2010.

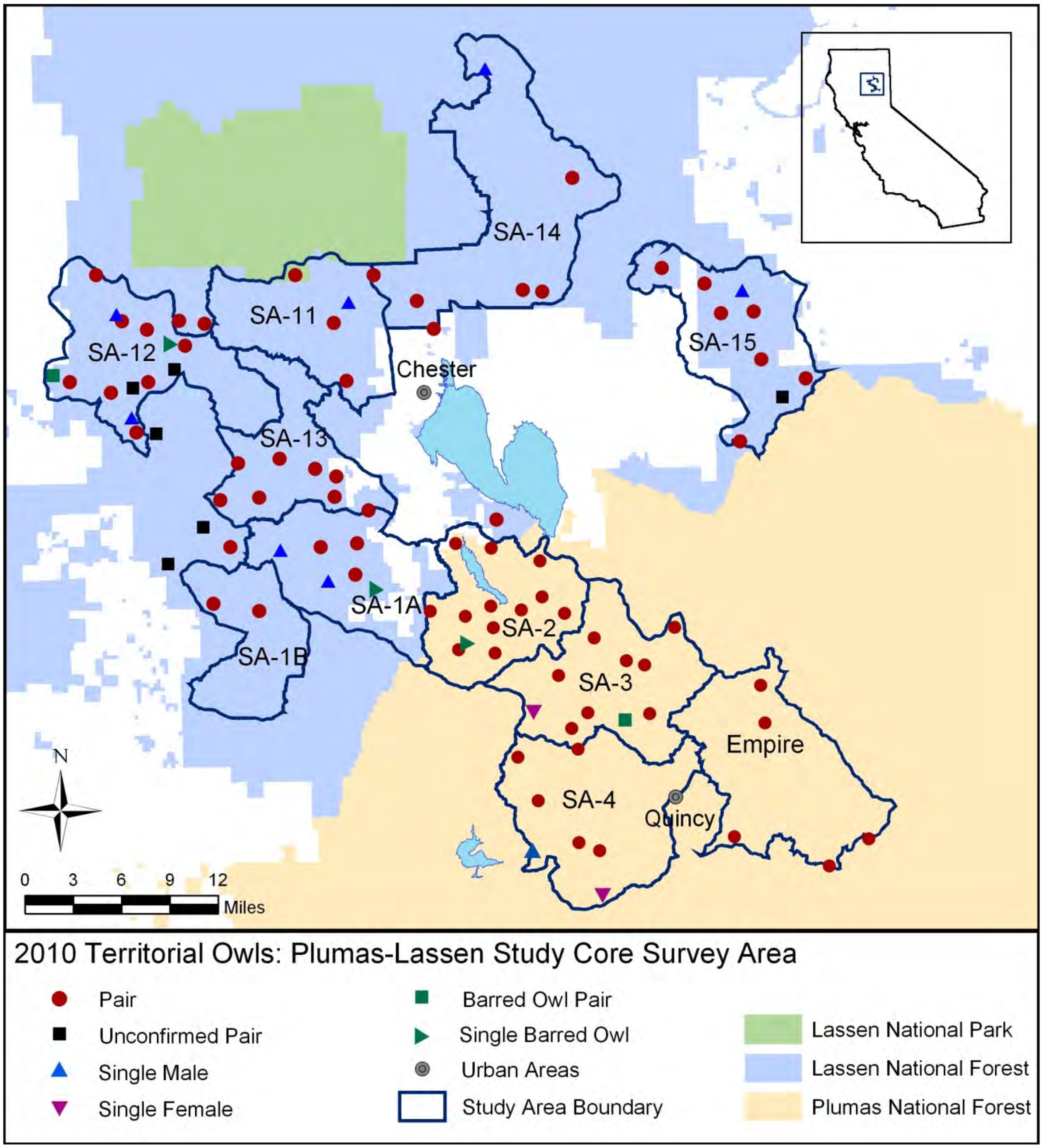


Figure 3. Monthly precipitation totals for Quincy, California, during January-May, 2004-2010 (data from Western Regional Climate Center).

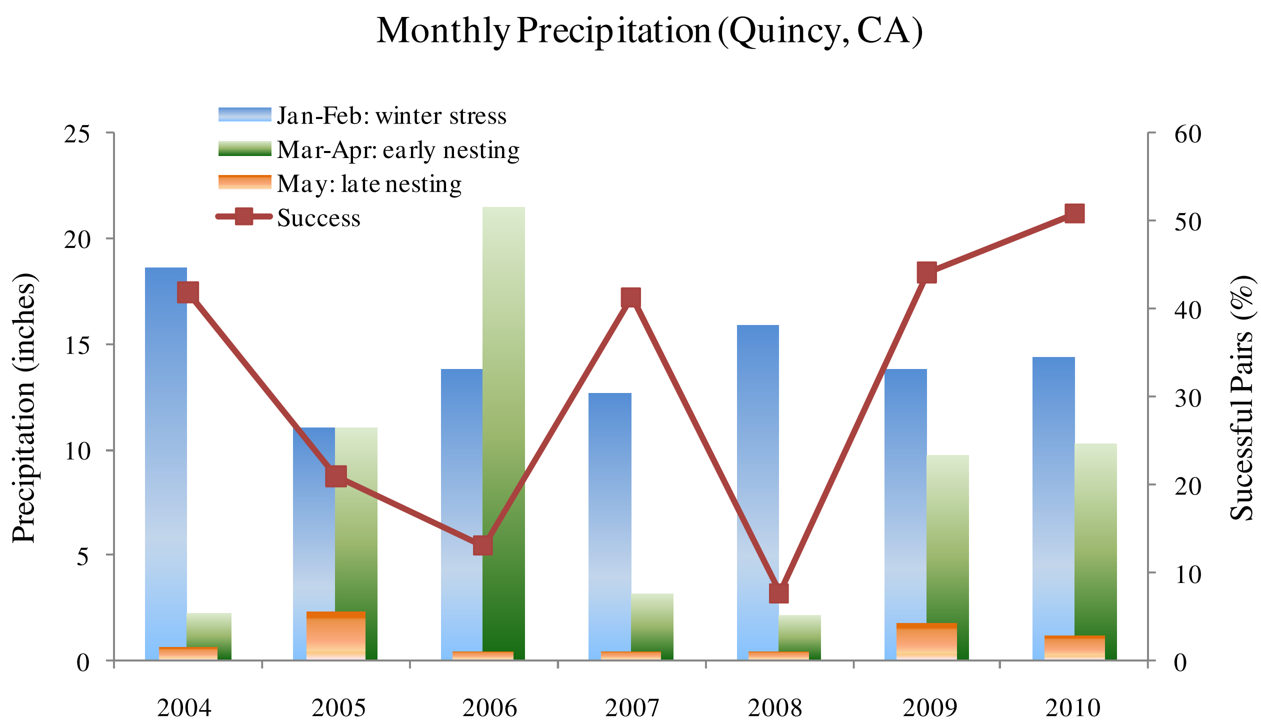


Figure 4. Distribution of California spotted owl (n = 103) nest sites by California Wildlife Habitat Relationship (CWHR) database vegetation classes on the Plumas and Lassen National Forests, California, 2004-2007. Descriptions of the CWHR classes are provided in Table 5 within the text of this document.

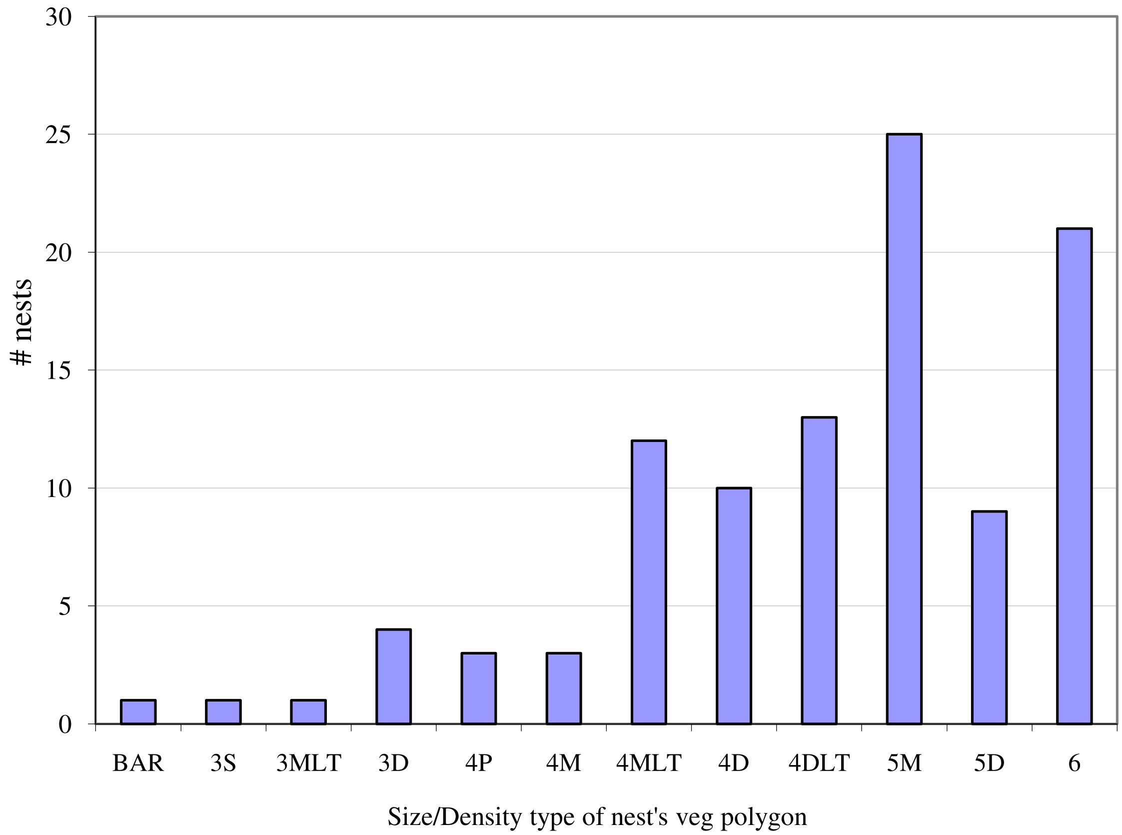


Figure 5. Percent suitable habitat (>=12 inch dbh trees with >=40% canopy cover) within 500 acre (201 ha) circles centered on California spotted owl (CSO, n = 102) and systematic grid points (Grid, n = 130) on the Plumas and Lassen National Forests, California, 2004-2007.

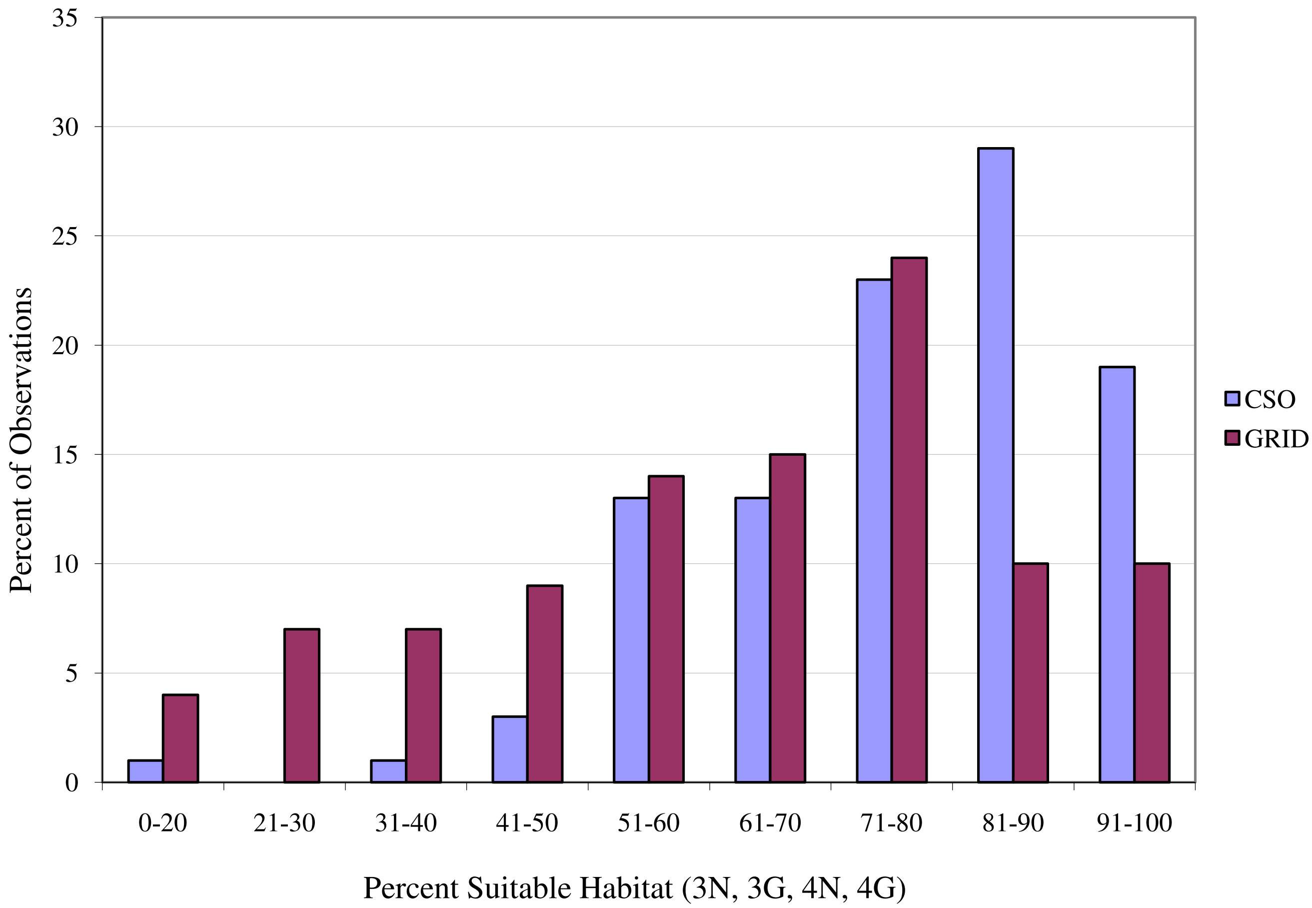


Figure 6. Percent large tree habitat (R5 classes 4N &4G: >=24 inch dbh trees with >=40% canopy cover) within 500 acre (201 ha) circles centered on California spotted owl (CSO, n = 102) and systematic grid points (Grid, n = 130) on the Plumas and Lassen National Forests, California, 2004-2007. Descriptions of R5 classes are provided in Table 7 within the text of this document.

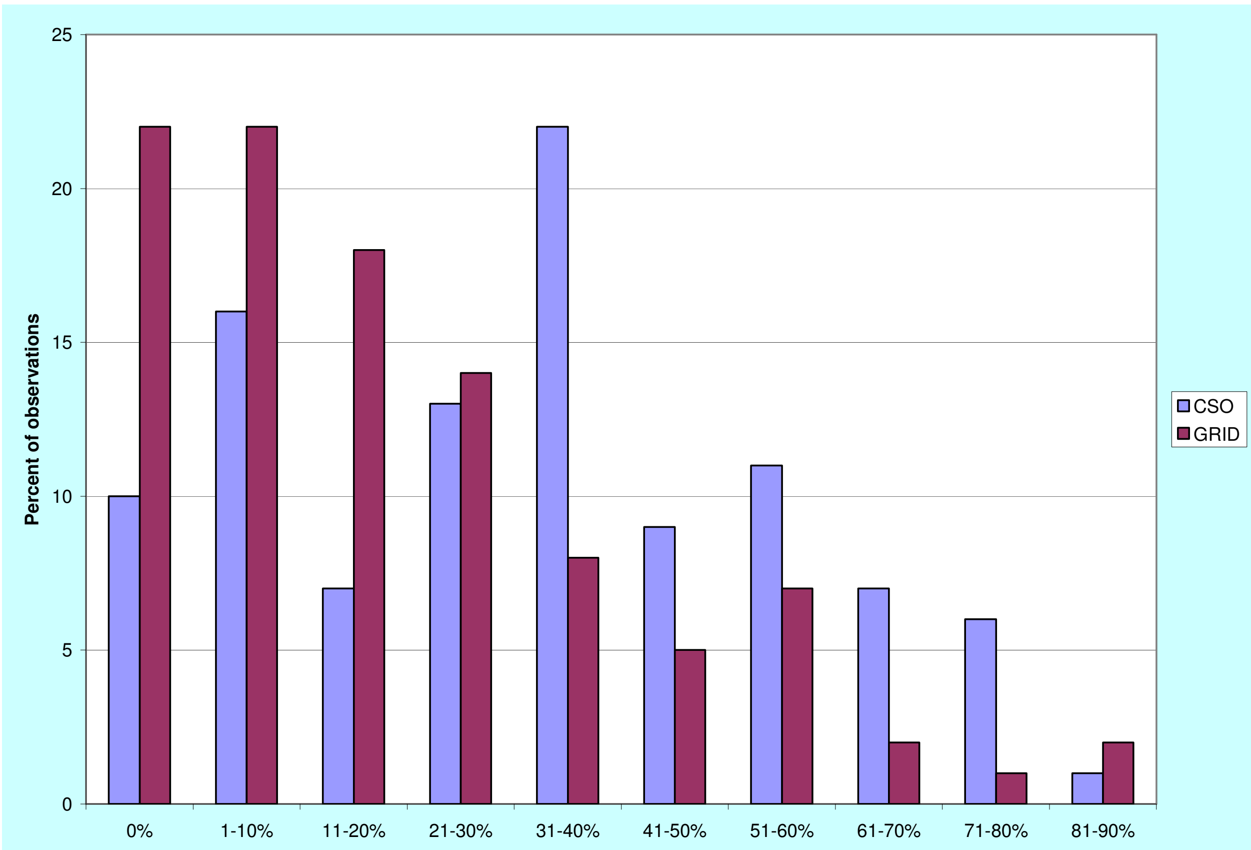


Figure 7. Distribution of proposed Meadow Valley Project Area forest management treatments and cumulative distribution of California spotted owl territorial sites between 2003-2009 in Survey Area-4 of the Plumas-Lassen Study, Plumas National Forest, California.

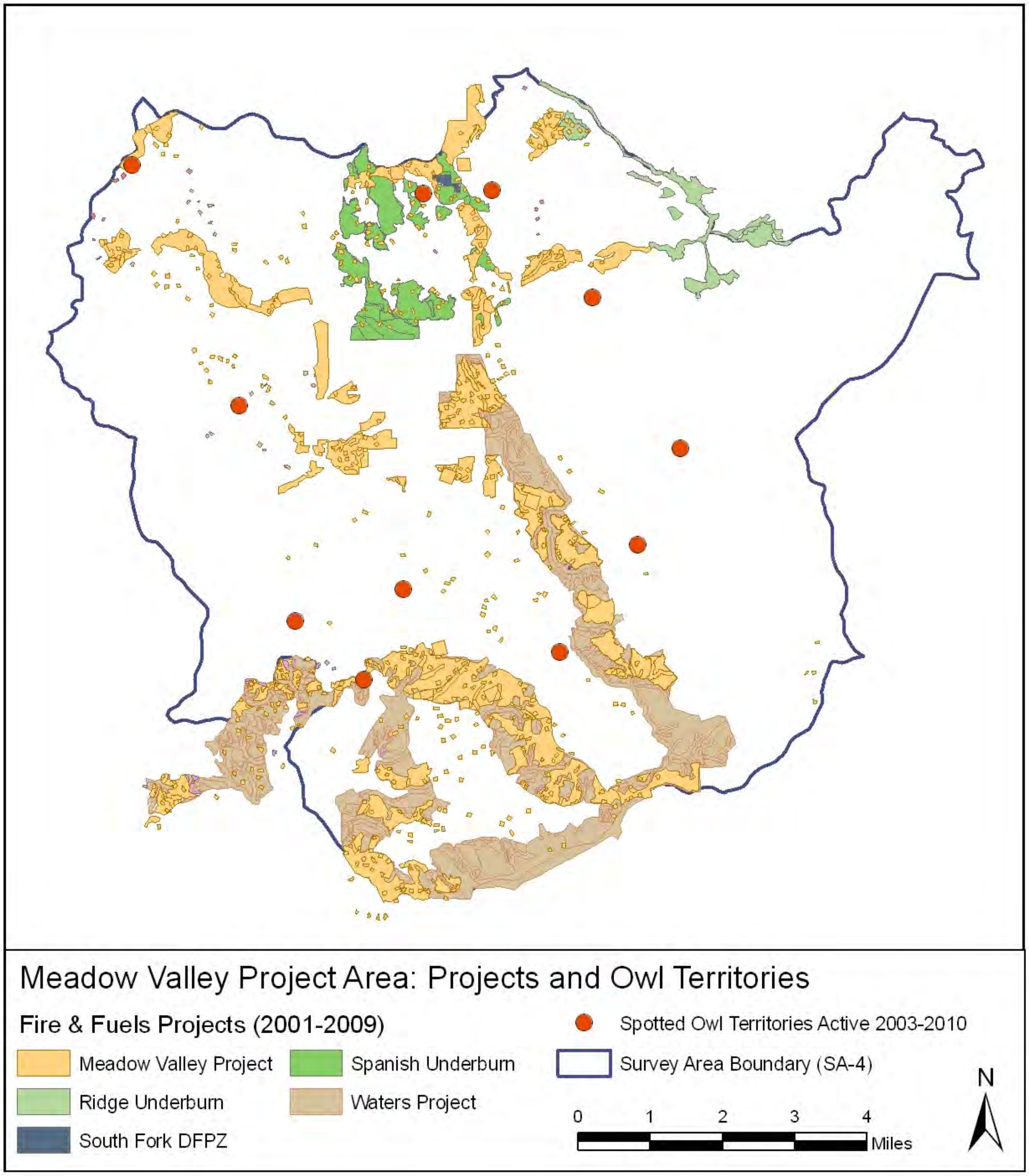


Figure 8a. Annual summary distribution of California spotted owl territorial sites across Survey Area-4 (Meadow Valley Project Area) of the Plumas-Lassen Study, Plumas National Forest, California, 2007-2010.

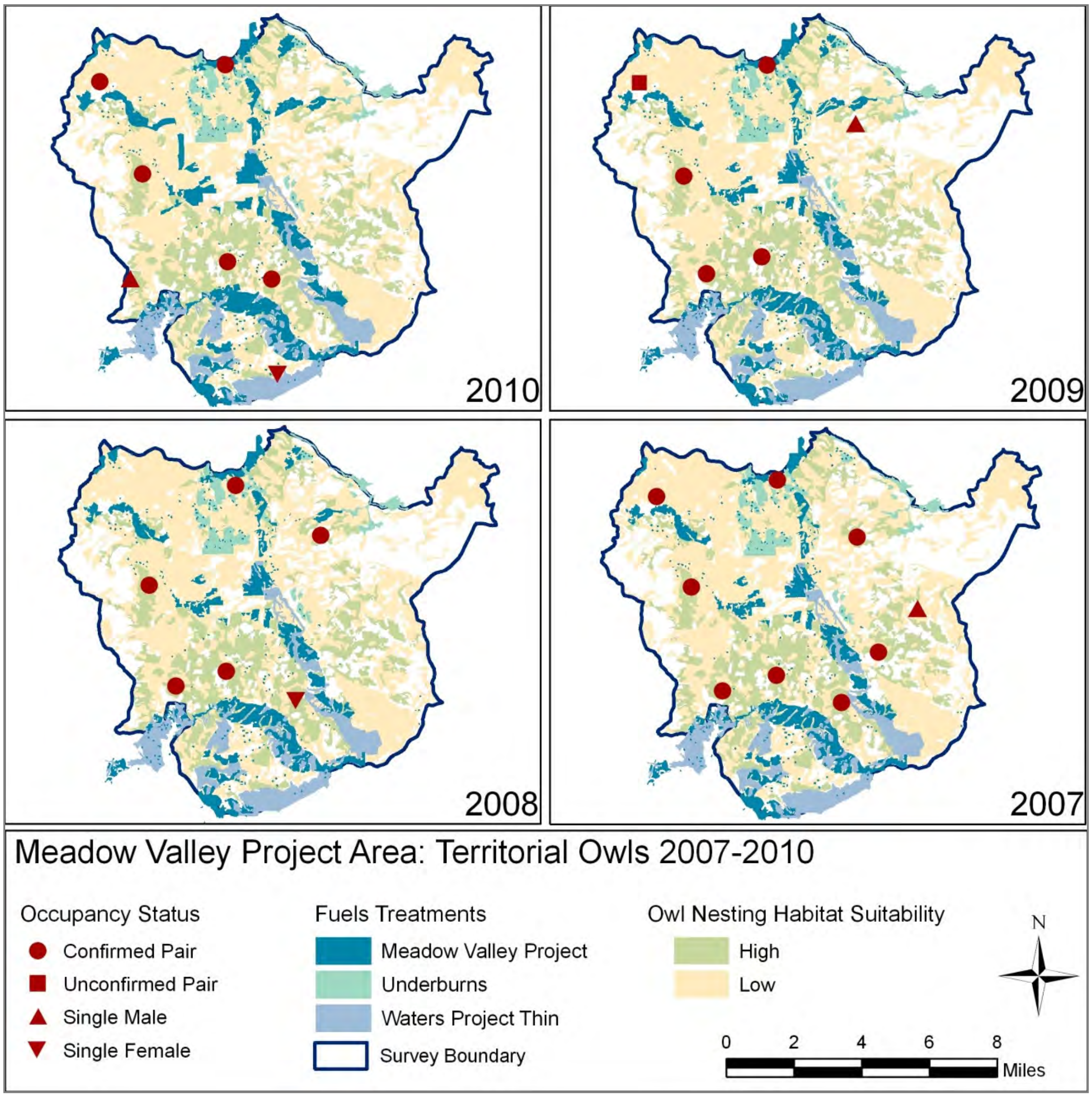


Figure 8b. Annual summary distribution of California spotted owl territorial sites across Survey Area-4 (Meadow Valley Project Area) of the Plumas-Lassen Study, Plumas National Forest, California, 2003-2006.

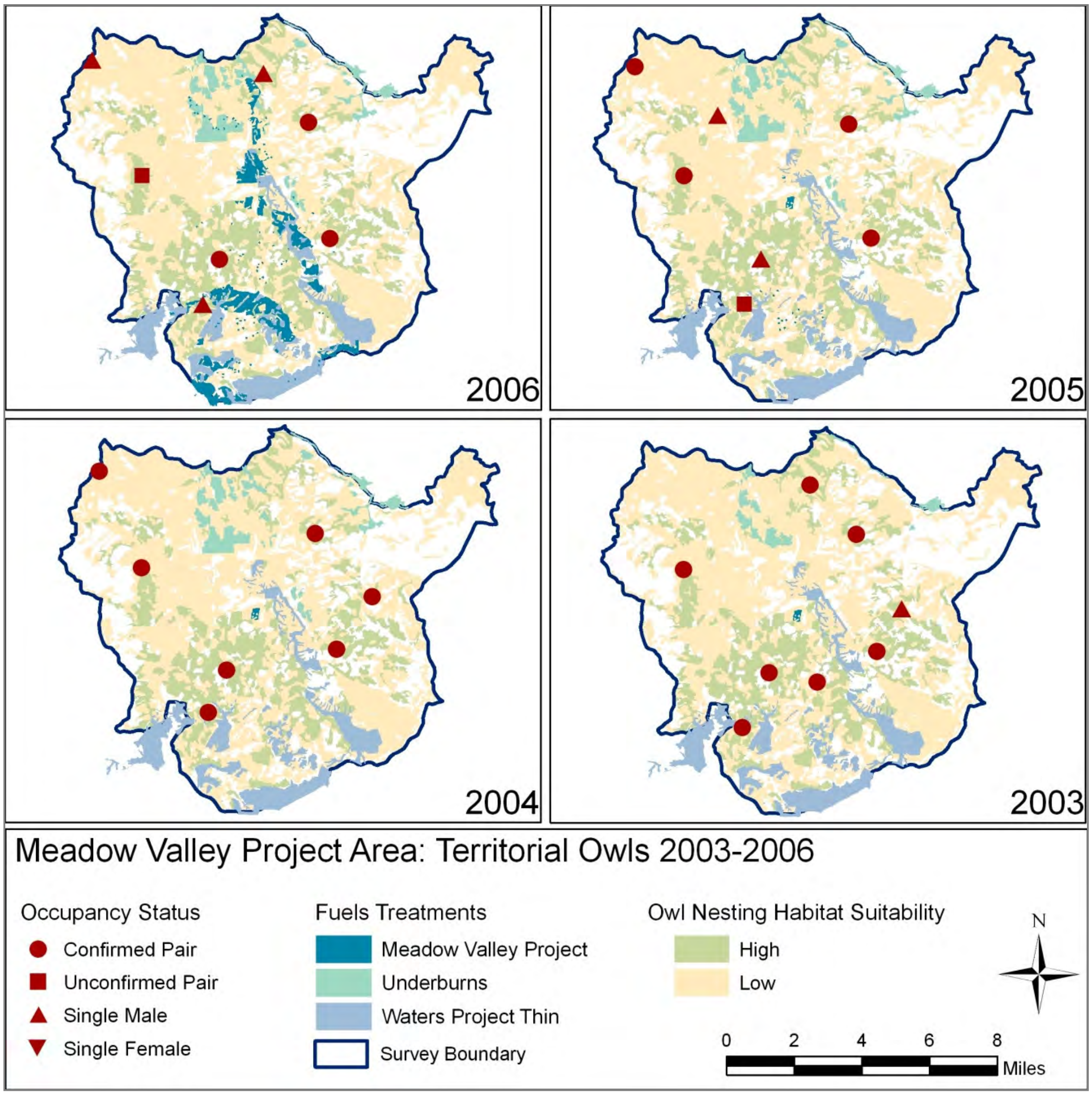
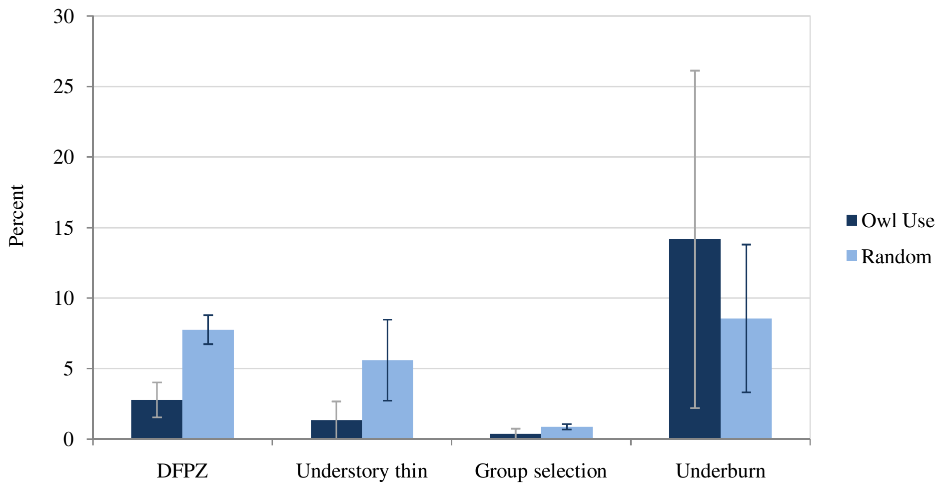


Figure 9. Average California spotted owl use locations compared with random for four fuels treatment types in the Meadow Valley Project area, Plumas National Forest, California, 2007-2008.[a]



[a]Individual owls were considered the sample unit and not all treatment types were available to each owl: Defensible Fuel Profile Zone (DFPZ; n = 9); understory thin (n = 5); group selection (n = 9); and understory thin followed by underburn (n = 4).

Figure 10. Maps of fire severity in the: (a) Moonlight-Antelope Complex fire (88,000 acres) of 2007; and (b) the Cub-Onion Complex fire (21,000 acres) of 2008, on the Plumas and Lassen National Forests, California.

(a)

(b)

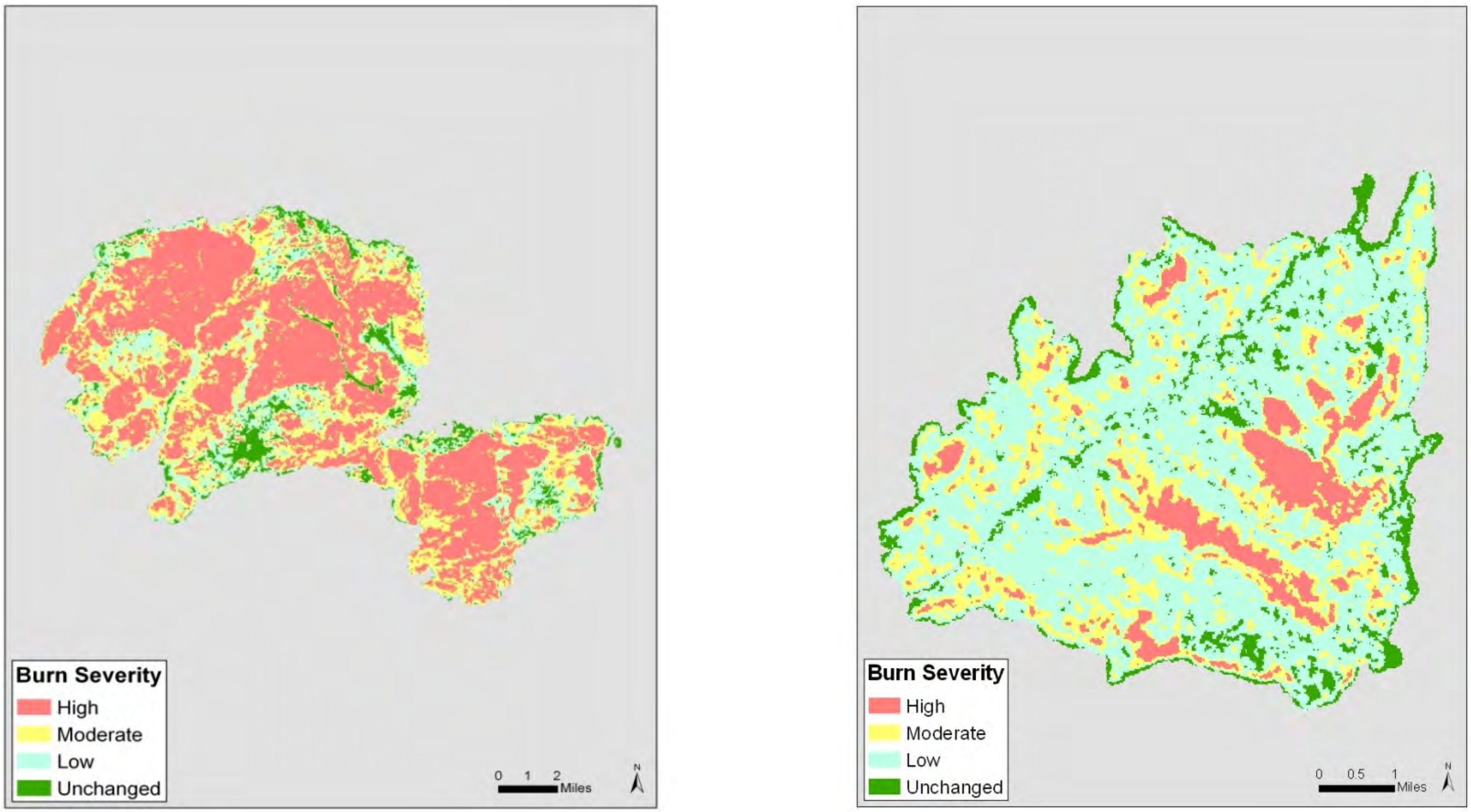


Figure 11. Distribution of the post-fire landscape by fire severity class for the Moonlight-Antelope Complex Fire Area (MACFA) and Cub-Onion Complex Fire Area (COCFA) on the Plumas and Lassen National Forests, California.

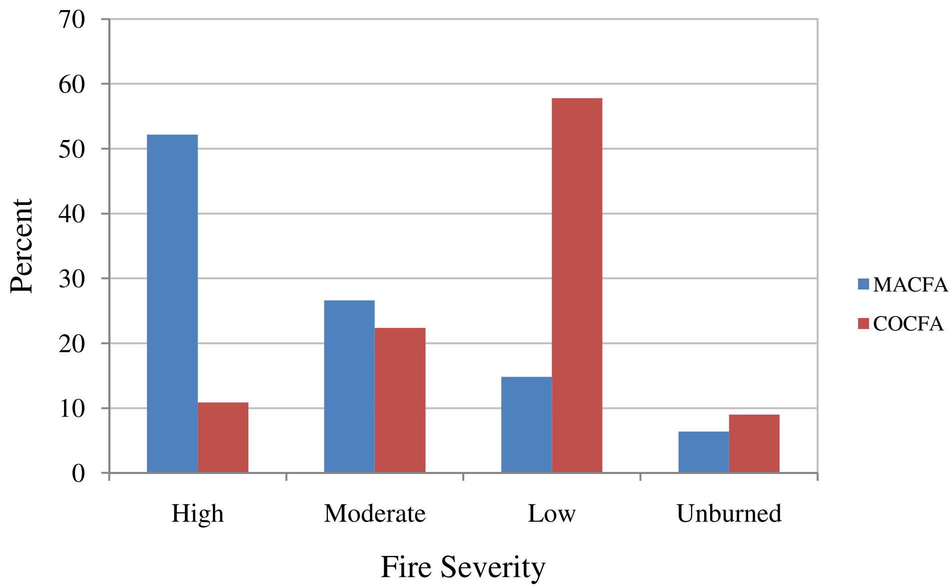


Figure 12. Distribution of pre- and post-fire California Wildlife Habitat Relationship vegetation classes within the Moonlight-Antelope Complex fire areas on the Plumas and Lassen National Forests, California, 2008.

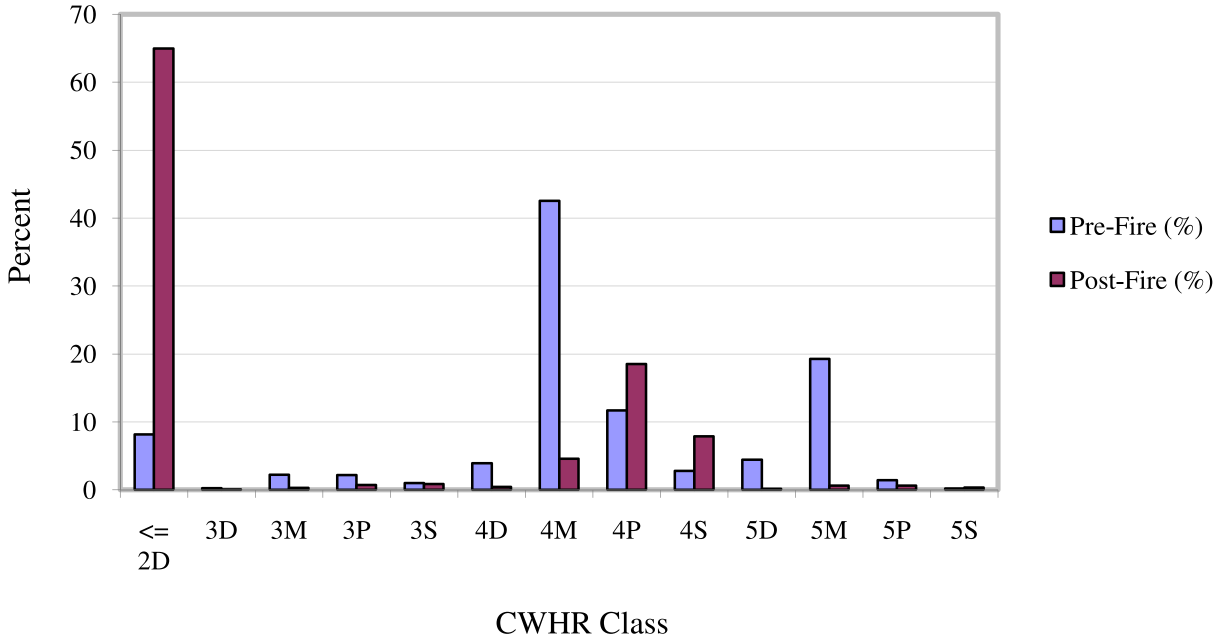
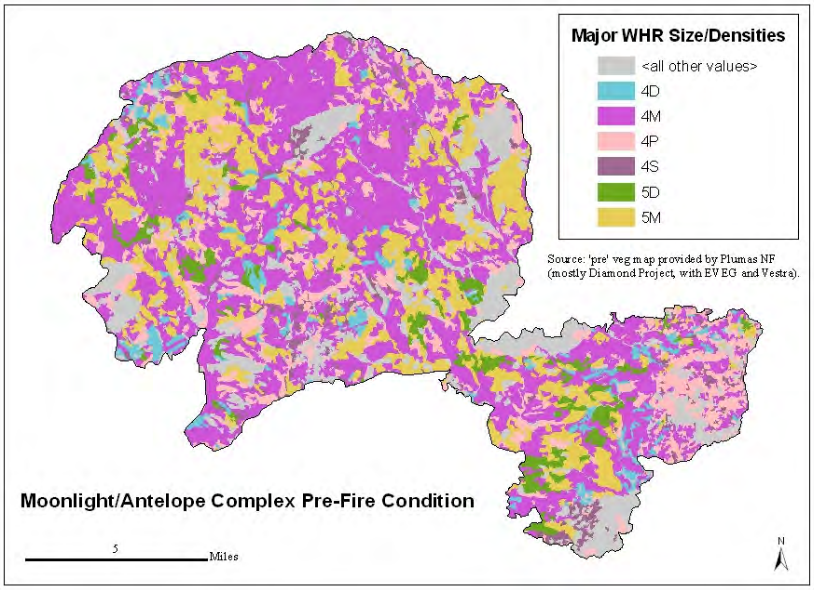


Figure 13. Maps of (a) pre-fire and (b) post-fire California Wildlife Habitat Relationship vegetation classes within the Moonlight-Antelope Complex fire areas on the Plumas and Lassen National Forests, California, 2008.

(a)



(b)

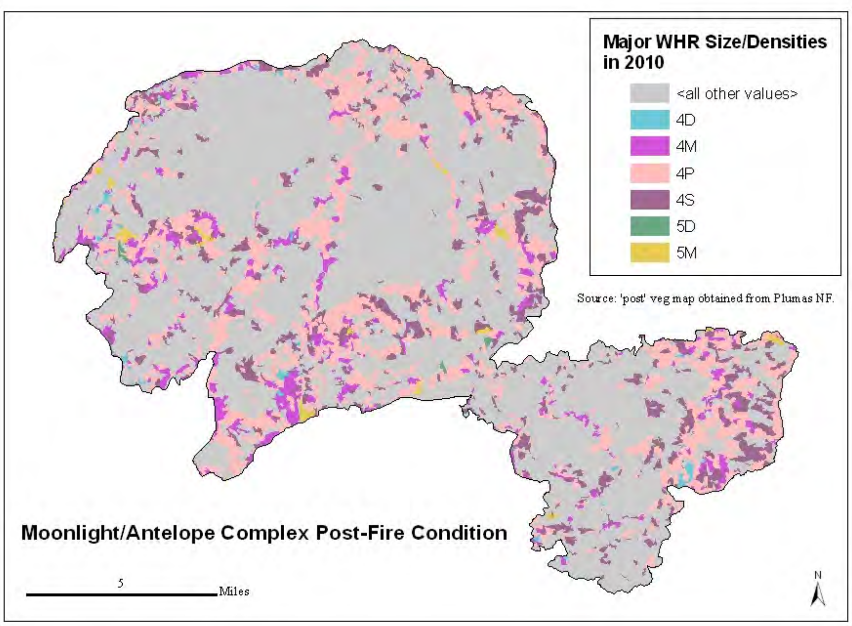


Figure 14. Distribution of California spotted owls within the Moonlight-Antelope Complex fire area and a 1.6 km buffer on the Plumas and Lassen National Forests, California, 2008-2009.

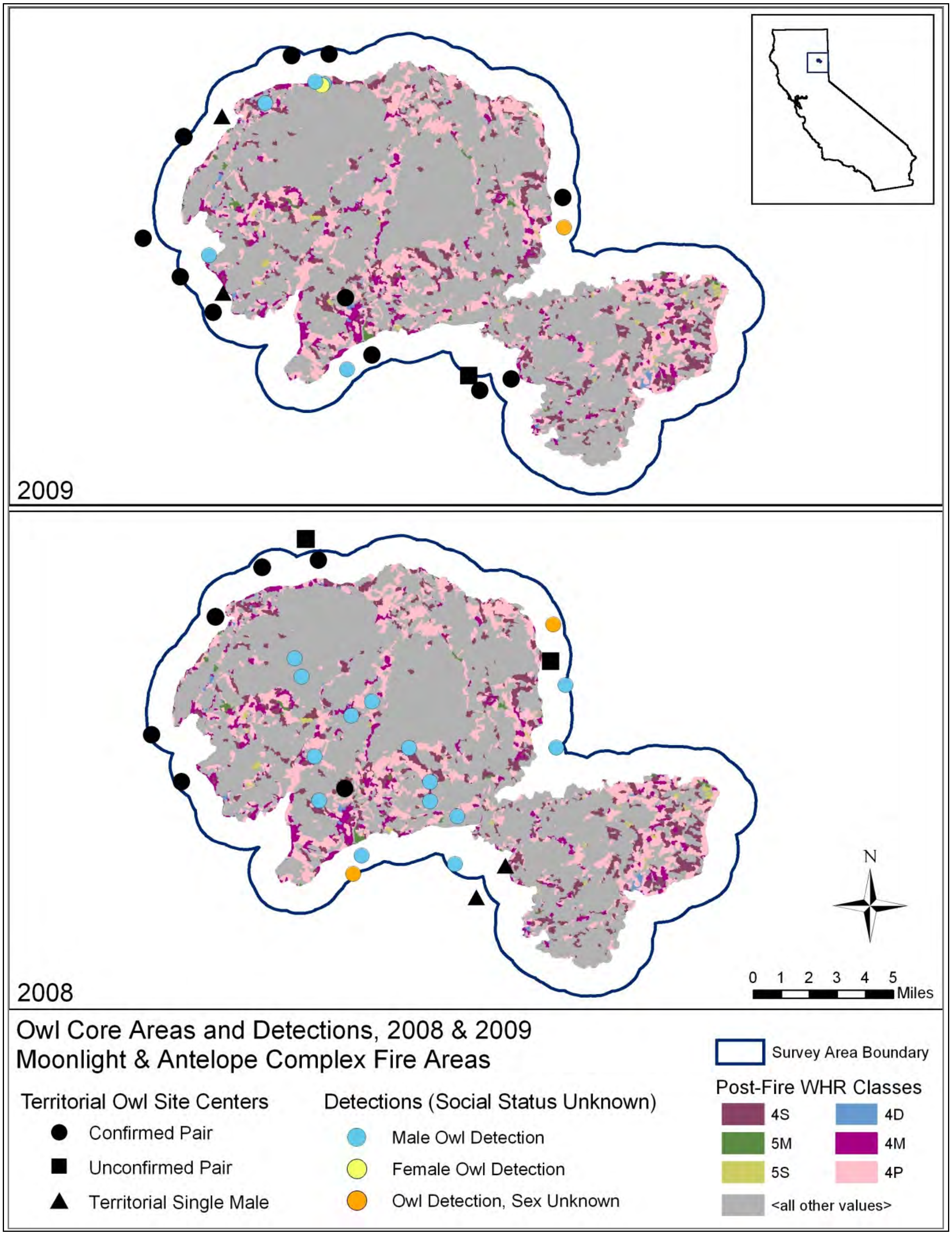
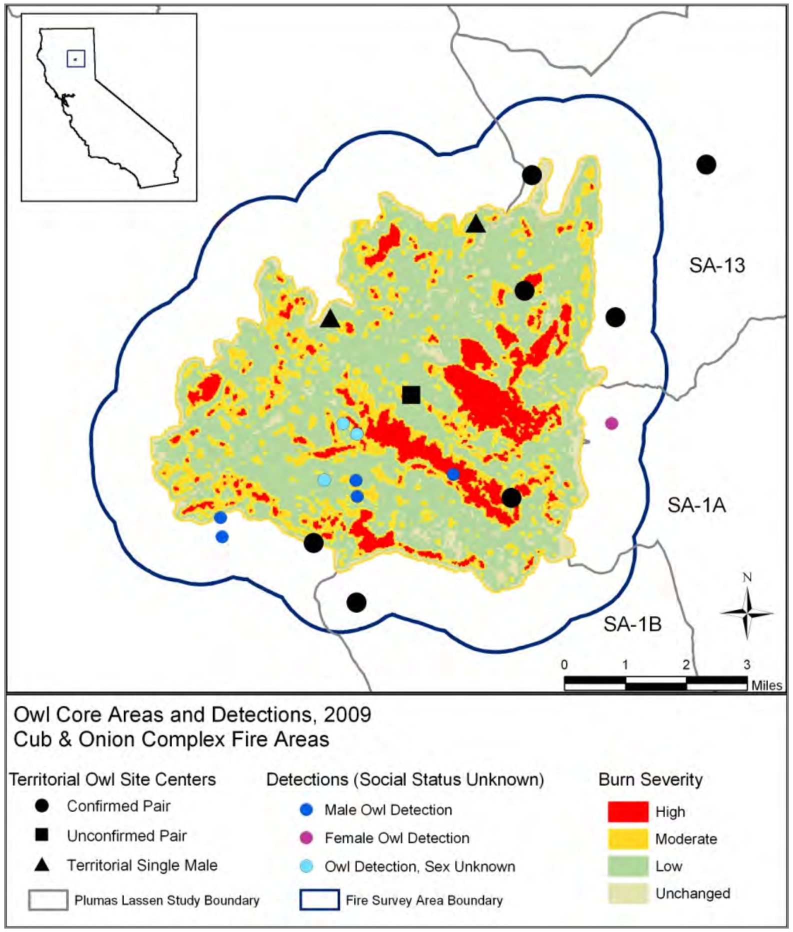


Figure 15. Distribution of California spotted owls detected in (a) 2009 and (b) 2010 within four wildfire burn severity classes in the Cub-Onion Complex Fire Area with a 1.6 km buffer, Lassen National Forest, California.

(a)



(b)

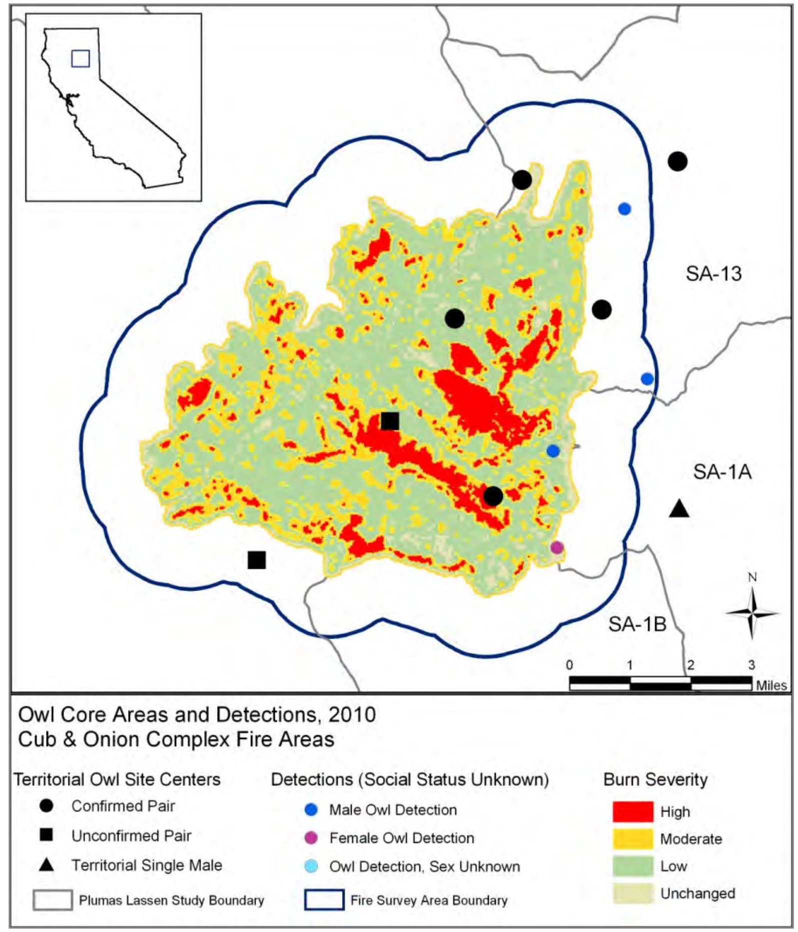


Figure 16. Distribution of Barred and Sparred (Spotted-Barred Hybrid) Owls within the HFQLG Project area, 1989-2010.