Calforests
California Forestry Association

NORTHERN SPOTTED OWL SCIENCE COMPENDIUM

California Dept. of Fish & Wildlife
California Fish & Game Commission
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NSO Science Compendium

EXECUTIVE SUMMARY

The California Forestry Association (Calforests) has assembled this *Northern Spotted Owl Science Compendium* to provide the California Department of Fish and Wildlife with important information for the preparation of their Status Review of the Northern Spotted Owl (NSO), currently a candidate species for potential listing under the California Endangered Species Act. This Compendium will provide a thorough discussion of many relevant issues associated with NSO on California's 2.4 million acres of private industrial ownership within NSO range. These include an overview of the current regulatory process in-place within California to protect the NSO; the status of private forestland NSO survey and monitoring efforts; the actual numbers of NSO present on these lands; as well as a discussion of threats to NSO in California.

Extensive Regulatory Protections

All timber-related operations on California's private lands are governed by an extensive, multi-agency regulatory process. The NSO is currently a federally listed species, with the U.S Fish and Wildlife Service (FWS) mandating measures to state agencies to avoid "take" of NSO. FWS involvement in the timber harvesting system in California has included the development of guidance documents for implementation by state agencies for the protection of NSO and its habitat in various regions of the NSO range. The FWS has aided CAL FIRE in the development of a number of NSO-specific Forest Practice Rules that require minimum protection measures. FWS staff has also provided both pre-consultation services and additional consultations for private landowners before and during the Timber Harvesting Plan process. In addition, the FWS has been instrumental in the establishment of an effective survey and monitoring protocol for the NSO.

Private industrial landowners have complied with these regulatory requirements, and in most cases, exceeded these requirements through the establishment of voluntary NSO and habitat protection programs. These programs include the establishment of federal Habitat Conservation Plans (HCPs) that specify additional protection and monitoring requirements. Currently there are 815,000 acres of lands covered by approved HCPs; another 669,000 acres are currently in various stages of development HCP development. Additional landowner-specific NSO protection measures currently in use in California include the Spotted Owl Management Plan and the Spotted Owl Resource Plan, both of which have additional NSO protection measures.

Surveys and Monitoring for up to a Quarter Century

Private industrial timber owners in California have been monitoring NSO for many years, and in most cases, for decades. An enormous network of private biologists, spotted owl experts, foresters, and other resource professionals have dedicated hundreds of thousands of hours of time in this collective monitoring effort. These monitoring programs have yielded a dataset of NSO population and habitat information on these lands that is unrivaled within the rest of the NSO range. In fact, while the FWS has used sample demography studies and modeling efforts to produce population estimates for NSO range-wide, in California, this extensive NSO-related dataset accumulated by California's private timberland owners provides the most comprehensive and detailed look at actual NSO population status and trends within California.

The results of this monitoring effort indicate that the population of NSO on California's private lands is dynamic yet stable. NSO are well-distributed within its range. The actual population estimates within the survey areas demonstrate that the population of NSO on private industrial timberlands is generally stable or increasing over time. This is in stark contrast to FWS estimates predicting that actual NSO numbers will decline 2.9% annually throughout its entire range, including Oregon and Washington. The NSO on California's private lands have a strong reproductive output over time, producing young NSO to both replace the existing population and, in many cases, actually expand the population.

Density Estimates Demonstrate Well-Distributed, Dynamic yet Stable Population

Example density estimates of occupied NSO pair territories per-square mile indicate that coastal NSO densities are dynamic but stable ranging from 0.29 in 2001 to 0.44 in 2013 (*Mendocino Redwood Co., NSO Compendium page 220*); 0.29 in 2003 to 0.36 in 2013 (*Conservation Fund, NSO Compendium Exhibit C*); 0.36 in 2003 to 0.47 in 2013 (*Humboldt Redwood Co., NSO Compendium page 34*); inland densities are generally stable, with approximately 0.17 occupied NSO pair territories/sq. mi. based upon surveys conducted between 2003-07 and 2011-13 (*Sierra Pacific Industries, NSO Compendium page 51*). Inland regions show a lower but also stable density primarily as a factor of hotter/drier natural habitat conditions, and reflect the differential size of inland NSO territories (3,398 acres/site) vs. coastal NSO territories (965 acres per site). In both cases, the NSO densities on private timberlands appears to exceed historic estimates of predicted NSO densities and populations. Furthermore, these densities can be extrapolated to develop a credible NSO population estimate for all of California's private and public lands showing that NSO are abundant and relatively stable in California. A reasonable total estimate of NSO pair territories throughout its California range could exceed 6,000 pair territories.

NSO Threats can be Addressed by Proactive Management

There are a number of threats to the NSO in California. These include destruction of habitat from catastrophic wildfire, the use of rodenticides associated with marijuana grows, and the increasing range of the barred owl, which is a larger, more-aggressive competitor of NSO. These threats can be addressed through the application of various management activities to reduce the occurrence of catastrophic wildfires, to reduce the number and size of illegal marijuana grows, and to evaluate the effectiveness of experimental barred-owl control programs.

Overview of Topics

This NSO Science Compendium provides an overview of these topics. It then includes detailed monitoring and survey information from the individual timber landowners. This highlights their NSO monitoring efforts over time, as well as their long-term NSO conservation strategies. In most cases, these landowners have provided NSO population data for long time periods, as well as estimates of NSO densities per square mile. There are also detailed discussions of the most important threats to NSO.

In summary, this NSO Science Compendium shows that the NSO populations on California's large industrial timberland holdings have been carefully monitored and surveyed over a long period of time. There is a robust regulatory process in place that has provided strong protections for the NSO. Landowners have willingly engaged in additional, effective voluntary programs to further protect NSO. The net result is that NSO within its California range is well-protected, well-distributed across the landscape, and is dynamic yet stable with quality nesting, roosting, and foraging habitat that moves across the landscape over time.

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Northern Spotted Owl (NSO) Science Compendium

California Forests and Regulatory Background

May 1, 2014

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California Forests, Communities and the Range of the NSO

California is the second most forested state in America with more than 33 million acres of forests, ranking only behind Alaska. Of California's total 100 million acres, approximately one-third is forest, with about 60% being in public ownership and 40% in private ownership (see Attachment A). Given the importance of our state's private forests to its environmental, economic and social well-being, it is critical to support its diverse set of uses and provide an effective, efficient and comprehensive system of regulation of its timberlands. This is especially true when addressing a species that is one of the most common raptors found in our forest, as is the Northern Spotted Owl (NSO). There are currently 3,061 NSO Pair Territories identified in the forests of California, and less than 60% of the potential habitat within the NSO range has been surveyed. Using a NSO Pair Territory density index of 0.278 Territories /sq. mile (3,061 current Territories / 11,000 sq miles), it is reasonable to project as many as 6,000 potential NSO Pair Territories may exist in California if the entire NSO range were surveyed. As such, it is necessary to recognize the NSO is likely to be involved with 50% or more of all Timber Harvesting Plans (THP) in the state.

Of the approximate 4.5 million acres of industrial timberland in California, nearly 2.4 million acres fall within the range of the NSO. Of equal importance, there is more than twice the acreage of small private owners (approximately 5.3 million acres) that fall within the range of the NSO. There are also 815,000 acres within the NSO range currently covered by federal Habitat Conservation Plans (HCP), and another 669,000 acres that are in varying states of HCP development (see Attachment B).

Of the 1.3 billion board feet of timber harvested sustainably from private forestlands in 2012, approximately 850 million board feet were produced from private forests within the range of the NSO. Should the forest industry timber activities be negatively impacted in any significant way, the net impact on statewide timber production could be up to $194 million (see Attachment E). Moreover, direct and indirect rural communities' jobs associated with primary wood processing and renewable biomass energy production, which are dependent upon a sustainable supply of wood resources within the NSO range, could reach 12,500 rural jobs (see Attachment D), with dozens of rural communities and hundreds of forest businesses being devastated; this, at a time when the industry is just beginning to recover from the worst economic recession in modern times.

History of NSO Pair Territories

After 25 years of surveying and tracking, NSO Pair Territory data for California suggests a healthy, well-distributed, dynamic yet stable population of pair territories with a substantial increase in known occupied habitat. Using recent and historic data from the Department of Fish and Wildlife (DFW) NSO database, the known population of NSO pair territories has been actually increasing in California (see Attachment C). In 1988, there were an estimated 950 known NSO pair territorial sites in California. By 1992, that estimate had increased to 2,061 and by 2003, that estimate had increased to 2,699. By 2012, this number has increased to 3,061 NSO pair territorial sites. In addition, the acres of NSO habitat protected pursuant to the California Forest Practice Rules (FPR) and U.S. Fish and Wildlife Service (USFWS) guidance have increased over this same period.

The current NSO pair territory data for large forest owners using California's regulations for NSO protection, suggests the actual population numbers generally demonstrate a dynamic but stable and robust NSO population. Large private landowners have present their data in the attached company specific papers, and have been conducting either project-level NSO surveys or landscape-wide NSO population and demographic surveys for years, often for decades. These data indicate that the overall numbers of occupied NSO territories have been dynamic yet stable for not only the past several years, but in many cases over decades while using the full range of California's NSO regulatory protections.

NSO population estimates starting with the May, 1990 "*Conservation Strategy for the Northern Spotted Owl,"* chaired by Dr. Jack Ward Thomas , there were 2022 known pairs of owls across its entire range in WA, OR, CA. Moreover, the number of know owl pairs in CA at that time was 533.

In Dr. Robert Taylor's May 10, 1193 paper, "*An Estimate of the Total Population of Northern Spotted Owls in California,"* he calculated a total number of CA NSO pairs as being 1774 (333% above the 1990 Thomas CA NSO estimate). While the range of variability of actual NSO population around the average was not calculated, it is interesting to note that Taylor's 1993 calculation of NSO pairs in CA was only 248 pairs less than Thomas' 1990 known NSO pairs across the entire three-state NSO range (1774 vs. 2022).

It is also significant to note that according to the USFWS, the overall NSO population range-wide (between Washington, Oregon and California) has been declining by an average annual rate of 2.9%. (The one non-HCP based demographic study in California has an average annual rate of decline of 1.7%.) Given these declining population trends range-wide, and even on California federal lands, the fact that the NSO populations on private lands in California have remained stable is a testament to the overall effectiveness of the State's protection measures for NSO and their habitat.

Potential Threats to NSO Populations in California

Three potential threats to NSO populations have been identified in California: Barred Owl encroachment, loss of habitat due to catastrophic wildfire, and pesticides associated with illegal marijuana plantations.

Barred Owls

In the most recent review of the condition of NSOs, the Revised Recovery Plan for the Northern Spotted Owl (Revised Recovery Plan) identified habitat loss and competition from the recently arrived barred owls as the most pressing threats to the NSO.

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."

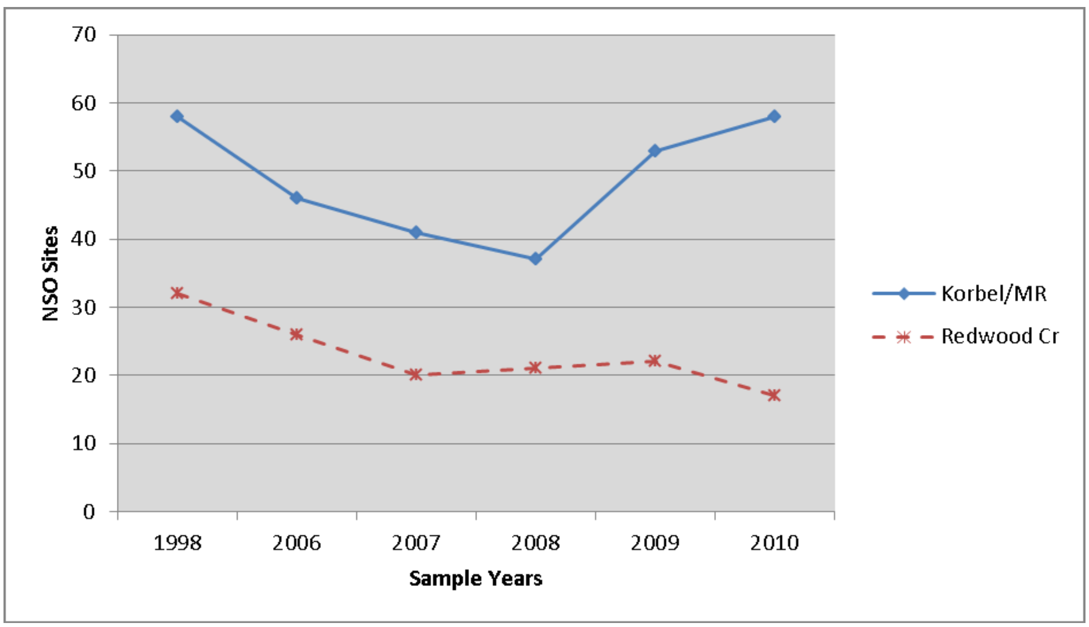
Barred owls are native to eastern North America, but only recently arrived in the West. They were first documented in the range of the NSO in Canada in 1959 and in western Washington in 1973. The range of the barred owl in the western United States now completely overlaps with the range of the NSO. Observations suggest that as the number of barred owls detected in historical spotted owl territories increase, the number of spotted owl responses have decreased. In the Pacific Northwest, barred owl populations developed first in Washington and spotted owl populations have apparently declined at the greatest rate in these areas. Evidence suggests that barred owl detections in the coastal NSO habitat of California are increasing.

Given the continuing range expansion and population growth of barred owl populations in the western United States and concurrent decline in NSO populations, the USFWS has proposed Recovery Action 29 in the Revised Recovery Plan, which involves experimental lethal removal of up to 3,600 barred owls in 11 study areas to determine if the removal would increase spotted owl site occupancy and improve population trends. Some coastal forest owners have also initiated/proposed barred owl removal research projects.

In 2009, Green Diamond Resource Company conducted a pilot project to remove Barred Owls from a portion of their ownership in the Redwood region. Their trend in estimates of population change indicated that the population of NSO on the Green Diamond study area was apparently stable or increasing until 2001, after which the population began an apparent downward trend.

“The barred owl covariate entered the top model for both survival and fecundity, which suggested that barred owls were the most likely cause for the recent decline of NSO on

Green Diamond's study area. This downward trend was reversed with a 20.5% increase in the number of occupied owl sites on Green Diamond's density study area in 2009 followed by a 3.0% increase in 2010 and a 1.0% increase in 2011. In 2011, they observed a 6% increase in the number of sites in the larger demographic study area. Factors that may have contributed to this increase included modifications of the survey protocol in 2009 to increase NSO detection rates, which resulted in locating banded resident NSO in historical sites that had appeared to have been abandoned in recent years. In addition, the Lower Mad River Tract has large areas of third growth that apparently were just now reaching suitable habitat attributes for colonization by NSO. Green Diamond also initiated a barred owl removal experiment in 2009, which involved removing all barred owls from treatment areas, i.e., approximately half of the total study area. Barred owls were removed from historical NSO sites, which allowed these sites to be re-colonized by NSO and these treatment areas could be colonized by NSO free from interference from this invasive species. Therefore, it probably was a combination of improving survey techniques, increasing amounts of suitable habitat and freeing approximately half of the study area from barred owls that led to the recent increase in occupied NSO sites."



Trend in occupied Northern Spotted Owl (NSO) Sites on Two Adjacent Tracts of land on Green Diamond Resource Company's ownership in coastal northern California. Barred owls were removed from Korbel/MR in 2009 and 2010, but no barred owls were removed from Redwood Creek.

Loss of Habitat from Wildfire

California's forests are largely ecosystems that have adapted over time from natural fire regimes. Fire exclusion and management (or non-management) practices have resulted in significant overly-dense forest conditions ripe for unnaturally large fire events. The potential values at risk to catastrophic wildfire include the stability and viability of spotted owl habitat.

Over the past dozen years, the average annual acres burned in California exceed 550,000. The percent of high severity fire has increased from 21% to 33% since 1985, and this year's Rim fire alone burned over a quarter of a million acres while partially or entirely destroying 22 of 46 California Spotted Owl Territories. Placing on top of this existing situation, CARB projects an increase of up to 55% in wildfire acres by the end of this century due to Climate Change induced temperature and drought increases.

The vast majority of owl habitat currently impacted by wildfire in California is on USFS ownership and is not within the range of the Northern Spotted Owl, but within the CAPO range in the Sierra Nevada and southern Cascade mountains (FRAP Assessment 2010). Moreover, recent research indicates that protecting spotted owls through proactive landscape management, which includes forest thinning and prescribed fire, suggests owls would be better serve than through strict habitat reserves (PNW, issue 125, July 2010). Key findings included, "A whole-landscape approach would help maintain habitats in dynamic landscapes: restore ponderosa and mixed-conifer forests; restore natural fire ecology; and maintain populations of species associated with old forests, such as the threatened northern spotted owl, especially given projected climate change scenarios."

Other California specific research (Nechodom, 2010) correlating the forest management benefits of biomass thinning to wildfire reduction:

- "A 22% reduction in the number of acres burned by wildfires. Even greater reductions can be anticipated by strategically locating thinning projects in areas of high fire hazard.
- A dramatic drop in fire severity. Again, strategic location of thinning treatments would likely enhance this result."

The Governor's fiscal 2014-15 budget includes a substantial commitment of resources to fuels management activities through allocations from climate change and state responsibility fire prevention funds. Clearly the risk of wildfire to NSO populations is not insignificant, but is manageable through planned and ongoing proactive forest management.

Pesticide from illegal land-uses

In addition to the barred owl threat to the NSO population, there is growing recognition of the potential for a new threat resulting from possible exposure to anti-coagulant rodenticide poisoning. Illegal marijuana is grown on public and private lands, and have been found to use often copious amounts of rodenticide in an attempt to prevent crop damage. In turn, the rodenticides can have both primary and secondary impacts on predators such as Pacific fisher (*Martes pennanti pacifica*), and possibly spotted owls (Thompson, et al 2013, Douglas 2013). In the redwood region, primary prey species of NSO include the dusky-footed woodrat (*Neotoma fuscipes*) and deer mice (*Peromyscus* spp.), which are also prey species of Pacific fisher and may be responsible for exposure of fishers to rodenticides used at grow sites. While these impacts on mortality are currently very limited, further research on this issue using the carcasses of lethally removed barred owls should shed light on this potential threat in the near term.

In response to these impacts, the DFW and the SWB have proposed in the governor's 2014-15 Budget an aggressive program of enforcement and environmental restoration designed to reduce and ultimately eliminate these illegal sources of environmental degradation.

Conclusions

For all three of these potential threats, adapting and enhancing pro-active forest management practices to address these risks will clearly contribute to the ongoing stability and viability of Northern Spotted Owls, as well as many wildlife species.

Forest Practice Act

The Z'berg-Nejedley Forest Practice Act of 1973 [Division 4, Chapter 8, Public Resources Code] (FPA) establishes legislative intent directed at encouraging prudent and responsible forest management calculated to meet the public's needs for timber and other forest products, while giving consideration to the public's need for a variety of forest-related resource values, including the public trust resources of water, fish and wildlife.

The FPA recognizes the need to balance forest-management objectives with the multiple goals of the California Environmental Quality Act of 1970, the California Endangered Species Act, the Porter-Cologne Water Quality Control Act, the Timberland Productivity Act, and other applicable state and federal statutes to ensure that the objectives of each are harmonized to the extent possible.

The FPA further requires a THP must be submitted for approval, and as a discretionary environmental permit, must meet the substantive requirements of the California Environmental Quality Act (CEQA) as a certified regulatory program (CEQA, Section 21080.5), including the analysis of potential impacts to the public trust resources of water, fish and wildlife.

The FPR provide a rigorous process for evaluating both potential site-specific and cumulative impacts that has been certified by the Natural Resources Secretary as functionally equivalent to CEQA.

For the roughly 5.5 million acres of timberland zoned as Timber Production Zoning (TPZ), the Forest Taxation Reform Act of 1976 (Govt. Code Section 51100 et seq.) and the California Forest Practice Rules (Title 14, CCR Chapter 4, Section 898) state, "On TPZ lands the harvesting per se of trees shall not be presumed to have a significant adverse impact on the environment."

Public Resources Code (PRC) Section 4513 states the intent of the FPA is to assure that: "(a) Where feasible the productivity of timberlands is restored, enhanced and maintained." And "(b) The goal of maximum sustained production of high-quality timber products is achieved while giving consideration to the values relating to recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment, and aesthetic enjoyment."

Pursuant to the provisions of the FPA, the Board of Forestry (BOF) has established extensive rules including Sustained Forestry Planning (14 CCR 913.10), Watercourse and Lake Protection (14 CCR Chapter 4, Article 6), and Wildlife Protection Practices (14 CCR Chapter 4, Article 9).

Federal Listing – NSO Specific Regulations

The NSO has been listed as a threatened species under the federal Endangered Species Act (ESA) since 1990. At the time of listing, it was thought that only 99 NSO Pair Territories existed in private California forests (see Attachment C). As a result of listing, "*take of NSO*" is prohibited unless authorized by the USFWS consistent with the ESA. The FPR contains a robust regime for conducting timber harvesting operations to avoid "*take of NSO.*"

The Forest Practice Rules require the Cal Fire Director to disapprove a THP if its implementation would result in a "*taking"* of a protected species. FPR § 898.2(d) ("The Director shall disapprove a plan as not conforming to the rules of the Board if … [i]mplementation of the plan as proposed would result in either a '*taking'* or finding of jeopardy of wildlife species listed as rare, threatened or endangered by the Fish and Game Commission, the National Marine Fisheries Service, of Fish and Wildlife Service…."). The FPR contain a more specific rule for NSO, requiring the Director to disapprove a THP if "[i]mplementation of the plan as proposed would result in the *taking*[1] of an individual Northern Spotted Owl prohibited by the Federal Endangered Species Act." FPR § 898.2(f).

The FPR have their own detailed provisions for the protection and conservation of NSO and their habitat. These rules have been updated to reflect changes in the procedures used by the involved federal and state agencies to ensure that take of NSO is not likely to result from timber operations. In addition, the rules have continuously been supplemented by guidance from USFWS and the other involved agencies as new information about NSO and their habitat has been generated and knowledge of NSO habitat needs has evolved. The whole purpose of these rules and the NSO program they establish is to ensure and enable compliance with the federal ESA's take prohibition which, of course, is broader (and, thus,

[1] The FPR have adopted the ESA's definition of "take." FPR § 895.1 ("Take for Federally Listed Species means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct as stated in 16 United States Code 1532(19)."). CESA defines "take" more narrowly than does the federal ESA. Under CESA, "take" means "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." *Cal. Fish & Game Code* § 86.

imposes greater restrictions) than the definition of *"take"* under CESA. Accordingly, the FPR rely upon federal ESA definitions and requirements with respect to NSO.

The FPR are replete with technical definitions concerning NSO and their habitat. *See* FPR §895.1 (definitions, including "activity center," "functional foraging habitat," "functional nesting habitat," "functional roosting habitat," "northern spotted owl breeding season," "northern spotted owl evaluation area," "owl habitat," "spotted owl expert," "spotted owl resource plan," "type A owl habitat," "type B owl habitat," "type C owl habitat"). The FPR require the plan submitter to follow certain procedures and provide information for the Director to use in making the take determination. FPR §§ 919.9, 939.9. If a timber operator proposes operations within the range of the Northern spotted owl or within 1.3 miles of a known NSO activity center, the proposed THP must include certain mandatory measures to ensure against any unlawful take of the species. FPR §§ 919.9, 939.9. The FPR provide the plan submitter a number of options for demonstrating compliance with the ESA, each specifying measures and requirements to ensure that the proposed operations will not result in unlawful take of NSO. FPR §§ 919.9(a)-(g), 939.9(a)-(g). These, too, were developed in collaboration with USFWS and the CDFW.

These different approaches for demonstrating that proposed operations will not result in unlawful take of NSO are known as options (a) through (g). They are all used, to varying degrees, by forest owners to conduct timber operations. Several of them require the involvement of a Spotted Owl Expert (SOE) to ensure that the Department of Forestry and Fire Protection (CAL FIRE) has the information necessary to determine if proposed operations, as conditioned by numerous measures to avoid impacts to NSO and their habitat, are likely to avoid take. As provided by FPR sections 919.9(a)-(g), 939.9(a)-(g):

(a) If the project proponent requests preliminary review of the proposed operation or Spotted Owl Resource Plan prior to filing, the proponent shall consult with an SOE to evaluate whether the proposed operation would result in the taking of an individual Northern spotted owl. This evaluation is preliminary to and separate from the final "take" determination to be made under 14 CCR § 919.10 [939.10]. In making that evaluation:

(1) The SOE shall apply the criteria set forth in 14 CCR § 919.10 [939.10].

(2) The SOE may request that the submitter provide additional information which the SOE finds necessary to evaluate if a "take" would occur, provided that the SOE states the type of information needed, the purpose of the information, and the level of accuracy necessary to meet the stated purpose.

(3) If the SOE concludes that no prohibited taking would occur, the SOE shall inform the submitter as soon as practicable and shall document the decision and the information which was relied upon by the SOE in the above evaluation. Reference data shall be readily available for the Director's review upon request;

(4) If the SOE concludes that the proposed timber operation or Spotted Owl Resource Plan would result in a taking, he or she shall inform the submitter as soon as practicable and shall comply with 14 CCR § 919.10© [939.10©] within 10 working days of making this determination.

(5) Requests for pre-filing consultation shall be handled in the order in which received.

(b) The RPF shall include the following information:

(1) On a planimetric or topographic map of a minimum scale of 1:24,000, provide the following:

(A) The location and acreage of owl habitat. This information shall be shown for the area within the boundary both as it exists before and after timber operations. The Director shall determine if timber typing maps may qualify as showing owl habitat.

(B) Identify any adjoining owl habitat by type within .7 miles of the boundary.

(C) When mapping functional owl nesting, roosting, and foraging habitat, include additional information which helps define those areas such as: location of topography features, riparian vegetation, hardwood component, water, potential nest and roost sites, and potential suitable forage areas.

(D) All known owl observations, identified by location and visual or nonvisual confirmation within 1.3 miles of the boundary. This information shall be derived from the landowners and RPF's personal knowledge, and from the Department of Fish and Game's spotted owl data base.

(2) Discussion on how functional characteristics of owl habitat will be protected in terms of the criteria stated within 14 CCR § 919.10 subsections (a) and (b) [939.10 subsections (a) and (b)].

(3) As adjacent landowners permit and from other available information, a discussion of adjacent owl habitat up to .7 mile from the proposed boundary and its importance relative to the owl habitat within the boundary.

(4) Describe any proposals for monitoring owls or owl habitat which are necessary to insure their protection. Monitoring is not required for approval.

(5) Discussion of any known owl surveys that have been conducted within 1.3 miles of the THP boundary. Include the dates, results and methodologies used if known.

(6) A proposed route that will acquaint the SOE and other reviewers with the important owl habitat.

(7) Attach aerial photos of the area, if available. (Aerial photos are not required.)

(c) Where certification is made by the RPF and adequate records are kept showing that owl surveys were conducted sufficient to demonstrate the absence of owls from an area, the THP will be reviewed on a high priority basis. The THP shall contain verification that:

(1) The surveys have been conducted throughout the area within .7 miles of the boundary in accordance with the USFWS approved protocol ("Protocol For Surveying Proposed Management Activities That May Impact Northern Spotted Owls"; USFWS; March 17, 1992).

(2) The surveys were conducted during the current or immediately preceding survey period as prescribed by the previously cited USFWS approved protocol.

(3) The surveys reveal no nest sites, activity centers or owl observations in the area surveyed; and

(4) The surveys reveal no activity center or repeated observations indicating the presence of mates and/or young within 1.3 miles of the boundary based on a review of the landowner's and RPF's personal knowledge and the Department of Fish and Game's spotted owl data base.

(d) If the plan submitter proposes to proceed under an *"incidental taking"* permit or any other permit covering the northern spotted owl issued by the U.S. Fish and Wildlife Service or the Department of Fish and Wildlife, the submitter shall supply a copy of the permit upon the Department's request.

(e) If the submitter proposes to proceed pursuant to the outcome of a discussion with the U.S. Fish and Wildlife Service, the submitter shall submit a letter prepared by the RPF that the described or proposed management prescription is acceptable to the USFWS.

(f) If:

(1) the submitter's proposed operations were reviewed by a SOE under 14 CCR § 919.9, subsection(a) [939.9, subsection(a)]; and

(2) the SOE recommended minimum modifications to the proposed operations which would be necessary to bring the impacts to a level at which no *"take"* would occur and the submitter has adopted those recommendations; and

(3) the proposed operations remain substantially the same as the operations which the SOE reviewed, the submitter shall provide a copy of the recommendations made by the SOE and the submitter shall explain how the proposed operations comply with those recommendations.

(g) Where an activity center has been located within the plan boundary or within 1.3 miles of that boundary, the RPF shall determine and document in the plan: (i) activity center-specific protection measures to be applied during timber operations and (ii) owl habitat, including habitat described in (1)-(5) below, that will be retained after the proposed operations are completed:

(1) Within 500 feet of the activity center the characteristics of functional nesting habitat must be maintained. No timber operations shall be conducted in this area during the northern spotted owl breeding season unless reviewed and approved by the Director as not constituting a take. Timber operations may be conducted in this area outside the breeding season if appropriate measures are adopted to protect nesting habitat.

(2) Within 500-1000 feet of the activity center, retain sufficient functional characteristics to support roosting and provide protection from predation and storms. No timber operations shall be conducted in this area during the breeding season unless reviewed and approved by the Director as not constituting a take.

(3) 500 acres of owl habitat must be provided within a .7 mile radius of the activity center, unless an alternative is reviewed and approved by the Director as not constituting a take. The 500 acres includes the habitat retained in subsections (1) and (2) above and should be as contiguous as possible. Less than 50% of the retained habitat should be under

operation in any one year, unless reviewed and approved by the Director as not constituting a take.

(4) 1336 total acres of owl habitat must be provided within 1.3 miles of each activity center, unless an alternative is reviewed and approved by the Director as not constituting a take. The 1336 acres includes the habitat retained within subsections (1)-(3) above.

(5) The shape of the areas established pursuant to subsections (1) and (2) shall be adjusted to conform to natural landscape attributes such as draws and stream courses while retaining the total area required within subsections (1) and (2) above.

Examples of Regulatory Approaches used by Forest Owners

For example, one of the prescribed approaches used in THPs submitted to CAL FIRE—the "option (g)" procedure, refers to subsection (g) of section 919.9, 939.9 of the FPR, which applies when "an activity center has been located within the plan boundary or within 1.3 miles of that boundary." FPR §§ 919.9(g), 939.9(g). Subsection (g) requires the Registered Professional Forester (RPF) to determine and document in the THP those activity center-specific protection measures to be applied during timber operations and the owl habitat that will be retained after operations are completed. FPR § 919.9(g). These standards are intended to ensure that modification of NSO habitat by timber operations does not result in *take* by requiring the creation and maintenance of "owl habitat circles" around known NSO sites within which habitat of sufficient quality and quantity will be retained so that take does not occur.

In regards to evaluating the use of option (g), and pursuant to a USFWS request, a forest owner in Trinity County conducted a long-term NSO population density study on 170,000 acres of their ownership over the 5-year period from 2003-2007; the survey effort has now been extended to include the period 2011-2013. The study results (currently in review) indicated that over the 23 years of total survey to date since 1989, the study area started with 42 NSO occupied activity centers, in 2003-2007 there were 47 occupied activity centers, and the latest estimate is that there are 48 NSO occupied activity centers, demonstrating a stable/increasing population while using option (g) pursuant to the current FPR options. The net increase of occupied activities centers is six from 1989 and an additional one from 2003-2007 period (net of the loss of one NSO occupied activity center that was attributed to wildfire). In 2011, 2012, and 2013 while most other study areas in California showed very poor reproductive success due to bad spring weather, of these 48 occupied activity centers, 25 were determined to have successful reproduction (producing a minimum observed count of 52 young). Remarkably, 7 of these 25 reproduced twice in this three year period and 3 nests reproduced 2 years in a row, so there were 32 individual known nesting efforts with a minimum observed count of 52 young.

Another example of prescribed approaches used in THPs submitted to CAL FIRE is the "option (e)" procedure, which refers to subsection (e) of section 919.9, 939.9 of the FPR, which applies when the THP submitter proposes to proceed pursuant to the outcome of a discussion with the USFWS; the submitter shall submit a letter prepared by the RPF that the described or proposed management prescription is acceptable to the USFWS. A 114,700-acre forest owner in Siskiyou County operates under this option via a USFWS-approved Spotted Owl Management Plan (SOMP). This forest ownership has been operating successfully pursuant to their SOMP since 1995. They have been involved in a number of collaborative research projects and published papers regarding NSO. Their estimate of owls recorded on and within 0.5 miles of their ownership in the year 2000 was 21, while the recorded owls on their ownership in 2012 were 22. As they indicate, "we have concluded that our owl population is dynamic, yet stable."

Another example of prescribed approaches used in THPs submitted to CAL FIRE is the "option (d)" procedure, which refers to subsection (d) of section 919.9, 939.9 of the FPR, which applies when the THP submitter proposes to proceed pursuant to an *"incidental take"* permit. There are currently three forest owners with a combined ownership of 815,000 acres operating pursuant to "option [d]." These forest owners have federal HCPs approved by the USFWS that provide measures intended for long-term conservation of the NSO on their ownerships.

Forest owners provided these and other population density estimates to the Fish and Game Commission (Commission), which are already a part of the record.

All of the FPR sections 919.9(a)-(g), 939.9(a)-(g) approaches and standards are intended to ensure that timber operations do not result in unauthorized take.

The Director does not exercise unfettered discretion in determining if a plan will cause "*take."* The FPR require the Director to find that proposed habitat modification would result in "harm" if feeding, breeding, nesting, or sheltering would be "significantly impaired." FPR §§ 919(a), 939.10(a). The FPR require the Director to find that "an individual northern spotted owl would be 'harassed' by the proposed timber operations if there is likelihood that feeding, breeding, nesting, or sheltering would be 'significantly disrupted.'" FPR §§ 919.10(b), 939.10(b). If the Director concludes that proposed operations will result in a "*taking"* of the owl, he will provide recommendations for modifications to the THP necessary to reduce impacts to a level at which take would not occur. FPR §§ 919.10(c), 939.10(c). It is important to note that the FPRs' use of the federal ESA's "*take"* standard – which encompasses habitat modification and harassment – means the FPRs' NSO program goes beyond what would be necessary to comply with CESA's take prohibition and, thereby, already affords the NSO greater protection than it would enjoy if advanced to candidacy or, ultimately, listed under CESA.

Of course, the FPR requirements only function as a floor. Through the site-specific, multi-agency THP review and approval process, including field inspections, habitat retention and other measures are considered and (if deemed necessary) required before THPs are approved. The USFWS continues to be involved in this process by providing technical assistance when requested by CAL FIRE or the public, when unique circumstances arise.

Moreover, earlier this year, the Department of Fish and Wildlife recognized the efficacy of the FPR's NSO program, as described above, in avoiding take of NSO from approved timber operations. See DFW Director Charlton Bonham to CalFire Director Ken Pimlott re Candidacy of the Northern Spotted Owl for Listing Under the California Endangered Species Act (Jan. 16, 2014). In light of the efficacy of this regulatory program, as recognized by DFW, there can be no doubt that existing management efforts directly benefit the species and are more than adequate to ensure its conservation. See Fish and Game Code section 2072.3 (petition shall include information regarding "the impact of existing management efforts"); see also id. at section 2067 (a species is "threatened" when, though "not presently threatened with extinction, [it] is likely to become an endangered species in the foreseeable future in the absence of the special protection and *management efforts*").

Listing Status

Notwithstanding the fact that the NSO is already protected under federal law, in September 2012, the Commission received a petition to also list the NSO as threatened or endangered under CESA. As required by CESA, the Commission referred the petition to CDFW for evaluation. In February 2013, CDFW completed its petition evaluation report, which concluded that the petitioned action may be warranted and that the petition should be accepted. The Commission received the CDFW evaluation report at its March 2013 meeting. The Commission considered the listing petition at its April 17-18, 2013 meeting, and decided to postpone the decision until its August meeting to allow further time to review the data submitted by forest owners and forestry professionals. The issue was taken-up at the August Commission meeting, with a 3-2 vote to accept the petition for listing as a *Candidate* species. The Commission voted on formal findings at its December 11, 2013 meeting.

It is important to note that a parallel and related petition was submitted to the Board of Forestry proposing to eliminate key Forest Practice Rules related to NSO protections by Environmental Protection Information Center (EPIC), the same petitioner in the action before the FGC proposing to list the NSO under the California Endangered Species Act. On July 8, 2013, after a thorough review of the effectiveness of the existing NSO rules, the Board of Forestry rejected the petition and reaffirmed the effectiveness of the existing regulatory program.

Acceptance by the FGC of the listing petition and adopting findings with formal noticing has conferred "candidate" status on the NSO under CESA until such time as CDFW completes a full status review of the species and the Commission determines whether to list the species as threatened or endangered. *See* Cal. Fish & Game Code §§ 2070-2079. The CESA take prohibition (section 2080) applies fully to a candidate species, even though the Commission has yet to determine whether that species should be listed as threatened or endangered. *Id.* § 2085. Under CESA, the "*taking*" of a candidate species is prohibited unless authorized consistent with CESA. *Id.*

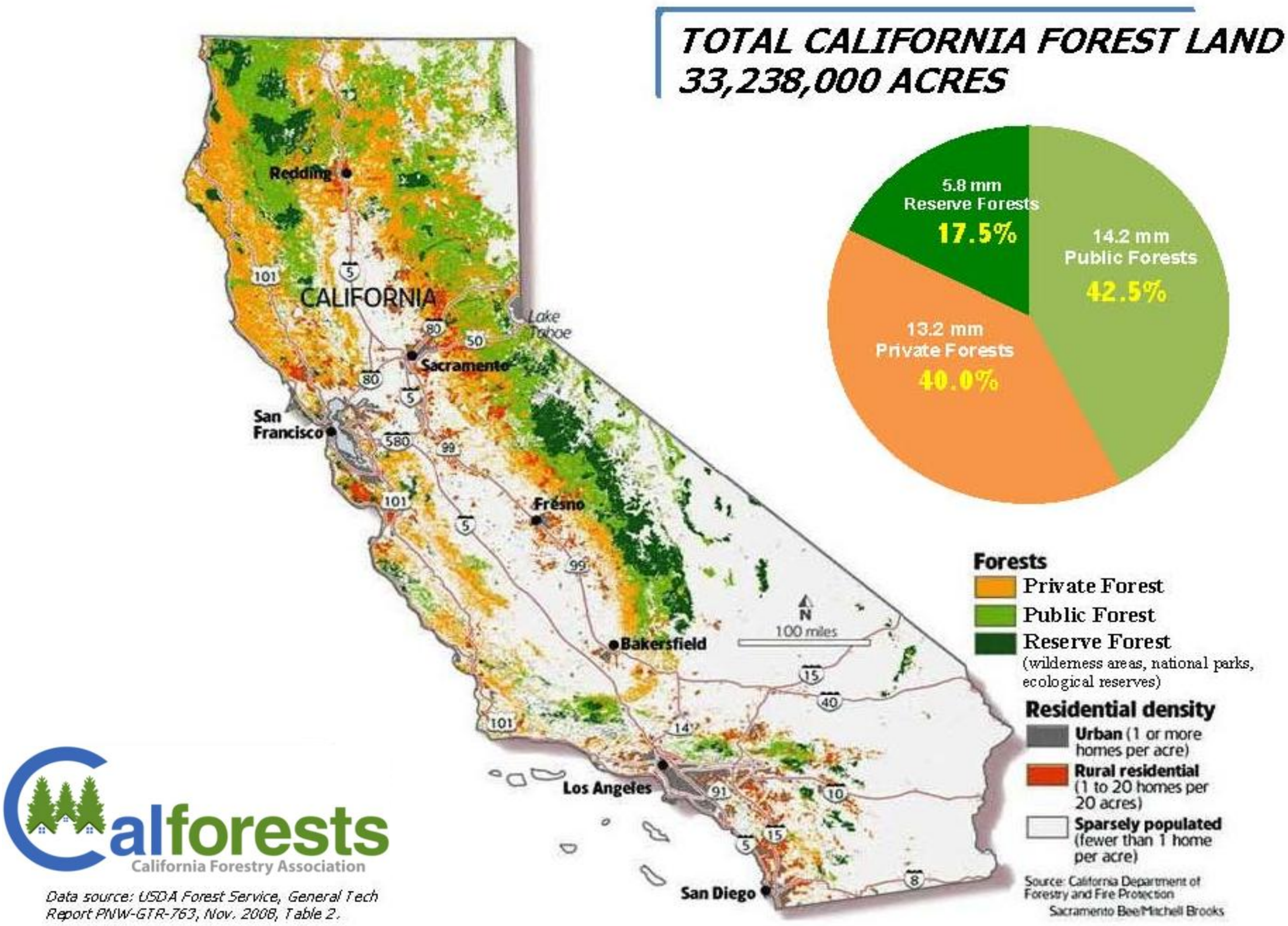
In regards to the nearly quarter-century of ongoing forest practice regulation of the NSO pursuant to the federal listing, on January 16, 2014 DFW Director Bonham wrote to Cal Fire Director Pimlott:

> During the past two decades after NSO became federally listed, sections 919.10 and 939.10 of the California Forest Practice Rules (FPRs) have obligated the California Department of Forestry and Fire Protection (CalFire) to make a finding for each timber harvesting plan (THP) within the range of the NSO that the THP will avoid take of any NSO as defined by the federal Endangered Species Act (ESA). To our knowledge, CalFire in coordination with the U.S. Fish and Wildlife Service and the Department, has effectively implemented this regulatory requirement, allowing THPs to proceed while avoiding take of NSOs. Take as defined by the ESA includes "harm" and "harass," activities which extend well beyond the definition under the Fish and Game Code; viz, "hunt, pursue, catch, capture or kill or attempt to hunt, pursue, catch, capture or kill." The Department concludes a CalFire finding that take under ESA of any NSO would be avoided in accordance with the FPRs would likely be valid for take as defined in the Fish and Game Code.

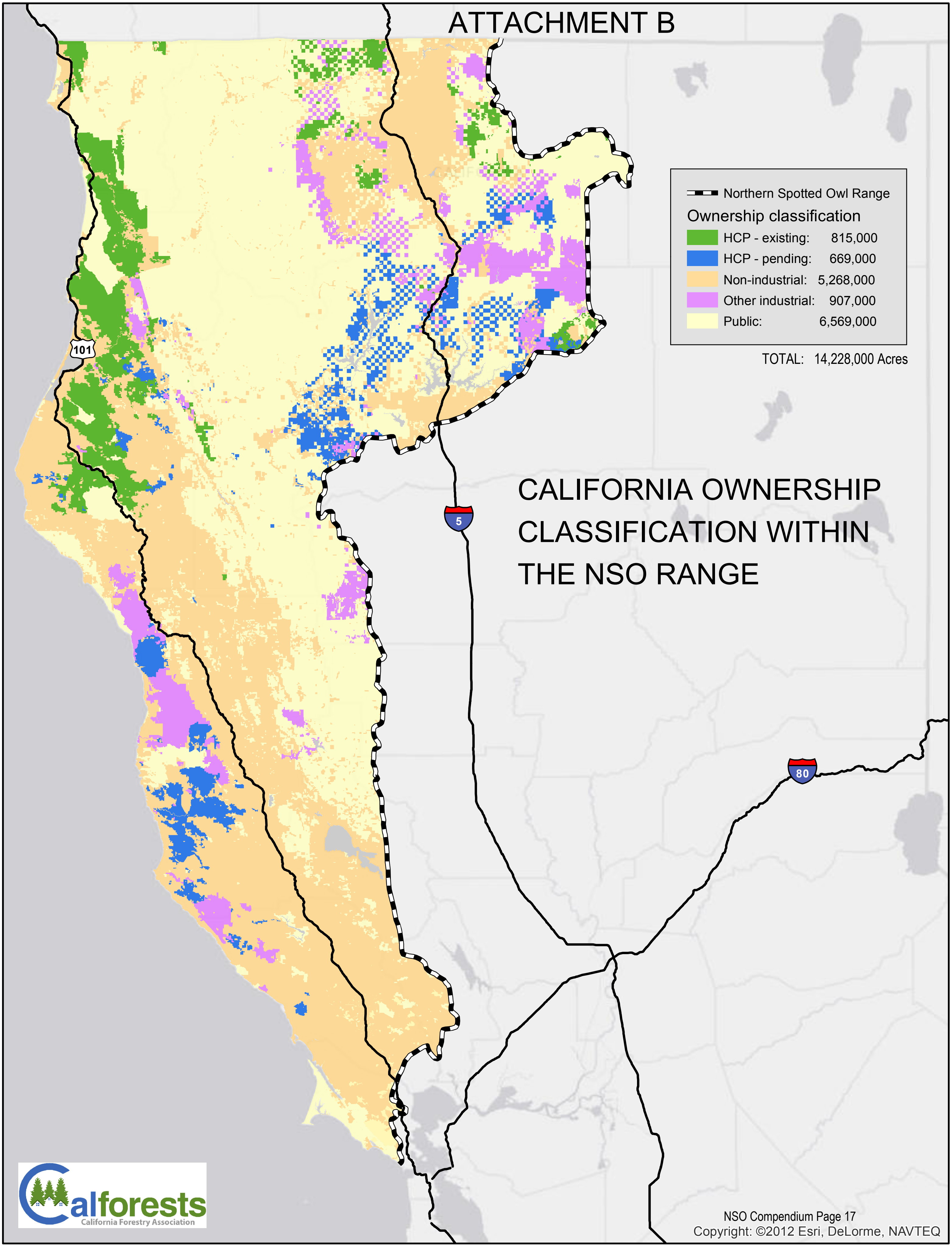
Conclusion

The original and applied science and monitoring activities our members' biologists and foresters have been conducting over the past years, decades, and in some cases quarter century of monitoring Northern spotted owl habitat needs and populations have led to the conclusion that California's NSO population is well distributed across the landscape, is dynamic yet stable over the past quarter century, and is subject to a regulatory system that protects against mortality while providing quality nesting, foraging, and roosting habitat that moves across the landscape over time.

ATTACHMENT A



ATTACHMENT B



CALIFORNIA OWNERSHIP CLASSIFICATION WITHIN THE NSO RANGE

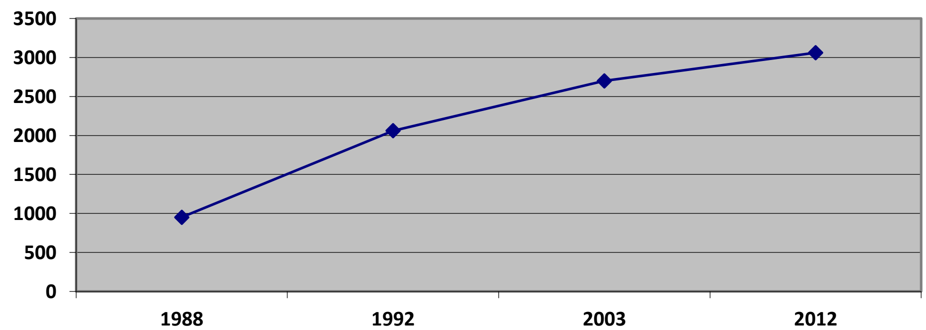
ATTACHMENT C

California's Total Acres within the Northern Spotted Owl Range

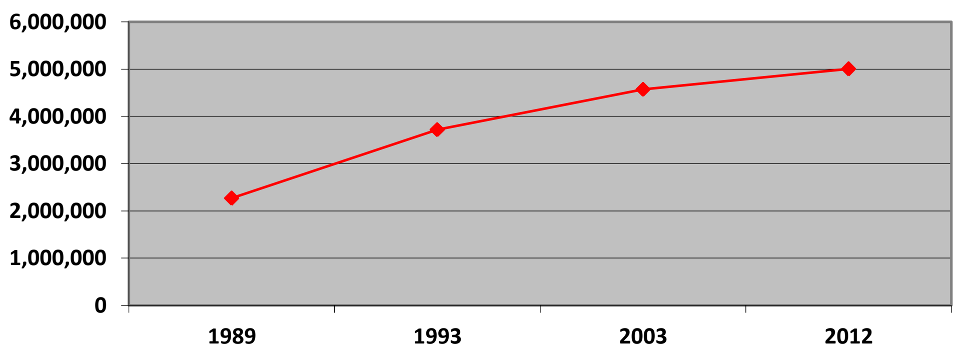
Public Forests	6.569 million acres
Private Non-industrial	5.268 million acres
Industrial Forests	2.391 million acres
TOTAL	14.228 million acres

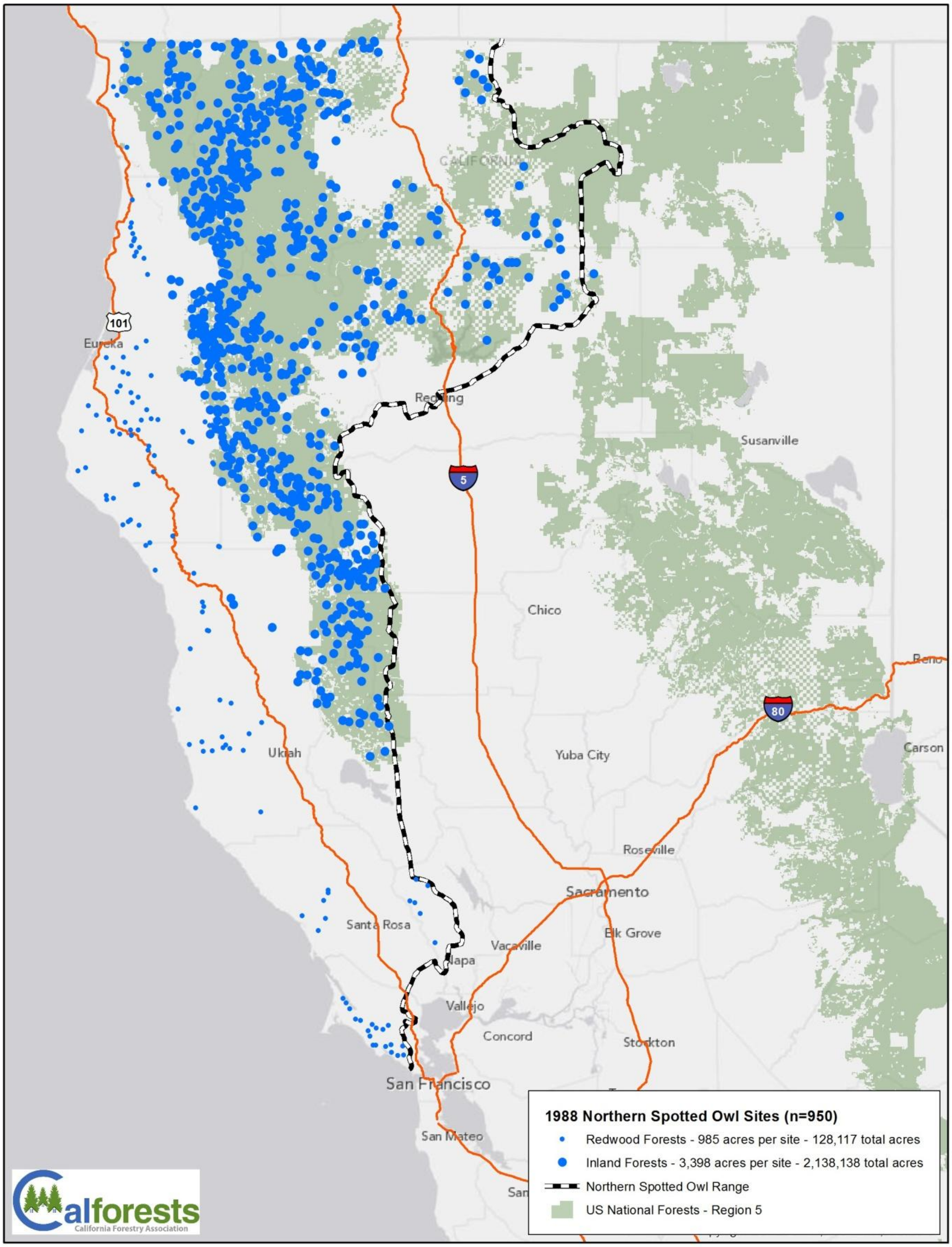
California Dept. of Fish & Wildlife Northern Spotted Owl Data

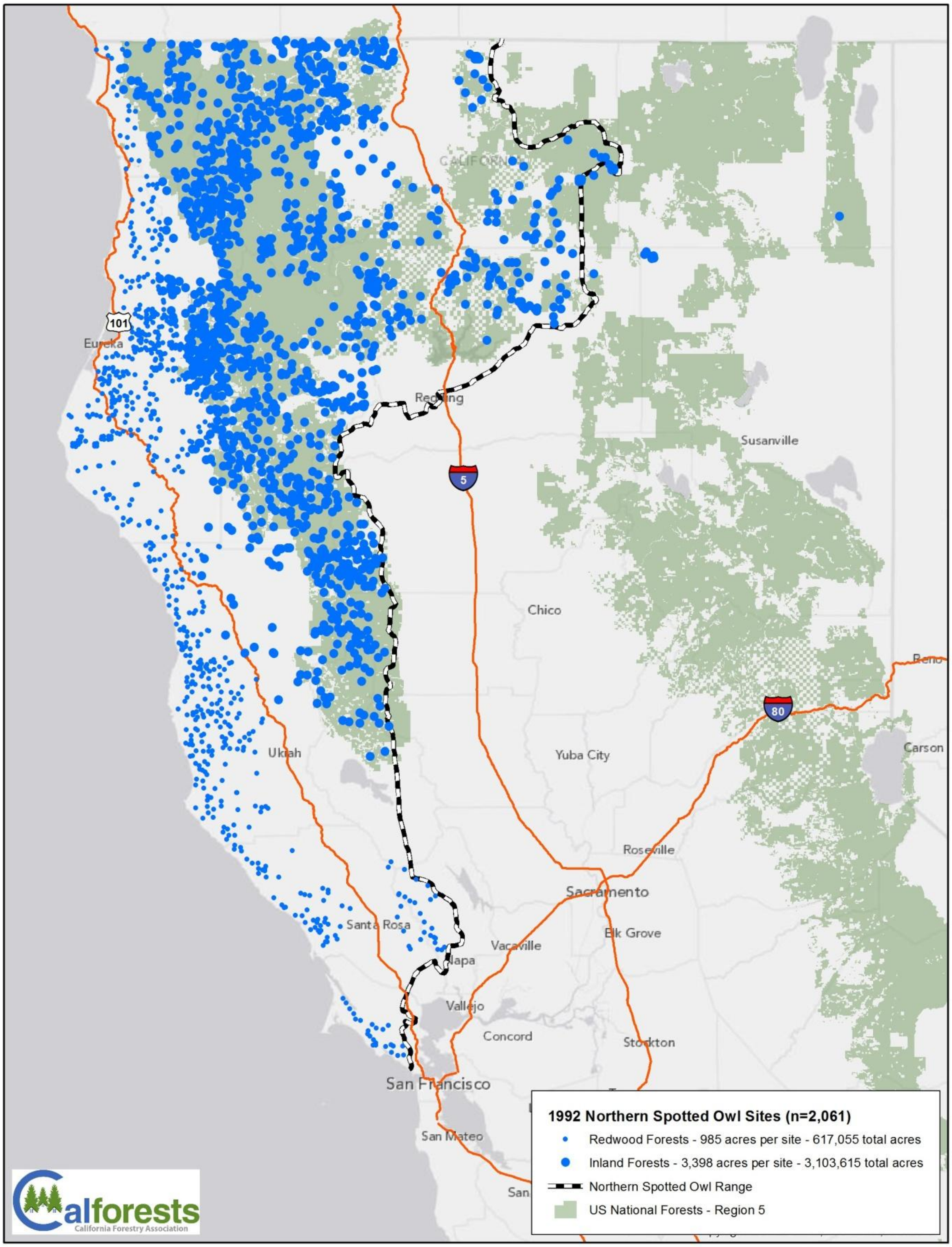
NSO Territorial Sites

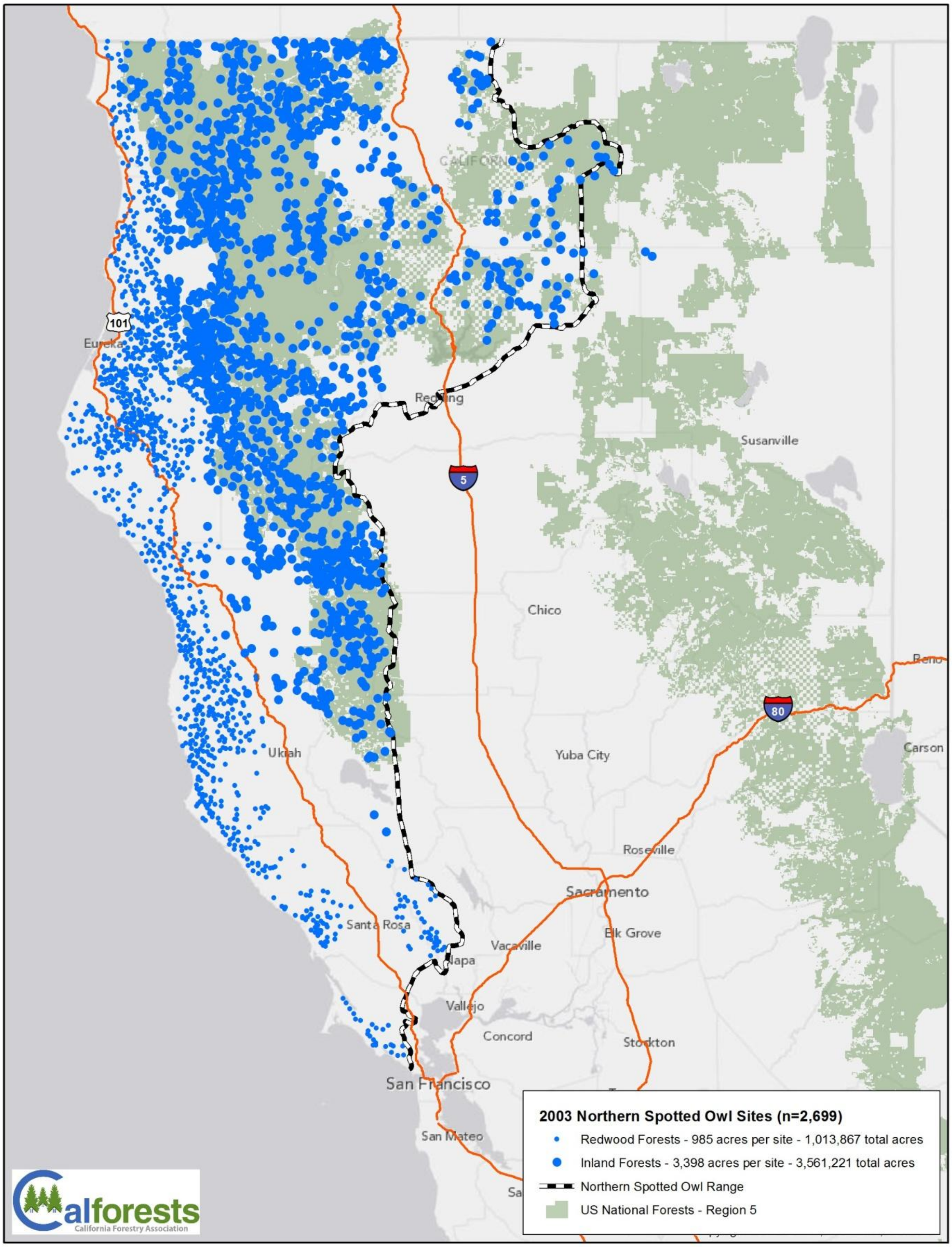


Acres of Habitat within USFWS Designated Owl Circles

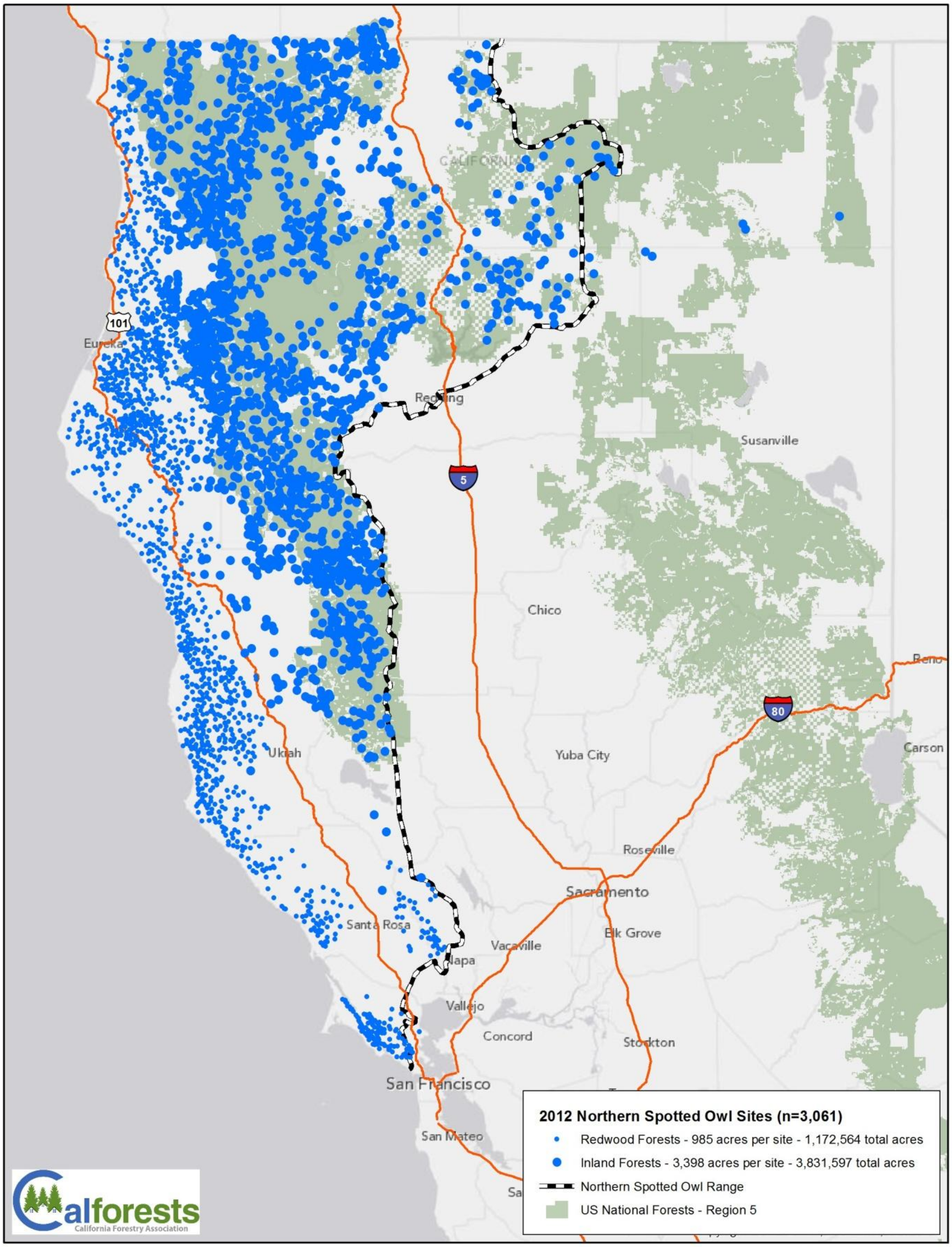



1988 Northern Spotted Owl Sites (n=950)
Redwood Forests - 985 acres per site - 128,117 total acres
Inland Forests - 3,398 acres per site - 2,138,138 total acres
Northern Spotted Owl Range
US National Forests - Region 5
Calforests
California Forestry Association
Eureka
Redding
Susanville
Chico
Ukiah
Yuba City
Reno
Carson
Roseville
Sacramento
Santa Rosa
Vacaville
Elk Grove
Napa
Vallejo
Concord
Stockton
San Francisco
San Mateo
101
5
80


1992 Northern Spotted Owl Sites (n=2,061)
Redwood Forests - 985 acres per site - 617,055 total acres
Inland Forests - 3,398 acres per site - 3,103,615 total acres
Northern Spotted Owl Range
US National Forests - Region 5
Calforests
California Forestry Association
Eureka
Redding
Susanville
Chico
Ukiah
Yuba City
Roseville
Sacramento
Santa Rosa
Vacaville
Napa
Elk Grove
Vallejo
Concord
Stockton
San Francisco
San Mateo
Reno
Carson
101
5
80



Eureka
101
Redding
5
Susanville
Chico
Reno
80
Carson
Ukiah
Yuba City
Roseville
Sacramento
Santa Rosa
Elk Grove
Vacaville
Napa
Vallejo
Concord
Stockton
San Francisco
San Mateo
2003 Northern Spotted Owl Sites (n=2,699)
Redwood Forests - 985 acres per site - 1,013,867 total acres
Inland Forests - 3,398 acres per site - 3,561,221 total acres
Northern Spotted Owl Range
US National Forests - Region 5
Calforests
California Forestry Association

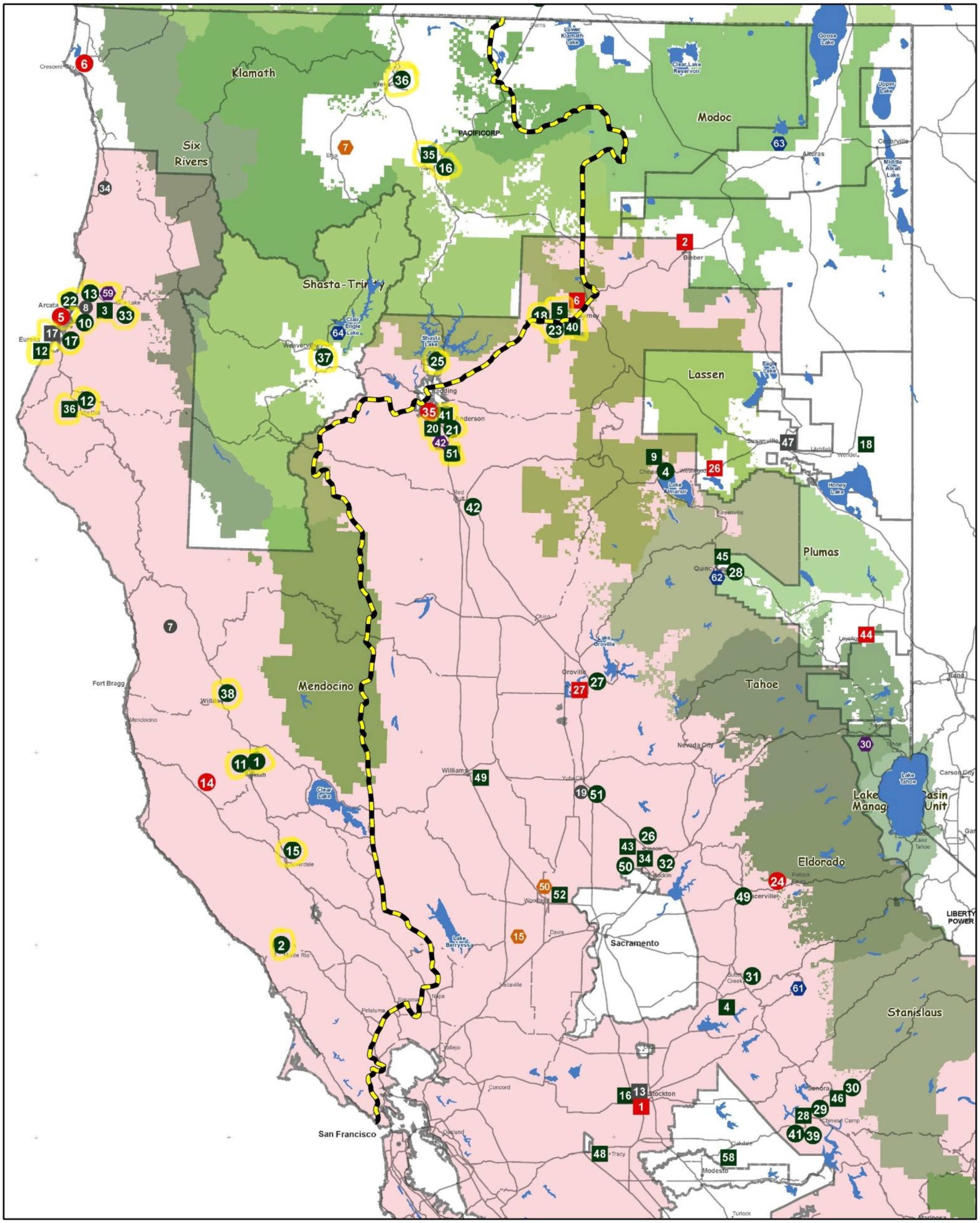


CALIFORNIA
Eureka
101
Redding
5
Susanville
Chico
Reno
80
Carson
Ukiah
Yuba City
Roseville
Sacramento
Santa Rosa
Elk Grove
Vacaville
Napa
Vallejo
Concord
Stockton
San Francisco
San Mateo
2012 Northern Spotted Owl Sites (n=3,061)
Redwood Forests - 985 acres per site - 1,172,564 total acres
Inland Forests - 3,398 acres per site - 3,831,597 total acres
Northern Spotted Owl Range
US National Forests - Region 5
Calforests
California Forestry Association

ATTACHMENT D

CALIFORNIA PRIMARY WOOD PRODUCTS AND BIOMASS ENERGY FACILITIES

(Within Northern Spotted Owl Range Highlighted)



California Primary Wood Products and Biomass Energy Facilities

(Within Northern Spotted Owl Range Highlighted)

Last Update: Aug 30, 2013

Wood Products Processing Facilities:

RecID	MapLabel	Status
1	Agwood Mill & Lbr.	Open
2	Berry's Sawmill	Open
3	Big Creek Lbr. Co. Sawmill	Open
4	Collins Pine Co. Sawmill	Open
5	Evergreen Pulp	Closed
6	Hambro Forest Products Particle Bd.	Closed
7	Harwood Products Sawmill	Liquidated
8	Humboldt Flakeboard Particle Bd.	Liquidated
9	JH Baxter Wood Preservation	Other Type
10	Mad River Lbr. Sawmill	Open
11	Mendocino Forest Products Sawmill	Open
12	Humboldt Redwood Co. Sawmill	Open
13	Arcata Forest Products Sawmill	Open
14	Redwood Empire Philo Sawmill	Closed
15	Redwood Empire Cloverdale Sawmill	Open
16	Roseburg Forest Products Veneer Mill	Open
17	Schmidbauer Lbr. Co. Sawmill	Open
18	Shasta Green Sawmill	Open
19	Sierra Cedar Products Sawmill	Liquidated
20	Sierra Forest Products Sawmill	Open
21	SPI Anderson Sawmill	Open
22	SPI Arcata Sawmill	Open
23	SPI Burney Sawmill	Open
24	SPI Camino Sawmill	Closed
25	SPI Shasta Lk. Sawmill	Open
26	SPI Lincoln Sawmill	Open
27	SPI Oroville Cedar Sawmill	Open
28	SPI Quincy Sawmill	Open
29	SPI Chinese Camp Sawmill	Open
30	SPI Sonora Standard Sawmill	Open
31	Sierra Pine Martell Particle Bd.	Open
32	Sierra Pine Rocklin MDF	Closed
33	Calif. Redwood Co., Korbel Sawmill	Open
34	Calif. Redwood Co., Orick Sawmill	Liquidated
35	Sound Stud Sawmill	Closed

RecID	MapLabel	Status
36	Timber Products Veneer Mill	Open
37	Trinity River Lbr Co. Sawmill	Open
38	Willits Redwood Sawmill	Open
39	California Wood Shavings	Open
40	Priority Pallets Sawmill	Open
41	SPI Keystone Bark Plant	Open
42	Lassen Forest Products	Open
43		
44		
45		
46		
47		
48		
49		Open
50	Mallard Creek Shavings/Pellets	Open
51	American Wood Fiber	Open
52		
53		
54		
55		
56		
57		
58		
59		
60		

	MBF	Direct and Indirect Employment
Total Processing Capacity	2,044,000	24,528
Total Processing Capacity within NSO Range	964,000	11,568

Biomass Energy Facilities:

RecID	Status	MapLabel	Name	MW_Gross	ST
1	Idle	Air Products Stockton Biomass Power	AIR PRODUCTS STOCKTON	45.000	CA
2	Idle	Big Valley Biomass Power	BIG VALLEY BIOMASS POWER	7.500	CA
3	Operational	Blue Lake Biomass Power	BLUE LAKE POWER	11.000	CA
4	Operational	Buena Vista Biomass Power	BUENA VISTA BIOMASS POWER	18.500	CA
5	Operational	Burney Forest Power	BURNEY FOREST POWER	31.000	CA
6	Idle	Covanta Burney Mtn. Power	BURNEY MOUNTAIN POWER	11.000	CA
7	Pilot	Cal Forest Nursery Gasifier Pilot	CAL FOREST NURSERY	0.041	CA
8	Operational	Chowchilla Biomass Power	CHOWCHILLA	12.500	CA
9	Operational	Collins Pine Biomass Power	COLLINS PINE CO. PROJECT	12.000	CA
10	Operational	Greenleaf Desert View Power	DESERT VIEW	47.000	CA
11	Operational	Covanta Delano Power	DELANO ENERGY CO. INC.	50.000	CA
12	Operational	Korea East West Power Fairhaven	DG FAIRHAVEN	18.000	CA
13	Non-operational	Diamond Walnut Biomass Power	DIAMOND WALNUT	4.500	CA
14	Operational	Dinuba Energy	DINUBA ENERGY INC.	12.000	CA
15	Operational	Dixon Ridge Farms Gasifier Power Pilot	DIXON RIDGE FARMS	0.100	CA
16	Operational	DTE Stockton Biomass Power	DTE STOCKTON (POSDEF)	45.000	CA
17	Non-operational	Freshwater Pulp Biomass Power	FRESHWATER PULP	50.000	CA
18	Operational	Greenleaf Honey Lake Power	HONEY LAKE POWER	32.000	CA
19	Idle	Imperial Valley Resource Recovery Power	IMPERIAL VALLEY RESOURCE RECOVERY PROJECT	18.000	CA
20	Operational	Shasta Renewables	KIARA SOLAR (WHEELABRATOR HUDSON)	7.200	CA
21	Idle	Madera Power	MADERA POWER LLC	28.000	CA
22	Operational	Covanta Mendota Power	MENDOTA BIOMASS POWER LTD	25.000	CA
23	Operational	Merced Power	MERCED POWER (EL NIDO)	12.500	CA
24	Non-operational	Mesquite Lake Resource Recovery Power	MESQUITE LAKE RESOURCE RECOVERY	18.500	CA
25	Operational	Mt. Poso Cogen	MT. POSO COGENERATION	44.000	CA
26	Idle	Covanta Mt. Lassen Power	MT. LASSEN POWER	11.500	CA
27	Idle	Covanta Pacific Oroville Power	PACIFIC OROVILLE POWER INC.	18.000	CA
28	Operational	Covanta Pacific Ultrapower Chinese Station	PACIFIC ULTRAPOWER CHINESE STATION	22.000	CA

29	Operational	Phoenix Energy	PHOENIX ENERGY	0.500	CA
30	Active Project	Placer County┬áBiomass Power Project	PLACER COUNTY	3.000	CA
31	Operational	Rio Bravo Fresno Biomass Power	RIO BRAVO FRESNO	25.000	CA
32	Proposal	Rio Bravo Jasmin Proposed Conversion	RIO BRAVO JASMIN	40.000	CA
33	Proposal	Rio Bravo Poso Proposed Conversion	RIO BRAVO POSO	40.000	CA
34	Operational	Rio Bravo Rocklin Biomass Power	RIO BRAVO ROCKLIN	25.000	CA
35	Operational	Roseburg Forest Products Biomass Power	ROSEBURG FOREST PRODUCTS	12.000	CA
36	Operational	Greenleaf Eel River Power	EEL RIVER	28.000	CA
37	Non-operational	Sierra Biomass Power	SIERRA BIOMASS (AUBERRY)	7.500	CA
38	Operational	Sierra Biomass Power Corp.	SIERRA POWER CORP.	9.500	CA
39	Non-operational	Soledad Energy	SOLEDAD ENERGY	13.400	CA
40	Operational	SPI Burney┬áBiomass Power	SPI BURNEY	20.000	CA
41	Operational	SPI Anderson Biomass Power	SPI ANDERSON	4.000	CA
42	Active Project	SPI Anderson Biomass Power Project	SPI ANDERSON PROJECT	31.000	CA
43	Operational	SPI Lincoln Biomass Power	SPI LINCOLN	18.000	CA
44	Idle	SPI Loyalton Biomass Power	SPI LOYALTON	20.000	CA
45	Operational	SPI Quincy Biomass Power	SPI QUINCY	25.000	CA
46	Operational	SPI Sonora Standard Biomass Power	SPI STANDARD	8.000	CA
47	Non-operational	Susanville Biomass Power Project	SUSANVILLE	12.500	CA
48	Operational	Greenleaf Tracy Biomass Power	TRACY BIOMASS PLANT	19.400	CA
49	Operational	Wadham Biomass Power	WADHAM	26.500	CA
50	Pilot	West Biofuels Gasifier Pilot	WEST BIOFUELS	0.200	CA
51	Operational	Wheelabrator Shasta Biomass Energy	WHEELABRATOR SHASTA	50.000	CA
52	Operational	DTE Woodland Biomass Power	WOODLAND BIOMASS POWER LTD	25.000	CA
53					
54					
55					
56					
57					
58	Operational	Central Valley Ag Grinding	PHOENIX ENERGY	1.000	CA
59	Active Project	Blue Lake Rancheria	BLUELAKE RANCHERIA	0.750	CA

60	Active Project	North Fork Project	North Fork Project	3.000	CA
61	Proposal	Wilseyville Proposed Project	Wilseyville Proposed Project	3.000	CA
62	Proposal	Quincy Proposed Project	Quincy Proposed Project	0.000	CA
63	Proposal	Devils Garden Conservation Camp Proposed Project	Devils Garden Conservation Camp Proposed Project	0.000	CA
64	Proposal	Trinity River Conservation Camp Proposed Project	Trinity Conservation Camp Proposed Project	0.000	CA
100	Operational	Dixon Ridge Farms Gasifier Power Pilot	DIXON RIDGE FARMS	0.100	CA
101	Cancelled	N/A	VALLEY BIO-ENERGY	33.000	CA
102					
103	Operational	Timber Products Veneer (Yreka)	TIMBER PRODUCTS	0.000	CA
104	Operational	Columbia Plywood	COLUMBIA PLYWOOD	0.000	CA

	Gross MW	Employees
Total Operational:	697	3,415
Total Idle/Planned:	0	0
Total within NSO Range:	181.2	888

ATTACHMENT E

REPORT YT-36
YTHR2

CALIFORNIA TIMBER HARVEST BY COUNTY
YEAR 2012 QUARTER 1 TO 4
(Highlighted Counties Within Northern Spotted Owl Range)

COMPILED ON 4/23/2013

TIMBER TAX SECTION

COUNTY	VOLUME (NET MBF)	VOLUME PERCENT	PERCENT PUBLIC	VALUE	VALUE PERCENT	PERCENT PUBLIC
ALAMEDA	0	0.00	0.00	$0	0.00	0.00
ALPINE	0	0.00	0.00	$0	0.00	0.00
AMADOR	10,594	0.81	9.35	$2,121,645	0.79	4.20
BUTTE	45,198	3.46	4.54	$9,573,425	3.58	1.93
CALAVERAS	39,458	3.02	7.67	$6,755,461	2.53	6.55
COLUSA	0	0.00	0.00	$0	0.00	0.00
CONTRA COSTA	0	0.00	0.00	$0	0.00	0.00
DEL NORTE	5,203	0.40	0.00	$1,290,905	0.48	0.00
EL DORADO	48,547	3.71	24.10	$7,075,521	2.65	18.09
FRESNO	13,129	1.00	56.40	$1,271,349	0.48	46.81
GLENN	4,520	0.35	100.00	$765,057	0.29	100.00
HUMBOLDT	221,617	16.95	1.50	$62,557,351	23.39	1.10
IMPERIAL	0	0.00	0.00	$0	0.00	0.00
INYO	0	0.00	0.00	$0	0.00	0.00
KERN	3,943	0.30	49.71	$375,045	0.14	57.46
KINGS	0	0.00	0.00	$0	0.00	0.00
LAKE	56	0.00	46.43	$7,900	0.00	41.14
LASSEN	74,433	5.69	18.06	$12,997,465	4.86	13.44
LOS ANGELES	0	0.00	0.00	$0	0.00	0.00
MADERA	9,900	0.76	89.91	$810,301	0.30	88.90
MARIN	0	0.00	0.00	$0	0.00	0.00
MARIPOSA	3,031	0.23	0.00	$370,270	0.14	0.00
MENDOCINO	121,850	9.32	0.00	$28,940,454	10.82	0.00
MERCED	0	0.00	0.00	$8,295	0.00	0.00
MODOC	40,006	3.06	21.94	$4,568,740	1.71	20.81
MONO	2,349	0.18	100.00	$201,590	0.08	96.72
MONTEREY	0	0.00	0.00	$3,003	0.00	0.00
NAPA	0	0.00	0.00	$0	0.00	0.00
NEVADA	14,531	1.11	3.72	$2,647,665	0.99	3.60
ORANGE	0	0.00	0.00	$25,804	0.01	0.00
PLACER	20,951	1.60	43.88	$3,300,234	1.23	28.76
PLUMAS	84,652	6.48	14.81	$13,669,163	5.11	13.58
RIVERSIDE	0	0.00	0.00	$0	0.00	0.00
SACRAMENTO	0	0.00	0.00	$40,374	0.01	0.00
SAN BENITO	0	0.00	0.00	$0	0.00	0.00
SAN BERNARDINO	0	0.00	0.00	$0	0.00	0.00
SAN DIEGO	0	0.00	0.00	$10,189	0.00	0.00
SAN FRANCISCO	0	0.00	0.00	$0	0.00	0.00
SAN JOAQUIN	0	0.00	0.00	$0	0.00	0.00
SAN LUIS OBISPO	0	0.00	0.00	$0	0.00	0.00
SAN MATEO	5,547	0.42	0.00	$1,979,488	0.74	0.00
SANTA BARBARA	0	0.00	0.00	$0	0.00	0.00
SANTA CLARA	1,209	0.09	0.00	$429,172	0.16	0.00
SANTA CRUZ	6,559	0.50	0.00	$2,363,485	0.88	0.00
SHASTA	185,799	14.21	3.05	$36,930,938	13.81	1.07
SIERRA	30,748	2.35	32.82	$4,115,291	1.54	27.88
SISKIYOU	144,874	11.08	18.68	$30,767,666	11.51	17.16
SOLANO	0	0.00	0.00	$23,929	0.01	0.00
SONOMA	4,426	0.34	0.00	$770,936	0.29	0.00
STANISLAUS	0	0.00	0.00	$0	0.00	0.00
SUTTER	0	0.00	0.00	$0	0.00	0.00
TEHAMA (50% 33,397 NSO)	66,795	5.11	0.00	$11,611,657	4.34	0.00
TRINITY	37,868	2.90	11.91	$7,785,690	2.91	8.51
TULARE	2,433	0.19	0.00	$214,647	0.08	0.00
TUOLUMNE	35,359	2.70	19.88	$6,073,861	2.27	15.33
VENTURA	0	0.00	0.00	$12,316	0.00	0.00
YOLO	0	0.00	0.00	$0	0.00	0.00
YUBA	21,752	1.66	20.36	$4,950,991	1.85	19.57
ALL COUNTIES	1,307,337	100.00	11.44	$267,417,273	100.00	7.54
TOTAL WITHIN NSO RANGE	**851,284**			**$193,999,229**		

22 October 2013

Humboldt Redwood Company, LLC: Northern Spotted Owl Science Forum Status Review

The purpose of this summary is to provide information on surveys, monitoring, and conservation measures for the Northern Spotted Owl (*Strix occidentalis caurina*, NSO) under the Humboldt Redwood Company, LLC (HRC) Habitat Conservation Plan (HCP). This summary provides detail to accompany our presentation given at the NSO Science Forum on 29 – 30 October, 2013 in Sacramento, CA, and is intended to aid the Department of Fish and Wildlife (DFW) in its consideration of scientific and regulatory factors regarding the potential listing of the NSO as threatened or endangered in California under CESA.

The Humboldt Redwood Company owns and conducts timber harvest operations on approximately 210,000 acres of coastal redwood and Douglas-fir forests in Humboldt County, CA (Figure 1). HRC conducts primarily uneven-age management using selection and group-selection harvest, with the long-term goal of having all of HRC forestlands covered with trees of multiple age and size classes.

NSO Survey and Conservation Measures

HRC (and the Pacific Lumber Company, the previous landowner) has conducted extensive surveys and monitoring of the NSO since the federal listing of the species in 1990. Take avoidance and other conservation measures have been applied according to the management strategy in place at the time. A summary of efforts from 1990 to the present is as follows:

- 1990 – 1992: survey efforts focused on U.S. Fish and Wildlife Service (Service) endorsed protocol surveys of potential habitat that was intended for timber harvest (Timber Harvesting Plan (THP) - specific surveys and consultation with the California Department of Fish and Game (Department) on measures to avoid take of NSO).
- 1992 – 1996: a Spotted Owl Management Plan was developed in cooperation with the Service. The Service's protocol (revised 1992) was used as a basis for NSO survey techniques. The Plan contained standard take-avoidance measures.
- 1997 – 1998: a Spotted Owl Resource Plan was developed in cooperation with the Department and Cal Fire. Again the Service's protocol was used, with survey modifications for regional conditions. Similar standard take-avoidance measures were applied.

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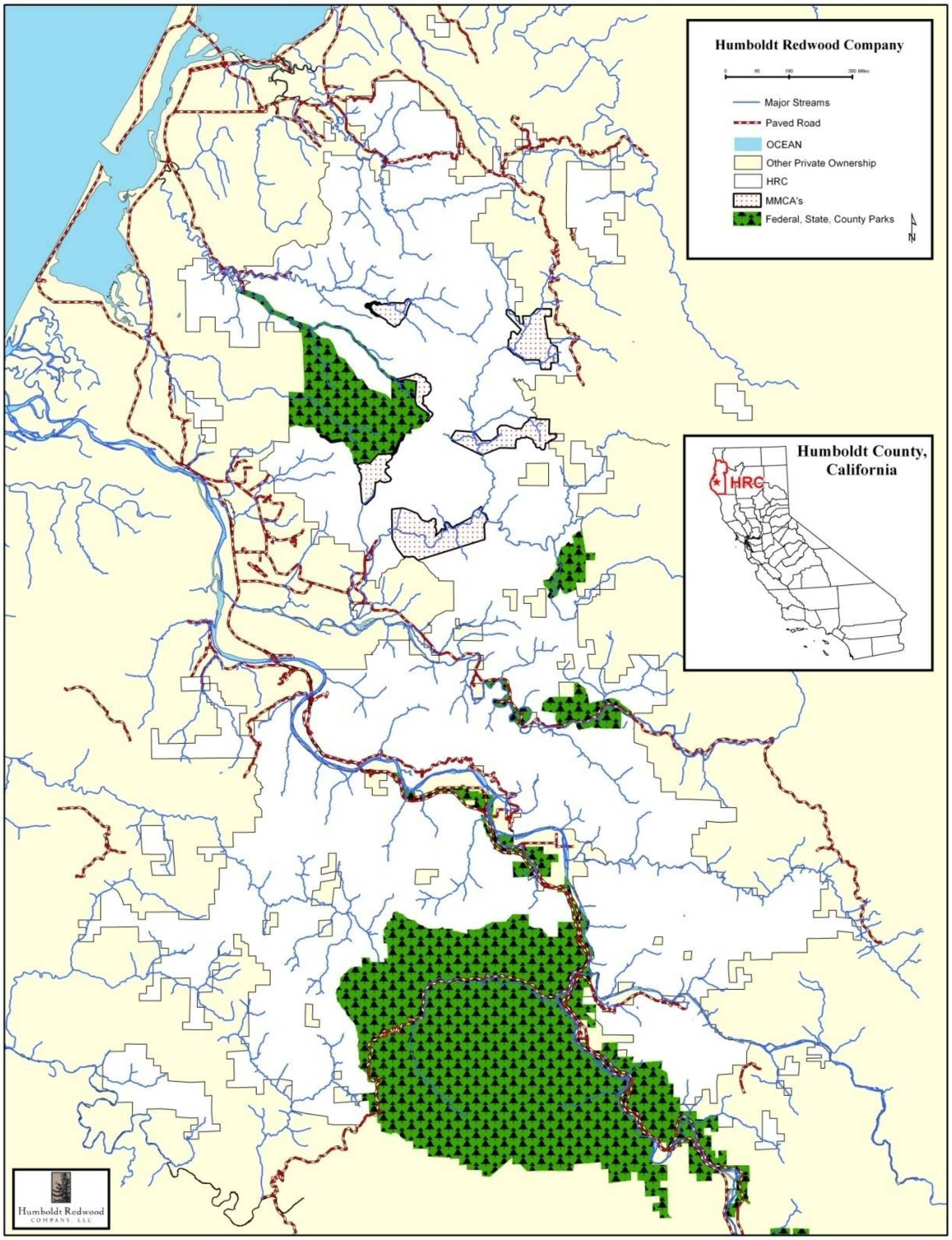

Figure 1. Humboldt Redwood Company, LLC lands, Humboldt County, CA.

- 1999 – Present: a multi-species Federal and State-approved HCP currently controls NSO conservation on HRC lands. The Service's protocol is still the basis for survey methods, with modifications for annual monitoring, and THP-specific surveys. The HCP conservation strategy is a habitat-based approach, with measures applied at the individual NSO territory, and also at the landscape-level.

HRC's 50-year multi-species HCP, which conserves the habitat of the NSO and 16 other species, was approved in 1999. For the past 14 years, HRC (and earlier the Pacific Lumber Company) has implemented the conservation measures in the HCP, including survey measures to avoid take, and application of approximately 28,000 acres of no harvest zones (about 13% of the HCP land-base), including NSO core areas, large old growth set-asides with young growth buffers (the Marbled Murrelet Conservation Areas or MMCAs), and inner band of riparian management zones (RMZs). In addition, the HCP established approximately 21,000 acres of limited harvest, high canopy retention zones on the HRC lands (about 10% of the HCP land-base), for example: outer bands of RMZs, and geologic areas of concern.

The HCP also contains a conservation strategy for habitat structural components, including retention of snags, snag replacement trees, large hardwood trees, large down logs, and high value wildlife trees, so that future forest stands will have structures suitable for NSO nesting. Over the life of the HCP there is a projected net increase in habitat of approximately 7,000 acres under the original even-age management scenario. It is anticipated that, with the changes in forest management implemented under HRC, more NSO habitat will occur on the landscape over time.

The HRC HCP requires that a minimum of 108 NSO activity sites[1] be maintained on the HCP forestlands. There are currently 210 mapped activity sites on the HRC ownership for which HCP conservation measures are applied. There were 132 sites occupied by a pair or single NSO in 2013. There was no NSO survey contact at 76 of the sites and 2 were not visited due to access issues. Spotted owls may have been present at the no contact sites, but due to barred owls (*Strix varia*) or other factors could not be found.

Conservation and protection measures under the HCP for the NSO are dependent upon the activity site level of protection (level one, two, or three) that is assigned:

- Level One: at least 80 occupied activity sites, for which protection is similar to take avoidance standards:
    - 500' radius core of nesting habitat.
    - 1,000' radius nesting and roosting habitat, or a Habitat Retention Area (polygon of at least 72 total acres of nesting/roosting).
    - 500 acres of habitat within a 0.7-mile radius.
    - 1,336 acres of habitat within a 1.3-mile radius.
- Level Two: at least 28 occupied sites, 18 acre core nesting habitat (500' radius or polygon).

[1] An activity site or center is the location where a pair, or single, NSO nests or roosts, roughly equivalent to their territory.

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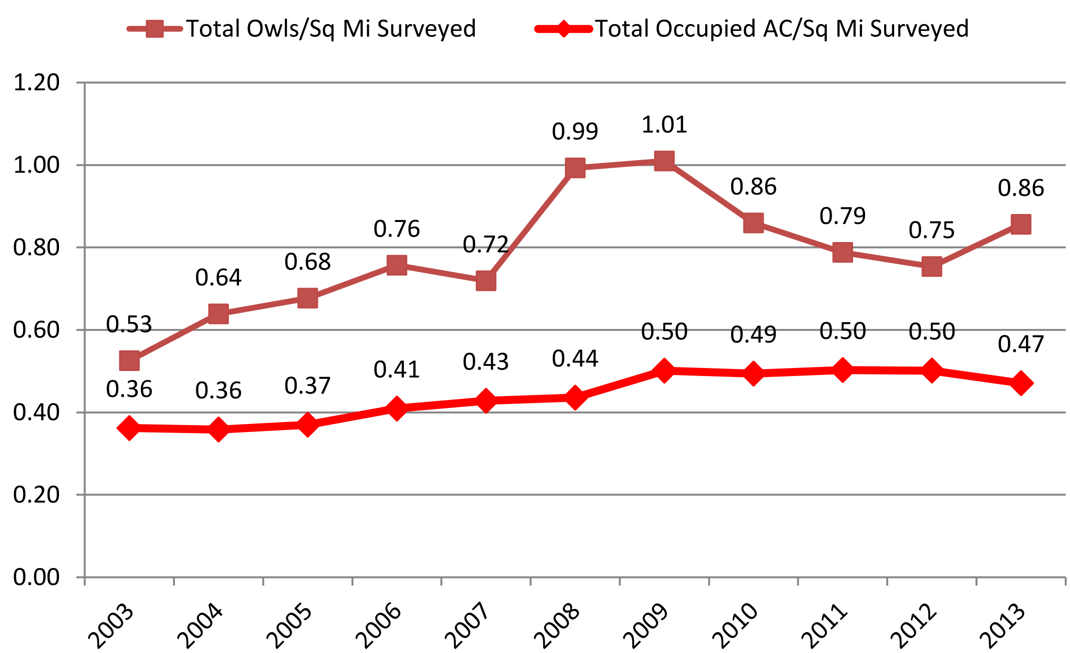
- Level Three: balance of the activity sites above the 108 level one and two sites. May be occupied or unoccupied. Harvest of habitat is allowed outside breeding season.
- All activity sites have 1,000' radius seasonal disturbance buffers from March 1 to August 31, unless found to be non-nesting, a nest has failed, or young have fledged.
- All known nest trees are retained, regardless of protection level.

There are now over 20 years of survey history on this landscape (1991 – 2013). HRC has, through our surveys and monitoring over time, found that HRC's forestlands contain a high density of NSO occurring on the managed landscape, currently at 0.86 spotted owls per square mile of area surveyed. The density of total occupied activity sites per square mile of area surveyed is currently 0.47. Density of total owls and occupied activity sites per square mile area surveyed from 2003 – 2013 appears stable or slightly increasing (Figure 2).

Figure 2. Density of total spotted owls and occupied activity sites/square mile of area surveyed.



Since 1991 we have captured and banded 747 northern spotted owls for identification and monitoring with no related NSO mortalities. Banding is conducted to aid in identification of individual owls, and to support further population research.

NSO population monitoring and THP surveys are currently done according to HCP requirements. From 1999 – 2002 annual property-wide night surveys were conducted. A sampling strategy for night surveys was approved by the HCP Agencies in 2003 wherein approximately 20% of the HCP lands are surveyed annually using a 'quadrat'

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survey approach, with the entire HCP property surveyed on a five-year rotation. In addition, all level one, all level two, and those level three activity sites within the survey quadrats are visited to determine occupancy and reproductive status. HRC endeavors to visit all activity sites at least twice during the breeding season if time allows.

HCP surveys for THPs can be conducted concurrently with operations early in the breeding season (i.e. March 1 to August 31), provided operations have begun prior to February 21 and that all known activity sites are protected with seasonal buffers. If a new NSO contact occurs in or near operations, another seasonal buffer is applied until NSO status is determined or negative surveys are completed. For new harvest operations that begin during the season, 3 complete surveys are required prior to operations (similar to a spot-check approach, recognizing HRC's history of surveys and protection of all known activity sites).

HRC currently employs an approach to NSO surveys during the breeding season using a "swing shift" that conducts activity site visits in the afternoon to evening, and then night surveys after dark. The swing shift averages 5 biologists and trained NSO surveyors ranging in experience from 1 – 2 seasons, to over 15 years of NSO monitoring. Similarly, a "day shift" conducts any necessary follow-up visits to night contacts so that a complete survey is ensured, and also does other scheduled activity site visits to determine occupancy and nesting status. The day shift averages 4 biologists ranging in experience from about 7 years to over 20 years of experience with NSO monitoring.

During the 2013 season, the Elk River, South Van Duzen, West Shively, and Upper Eel quadrats were surveyed (Figure 3). A total of 808 calling stations were used to conduct a total of 2,524 night surveys of the quadrats, THPs, and activity sites. 208 of the activity sites received one to several visits to determine occupancy and status (range 1 – 13, mean = 4.2 visits per site). Two sites were not visited due to access issues.

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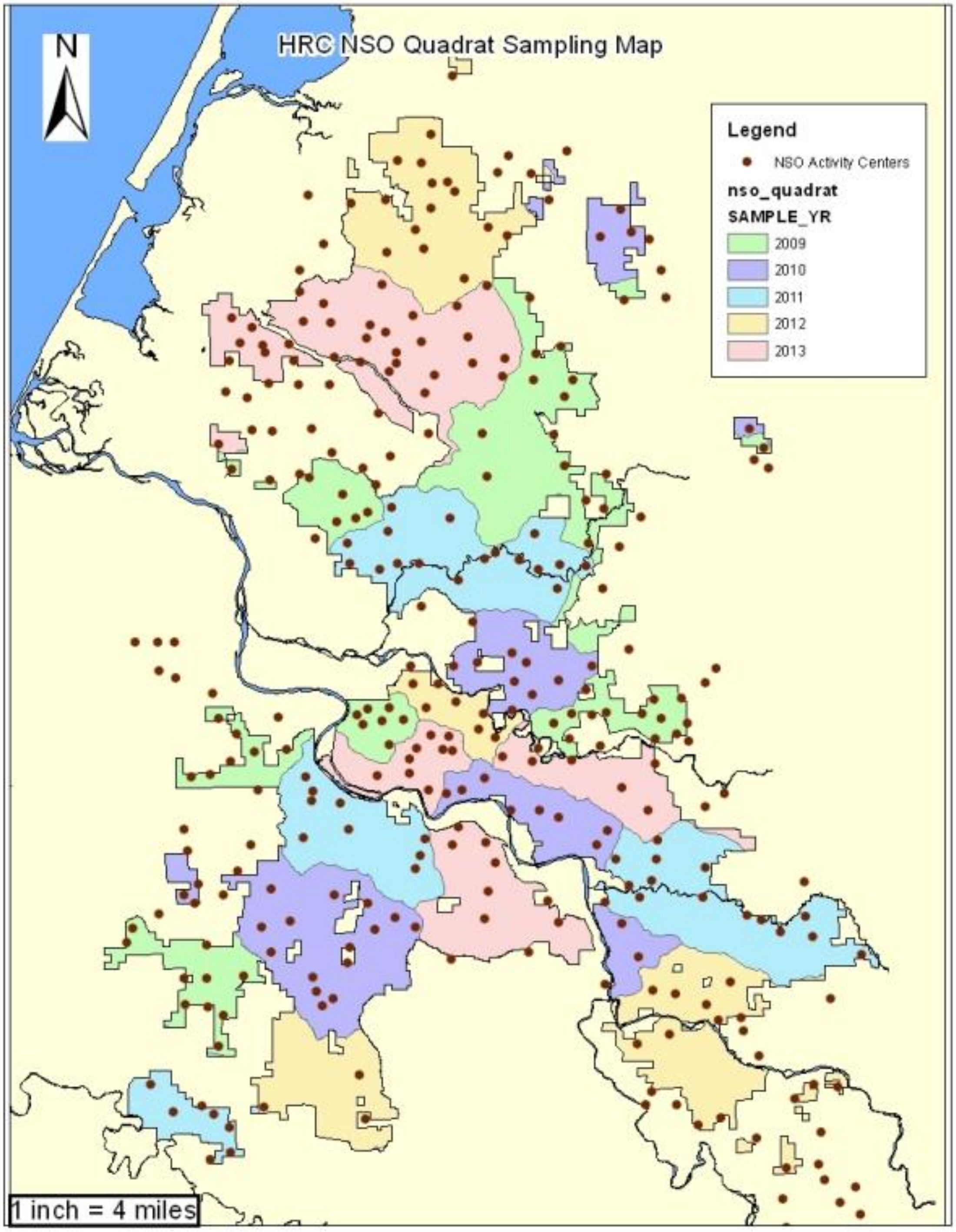

Figure 3. Quadrat Survey Map for HRC Lands.

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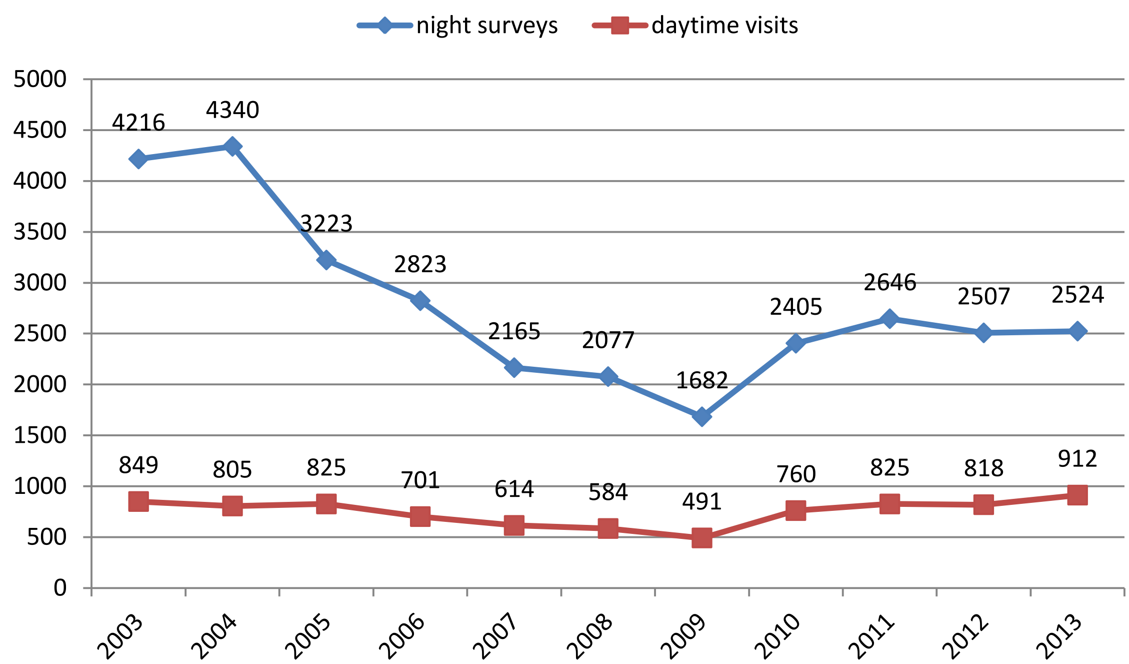
The 2013 survey effort was similar to the last 3 years (Figure 4). Since 2003 when the quadrat method was fully implemented, the number of night surveys per year has ranged from 1682 (2009) to 4340 (2004), with a mean of 2783. The number of night surveys per year during this period includes a similar annual number of quadrat surveys, and a variable number of THP surveys, with the number of surveys being dependent on harvest activity levels. For example, a higher level of harvest activity occurred in 2004 than in 2009 when lumber markets were poor and harvest was at a relatively low level. Daytime visits per year have ranged from 491 (2009) to 912 (2013), with a mean of 744. A higher number of daytime visits in recent years reflect the increased difficulty of finding the NSO during this period of increased barred owl presence.

Figure 4. NSO night survey and daytime visit totals 2003 – 2013.



NSO Population Monitoring Results

The HRC HCP requires the monitoring of NSO activity site numbers, pair occupancy rates, and reproductive rates.

As stated above, we currently have 210 NSO activity sites on the HRC forestlands, 132 of which were occupied by a pair or single NSO in 2013. The total number of activity sites retained and occupied activity sites from 2003 – 2013 is shown in Figure 5. There is some annual variation in the counts, but there appears to be a stable population.

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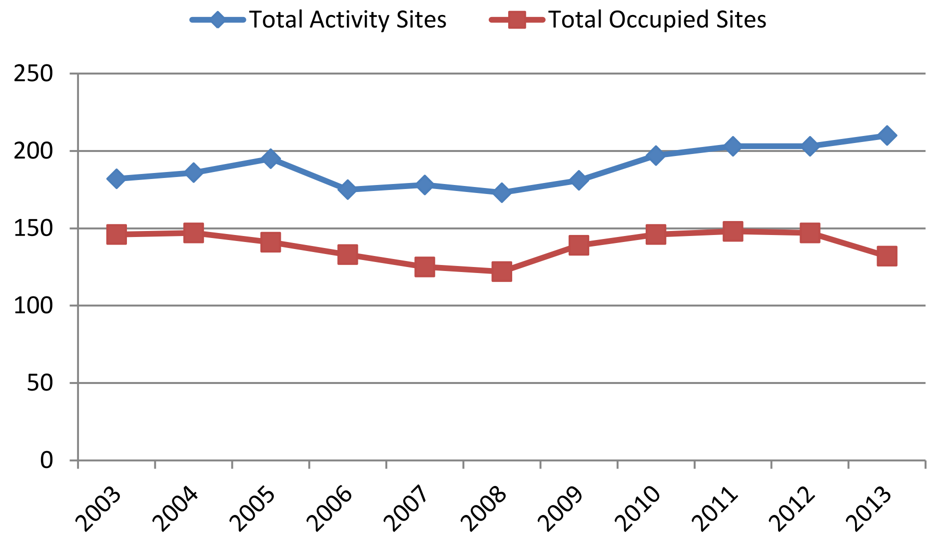
Figure 5. Total retained and total occupied activity sites 2003 – 2013.



The Department's evaluation of the listing petition[2] contains a statement that annual reports from HRC and others indicate a steady decline in population in this region over at least a 10-year period. HRC's annual reports include two simple measures of the population: total NSO activity sites (Figure 5) and total number of NSOs based on our surveys (number of NSO pairs, single adults, and juveniles) (Figure 6).

Prior to HCP implementation the level of survey effort was dependent on harvest acreage and was therefore somewhat inconsistent. Since HCP implementation in 1999 the level of effort has been more consistent, and has followed the same sampling strategy since 2003. Thus, the information on the HRC NSO population presented herein is shown from 2003 - 2013 for purposes of consistency, and, more importantly, addresses the 10-year period referenced by the Department in their evaluation of the listing petition. There does not appear to be a steady decline in the population over the last ten years by these measures, but instead a dynamically stable population.

[2] Report to the Fish and Game Commission: Evaluation of the Petition from the Environmental Protection Information Center to List the Northern Spotted Owl as Threatened or Endangered under CESA (January 2013).

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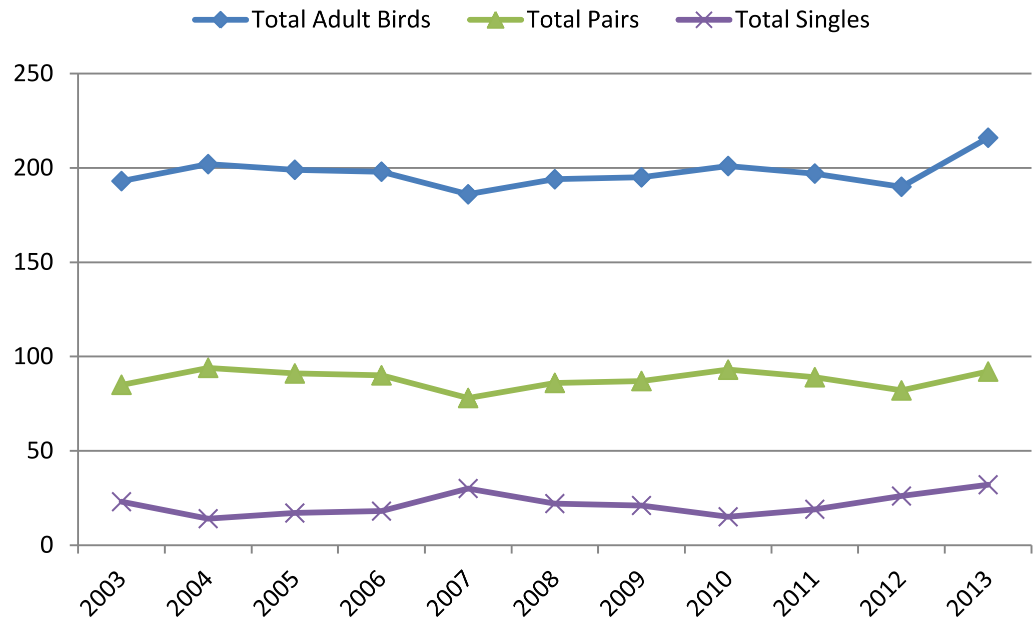
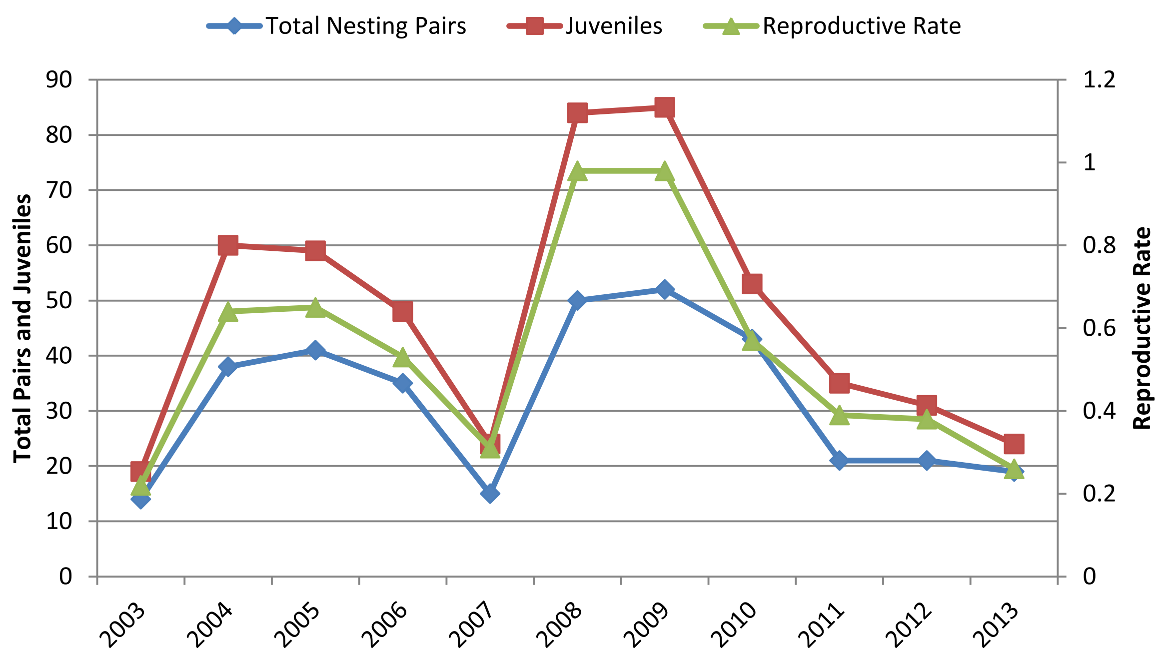
Figure 6. Total adults, pairs, and single NSO 2003 – 2013.



Finally, the numbers for NSO nesting pairs, juveniles, and reproductive rate (number of juveniles produced per pairs monitored for reproduction) is shown in Figure 7. While there appears to be a decline over the last 2 – 3 years, lower numbers have occurred in poor reproductive years previously (e.g. 2003 and 2007), and again there is annual variation.

Figure 7. Total NSO nesting pairs, juveniles, and reproductive rate 2003 – 2013.



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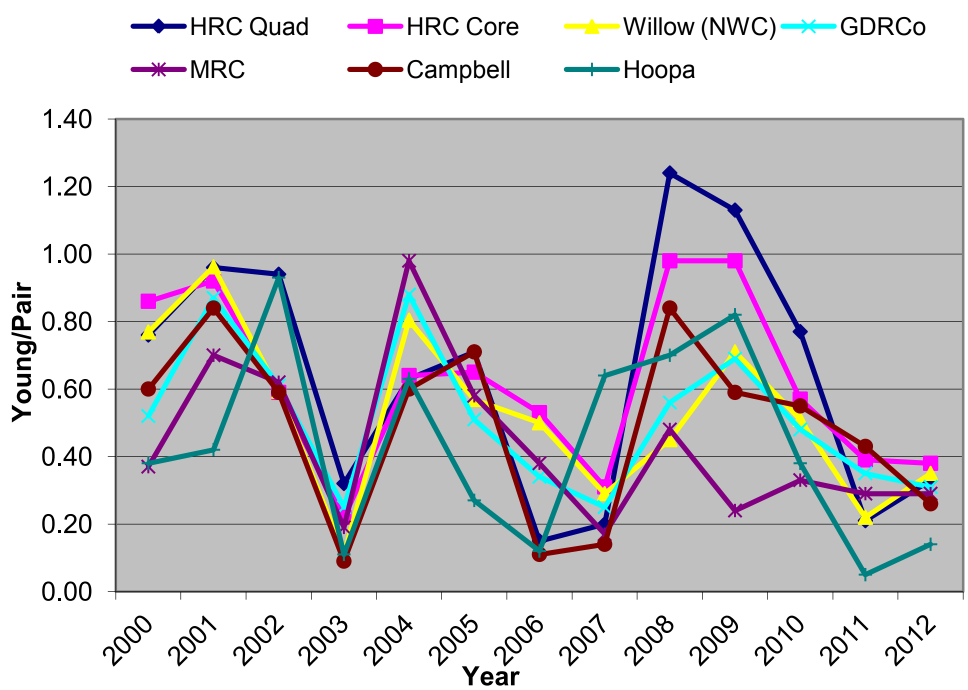
Following both the 2003 and 2007 survey seasons, which were very poor reproductive years (Figure 7) the Pacific Lumber Co., the NSO science advisory panel (NSOSRP), and the HCP Agencies convened and discussed the HCP management objectives, potential reasons why they may not be met, and potential corrective measures to implement if necessary. On both occasions the NSOSRP recommended that HCP results be compared to those of other study areas in the region. Figure 8 below illustrates the regional northern spotted owl reproductive rates for several study areas of Northern California (Douglas, Early, Fullerton, Higley, Carlson, pers. comm. 2012).

As demonstrated in Figure 8, results for both the core (108 Level 1 and 2 sites) and quadrat (all sites in the monitoring survey areas) sites on HRC track the results of other study areas over the HCP period. For example, 2003 and 2007 were poor reproductive years for all study areas, while 2004 and 2008 were relatively good years for all. As with other studies in the region (Anthony, et al 2004, Franklin 1997, Franklin 2000) data indicate that reproductive results are strongly correlated to regional trends in climate (Franklin, et al. 2000, HRC, unpublished data). Glenn (2009) found that climate accounted for 78-84% of the temporal variation in population change in the Oregon coast range. Both 2003 and 2007 were the wettest years on record in our region for this decade.

Thus, there are good and bad reproductive years that track precipitation early in the breeding season. All cooperators reported relatively poor reproductive results for 2012, which is consistent with the higher than average rainfall events of late spring. Results for 2013 were not available as of the date of this report.

Figure 8. Reproductive rates for NSO study areas in Northern California 2000 – 2012.



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Unregulated Threats: Barred Owls and Rodenticides

Unregulated threats to our NSO population may prove to be a significant problem, chief among them the ongoing barred owl invasion, and a recently identified threat of possible poisoning due to rodenticides.

HRC has tracked detections of barred owls, as did the previous landowner, since the species began responding to spotted owl calls on surveys starting in about 1991. The number of barred owl detections within 0.5-mile of spotted owl activity sites from 2003 – 2013 is shown in Figure 9. Studies have indicated that NSO occupancy, reproduction, and survival declines when barred owls are detected within 0.5-mile of spotted owl activity sites (Kelly et al 2003, Olson et al 2005, Dugger et al 2011). The increasing trend in barred owl detections within 0.5-mile of HRC NSO sites could prove to be significant if these same population declines are seen in this region.

Barred owl detections on HRC lands have shown a similar pattern as has been seen elsewhere during the invasion, with an increasing trend as they moved into the area, followed by a decrease in night detections as they appeared to pair up and nest, and the another increase as they moved into locations near NSO activity sites. Barred owls are now detected on most of HRC's lands, with a pattern of greater activity near lower elevation watercourses and old growth reserves (Figure 10).

Given the evidence from Washington, Oregon, and other regions of California that barred owls can have a very significant impact on occupancy and breeding of spotted owls (Anthony et al. 2004, Courtney et al. 2004, USFWS 2008, USFWS 2011), HRC remains concerned about the potential for barred owls to disrupt the management goals of the HRC HCP for spotted owls. In fact, the Service has recognized that barred owls appear to be a greater threat to the recovery of spotted owls than was envisioned at the time of the spotted owl listing in 1990, and as a result has recommended immediate and coordinated action (USFWS 2008, USFWS 2011). As a result, barred owl removal is expected to begin on select long-term demographic monitoring study areas within the next 1 – 2 years.

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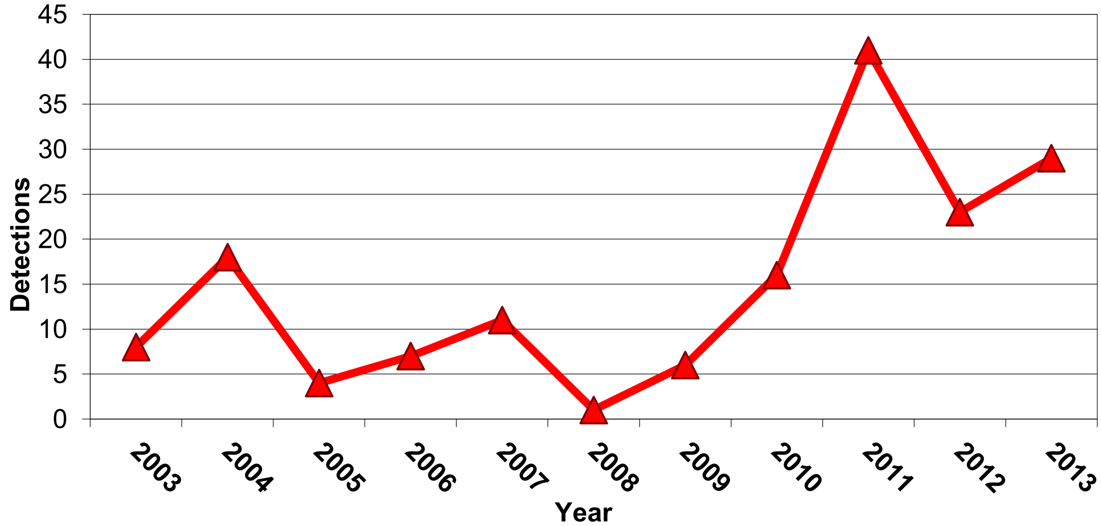
Figure 9. Barred owl detections within 0.5-mile of NSO activity sites 2003 - 2013.



In addition to the barred owl threat to the NSO population, there is growing recognition of the potential for a new threat resulting from possible exposure to anti-coagulant rodenticide poisoning. Both legal and illegal marijuana grows on public and private lands have been found to use often copious amounts of rodenticide in an attempt to prevent damage to planted marijuana. In turn, the rodenticides can have both primary and secondary impacts on predators such as Pacific fisher (*Martes pennanti pacifica*), and possibly spotted owls (Thompson et al 2013, Douglas 2013). In the redwood region, primary prey species of NSO include the dusky-footed woodrat (*Neotoma fuscipes*) and deer mice (*Peromyscus* spp.), which are also prey species of Pacific fisher and may be responsible for exposure of fishers to rodenticides used at grow sites (Thompson et al 2013). Further research on this issue using the carcasses of lethally removed barred owls could shed light on this potential threat in the near term.

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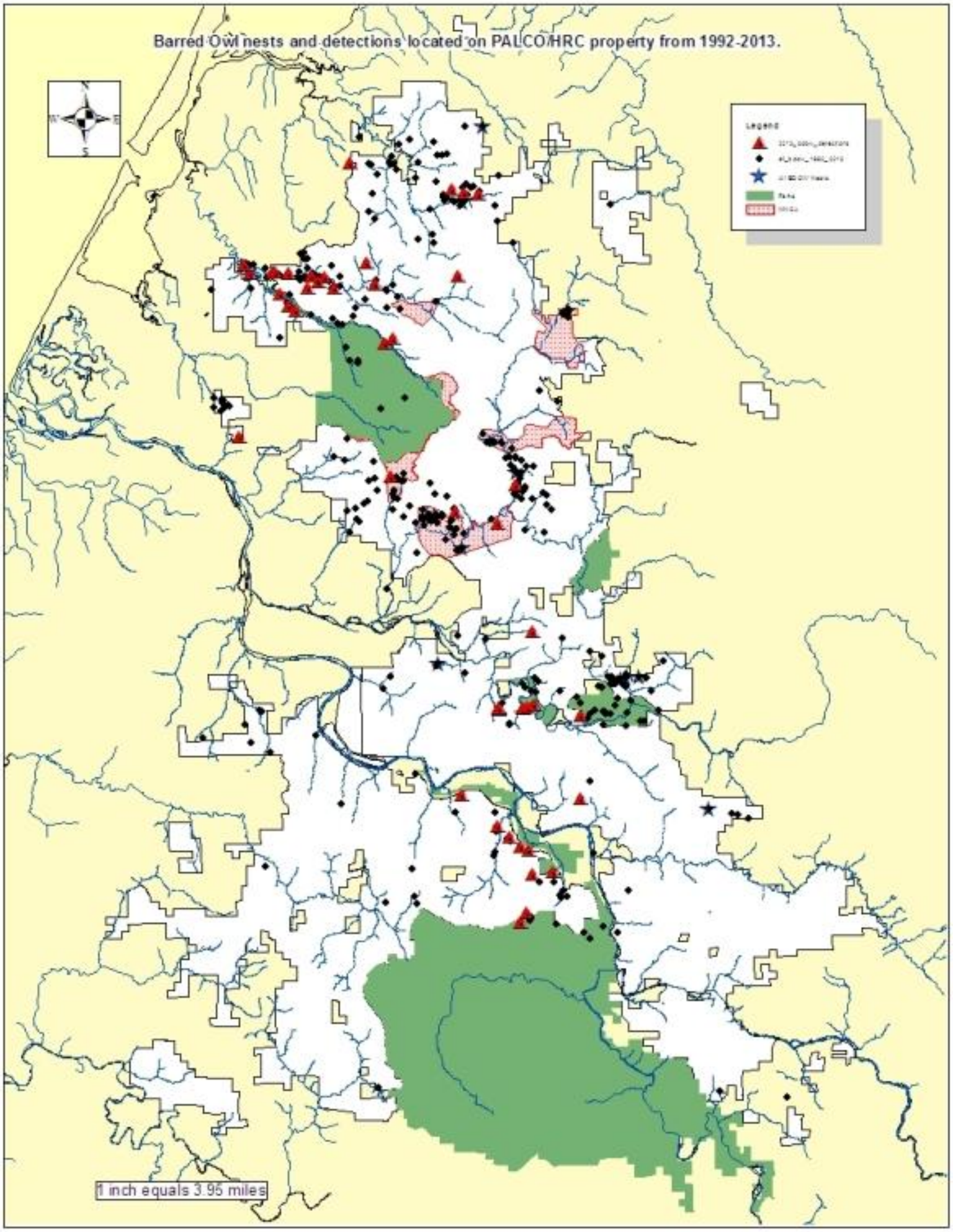

Figure 10. Barred Owl Detections and Nest Locations on HRC Lands 1992 – 2013.

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Summary

HRC lands have had over 20 years of surveys and monitoring of the NSO population. Prior to approval of the HCP in 1999, take avoidance strategies were implemented through consultation with either USFWS or CDFW. Since 1991 we have captured and banded 747 northern spotted owls for identification and monitoring with no related NSO mortalities.

HRC currently operates under a Federal and State-approved multi-species HCP that provides long-term conservation for the NSO. The HCP is a habitat-based approach, with habitat retention requirements associated with individual NSO activity sites, riparian management zones, mass wasting areas of concern, marbled murrelet conservation areas, late seral habitat retention, and retention of habitat structural components. The habitat strategy is expected to provide habitat now and through the HCP term of 50 years. There is a projected net increase in habitat at the end of the HCP term under the original (even-age) management strategy. HRC currently implements policies including uneven-age forest management with selection harvest, retention of all old growth trees, and Forest Stewardship Council protection for High Conservation Value Forests.

The current survey strategy includes protection of all known sites during the breeding season, 3 surveys of all THP areas, daytime visits to all previously known and any new activity sites, and property-wide surveys on a 5-year rotating basis. HRC staff has a high-level of NSO experience.

Population monitoring results from 2003 – 2013, when survey effort was similar; indicate that there is a ***dynamically stable population of NSO on HRC lands***. Numbers of total adults, pairs, and single NSO do not show a declining trend. Reproduction is currently at a low point, but there is much annual variation, and results are similar to those on other study areas within the region. Cold, wet weather early in the breeding season has resulted in poor reproductive results for many study areas in the region. More recently, barred owls appear to have negatively affected spotted owl reproduction even during springs with relatively mild weather.

The barred owl invasion and toxics from marijuana cultivation activities may prove to be the biggest threat to the NSO population moving forward. Increasing detections of barred owls near spotted owl activity sites has been shown to reduce occupancy, reproduction and survival of NSO. Barred owl removal studies should provide results over the next 3 - 4 years. In addition, the use of barred owl carcasses from these studies should help us understand the extent of the rodenticide threat.

In conclusion, we believe that it is not necessary for the NSO to be listed as threatened or endangered in California because 1) there are existing regulatory mechanisms in place, like the HRC HCP, to provide short-term protection and long-term conservation of the NSO, and 2) long-term monitoring data indicate that the HRC NSO population is dynamic, yet stable.

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OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- HUMBOLDT REDWOOD COMPANY-
NORTHERN SPOTTED OWL HABITAT CONSERVATION PLAN;
SAL CHINNICI, FOREST SCIENCES MANAGER

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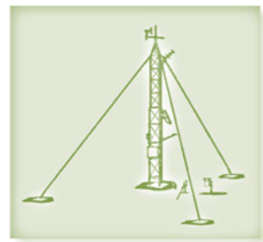
Northern Spotted Owls

Near Weaverville and Trinity Lake

In Trinity County



Reporting Results from Within the Landscape Survey Strategy Area

(An Interim Report)

Sierra Pacific Industries
October 2013

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Sierra Pacific Research & Monitoring

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Northern Spotted Owls near Weaverville and Trinity Lake, Trinity County
Within the Landscape Survey Strategy Area
(An Interim Report)
October 2013

Introduction

In 2003, Sierra Pacific Industries (SPI) coordinated with the US Fish and Wildlife Service (Service) to design a comprehensive multi-year survey of northern spotted owls (NSO), which we called the Landscape Survey Strategy (LSS). It was designed to survey all suspected spotted owl nesting/roosting habitat within SPI lands and extending out to 0.7 miles from SPI. The total area within the LSS was 307,408 acres, of which 142,279 acres (46%) belonged to SPI. Most of the neighboring lands are under the control of the Shasta-Trinity National Forest. This strategy established 474 permanent survey points (Figure 1) that were surveyed for the five years from 2003 through 2007.

In years previous to the 1990 listing of the NSO under the U.S. Endangered Species Act, SPI surveyed much of their ownership in Trinity County to the north and south of Weaverville to determine how many NSO activity centers were present. Surveys were done using protocols existing at the time, but may not have been comprehensive in area coverage, and negative results were not compiled. In addition, activity centers in older California Natural Diversity Data Base records were included in the SPI database.

Thus, while we had a good general idea of the extent and numbers of sites on SPI lands, we knew that we did not have an accurate estimate of the number of NSO occupied activity centers. During the 1990s, our approximate estimate of activity centers on or near the property was 52 (Figure 2), but that estimate was subject to several sources of error, especially inclusion of older sites from over a decade earlier (some from as early as 1974). We could not estimate how many of these met the protocol definition of occupied.

In the decade following the 1990 federal listing of the NSO, the activity centers recorded prior to the listing were not surveyed systematically. Instead, most surveys during that period were project based (i.e., during THP prep for the THP area only). Through the 1990s and early 2000s, all THPs were surveyed and harvested under no-take guidance, according to the Forest Practice Rules and to whichever agency process was in place at the time. We occasionally found occupied sites in new areas, but many older sites were not revisited over a period of several years. Birds were not marked (by banding), so we could only speculate as to movements.

Also during the early 1990s, the Service designated five sites as abandoned. Three of these ACs had been subject to more extensive timber harvest prior to the listing, and they had not been found to be occupied at any time since the listing of the NSO (Figure 3).

Results

The number of occupied activity centers found during the 2003 - 2007 surveys was 47 (Figure 3), of which nine were not known previously. Coincidentally, nine older activity centers were not occupied during this five-year survey period. Most of the new activity centers established by this LSS effort were near older, unoccupied activity centers.

In 2011, we began a three-year re-survey of the LSS stations. During the this new 3 year effort, we found 48 occupied activity centers within the original LSS area, 12 of which were in new locations (Figure 4). One activity center occupied during the 2003-2007 surveys was destroyed by wildfire prior to 2011. Again, new activity centers were usually near older activity centers now unoccupied. Despite the loss to wildfire the estimated population density is stable to increasing. The raw density of 48 occupied ACs found on the 173,316 acre survey area results in 0.1772 occupied ACs per square mile. Up from 0.1736 in 2003-2007 based upon 47 occupied ACs and up from an estimated 0.1551 occupied ACs per sq. mi. in 1989 based upon an estimated 42 occupied ACs (80% of 52 known ACs). See table below:

Year	1989	80% (Recovery)	1989-2003	2003-2007	2011-2013
Occupied ACs	52 (max known 1974-1989)	42	47 (max)	47	48
Crude Density[1]	Not Applicable	0.1551[2]	0.1736[2]	0.1736	0.1772
Comment	Assumed 100% occupancy since actual surveys were not conducted.	Assume the population was a fully recovered population. (80% occupancy per 2008 NSO Recovery Plan)	Max estimate. Assumed all ACs occupied. (Removed 5 abandoned sites with USFWS concurrence)	Occupancy determined at all sites	Occupancy determined at all sites

[1] Note: Crude density is based upon the 173,316 acre area within .5 mile of a survey station, since the larger area inside the general survey boundary includes the town of Weaverville and a significant area that as a result of wildfires or site quality would never be considered potential habitat. See Figure 7 for the estimated effective survey area.
[2] Grey highlighted numbers are the result of assumptions not actually measured/calculated.

In both of these survey periods, some ACs were determined to not have any responses and historically would have been declared abandoned by the USFWS. Service direction changed in this time period, and the 2011 protocol no longer included a definition for abandoning sites. Thus ACs from owls that may have moved on the landscape continue to increase in number while numbers of occupied ACs and density of owls remained constant.

In response to the Service's revision of the survey protocol in 2011, we switched to using electronic calling machines for these surveys, and also added over 180 new calling stations, extending geographic extent of the survey effort by about 40 percent, most of which is US Forest Service land within 1.3 miles of SPI ownership. This resulted in location of still more activity centers outside the original LSS area; these sites have not been included in the summary previously mentioned (Figure 5). Also, in 2011, we began banding all NSO on the ownership, so that in the future we will be able to ascertain whether birds in new locations are residents that have relocated, or whether they are immigrants. In 2011 and 2013 we have banded 104 NSO (78 adults/sub adults and 26 juveniles).

Reproduction

During this recent 2011- 2013 effort we were able to determine that 24 of these 48 occupied activity centers were reproductive, producing at least 52 fledglings (Figure 6). This represents 32 individual nesting attempts as 8 of these AC's reproduced twice in the three year period.

Summary and Conclusion

In summary, the uncertainty associated with the estimate of territories extant at the time of listing precludes precise comparison of numbers over the past 23 years. However, while we have seen some change in the location of occupied activity centers, we see no indication of a population decline in the LSS area during the period between the 2003-2007 LSS surveys and the surveys being conducted now. While we recognize that this is a very small portion of the California population and our work is not a demographic study; it is worth noting that the LSS area apparently is not showing a similar decline as reported from the NSO demographics studies. The Willow Creek Study area (referred to as NWC) is the nearest USFS demographic study area to the LSS and they have an estimated annual decline of 1.7%. The current range wide demographic average is an estimated annual decline of 2.9% (Forsman et al, 2011). Compared to those values our numbers of occupied ACs and density of owls appears stable. If our study area NSOs were following these rates and assuming that our original 1989 AC count of 52 (minus those the service declared abandoned) we would have a 1989 starting estimate of 47 ACs and assuming 100% occupancy, the NWC study estimated decline would have expected a reduction to only 31.1 occupied ACs and based upon the NSO range wide estimated rate we would have only 23.2 occupied ACs today.

Since the listing over the past 22 years, all THPs have been conducted under no-take guidance in effect at the time of harvest. The increased survey effort, improved protocols, and initiation of banding should improve our understanding of the owl population in this area in the future.

In conclusion, to our knowledge, our LSS effort to determine the number of occupied ACs on a fixed area of land is the only existing dataset upon which to assess potential impacts over time of Forest Practice Rule - guided management on NSO density. This study shows that for the period from 2003 through 2013, despite active timber harvest, there has been no discernible change in population density. While there have been apparent movement of owls on this landscape, and as described above, a resultant increase in the number of ACs, the numbers of occupied ACs and density of owls have increased slightly but clearly at a minimum remained constant.

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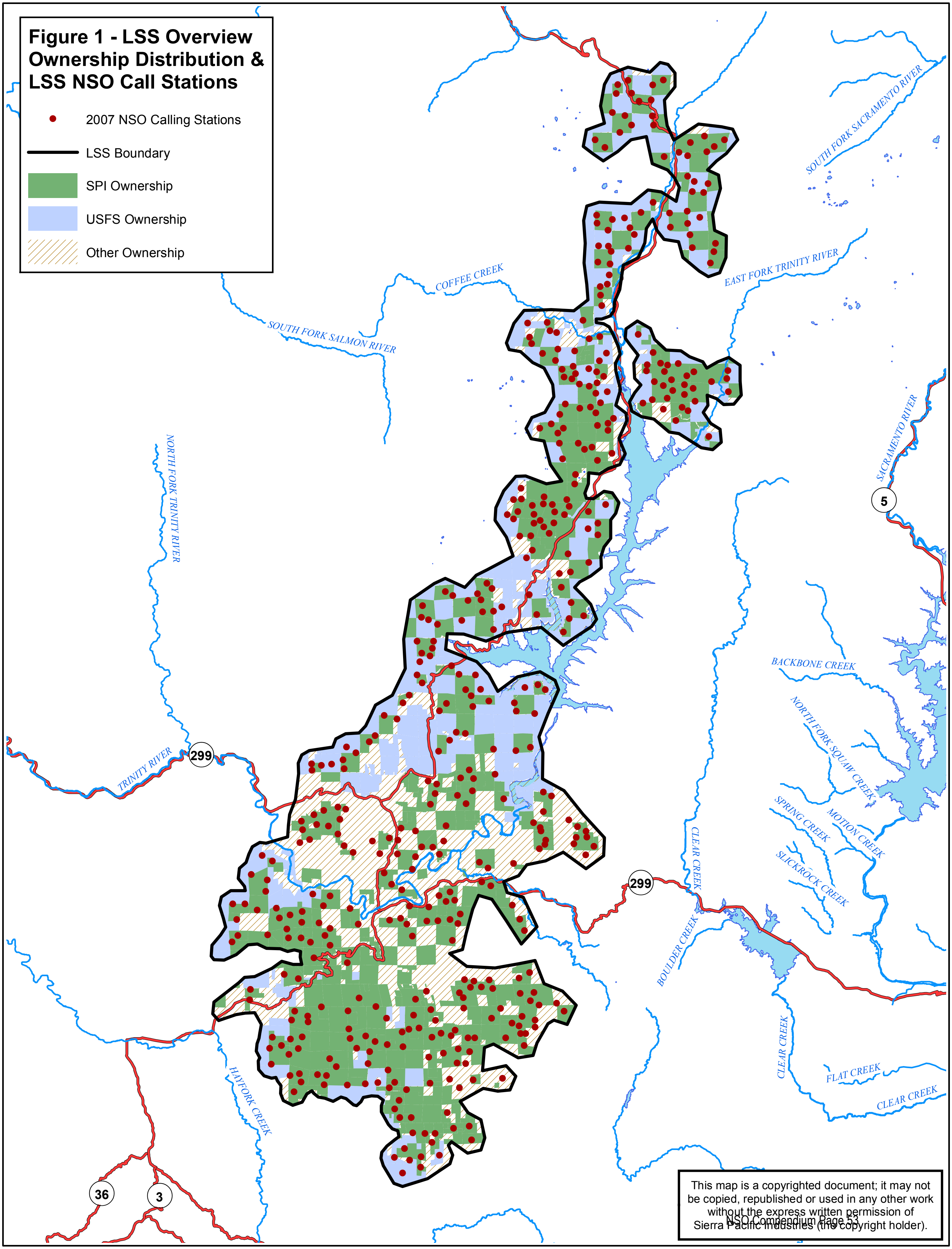


Figure 1 - LSS Overview Ownership Distribution & LSS NSO Call Stations

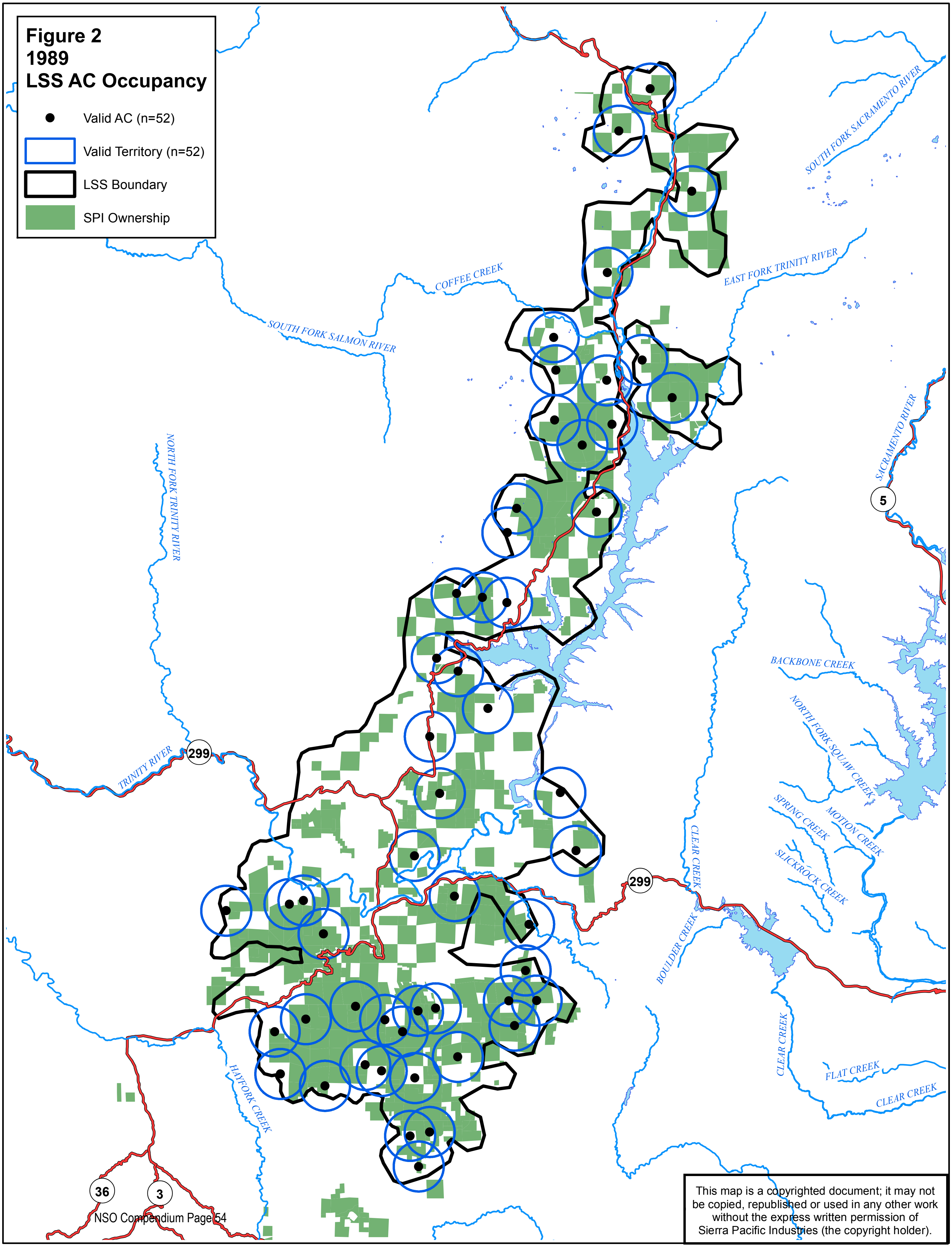


Figure 2
1989
LSS AC Occupancy
Valid AC (n=52)
Valid Territory (n=52)
LSS Boundary
SPI Ownership
COFFEE CREEK
SOUTH FORK SALMON RIVER
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
NORTH FORK TRINITY RIVER
SACRAMENTO RIVER
5
TRINITY RIVER
299
BACKBONE CREEK
NORTH FORK SQUAW CREEK
SPRING CREEK
MOTION CREEK
SLICKROCK CREEK
CLEAR CREEK
BOULDER CREEK
299
HAYFORK CREEK
CLEAR CREEK
FLAT CREEK
CLEAR CREEK
36
3

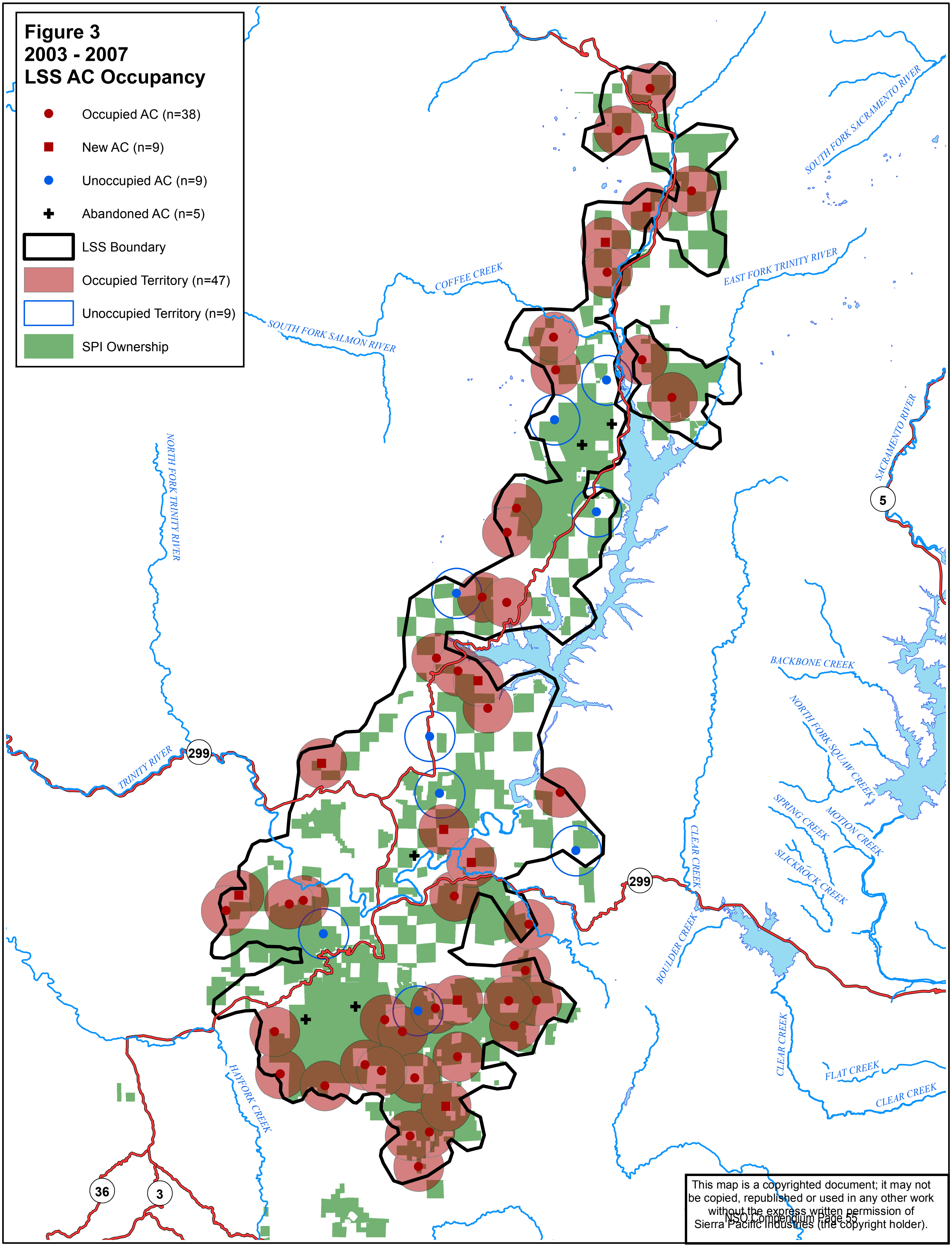


Figure 3
2003 - 2007
LSS AC Occupancy
Occupied AC (n=38)
New AC (n=9)
Unoccupied AC (n=9)
Abandoned AC (n=5)
LSS Boundary
Occupied Territory (n=47)
Unoccupied Territory (n=9)
SPI Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
SOUTH FORK SALMON RIVER
NORTH FORK TRINITY RIVER
SACRAMENTO RIVER
5
BACKBONE CREEK
NORTH FORK SQUAW CREEK
SPRING CREEK
MOTION CREEK
SLICKROCK CREEK
CLEAR CREEK
TRINITY RIVER
299
BOULDER CREEK
HAYFORK CREEK
FLAT CREEK
CLEAR CREEK
36
3

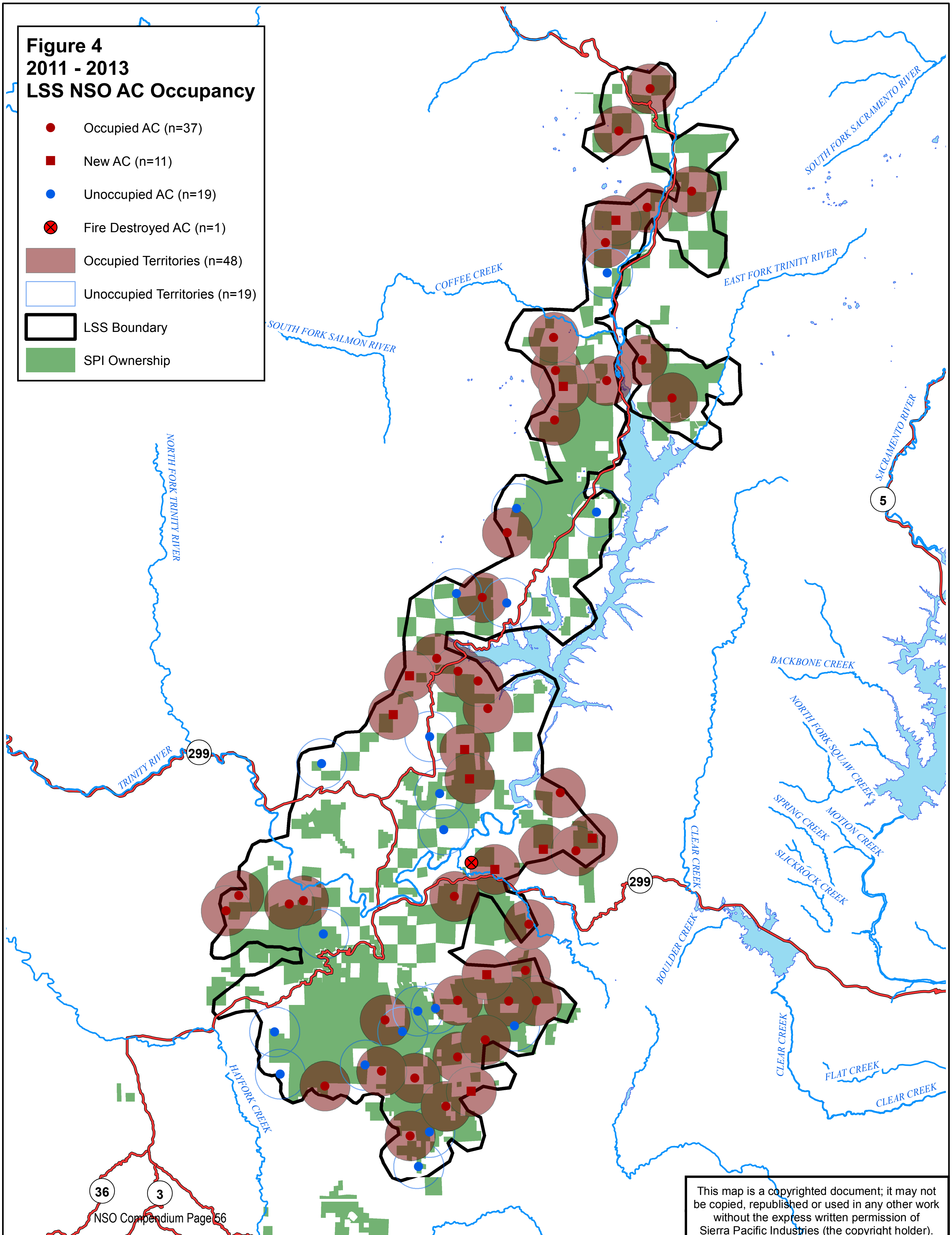


Figure 4
2011 - 2013
LSS NSO AC Occupancy
Occupied AC (n=37)
New AC (n=11)
Unoccupied AC (n=19)
Fire Destroyed AC (n=1)
Occupied Territories (n=48)
Unoccupied Territories (n=19)
LSS Boundary
SPI Ownership
SOUTH FORK SACRAMENTO RIVER
COFFEE CREEK
EAST FORK TRINITY RIVER
SOUTH FORK SALMON RIVER
SACRAMENTO RIVER
5
NORTH FORK TRINITY RIVER
BACKBONE CREEK
NORTH FORK SQUAW CREEK
TRINITY RIVER
299
SPRING CREEK
MOTION CREEK
CLEAR CREEK
SLICKROCK CREEK
299
BOULDER CREEK
HAYFORK CREEK
CLEAR CREEK
FLAT CREEK
CLEAR CREEK
36
3

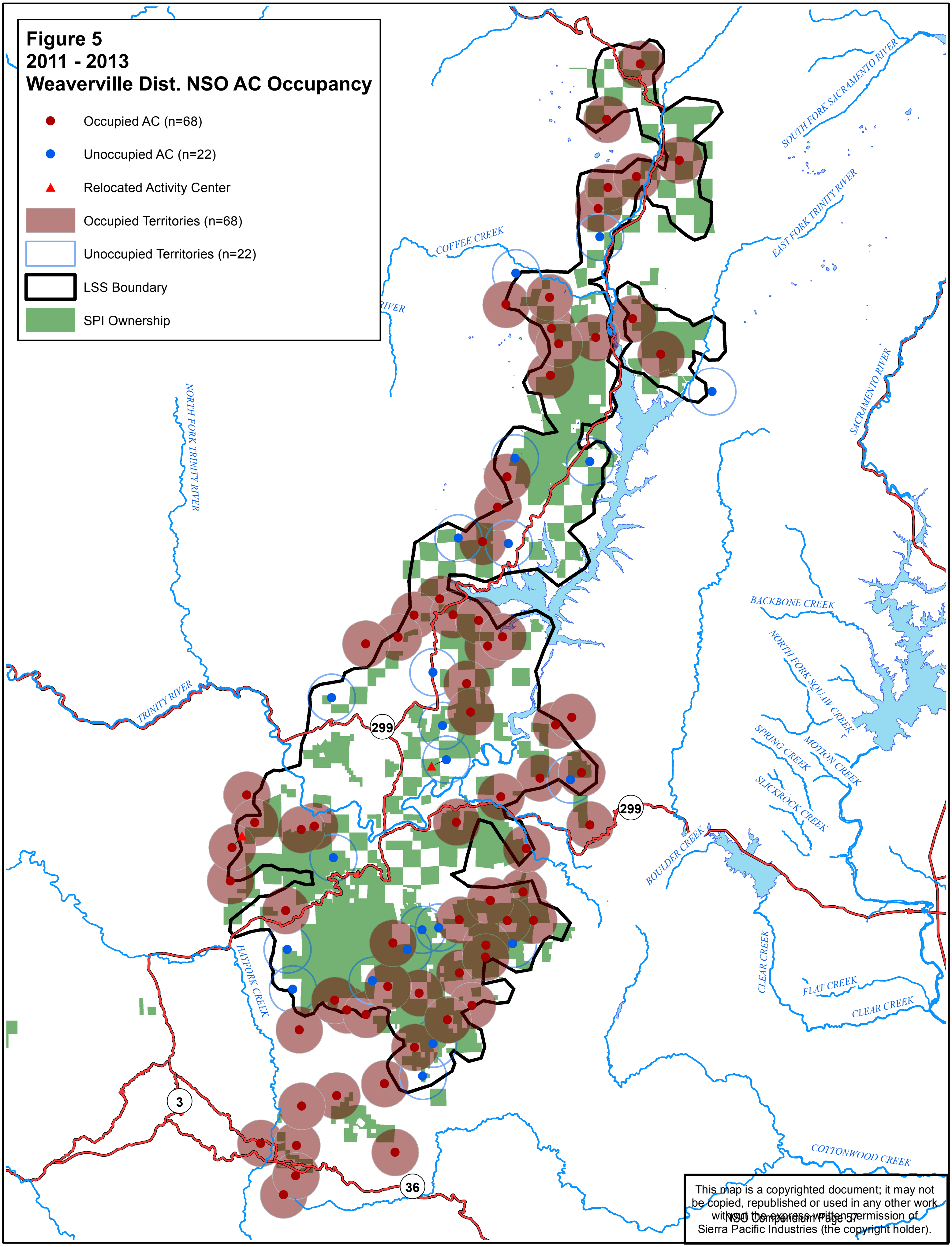
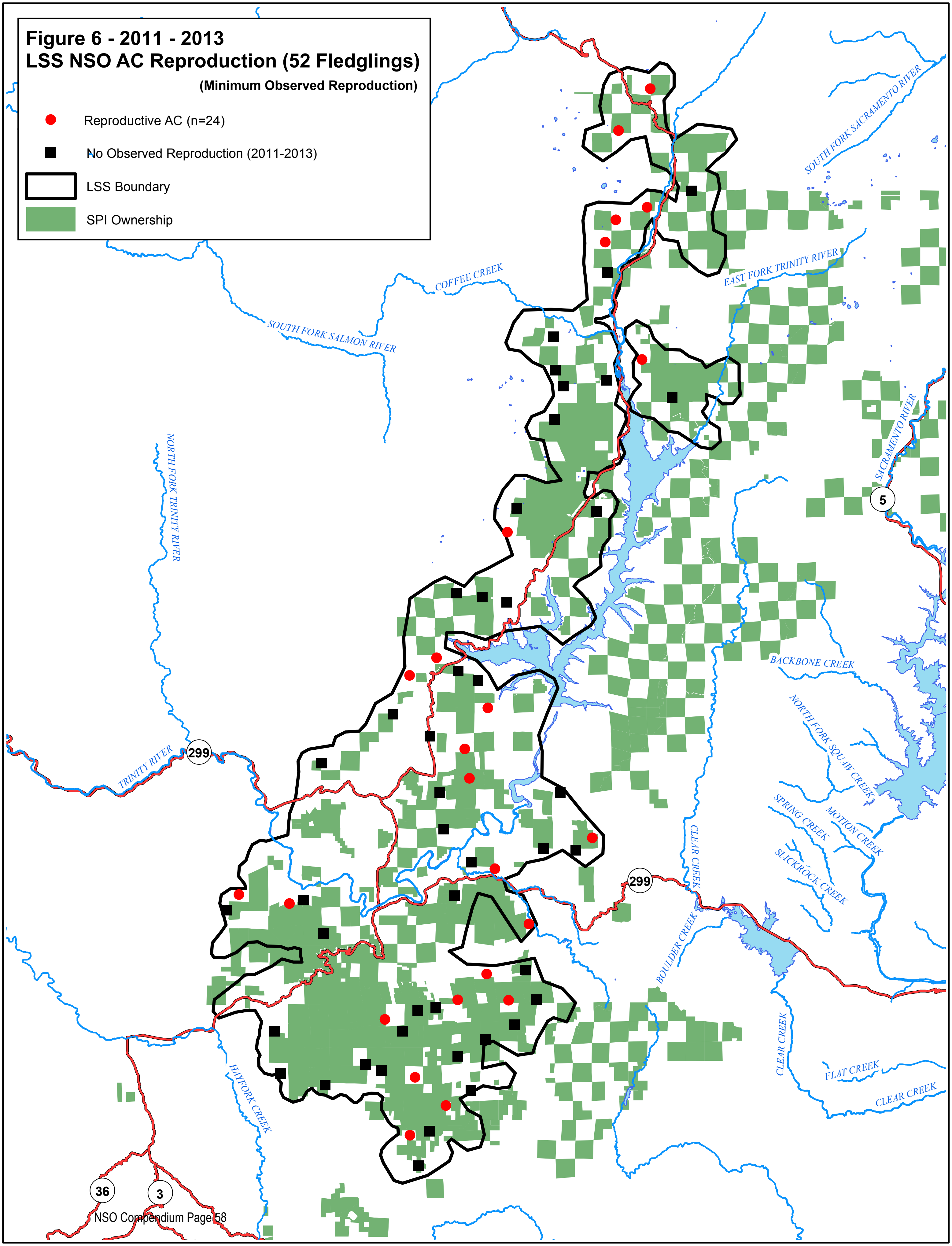


Figure 5
2011 - 2013
Weaverville Dist. NSO AC Occupancy
Occupied AC (n=68)
Unoccupied AC (n=22)
Relocated Activity Center
Occupied Territories (n=68)
Unoccupied Territories (n=22)
LSS Boundary
SPI Ownership
COFFEE CREEK
NORTH FORK TRINITY RIVER
TRINITY RIVER
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
SACRAMENTO RIVER
BACKBONE CREEK
NORTH FORK SQUAW CREEK
SPRING CREEK
MOTION CREEK
SLICKROCK CREEK
BOULDER CREEK
CLEAR CREEK
FLAT CREEK
CLEAR CREEK
HAYFORK CREEK
COTTONWOOD CREEK
299
299
3
36

Figure 6 - 2011 - 2013
LSS NSO AC Reproduction (52 Fledglings)
(Minimum Observed Reproduction)



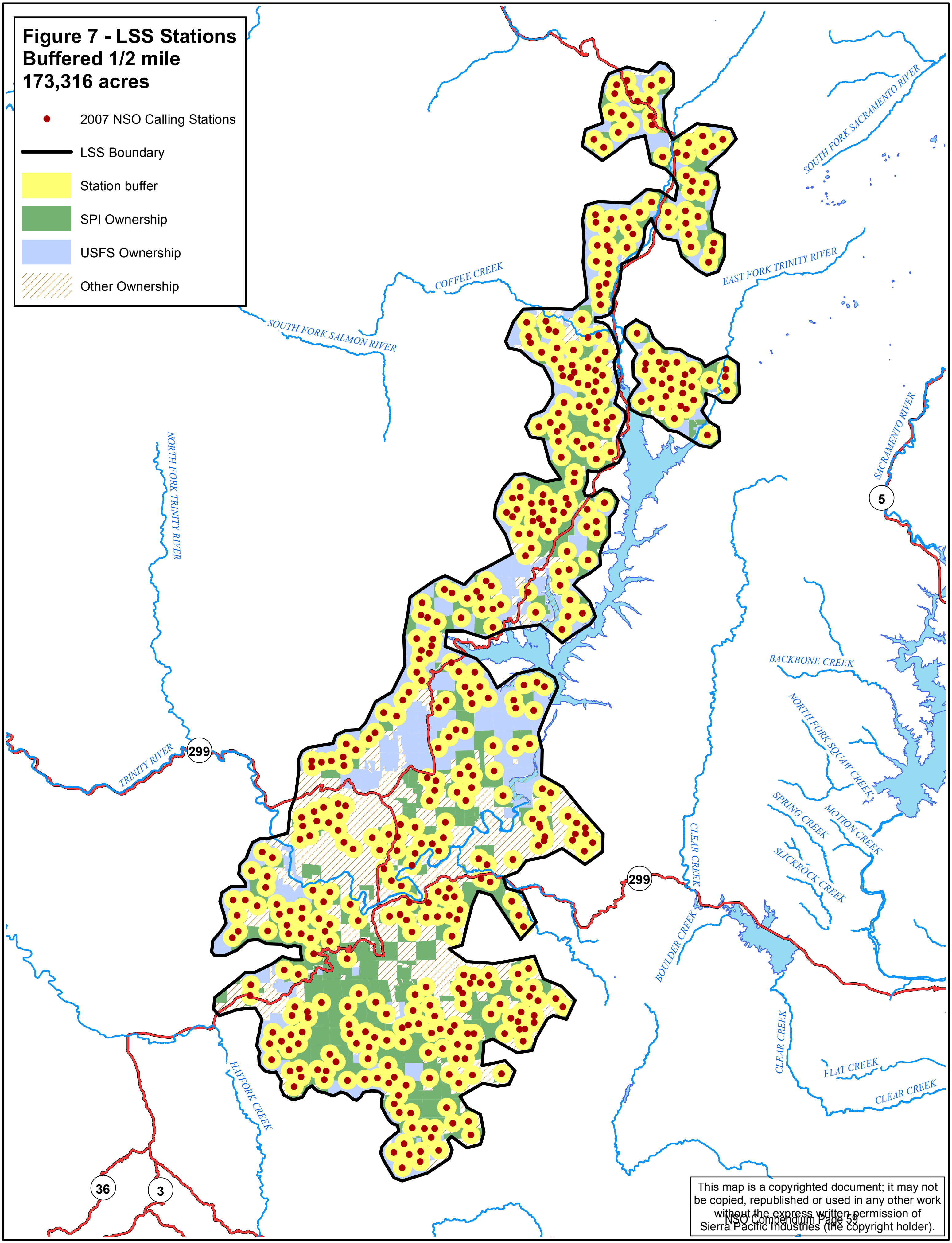


Figure 7 - LSS Stations
Buffered 1/2 mile
173,316 acres
2007 NSO Calling Stations
LSS Boundary
Station buffer
SPI Ownership
USFS Ownership
Other Ownership
SOUTH FORK SACRAMENTO RIVER
COFFEE CREEK
EAST FORK TRINITY RIVER
SOUTH FORK SALMON RIVER
SACRAMENTO RIVER
NORTH FORK TRINITY RIVER
5
299
TRINITY RIVER
BACKBONE CREEK
NORTH FORK SQUAW CREEK
SPRING CREEK
MOTION CREEK
CLEAR CREEK
SLICKROCK CREEK
299
BOULDER CREEK
HAYFORK CREEK
CLEAR CREEK
FLAT CREEK
CLEAR CREEK
36
3

OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- SIERRA PACIFIC INDUSTRIES-
EDWARD C. MURPHY,
MANAGER, RESOURCE INFORMATION SYSTEMS

http://www.calforests.org/wp-content/uploads/2014/01/NSO-Science-Forum-MURPHY.pdf

Northern Spotted Owl Status Report for The Conservation Fund's California North Coast Forestlands

INTRODUCTION

The Conservation Fund (TCF) is a non-profit organization that is dedicated to protecting high conservation value lands throughout the United States through a variety of programs that integrate environmental and economic goals. In response to the increasing threat of rural residential subdivision and vineyard conversion of large forest ownerships across the California North Coast, TCF initiated the North Coast Forest Conservation Initiative with the acquisition of the 23,780 acre Garcia River Forest in 2004. TCF followed the Garcia River Forest acquisition with the acquisition of the Big River and Salmon Creek forests (16,020 acres) in 2006, the acquisition of the Gualala River Forest (13,542 acres) in 2011, and the acquisition of the Buckeye Forest (19,650 acres formerly known as Preservation Ranch) in 2013. In total, TCF currently owns and manages approximately 73,000 acres of timberland in Mendocino and Sonoma counties. Through the North Coast Forest Conservation Initiative, TCF seeks to demonstrate that large, under-stocked tracts of coastal forest can be returned to ecological and economic viability through patient, adaptive management by a non-profit organization in partnership with private and public entities and community stakeholders.

Current Timber Stand Conditions

All of the Fund's North Coast properties have a long history of industrial forest management that has shaped the current forest structure and composition. Most stands on the Big River and Salmon Creek properties have been harvested at least twice since the initial entries around the turn of the 20th century. Recent past management in the 1990s-early 2000s focused on even-age silviculture (primarily clearcutting) with some uneven aged silviculture (single tree and group selection) used less frequently between clearcut blocks. This has created a wide range of tree sizes and ages with stands ranging from young, 5-10 year old plantations to more mature 60+ year old stands of second growth timber. The Garcia River, Gualala River, and Buckeye Forests comprise one contiguous block of TCF's property with similar forest structure/composition and harvest history. Most stands on these properties were initially harvested in the 1950's-1960s. A second round of timber harvests occurred in the 1980s and 1990s during which most of the residual larger timber was removed and some of the smaller size classes were thinned. This has resulted in a relatively continuous landscape of closed canopy 45-60 year old timber. The forest type across all properties can be best characterized as mixed redwood/Douglas-fir. Site quality tends to be higher on the Big River and Salmon Creek Tracts than the Garcia, Gualala, and Buckeye Tracts. Big River and Salmon Creek tend to have higher redwood stocking, while Garcia, Gualala, and Buckeye Forests tend to have a higher composition of Douglas-fir and hardwoods, primarily tanoak. Current timber inventories on the Big River and Salmon Creek properties average approximately 25,000 board feet/acre. Timber inventories on the Garcia River Forest currently average approximately 10,000 board feet/acre. Given TCF's commitment to harvesting less than growth in the next few decades, it is forecast that timber inventories across the ownership will double over the next 50 years.

NSO habitat mapping has been done for the Garcia River, Big River, and Salmon Creek tracts utilizing a combination of air photo interpretation, inventory data, and on-the-ground knowledge.

The NSO habitat definitions described in the Arcata USFWS Office's "Attachment A" guidelines were used in this analysis. Based on this analysis, on the Big River and Salmon Creek tracts 23%, 44%, and 31% of the acres have been classified as nesting/roosting, foraging, and non-habitat respectively. On the Garcia River Forest, 27%, 55%, and 18% of the acres have been classified as nesting/roosting, foraging, and non-habitat respectively. Additionally, TCF possess LiDAR imagery for all of its North Coast ownership and we plan to utilize this imagery for further NSO habitat analysis. Utilizing the LiDAR data we have completed some trial NSO habitat mapping on the Garcia River Forest. However, we are still working to refine and verify these models.

Forest Management Strategies

- Silviculture practiced across the ownership will be primarily uneven-aged single-tree or small group selection in order to develop and maintain a range of tree sizes and ages within a stand, with the goal of producing valuable sawtimber and utilizing natural regeneration. Even-aged variable retention harvests (that retain large trees and habitat features) may be used to rehabilitate conifer sites now dominated by hardwood.
- Harvest levels will be less than growth rates over the next few decades so as to increase timber inventory.
- Increased riparian buffers will be provided so as to improve riparian habitat conditions and increase water quality protection.
- Special attention will be given to developing and retaining critical wildlife habitat features, such as snags, downed wood, and trees with structural elements such as large limbs, forks, cavities and basal hollows.
- While the forests presently contain smaller trees and more hardwoods than would have occurred historically, over time the silvicultural methods used are intended to ensure the forests more closely approximate historic conditions.
- There are no old growth stands on the properties; there are individual trees that are residual old growth—these and other selected large trees and true oaks will be maintained
- TCF has obtained, and will continue to maintain, certification under the Forest Stewardship Council and Sustainable Forestry Initiative standards.

NSO Survey History

The Big River and Salmon Creek Tracts have been surveyed for NSO since 1989 when they were owned by Georgia Pacific (GP). Initially, surveys were conducted by GP in and around known NSO territories, and then shortly after were conducted on a THP-by-THP basis. By 1994 Georgia-Pacific biologists affirmed that all NSO territories within these tracts had been identified. The survey methodology after 1994 largely consisted of monitoring known NSO territories for occupancy and reproductive status with some additional point calling associated with THPs. These extensive survey efforts have provided up to 20 years of reproductive and occupancy information for some NSO territories and at least 15 years of information on the remaining territories. When Georgia-Pacific sold these tracts to Hawthorne Timber Company in 1999 there were no significant changes in NSO survey methodology.

Historic NSO surveys by the previous landowners on the Garcia, Gualala, and Buckeye Tracts consisted of calling on a project specific basis through the 1990s to early 2000s and little effort was made to monitor known NSO territories for occupancy and reproductive status. As such, the NSO survey dataset for these properties was less extensive than the dataset for Big River and Salmon Creek prior to TCF's acquisition.

The Conservation Fund's Survey Efforts

Since acquiring these its properties, TCF has implemented a new NSO survey methodology to reflect changes in the accepted survey protocol and fill in some of the gaps in survey coverage that resulted from calling on a THP by THP basis. The new survey methodology required that NSO surveys eventually be conducted ownership-wide, in addition to monitoring historic NSO territories for occupancy and reproductive status. Specifically, known NSO territories would be monitored for occupancy and reproductive status (if obtainable) and then call-point surveys would be conducted in areas between the occupied territories.

Ownership wide surveys of Big River and Salmon Creek have been conducted since 2008 and 2007 respectively. The entire northwest portion of the Garcia River Forest (the North Fork Garcia River, Olsen Gulch, and Blue Waterhole Creek watersheds) has been surveyed annually since 2008. The rest of the ownership has been surveyed annually since 2009. The Gualala River Forest has been surveyed annually since 2012. TCF has yet to conduct any NSO surveys on the Buckeye Forest as this property was just recently acquired in June 2013.

All survey work on the Garcia and Gualala River forests has been conducted consistent with the most recently approved USFWS NSO survey protocol for the year during which surveys were conducted. As such, 3 survey visits were conducted on the Garcia River Forest in both 2008 and 2009 and 6 visits were conducted annually in 2010-2013. The Gualala River Forest was called 6 times in both 2012 and 2013. Surveys of the Big River and Salmon Creek forests are conducted consistent with the Spotted Owl Management Plan that covers these properties (this is discussed further in the following section), which requires 3 annual survey visits. All NSO survey work has been conducted by staff from Mike Stephens Wildlife Consulting and TCF staff foresters.

Since 2008, survey effort across the TCF ownership has generally been increasing partly due to the implementation of new USFWS survey protocols and partly due to property acquisitions (i.e. survey effort increases in 2012 coinciding with the acquisition of Gualala River Forest). The following table summarizes survey effort across TCF's ownership since 2008:

	2008	2009	2010	2011	2012	2013
# Stations Called*	433	583	932	1076	1438	1410
# Territory Visits**	56	56	67	66	92	75

*the total number of nighttime station visits across the ownership each year. This includes multiple visits to each call station.

**the total number of daytime walk-in visits. This includes monitoring visits at historic NSO sites and follow-up visits to nighttime detections.

In conjunction with the survey efforts, a banding program is in place to band as many NSO territories as possible. Banding has been conducted by permitted individuals employed by Mike Stephens Wildlife Consulting. Additionally, Mendocino Redwood Company has assisted with much of the banding work conducted on TCF's ownership. Currently over 75% of the NSO territories across TCF's ownership have banded individuals present. The additional banding effort allows us to track diurnal and nocturnal locations of individuals. This give us a better idea of the habitat used for both nesting/roosting and foraging and in some cases has provided us with estimates of home ranges.

Regulatory Compliance/Take Avoidance

When submitting THPs, TCF follows the guidelines outlined in 919.9(e) of the California Forest Practice Rules. However, different portions of the ownership are subject to different take avoidance guidelines. In 2009 and 2010, TCF worked with the USFWS to develop a Spotted Owl Management Plan (SOMP) for the Big River and Salmon Creek tracts that outlines take avoidance guidelines applied to THPs on these tracts. There is currently no programmatic take avoidance plan for other portions of the ownership, so take avoidance for THPs outside the Big River and Salmon Creek tracts is demonstrated through adherence to the USFWS Arcata Office's "Attachment A" guidelines.

Habitat retention guidelines and operational provisions outlined in the SOMP and "Attachment A" are largely the same. Key habitat retention components of both documents include the establishment of a 100 acre core area of the best available habitat (preferably nesting/roosting) around each NSO activity center where very limited timber operations are permitted and the requirement to retain at least 500 acres of suitable habitat (nesting/roosting and foraging) within 0.7 mi of each NSO activity center. The definitions used to describe nesting/roosting habitat, foraging habitat, and non-habitat are the same in both in the SOMP and "Attachment A". Both the SOMP and "Attachment A" prohibit timber operations within 0.25 mi of each NSO activity center until after July 31 unless non-nesting status, nesting failure, fledging success is confirmed

The primary differences in the SOMP and "Attachment A" relate to survey protocols and survey requirements prior to initiating timber operations. Under the "Attachment A" guidelines, surveys consistent with the 2011 USFWS NSO survey protocol are required. These consist of at least two years of surveys, six visits per year, within 0.7 mi of the THP prior to initiating operations. In years 3 and 4, spot check surveys consisting of 3 survey visits are required prior to initiating operations. Under the SOMP, NSO surveys are conducted annually across the entirety of the Big River and Salmon Creek tracts. These surveys consist of 3 nighttime station visits and monitoring of occupancy and reproductive status of all known NSO territories on the Big River and Salmon Creek tracts. In the event that historic NSO territories fail to be detected using this methodology, the areas around these historic NSO sites are called utilizing the most recently approved USFWS NSO survey protocol. Under the current USFWS survey protocol, 6 annual survey visits as opposed to 3 would be conducted in these areas. Additionally, under the SOMP, timber operations may commence any time after March 1 once all historic NSO territories within 0.7 mile of the THP boundary are verified as occupied. Any detection (nighttime or daytime) of NSO within 1000 feet of their historic activity center is sufficient to demonstrate occupancy for a given year.

The primary justification for the operational guidelines and survey procedures outlined in the SOMP is the extensive NSO survey history on the Big River and Salmon Creek properties and the commitment to continue conducting annual ownership scale NSO surveys into the future. The Garcia River Forest was not included in the SOMP because at the time of the SOMP development it was felt that there was not sufficient NSO survey history. By the beginning of 2010, there were less than 2 years of recent surveys on the majority of the Garcia River Forest. The Gualala River Forest and Buckeye forest were not included in the SOMP because they were acquired after the SOMP was approved.

TCF has voluntarily implemented ownership wide NSO surveys, even in areas not covered under the SOMP, because we feel that it allows TCF operational flexibility and aids in project permitting. Other non-THP projects which require CEQA compliance, such as stream habitat improvement and road improvement projects require a 1600 permit and the extensive survey efforts help facilitate permit acquisition. By monitoring known NSO territories and surveying areas that do not contain NSO, we are better able 1) Annually locate and identify current NSO activity centers 2) find any new NSO territories if they become established 3) know which NSO territories have become unoccupied and 4) determine if barred owls have moved into the property(s) thus triggering additional surveys if any known NSO territories are being affected by the barred owls. Additionally, ownership wide "blanket" surveys allow land managers to plan projects already knowing where NSO territories are located. This streamlines the project planning process and allows us to identify key areas to protect and areas where additional survey effort may be warranted.

NSO Population Trends

Since implementing ownership wide NSO surveys in 2008, the NSO population across TCF's ownership has remained relatively static. The following table displays the number of occupied NSO territories identified as a result of surveys on each tract each year. These data only include NSO territories with activity centers located on TCF ownership. Buckeye Forest data is not presented as TCF has yet to conduct survey of this property. There are another 10+ additional territories with activity centers located immediately outside TCF ownership that are regularly detected and monitored during surveys conducted by TCF, but occupancy data for these territories is not included.

Number of Occupied Territories Each Year by Property

	2008	2009	2010	2011	2012	2013
Garcia	6	8	9	9	10	10
Gualala					1	1
Salmon Creek	6	6	6	6	5	5
Big River	6	7	7	7	7	7
Ownership Wide	18	21	22	22	23	23

As shown in the following table, NSO density is highly variable across TCF ownership. Higher densities of NSO territories are found in the more northern and coastal Big River and Salmon Creek tracts. Salmon Creek, in particular, has an especially high NSO density with one territory every 700-800 acres. Density of NSO territories decreases across the TCF ownership moving to the south and east as climate becomes hotter and drier. To date, only one NSO territory has been identified on the Gualala River Forest. Differences in management history and current vegetation structure/composition may also explain some of this difference in NSO territory density across the TCF ownership. Big River and Salmon Creek have a history of even-aged management and currently possess a patchwork of different sizes and ages of timber ranging from 10 year old plantations to 80+ year old stands of large diameter trees with high canopy cover. The Garcia and Gualala River tracts, on the other hand, are characterized by a relatively continuous landscape of closed canopy 45-60 year old mixed hardwood/conifer stands with few early seral 5-25 year old stands.

Acres/NSO Territory/Year for Each Tract

	2008	2009	2010	2011	2012	2013
Garcia	3963	2973	2642	2642	2378	2378
Gualala					13542	13542
Salmon Creek	708	708	708	708	850	850
Big River	1962	1681	1681	1681	1681	1681
Ownership Wide	2211	1895	1809	1809	2319 (1809 excluding Gualala)	2319 (1809 excluding Gualala)

Reproductive output since 2008 across TCF ownership has been highly variable from year to year. 2013 was an especially poor year for reproduction with no nesting attempts or successfully fledged young across the entire TCF ownership. The numbers of nesting attempts/year and successfully fledged young/year across the entire TCF ownership are summarized in the following table.

Ownership Wide Reproductive Output

	2008	2009	2010	2011	2012	2013
# nesting attempts	6	7	7	3	4	0
# young fledged	3	5	6	3	4	0

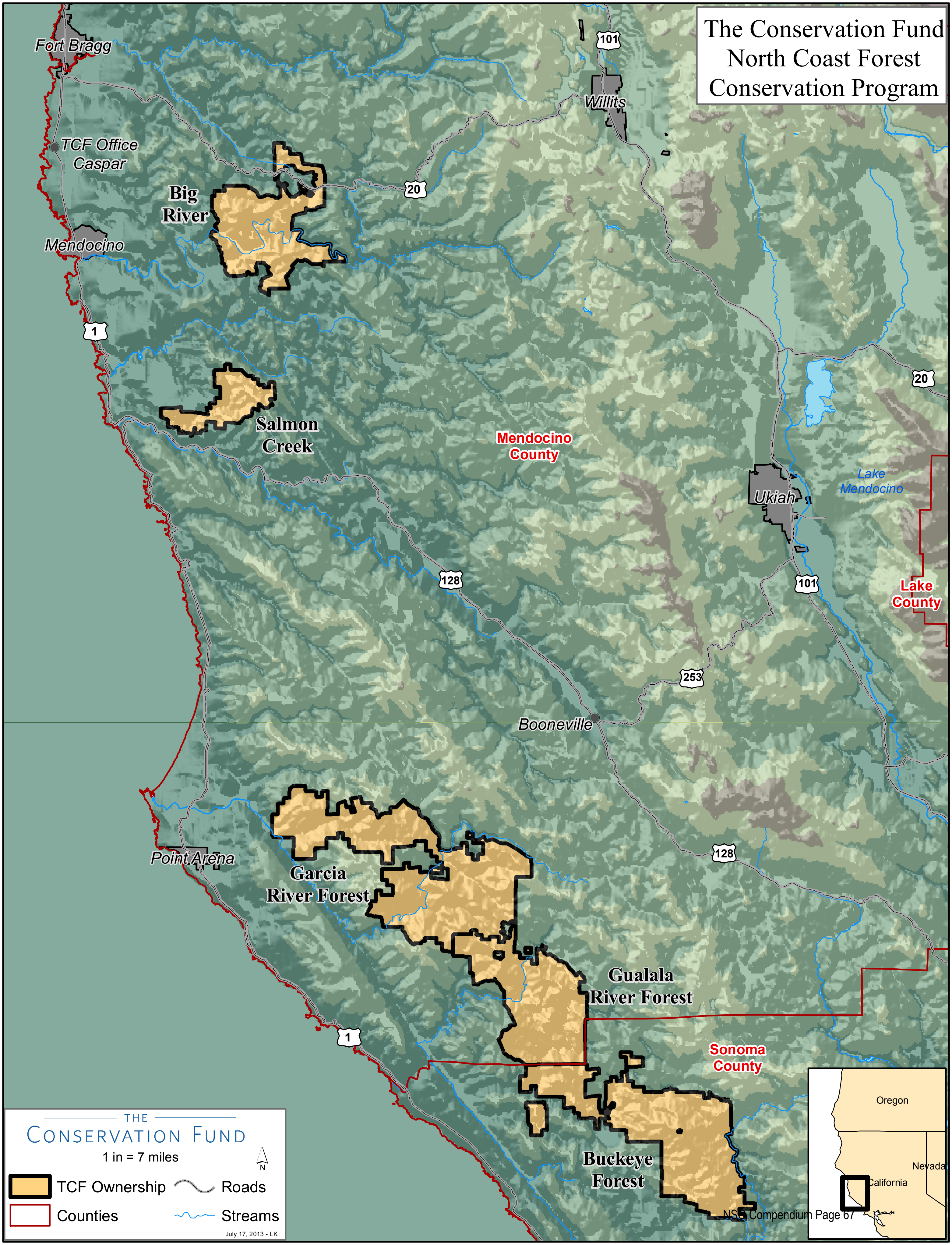
Barred owls

Barred Owls have been detected across the TCF ownership since 2009. There are currently 4 sites where barred owls are regularly detected across the property, two sites on Salmon Creek and two sites on Garcia River. Barred Owls are also occasionally detected around the periphery of the Big River Forest, but no established territories have been identified on that property. There are two historic NSO territories on Salmon Creek that are associated with barred owl territories and neither NSO territory has been detected since 2011. One barred owls site on the Garcia River forest is associated with an NSO territory. This NSO territory has still been detected in the general vicinity of its historic activity center, but detections have been inconsistent and reproductive status has not been obtained since 2009. The other barred owl site on the Garcia River Forest has not affected any known NSO territories and is in an area of with minimal nesting/roosting habitat.

Other Issues

Illegal trespass marijuana grows and the associated chemical use is an increasing concern related to NSO on TCF ownership. In 2012, a dead NSO was found on the Salmon Creek tract. The carcass was biopsied at UC Davis and traces of blood thinning rodenticides were detected. Though the concentration was not sufficiently high to have been the cause of death, the presence of blood thinning rodenticides in this bird suggests that this issue may become an increasingly important factor in NSO population dynamics in certain areas.

Questions and comments related to NSO issues on TCF's North Coast ownership can be directed to Madison Thomson: mthomson@conservationfund.org; (707)357-3919


The Conservation Fund
North Coast Forest
Conservation Program
Fort Bragg
TCF Office
Caspar
Mendocino
Big
River
Willits
101
20
1
Salmon
Creek
Mendocino
County
Lake
Mendocino
Ukiah
128
101
Lake
County
253
Booneville
Point Arena
Garcia
River Forest
128
Gualala
River Forest
1
Sonoma
County
Buckeye
Forest
Oregon
Nevada
California
THE
CONSERVATION FUND
1 in = 7 miles
N
TCF Ownership
Roads
Counties
Streams
July 17, 2013 - LK

OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- THE CONSERVATION FUND-
MADISON THOMSON, FORESTER

http://www.calforests.org/wp-content/uploads/2014/01/NSO_Presentation_TCF-THOMSON.pptx

NSO Occupancy and Population Information

Michigan-California Timber Company

January 20, 2014

The Michigan-California Timber Company manages approximately 114,700 acres in Siskiyou, Trinity, and Shasta counties, California (Figure I). The entire ownership lies within the range of the federally Threatened northern spotted owl (*Strix occidentalis caurina;* NSO). Since 1995, the Company has successfully operated under a Spotted Owl Management Plan (SOMP; 14 CCR 939(e)). In addition to completing annual surveys and monitoring, the Company has been involved in a number of research projects and published papers regarding NSOs. As discussed below, there are 55 known NSO activity centers (sites or territories) located within 0.5 miles of the ownership, nine of which are also considered monitoring birds under our SOMP.

In an attempt to detect changes in owl numbers and site occupancy of owls near the ownership over time, we compiled and evaluated available data associated with the 55 known NSO activity centers located within 0.5 miles of the ownership from year 2000 through 2013 (14 years). This assessment included review of Department of Fish and Wildlife's NSO database (CNDDB Spotted Owl Viewer, Version 4.18), survey and monitoring data forms, including data provided by adjacent landowners, and data stored in our in-house NSO GIS data base. Although this analysis was coarse due to annual variation in survey effort (not all sites are surveyed every year) and results, and did not account for differences in the detectability of owls during good reproductive years versus poor reproductive years, it does indicate a more or less stable population in terms of site occupancy, and clearly shows that owls near the ownership are not experiencing the approximate three percent annual decline purported elsewhere within their range (Forsman 2011). A 3% annual decline would represent a cumulative decline of approximately 33% over the last 14 years.

Site Occupancy

Site occupancy is based on the results of protocol surveys and the presence of a pair or resident single owl, as defined by the protocol (USFWS 2012). Site occupancy does not reflect breeding status. Sites with single nighttime detections only and sites where barred owls (*Strix varia*) were detected were excluded from this analysis for that year. Nighttime detections could be from a resident NSO or from an owl out foraging in a different territory, which could result in associating that owl with more than one site. Sites where barred owls were detected likely reflects the displacement of spotted owls, which may still be in the area, but not respond to our calls due to the new threat. According to Olson et al. (2005), the presence of barred owls reduces the detectability of NSOs, which could lead to the misclassification of an occupied site.

Verified status includes confirmed pairs, territorial singles, and confirmed vacant. The percent occupied is simply the number of verified occupied sites divided by the total number of verified sites surveyed. Although this is fairly coarse analysis, and assumes equal detectability in all years, it does show a fairly steady occupancy rate of owls on and near the ownership over the past 14 years (Figure II).

As shown in Figure II, site occupancy has ranged from a high of 67% in 2001 to a low of 32% in 2009, and has averaged 45% over the last 14 years. In 2000, 35% of the sites with verified status were occupied while in 2013, 52% were occupied.

Owl Numbers

Owl numbers are simply the sum of all adult owls found at the territories surveyed in a given year. This only includes adult owls observed during daytime visits and does not include sites with single nighttime detections. A territory has either a pair, single, or no owls. Sites with single nighttime detections and territories where barred owls were detected were excluded from this analysis for those years. Owl numbers are reported as the number of adult owls divided by the number of sites surveyed. The number of owls recorded each year is dependent on a number of factors, including the amount of area and number of activity centers surveyed, the number of survey visits to occupied sites, the presence of barred owls, and the detectability of owls in good reproductive years vs. poor reproductive years.

The number of adult owls per site surveyed has ranged from a high of 1.17 owls per site in 2001 to a low of 0.60 owls per site in 2009, and has averaged 0.85 adult owls per site surveyed over the last 14 years (Figure III). In 2000, there were 0.68 owls per site surveyed and in 2013, there were 0.72 owls per site surveyed.

Monitoring Sites

There are currently nine monitoring sites, five of which were designated as such under the 2007 SOMP, one was added shortly thereafter, and three additional sites were added as part of the 2013 SOMP (Table I). All but one of these sites are located on the ownership. As specified in the 2013 SOMP, a minimum of five of these sites will be surveyed to determine occupancy, status, and reproductive success each year. Eight of the nine sites were surveyed in 2013. As previously discussed above, sites where barred owls were detected were dropped from this analysis for that year.

As shown in Table I, site occupancy of the monitoring birds has ranged from a low of 50% in 2009 (3/6) and 2011 3/6), to a high of 86% (6/7) in 2013, followed by 83% (5/6) in 2010, and 80% (4/5) in 2008. The number of sites with nesting NSOs has ranged from a low of 0 (0/6) in

2009 and 2011 to a high of 50% (3/6) in 2010. In 2013, 29% (2/7) of the sites had nesting birds and one site was occupied barred owls. The two years (2009 and 2011) with the lowest reproduction corresponded with the two years of lowest site occupancy, which was 50% in both years. Of the six sites monitored between 2007 and 2012, one site (SK493) was not occupied at all during this six year period, two sites (SK391 and SK541) were occupied in four of the six years; two sites (SK542 and SK553) were occupied in five of the six years, and one site (SK152) was occupied in all six years. In 2013, six of the eight sites surveyed were confirmed occupied by NSOs. Site SK493 was again vacant, while barred owls were detected at SK549. Site SK553 was not surveyed in 2013.

Table I. Site Occupancy and Status of monitoring sites 2007-2013.

SK#	2007	2008	2009	2010	2011	2012	2013
SK391	PN	PN	PU	PN	ND	ND	PN
SK553	PNN	PNN	ND	PNN	PU	PN	NS
SK542	SM	PNN	SM	PN	ND	PNN	SF
SK493	ND	ND	ND	ND	ND	ND	ND
SK152	PNN	PN	PNN	PNN	SF	SU	SF
SK541	ND	NS	ND	PN	PNN	PN	PNN
SK549	N/A	N/A	N/A	N/A	N/A	N/A	BO
*SK012	N/A	N/A	N/A	N/A	N/A	N/A	PN
SK051	N/A	N/A	N/A	N/A	N/A	N/A	PNN
Occupancy	4/6 (67%)	4/5 (80%)	3/6 (50%)	5/6 (83%)	3/6 (50%)	4/6 (67%)	6/7 (86%)
# of adults	7/6 (1.17)	8/5 (1.6)	5/6 (0.83)	10/6 (1.7)	5/6 (0.83)	7/6 (1.17)	10/7 (1.43)
# Nesting NSO's	1/6 (16%)	2/5 (40%)	0/6 (0%)	3/6 (60%)	0/6 (0%)	2/6 (33%)	2/7 (29%)

ND = No Detections; NS = Not Surveyed; PN = Pair, Nesting; PNN = Pair, Non-nesting; SF = Single Female; SU = Single Unknown; PU = Pair, Status Unknown; SM = Single Male; BO= Barred Owl; N/A = Not Applicable (territories not designated as monitoring sites at this time); *SK012 is located on federal land.

Barred Owls

Although barred owls have been detected on and in the vicinity of the ownership, their occurrence is rare. Based on our review of available survey information, barred owls were detected at two sites in 2009 and 2013, one site in 2010 and 2012, and none in the other 10 years.

Summary

There are 55 known NSO sites located within 0.5 miles of the ownership. Although not all sites are surveyed annually, between 24 and 35 sites (44% to 65%) have been surveyed by MCTC and/or adjacent land owners each year since 2000. Based on our review of available information, site occupancy has ranged from 32% to 67% since 2000, while the occupancy rate of our monitoring sites has ranged from 50% to 86%. The number of adult owls per site surveyed has also varied from a low of 0.60 adult owls per site surveyed to a high of 1.17. Our monitoring sites have ranged from a low of 0.83 adults per site surveyed to a high of 1.70.

Part of this difference could be attributed to survey effort whereas the monitoring birds generally receive significantly more effort in determining status than most of the other sites surveyed each year. We believe that survey effort can influence the number of adult owls detected at each site because surveys are often suspended to avoid unnecessary disturbance to NSOs once a territory is determined to be occupied, even if only one owl is detected. This bias is expected to increase going forward due to the expansion of our survey area from 0.7 miles to 1.3 miles around proposed project areas that began in 2013. This will generally result in more territories being surveyed each year, yet determining status may not be necessary given the distance between the activity center and the project area.

Although barred owls have been detected on and in the vicinity of the ownership, their impact on NSOs has been fairly limited. Of the sites surveyed each year, two were known to be occupied by barred owls in 2013, one of which is one of our monitoring sites.

Based on our review of available data associated with the 55 known NSOs activity centers located within 0.5 miles of the MCTC ownership, we have concluded that our owl population is dynamic, yet stable.

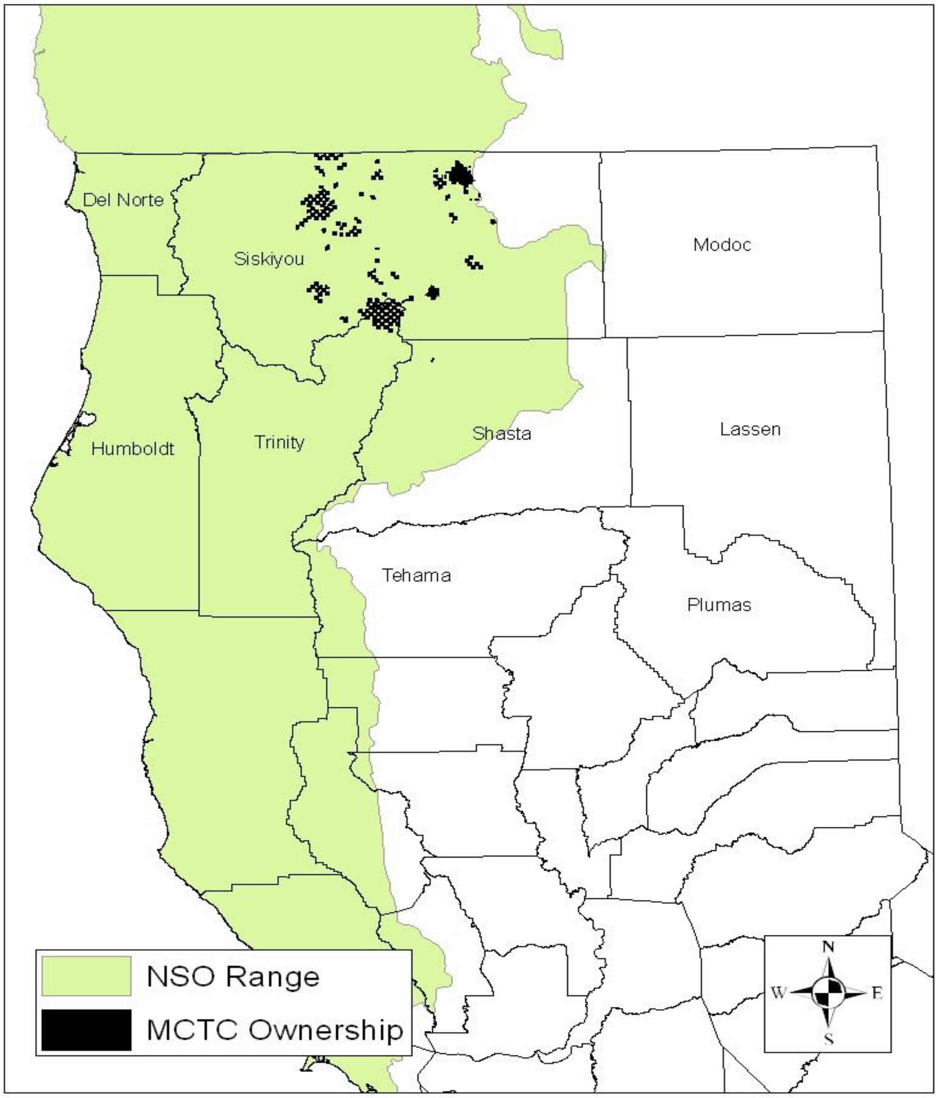


Figure I. MCTC Vicinity Map and the Range of the Northern Spotted Owl.

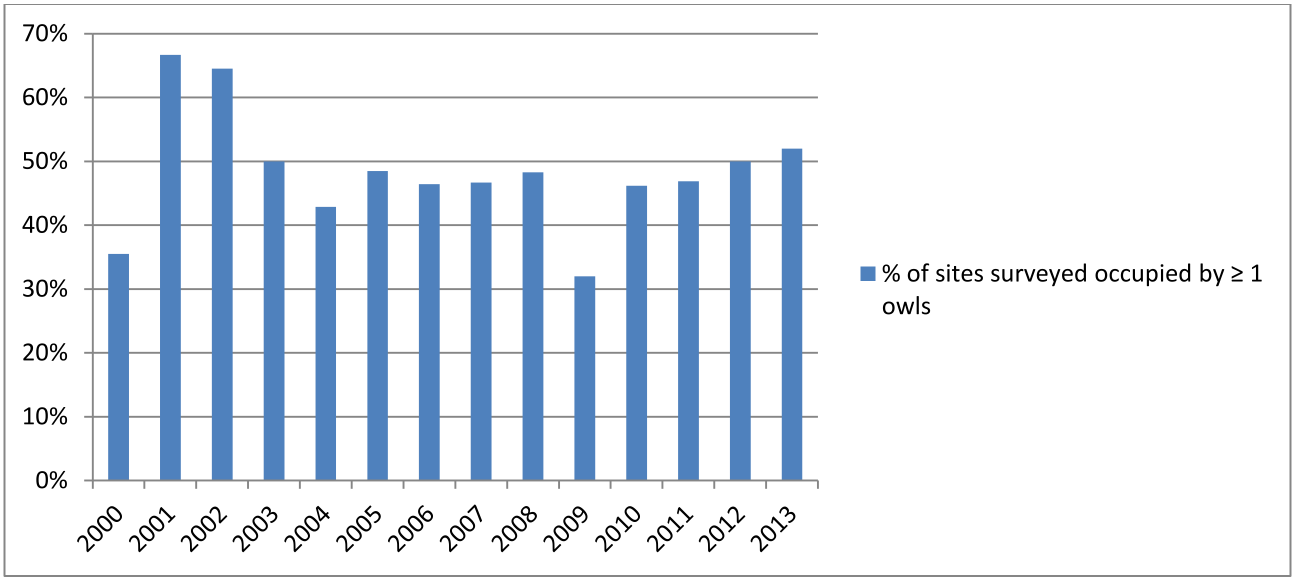


Figure II. Percent of sites surveyed occupied by one or more owls.

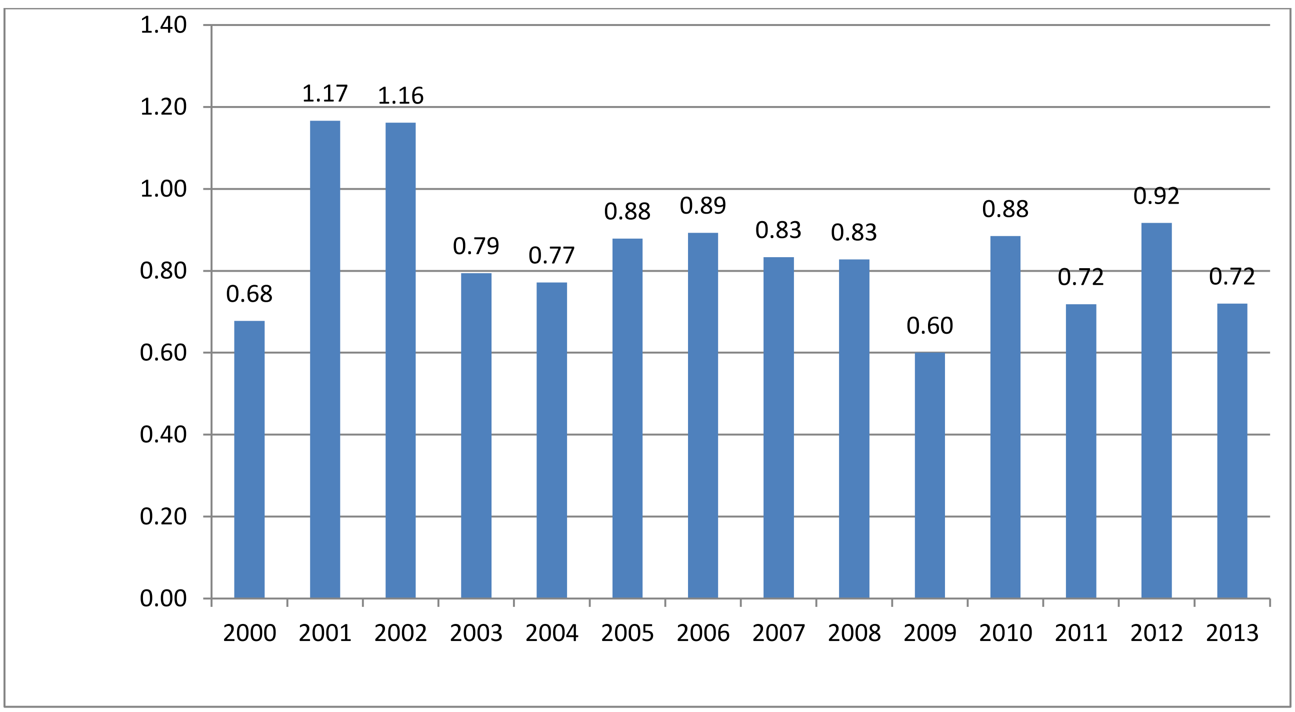


Figure III. Number of adult NSOs per site surveyed between 2000 and 2013.

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OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- MICHIGAN-CALIFORNIA TIMBER COMPANY -
DIRK EMBREE, WILDLIFE BIOLOGIST

http://www.calforests.org/wp-content/uploads/2014/01/MCTC_NSO-EMBREE.pptx

21st ANNUAL REPORT

submitted to
the United States Fish and Wildlife Service
by
Green Diamond Resource Company

in fulfillment of requirements specified in condition I. of permit # PRT-767798, incidental take permit for northern spotted owls, under section 10(a)(1)(B) of the Endangered Species Act

15 February 2014

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I. Introduction

On September 17, 1992, three years of spotted owl research and two years of preparation by Green Diamond Resource Company culminated in the acceptance of Green Diamond Resource Company's Habitat Conservation Plan (HCP) for northern spotted owls. The plan was the first HCP for the owl on private lands and was part of Green Diamond Resource Company's application for a section 10(a)(1)(B) incidental take permit under the Endangered Species Act (ESA). The signing of the permit by the U.S. Fish and Wildlife Service (the "Service") allowed Green Diamond Resource Company to harvest owl habitat that could result in the incidental take of a maximum of 50 owl pairs in 10 years for an average of 5 owl pairs per year. Incidental take was anticipated to result primarily from modification of owl habitat that could displace owls, i.e., causing them to move to new areas, impairing their essential behavioral patterns, and causing death or injury. On December 10, 2007, the Service approved the first amendment to the HCP and Implementation Agreement authorizing the incidental take of an additional 8 pairs of Northern Spotted Owls as described in the amendment permit and attachments.

The key elements of the amended HCP were that:

- owl habitat would be created and its development accelerated,
- 39 areas comprising 13,252 acres would be set-aside for owls,
- a 20,310-acre special management area where owls were the most reproductively successful would be managed on a "no-take" basis
- reproductive pairs and their young would be protected during the breeding season, and
- research and monitoring of the owl population across the property would continue.

The following report documents the twenty-first year of the HCP and includes details specified to comply with the HCP. Included are sections about spotted owl surveys, owl habitat retention in timber harvest plans, levels of take, amount of owl habitat, spotted owl studies, conservation areas, and other information required for annual reports by section III.C.1.a of the implementation agreement.

The reporting period of this report was from Sept. 1, 2012 to Sept. 1, 2013

II. Spotted Owl Surveys

As noted in the HCP, all stands scheduled for timber harvest must be surveyed for spotted owls. Although the HCP outlined survey procedures and requirements, it did not provide specific details. The following describes these details as well as the results of the surveys.

A. Methods

To protect nesting owls and their young from direct harm due to timber operations during the breeding season and to identify owl activity centers, all stands scheduled to be harvested were HCP protocol surveyed for spotted owls during the breeding season, March 1 - August 31. All timber harvest plans (THP's) initiated between Sept. 1, 2012 and March 1, 2013 were protocol surveyed in 2012 and those initiated after March 1, 2013 were surveyed in 2013 prior to start of operations.

Second year surveys were conducted for timber harvest plans that had been HCP protocol surveyed the previous year. The protocol for second year surveys was presented in Green Diamond's fourth annual report of the HCP and in this report.

1. HCP protocol surveys

HCP protocol surveys were conducted by Green Diamond wildlife biologists, and, in some cases, by other employees meeting the following qualifications recommended for spotted owl surveyors by the U.S. Fish and Wildlife Service (Protocol for surveying proposed management activities that may impact northern spotted owls, revised March 17, 1992):

> Normal hearing abilities are requisite. An owl caller must be able to hear the owl(s) if they were calling AND
>
> • Have training in spotted owl survey techniques OR
>
> • Have 1 year/season of spotted owl survey experience

Green Diamond's THP's are often comprised of multiple units. The number of units surveyed is usually referenced in regard to owl surveys because owl surveys are conducted on a unit-by-unit basis, and not all units surveyed are eventually incorporated into THP's.

The surveys provided coverage of each THP unit and at least a 1/4-mile buffer around it, with some calling points established at least 1000 feet from the plan boundary. The calling points were strategically placed to assure complete coverage of the survey area. If an occupied owl site was located in any portion of a survey area, a 0.5-mile radius around the owl site was not called to avoid harassing the owls. Each calling point was called for a minimum of 10 minutes unless an owl responded sooner.

Prior to April 2013, surveys were conducted in each THP unit until an owl was located or for a maximum of four times per unit. A statistical analysis of THP detections was conducted in 2012 to determine the number of THP surveys necessary to achieve a 95% detection probability of territorial spotted owls within approximately 0.5 miles of a timber harvest unit. This analysis utilized ownership specific THP survey data and site occupancy data. THP detection data collected from 1994-2011 were analyzed in conjunction with spotted owl site occupancy of each corresponding year. Results from the analysis indicated 4-6 surveys of each THP unit are necessary to achieve a 95% detection probability of a territorial owl. More surveys (up to 6) are needed in the earlier part of the breeding season to achieve the 95% probability because the probability of detection increases throughout the season. Four surveys are needed later in the season to reach the same probability. To capture the variation in probability throughout the season, a calculator was formulated from the analysis. The calculator assigns a detection probability to each Julian date and is used to determine the number of surveys required to achieve a 95% probability of detection. Surveys are conducted until the sum total probability of the 4-6 surveys is greater than or equal to 0.95. Starting in April 2013, surveys were conducted in each THP until an owl was located or until the number of surveys required to achieve a 95% detection probability were completed as determined by the detection probability calculator.

Each survey for an individual THP unit was spaced at least one week apart. In areas where no owls were detected, at least one survey was conducted after April 1. At least one follow-up visit was conducted after May 1 to determine that the owls were not nesting.

Each survey response was followed-up with a daytime visit by Green Diamond biologists to locate the owl and determine its pair status, activity center, or nest site (see section VII.A.4 for details). If three follow-ups were conducted and an owl was not located, it was concluded that the initial response was from an owl that did not have an activity center in the THP area.

If owls were located in or within 0.25-miles of a THP early in the nesting season, the THP was not entered until after April 15 if a nest site was not located. A 0.25-mile buffer was maintained around the owl pair's activity center until its nesting status was determined. If the pair was still not nesting by May 1, then the radius of protection was no longer maintained and the whole plan became available for timber falling. As detailed in section V, these procedures did not apply to displacement pairs. Timber falling in displacement THP's was allowed within 0.25 mile of a pair unless a nest was found.

If a nest was found, the nest tree was marked and the THP was immediately available for harvest providing that no timber falling or yarding was allowed within a

0.25-mile radius of the nest tree until it was determined that the owlets had fledged or that the nest had failed. After the owlets fledged, the radius of protection was 500 feet from the owlets and connectivity to continuous habitat was maintained. When the owlets dispersed or were capable of dispersing, or it was determined that the nest had failed, falling and yarding was allowed within the 500-foot radius.

To protect nesting owls from potential impacts of spring slash burns, Green Diamond biologists reviewed a list of THP units to be burned after March 1. If it was determined that the fire or smoke generated from a burn would likely disturb a nesting pair, then appropriate measures were taken to prevent the disturbance (canceling or postponing the burn).

Barred Owls

Because barred owls reduce the probability of detecting spotted owls, and as a result of increased barred owl presence within the Green Diamond study area, survey effort at spotted owl territories invaded by barred owls will include measures to increase the likelihood that resident spotted owls are detected. When THP units occur within 0.5 miles of a historic spotted owl nest site or activity center that is occupied by barred owls, Green Diamond will conduct at least one stand search protocol visit to assess site occupancy of spotted owls. Biologists will conduct a thorough visit of the stand by walking the THP unit and a 500’ buffer area of suitable habitat surrounding the unit. Biologists will look for sign from owls (roosts with whitewash, pellets, feathers, etc.) and will not attempt to elicit vocal responses from spotted owls.

2. Additional spot calling and second year surveys

Sites identified in surveys conducted from March 1 - August 31 in 2012 were considered valid until March 1, 2013, and surveys conducted during the same period in 2013 are considered valid until March 1, 2014. However, timber harvest in some plans spanned two owl survey years. For example, several 2013 THPs were surveyed during the 2012 breeding season and were found to be free of owls. The plans were initiated before March 1, 2013, but harvest had not been completed by that date. Although the likelihood of owls establishing a territory in such plans was considered low, it was possible. Depending on the status of the THP, it may have required additional calling. In addition, due to the scheduling of contractors, continuous timber falling within a THP unit often does not occur. Contractors temporarily stop falling in a unit and return later, or different contractors move in to the THP area and resume falling. As a result, small portions of a plan area can be felled, and a THP unit can remain virtually unharvested for an extended period until chopping resumes. Because this could occur near the owl-breeding season, a greater likelihood of owls moving into the area would exist than if continuous timber operations occurred in the THP unit. Finally, in many cases, low priority THP areas that are surveyed in one year are actually not harvested until the next year. If a given area was surveyed with the four-survey protocol and no timber was harvested before March 1 of the following year, a possibility exists that owls may move into the area. However, because the area was previously surveyed, the probability of new owls moving into the area would be considered low.

To detect the possibility that owls moved into a THP unit under the circumstances described above, Green Diamond initiated the following modified spot calling and second year protocol procedures to be implemented on March 1 each year:

- If more than 10 acres of contiguous timber remain in the unit, falling is not continuous, and less than 25% of the unit has been felled (including units where no timber has been felled), then timber harvest must be temporarily deferred until a second year protocol survey has been conducted. The second year protocol consists of three nighttime surveys spaced at least five days apart, with at least one survey on or after April 1. If more than 30 days elapsed since the last protocol survey, the unit(s) was called once prior to the initiation of the THP.

- If more than 10 acres of contiguous timber remain in the unit, more than 25% of the unit has been felled, and harvest is not continuous, harvest must be temporarily suspended until two nighttime calls at least 5 days apart have been conducted.

- If more than 10 acres of contiguous timber remain in the unit, and falling is continuous from on or before February 21, timber harvest may continue with spot calling. The spot calls will be concurrent with operations and will occur once a week until less than 10 acres of contiguous timber remain, or for a maximum of four weeks.

- If less than 10 acres of contiguous timber remain in the unit, then harvest may continue with no special provisions.

- If less than 10 acres of contiguous timber remain in the unit, and harvest is deferred until the following breeding season, a possibility exists that owls may have moved into the area. Therefore, before resuming cutting activity after March 1, a biologist conducts two night surveys at least five days apart. If no owls are detected, operations may commence.

For spot calling, qualified employees called the remaining timber in the plan from one or several locations to ensure adequate coverage of the area. The calling was done, weather permitting, at least once a week until less than 10 acres of contiguous standing timber remained, or for a maximum of four weeks. The spot calling was concurrent with timber operations, i.e. conducted before or after actual falling activity on a given survey day.

The following second year survey protocol was developed to address continuous operations in large acreage THP units with non-clearcut silviculture prescriptions.

Harvest must be initiated on or before February 21. Starting on March 1, biologists will conduct night surveys of the entire THP area concurrently with continuous harvest operations. Typically, the same survey stations used during the first year of surveys will be used for this effort. Surveys should be conducted starting at dusk to maximize the probability of detecting a resident owl. Surveys will be conducted once a week for three weeks. A fourth night survey will be conducted on or after April 1, at which time the unit will be free of further operational restrictions if no spotted owls have been detected. If an owl is detected during one of the surveys, operations must stop until Green Diamond biologists determine if an owl activity center exists.

Unless spot calls detected an owl within 0.25 miles of the remaining timber in a THP, operations continued. If an owl was found, timber falling was suspended within 0.25 miles of its activity center until it was determined that the owl was not nesting.

In THPs where timber falling was temporarily terminated and resumed several times, spot calling was conducted in the remaining timber if the following criteria were met:

- the THP was not a displacement plan,
- no falling had occurred in the THP for more than 30 days,
- more than 10 acres of contiguous timber remained, and
- falling was in the 1 March - 31 August breeding season.

Similarly, spot calling was done between March 1 and August 31 for each THP that had not been initiated (first entry into plan) within 30 days of the last protocol survey for the plan. Again, calling was done by qualified individuals and provided adequate coverage of the area.

3. Additional surveys on acquired THPs
There were no acquired THPs during this reporting period.

B. Survey Results

1. HCP protocol surveys

One hundred twenty-four THPs comprised of 355 units (Appendix I) were surveyed for spotted owls in 2013 using the original survey protocol described above. (23.3%) of these units had been surveyed in previous years and were surveyed with the 2nd year protocol. Three new activity centers were found within 0.5 mile of a THP that was previously surveyed. Ninety-eight units (27.6%) that had been surveyed in previous years following the original 4-call protocol were surveyed 4-6 times in 2013 until 95% detection probability was achieved. One hundred forty-four units (40.5%) were surveyed for the first time in 2013 until 95% detection probability was achieved. All THPs will be surveyed using detection probability calculations in 2014.

Spotted owl responses were heard during surveys of 38 THPs. Thirty-one THPs had owl activity centers located within 0.5 mile. Thirty-nine unique owl sites were associated with these THPs. There were thirteen THPs with responses from owls whose activity centers were greater than 0.5 mile from the THP boundary.

A total of 225 THP units were initiated through timber falling or road construction during the reporting period. Timber operations were delayed on 3 THP units due to nesting pairs in 2013. In compliance with GDRCo protocol, if a pair was found to be nesting, operations would have not been conducted within 0.25 miles of the nest until it was determined that the owlets had fledged or the nest had failed. Once the owlets fledged, no operations were conducted within 500 feet of the owlet(s) until it was determined that the owlets dispersed or were capable of dispersing. An additional eleven plans were delayed due to spotted owl detections that resulted in follow-up visits. Six THP units occurred within 0.5 mile of historical spotted owl sites that were occupied by barred owls. A thorough stand search of each THP unit and a 500-foot buffer of suitable habitat surrounding each unit was conducted by GDRCo biologists. No spotted owls were detected during these surveys, but one barred owl was detected. No slash burns were delayed due to the proximity of nesting spotted owls.

2. Additional spot calling

Eleven THP units initiated before March 1, 2013 and having more than 10 contiguous acres remaining at that date were spot called for owls. No spotted owls were heard in these plans. One hundred and one THP units were spot called once from March 1 - August 31 because more than 30 days had elapsed since the last 2013 protocol survey, activity in the plan had been suspended for more than 30 days or continuous cutting was conducted from on or before February 21st.

C. Discussion

There were no instances where unknown spotted owl sites were found near initiated THPs that were protocol surveyed. Green Diamond's survey protocol appears to be effective in locating owl sites prior to harvest operations, and ensuring that owl sites are not unknowingly harvested below displacement thresholds. Furthermore, about 51% of THP units were resurveyed during 2013. Additional survey effort was provided through spot calling, which increases the probability that owls within the THPs will be detected prior to THP initiation. Resurveys and spot calling provide an increased level of survey effort prior to timber operations.

III. THP Conservation Measures

A. Methods

As outlined in the HCP, habitat management measures for spotted owls include timber harvest planning, owl habitat planning, and overall environmental resource planning. Site-specific measures were identified on forms for each THP initiated. The following summarizes the data collected on the forms.

1. Pre-harvest habitat retention planning

The four major habitat management measures quantified were:

- habitat retention areas (HRAs) planned specifically for owls (number, acres, justification of choice),

- habitat retained as a result of surpassing California Forest Practice rules regarding retention in the AHCP Riparian Management Zones (RMZ) i.e., increased width of or percent overstory canopy retained in the zones,

- retention of green wildlife trees outside of HRAs or RMZs, (planned number of trees to be retained per acre individually or in clumps), and

- snag retention (estimated number per acre present before harvest)

In addition to providing HCP habitat, the retention of green wildlife trees addressed state concerns for the retention and recruitment of snags. As a result of these concerns, Green Diamond foresters and biologists developed green tree retention guidelines for young growth stands in 1993, which were further refined in 1999 and 2003. The guidelines used in the reporting period are presented below. In June 2007, Green Diamond began operating under an approved Aquatic HCP/CCAA. The riparian and slope protection measures under the AHCP will also contribute to the development of future owl habitat across the landscape.

For young growth THPs, the amount of acreage retained in Class I and II RMZs or other partial harvest areas guided habitat retention. If a THP had 15% or more of its acreage in these areas, then no further habitat retention was prescribed. If it had less than 15%, then guidelines suggested at least one HRA be added in cable yarding areas and tree clumps (1-2 trees per clearcut acre, depending on the area) were added in ground-based yarding areas.

GREEN DIAMOND RESOURCE COMPANY'S HCP GENERAL GUIDELINES FOR LIVE (GREEN) WILDLIFE TREE RETENTION IN YOUNG GROWTH STANDS

General guidelines for green wildlife tree retention in Habitat Retention Areas (HRAs) and Tree Clumps

Candidate Tree Preferences:

Prefer defective or poorly formed trees (i.e. Animal damaged, forked top, broken top, etc.).

Prefer mix of conifers and hardwoods (approximately 50/50 mix).

Species preference: Douglas fir, hemlock, white fir, cedar, spruce, redwood, tanoak, madrone, California laurel, chinquapin.

Retention Guidelines:

Retain at least 1 tree per clearcut acre harvested (these trees are in addition to trees retained within the RMZ).
Note: 2 trees per clearcut acre are retained within specific areas on GDRCo ownership, when prescribed by biologists to further enhance habitat qualities that are deemed insufficient, e.g., the Mad River and Fortuna tracts

Prefer "pocket" or "group" retention (-HRAs ≥1/2 acre, or clumps of trees of ten or more rather than individual trees).

Retain trees that are equal to or greater than the average DBH of the stand.

Retain "defective" trees if available in a particular stand.

Relationship with snag and RMZ retention:

Live tree retention is in addition to snag and RMZ retention. Retained snags as well as green trees retained within the RMZ will not be considered as part of the count for "Wildlife Leave Trees". Green trees retained as described in the retention guidelines above as "Wildlife Leave Trees" will augment structure provided by snag and RMZ retention.

Snags - Leave all questionable merchantable snags. Take only the very best high value (volume and grade) redwood. Marginally merchantable snags that have been chosen for retention will also be marked with a "Wildlife Tree" tag. All other "safe snags" will not be felled (or marked) based on instructions from the Contract Administration Department.

2. Post harvest habitat retention

Post harvest completion data were collected for logged units that received company harvest plan completions during the reporting period or for plans in which logging activity had terminated. For plan completions, the number of green wildlife trees retained was estimated as the number of remaining trees > 12" dbh per acre. If the THP was to be burned for site preparation, the completion data was not collected until after the plan was burned. It was noted for each completion whether site preparation, burning, wind throw or some other form of forest management damaged the retained habitat features.

B. Results

1. Pre-harvest conservation measures

The planned habitat retention measures to be implemented in 27 THPs (comprised of 83 units and 2,874.3 total acres) approved during the reporting period are presented in Appendix II and summarized in Table 1. The size of the THPs ranged from 14.7 to 323.5 acres and averaged 106.5 acres. Green wildlife trees (GWTs) or habitat retention areas (HRAs) were prescribed for all but 3THPs each of which had >15% of the THP unit acreage in Class I or II RMZs or alternate thinning prescriptions not requiring additional retention. Among the 27 THPs, 39 HRAs comprising 37.4 acres were prescribed. Of the 27 THPs, there was an average of 1.4 HRAs per plan, with an average HRA size of 1.39 acres per THP prescribed. Of the fourteen THPs which prescribed HRAs, an average of 2.8 HRAs and 2.7acres of HRAs were retained per plan. Twenty-six percent of THPs prescribed a combination of GWTs and HRAs.

As summarized in Table 2, the majority of HRAs were placed in areas of habitat potential or hardwood stands. Areas of habitat potential consisted primarily of stands that displayed characteristics thought to be beneficial to wildlife. Habitat features associated with some of these HRAs include a mature stand age class and tree structure that is conducive to nesting. Several areas of operational constraint were also designated as HRAs to provide the greatest flexibility for avoidance during timber harvesting activities. Additionally, HRAs were placed adjacent to class III watercourses. No class I or II watercourses, unstable areas, or wet areas were selected as the focal point for HRA tree retention in these units.

An average of 0.97 GWTs per acre was planned for retention in all THPs. The average number of snags pre-harvest was estimated to be 0.67 per acre. Of 27 plans that had watercourses in them, 27(100%) were planned to have at least one RMZ that was wider or had more retained canopy cover than required by California Forest Practice Rules.

Table 1. Summary of planned pre-harvest THP conservation measures for individual THPs. N= 27 for all variables.

	GWT/ Acre	Snags/ acre	HRAs (#)	Area of HRAs (acres)
Minimum	0.0	0.0	0.0	0.0
Maximum	3.17	3.00	8.00	8.00
Average	0.97	0.67	1.44	1.39

GWT = green wildlife tree
HRA = habitat retention area
THP = timber harvest plan

Table 2. Characterization of planned habitat retention areas for individual THPs.

Retention feature	N
Adjacent to Class I and II watercourses	0
Adjacent to Class III watercourses	3
Wet areas	0
Hardwood areas	13
Habitat potential	16
Operational constraints	7
Unstable areas	0
Total	39

2. Post-harvest habitat retention

Completion forms were filled out for 64 THPs comprising 7,227.54 acres (Appendix III, Table 3) completed during the reporting period. Timber harvest was completed in several other THPs, but these plans were scheduled for site preparation. The post harvest habitat retention for these plans will be reported in future annual reports.

An average of 0.46 snags per acre was retained in logged units. The number of green wildlife trees > 12" dbh retained per acre ranged from 0 – 2.61 and averaged 0.68 per acre. Forty-six HRAs totaling 34.15acres were retained in 29 THPs comprising 3,143.47acres. Overall, the average was 0.72 habitat retention areas per THP, with .53acres of habitat retention area per THP. Of 29 THPs which prescribed HRAs, an average of 1.59HRAs and 1.18acres of HRAs were retained per plan.

The average area of RMZ retained per THP was 22.50 acres and ranged from 0.50- 60.0acres. Sixty-three THPs (98% of all THPs) had Class I or II watercourses (n= 64) and were given protection exceeding state requirements. Of the 64 plans, 1440.30 acres (20%) were in the watercourse protection zones. No plans were burned. . The majority of plans not burned by a broadcast method used piling or biomass removal to reduce fuel loads.

3. Comparison of pre- and post-harvest wildlife retention measures

The prescribed pre-harvest and post-harvest data were compared for the 64 THPs completed during the reporting period (Table 4). Pre-harvest data for those plans initiated but not completed prior to the reporting period have been reported in previous annual reports. At times, trees were left for unanticipated reasons and as long as they satisfied the criteria for a green wildlife tree, they were counted as additional trees in the post-harvest evaluation; however they were not counted towards GWT tallies unless previously marked during plan layout. In some cases additional tree clumps were retained to comply with the Forest Stewardship Council (FSC) standards. This additional retention was not counted towards GWT tallies unless it satisfied the criteria for GWT. FSC retention was also not counted towards HRA numbers unless the retention met HRA criteria. Average post-harvest retention of GWTs was slightly greater than pre-harvest retention levels during the reporting period. Loss of green wildlife trees in harvest plans can occur due to felling by mistake, operational constraints, safety reasons, wind throw and site preparation (burning). Increase of green wildlife trees in harvest plans may occur due to additional marking of trees prior to operations. These trees are counted post-harvest because they were marked, however, they were not reported on during pre-harvest because they had not been marked nor were they recorded on the pre-harvest form. This year, any loss of green wildlife trees was compensated for by additional marking of trees.

The post-harvest estimate of retained snags was slightly less than the pre-harvest estimate. Discrepancies between estimates of pre- and post-harvest snags are common. Since snags are not marked and tallied individually, inaccurate ocular estimates are often made on the number per acre, particularly during the pre-harvest phase when they are less obvious in the un-harvested stand.

The post-harvest acreage of HRAs was slightly greater than the pre-harvest acreage.

Table 3. Summary of post-harvest habitat retention of THP conservation measures for individual THPs. THPs involved are not necessarily the same as those in Table 1. N= 64 for all variables.

	GWT/ acre	Snags/ Acre	HRAs (#)	Area of HRAs (acres)	Area of RMZ (acres)
Min.	0.00	0.0 0	0.00	0.00	0.50
Max.	2.61	2.00	5.00	6.00	60.0
Average	0.68	0.46	0.73	0.54	22.5

THP = Timber harvest plan
GWT = Green wildlife tree
HRA = Habitat retention area
RMZ = Riparian Management Zone

Table 4. Comparisons of pre- and post-harvest habitat retention for the same individual THPs (N= 64).

	pre GWT/ acre	post GWT/ acre	pre Snag/ acre	post Snag/ acre	pre acres HRA	post acres HRA
Average	0. 66	0.68	0.49	0.46	0.53	0.54
Average change/THP	0.02		-0.03		0.01	

THP = timber harvest plan
GWT = green wildlife tree
HRA = habitat retention area

C. Discussion

HCP retention measures were implemented in compliance with the HCP and implementation agreement. Most of the planned habitat retention features were successfully retained. Areas of habitat retained compared to the planned level of retention were equal in acreage. Overall, post-harvest retention of green wildlife trees was slightly greater than planned pre-harvest estimates. An overall loss of green wildlife trees was avoided due to the RPF or contract administrator marking additional trees that presented operation constraints during and after falling was initiated. There was some individual loss of green wildlife trees due to wind throw. Prior to becoming FSC certified, Green Diamond worked to minimize tree loss from wind throw by planning the retention of fewer wildlife tree groups or clusters and instead designated more HRAs and larger RMZs. Subsequent retention efforts have placed more emphasis on scattered and clumped tree retention throughout the units. However, planned individual tree or clump retention is placed in a topographic location that will minimize wind throw where possible while still meeting FSC standards. Individual wind firm trees from the original stand can often be more successfully retained than second growth. Increasingly, RPFs noted the additional incidental retention of scattered and clumped sub-merchantable trees. These habitat features are not quantified in this report. In many instances, this incidental structure is likely to add another element of structural diversity to future forest stands.

The greatest amount of habitat retention in THPs has occurred in RMZs. Because most THPs have Class I or II watercourses and most are given canopy retention that exceeds the standard Forest Practice Rules, this represents a significant amount of retention for future owl habitat. Because owls often occupy areas near streams lower on the slope, these areas are anticipated to provide excellent future core habitat for owls.

IV. Northern Spotted Owl Habitat

A. Land Acquisition and Disposal

The major premise of Green Diamond's HCP was that habitat suitable for owls would increase throughout the 30-year period of the plan. To quantify the amount of owl habitat, Green Diamond's land base was categorized into age classes according to their value to owls. The distribution of acres in each of the age classes changes through time as stands age and enter older age classes and as stands are harvested and enter the younger age classes. Another factor that could affect this distribution is land acquisition and disposal.

It should be noted that land exchanges, harvest, and growth of stands are not the only factors that affect age-class distribution. Other factors, such as improved cruise data, can also cause changes. However, given the extent of the ownership, the acreage involved should be insignificant.

B. Methods

1. Overall habitat

The acreage of the following age classes, categorized according to their value to spotted owls, was quantified.

Age in years	Importance to spotted owls
0-7	Recently regenerated stands, no direct value to owls
8-30	Potential foraging and woodrat habitat
31-45	Foraging, roosting, and occasional nesting habitat
46+	Prime nesting and roosting habitat and also foraging habitat
NF	Non-forested land, no direct value to owls

These acreages were estimated by the GIS to determine the change in total owl habitat, i.e. change in acreage of stands greater than 30 years old. To provide an objective measure for comparison, the change in habitat composition between January 1, 2013 and January 1, 2014 was reported because Green Diamond’s GIS does not have the capability of reporting recently harvested acres on September 1 of a given year due to the timing of system updates. Although this does not coincide with the dates of the reporting period, it more accurately reflects habitat changes from one year to the next.

2. Proportion of habitat harvested

The total change in habitat due to timber harvest was also quantified around owl sites. Each THP initiated (trees harvested) during the reporting period was evaluated to determine if it was located within 1000 ft., 0.5 miles, or 0.7 miles of an owl's activity center. If so, a GIS exercise was conducted to determine the amount of habitat harvested around the owl sites. Circles with radii of 1000 feet. (72 acres), 0.5 miles (502 acres), and 0.7 miles (985 acres) were centered on owl sites affected by timber harvest. The amount of habitat within each of these circles was determined for both before and after harvest. In most cases, the amount of habitat harvested was based on the total acreage of THPs that had been initiated during the reporting period, whether or not harvest of the plans had been completed. However, multi-unit THPs were an exception to this. For these plans, certain individual units may have been deferred from harvest to avoid an owl displacement or for other operational reasons. Thus, for determining decrease in owl habitat, it was appropriate to evaluate harvest of THPs on a unit-by-unit basis to better document the timing of habitat loss.

To produce a standard for comparison, the percentage of owl habitat (stands > 30 yrs) originally present is reported for each area of interest. The percent change reflects the change in owl habitat through timber harvest relative to the total amount of owl habitat present prior to harvest. The results of the stand age distribution for the owl circles determined by the GIS were verified by examining aerial photographs. If stand ages were not quantified in the GIS, or were found to be inconsistent with the aerial photographs, then stand age typing was based on aerial photo interpretation. Aerial photo typing was done primarily for owl site circles that encompassed land outside of Green Diamond's ownership. In some cases, the exact age of the stand could not be discerned by examining the photos so that habitat was classified into "habitat" (suitable roosting and nesting) and "non-habitat" categories.

C. Results

1. Overall habitat

Table 5 summarizes the change in age class distribution between January 1, 2013 and January 1, 2014. A total of 242,361 acres of potential spotted owl habitat was estimated to occur on Green Diamond's ownership. The total amount of owl habitat (≥31 years) on the ownership decreased by approximately 3,733 acres after accounting for land exchanges, harvest, growth, or reclassification of forest into different age classes. The amount of 31-45 age class decreased by 9,030 acres, and the amount of 46+ age class increased by 5,297 acres.

2. Land Acquisition and Disposal

There were three land disposals and no land acquired in the permit area during this reporting period. Approximately 10,730 acres were removed from ownership for a net reduction of 7,737 acres of spotted owl habitat.

3. Proportion of habitat harvested

The percentage of habitat decrease due to timber harvest within 1000 ft, 0.5-mile and 0.7-mile radius circles centered on 42 owl sites are presented in Table 6. Aerial photo interpretation was used to augment the GIS information on owl sites whose areas extended beyond Green Diamond's ownership. Of the 42 sites evaluated, 18 sites were the subject of a report of owl displacement resulting from timber harvest in this or previous reporting periods.

Displacement sites had an average of 4.5%, 7.6%, and 9.9% of habitat harvested within 1000 foot, 0.5-mile, and 0.7-mile circles, respectively. Non-displacement sites had an average of 8.2%, 9.9%, and 10.3% of habitat harvested within 1000 foot, 0.5-mile, and 0.7-mile circles, respectively.

Table 5. Acreage of Green Diamond timberlands by age or habitat class at beginning and end of the HCP reporting period based on acreage as of Jan. 1, 2013 and Jan. 1, 2014.

Age or Habitat Class	GDRCo Acres as of Jan. 1, 2013	GDRCo Acres as of Jan. 1, 2014	Change in GDRCo acreage
Non-forest	8,984	6,353	-2,630
0-7 yrs	31,518	29,849	-1,669
8-30 yrs	102,599	99,870	-2,729
31-45 yrs	114,487	105,457	-9,030
46+ yrs	131,606	136,903	5,297
Total	389,193	378,433	-10,761

Figure 1. Change in spotted owl habitat (stands > 30 years old) on Green Diamond Resource Company lands since approval of the HCP.

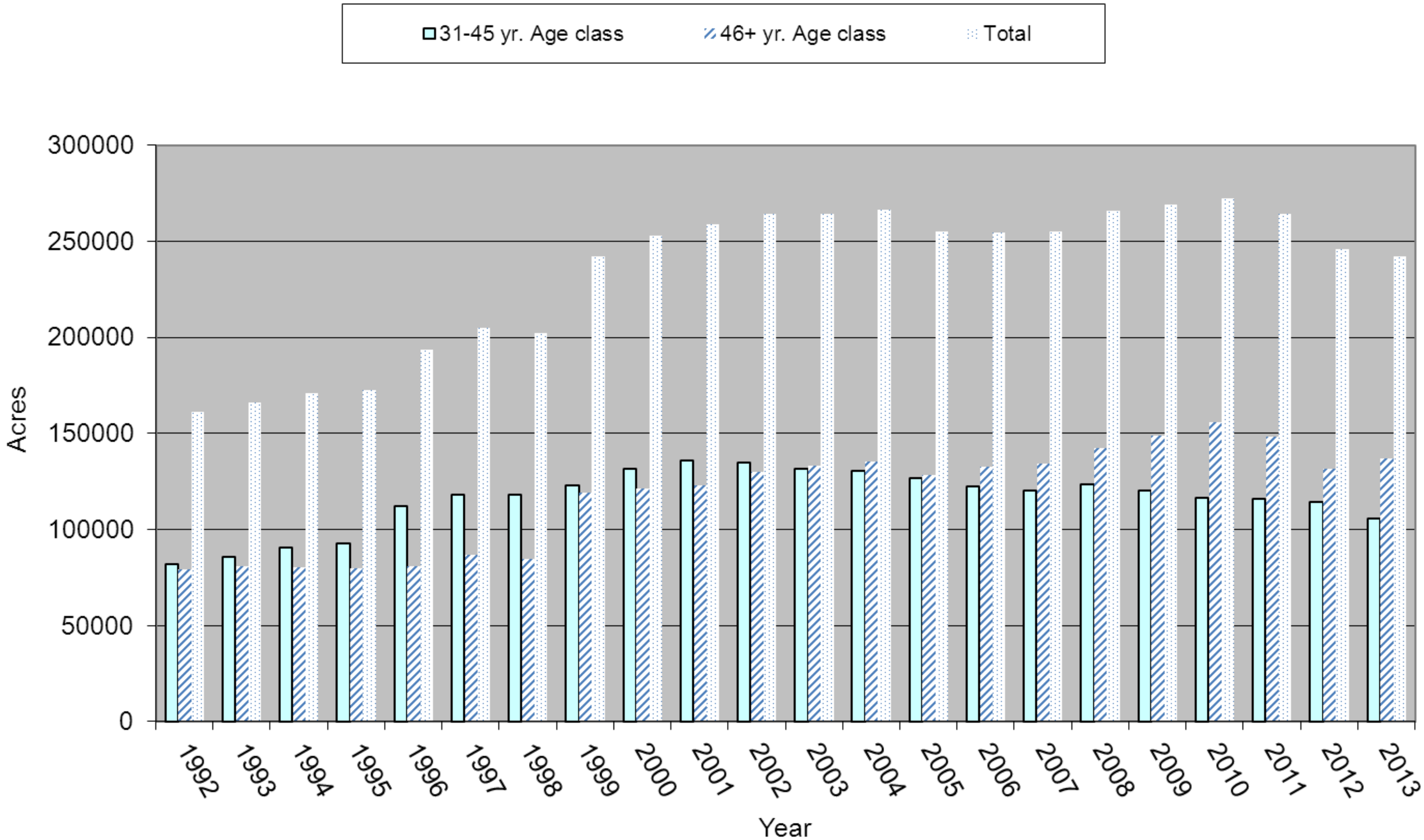


Table 6. Percent of owl habitat (stands greater than 30 years old) within 1000 ft., 0.5-mile, and 0.7- mile radius circles centered on owl sites, and percent of the total area changed (i.e. habitat removed) by timber harvest. Bold indicates sites assumed to be displaced (both direct and indirect) by timber harvest. Site names followed by an asterisk (*) are direct displacement sites. "Previous" indicates previous displacement.

	1000 feet		0.5 mile		0.7 mile	
Site	% Habitat	% Change	% Habitat	% Change	% Habitat	% Change
4230 #2	0.7	0.0	1.7	0.0	3.1	9.5
Boundary Creek (previous)	58.6	0.0	24.1	3.2	24.8	11.0
C2300 (previous)	29.8	0.0	18.2	37.1	14.7	28.7
Camp Bauer	100.0	0.0	67.7	5.3	59.5	8.3
EBF	100.0	3.4	81.8	8.6	66.6	5.6
Garrett South	100.0	11.9	85.2	8.1	84.6	4.2
Graham Creek	88.7	0.0	75.4	0.0	69.3	1.7
Guptil Gulch	56.4	0.0	50.5	0.0	38.5	0.4
Henderson Gulch	90.6	0.0	57.0	0.0	48.4	2.8
Jurin	96.3	0.0	75.3	0.0	71.3	0.6
Little River #2* (previous)	29.2	72.2	22.3	20.6	20.0	11.7
Lower Dolf Creek	82.0	7.4	61.2	11.3	53.4	11.3
Lower Dry Creek	86.9	0.0	51.3	4.4	48.3	10.7
Lower McCloud Creek	99.6	0.3	95.0	11.7	95.6	8.7
Lupton Creek #2	96.5	0.0	88.0	0.0	83.2	3.6
Mad River STS	5.0	0.0	3.7	0.0	11.6	13.6
McCloud Creek	67.5	0.0	56.4	0.0	62.0	3.0
Middle Stevens Creek* (previous)	63.0	12.7	58.1	13.1	62.4	12.3
Middle Stevens Creek* (previous)	61.1	15.9	54.0	15.8	59.7	14.0
Miller Ridge	100.0	0.0	86.4	4.2	78.1	9.3
Mule Creek* (previous)	84.6	0.0	57.8	1.8	53.2	3.4
NF1300* (previous)	29.5	0.0	18.7	27.4	20.7	12.6
Old 299 #1	98.3	12.5	68.6	7.3	67.0	12.8
Panther Creek (previous)	76.8	2.2	60.3	16.2	58.9	8.6
Quiet Lane*	78.1	52.8	27.2	23.1	19.7	16.3
R200* (previous)	57.7	54.9	24.8	25.3	27.5	15.6
R-8-1 (previous)	42.6	0.0	44.4	30.7	45.6	40.3
Salmon Creek #2* (previous)	54.0	3.1	47.6	14.7	53.4	17.1
Salmon Creek #3	90.1	0.0	73.4	4.1	65.5	15.2
Salmon Creek #3	94.1	0.0	74.0	5.3	65.2	16.0
Salmon Creek #4	90.4	4.0	70.3	4.7	74.5	4.9
Salmon Creek #4	69.0	0.0	80.3	4.1	77.8	2.4
Salmon Creek #5	98.8	0.0	75.5	8.1	64.7	14.7
Salmon Creek #5	61.4	33.1	63.4	24.7	62.6	21.5
Stevens Creek East	85.7	0.0	78.3	0.0	79.3	2.8
Stone Lagoon	96.3	15.5	86.3	4.9	81.5	2.6
Sunny Slope	22.3	10.0	40.1	7.6	37.6	4.1

Site	1000 feet % Habitat	1000 feet % Change	0.5 mile % Habitat	0.5 mile % Change	0.7 mile % Habitat	0.7 mile % Change
Upper Beach Creek* (previous)	54.0	5.5	43.9	42.8	38.9	33.2
Upper Bear Gulch	12.4	0.0	22.5	17.4	30.9	18.7
Upper Black Dog Creek	99.1	1.4	77.7	8.9	68.8	5.2
Upper Roach Creek	78.2	28.9	80.7	4.8	77.8	2.5
Upper Stevens Creek* (previous)	72.8	8.3	71.9	17.0	67.1	15.1
Upper Toss-Off	99.9	0.0	97.3	0.0	90.1	0.2
W302	82.4	0.0	82.5	0.0	78.5	1.0
Winchuck River	72.7	0.0	49.0	0.0	47.0	2.6
Windy Point*	95.1	19.4	52.8	10.1	57.8	11.5

D. Discussion

During development of the HCP, harvest and growth modeling predicted that the amount of owl habitat would increase through the term of the HCP permit. The results of the habitat analysis for this annual report showed an overall increase in the total amount of owl habitat since 1992, indicating that growth of timber stands into owl habitat exceeded timber harvest. The decrease in owl habitat from the 2010 reporting period is likely the result of the land disposal discussed in the current reporting period. The periodic acquisitions and disposals that have occurred over the course of the HCP to date provide a net increase in the amount of owl habitat that is in Green Diamond ownership. Typically, these exchanges have been relatively small acreages, but one large acquisition occurred in 1998 (~70,000 acres, Figure 1), one large disposal (~16,000 acres) occurred during the 2005 reporting period, one relatively large disposal (~13,000 acres) occurred during the 2011 reporting period, one relatively large disposal (~13,366 acres) occurred during the 2012 reporting period, and one relatively large disposal occurred (~9,000) during the current reporting period. There were two recent transactions (2009, 2010) with Western Rivers Conservancy that accounted for approximately 10,148 acres. As discussed in previous reports, the number of permitted displacements did not increase with the net increase in land area, which should reduce potential negative effects on the regional owl population since the permitted number of displacements is spread over a larger area. In addition, the density study area was increased in size in 2004 to reflect these changes. This provides a larger area for inclusion in the study and subsequently a larger area for which to make inferences about the owl population and the habitat.

V. Displacement

Although Green Diamond's incidental take permit covers all take of spotted owls incidental to timber harvest operations, the primary form of incidental take anticipated in the HCP is the displacement of owls due to modification of owl habitat. It was recognized that such displacement could impair essential behavioral patterns and result in actual death or injury to owls. Rather than examining the circumstances of each case to determine whether a take as defined in the ESA had in fact resulted from Green Diamond's habitat modification, the implementation agreement calls for reporting as a "displacement" any instance where an owl site itself is harvested or habitat around an owl site is reduced below thresholds established in the HCP. This approach provides for an ongoing evaluation of the actual suitability of owl habitat where displacements are reported as a result of Green Diamond's timber harvesting. The results of this ongoing evaluation could be used in some cases to reduce the total number of displacements reported previously by Green Diamond.

The total number of displacements reported under this system is significant because: 1) it provides guidance on Green Diamond's compliance with the formal permit limit on incidental taking (50 owl pairs during the ten-year permit term) and, 2) it would have triggered a five-year plan review if more than 33 displacements had been reported within the first five years of the permit period.

During the 1995 reporting period, Green Diamond and the Service agreed upon a system for displacement accounting. With this system, owl sites where harvesting occurred would be: 1) reported and added to the displacement total when timber harvest triggers the criteria for direct or indirect displacement, 2) evaluated subsequently to the harvest that triggered the report of displacement and 3) removed from the displacement total if the site met specified post-harvest criteria for owl occupancy and reproduction. The criteria for removing sites from the displacement tally were presented to the Service in the 1996 annual report and are described below in "Removal of displacements".

A. Definitions

Green Diamond and the Service agreed upon the following definitions to use when determining displacement.

Owl site: the area within a five hundred-foot radius of the activity center for a single owl or activity center/nest site of a pair of owls. Temporary roosts of floater owls do not constitute owl sites. Pair status is determined by 1992 USFWS guidelines, except that single status must be determined from at least three site visits.

Perennial owl site: an owl site that has been established for at least two consecutive field seasons.

Newly colonized owl site: a new owl site found in an area that was surveyed in a previous field season and unoccupied by owls.

Newly discovered owl site: a new owl site found in an area not surveyed for owls in a previous field season.

Nest site: a tree in which a pair of spotted owls has nested.

Activity center: When a nest site is not known, the activity center is the location (point in space) most frequently used as a daytime roost during the breeding season. A minimum of three successful daytime follow-ups is usually needed to establish an activity center. Establishing the central location of an activity center is primarily a biologist's judgment call based on evidence found and evaluated in the field. It may be a primary roost site identified by the consistent presence of owls or whitewash and pellets, or the geometric center of several roosts where owls or owl sign had been detected. In the latter case, the activity center must be located in suitable habitat. Activity centers may be established based on nighttime responses if they are consistently heard in the same area.

Owl home range: areas predominantly used by territorial owls. Home ranges will be determined using the known locations of individual owls, the spatial distribution of all owls in the area of concern, and major topographic features.

Floater owl(s): owl found sporadically in an area, but not showing site fidelity so that an activity center could not be established by the criteria listed under "designation of activity centers for new responses" (floaters are defined by the inability to meet the criteria for an activity center).

Direct displacement: Harvesting within an owl site; such harvesting is assumed to cause a displacement of owls and therefore triggers a report as such, whether or not the location of the owl site actually changes. In most cases, a direct displacement of a single owl occupying a site is considered to be the same as a direct displacement of an owl pair. The accounting of direct displacement for sites perennially occupied by single spotted owls is addressed by including site occupancy (by a single or pair of owls) in the criteria for removal of displacements.

Indirect displacement: Harvesting that reduces habitat within 1/2 mile of a nest site or activity center (center of owl site) below the following thresholds within a 0.5-mile radius (502-acre) circle around the owl site:

- 89 acres of stands 46 years old and older, and

- 233 acres of stands 31 years and older.

Such harvesting is assumed to cause an indirect displacement and therefore triggers the reporting of a site as such, whether or not the location of the owl site actually changes. As discussed for direct displacement an indirect displacement of a single owl occupying a site is considered to be the same as an indirect displacement of an owl pair.

Permanence of owl sites: Only the most current owl site within a home range is considered for evaluation of displacement. The current owl site shall be defined based upon the most recent nest site found in the last three years. If spotted owls have not nested in an established home range in the past three years, the most recent activity center shall be used to define the current owl site.

If no owls are detected in a home range after conducting HCP surveys in a given year the following scenarios apply.

1) If in the previous year the owl site was either a) newly colonized by a pair that nested, b) perennial, or c) newly discovered, the owl site shall be maintained for three subsequent breeding seasons. If after three breeding seasons no occupied sites are found within a home range, past owl sites within that home range will no longer be considered for potential displacement .

2) The presence of barred owls within spotted owl territories has the potential to reduce detection probabilities of spotted owls. If barred owls occupy a spotted owl territory described in 1) a-c above, and the spotted owls have not been detected for at least three breeding seasons, Green Diamond will seek technical assistance from the Service to determine the time period and survey effort necessary to preclude the site from consideration for potential displacement. Green Diamond may exercise use of a displacement at such sites within the three-year abandonment period.

3) If the owl site was established the previous year as a newly colonized site where owls did not nest, that owl site shall be maintained for one breeding season. If the site is found to be unoccupied by owls in the following breeding season, then that site will no longer be considered an owl site.

Designation of activity centers for new responses: For owl responses detected during the breeding season in areas where an owl site has not been previously designated, an activity center will be designated if either:

- a pair is detected at least two times in the same area for at least one month
- a single is detected in the same area for at least two months
- or the response was not followed-up adequately using the standards described below

The responses will not lead to the designation of an activity center if:

- three adequate, HCP-protocol site visits at least five days apart all result in no owls being found within 30 (pair) or 60 (single owl) days of the initial response. If the initial response occurs in March, then at least one of the three site visits shall be done in April.

Late breeding season responses: Responses of owls in August in areas where no previous responses by owls were detected earlier in the breeding season of the same year will not be used to determine an owl site when the required number or survey visits and follow-ups can not be completed. In addition, the area will not be cleared for timber harvest until after surveys are conducted in the subsequent breeding season. If the required number of night surveys and follow-up visits are conducted before the end of the breeding season and the results are negative, the area will be cleared for harvest.

Special displacement circumstances: A direct displacement will not be reported if owls establish an owl site during the breeding season within 500 feet of an area where timber falling has already been completed. If owls establish an activity center during the breeding season within 500 feet of an active THP unit where timber falling has not been completed, timber harvest will be suspended until the appropriate HCP measures (sections III.A.1.(a) (3) and III.A.1.(a) (4) of the Implementation Agreement) have been taken to determine reproductive status and protect nesting owls. If harvesting is not suspended until this occurs, a direct displacement will be reported.

If Green Diamond resumes timber harvesting after complying with the HCP measures, the following shall apply: 1) if less than 10 acres remain to be felled, a direct displacement will not be reported and 2) if more than 10 acres remain, Green Diamond will consult with the Service to determine whether a displacement will be reported.

Indirect displacements are assessed and reported based on the location of all known owl sites at the time that falling is initiated. Any subsequent movement of owl sites during the falling and harvesting period are not assessed for potential indirect displacement. If any other situation arises in which the determination of whether to report a displacement is questionable, the Service will be consulted to resolve the determination.

Removal of displacements: Each displacement is originally reported on the basis of harvest activity in relation to an owl site within a particular home range -- harvesting within an owl site (direct displacement) or harvesting the area within one half mile of an owl site to below-threshold levels (indirect displacement). Displacement associated with a particular owl site in a home range can occur only once, but individual owls can be displaced more than once if they occupy successive owl sites in different home ranges where harvesting triggers a report of displacement.

Removing previously reported displacements from the cumulative total will be based on the post-harvest performance of owls within the home range where harvesting triggered the original report of displacement. The proposed performance criteria are based upon occupancy and/or reproduction of any owls at a site; i.e., different owls occupying a site will be judged as if the same individual owls continuously occupied and reproduced at the site. Including occupancy in the criteria allows sites perennially occupied by single owls to be evaluated for removal from the displacement total. Owl performance within a home range where a displacement has been reported may be evaluated in a subsequent annual report to determine whether the displacement will be removed. This evaluation can occur beginning at the third and ending at the fifth breeding season following a displacement. The criteria for removing displacements from the total are as follows.

Displacement removed in third breeding season following trigger of displacement if:

- owls nest in at least 2 years **or**
- owls nest in one year with 3 years occupancy (including occupancy by single owls)

Displacement removed in fourth breeding season following trigger of displacement if:

- owls nest in at least 2 years **or**
- owl(s) occupy the site for four years

Displacement removed in fifth breeding season following trigger of displacement if:

- owl(s) occupy site four out of five years

If cumulative harvest occurs in a home range, the displacement removal assessment will occur between the third and fifth breeding seasons after the last THP harvest associated within the home range that triggered the report of displacement. If the owl site shifts to a new location where harvest occurs within 1/2 mile but does not cause displacement, the last year in which harvesting triggered a report of displacement will be the starting point for evaluation of displacement removal within the five-year period. If five breeding seasons have passed since the displacement was triggered and the owls still have not met the displacement removal criteria, the original displacement will not be removed from the total.

B. Methods

Owl sites as defined above were used to determine whether displacement would be reported. If a plan was considered to cause a report of direct or indirect displacement, the report was triggered when the plan was initiated, i.e. when the first tree in a THP unit was felled. This pertained to plans that were contiguous or comprised of units spaced closely together. If a plan was comprised of several units spaced widely apart, harvest progress was evaluated to determine when the displacement would be reported. As indicated in the 1994 annual report, the Service agreed that timber harvest activities may continue in displacement plans during the owl breeding season as long as a nest was not found. If a nest was found, the site was protected by measures described in section II.A.1

1. Displacement

The reporting of a direct displacement was triggered when timber was harvested within a 500-foot radius of an owl site. All owls occupying sites where harvesting triggered a report of direct displacement were monitored to determine their response to the harvest. Contractors were informed that owls were in the area and any owl behavior observed during falling operations was noted. Post harvest owl surveys were also conducted as conditions allowed. If possible, the owls associated with direct displacement THPs were located before slash burning was conducted.

Each THP initiated within the reporting period that had an owl site within 0.5 miles of the plan was evaluated for indirect displacement by using the process described in section IV.B.2. This involved estimating the amount of habitat within the 0.5-mile radius circle around each owl site using Green Diamond's GIS and aerial photographs. If the entire 500-acre circle was not on Green Diamond land, aerial photographs were used to determine the age class or habitat category of areas outside of the ownership, because Green Diamond's GIS does not include data from other ownerships.

2. Displacement evaluation

The status of owls at sites displaced in previous years was assessed by noting the 2013 location and behavior of the owls. All owl sites for which a report of displacement was triggered before March 1, 2011 were evaluated to determine if the displacement could potentially be removed.

3. Projected displacement

a. Outcome of 2013 projected displacements

The number and type of displacements projected in the last reporting period were compared to the numbers actually displaced in this reporting period.

b. Projected 2014 displacements

The results of the owl surveys (section II.B.1.) in conjunction with planned THP locations were used to estimate the type and location of displacements for the next reporting period.

C. Results

1. Displacement of Owl Sites

Harvest initiated in the reporting period resulted in reports of two direct displacements and two indirect displacements (Table 7). Thirty-one sites that had potential for direct or indirect displacement were evaluated during the reporting period (Table 8).

In 1996, pursuant to the original implementation agreement, Green Diamond and the Service agreed on a process of removing reported displacements from the total tally (see above), and this process has resulted in a total of 33 displacements removed from the total. No previous displacements were removed during this reporting period.

Table 7. Summary of spotted owl sites displaced since implementation of the HCP, including displacements reported for the current reporting period (2012). Bold indicates direct displacement and underline indicates displacement removals..

Year									
1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Pelletreau	**<u>Boundary Cr.</u>**	**R200**	**<u>B-10</u>**	**Omagar Cr.**	**R1400**	A400	**Bear Gulch**	**<u>G400</u>**	R-13
<u>5700</u>	C2300	<u>Quarry Cr.</u>	**H110**	**<u>Cappell Cr.</u>**	T300	**6400**	Boundary Creek	<u>Henderson Gulch</u>	**M-Line Cr.**
Dolf Cr.	**B140**	W400	**Miñon Cr.**	**S-12**	**<u>Salmon Cr. #2</u>**	**<u>Klamath Mill</u>**	**Cuddeback South**	**<u>Lower Dolf Cr.</u>**	Little River #2
<u>Liscom Hill</u>	**P200**	<u>Johnson Cr.</u>	D100	**<u>Morek Cr.</u>**	<u>Old 299 #2</u>	**<u>Salmon Cr East</u>**	Little River #1	**Lower S.F. #1**	**<u>HWY 101</u>**
H510	**<u>Tectah Mouth</u>**			<u>Dolly Varden</u>	Fielder Cr.	Upper S.F. #2	Upper Little River	**NF1300**	**<u>Jackson Hill</u>**
<u>Buzzard Cr.</u>	<u>W100</u>			<u>Lower Dry Cr</u>.			Upper S. F. #1	<u>Ryan Creek</u>	**Lower S.F. #2**
H300				**<u>Lake Mountain</u>**			**<u>Walsh</u>**		**<u>Mule Creek</u>**
				<u>4230#1</u>					**<u>Quarry Creek</u>**
				<u>Powerline North</u>					
				<u>NF1300</u>					
				Ayres Cabin					
Cumulative Total Displacements									
7	13	17	21	32	37	42	49	55	63
Cumulative Displacement Removals									
			2	4	6	8	13	17	20
Cumulative Net Displacements									
			19	28	31	34	36	38	43

Displacements occurred from 1 Sept. of the previous year through 1 Sept. of the indicated year.

Table 7. Summary of spotted owl sites displaced since implementation of the HCP, including displacements reported for the current reporting period (2013). Bold indicates direct displacement and underline indicates displacement removals..

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
R-8-1	**Upper Beach Cr.**	**Upper Stevens Creek**	**R-15**	**Mynot School**	Puter Creek	**Upper Maple BL**	Salmon Creek #2	**Middle Stevens**	Panther Creek	**Quiet Lane**
	Salmon Cr. East	**M1150**		**Middle Salmon Creek**	**Panther Creek**					Sunny Slope
	Klamath Mill				HWY 101					**Windy point**
	B900[1]									Upper Bear Gulch
Cumulative Total Displacements										
64	68	70	71	73	76	77	78	79	80	84
Cumulative Displacement Removals										
20	23	25	26	28	30	30	32	33	33	33
Cumulative Net Displacements										
44	45	45	45	45	46	47	46	46	47	51

Displacements occurred from 1 Sept. of the previous year through 1 Sept. of the indicated year.

[1] The B900 site was considered a displacement during the 2004 reporting year due to an herbicide injection treatment for hardwood trees within 500 feet of a historical nest site.

Table 8. Acres of age and habitat classes within 0.5-mile radius circles (502 acres) centered on owl sites potentially impacted by timber harvest. Bold indicates displacement sites. Asterisk indicates direct displacement and “previous” indicates displacement triggered in a previous reporting period and often at a different activity center.

Site	Owl site year	Non forest or 0-7 yrs. (acres)	8-30 yrs. (acres)	31-45 yrs. (acres)	46+ yrs. (acres)	Total acres owl habitat (31+)
Boundary Creek (previous)	2013	25.6	356.0	0.0	117.1	117.1
C2300 (previous)	2013	85.7	325.3	0.0	57.6	57.6
Camp Bauer	2013	43.2	119.2	0.0	322.0	322.0
EBF	2011	36.6	54.5	190.9	185.4	376.4
Garret South	2013	36.8	37.4	299.9	93.8	393.7
Little River #2* (previous)	2010	101.3	289.1	0.0	89.1	89.1
Lower Dolf Creek	2013	12.3	182.9	34.0	238.7	272.7
Lower Dry Creek	2012	35.5	208.3	0.0	247.5	247.5
Lower McCloud Creek	2013	25.0	0.0	0.0	421.6	421.6
McCloud Creek	2011	153.1	285.5	26.4	540.4	566.5
Middle Stevens Creek* (previous)	2012	117.8	92.8	18.3	235.5	253.8
Middle Stevens Creek* (previous)	2013	130.9	100.2	15.6	213.0	228.5
Miller Ridge	2013	68.1	0.0	220.2	196.2	416.4
Mule Creek* (previous)	2012	45.3	166.3	11.3	274.5	285.8
NF1300* (previous)	2013	64.2	343.7	0.0	68.9	68.9
Old 299 #1	2013	51.2	106.7	31.5	288.0	319.5

Table 8. Acres of age and habitat classes within 0.5-mile radius circles (502 acres) centered on owl sites potentially impacted by timber harvest. Bold indicates displacement sites. Asterisk indicates direct displacement and "previous" indicates displacement triggered in a previous reporting period and often at a different activity center.

Site	Owl site year	Non forest or 0-7 yrs. (acres)	8-30 yrs. (acres)	31-45 yrs. (acres)	46+ yrs. (acres)	Total acres owl habitat (31+)
Panther Creek	2013	128.2	70.6	126.1	128.6	254.7
Quiet Lane*	2011	171.8	194.2	21.6	83.5	105.1
R200* (previous)	2013	64.5	313.3	0.0	93.2	93.2
R-8-1* (previous)	2013	40.2	239.2	74.3	80.4	154.7
Salmon Creek #2* (previous)	2012	99.9	163.5	0.7	203.4	204.1
Salmon Creek #3	2012	43.3	90.5	0.3	353.6	353.9
Salmon Creek #3	2013	39.2	91.0	0.0	352.8	352.8
Salmon Creek #4	2011	112.0	36.9	169.9	167.1	337.1
Salmon Creek #4	2013	75.9	23.0	208.2	179.0	387.3
Salmon Creek #5	2012	46.3	76.6	0.1	349.0	349.1
Salmon Creek #5	2013	70.6	113.3	0.0	239.9	239.9
Stone Lagoon	2011	7.4	61.1	0.0	413.0	413.0
Sunny Slope	2013	98.0	202.9	71.1	115.3	186.4
Upper Beach Creek* (previous)	2013	92.7	184.7	10.6	120.1	130.8
Upper Bear Gulch	2013	20.5	369.0	59.0	34.4	93.4

Table 8. Acres of age and habitat classes within 0.5-mile radius circles (502 acres) centered on owl sites potentially impacted by timber harvest. Bold indicates displacement sites. Asterisk indicates direct displacement and "previous" indicates displacement triggered in a previous reporting period and often at a different activity center.

Site	Owl site year	Non forest or 0-7 yrs. (acres)	8-30 yrs. (acres)	31-45 yrs. (acres)	46+ yrs. (acres)	Total acres owl habitat (31+)
Upper Black Dog Creek	2013	24.7	86.9	0.0	356.5	356.0
Upper Roach Creek	2013	29.9	66.5	35.8	351.1	386.8
Upper Stevens Creek	2013	121.3	20.0	8.4	291.5	299.9
Windy Point*	2012	133.6	102.0	0.0	240.1	240.1

2. Activity at Displaced Owl Sites

a. Quiet Lane

This site was associated with GDRCo THP #081001 (CDF #1-10-054HUM). The following is a summary of the birds' known activity within the reporting period.

Date	Activity/Response
7/28/2013	Falling initiated causing direct displacement
4/24/2013	Site visit with no response
4/24/2013	THP survey pair response
5/16/2013	Site visit with male found not nesting
6/14/2013	Site visit pair found not reproductive
7/17/2013	Site visit no response
7/18/2013	Site visit pair found not reproductive
7/19/2013	Site visit pair found not reproductive

b. Sunny Slope

This site was associated with GDRCo THP #081001 (CDF #1-10-054HUM). The following is a summary of the birds' known activity within the reporting period.

Date	Activity/Response
8/6/2013	Falling initiated causing indirect displacement
4/15/2013	Site visit pair response
4/24/2013	Site visit with no response
5/16/2013	Site visit with male found not nesting
5/22/2013	Site visit female response
5/30/2013	THP survey no response
6/14/2013	Site visit male response
6/17/2013	Site visit no response
7/19/2013	Site visit no response
7/10/2013	Site visit male response
7/17/2013	THP survey pair response
7/19/2013	Site visit male found not reproductive
7/26/2013	Site visit pair response

c. Windy Point

This site was associated with GDRCo THP #471019 (CDF #1-10-101HUM). The following is a summary of the birds' known activity within the reporting period.

Date	Activity/Response
11/15/2012	Falling initiated causing direct displacement
3/27/2013	Site visit female resighted

4/01/2013	THP survey unknown NSO response
4/02/2013	Site visit with no response
4/08/2013	Site visit unknown NSO response
4/16/2013	Site visit male found not nesting
5/17/2013	Site visit no response
5/23/2013	Site visit male found not reproductive
6/21/2013	Site visit no response
8/13/2013	Site visit no response
8/20/2013	Site visit no response

d. Upper Bear Gulch

This site was associated with GDRCo THP #190802 (CDF #1-08-155HUM). The following is a summary of the birds' known activity within the reporting period.

Date	Activity/Response
6/25/2013	Falling initiated causing indirect displacement
4/08/2013	THP survey male response
4/10/2013	Follow-up with no response
4/15/2013	Follow-up with no response
4/18/2013	Follow-up with no response
4/25/2013	Follow-up with no response
5/01/2013	THP survey with male response
5/06/2013	Follow-up male response
5/06/2013	THP survey pair response
5/12/2013	Follow-up pair response
5/24/2013	Follow-up no response
6/03/2013	Follow-up no response
6/03/2013	THP survey barred owl response
6/04/2013	Follow-up no response
6/04/2013	THP survey no response
6/05/2013	Follow-up barred owl response
6/18/2013	Follow-up no response
6/18/2013	THP survey no response
7/04/2013	Follow-up no response
7/10/2013	Follow-up no response

3. Displacement evaluation/accounting

a. Potential displacement circumstances

A provision in Green Diamond's Implementation Agreement for the HCP specifies that if an area is harvested without being surveyed for owls, a displacement must be reported. During this reporting period, there were no known instances where this provision might be applied.

b. Removal evaluation

Ten sites were available to evaluate for removal of reported displacements, because at least three breeding seasons had passed subsequent to harvest triggering displacement. Table 9 summarizes the occupancy and nesting status of displacement sites in breeding seasons subsequent to those in which the report of displacement was triggered. Based on the evaluation below, no sites that were previously reported as a displacement were removed from the displacement total during the 2013 reporting period.

Table 9. Spotted owl habitat (≥31 years of age), occupancy, and reproductive status at displaced sites. Bold indicates direct displacement and shading indicates removal from displacement total.

Site	Activity center year evaluate for displacement	Habitat within ½ mile	Status prior to displacement	Status 1 year after	Status 2 years after	Status 3 years after	Status 4 years after	Status 5 years after	Status 6 years after	Status 7 years after	Status 8 years after	Status 9 years after	Status 10 years after	Status 11 years after
Little River #2	2002	89.1	non-nesting pair	non-nesting pair	non-nesting pair, +harvest	non-nesting pair, +harvest	single female, +harvest	nesting pair	non-nesting pair, +harvest	non-nesting pair	nesting pair	single male, +harvest	Non-nesting pair, +harvest	UO, +harvest
Lower S.F. #2	2002	179.7	single male	UO	single female, unconf.	single male, +harvest	non-nesting pair, +harvest	single male, +harvest	UO, +harvest	single male, unconf.	non-nesting pair	single female, unconf., +harvest	UO, +harvest	UO
R-8-1	2003	154.7	pair newly colonized	nesting pair, +harvest	nesting pair, +harvest	single male, unconf.	UO+ harvest,	UO	AB	AB	single male, recolonized	Non-nesting pair	Non-nesting pair, +harvest	
Upper Beach Cr	2004	130.8	pair, unconf. status	UO	UO	pair, unconf.	non-nesting pair, +harvest	nesting pair, +harvest	non-nesting pair	non-nesting pair	non-nesting pair, +harvest	Non-nesting pair, +harvest		
Salmon Cr East	2004	201.1	nesting pair	nesting pair	nesting pair, +harvest	non-nesting pair	pair, unconf.	single male, unconf.	pair, unconf.	pair, unconf.	Single male	Non-nesting pair		
Middle Salmon Cr	2006	187.4	non-nesting pair.	UO	UO	non-nesting pair	nesting pair	pair unconf.	Non-nesting pair, +harvest	Single female				
Mynot School	2006	225.4	single male	non-nesting pair	non-nesting pair	UO	single, unconf. status	non-nesting pair	UO, +harvest	UO				
HWY 101	2007	201.5	single male	UO	UO, +harvest	single, unconf. status	UO	UO	AB					
Panther Cr	2007	227.2	nesting pair	nesting pair	nesting pair	nesting pair	non-nesting pair							

Explanation of abbreviations: +harvest = additional harvest; AB = abandoned; Unconf. = Unconfirmed; UO = unoccupied

Table 9 continued. Spotted owl habitat (≥31 years of age), occupancy, and reproductive status at displaced sites. Bold indicates direct displacement and shading indicates removal from displacement total.

Site	Year upon which activity center evaluated for displacement	Acres of post-harvest owl habitat within 1/2 mile	Status before displacement	Status 1 year after displacement	Status 2 years after displacement	Status 3 years after displacement	Status 4 years after displacement	Status 5 years after displacement	Status 6 years after displacement	Status 7 years after displacement	Status 8 years after displacement
Puter Cr	2007	9.4	single male, unconfirmed	non-nesting pair, harvest	unoccupied	pair, unconfirmed status	unoccupied	unoccupied	Female, unconfirmed		
Upper Maple BL	2008	258.9	single male, unconfirmed	unoccupied, harvest	unoccupied	abandoned, harvest	abandoned	abandoned			
Salmon Cr #2	2010	204.1	nesting pair	pair unconfirmed	nesting pair, additional harvest	Non-nesting pair, additional harvest					
Middle Stevens Cr	2011	228.5	pair unconfirmed	non-nesting pair	Nesting pair, additional harvest						
Panther Creek	2012	254.7	Nesting pair	Non-nesting pair, +harvest							
Windy Point	2012	240.1	Nesting pair	Non-nesting pair, +harvest							
Quiet Lane	2013	105.1	Non-nesting pair								
Sunny Slope	2013	186.4	Non-nesting pair								
Upper Bear Gulch	2013	93.4	Pair, unconfirmed status								

c. Summary of displacement evaluations by year.

Displacement based on year 2002 owl sites

Little River #2 (indirect)
A non-nesting pair occupied this site in 2003 and 2004. Additional harvest triggering continued displacement occurred at this site in 2004 and 2005. A single female with unconfirmed status occupied this site in 2006, and additional harvest triggered continued displacement. This site was occupied by a nesting pair in 2007. A non-nesting pair occupied this site in 2008, and additional harvest triggered continued displacement. In 2009, a non-nesting pair occupied this site. A nesting pair occupied the site in 2010. A single male occupied this site in 2011, and additional harvest triggered continued displacement. A non-nesting pair occupied this site in 2012, and additional harvest triggered continued displacement. A non-nesting pair occupied this site in 2013, and additional harvest triggered continued displacement. This site does not qualify for removal from the displacement total.

Lower SF #2 (direct)
This site was unoccupied in 2003 and a single female with unconfirmed status occupied this site in 2004. A single male occupied this site in 2005 and additional harvest triggered continued displacement. A non-nesting pair occupied this site in 2006 with additional harvest causing displacement. A single male occupied this site in 2007 and additional harvest caused displacement. This site was unoccupied in 2008, and additional harvest triggered continued displacement. A single male of unconfirmed status occupied this site in 2009. A non-nesting pair occupied this site in 2010. A single female occupied this site in 2011, and additional harvest triggered continued displacement. This site was unoccupied in 2012, and additional harvest triggered continued displacement. This site was unoccupied in 2013. This site does not qualify for removal from the displacement total.

Displacement based on year 2003 owl sites

R-8-1 (indirect)
A nesting pair occupied this site in 2004 and 2005. Additional harvest occurred at this site in 2004 and 2005, triggering continued displacement. A single male with unconfirmed status occupied this site in 2006. This site was unoccupied in 2007, 2008, 2009 and 2010. A single male occupied this site in 2011, and a pair with unconfirmed reproductive status occupied this site in 2012. This site was occupied by a non-nesting pair in 2013, and additional harvest triggered continued displacement. This site does not qualify for removal from the displacement total.

Displacement based on year 2004 owl sites

Upper Beach Creek (direct)
This site was unoccupied in 2005 and 2006. A pair with unconfirmed status occupied this site in 2007. A non-nesting pair occupied the site in 2008, and additional harvest triggered continued displacement. A nesting pair occupied this site in 2009, but additional harvest occurred at the site. A non-nesting pair occupied this site from 2010 through 2012, and additional harvest triggered continued displacement in 2012. This site was occupied by a non-nesting pair in 2013 and additional harvest triggered continued displacement. This site does not qualify for removal from the displacement total.

Salmon Creek East (direct)
This site was occupied by a nesting pair in 2005 and 2006. In 2006, additional harvest caused continued displacement. The site was occupied by a non-nesting pair in 2007 and a pair with unconfirmed status in 2008. A single male of unconfirmed status occupied this site in 2009. An unconfirmed pair occupied this site in 2010 and 2011, and an unconfirmed single male occupied this site in 2012. This site was occupied by a non-nesting pair in 2013. This site does not qualify for removal from the displacement total.

Displacement based on year 2006 owl sites

Middle Salmon Creek (direct)
This site was occupied by a non-nesting pair in 2006. This site was unoccupied in 2007 and 2008. A pair of unconfirmed status occupied this in 2009. A nesting pair occupied this site in 2010. An unconfirmed pair occupied this site in 2011, and a non-nesting pair occupied this site in 2012. Additional harvest in 2012 triggered continued displacement. This site was occupied by a single female in 2013. It does not yet qualify for removal from the displacement total.

Mynot School (direct)
This site was occupied by a single male in 2006 and a pair with unconfirmed status in 2007. A non-nesting pair occupied the site in 2008. In 2009, this site was unoccupied. This site was occupied by a single spotted owl in 2010 and by a non-nesting pair in 2011. This site was unoccupied in 2012 and 2013. This site does not qualify for removal from the displacement total.

Displacement based on year 2007 owl sites

HWY 101 (direct)
This site was occupied by a single male in 2007 and unoccupied in 2008. The harvest that triggered displacement at this site occurred during June 2008. This site was unoccupied in 2009 through 2012. This site was classified as abandoned in 2013. This site does not qualify for removal from the displacement total.

Panther Creek (direct)
This site was occupied by a nesting pair in 2008 and harvest causing a direct displacement occurred after the nesting attempt. The site was occupied by a nesting pair in 2009 and 2010. This site was occupied by a non-nesting pair in 2011. This site qualified for removal from the displacement total in 2011.

Puter Creek (indirect)
A non-nesting pair occupied this site in 2008. In 2009, this site was unoccupied. A pair with unconfirmed nesting status occupied this site in 2010. This site was unoccupied in 2011 and 2012. This site was occupied by a single female with unconfirmed pair status in 2013. This site does not qualify for removal from the displacement total.

Displacement based on year 2008 owl sites

Upper Maple BL (direct)
This site was occupied by a single male in 2008 and unoccupied in 2009. The harvest that triggered displacement occurred during February and March of 2009. The site was unoccupied in 2010. This site was unoccupied in 2011, 2012, and 2013, and additional harvest triggered continued displacement in 2011. This abandoned site does not qualify for removal from the displacement total.

Displacement based on year 2010 owl sites

Salmon Creek #2 (indirect)
This site was occupied by a nesting pair in 2010 and a non-nesting pair in 2011. The harvest that triggered displacement occurred during August of 2010. A nesting pair occupied this site in 2012. Additional harvest triggered continued displacement in 2012. This site was occupied by a non-nesting pair in 2013, and additional harvest triggered continued displacement. This site does not yet qualify for removal from the displacement total.

Displacement based on year 2011 owl sites

Middle Stevens Creek (direct)

This site was occupied by an unconfirmed pair in 2010. The harvest that triggered displacement occurred during February and March of 2011. In 2011 the site was occupied by an unconfirmed pair and by a non-nesting pair in 2012. This site was occupied by a nesting pair in 2013, and additional harvest triggered continued displacement. This site does not yet qualify for removal from the displacement total.

Displacement based on year 2012 owl sites

Panther Creek (indirect)

Harvest in 2008 caused a direct displacement, but the site was occupied by a nesting pair in 2009 and 2010 and by a non-nesting pair in 2011. In 2011 this site was removed from the displacement total. Harvest in July 2012 initiated an indirect take. This site was occupied by a nesting pair in 2012. This site was occupied by a non-nesting pair in 2013, and additional harvest triggered continued displacement. This site does not yet qualify for removal from the displacement total.

Windy Point (Direct)

Harvest in November of 2012 initiated a direct displacement on the 2013 reporting period. This site was occupied by a nesting pair in 2012 prior to the displacement. This site was occupied by a non-nesting pair in 2013, and additional harvest triggered continued displacement. This site does not yet qualify for removal from the displacement total.

Displacement based on year 2013 owl sites

Quiet Lane (Direct)

Harvest in July of 2013 initiated a direct displacement. This site was occupied by a non-nesting pair in 2013 prior to the displacement. This site does not yet qualify for removal from the displacement total.

Sunny Slope (Indirect)

Harvest in August of 2013 initiated an indirect displacement. This site was occupied by a non-nesting pair in 2013 prior to the displacement. This site does not yet qualify for removal from the displacement total.

Upper Bear Gulch (Indirect)

Harvest in June of 2013 initiated an indirect displacement. This site was occupied by a pair with unconfirmed reproductive status in 2013 prior to the displacement. This site does not yet qualify for removal from the displacement total.

4. Projected displacement

a. Outcome of previous projected displacements

In the February 2013 report, it was estimated that four owl sites would be displaced in the current reporting period. Timber harvest was initiated at four owl sites triggering two indirect displacements and two direct displacements during this reporting period (Table 10).

b. 2014 Projected Displacements.

In December 2007, the USFWS approved the first amendment to the HCP and IA. Green Diamond is authorized incidental take of 58 pairs of owls subject to criteria in the permit and attachments during the permit term which expires in 2022. Accordingly, Green Diamond is projecting one displacement for the next reporting period (Table 11). The number of projected displacements could change as new owl sites or site locations are discovered during 2014 and priorities related to harvest are reevaluated.

5. Direct harm

No direct harm or injury to spotted owls inadvertently occurred within the purview of Green Diamond's 10(a)(1)(B) permit. However, one juvenile spotted owl died after it was banded. The death of the spotted owl was covered under Green Diamond's Federal Endangered Species Permit and the appropriate authorities were promptly notified. Results from the preliminary necropsy findings indicated that the owlet was suffering from severe myocarditis. Investigations into the cause of the inflammation are ongoing, but thus far results have been negative for West Nile Virus, Chlamydia, and anticoagulant rodenticides. It is likely the stress from the capture in addition to the owlet's preexisting condition resulted in the death of the owlet. In addition, an adult female spotted owl was recovered on an adjacent landowner's property on September 29, 2013. The female was originally banded as a subadult (S_2) by Green Diamond biologists in 1998 and resighted consistently through 2013. The female reproduced successfully in 2013. The female was 17 years old and likely died of natural causes, but a necropsy will be performed to confirm the cause of death and /or any contributing factors.

Table 10. Actual displacement status of owl sites in 2013 projected in 2012 to be displaced from Sept. 1, 2012 - Sept. 1, 2013, and type of displacement projected.

Owl site	Projected type of displacement	Actual displacement status
Freeman	Direct	No Displacement
Quiet Lane	Direct	Direct
Sunny Slope	Indirect	Indirect
Windy Point	Direct	Direct
Upper Bear Gulch	Not projected	Indirect

Table 11. Owl sites projected to be displaced from Sept. 1, 2013 - Sept. 1, 2014 and type of displacement anticipated.

Owl site	Type of displacement	Site Status
Winchuck River	Direct	Pair

D. Discussion

Analyses have suggested that site occupancy subsequent to displacement was strongly correlated with the type of displacement. Twenty-four of 33 displacement removals thus far have been direct displacements. Presumably this is the result of the total amount of post-harvest habitat within 0.5 miles in direct versus indirect displacement sites. If displacement reporting is triggered as a result of timber harvest within 500 feet of an activity center, but an adequate amount of habitat remains within the territory, the owls are more likely to persist in the area and the reported displacement may eventually be removed from the total. Green Diamond's incidental take permit allows 58 owl pairs to be taken during the 30 year term of the HCP. Although the number of reported displacements per year has been variable, the average is approximately three owl sites per year that were originally reported as displaced.

VI. Conservation Areas

The HCP established two types of special conservation areas: set asides that would not be harvested and a special management area in the Hunter and Wiggins Ranch area that would be managed for owls on a no-take basis. The methods and results of owl monitoring in the conservation areas are reported below.

Starting in 2004, approximately 16,188 acres of the special management area were initiated for disposal from Green Diamond ownership in a three-phase sale. Phase one of the sale was completed in May 2004 and phase two was completed in December 2004. Phase three was completed in 2005. As a result of this sale, the density study area was adjusted in 2004, and owl survey and demographic work was no longer conducted in this portion of the special management area. Starting in 2010, Green Diamond entered into a sale agreement of 47,000 acres (the “Sale Area”) east of the Klamath River. Within this Sale Area, there were two set asides (Starwien Ridge, and Bear Creek) and part of a third set aside (Blue Creek Cabin). With the approval of the U.S. Fish and Wildlife Service in 2010, three substitute set asides (Johnson Creek, Morek Creek, and Lower Tulley Creek) were added to replace Starwein Ridge, Bear Creek, and the eastern part of Blue Creek Cabin set asides. The substitute set asides were selected from the same geographic area (the Klamath River corridor) and were chosen based on the same criteria as the previous set asides with the additional benefit of having twenty years of demographic data to support the selection.

A. Methods

Each of the 40 set asides and the remaining 18,566-acre special management area were surveyed for owls. Site visits were conducted at known owl sites and surveys were conducted in areas where owls had not been previously detected. The number of owl sites within and adjacent to the boundaries of the set asides and special management area was quantified. The special management area and set asides were considered to be occupied by an owl site if the activity center or nest site of the owl(s) was located within the boundaries of the conservation area. A conservation area was considered to be used by an owl(s) if: 1) the activity center or nest site was outside the conservation area but the owl(s) was seen or heard within the conservation area, or 2) the proximity of the activity center or nest site and the distribution of habitat suggested that the owl(s) foraged within the conservation area. All owl activity centers were classified according to the definitions in section VII.A.1.

B. Results

1. Set asides

A total of 54 spotted owl sites were associated with the 40 set asides (Table 12). Twenty-seven sites were within the boundaries of the set asides and 27 sites were occupied by owls using the set asides based on the criteria listed above. The number of owl sites per set aside ranged from 0-4 for sites within the set asides and 0-8 for sites within or using the set asides. Ten set asides had no evidence of consistent occupancy or use by spotted owls in 2013.

Four set asides (Black Dog Creek, Fawn Prairie, McCloud Creek, and Wiregrass) were in areas initially selected as set asides because they were believed to be habitat for owls even though territorial owls were not known to occupy the area. Two of these (Black Dog Creek and McCloud Creek) have been occupied or used by territorial owls since the HCP was approved.

In 2013, the boundary of a THP unit (GDRCo# 14-1002, State I.D. # 1-10-107HUM, unit B) was marked inaccurately on the ground and resulted in the harvest of approximately 0.94 acres of the McCloud Creek set aside. The boundary of the set aside was expanded to include approximately 0.95 acres of replacement habitat of similar age and stand characteristics. Steps have been taken in the pre-harvest phase to prevent future marking errors near set aside boundaries.

2. Special management area

A total of 16 spotted owl sites were associated with the special management area (Table 13). Twelve sites were within the boundaries of the special management area, and four sites were assessed as using the area. Pairs of owls occupied 10 of the 16 sites.

Although timber harvest had occurred in the special management area prior to the approval of Green Diamond's HCP in 1992, it had not occurred in this area under the HCP until 1996. Two timber harvest plans consisting of 157.87 acres were harvested between September 1, 2012 and August 31, 2013 within the special management area. Although two owl sites were each adjacent to one of the timber harvest plans, harvest operations were not impacted due to sufficient habitat.

Table 12. List of set asides with owl occupancy (sites located within) or use (sites adjacent) based on current reporting period.

Region/set aside Name	Acreage of set aside	Owl sites in set aside	Owl sites adjacent to set aside*	Total sites
Klamath				
H131	167.1	0	1	1
Upper Tully Cr.	239.7	0	0	0

Region/set aside Name	Acreage of set aside	Owl sites in set aside	Owl sites adjacent to set aside*	Total sites
T 300	71.9	0	1	1
Williams Ridge	262.0	0	1	1
Mettah Creek	176.4	0	1	1
Blue Cr. Cabin	498.8	0	0	0
Johnson Creek	125.2	0	1	1
Morek Creek	1002.6	0	1	1
Lower Tulley Creek	376.1	0	0	0
Subtotal	2910.8	0	6	6
Korbel				
Roddiscraft Powerline	303.9	0	1	1
Mule Creek	811.9	1	0	1
Poverty Creek	405.4	1	0	1
Camp Bauer	241.2	1	0	1
Bald Mt. Creek	61.3	0	0	0
SF Bald Mt. Cr.	130.0	1	1	2
Cal Barrel	192.7	0	0	0
Old 299	172.2	1	0	1
Lupton Creek	248.5	1	0	1
Wiregrass	229.3	0	0	0
Redwood Creek	181.2	0	0	0
Fawn Prairie	242.4	0	0	0
Dolly Varden	374.5	0	0	0
Canyon Creek	193.2	1	0	1
Subtotal	3787.7	7	2	9
Mad River				
6007	193.8	1	1	2
Puter Creek	127.8	1	0	1

Region/set aside Name	Acreage of set aside	Owl sites in set aside	Owl sites adjacent to set aside*	Total sites
4230	77.1	1	1	2
4076	294.7	3	2	5
5700	76.3	1	0	1
Black Dog Creek	167.7	0	2	2
Devil's Creek	113.3	0	1	1
4850	876.4	2	3	5
Noname Creek	747.6	2	0	2
Subtotal	2674.7	11	10	21
Upper Mad River				
Boulder Cr	2002.5	4	4	8
Humbug Creek	168.4	1	0	1
Bug Creek	371.7	0	0	0
Little Deer Creek	681.2	1	0	1
Subtotal	3223.8	6	4	10
South				
Salmon Creek	218.1	1	1	2
EBF	111.7	1	1	2
Walsh	140.7	1	1	2
McCloud Creek	175.0	0	2	2
Subtotal	645.5	3	5	8
Total (n=40)	12021.2	27	27	54

* Activity center of owls not in the set aside, but based on their proximity and habitat, the owls are likely to be using the set aside for foraging and occasionally roosting.

Table 13. Summary of owl occupancy (sites within) and use (sites adjacent) of the special management area during the current reporting period.

	Sites in Special Management Area (n)	Sites using Special Management Area (n)	Total
Paired	7	3	10
Single	5	1	6
Total	12	4	16

3. Barred owls

Barred owls were associated with14 (35.0%) of the 40 set asides (Table 14). Barred owls were located within the boundaries of nine set asides and five set asides were occupied by barred owls using the set asides based on the criteria listed above. The number of set asides per region ranged from 0-4 for set asides with barred owl occupancy and 0-4 for set asides with barred owl use. One of the 40 set asides (Fawn Prairie) has had no spotted owl or barred owl occupancy or use since the HCP was approved.

Table 14. Number of set asides with barred owl occupancy (sites located within) or use (sites adjacent) based on current reporting period.

Region	Set Asides with barred owl occupancy	Set asides with barred owl use*	Total Set asides
Klamath	3	3	6
Korbel	4	1	5
Mad River	0	1	1
Upper Mad River	1	0	1
South	1	0	1
Total	9	5	14

* Activity center of barred owls not in the set aside, but based on their proximity and habitat, the owls are likely to be using the set aside for foraging and occasionally roosting.

C. Discussion

One of the set asides (Fawn Prairie) that has had no owl occupancy or use since the HCP was approved, continued to have no evidence of use by territorial owls. This area was selected as a set aside because of its location and apparent suitable habitat for spotted owls. Based on owl responses in this area, it is likely that non-territorial owls (dispersers or floaters) occasionally use this set-aside. However, it may lack some critical element to facilitate territorial occupancy. This area will continue to be carefully monitored to assess its future conservation value.

VII. Spotted Owl Studies

Green Diamond's spotted owl studies from 1989 through 1991, which included a two-year graduate study of the owls' habitat, provided a firm biological basis for the conservation strategy of the HCP. The demographic portion of these studies, which were continued in 2013, addressed population density, reproductive success, site occupancy, population turnover rates, and other demographic information pertaining to the owls.

The objectives of Green Diamond's continuing owl studies are to monitor the efficacy of the HCP through:

- Estimating distribution and population density of northern spotted owls through direct counts of banded birds in large tracts of managed young-growth forests in northern California.

- Estimating demographic parameters (reproductive success, survival rates, site occupancy, and turnover rates) to determine viability of this population.

- Assessing the long-term dynamic relationship between owl distribution, habitat loss through timber harvest, and habitat gain through forest growth.

- Assess the potential impact on spotted owl viability from barred owls, West Nile Virus or other new threats

A. Materials and Methods

1. Site occupancy/ status

Surveys for spotted owls were conducted by spot calling. The sites were classified as follows:

Occupied - history of responses in a consistent location (daytime and/or nighttime) or daytime visits successful with roost locations or nest site established based on protocol.

Possible - multiple new nighttime responses in a general area, but not in a consistent location; daytime follow-ups not attempted or not successful.

We checked owl sites located in 2012 for occupancy in 2013. A site was considered occupied in 2013 if owls were detected at the same roost and/or nest site from previous years. A site was considered unoccupied in 2013 if it previously was a confirmed site, but not occupied for the first time in 2013. If a site was occupied early in the 2013 season, but apparently unoccupied later in the season, it was considered occupied in 2013. Such a site will not be considered unoccupied unless it is still unoccupied in 2014.

We categorized new sites in 2013 according to their survey history. A site was designated as a “newly discovered” site if it had been found in 2013 in an area that had not been surveyed or had inadequate survey coverage prior to 2013. A site was classified as a “newly colonized” site if it had been found in 2013 in an area that had been adequately surveyed prior to 2013, but no owls had been previously detected in the area. A site was classified as recolonized if it had been occupied in one or more previous years, unoccupied for one or more years prior to 2013 and then occupied again in 2013.

2. Spotted owl banding

When we located unbanded owls or owls banded with cohort auxiliary leg bands (owls banded as juveniles with a color band identifying the year in which they were banded) in follow-up visits, we used bait mice or artificial lures to attract the owls within range of capture. All age classes of spotted owls were primarily captured using a snare pole. Once we captured an owl, we placed a USFWS band on one of its legs and an auxiliary colored leg band on the other. The following measurements were usually taken in earlier years of the study: wing cord, body mass, length of tarsus, length of footpad, and tail length. If conditions permitted, toe, claw, bill length and bill depth also were measured. The age class of the owl was recorded. Subadults (one or two year old owls) were distinguished from adults (greater than two years old) by having pointed retrices. One-year-old (S1) and two year old (S2) subadults were distinguished using the methods of Moen et al. (1991). We also checked the owls for molt, previous or current injuries, parasites, and presence of brood patches for females. We released the owls immediately after they were banded and measured.

3. Turnover

Adult and subadult owls banded or resighted in one year were used to determine turnover rates in the subsequent year. We considered owls to be "missing" if they were banded or resighted at least once during one season, but not resighted the next year. If an owl disappeared in the same season in which it was earlier banded or resighted, it was reported as missing the next season if its whereabouts were still unknown. Owls that were present at a site but could not be positively resighted were excluded from the analysis. New recruits were defined as owls that became territorial for the first time.

4. Reproductive success

We designated pair status by observing a male and female in close proximity (less than 1/4 mile) in any of the following contexts: roosting, vocalizing, nesting, delivering prey, or tending young. An owl was judged to be single if the same owl was observed on three or more occasions in the same general area without detecting an owl of the opposite gender.

We judged pairs to be nesting if the female was observed incubating eggs or brooding young between April 1 and May 31. In some instances, incubation was determined in late March but a second visit was generally conducted prior to May 31 to confirm nesting. We determined reproductive success of nesting owl pairs that were monitored to protocol from June 1- August 31. Pairs were considered to have successfully nested if at least one owlet was observed to have fledged. In special circumstances, the location and stage of development of an owlet found dead were evaluated to determine whether the owlet had fledged.

5. Juvenile dispersal

Owls banded as juveniles were assigned to the appropriate age class when they were recaptured. We used locations of spotted owls banded as juveniles (both within and outside the Green Diamond study area) and recaptured as adults or subadults to measure juvenile dispersal distances. Distances were determined for juveniles: 1) dispersing within Green Diamond's study area and 2) dispersing from Green Diamond's study area to another area or dispersing from another area to Green Diamond. Other study areas included the Willow Creek Study Area, Hoopa Reservation, Humboldt Redwood Company, Redwood National Park and regional studies in Oregon.

6. Owl density

Large areas (typically greater than 50,000 acres) completely surveyed for spotted owls and owl locations were mapped on a GIS database. GIS programs determined the acreage of thoroughly surveyed areas that included a northern and a southern study area. Once the owl sites were plotted, the number of sites in the surveyed areas was determined. The sites were classified into those occupied by paired or single owls. It was assumed that a single owl occupied the site 1) if it was confirmed that a single bird was at the site, or 2) if the pair status of the site was unknown. The total number of territorial owls associated with the sites in completely surveyed areas was used to calculate overall owl density and density of owls in the northern and southern areas. The density study area on and adjacent to Green Diamond ownership is shown in Figure 2.

7. Demography

Green Diamond Resource Company has been conducting a demography study on Northern Spotted Owls since 1990 to monitor trends in the owl's population within Green Diamond's ownership. In January 2009, Green Diamond biologists attended a workshop convened in Corvallis, Oregon to analyze demographic data on Northern Spotted Owls. The workshop was attended by biologists from 11 study areas throughout Washington, Oregon and California along with a large contingent of biometricians and statisticians from several academic and research institutions across North America. Most of the study areas were on federal lands or a mix of federal, state and private lands, with only one entirely on private lands and one on Indian Reservation lands.

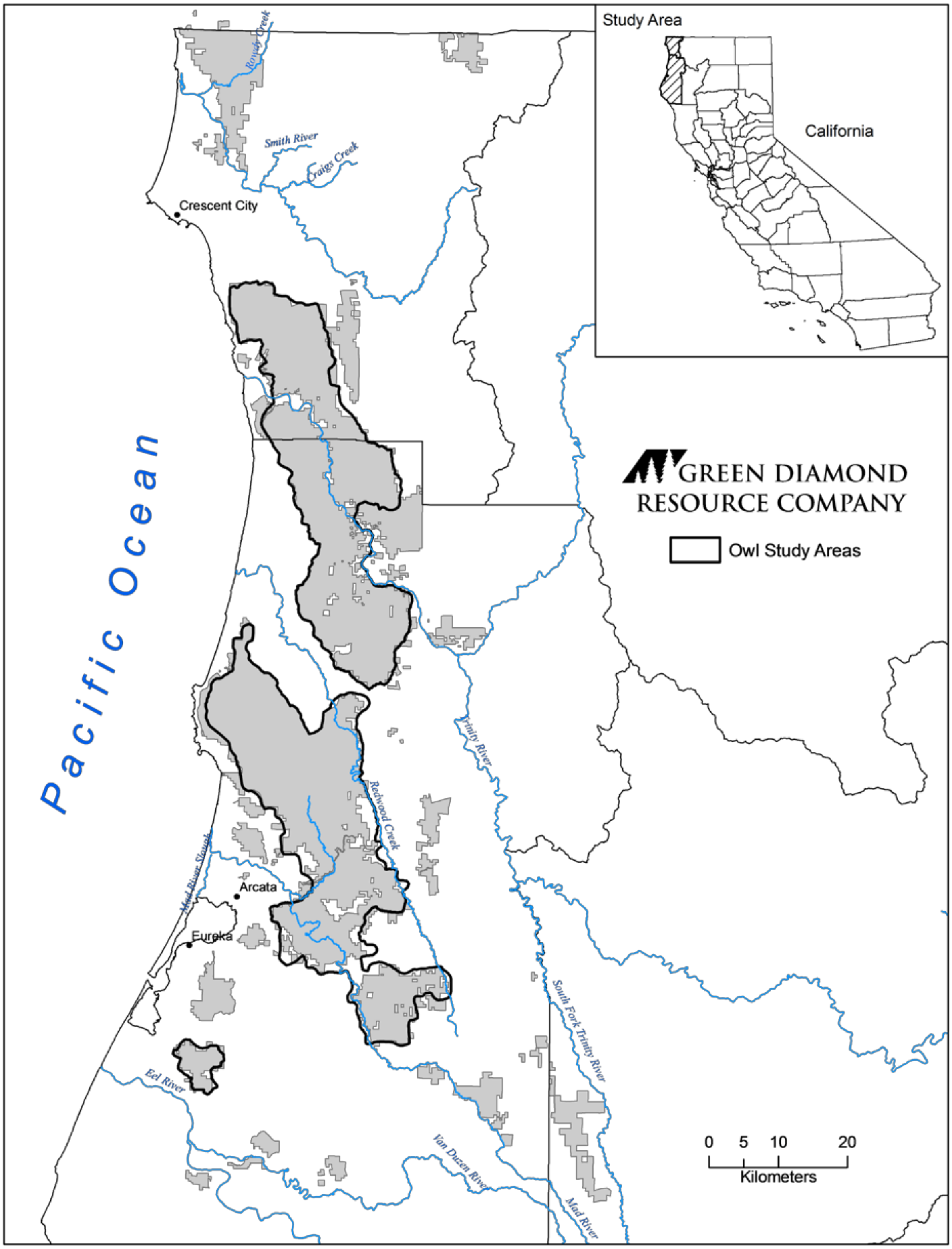


Figure 2. Location of Green Diamond density study area for northern spotted owls in northern California

8. Barred Owls

Since 1989, Green Diamond biologists have noted the incidental detection of barred owls on or adjacent to the ownership while conducting surveys for spotted owls. We recorded all barred owl detections from daytime and nighttime owl surveys since 1989. We defined a barred owl site as an area having a history of detections from a single bird on multiple occasions within the same year or in multiple years. Single detections of pairs or evidence of young were also included as sites. The assessment for number of sites was limited to the density study area since this area has consistent and adequate annual survey coverage. We did not conduct site visit level surveys for barred owls to determine paired or reproductive status.

Upon approval of the amendment to the HCP in December 2007, Green Diamond committed to further research on the interactions between spotted owls and barred owls. In 2008, Green Diamond contributed funding to a cooperative study with Redwood National Park and the National Council for Air and Stream Improvement. The primary goal of this project was to collect habitat use information from coterminous territories of barred owls and spotted owls. This work continued in 2009 with a more limited scope as a result of difficulty locating resident barred owls. The results have not been analyzed to date.

In 2009, Green Diamond began conducting barred owl surveys in select areas within the spotted owl density study area. Surveys were conducted using electronic solid state callers (Wildlife Technologies) with a variety of barred owl vocalizations. Coincident with the specific surveys for barred owls, Green Diamond launched a study in participation with the California Academy of Sciences. The removal of barred owls was conducted in the context of an "invasion study." The first objective of this study is to estimate the impact of barred owls on spotted owl vital rates. This type of a removal experiment can only be carried out in areas that are near the presumed advancing edge of the barred owl expansion and where barred owl numbers are currently low. A critical assumption of this study design is that barred owl numbers are currently low only because of insufficient time for the expansion of the population, and that within a relatively short period, their numbers will substantially increase. The spotted owl response variables will be population vital rates (i.e., survival, fecundity and occupancy) compared between the treatment and control areas. The portion of the study area with removal will be considered the control and the treated area will be the portion in which barred owl numbers will be allowed to increase. We hypothesize that at low barred owl numbers the vital rates of spotted owls for both portions of the study area will be the same. However, as barred owl numbers increase in the treatment area, a threshold will be reached at which point there will be measurable decreases in spotted owl vital rates relative to the control area (i.e., the landscape area in which barred owls were maintained at low levels). A key limitation of this study design is that it is dependent on a "natural" increase in barred owl numbers, which may not occur or occur so slowly that the study becomes impractical. However, if such an outcome should occur, it would mean that barred owls did not become a significant threat in the study area and no additional barred owl control measures would need to be considered. In addition to estimating the impact of barred owls on spotted owl vital rates, this study will also have the potential to estimate the threshold of barred owl population density above which spotted owl vital rates are impacted.

A secondary objective of this study is to observe more “case studies” of how spotted owls respond to the removal of territorial barred owls. The highest priority will be given to removing barred owls from nest sites or activity centers that were formerly occupied by spotted owls. Following removal, we will document the specifics of the site relative to potential recolonization by either species of owl. These case studies will provide insight into how spotted owls respond, when they have been displaced by barred owls. For example, if the original spotted owl territory holders rapidly recolonize a site (i.e., several weeks to a month) following the removal of an invading pair of barred owls, this would suggest the spotted owls remained in or near their original territory after being displaced. However, if a site that has been “freed” of barred owls takes a long time (i.e., a year or more) to be recolonized and/or the spotted owls are new individuals at the site, this would suggest that displaced spotted owls abandon their territories after being displaced.

In 2010, we conducted occupancy surveys for barred owls within the spotted owl Density Study Area. We established 68 survey points from which we conducted the occupancy surveys. Occupancy surveys were conducted during the early breeding season and in the late fall/winter. We used a variety of barred owl vocalizations broadcast from digital wildlife callers (Wildlife Technologies, MA-15). Each survey point was called for a minimum of sixteen minutes. The goal is to conduct occupancy surveys on an annual basis to assess occupancy over the long-term in relation to potential management actions.

In 2011, 2012 and 2013, we conducted occupancy surveys for barred owls throughout the spotted owl Density Study Area. We modified our survey protocols to include nine minutes of spotted owl vocalizations followed by nine minutes of barred owl vocalizations broadcast from digital wildlife callers (Wildlife Technologies model MA-15). In order to cover the study area more completely, we increased the number of survey points from 68 to 460 or approximately one station/786 acres within the density study area. Each survey point was called for a minimum of eighteen minutes at least twice during the spotted owl breeding season (March 1 through August 31). A subset of the 460 points was called at least one additional time during the fall (after July) to establish seasonality of barred owl occupancy.

9. West Nile Virus

In 2004, 2005, 2006 and 2008, Green Diamond participated in a collaborative arrangement with Dr. Alan Franklin who is conducting spotted owl research on the Willow Creek Study Area. This collaborative work involved collecting blood samples from northern spotted owls to test for the presence of West Nile Virus. There were no collections in 2009, 2010, 2011, 2012 or 2013.

B. Results

1. Site occupancy
In 2013, a total of 133 owl sites were located in the Green Diamond study area (Table 15). Of these sites, 127were confirmed as occupied and six were confirmed as possible sites. Ninety-eight sites were occupied by pairs, 3 were occupied by a single owl and 32 were occupied by owls with unknown social or reproductive status. Thus, a minimum of 231 territorial owls were on the study area in 2013. The annual variation in confirmed and possible owl sites is shown in Table 16.

Of the sites occupied in 2012, 83% were occupied in 2013. Five sites occupied by pairs in 2012 were occupied by single birds or birds with unknown social status in 2013. Similarly, 11 sites occupied by single birds or birds of unknown social status in 2012 were occupied by pairs in 2013. Owl sites occupied in 2013 that were not accounted for in 2012 included four recolonized sites, and four newly colonized sites (Table 17). Since 1994, there were 70 sites considered newly colonized in the density study area and 83 sites considered newly colonized in the demographic study area. No sites were newly discovered in 2013.

2. Reproductive success

Thirteen pairs at 80 sites (16%) monitored (paired sites with confirmed reproduction) during the nesting season attempted nesting (Table 18). Ten nesting pairs successfully fledged a minimum of 12 owlets, for a reproductive success rate of 0.15 owlets fledged per monitored site. To date, seven pairs have made ten nesting attempts in nest boxes. Six attempts were successful and seven owlets were fledged.

The trend in the number of owlets fledged per monitored pair from 1992-2013 is shown in Figure 3. The equation of the straight line relating owlets fledged per monitored pair versus year was estimated as: owlets fledged/monitored pair = 34.13-0.0168*year. The slope of the regression line is -0.01684with a standard error of 0.0064. Due to this relatively high annual variation, the significance test that the slope is zero resulted in a t-value of -2.64with $P = 0.01$.

Figure 3. Trend in the number of owlets fledged per monitored pair, 1992-2013

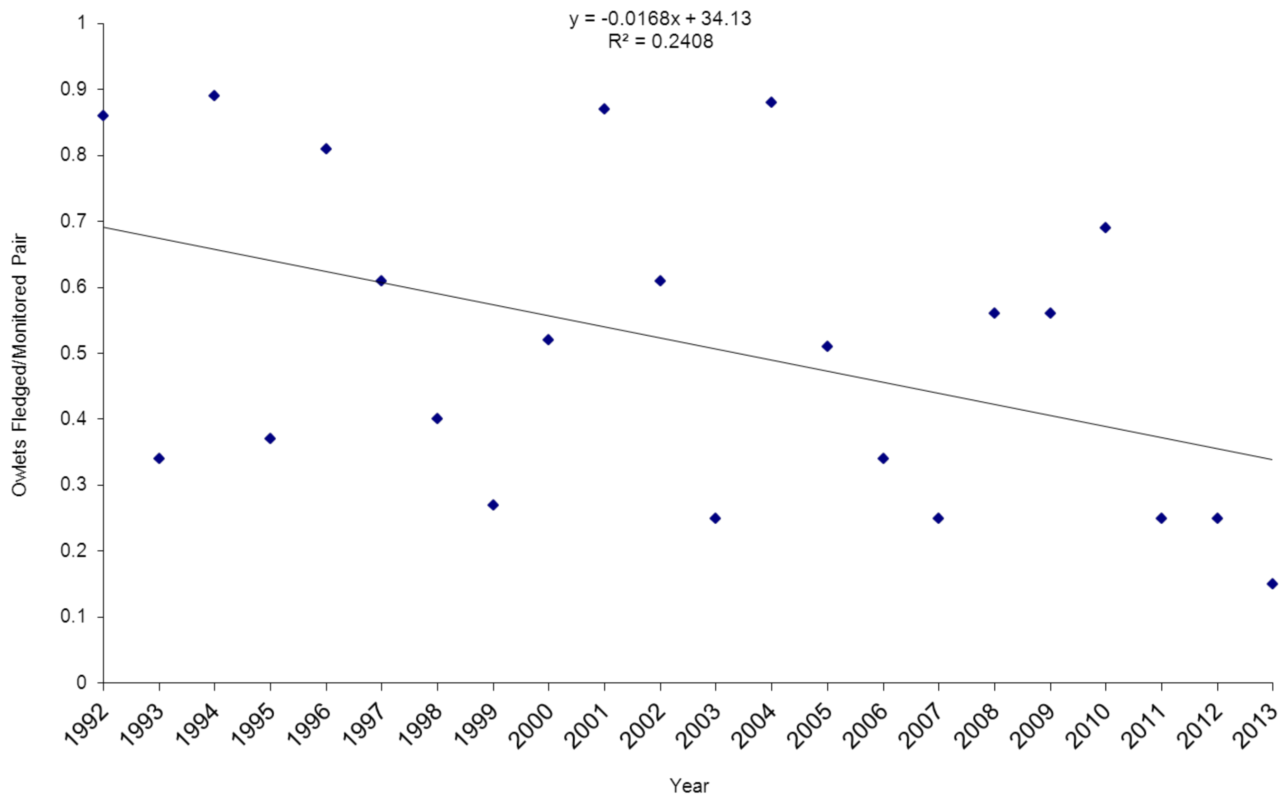


Table 15. Status of northern spotted owls, Green Diamond study area, 2013.

Nesting pairs (n)	Non-nesting pairs (n)	Breeding Status unknown pairs (n)	Singles (n)	Social status unknown (n)	Total sites (n)	Fledged owlets (n)
13	51	34	3	32	133	12

Table 16. Annual variation in northern spotted owl sites, Green Diamond demographic study area 1990-2013.

	Sites		
Year	Confirmed	Possible	Total
1990	86	1	87
1991	142	2	144
1992	171	18	189
1993	185	15	200
1994	183	5	188
1995	163	3	166
1996	155	0	155
1997	167	3	170
1998	186	3	189
1999	168	0	168
2000	163	0	163
2001	161	1	162
2002	156	1	157
2003	146	0	146
2004	141	0	141
2005	123	0	123
2006	128	0	128
2007	107	0	107
2008	99	0	99
2009	116	4	120
2010	117	2	119
2011	125	1	126
2012	125	2	127
2013	127	6	133

Table 17. Site occupancy of northern spotted owls, Green Diamond demographic study area, 2013.

		Sites Located in 2013			
Pair Status	Sites occupied in 2012	Sites occupied in 2012 and 2013	Sites Newly Colonized	Sites Recolonized	Sites Newly Discovered in 2013
Total	127	105	4	4	0

Table 18. Reproductive success of northern spotted owl pairs monitored from 1990 - 2013, Green Diamond demographic study area.

Year	# Sites monitored	# Pairs not nesting	# Pairs nesting	# Pairs successful	# Fledged owlets	# Owlets fledged/ monitored site
1990	56	18	38	29	46	0.82
1991	101	45	56	47	70	0.69
1992	126	39	87	73	109	0.86
1993	92	56	36	20	31	0.34
1994	131	46	85	76	117	0.89
1995	106	59	47	30	39	0.37
1996	117	40	77	62	95	0.81
1997	94	54	40	35	57	0.61
1998	100	49	51	29	40	0.40
1999	111	86	25	20	30	0.27
2000	120	60	60	40	62	0.52
2001	114	40	74	58	99	0.87
2002	112	53	59	43	68	0.61
2003	91	71	20	16	23	0.25
2004	94	34	60	51	83	0.88
2005	98	37	61	32	50	0.51
2006	71	44	27	18	24	0.34
2007	67	55	12	10	17	0.25
2008	77	44	33	26	43	0.56
2009	66	29	37	23	37	0.56
2010	65	26	39	28	45	0.69
2011	75	58	17	12	19	0.25
2012	63	48	15	10	16	0.25
2013	80	67	13	10	12	0.15
Overall Mean						0.53

3. Spotted owl banding

Sixteen adults, six subadults and three juvenile spotted owls were captured and banded on the Green Diamond study area in 2013 (Table 19). Combined with 1990-2012 banding totals, 825 (45.5%) adults and subadults, 990 (54.5%) juveniles and one unknown gender subadult, for a total of 1815 owls have been banded. Of all non-juvenile owls that were banded on the Green Diamond study area through 2013, 31.7% were subadults and 68.3% were adults. From 1990-2013, 56 owls recaptured on the Green Diamond study area were originally banded on other study areas such as the Willow Creek Study Area, Redwood National Park, Hoopa Reservation, and Humboldt Redwood Company lands (Table 20). These 56 owls included with the 1815 owls reported above combine for a grand total of 1871 individual owls captured on the Green Diamond study area. There were a total of three recaptures of juveniles in 2013, for a total of 243 juveniles banded on the Green Diamond study area that were later recaptured within the Green Diamond study area (Table 21).

4. Juvenile dispersal

Three hundred fifty-six juveniles were known to have dispersed within, to, or from the Green Diamond study area between 1990 and 2013. Dispersal distance information for 355 of these owls ranged from 0.5 to 93 miles, with a mean of 9.0miles. Dispersal distance for one male was unknown. Dispersal distances of 174 males ranged from 0.5 to 93 miles, with a mean of 7.7 miles. One hundred seventy-six females dispersed an average of 10.5 miles, with a range of 0.8 to 87.4 miles. The gender of five owls was unknown. Owls dispersing within the Green Diamond study area (n=246) dispersed an average of 6.9 miles while those dispersing to or from the study area averaged 14.5 miles (n=109).

Table 19. Age and gender of northern spotted owls banded on the Green Diamond study area, 1990-2013.

Years	Gender	Age			Total
		Adults	Subadults	Juveniles	
1990-2012	males	303	120	-	423
	females	245	133	-	378
	unknown	-	2	987	989
Subtotal		548	255	987	1790
2013	males	4	4	-	8
	females	12	2	-	14
	unknown	-	0	3	3
Subtotal		16	6	3	25
Total		564	261	990	1815

Table 20. Age and gender of northern spotted owls banded as juveniles by Willow Creek Study Area, Humboldt Redwood Company, Hoopa Indian Reservation studies or Oregon Bureau of Land Management and recaptured as territorial owls on the Green Diamond study area 1990-2013.

	Age			
Gender	Adults	1st year Subadults	2nd year Subadults	Total
Males	14	1	9	24
Females	9	11	12	32
Total	23	12	21	56

Table 21. Recaptures of juveniles banded on the Green Diamond study area 1991-2013. Parentheses indicate number of recaptures of juveniles banded by Green Diamond and captured on other study sites.

Year of recapture with the number of recaptures in the column below

Cohort	# banded	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	% recapture
1990	38	5	1	3	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	28.9
1991	64		6	5	8	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23	35.9
1992	95			11	7	8	4	1	1	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	36	37.9
1993	27				10	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	51.9
1994	103					15	6	6	5	7	1	3	1	0	0	1	0	0	0	0	0	0	0	0	45	43.7
1995	37						2	2	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	18.9
1996	76							8	3	3	2	3	0	1	0	0	0	0	0	0	0	0	0	1	21	27.6
1997	50								6	5	5	1	1	0	0	1	0	0	0	0	0	0	0	0	19	38.0
1998	36									2	5	1	1	0	0	0	0	0	0	0	0	0	0	0	9	25.0
1999	23										3	3	0	1	1	0	0	0	0	0	0	0	0	0	8	34.8
2000	52											7	1	0	1	2	0	0	0	0	0	0	0	0	11	21.2
2001	82												6	9	7	1	1	0	0	0	1	0	1	0	26	31.7
2002	53													3	7	5	3	0	0	0	0	0	0	0	18	34.0
2003	19														1	1	0	1	0	0	0	0	0	1	4	21.1
2004	67															7	3	4	1	3	1	0	0	0	19	28.4
2005	45																1	1	3	3	1	0	1	0	10	22.2
2006	17																	0	1	0	0	0	0	0	1	5.9
2007	14																		1	0	0	1	0	0	2	14.3
2008	30																			3	2	2	0	1	8	26.7
2009	24																				0	3	1	1	5	20.8
2010	16																					1	1	0	2	12.5
2011	9																						1	1	2	22.2
2012	10																							0	0	0.0
Total	987	5	7(3)	19(1)	26(8)	25(10)	16(2)	18(2)	15(2)	23(3)	17(3)	19(7)	10(2)	15 (1)	17(6)	18(2)	8(1)	6(1)	6	9	5	7(1)	5	5(2)	303 (57)	30.7

5. Turnover

a. Missing owls

In 2013, 8 non-juvenile territorial owls (four males and four females) were found at sites different from those that they occupied in 2012 (Table 22). An additional 29 banded non-juvenile territorial owls present in 2012 were not resighted in 2013 (Table 22).

b. New recruits

Six of the new recruits into the territorial population were subadults and 16 were adults (Table 23). Of the 6 subadults, two were females, and four were males. Twelve of the adults were females and four were males. The cumulative total of new recruits of known age class was 301 subadults (47%) and 346 adults (53%).

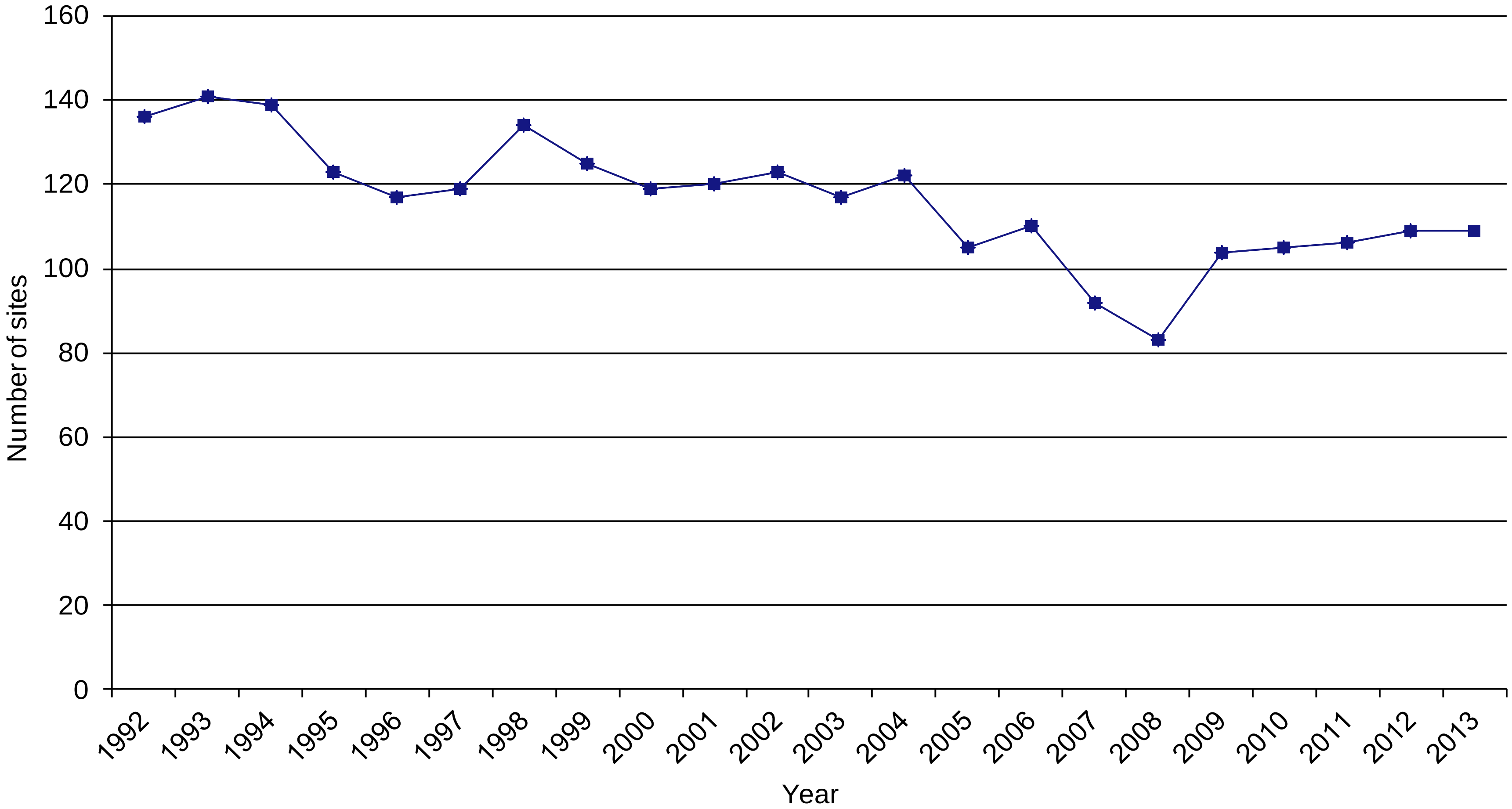
6. Owl density

An estimated 395,109 acres (88%) of Green Diamond Resource Company timberlands have been surveyed to date. This acreage includes numerous blocks of land that are typically surveyed for owls, but are too small and isolated to use in our density estimates. For estimating density, we use 3 large contiguous blocks of land; one in the northern area and 2 in the southern area. The northern study area had 19 owl sites occupied by 30 owls within 164,445 acres, or 0.18 territorial owls/1000 acres. The southern study area had 90 owl sites occupied by 163 owls within 197,239 acres, or 0.83 territorial owls/1000 acres. Thus, a total of 109 owl sites occupied by a minimum of 193 owls were within 361,684 acres, for an overall density of 0.53 territorial owls/1000 acres. The total number of spotted owl sites on the density study area is shown in Figure 4. In 1998, Green Diamond acquired approximately 70,000 acres of timberland in Humboldt County. This area was included in the density study area as a one-time expansion. The increase in the number of sites in 1998 as shown in Figure 4 is a reflection of this expansion. The increasing trend in sites from 2008-2012 is likely a combination of barred owl control in portions of the ownership and a greater number of newly colonized, newly discovered and recolonized sites from 2009 through 2013 compared to the long-term study averages. From 1996-2013, an average of 5.7 sites (n = 97) was recolonized, newly colonized or newly discovered each year, but an average of 8.0 sites (n = 41) was recolonized, newly colonized or newly discovered each year from 2009 through 2013.

7. Demography

Green Diamond initiated mark-recapture studies throughout its ownership in 1990 to estimate key demographic parameters and trends in the population. Along with other range-wide demographic studies of NSO, Green Diamond participated in three meta-analyses in 1998, 2004 and 2009. Results from the most recent meta-analysis that analyzed Green Diamond data from 1990-2008 indicated that mean apparent survival probabilities of adult NSO on Green Diamond land were 0.851 and 0.853 for males and females, respectively (Forsman et al. 2011). These estimates were similar to adult

Figure 4. Total number of spotted owl sites on Green Diamond density study area, 1992-2013



survival estimates from the nearby Willow Creek and Hoopa study areas and there was evidence that all three areas showed a decline in survival.

There tends to be high annual variation in reproduction for NSO throughout their range (Forsman et al. 2011). For many study areas, this annual fluctuation takes on an even-odd year pattern. Estimated overall mean annual fecundity for adult NSO on Green Diamond land was 0.305, which was similar to the estimate from Willow Creek and higher than the estimate from Hoopa. However, there was evidence of a declining trend in fecundity for Green Diamond and Willow Creek, but Hoopa showed an overall stable trend.

Estimated rate of NSO population change (lambda RJS) on Green Diamond land was 0.972 (95% CI = 0.949-0.995), which was slightly lower than lambda for Hoopa (0.989, 95% CI = 0.963-1.014) and NW California (0.983, 95% CI = 0.968-0.998). Since the 95% CI did not overlap 1.0, this was considered evidence of a statistically significant decline for Green Diamond and Willow Creek, but not for Hoopa (Forsman et al. 2011). The trend in estimates of the realized population change indicated that the population of NSO on the Green Diamond study area was apparently stable or increasing until 2001 after which the population began an apparent downward trend.

The barred owl covariate entered the top model for both survival and fecundity, which suggested that barred owls were the most likely cause for the recent decline of NSO on Green Diamond’s study area. Potentially, this downward trend was reversed with a 20.5% increase in the number of occupied owl sites on Green Diamond’s density study area in 2009 followed by a 3.0% increase in 2010 and a 1.0% increase in 2011. In 2011, we observed a 6% increase in the number of sites in the larger demographic study area. Factors that may have contributed to this increase included modifications of the survey protocol in 2009 to increase NSO detection rates, which resulted in locating banded resident NSO in historical sites that had appeared to have been abandoned in recent years. In addition, the Lower Mad River Tract has large areas of third growth that apparently were just now reaching suitable habitat attributes for colonization by NSO. Green Diamond also initiated a barred owl removal experiment in 2009, which involved removing all barred owls from treatment areas, i.e., approximately half of the total study area. Barred owls were removed from historical NSO sites, which allowed these sites to be re-colonized by NSO and these treatment areas could be colonized by NSO free from interference from this invasive species. Therefore, it probably was a combination of improving survey techniques, increasing amounts of suitable habitat and freeing approximately half of the study area from barred owls that led to the recent increase in occupied NSO sites.

8. Barred Owls

The 2013 survey effort which consisted of THP surveys, spotted owl and barred owl property-wide calling, and spotted owl site visits resulted in 170 detections of barred owls. One hundred sixteen of these barred owl detections were within the density study area. The number of detections at the same site or area ranged from one to 8 (mean =2.1). We estimated a minimum of 58 barred owl territories from these detections. Forty-two of these territories were located within the density study area. The total number of barred owl sites increased by 57% from 2011 to 2013. We cannot make a valid comparison of the 2011, 2012 and 2013 estimates to past years due to differences in survey effort, but the number of detections and territories increased in 2011, 2012, and 2013.

In 2006, Green Diamond assisted the California Academy of Sciences (CAS) in obtaining a small collection of barred owls in California. To maximize the scientific value of the individuals collected, CAS targeted barred owls to be collected from sites that were historically occupied by NSO. Thus, these initial collections provided an opportunity to do preliminary *removal case studies* that would document the response of individual NSO to the removal of barred owls. Seven barred owls were collected from four different historical NSO sites during May and June 2006 on Green Diamond's ownership in Humboldt County. Although based on just four *case studies*, these results suggested that NSO were quick to re-colonize their former territories following removal of barred owls.

As part of the implementation of the final recovery plan, a Barred Owl Work Group (BOWG) was formed to consider implementation of a suite of barred owl removal studies. The BOWG evaluated a proposal to do an additional barred owl study on Green Diamond's ownership and provided full support for a study that was designed to be complementary to other removal experiments that were being planned for public lands in Washington, Oregon and California. Still working under CAS scientific collecting permits that allowed removal of 20 additional barred owls, a preliminary barred owl removal experiment was initiated on a portion of Green Diamond's NSO demographic study area in 2009. The study was designed to determine the impact of barred owls on site occupancy, survival and fecundity of NSO using paired treatment and control areas where barred owls were removed in treatment areas, while they were allowed to increase *naturally* in control areas. The additional collections in 2009 also allowed for added removal case studies of the response of individual NSO to the removal of barred owls from sites that were previously known to be occupied by NSO.

The results of the early barred owl removal work were encouraging, but the sample sizes were still too small and the time interval too short so that any conclusions from this work were too preliminary. In response, Green Diamond sought and was granted in 2010 the authorization from the USFWS and California Department of Fish and Game (CDFG) to fully implement a barred owl removal study within the Green Diamond NSO demography study area. The authorization allowed for a total of 70 barred owls to be taken over three years with a maximum of 30 individuals in any year. To account for geographic variation in habitat and both NSO and barred owl population densities, Green Diamond's demographic study area was subdivided into three treatment (Salmon Creek, Korbel/Mad River/Little River and Wilson/Hunter/Terwer Tracts) and three control areas (Ryan Creek, Redwood Creek and Bald Hill/County Line Tracts).

One of the valuable findings from these initial removal efforts was that using a lethal method, i.e., adult territorial individuals were attracted to within 20-30m using recorded calls and shot with a 20 gauge shotgun, barred owls could be collected humanely, efficiently and with minimal effort and cost. For example, in late winter early spring of 2009, one field person made a total of 16 visits to six territories with a mean of one hour 23 minutes per visit (not including vehicle travel time) to collect 100% of the known (11) territorial barred owls in the Korbel/Mad River treatment area. This equated to approximately two field hours per barred owl removed, which has been repeated in 2010, 2011, 2012 and 2013. By far, the greatest expense associated with the barred owl removal study is doing the initial surveys of the study area. However, Green Diamond minimized the cost of this effort due to existing commitments for the NSO monitoring program under the 1992 HCP.

Through July 2011, a total of nine NSO sites have met the criteria for a removal case study, i.e., barred owls removed from a historical NSO nest site or activity center, but two were created in 2011 and have had insufficient time to fully assess the NSO response. All of the historical sites from which barred owls were removed have been re-occupied by NSO with the maximum time for re-occupation ranging from a minimum of 13 days to a maximum of 152 days. Four of the sites were re-occupied by the original resident NSO, including one female that had not been seen for seven years, and the remaining sites were re-occupied by new or unknown individuals. Following removal, the NSO were again displaced by barred owls at three sites. Of the initial three sites from 2006, Salmon #3 was re-colonized once, while Poverty Creek site was re-colonized by barred owls twice in five years. One other site (CG South) had a single male barred owl removed in 2010 and was re-recolonized by a pair of barred owls in 2011.

There were five additional barred owl removal sites that did not meet the criteria for a removal case study, because the barred owls did not occupy the historical NSO site. However, the barred owls were removed from sites immediately adjacent to occupied NSO nest sites or activity centers, i.e., the barred and NSO were *neighbors* with home ranges that were likely to be overlapping. These neighbor case study situations were more difficult to summarize, but the general pattern in all cases was for the NSO to either shift their territories away from the barred owls and not nest or become silent so that it was difficult to find and determine the nesting status of NSO. Following barred owl removal, the NSO tended to shift their territories back to their original location, nest normally and become more vocal.

As noted above, treatment and control areas relative to barred owl removal were created on Green Diamond’s NSO demography study area and in 2009, 20 barred owls were removed from the treatment areas. The level of barred owl take was not sufficient to fully implement a barred owl removal study, but all the known barred owls (16) were removed from the Korbel/Mad River area. In 2010, all of the barred owls (8 individuals) that recolonized this area were removed. Since the other treatment areas had no or only partial barred owl removal in 2009, and the removal from all treatment areas in 2010 did not occur until mid-summer, the Korbel/Mad River area was the only area for which changes in NSO occupancy in the absence of barred owls could be fully addressed. Although there has not been enough time to fully investigate differences in occupancy rates, Green Diamond did a preliminary analysis of the trend in occupied NSO sites for the Korbel/Mad River treatment versus immediately adjacent Redwood Creek control area. The year 1998 was selected as a reference point, which was the year before when barred owl numbers began to rapidly expand in the study area. Figure 4 below shows the recent trend in occupied NSO sites between the treatment and control areas. There was an apparent dramatic 43.2% increase in the number of occupied NSO sites in the Korbel/Mad River treatment area from 2008 (pre-treatment) to 2009 (first year of barred owl removal) and another 9.4% between 2009 and 2010. In contrast, the Redwood Creek control area remained relatively constant from 2008 to 2009 and then decreased by 22.7% from 2009 to 2010.

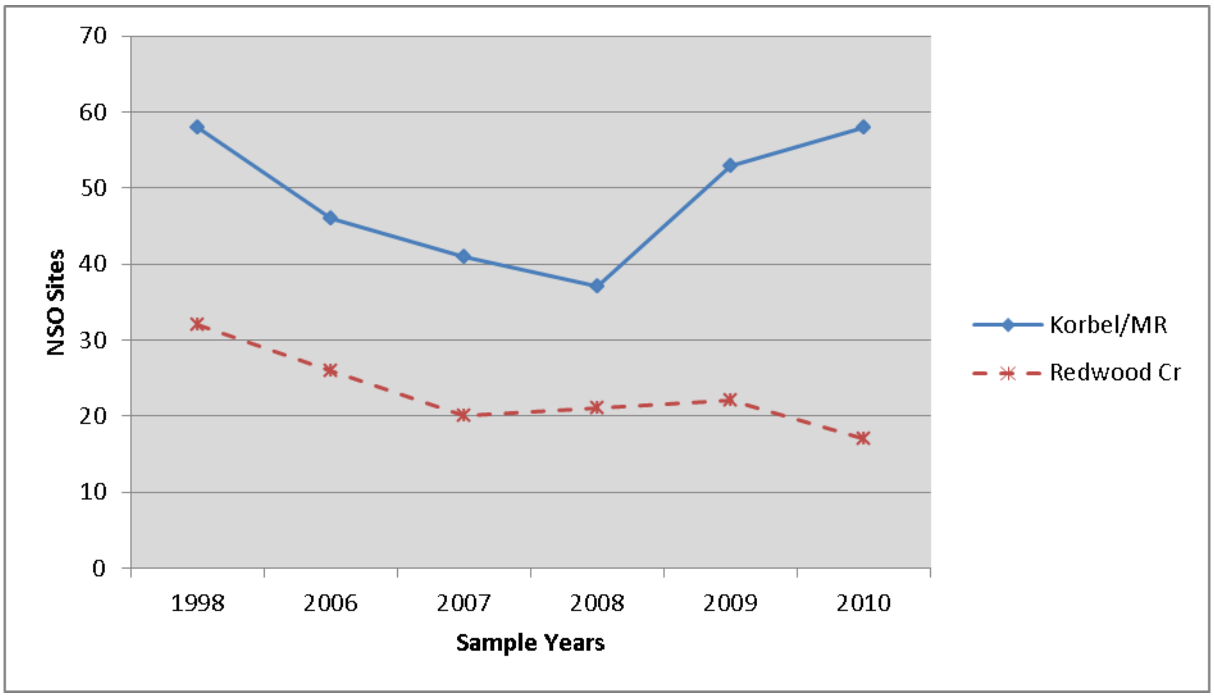


Figure 5. Trend in occupied Northern Spotted Owl (NSO) Sites on Two Adjacent Tracts of land on Green Diamond Resource Company's ownership in coastal northern California. Barred owls were removed from Korbel/MR in 2009 and 2010, but no barred owls were removed from Redwood Creek.

The apparent 43% increase in the number of occupied NSO sites in the Korbel/Mad River area from 2008 to 2009 was not due exclusively to unoccupied NSO sites being *freed* of barred owls, because the number of newly occupied sites (16) greatly exceeded the number of sites (six) from which barred owls were removed (Figure 4.10). Modifications of the survey protocol in 2009 to increase NSO detection rates also resulted in locating banded resident NSO at sites that were unoccupied in recent years. However, subadults comprised nearly 65% of the NSO Green Diamond banded or resighted at these reoccupied sites in 2009 and 2010. The Korbel/Mad River area also has large areas of third growth (~25-30 years-old) that apparently was just now reaching suitable habitat attributes for colonization by NSO. Therefore, it probably was a combination of freeing historical NSO sites, improving survey techniques and increasing amounts of suitable habitat that led to the dramatic increase in occupied

NSO sites in the removal area. However, the lack of a similar increase in the Redwood Creek tract suggested that removal of barred owls in the Korbel/Mad River/Little River area may have had a synergistic effect on all of these factors. Green Diamond hypothesizes that creating an area free of barred owls may have increased the probability that resident NSO that previously were silent would now be more inclined to respond to surveys and it would make colonization of the area more likely when floater NSO were not being rebuffed by resident barred owls. The veritable result may be increased appeal to prospecting NSO because they detect other resident NSO. This social facilitation may promote colonization of areas that are maturing into suitable habitat and are free of barred owls.

The continued upward trend in occupied NSO sites in the Korbel/Mad River area between 2009 and 2010 was also likely due to a combination of factors as was described above for the increase between 2008 and 2009. However, there were no additional changes in the survey protocol so the increase was most likely due to removing barred owls and increasing amounts of suitable habitat. The decline in occupied NSO sites in Redwood Creek after a temporary flattening of the curve between 2007 and 2009 would suggest that the temporary benefits of improved survey techniques had been offset by the negative impact of barred owls on NSO occupancy. The negative impact of barred owls is quite dramatic in some stretches along Redwood Creek that historically had high densities of nesting NSO, which have now been almost totally replaced by barred owls. Although some NSO are likely to still persist in these areas, every attempt to survey for them results in an aggressive response from a barred owl, which precludes any further attempts to locate NSO.

When this study is completed, Green Diamond will also be able to estimate impacts of barred owls on apparent survival and fecundity of NSO. Currently, Green Diamond lacks even preliminary estimates on these demographic parameters, but there is little doubt that if the trend in occupancy between treatment and control areas continues, there also will be dramatic differences in apparent survival and fecundity.

9. West Nile Virus

In 2013, we did not collect blood samples or oral swabs from spotted owls. We are not aware of any samples collected to date with the presence of WNV antibodies.

Table 22. Turnover rates of individual northern spotted owls, Green Diamond study area, 2013.

Gender	Banded or Resighted in Previous Year and Resighted in Current Year n (%)	Banded or Resighted in Previous Year Not Resighted in Current Year n (%)	Resighted at Site Different from that of Previous Year n
males	63	18	4
females	61	13	4
Total	124 (80)	31 (20)	8

Table 23. Gender and age class of northern spotted owl new recruits, Green Diamond study area 1991-2013.

Year	Gender	Age: Subadults n (%)	Age: Adults n (%)	Total (n)
Cumulative Total 1991-2012	Males	130	197	327
	females	164	133	297
	unknown	1	0	1
	subtotal	295 (47)	330 (53)	625
2013	males	4	4	8
	females	2	12	14
	unknown	0	0	0
	subtotal	6(27)	16(73)	22
Total		301(47)	346(53)	647

C. Discussion

The trend in the total number of owl sites (occupied and possible) in the density study area provided the most accurate estimate of the real trend in total owl sites for the entire ownership, because peripheral areas tended to have less consistent survey effort. The apparent initial increase from 1990-1993 was the result of a “learning curve” associated with field crews becoming familiar with the study area and documenting all perennial owl sites. The peak in total owl sites occurred in 1993-1994 followed by a decline until 1998, a relatively stable period through 2004, and a further decline from 2004 through 2008. This was followed by an increase of sites in 2009. From 2009-2012 the number of sites in the density study area continued to increase, and in 2013 the number of sites neither increased nor decreased from 2012. In 1998, the apparent increase in sites was a result of an expansion in the size of the density study area after a land acquisition and a resultant increase in sites. The increase in sites since 2008 did not result from any changes in the study area, but the average number of recolonized, newly colonized, and newly discovered sites in the last five years increased 154% over the 17-year average. The removal of barred owls within portions of the study area was the most likely factor influencing the increase in the number of recolonized spotted owl sites.

The negative trend in number of owlets fledged per monitored pair (fecundity) although not statistically significant until the current monitoring period, is one of several potential factors that could have contributed to the overall decline in spotted owl sites during the study period. The decline is also partially due to the net displacements that occurred during this time period under the incidental take permit for the HCP. However, the number of owl sites has declined similarly in areas with and without significant timber harvest indicating other factors were involved. Additional analyses using mark-recapture data with covariates such as weather, habitat elements, barred owls and timber harvest are necessary to assess the factors responsible for the trend in owl sites. The direct competitive interactions with the barred owl and recent disease factors such as West Nile virus may further contribute to declining trends in the spotted owl population that are not easily identified.

The fundamental premise of the spotted owl HCP is that owl sites lost through timber harvest will be replaced in other areas as stands mature and become suitable for occupancy by owls. The number of newly colonized owl sites has off-set the number of net displacements. However, newly colonized owl sites have not offset the number of net displacements when combined with other abandoned sites. The 21-year period that the HCP has been implemented provides a relatively brief view of the dynamics of the owl population on Green Diamond’s ownership, and it would be expected that stochastic population fluctuations would occasionally lead to a lack of concordance between available habitat and the size of the population. Another plausible explanation for the difference in newly colonized sites and net reported displacements may be related to the distribution of stand ages throughout Green Diamond’s ownership and our current definitions of owl habitat that have discrete thresholds through which stands transform from “non-habitat” to “habitat.” Excluding the LP acquisition, there has been a slight upward trend in the amount of suitable (> 30 years) owl habitat. However, simply tracking stands transitioning from one age class to another may not adequately predict suitable owl habitat on the landscape, if a high proportion of stands have recently matured into age classes defined as suitable owl habitat. Habitat used by spotted owls (whether foraging, roosting or nesting) develops gradually through time and a simplistic accounting of the proportion of the landscape in different age classes of forest may not accurately reflect the amount of habitat available to spotted owls. The use of spatially explicit models incorporating foraging and nesting site selection along with demographic parameters will provide insight into the matrix of habitat ages, types and components necessary to support owls on the landscape and further refine our definitions of owl habitat. Continued monitoring of the population and analyses of how timber harvest has affected the owl population will lend insight to future management of the forests within Green Diamond's ownership.

The best example verifying the dynamic nature of habitat within a given region and the prediction of an overall increase in NSO habitat comes from the Lower Mad River Tract. The Lower Mad River Tract of the Plan Area is an area of approximately 22,000 acres that is primarily composed of third growth redwood forests between 15-30 years-old except for approximately 2,000 acres of 70-80 year-old second growth contained mostly within nine set-asides that occur within or overlap at least partially with this region. Clearcut harvesting of the second growth within this tract started in 1979 and continued at or near the maximum rate allowed by California FPRs for approximately 20 years until adjacency constraints slowed the rate of harvest on small amounts of the remaining second growth stands. By the late 2000s, virtually all non-constrained stands had been harvested. The pattern of harvesting in the Lower Mad River differs somewhat from future harvesting since the area was harvested in the 1980s and early 1990s when retention of overstory trees on most streams was at the minimum requirement and maximum clearcut size was 80 acres. These practices will not be repeated in the future, and instead, a pattern of small clearcuts of different ages scattered across the landscape interconnected with substantial older riparian stands is expected. So although the Lower Mad River example will not be duplicated in the future, the pattern observed in future similar tracts should foretell an even more optimistic future trend in the NSO population in the Plan Area.

A complete NSO survey of the Lower Mad River Tract was initiated in 1990 and it has been continued until the present. The number of sites was slightly lower in 1990 relative to 1991, because it was the first complete survey and Green Diamond may have missed one or two NSO sites (Figure 6). In 1989, approximately 40% of the area had been recently harvested, which created ideal habitat heterogeneity in some areas. However, the pattern of harvesting had almost completely removed all mature second growth from other areas, which would have displaced any NSO that were in those areas. Operating under the 1992 NSO HCP, two additional sites were taken by timber harvest in the Mad River (one in 1999 and one in 2000), but 6 other sites that were in commercially valuable stands were not available for take since they occurred within set-asides.

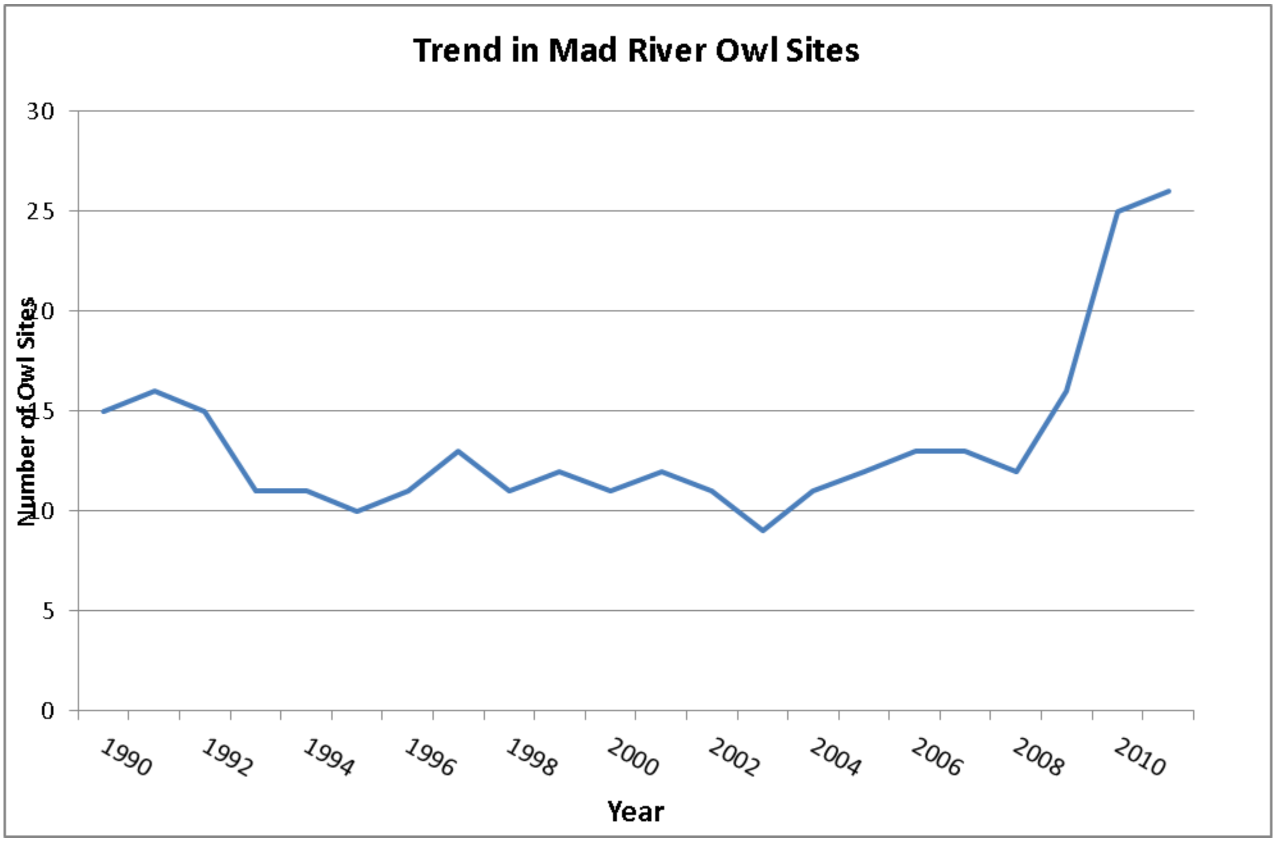


Figure 6. Trend in the Number of Known Occupied spotted owl Sites in the Lower Mad River Tract, 1990-2011.

The Lower Mad River Tract also happens to occur within the Korbel/Mad River treatment area of the Green Diamond barred owl removal experiment and all barred owls have been removed from the area beginning in 2009. This probably facilitated NSO to begin recolonization of the area based on newly emerging habitat suitability. In the spring of 2009, there were 15 occupied sites within this area, and from that time until the spring of 2011, 11 new sites (three in 2009, seven more in 2010 and one new site confirmed by early spring 2011) have been colonized in the area. The barred owl removal experiment may have contributed to a very sharp increase in NSO sites, which potentially would have been more gradual if the barred owl numbers had not been allowed to increase beginning in the early 2000s. Nevertheless, with 26 NSO sites in an area of approximately 22,000 acres, the region probably may soon be at its maximum carrying capacity with NSO densities higher than anything reported in the literature. This Mad River example, although not directly comparable to future landscape dynamics, which will have a higher proportion of retained riparian zones, provides evidence that the number of future occupied NSO sites will be dynamic in any given sub-basin with the low portion of the cycle extending for 15-20 years of the average 50-year cycle. But most importantly, it provides evidence that if the barred owl threat is removed, NSO can and will respond favorably to improving habitat conditions.

D. Future Studies

1. Owl studies

Surveys, banding, and monitoring of spotted owls will continue in 2014 to evaluate the efficacy of the HCP and to estimate the rate of population change. In addition to the owl studies, several other studies will continue or be initiated. The results of these studies may have implications for Green Diamond's conservation strategy for owls. For example, if a particular habitat component is found to be important to another sensitive species, and also provides habitat for owls, habitat retention areas could be designed to benefit both species.

2. Prey Base studies

Green Diamond initiated a property-wide project in 2004 that was focused on developing a mark-recapture estimate of woodrat abundance. This effort has resulted in the capture of 1841 individual woodrats in over 30,000 trap nights. This effort is scheduled to continue in 2014, and the data is planned for use in future modeling efforts of spotted owl habitat and demographic parameters.

3. Barred owls

Green Diamond initiated preliminary research on barred owls in early 2006. The cooperative work with the California Academy of Sciences will continue in 2014.

F. Literature Cited

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VIII. Efficacy of HCP

As detailed in the HCP, if the reproductive success rate (# of owlets fledged per pair) of a sample of the spotted owl population falls significantly ($P < 0.05$) below the rate of the HSU Foundation Willow Creek Study Area (WCSA) for three consecutive years, then Green Diamond will propose corrective measures. The reproductive success of Green Diamond's owls was greater than that of the WCSA from 1993-1995. However, in 1996, the reproductive success of owls on Green Diamond's study area was significantly less than that of the WCSA ($P < 0.025$). In 1997 and 1998, Green Diamond's reproductive success was lower, but not significant and in 1999 Green Diamond's reproductive success was higher than WCSA. In 2000 and 2001, the reproductive success of owls on Green Diamond was not significantly lower than the WCSA. In 2002, 2003 and 2004, the reproductive success of owls on Green Diamond was slightly higher than that observed on the WCSA. The reproductive success of owls on Green Diamond was slightly lower than the WCSA from 2005 through 2009 but the estimates were not significantly different. The reproductive success of owls on Green Diamond was slightly higher than WCSA in 2010 and 2011. The reproductive success of owls on Green Diamond was slightly lower than the WCSA in 2012, but the estimates were not significantly different.

In 2013, the average reproductive success of owls on Green Diamond's study area was 0.15 young fledged per pair (n=80 SE=0.047). In 2013 the average reproductive success of owls on the WCSA (core study area) plus the RSA (surrounding satellite sites) was 0.625 young fledged per pair (n=24 SE=0.168). The estimates of reproductive success were significantly different when analyzed with a one-tailed T-test for means and standard errors with equal variances (t= -3.777, p=0.0001).

It is difficult to determine the overall long-term effectiveness of conservation measures to provide future owl habitat across the plan area since inception of the HCP twenty-one years ago. However, ingrowth of habitat and colonization of spotted owls in some third growth forest has occurred. For example, since 2009 43% of the sites that have been located in the Mad River drainage have occurred in third growth forests. Also, measures to protect owls and to retain habitat continue to be successful based on our monitoring efforts. Progress was continued for developing specific procedures and protocols, training Green Diamond employees, and planning and implementing conservation measures for spotted owls.

A. Budget

Green Diamond has identified the following approximate budget for implementing the survey, monitoring and research requirements of the HCP for the upcoming year.

Item	Dollar amount
Payroll	
Salaries	305,000
Hourly	106,000
Benefits	104,000
Supplies (includes vehicle maintenance, fuel, etc.)	89,000
Misc. costs	75000
Total	679,000

Appendix I. Results of THP surveys for spotted owls 2013.

THP #/Setting ID	THP Name	Survey Type	Owl sites w/in 1/2 mile
06-1001 A	Rio Dell Finally	4-survey protocol	
06-1001 B	Rio Dell Finally	4-survey protocol	R200
06-1001 C	Rio Dell Finally	4-survey protocol	R200 (on edge of unit)
08-1001 A	Carlotta Last '11	Detection probability	Quiet Lane
08-1001 B	Carlotta Last '11	Detection probability	C2300
08-1001 C	Carlotta Last '11	Detection probability	C2300
08-1001 D	Carlotta Last '11	Detection probability	C2300 (on edge of unit)
08-1001 E	Carlotta Last '11	Detection probability	Sunny Slope
09-1001 C	Steven's Creek East	Spot call	Steven's Creek East, Middle Steven's Creek (on edge of unit)
09-1001 D	Steven's Creek East	2nd-year 3-survey protocol	Middle Steven's Creek
09-1001 A	Steven's Creek East	2nd year Detection probability	
09-1101 A	Steven's Creek North	4-survey protocol	Upper Steven's Creek (on edge of unit)
09-1101 B	Steven's Creek North	4-survey protocol	Upper Steven's Creek
09-1101 C	Steven's Creek North	4-survey protocol	Upper Steven's Creek
09-1101 D	Steven's Creek North	4-survey protocol	Upper Steven's Creek
14-1001 A	S2100 '11	2nd-year 3-survey protocol	
14-1001 C	S2100 '11	Spot call	Salmon Creek #3, Salmon Creek #5
14-1002 A	McCloud Creek #4	2nd-year 3-survey protocol	EBF
14-1002 B	McCloud Creek #4	2nd-year 3-survey protocol	Lower McCloud Creek, McCloud Creek, Little South Fork

14-1003 B	F 1400 '12	2nd-year 3-survey protocol	Salmon Creek #5
14-1003 C	F 1400 '12	2nd-year 3-survey protocol	Salmon Creek #2, Salmon Creek #3, Salmon Creek #5
14-1003 D	F 1400 '12	2nd-year 3-survey protocol	Salmon Creek #2, Salmon Creek #3, Salmon Creek #5
14-1101 A	Salmon Creek Central '12	4-survey protocol	
14-1101 B	Salmon Creek Central '12	4-survey protocol	
14-1101 C	Salmon Creek Central '12	4-survey protocol	
14-1101 D	Salmon Creek Central '12	4-survey protocol	
14-1101 E	Salmon Creek Central '12	4-survey protocol	
15-0801 A	G127	2nd year Detection probability	
15-0801 B	G127	2nd year Detection probability	
17-1102 A	Upper Madrone '12	Detection probability	
17-1102 B	Upper Madrone '12	Detection probability	
17-1102 C	Upper Madrone '12	Detection probability	
17-1102 D	Upper Madrone '12	Detection probability	Miller Ridge
17-1102 E	Upper Madrone '12	Detection probability	Miller Ridge
17-1102 F	Upper Madrone '12	Detection probability	Miller Ridge
17-1102 G	Upper Madrone '12	Detection probability	
17-1102 H	Upper Madrone '12	Detection probability	Miller Ridge
17-1203 A	Victor Lake	Detection probability	
17-1203 B	Victor Lake	Detection probability	
17-1203 C	Victor Lake	Detection probability	East Goodman (on edge of unit)
18-1101 A	Little Boulder	2nd year Detection probability	Little Boulder Creek
18-1101 B	Little Boulder	2nd year Detection probability	
18-1101 C	Little Boulder	2nd year Detection probability	
18-1101 D	Little Boulder	2nd year Detection probability	
18-1102 A	Roddi/SC 2400 '12	2nd year Detection probability	

18-1102 B	Roddi/SC 2400 '12	2nd-year 3-survey protocol	
18-1102 C	Roddi/SC 2400 '12	Detection probability	
19-0802 A	McKay '10	Detection probability	
19-0802 B	McKay '10	Detection probability	Upper Bear Gulch
19-0802 C	McKay '10	Detection probability	Upper Bear Gulch
19-1101 A	McKay R-5 Thin	Detection probability	R-8-1
22-1001 E	Mad River '11	2nd year Detection probability	Fickle Hill Devil
22-1101 A	5300/5300A	Detection probability	Boundary Creek
22-1101 B	5300/5300A	Detection probability	Boundary Creek, Upper Black Dog Creek
22-1101 C	5300/5300A	2nd year Detection probability	Mad River STS
26-0803 C	Knutz Creek	2nd year Detection probability	
26-0803 D	Knutz Creek	2nd year Detection probability	
26-0803 F	Knutz Creek	2nd year Detection probability	Canyon North
26-1103 A	Long Prairie Creek '13	Detection probability	
26-1103 B	Long Prairie Creek '13	Detection probability	
26-1103 C	Long Prairie Creek '13	Detection probability	
26-1103 D	Long Prairie Creek '13	Detection probability	Old 299 #1
26-1201 A	CB 1100 '13	2nd-year 3-survey protocol	
26-1201 B	CB 1100 '13	2nd-year 3-survey protocol	
26-1201 C	CB 1100 '13	2nd-year 3-survey protocol	
26-1201 D	CB 1100 '13	2nd-year 3-survey protocol	
26-1201 E	CB 1100 '13	2nd-year 3-survey protocol	
26-1201 F	CB 1100 '13	2nd-year 3-survey protocol	Camp Bauer
26-1201 G	CB 1100 '13	2nd-year 3-survey protocol	
26-1201 H	CB 1100 '13	2nd-year 3-survey protocol	

26-1202 A	CB 1000 '13	Detection probability	
26-1202 B	CB 1000 '13	Detection probability	
26-1203 A	Fulton Ranch '14	Detection probability	
26-1203 B	Fulton Ranch '14	Detection probability	
26-1203 C	Fulton Ranch '14	Detection probability	
26-1203 D	Fulton Ranch '14	Detection probability	Canyon Creek #1
26-1203 E	Fulton Ranch '14	Detection probability	
26-1204 A	Ward Road '14	Detection probability	Canyon Creek #1
26-1204 B	Ward Road '14	Detection probability	Canyon Creek #1 (on edge of unit)
26-1302 A	Bald Mtn. 1200 '14	Detection probability	
26-1302 B	Bald Mtn. 1200 '14	Detection probability	
26-1302 C	Bald Mtn. 1200 '14	Detection probability	
26-1302 D	Bald Mtn. 1200 '14	Detection probability	
27-0802 B	High Prairie '08	2nd year Detection probability	
27-1101 B	CP 1000	2nd-year 3-survey protocol	
27-1201 A	Fernwood '14	Detection probability	
27-1201 B	Fernwood '14	Detection probability	
27-1201 C	Fernwood '14	Detection probability	
34-1001 A	McKinleyville East '11	2nd-year 3-survey protocol	
34-1001 B	McKinleyville East '11	2nd-year 3-survey protocol	
34-1001 C	McKinleyville East '11	2nd-year 3-survey protocol	
34-1001 D	McKinleyville East '11	2nd-year 3-survey protocol	
34-1301 A	Lindsay Flat	Detection probability	
34-1301 B	Lindsay Flat	Detection probability	
34-1301 C	Lindsay Flat	Detection probability	
34-1301 D	Lindsay Flat	Detection probability	
34-1302 A	Murray Road	Detection probability	
34-1302 B	Murray Road	Detection probability	
34-1302 C	Murray Road	Detection probability	
34-1302 D	Murray Road	Detection probability	
35-1001 A	Strawberry Mather '11	2nd year Detection probability	Mather #2

35-1001 D	Strawberry Mather '11	2nd year Detection probability	
35-1201 A	Mather Creek Thin	4-survey protocol	
37-1001 A	CR 2270	2nd-year 3-survey protocol	
38-1001 C	Ribar Heights	2nd-year 3-survey protocol	
38-1101 A	Ribar Central	4-survey protocol	
38-1101 B	Ribar Central	4-survey protocol	
38-1101 C	Ribar Central	4-survey protocol	
38-1101 D	Ribar Central	4-survey protocol	
40-1001 B	NF 1000 N '11	2nd-year 3-survey protocol	Lower Dolf Creek
40-1001 C	NF 1000 N '11	2nd-year 3-survey protocol	Lower Dolf Creek (on edge of unit)
40-1001 D	NF 1000 N '11	2nd-year 3-survey protocol	
40-1001 E	NF 1000 N '11	2nd-year 3-survey protocol	
40-1002 A	NF 1200 '11	2nd year Detection probability	Poverty Creek (on edge of unit)
40-1102 A	Denman Creek '12	Detection probability	NF 1300
40-1102 B	Denman Creek '12	Detection probability	
40-1102 C	Denman Creek '12	Detection probability	
42-1101 A	K&K 400	2nd year Detection probability	
42-1101 B	K&K 400	2nd year Detection probability	
42-1102 A	Basin Thin	2nd year Detection probability	
42-1103 A	East Fork Thin '12	2nd year Detection probability	
42-1103 B	East Fork Thin '12	2nd year Detection probability	
42-1103 C	East Fork Thin '12	2nd year Detection probability	
42-1301 A	K&K 610	Detection probability	
42-1301 B	K&K 610	Detection probability	
42-1301 C	K&K 610	Detection probability	
42-1301 D	K&K 610	Detection probability	
42-1301 E	K&K 610	Detection probability	

43-1003 C	CR 3004	2nd year Detection probability	
43-1101 B	CR 2790 '12	2nd-year 3-survey protocol	
43-1102 B	CR 3210 '12	2nd year Detection probability	
43-1103 B	Crannell CT Thin	2nd year Detection probability	
43-1103 C	Crannell CT Thin	2nd year Detection probability	
43-1103 D	Crannell CT Thin	2nd year Detection probability	
43-1103 F	Crannell CT Thin	2nd year Detection probability	
43-1201 A	CR 2230/3125	Detection probability	
43-1201 B	CR 2230/3125	Detection probability	
43-1202 A	CR 2761 '13	4-survey protocol	
43-1202 B	CR 2761 '13	4-survey protocol	
43-1204 A	CR 3500 '13	Detection probability	
43-1301 A	CR 2420/2008	Detection probability	
43-1301 B	CR 2420/2008	Detection probability	
43-1301 C	CR 2420/2008	Detection probability	
43-1302 A	CR 3550	Detection probability	
43-1302 B	CR 3550	Detection probability	
44-1101 A	Wiregrass 2012	2nd year Detection probability	
44-1101 C	Wiregrass 2012	2nd year Detection probability	
44-1102 A	K&K 700 '13	2nd year Detection probability	
44-1102 B	K&K 700 '13	2nd year Detection probability	
44-1102 D	K&K 700 '13	2nd year Detection probability	
44-1102 F	K&K 700 '13	2nd year Detection probability	
44-1102 G	K&K 700 '13	2nd year Detection probability	
44-1102 H	K&K 700 '13	2nd year Detection probability	
44-1103 A	Wiregrass Gate '12	2nd-year 3-survey protocol	
44-1103 C	Wiregrass Gate '12	2nd-year 3-survey protocol	

44-1103 D	Wiregrass Gate '12	2nd-year 3-survey protocol	
45-1002 B	CR 2520	Spot call	
45-1011 C	CR 1400/2400	2nd-year 3-survey protocol	
45-1012 A	CR 2431	Spot call	
45-1104 A	CR 2900 '13	2nd-year 3-survey protocol	Panther Creek
45-1104 B	CR 2900 '13	2nd-year 3-survey protocol	Panther Creek
45-1106 A	CR 2440 '13	Spot call	
45-1106 B	CR 2440 '13	2nd year Detection probability	
45-1106 C	CR 2440 '13	Spot call	Upper Beach Creek
45-1106 D	CR 2440 '13	2nd year Detection probability	Upper Beach Creek
45-1106 E	CR 2440 '13	2nd year HCP	
45-1201 A	CR 2510 '13	2nd year Detection probability	
45-1201 B	CR 2510 '13	2nd year Detection probability	
45-1202 A	CR 2500 '13	Detection probability	
45-1202 B	CR 2500 '13	Detection probability	
45-1202 C	CR 2500 '13	Detection probability	
47-1004 C	CR 1950 '11	2nd-year 3-survey protocol	Windy Point
47-1011 A	CR 1000/1900	2nd-year 3-survey protocol	
47-1011 B	CR 1000/1900	2nd-year 3-survey protocol	
47-1011 C	CR 1000/1900	2nd-year 3-survey protocol	
47-1011 D	CR 1000/1900	2nd-year 3-survey protocol	
47-1011 E	CR 1000/1900	2nd-year 3-survey protocol	
47-1013 A	BL 2260 Ridge '12	2nd year Detection probability	
47-1013 B	BL 2260 Ridge '12	2nd year Detection probability	
47-1014 A	BL 2630 '12	2nd year Detection probability	
47-1014 B	BL 2630 '12	2nd year HCP	

47-1018 B	CR 1012	2nd year Detection probability	
47-1018 C	CR 1012	2nd year Detection probability	
47-1018 D	CR 1012	2nd year Detection probability	
47-1018 E	CR 1012	2nd year Detection probability	
47-1019 D	CR 1600	2nd-year 3-survey protocol	Windy Point
47-1021 C	BL 3800 '12	2nd year Detection probability	
47-1025 A	BL 2400 '12	Detection probability	
47-1025 B	BL 2400 '12	Detection probability	
47-1025 C	BL 2400 '12	Detection probability	
47-1025 D	BL 2400 '12	Detection probability	
47-1025 E	BL 2400 ‘12	Detection probability	
47-1101 A	BL 2221 13	2nd-year 3-survey protocol	
47-1101 B	BL 2221 13	2nd-year 3-survey protocol	
47-1101 C	BL 2221 13	2nd-year 3-survey protocol	
47-1102 A	Caboose Gap	Spot call	
47-1102 B	Caboose Gap	Spot call	
47-1103 A	BL 2850	2nd-year 3-survey protocol	
47-1103 B	BL 2850	2nd-year 3-survey protocol	
47-1103 C	BL 2850	2nd-year 3-survey protocol	
47-1103 D	BL 2850	2nd-year 3-survey protocol	
47-1104 A	BL 2004	2nd-year 3-survey protocol	
47-1104 B	BL 2004	2nd-year 3-survey protocol	
47-1104 C	BL 2004	2nd-year 3-survey protocol	
47-1105 A	BL 2611 '13	2nd year Detection probability	
47-1105 B	BL 2611 '13	2nd year Detection probability	
47-1105 C	BL 2611 '13	2nd year Detection probability	

47-1105 D	BL 2611 '13	2nd year Detection probability	
47-1106 A	BL 2683 '13	2nd-year 3-survey protocol	
47-1106 B	BL 2683 '13	2nd-year 3-survey protocol	
47-1106 C	BL 2683 '13	2nd-year 3-survey protocol	
47-1107 A	BL 1300	Spot call	
47-1107 B	BL 1300 '13	2nd year Detection probability	
47-1107 C	BL 1300 '13	2nd year Detection probability	
47-1107 D	BL 1300 '13	2nd year Detection probability	
47-1201 A	BL 2650 '13	Detection probability	
47-1201 B	BL 2650 '13	Detection probability	
47-1202 A	BL 2300 Thin	2nd-year 3-survey protocol	
47-1202 B	BL 2300 Thin	2nd-year 3-survey protocol	
47-1203 A	BL 1600 Thin	2nd-year 3-survey protocol	
47-1203 B	BL 1600 Thin	2nd-year 3-survey protocol	
47-1204 A	BL 2006 '14	Detection probability	
47-1204 B	BL 2006 '14	Detection probability	
47-1204 C	BL 2006 '14	Detection probability	
47-1205 A	BL 2011	Detection probability	
47-1205 B	BL 2011	Detection probability	
47-1205 C	BL 2011	Detection probability	
47-1205 D	BL 2011	Detection probability	
47-1205 E	BL 2011	Detection probability	
47-1206 A	BL 2200 '14	Detection probability	
47-1206 B	BL 2200 '14	Detection probability	
47-1206 C	BL 2200 '14	Detection probability	
47-1206 D	BL 2200 '14	Detection probability	
47-1207 A	BL 2610	Detection probability	
47-1207 B	BL 2610	Detection probability	
47-1208 A	BL 2000 '14	Detection probability	
47-1208 B	BL 2000 '14	Detection probability	
47-1208 C	BL 2000 '14	Detection probability	
47-1208 D	BL 2000 '14	Detection probability	

47-1301 A	BL 2750	Detection probability	
47-1301 B	BL 2750	Detection probability	
47-1301 C	BL 2750	Detection probability	
47-1303 A	BL 3000/3500	Detection probability	
47-1303 B	BL 3000/3500	Detection probability	
47-1303 C	BL 3000/3500	Detection probability	
47-1303 D	BL 3000/3500	Detection probability	
47-1303 E	BL 3000/3500	Detection probability	
48-0801 C	K&K 900	2^{nd} year Detection probability	Garrett South
48-0801 F	K&K 900	2^{nd} year Detection probability	Garrett South
48-0803 D	K&K 860 '09	2^{nd} year Detection probability	
48-0804 A	Northern Siberia	2^{nd} year Detection probability	
48-0804 D	Northern Siberia	2^{nd} year Detection probability	
48-0804 E	Northern Siberia	2^{nd} year Detection probability	
48-1001 A	Wiregrass Extension	Detection probability	
48-1001 B	Wiregrass Extension	Detection probability	
48-1001 C	Wiregrass Extension	Detection probability	
51-0802 A	THP 574	2^{nd} year Detection probability	
51-0802 B	THP 574	2^{nd} year Detection probability	
51-0802 C	THP 574	2^{nd} year Detection probability	
51-0802 D	THP 574	2^{nd} year Detection probability	
51-0802 F	THP 574	2^{nd} year Detection probability	
51-0803 A	THP 577	2^{nd} year Detection probability	Upper Roach Creek
51-0803 B	THP 577	2^{nd} year Detection probability	Upper Roach Creek
51-0803 D	THP 577	2^{nd} year Detection probability	
51-0803 E	THP 577	2^{nd} year Detection probability	
51-1101 A	THP 590	2^{nd} year Detection probability	

51-1101 B	THP 590	2nd year Detection probability	
51-1201 A	THP 591	Detection probability	
51-1201 B	THP 591	Detection probability	
51-1201 C	THP 591	Detection probability	
56-0703 A	THP 562	2nd-year 3-survey protocol	
56-0703 C	THP 562	2nd-year 3-survey protocol	
56-0703 D	THP 562	2nd-year 3-survey protocol	
56-0703 F	THP 562	2nd-year 3-survey protocol	
56-0802 A	THP 570	2nd year Detection probability	
56-0802 B	THP 570	2nd year Detection probability	
56-0802 D	THP 570	2nd year Detection probability	
56-0803 A	THP 573	2nd year Detection probability	
56-0803 B	THP 573	2nd year Detection probability	
56-0803 C	THP 573	2nd year Detection probability	
56-0803 D	THP 573	2nd year Detection probability	
56-0804 A	THP 578	2nd year Detection probability	
56-0804 B	THP 578	2nd year Detection probability	
56-0804 D	THP 578	2nd year Detection probability	
56-0901 A	THP 581	2nd year Detection probability	
56-0901 B	THP 581	2nd year Detection probability	
56-1001 A	THP 584	2nd-year 3-survey protocol	
56-1001 B	THP 584	Spot call	
56-1001 C	THP 584	2nd-year 3-survey protocol	
56-1001 D	THP 584	2nd-year 3-survey protocol	

56-1001 E	THP 584	2nd-year 3-survey protocol	
56-1002 B	THP 585	2nd-year 3-survey protocol	
56-1002 E	THP 585	2nd-year 3-survey protocol	
56-1101 A	THP 586	2nd-year 3-survey protocol	
56-1101 B	THP 586	2nd-year 3-survey protocol	
56-1101 C	THP 586	2nd-year 3-survey protocol	
56-1302 A	CL 1000/1500	Detection probability	
56-1302 B	CL 1000/1500	Detection probability	
56-1302 C	CL 1000/1500	Detection probability	
56-1303 A	THP 596	Detection probability	
56-1303 B	THP 596	Detection probability	
56-1303 C	THP 596	Detection probability	
56-1303 D	THP 596	Detection probability	
61-0801 A	THP 579	2nd year Detection probability	
61-0801 C	THP 579	2nd year Detection probability	
61-0801 D	THP 579	2nd year Detection probability	
61-1301 A	S-line THP	Detection probability	
61-1301 B	S-line THP	Detection probability	
61-1301 C	S-line THP	Detection probability	
61-1301 D	S-line THP	Detection probability	
61-1301 E	S-line THP	Detection probability	
61-1301 F	S-line THP	Detection probability	
71-0801 A	THP 564	2nd-year 3-survey protocol	
71-0801 D	THP 564	2nd-year 3-survey protocol	
71-0803 A	THP 568	2nd-year 3-survey protocol	
71-0803 B	THP 568	2nd-year 3-survey protocol	
71-0803 C	THP 568	2nd-year 3-survey protocol	
73-1001 B	THP 580	2nd year Detection probability	

73-1001 C	THP 580	2nd year Detection probability	
85-0801 C	THP 571	Spot Call	
85-0801 F	THP 571	2nd year Detection probability	
87-1101 A	THP 587	Detection probability	
87-1101 B	THP 587	Detection probability	
87-1101 C	THP 587	Detection probability	
87-1101 D	THP 587	Detection probability	
93-0801 D	THP 567	Detection probability	
93-0802 B	THP 572	Detection probability	
93-0803 A	THP 575	2nd year Detection probability	
93-0803 B	THP 575	2nd year Detection probability	
93-0804 A	THP 576	2nd-year 3-survey protocol	
93-0804 B	THP 576	2nd-year 3-survey protocol	
93-0804 C	THP 576	2nd-year 3-survey protocol	
93-0804 D	THP 576	2nd-year 3-survey protocol	
93-0804 E	THP 576	2nd-year 3-survey protocol	
93-1101 A	THP 588	2nd year Detection probability	
93-1101 B	THP 588	2nd year Detection probability	
93-1101 C	THP 588	2nd year Detection probability	Winchuck River
93-1101 D	THP 588	2nd year Detection probability	
93-1101 E	THP 588	2nd year Detection probability	Winchuck River
93-1301 A	THP 593	Detection probability	
93-1301 B	THP 593	Detection probability	
93-1301 C	THP 593	Detection probability	
93-1301 D	THP 593	Detection probability	
93-1302 A	THP 594	Detection probability	
93-1302 B	THP 594	Detection probability	Lower SF Winchuck
93-1302 C	THP 594	Detection probability	Lower Gilbert Creek

93-1302 D	THP 594	Detection probability	Lower SF Winchuck
93-1302 E	THP 594	Detection probability	
93-1302 F	THP 594	Detection probability	Lower SF Winchuck
94-1101 A	THP 589	Detection probability	
94-1101 B	THP 589	Detection probability	
94-1101 C	THP 589	Detection probability	
94-1101 D	THP 589	Detection probability	
95-0801 B	THP 563	Detection probability	
95-0801 C	THP 563	Detection probability	

Spot call survey type indicates a unit was surveyed in 2012 to meet HCP protocol standards. These units were cut continuously through the beginning of the survey period. They were called once a week until less than 10 acres of continuous timber was standing or until four calls were completed.

2nd-year 3-survey protocol type indicates a unit was surveyed in both 2012 and 2013. Because these units were surveyed in consecutive years, three surveys were conducted in 2013 to meet HCP protocol standards prior to the implementation of the detection probability protocol.

Four-survey protocol type indicates a unit was surveyed four times in 2013 to meet HCP protocol standards prior to the implementation of the detection probability protocol. These units were not surveyed in the prior year.

Detection probability survey type indicates a unit was surveyed four to six times in 2013 until 95% probability of detection was achieved.

2nd year Detection probability survey type indicates that a unit was surveyed in 2012 to meet HCP protocol standards in 2012, but was surveyed four to six times in 2013 until 95% probability of detection was achieved.

Appendix II. Raw data for pre-harvest habitat retention measures for individual THPs summarized in Table 1 (2013).

THP #	Name	Units	Acres	GWT/acre	Snags/acre	# HRA	HRA Acres
14-1201	Salmon Creek Ctrl.	5	108.51	0.00	0.20	8	8.00
17-1202	Roddi 1000	2	58.54	0.00	0.50	2	1.50
17-1203	2013 Victor Lake	3	113.37	1.57	1.00	0	0.00
26-1103	Long Prairie	4	102.17	2.00	0.50	0	0.00
26-1201	CB 1100	8	273.24	0.89	0.50	0	0.00
26-1203	Fulton Ranch ‘14	5	131.48	0.00	0.20	3	3.00
26-1204	Ward Road 2014	2	66.54	0.00	0.00	1	1.03
26-1301	Lupton North ‘14	3	72.96	0.00	0.50	6	7.00
26-1302	Bald Mtn. 1200 ‘14	4	77.49	3.17	1.95	7	3.90
27-1201	Fernwood 2014	3	109.38	1.75	1.00	0	0.00
35-1201	351201	1	188.74	0.00	1.00	0	0.00
43-1201	CR 2230 ‘13	2	63.98	1.58	0.25	1	0.68
43-1202	CR 2761 ‘13	2	62.71	1.79	0.10	0	0.00
43-1204	CR 3500 ‘12	1	14.76	0.68	0.10	1	1.40
43-1301	CR 2420-CR2008	3	72.16	2.00	0.33	2	1.90
43-1302	CR 3550 ‘14	2	49.93	2.20	0.10	2	1.50
45-1202	CR 2500 ‘13	3	106.72	1.43	0.60	1	1.50
47-1201	BL 2650 ‘13	2	72.40	0.00	1.50	0	0.00
47-1202	BL 2300 Thin ‘13	2	323.55	0.00	0.00	0	0.00
47-1203	BL 1600 Thin	2	151.97	1.00	0.30	0	0.00
47-1204	BL 2006 ‘14	3	67.05	1.50	0.13	1	0.50
47-1205	BL 2011	5	149.31	1.51	1.60	0	0.00
47-1206	BL 2200 ‘14	4	113.73	0.00	0.50	1	1.00
47-1207	BL 2610 ‘14	2	69.89	0.44	3.00	0	0.00
48-1201	K&K 940 ‘14	2	49.94	0.00	0.75	3	4.50
51-1201	THP 591	3	56.75	2.45	0.50	0	0.00
93-1101	THP 588	5	147.02	0.25	1.00	0	0.00

Appendix III. Raw data for post-harvest habitat retention for individual THPs summarized in Table 3 (2013).

THP #	Acres	Name	Pre GWT /acre	Post GWT /acre	Pre snags /acre	Post snags /acre	HRA #	Pre HRA acres	Post HRA acres	WLPZ acres
14-0801	193.51	Salmon Creek '09	0.95	0.99	0.20	0.20	1	0.50	0.50	28.0
14-0901	96.15	Tom's Gulch #1	0.00	0.00	0.20	0.20	3	2.50	2.50	0.50
15-0702	133.58	WA Gulch THP	0.90	0.90	1.00	1.00	1	0.50	0.50	24.5
17-1001	171.46	Graham Ridge '11	1.90	1.90	0.25	0.25	0	0.00	0.00	28.9
17-1101	100.48	Boulder Creek South '12	0.00	0.00	0.50	0.33	2	1.00	1.00	13.2
22-1002	56.89	FH 1300 2012	0.00	0.00	0.25	0.25	1	1.00	1.00	12.5
24-1002	124.77	Ward Road 4 Pack	1.69	1.21	1.00	0.05	0	0.00	0.00	23.2
26-0801	52.27	Lord Ellis S.	2.16	2.16	0.00	0.10	0	0.00	0.00	6.0
26-1001	69.20	Hungry Hollow '10	0.00	0.00	0.13	0.00	2	1.10	1.10	10.1
26-1002	74.65	CB 1000 '12	0.00	0.00	0.19	0.23	0	0.00	0.00	21.9
26-1101	135.49	Pollock Creek '12	0.00	0.00	0.42	0.42	0	0.00	0.00	18.9
27-0802	68.31	High Prairie '08	1.72	1.72	0.50	0.50	0	0.00	0.00	24.3
27-0804	60.60	Fernwood '08	0.00	0.00	1.00	2.00	0	0.00	0.00	22.0
27-0806	64.35	Lupton Creek '08	0.00	0.00	0.20	0.20	0	0.00	0.00	19.0
27-1001	89.49	Bald Mtn. 2012	2.93	2.61	0.01	0.15	2	2.00	2.00	13.0
34-1001	72.28	McKinleyville East	1.00	1.14	0.20	0.20	1	0.50	0.50	10.0
34-1101	246.32	341101	0.00	1.00	0.20	0.20	0	0.00	0.00	18.6
35-1201	188.74	351201	0.00	0.00	2.00	2.00	0	0.00	0.00	14.0
37-1001	19.87	CR 2270 '11	0.00	0.76	0.25	0.25	0	0.00	0.00	3.8
38-0802	134.78	Ribar West 2010	1.75	1.75	0.20	0.20	1	0.50	0.50	13.5
40-1003	81.20	K&K 130/N. Fork 1900	0.00	0.00	0.10	0.10	3	1.50	1.50	11.0
41-0701	53.63	CR 2150	0.00	0.00	0.50	0.10	0	0.00	0.00	17.5
41-1001	104.29	CR 2134/2220 '11	0.00	0.00	0.30	0.16	1	0.50	0.50	16.5
42-0801	174.44	K&K 100	0.00	0.00	1.00	0.50	3	6.00	6.00	31.4
42-1001	58.15	CR 3360 '11	0.00	0.00	1.00	1.00	2	1.00	1.00	5.00
42-1002	118.94	K&K 490 '11	0.00	0.00	0.50	0.50	0	000	0.00	21.8
42-1003	59.43	Mule Creek '10	0.00	0.00	1.00	1.00	1	0.50	0.50	6.7
43-0706	169.24	Crannell 2310	0.00	0.00	0.20	0.18	2	3.70	3.70	37.8
43-0708	157.49	CR3300/3000	1.87	1.56	0.50	0.23	0	0.00	0.00	40.1
43-0802	82.54	CR3120/3170	1.93	1.93	0.50	0.33	0	0.00	0.00	7.40
43-1001	98.18	CR3543 '11	1.80	1.80	0.20	0.28	1	0.50	0.50	21.0
43-1002	123.09	CR2710 '11	2.14	2.14	.05	.21	0	0.00	0.00	31.0
43-1004	110.97	CR2230/3120	1.72	1.72	0.50	0.50	1	0.50	0.50	25.5
43-1005	34.70	CR2200/3100 '12	0.00	0.00	0.00	0.75	2	1.00	1.00	1.20
45-0902	134.95	CR2019 '10	2.23	2.32	0.10	0.05	0	0.00	0.00	25.3
45-1001	74.45	CR2432 '11	0.80	1.11	0.50	0.31	0	0.00	0.00	12.0

45-1002	154.41	CR2520 ‘11	0.83	1.03	0.20	0.26	0	0.00	0.00	42.6
45-1010	87.73	451010	1.04	1.04	1.00	1.00	0	0.00	0.00	30.0
45-1012	111.23	CR2431	0.00	0.00	0.56	0.50	1	1.20	1.20	22.0
45-1013	110.26	451013	0.87	0.16	0.20	0.33	0	0.00	0.00	25.4
45-1101	106.71	CR2540 ‘12	0.00	0.00	0.30	0.37	1	0.50	0.50	28.5
45-1102	127.29	451102	0.00	0.00	0.50	0.50	0	0.00	0.00	39.0
45-1103	137.55	CR2460 ‘12	0.00	0.00	0.10	0.33	0	0.00	0.00	40.0
45-1105	83.00	CR2550 ‘12	0.79	0.79	0.50	0.50	0	0.00	0.00	17.3
47-0703	179.69	BL 2840-07	1.85	1.85	1.50	0.33	0	0.00	0.00	33.9
47-0707	99.11	BL 2682	0.00	0.00	0.50	0.37	0	0.00	0.00	36.5
47-0714	140.41	BL 27/2800	0.00	0.00	0.75	0.55	0	0.00	0.00	29.7
47-0804	121.16	BL 2643	1.06	1.06	0.40	0.40	0	0.00	0.00	22.4
47-0805	162.83	BL 2720	0.00	0.00	0.00	0.25	1	0.50	0.50	27.0
47-0806	114.93	BL 2007/11	0.86	0.86	0.40	0.10	0	0.00	0.00	26.3
47-0807	122.70	BL2005/BL2010	0.00	0.00	0.20	0.13	0	0.00	0.00	24.3
47-0904	155.80	BL2220/3100	0.00	0.00	0.44	0.44	1	0.50	0.50	52.0
47-1001	162.39	CR 1940 ‘11	0.00	0.00	0.75	0.75	1	0.50	0.50	35.7
47-1009	51.69	BL 2012.5 ‘11	2.01	2.01	0.20	0.20	0	0.00	0.00	1.00
47-1010	129.98	BL 2500/2700	0.00	0.00	1.00	1.00	2	1.40	1.40	22.0
47-1015	114.48	BL 2640 ‘12	0.00	0.00	1.00	1.00	0	0.00	0.00	46.7
47-1017	107.92	CR 1921	0.00	0.00	0.33	0.53	0	0.00	0.00	25.5
47-1019	78.95	CR 1600 ‘12	0.97	1.47	0.50	0.63	1	0.50	.50	15.0
47-1022	113.76	BL-1500	0.00	0.00	1.00	1.00	1	0.50	0.50	21.0
47-1024	287.15	BL 1200/1000 Thin	0.00	0.00	1.00	2.00	0	0.00	0.00	60.0
48-0802	84.92	Old K&K 200	0.00	0.00	0.50	0.50	1	0.50	0.50	16.8
48-1101	88.43	K&K 830 ‘12	1.82	1.82	0.50	0.25	2	2.75	2.75	1.00
61-0701	111.51	THP 549	2.04	1.66	1.00	1.00	1	0.00	0.50	25.5
93-0702	92.67	THP 557	0.83	0.89	0.50	0.38	0	0.00	0.00	36.3

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Appendix IV. Abandoned and Recolonized owl sites on the Green Diamond Resource Company study area, 1993-2013.

Site Name	Year(s) Abandoned	Year(s) Recolonized
4107	1997	2010
4128	1995	2010
4230 #2	1994	2010
4300	1996	2011
4850	2008	
6007	1994, 2000	1997, 2001
6400	2007	
6600	2000, 2010	2004, 2011
6610	2013	
7000	2005	2006
A400	2001	
Ah Pah Mouth	1996	
Aldo Dusi	2000	2003
Arrow Mills	2009	
B.C. Powerline	1996	
B10	2008	
B1200	1998	
B140	1997, 2010	2006
B900	2009	
B922	1995	
Bald Mt. Creek	2008	
Bear Creek - Klamath	1993	
Bear Gulch	2002	
Bear Mouth	2009	
Beaver Creek	2009	
Beaver West	2011	
Big Lagoon Mill	2007	
Blue Creek Cabin	2009	
Boulder Creek #1	1998	2011
Boulder Creek #3	2007	2008
Boulder Creek #4	2000	2012
Boulder Creek #5	2007	2010
Boundary Creek	2002	2005
Bradford Creek	1995	
Bradford West	2001	2002
Bradshaw	2007	
Bug Creek	2000	
Butler Ridge	2010	
C2100	1996	

Site Name	Year(s) Abandoned	Year(s) Recolonized
C2300	1998	2001
Cabin North	2001	
Cal Barrel	2012	
Camp Bauer	2008	2009
Canyon Creek #2	2000	
Cedar Creek	2003	
CL1010	2008	
Crowsfoot	2005	
D100	1999	
Dandy Creek	2005	
Denman	2009	
Devil's Creek	1994	1999
Dolf Creek	1998	
Dolly Varden	2009	
Dominie Creek	1994	
Eighteen Creek	2001	
Fielder Creek	2002	
Fish Creek	2001	
Fulton Ranch	2008	
GAP	2007	
Gardelia	1996	
Girls Camp	1997	2013
Girls Camp North	2001	
Graham Ridge	2000	2013
Graham West	1997	
H132	1995	
Hancorne Prairie	1999	
High Prairie 340	2001	
Humbug South	1997	
Hunter 110	1999	
Hunter 240	2005	
Hunter 300	1999, 2008	2003, 2010
Hunter 410	1996	
Hunter 510	1996	
Jackson Hill	2013	
Jacoby Barnum	2003	
Jacoby Creek #1	2007	
Jiggs Creek	2009	
K&K 1400	2000	
K&K 400	2001	
K&K 600	2001	
Kermit	2001	
Klamath Mill	2011	

Site Name	Year(s) Abandoned	Year(s) Recolonized
L2000	1996	
Lake Prairie Franklin	1996	
Lindsay Creek	1998	
Liscom Hill	2001	
Little Deer Creek	1997	1998
Little River #1	2010	
Little Surpur	2001	
Lower Beach Creek	2012	
Lower Potato	2009	
Lower Ribar	2000	
Lower Roach	1995, 2007	1996
Lower South Fork #1	2004	
Lower Tulley Creek	2003	2007
Lucchesi SPI	2004	
Lupton Creek #2	2001, 2005	2002, 2006, 2009
Lupton Creek #3	2009	
M1150	1995	1996
Madrone Creek	1997, 2007	2001
Madrone South	2008	
Maple B.L. #1	2002	
Maple Creek Bridge	2007	2009
Martin's Ferry #2	2008	
Mather #1	2008	
Mather #2	2002	2006
McDonald Creek	2001	
McGarvey Creek	1998	
Mettah Creek #1	1994	
Mettah Creek #2	1999	
Mettah Forks	2011	
Middle Ribar	2010	
Middle Tulley Creek	1996	
Mill West	2000	
Minon Creek	2001	
M-Line Creek	2009	
Morek Creek	2007	2009
Morgan Creek	2008	2011
Muddy Creek	2007	
NF1300	2007	2009
Noisy Creek	1996	1997
North Fork Maple Creek	2004	
Notchkoo	1996	1997
Old 299 #2	2006	

Site Name	Year(s) Abandoned	Year(s) Recolonized
Omagar Creek	2003	
Omagar East	1998	
P200	2000	
Panther East	2005	
Pardee Creek	1995	
Pollock Creek #1	1995	
Potato Patch	1997	
Powerline North	2007	2008
Quarry Creek	2011	2013
R-8-1	2009	2011
R13	2004	2009
R1400	2008	
R15	2008	
Redwood House	2006	2010
Ribar Rock Pit	2003	
Rice Windy	2000	
Roach LP	1998	
Rock Ranch	2004	
Rocky Gulch	2000	
Rowdy Creek	1992	
S12	1999	
Salmon Creek #4	1996	2009
Sampson	1993	
SF Ah Pah Creek	2003	
Snow Camp Creek	2009	
SP 10	2010	
Stone Lagoon	2013	
Substation	2008	2009
Summit West	1997	
Surpur Creek	1998	
Surpur Mouth	1996	
T300	2003, 2010	2004, 2011
Tectah Mouth	2001	
Terwer 200	2001	
Thompson	2001	
Tom Creek	2002	
Toss-Off South	2006	
Toss-Up Creek	2011	
Tree Farm	2003, 2012	2004, 2013
Tree Farm North	1996	2003
U10	2000	
U700	1997	
Upper Little River	2009	

Site Name	Year(s) Abandoned	Year(s) Recolonized
Upper Maple BL	2011	
Upper Maple Creek	1995	2009
Upper Morgan	2008	
Upper Pardee	1997	
Upper Ribar	2002	
Upper Roach Creek	2002	2012
Upper South Fork #1	2012	
Upper South Fork #2	2002	
Upper Tulley Creek	1999	
W. Goodman Prairie	2001	
W100	2010	
W400	1998	2008
West Fork Stevens	2006	
Weyerhauser Shop	2000	
Wiggins Pond	2005	
Wildcat Creek	2001	
Williams Ridge	1998, 2006	2002, 2013
Windy Point	2006	2010
WM1600	1998	
WM200	2008	

OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- GREEN DIAMOND RESOURCE COMPANY - SUMMARY OF IMPLEMENTATION AND FINDINGS FOR THE GREEN DIAMOND NSO HCP SINCE 1992; KEITH HAMM, CONSERVATION PLANNING MANAGER, CALIFORNIA TIMBERLANDS

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CRANE MILLS AND THE NORTHERN SPOTTED OWL POPULATION TRENDS, 1989 THROUGH 2013

This paper summarizes comments made by Frank Barron, Chief Forester, at the NSO Science Forum hosted by the California Forestry Association on October 29, 2013 in Sacramento at the Hyatt Hotel. The original comments were made as part of a Powerpoint presentation to forest products industry representatives and California Department of Fish and Wildlife (DFW) personnel.

Background

Crane Mills is a third generation family-owned company that owns 92,000 acres of forest land in six counties: Tehama (68,100 acres); Shasta (16,100 acres); Trinity (6,400 acres); Siskiyou (1000 acres); Butte (300 acres); and Plumas (100 acres). The first acquisition of 36,000 acres was made in 1945. The most recent large acquisition of 20,000 acres was made in 2001 when we purchased the North and Middle Commander Tracts from Pioneer Resources (formerly Louisiana Pacific land). Ninety-nine (99) percent of the ownership is in the range of the Northern Spotted Owl (*Strix occidentalis caurina*). Ninety-eight (98) percent of the ownership is in the Interior Coast Range Mountains. Other than the Trinity County ownership, the entire company land base drains into the Sacramento River system. The Trinity County ownership is tributary to the Trinity River.

Mixed conifer forest is the dominant vegetation type on the ownership. Klamath Mixed Conifer (KMC) and Montane Hardwood Conifer (MHC) are the most prevalent WHR habitat types. Conifers present are ponderosa pine, sugar pine, Douglas-fir, white fir, and incense cedar with some red fir above 6000 feet. Hardwood species present are black oak, interior live oak, tanoak (in Shasta and Trinity Counties), big-leaf maple, and white alder. The latter two species are primarily in riparian areas. Species composition is strongly driven by aspect with south aspects having more pine, and north aspects having more Douglas-fir relative to the other mixed conifer species. Average annual precipitation on the Tehama County “Main Block” is 50 inches.

For the purposes of this discussion, the “Main Block” refers to the Tehama County property, and the “North Block” refers to the Shasta, Trinity, and Siskiyou County properties. The Butte and Plumas County properties are not within the range of the NSO.

Silviculture

Historically, Crane Mills has managed its forest land with an uneven-aged objective and maintained more or less continuous forest cover over the ownership. The first 30 years of harvesting was characterized by high-risk sanitation salvage. Our first efforts in artificial regeneration began in 1979 after the Skinner Mill Fire (1976) in western Tehama County. In the late 1970’s and early 1980’s, Selection or Modified Selection was the most often used silvicultural prescription in our Timber Harvest Plans (THP). By the mid-1980’s and early 1990’s we were moving towards Modified Selection and Alternative prescriptions in recognition of the need to open up canopy to encourage survival and growth of our future timber stands. Since 1994 we have used Alternative prescriptions almost exclusively which are a mix of

Modified Shelterwood Removal (i.e. partial overstory removal) and thinning of the understory with residual basal areas of trees ≥12" DBH under the Selection standards of 75 sq. ft.. There are only two 20 acre clearcuts on the Main Block as of this date. The clearcuts were in high elevation true fir stands that were falling apart. With the purchase of the Pioneer property in 2001, we acquired a lot of land that had been managed with an even-aged objective. In the future, we will probably move toward a hybrid between even-aged and uneven-aged silviculture.

In 2008, about 7300 acres of the North Block burned with varying intensities in the Moon Complex Fire in western Shasta County. Salvage logging was completed in 2012 on those portions of the burn area that were accessible to conventional tractor and cable logging. Reforestation efforts are continuing and will result in the establishment of even-aged units. Future fires will probably lead to the establishment of more even-aged units.

Most of the North Block contains a significant amount of brush- and tree-form tanoak in the understory. We have utilized the Rehabilitation prescription on some of our recent THPs on the North Block which has also created even-aged units. This trend will continue in the future where we have significant tanoak competition with our mixed conifer stands.

<u>Main Block Survey History</u>

Surveys began in 1989 in anticipation of the listing of the NSO under the ESA to determine the amount of exposure that we had to harvesting restrictions due to the presence or absence of the NSO. Those early surveys were extensive in nature, covered the entire Main Block at the time (which consisted of about 47,000 acres), and were intended to determine the presence/absence of NSO not the status of owls detected. The surveys were conducted by the Crane Mills forestry staff. Call points were established after consultation with California Department of Fish & Game (DFG) biologists. Louisiana Pacific foresters and biologists did the same on their land which would later (2001) become part of the Crane Mills ownership.

Once the NSO was listed in 1990 and the USFWS produced survey protocols in 1992, our survey efforts were project-driven, that is, tied to avoiding "take" on Timber Harvesting Plans (THP). In the 1990's, consultations were with DFG and we utilized a Private Consulting Biologist (PCB) to write the reports and request "no take" determinations. In the 2000's, we obtained Technical Assistance (TA) for our THPs from the USFWS under Forest Practice Rule sections 939.9(g) and (e). Beginning in 2009, requests for TA went through the California Department of Forestry and Fire Protection (CDFFP) using one of the Scenarios provided by USFWS to the CDFFP for guidance. Since 2011, CDFFP has been passing through our requests for Technical Assistance under 939.9(e) to the USFWS because all of our activity centers are in "deficit" condition under current habitat definitions.

Since 1989, the Crane Mills forestry staff has done most of the survey calling. In certain years and in certain locations contract surveyors have been utilized where we could not handle the work load ourselves. Surveys were initially conducted with taped calls. We gradually transitioned to voice calling which we utilized up until 2011. Since 2011, we have used electronic calling devices (i.e. FoxPro) as directed by the latest USFWS protocols.

Other than the first two or three years of calling beginning in 1989 when we surveyed the entire Main Block, our surveys have been tied to THPs. We now have 25 years of calling records, plus associated status determinations for our Main Block. Because we are on a 20 to 25 year cutting cycle, not all NSO activity centers are surveyed every year. There are often 10 to 20 year gaps between detections and/or status determinations. Demographic studies and banding/tracking of individual owls have never been conducted by our forestry staff due to time, manpower, and money constraints.

Coordination with adjoining landowners has occurred from time to time over the last 25 years. Prior to the purchase of the Commander Tract from Pioneer, we cooperated with Louisiana Pacific and then Pioneer Resources on surveys where it was feasible to do so. The Mendocino National Forest is our main neighbor but survey coordination has been infrequent over the years because their survey program is also project-driven. The USFS simply has not had many projects over the last 20 years where it was possible to cooperate with them on surveys.

North Block Survey History

Surveys began in 1992 with one of our THPs in Shasta County. Since then, surveys generally have been conducted by the Crane Mills forestry staff with occasional help by contract survey crews. In the 1990's, we utilized the services of a PCB to supervise our calling and to write the reports for DFG. Federal and state agency involvement in "no-take" or take avoidance determinations has followed the same course as described above in the Main Block Survey History discussion.

Surveys have been THP-driven. We have 21 years of survey records and associated status determinations for portions of the North Block. We have never conducted extensive block-wide surveys for the North Block. Demographic studies and banding/tracking of individual owls have never been conducted by our forestry staff due to time, manpower, and money constraints.

Coordination with adjoining landowners has occurred from time to time over the last 21 years, mostly with Sierra Pacific Industries.

NSO Population Trends

Our estimates of occupied NSO activity centers are based upon 25 years of survey experience with the same piece of ground. In 2013, we analyzed the DFW NSO database and our own company NSO database and survey records. Our database includes survey data collected by Louisiana Pacific/Pioneer Resources, whose land we acquired in 2001. Some USFS survey information is contained in the DFW NSO database, but most of it dates from 1981 to 1992 when almost all timber harvest activity ceased on the Mendocino National Forest. As a result, almost all USFS survey work also came to halt. However, in the last two years, we have coordinated with the Mendocino NF on owl surveys in a few areas.

In the early 90's we estimated that there were 30 to 35 occupied activity centers (then called territories). Based upon the above described analysis, we now have 38 occupied activity centers. The acquisition of LP/Pioneer in 2001 probably added 4 to 5 occupied activity centers that were not previously included in the early 1990's estimate because they were outside the 1.3 mile buffer around company land.

The table below summarizes some basic information about the 37 occupied activity centers on our Main Block. Of the 37 occupied activity centers, 43% are on public land, 25% are on Crane Mills property, and the remaining 32% are a combination of both public and private land that the owls are using for nesting and roosting. Our experience over 25 years of surveying has shown that the owls use our land for at least roosting and foraging whether it fits the current definition of suitable habitat or not. It should be noted that the definition of suitable habitat has changed several times since 1990. In the table below, MNF = Mendocino National Forest and CM = Crane Mills. "AC Name" refers to the "DB Name" in the attached spreadsheet.

AC Name	**# Yrs Detected**	**Date Range of Surveys**	**Landowner**
ME410	6	1992-2013	MNF
TE015	3	1982-2013	MNF
TE016	5	1992-2013	MNF/CM
TE017	3	1991-1999	MNF
TE023	4	1994-2003	MNF
TE024	13	1989-2012	MNF/CM
TE025	5	1987-2013	MNF
TE027	7	1991-2006	MNF
TE028	7	1994-2007	MNF
TE029	7	1992-2005	MNF
TE030	6	1992-2013	MNF
TE031	7	1996-2004	CM
TE032	2	1992-2002	MNF
TE033	8	1992-2013	CM/MNF
TE035	8	1988-2013	MNF/CM
TE036	5	1993-2013	MNF
TE037	10	1992-2013	MNF/CM
TE039(W)	4	1998-2002	CM/MNF
TE041	3	1994-2002	CM/MNF
TE043	6	1994-2013	CM
TE050	1	1996	MNF
TE051	1	1992	CM
TE072	2	1990-2013	CM
TE075	10	1989-2013	CM
TE087	5	1998-2013	CM/MNF
TE106	5	1992-2004	MNF/CM
TE111	3	1995-1998	CM
TE114	6(7?)	1991-2013	MNF
TE115	3	1998-2002	MNF
TE116	2	1991-1999	MNF/CM
TE117	4	1996-2013	MNF

TE133	5	1994-2002	MNF/CM
TE147	2	1999-2002	CM
TE112/148?	3	1991-2006	CM
(Govt40)P99	1	1998	MNF
RP01	5	1998-2013	CM
Slate Creek	2	2001-2002	CM/MNF

Only one barred owl has been located on our Main Block and this individual owl has remained in the same location for the last five years. This owl is in the upper NE corner of our Main Block at the lower end of timberline adjoining an area that was severely burned in 1976. We have never picked up an NSO in this area since we started surveying in 1989.

In summary, the following general observations can be made from our analysis of the Main Block data: 1) occupied activity centers have consistently been found in every major drainage since 1989 (c.f. attached map); 2) reproductive activity is usually encountered annually somewhere on the ownership; 3) the owl population is stable; and 4) habitat on the ownership is at or near full utilization. It should be noted that there are a large number of apparently unoccupied activity centers in the state database, but it is our opinion that many of these were the result of night-time detections being treated as territories in the early years of database development. It is also likely that an owl pair uses more than one activity center over a period of years, rotating possibly between 2 or 3 different sites that are in the same general area.

Population trends for the North Block ownership are harder to discern because there has only been one occupied activity center on or near (within 1.3 miles) active harvesting operations over the last 22 years. A block-wide extensive survey has never been conducted so no baseline exists with which we can make comparisons. However, survey efforts over that time period for THPs in various locations on the North Block (Rainbow Lake, French Gulch, Bohemotash Mountain, North Salt Creek, Ney Springs, and the McCloud River) have not detected any NSO presence other than the one activity center in the Moon Fork of Cottonwood Creek. The one known activity center and the surrounding suitable habitat was severely burned in 2008 by the Moon Complex Fire (Shasta County) and subsequently salvage-logged. The owl has not been detected in the area since 2009. In fact, over one-third of the North Block acreage has been affected by wildfire since 1990.

Low utilization of habitat on the North Block ownership can be attributed to: 1) low elevation; 2) warmer air temperatures; 3) dense tanoak in the understory; and 4) proximity to foothill woodland and chaparral vegetation types. Stated another way, habitat on the North Block is on the forested fringe of the NSO range. There is presumably better habitat on the Trinity County portion of our North Block, but we have not harvested in that area since purchasing the properties in the 1970's except for some minor sanitation/salvage logging in response to high-wind or fire events. We have not surveyed any of the potential habitat in that area because we have not proposed any THPs in the area.

Personnel

Crane Mills foresters that have been involved in NSO surveys and status determinations since 1989 include Roy Henson (RPF #969), Frank Barron (RPF #2007), Mark Pritchard (RPF #2564), Jeff Caster (RPF #2658), David Haas (RPF #2950), Julian Howell, and Kevin Berry. The services of Peter Lewendal, Private Consulting Biologist, were utilized from the mid-1990's through 2001. Louisiana Pacific/Pioneer Resources wildlife biologists involved were Ben Rowe and Matt Reischman.

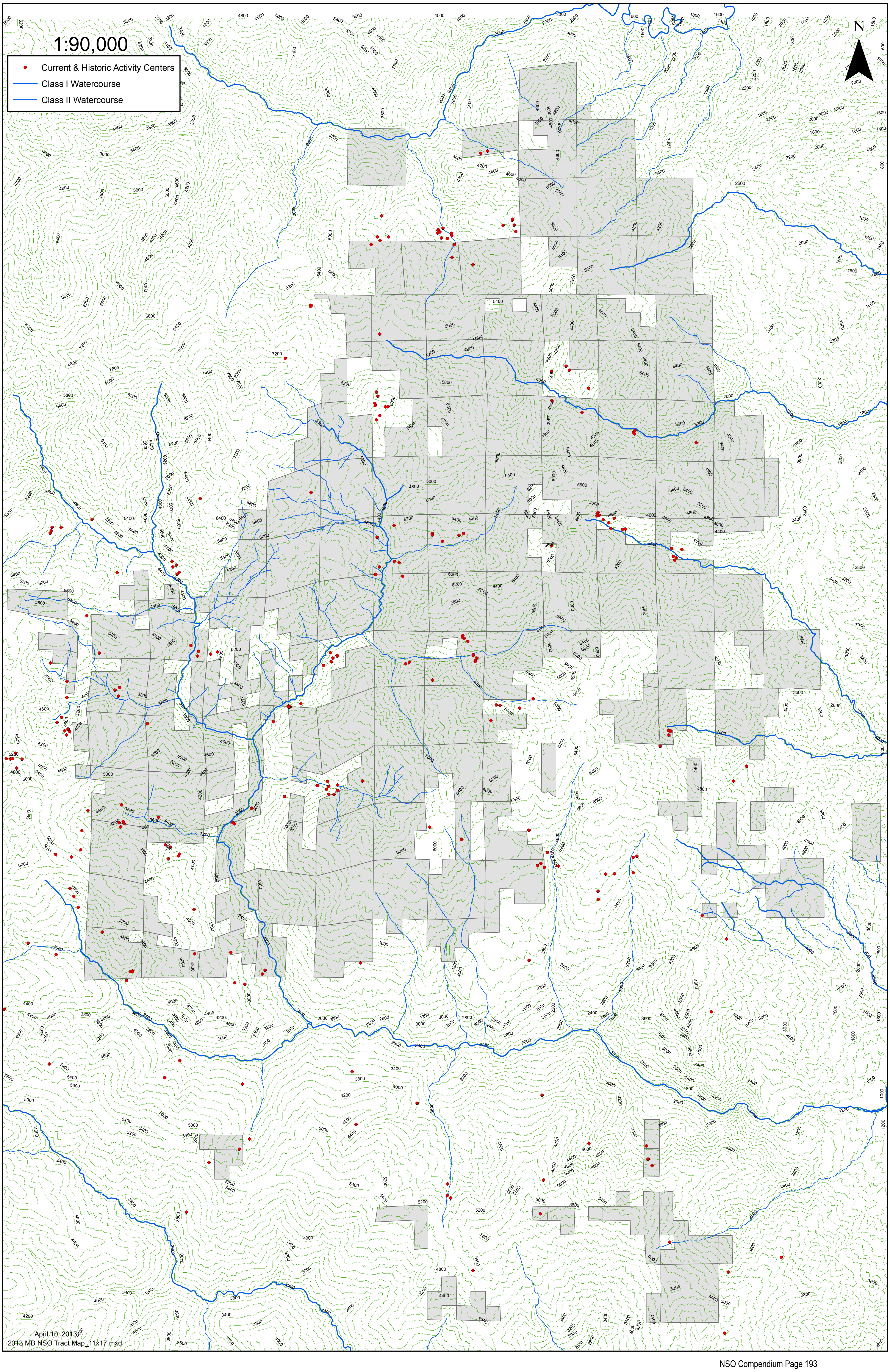
In the 1990's, DFG biologists that we worked with were Tom Stone, John Hummel and Jack Miller. USFWS biologists that have provided Technical Assistance include Jan Johnson, Jennifer Jones, and Tim Burnett (no longer with USFWS). We also have worked with Linda Angerer and Cherie Keckler from the Mendocino National Forest on NSO and other wildlife issues.

Consultants that have assisted with surveys include W. M. Beaty & Associates, Black Fox Timber Management Group, Klamath Wildlife Resources, Mason, Bruce, & Girard (for Louisiana Pacific and Pioneer Resources), Olympic Resource Management, and Vasquez Forest Management.

Attachments

2013 MB NSO Tract Map_11x17.pdf
CM_NSO_ACtable_Rev.xls

FMB 01/28/2014


1:90,000
Current & Historic Activity Centers
Class I Watercourse
Class II Watercourse
N
April 10, 2013
2013 MB NSO Tract Map_11x17.mxd

CRANE MILLS NSO DATABASE: DETECTIONS & STATUS DETERMINATIONS--PRELIMINARY UPDATE & REVISION THROUGH 2013 SEASON, 01/28/2014						
Name	DB Name	Status	Dte	TRS	Notes	CM #
	GLE022	DFG, HT, U	1991/05/13	230706	DFG Database location. Nighttime response. 1U. MDNF.	0
	ME410	DFG, Reprod. Pair, 2 yng	1992/08/11	241012	DFG Database Location. Time = 1119. Pair w/2 young. MDNF.	0
	ME410	Nesting Pair, 1 yng	2009/07/22	241011	Nest time = 0745. One fledgling, ambulatory & able to fly short distances. No nest in sight.	0
	ME410	Roosting Pair	2010/07/16	241012	Roost time = 0700	0
	ME410	Roosting Single	2011/06/29	241012	Roost time = 1309	0
	ME410	Roosting Single	2012/05/01	241012	Male; Roost time = 1340	0
	ME410	Roosting Single	2013/05/06	241013	Unknown sex, Roost time =1313, owl ate 3 mice	
	ME420	DFG, HT, M	1992/06/04	241002	DFG Database location. Nighttime response. 1M. MDNF.	0
Cull Pile	Pair 3(?)	Roosting Male	2002/06/02	250827	Roost time = 0710. Klamath Wildlife Resources for CM.	53
	TE002	DFG, HT, M	1993/05/04	230910	DFG Database location. Nighttime response. 1M. Spence-Closson.	0
	TE003	DFG, HT, Pair	1981/06/30	230912	DFG Database location. Nighttime response. Pair. Cordano.	0
	TE004	DFG, HT, U	1981/07/27	230918	DFG Database location. Nighttime response. 1U. Cordano.	0
	TE005	DFG, HT, F	1990/07/11	230815	DFG Database location. Nighttime response. 1F. MDNF.	0
	TE015	Pair	1982	240827	From 1999 Prong THP NSO Pre-survey Consultation Map.	0
	TE015	DFG, HT, M	1992/04/27	240827	DFG Database location. Nighttime response. 1M. MDNF	0
Dark Canyon 2	TE016	Pair	1992	240828	From 1999 Prong THP NSO Pre-Survey Consultation Map.	37
Dark Canyon 2	TE016	DFG, Reprod. Pair, 1 yng	1992/06/08	240828	DFG Database location. Pair, 1 Young. Ponting.	37
Dark Canyon 2	TE016	Roosting Pair	2000/03/24	240827	Roost time = 1352	37
Dark Canyon 2	TE016	Roosting Male	2001/06/20	240827	Roost time = 1315	37
Dark Canyon 2	TE016	Roosting Male	2012/05/11	240822	Roost time = 1400, 2 mice taken/eaten	37
Dark Canyon 2	TE016	Roosting Pair	2013/05/06	240827	Roost time = 0816, 2 mice eaten, roost site used over long period of time, no nesting behavior observed	
	TE017	DFG, Roosting Pair	1991/07/24	240823	DFG Database location. Time = 1200. Pair. MDNF.	0
	TE017	Nesting Pair, 0 yng	1998/06/27	240826	From DFG Database. Nest time = 0833. Pair seen at nest w/ no young. Contributor (Not CM, USFS?)	0
	TE017	Roosting Pair	1999/06/07	240826	From DFG Database. Time = 1915. Likely nighttime response. 1/4-sec. centroid. Not CM, USFS?	0
Sulphur Creek	TE023	Reproductive Pair, 1 yng	1995	260830	LP 445. From LP Sulphur Creek THP. Pair w/at least 1 fledgling. No comment about nest location.	23
Sulphur Creek	TE023	Reproductive Pair,3 yng	1994/06/24	260830	LP445. From LP Sulphur Creek THP. Pair w/ 3 fledglings. No nest found.	23
SulphurCreek	TE023	DFG, Roosting Pair	1999/05/28	260830	LP445. DFG Database location. Time = 1210. Pair. Pioneer. Same DFG AC in 1996, 1998.	23
Sulphur Creek	TE023	Pair	1999/06/07	260830	LP445. Approximate location from Pioneer records.	23
Sulphur Creek	TE023	Nesting Pair, 0 yng	2003/06/02	260831	LP445. Roost time = 1208. Female seen in nest but no young present. Roosted by Beaty for CM.	23
	TE024	Roosting Pair	1989	260829	From LP Sulphur Creek THP. Time = 1050.	4
	TE024	Roosting Pair	1994	260832	LP448. From LP Sulphur Creek THP.	4
	TE024	Roosting Pair	1995	260833	LP448. From LP Sulphur Creek THP.	4
	TE024	DFG, Pair	1996	260829	DFG Database location. Pair. LP.	4
	TE024	Roosting Pair	1996	260829	~ location from LP records: 260829, SE-SE-SW.	4
	TE024	Roosting Pair	1995/05/26	260832	Roost time = 0930. Roosted in oak stand.	4
	TE024	Roosting Pair	1995/06/08	260829	Roost time = 0830. Likely same pair from 5/26/95. Likely source of DFG DB location.	4
	TE024	Roosting Pair	1999/07/20	260829	Location from Pioneer records.	4
	TE024	Roosting Pair	2002/05/15	260829	Roost time = 1350. 1 bird in 46" DF, 1 in 18" DF ~50' NE.	4
	TE024	Roosting Pair	2003/04/23	260829	Roost time = 1354. M & F roosted in different trees. MP has no mice for surveying.	4
	TE024	Roosting Single	2006/06/05	260829	Roost time = 1406	4
	TE024	Roosting Single	2006/06/21	260829	Roost time = 1037.	4
Elkhorn NSO	TE024	Roosting Single	2007/05/21	260828	Roost time = 0700. Roost tree = 36" DFw/ double top; 1 top broke out & hollow.	54
Elkhorn NSO	TE024	Roosting Pair	2008/05/20	260828	Roost time = 0730.	54
Elkhorn NSO	TE024	Roosting Pair	2009/05/27	260828	Roost time = 0730	54
Elkhorn NSO	TE024	Nesting Pair, 0 yng	2011/05/20	260828	No visual contact w/nest or young; Nest time=0900	54
Elkhorn NSO	TE024	Nesting Pair, 0 yng	2012/05/09	260828	No visual contact w/ nest or young; Nest time=1708	54
Thomes Pocket	TE025	DFG, HT, Pair	1987/07/01	250920	DFG Database Location. Nighttime response. Pair. Spangle+.	0
Thomes Pocket	TE025	Nesting Male, 1 yng	2009/07/24	251024	Nest time = 0805; One full size fledgling able to fly. No F seen.	0
Thomes Pocket	TE025	Roosting Single	2011/06/22	251024	Roost time = 0900	0
Thomes Pocket	TE025	Roosting Single	2012/04/30	251024	Male; Roost time = 1315	0
Thomes Pocket	TE025	Roosting Single	41386	251024	Roost time = 1104, visual contact, owl not interested in mice, 4-note and "monkey" calls	
	TE026	DFG, HT, M	1981/08/19	250921	DFG Database location. Nighttime response. 1M. Coprdano.	0
Ovenlid	TE027	DFG, HT, U	1991/05/07	250807	DFG Database location. Nighttime response. 1U. MDNF.	0
Ovenlid	TE027	Roosting Male	2000/05/25	250818	Roost time = 0930. Also roosted in ~ same location on 5/18/00 at 0900.	41
Ovenlid	TE027	Roosting Pair	2001/05/17	250818	Roost time = 1155	41
Ovenlid	TE027	Nesting Pair, 0 yng	2002/05/05	250818	Nest time = 1715. Nest tree ~ 3.5' DF, 35' up. Wing tip sticking out of nest. Klamath Resources.	41
Ovenlid	TE027	Nesting Pair, 0 yng	2004/05/06	250818	Nest time=1520. M takes mice to nest cavity in big DF leaning over crk.No female,nest or young seen	0
Ovenlid	TE027	Nesting Pair, 0 yng	2005/05/31	250818	Same nest tree as 2004 = 40" DF on N bank. M takes M1 to F inside cavity ~80' up. No young seen.	0
Ovenlid	TE027	Roosting Pair	2006/05/31	250818	Roost time = 1225. Roosting in 2 large pine snags.	0
Ovenlid	TE027	Roosting Single	2006/06/09	250818	Roost time = 0725. Second owl from 5/31/06 not found.	0
Pair 1	TE028	DFG, HT, U	2007	250810	DFG Database location. 2007/05/10 nighttime response from BC15/EH14. No Sts Det. ~Section centroid.	21
LP416	TE028	Reproductive Pair, 1 yng	1994/07/21	240815	From LP N.F.Elder Creek THP. Pair w/at least 1 fledgling. No nest located.	48

Pair 1	TE028	Nesting Pair, 3 yng	1999/06/21	250810	Nest time = 2047. ~ location NW-SE-SE. Reproductive pair w/3 young. Strategic Timber for Pioneer.	21
Pair 1	TE028	Roosting Pair	2002/04/14	250810	Roost time = 0902.	21
LP416	TE028	Historic Territory, UNK	1995,1996	250815	LP location. Status was determined by 3 daylight responses. Surveyed 99-02 by CM.	48
S. Elder Pair 3	TE029	DFG, Roosting Pair	1992/04/23	250825	DFG Database location. Roosting Pair (from Raglin Ridge survey notes-04/22/92). DFG DB says @ nest.	14
S. Elder Pair 3	TE029	Nesting Pair, UNK yng	1998/06/27	250826	~ location. Nested by Pioneer PCB in NW 1/4. Fledglings present, # UNK. From 1998 Raspberry notes.	14
S. Elder Pair 3	TE029	Roosting Pair	1999/06/07	250826	Roost time = 2015. Strategic Timber for Pioneer. TE029(?).	14
S. Elder Pair 3	TE029	Nesting Male, 1 yng	2002/05/08	250823	Nest time = 2022. Male NSO take mouse to nest. 1 juvenile heard. KWR	14
S. Elder Pair 3	TE029	Roosting Female	2002/05/09	250826	Roost time = 0830. Mark (?) for CM.	14
S. Elder Pair 3	TE029	Roosting Male	2003/04/17	250823	Roost time = 1114. Roost tree = 40-50" cedar	14
S. Elder Pair 3	TE029	Roosting Male	2003/05/22	250826	Roost time = 0652. Roosting in small grove of DF regen.	14
S. Elder Pair 3	TE029	Roosting Single	2004/06/02	250826	Roost time = 0835. Could be female, but MP unsure.	14
S. Elder Pair 3	TE029	Roosting Single	2005/05/16	250826	Roost time = 1454.	14
S. Elder Pair 3	TE029	Roosting Single	2005/06/06	250826	Roost time = 0855. Roost tree = 30" live oak.	14
	TE030	Roosting Pair	2004	240901		33
Fish Creek	TE030	DFG, Nesting Pair, 0 yng	1992/07/30	240901	DFG Database location. Time=1152. Nesting pair w/0 yng. MDNF. DB has 1998 as AC, but at this loc.	33
Fish Creek	TE030	Nesting Pair, 1 yng	1998/06/23	240901	Nest time = 1430. Single juvenile. Nested by MB&G for Pioneer.	33
Fish Creek	TE030	Roosting Pair	2004/05/24	240901	Roost time = 0732	33
Fish Creek	TE030	Roosting Pair	2011/06/03	240901	Roost time = 1259	33
Fish Creek	TE030	Roosting Pair	2012/05/11	240901	Same spot as 2011; Roost time = 1145	33
Fish Creek	TE030	Roosting single	41388	240901	Audio response at 1052, visual contact at 1400, Single roosting male, not interested in mice	
	TE031	DFG, Pair	1996	240805	DFG Database location. Pair. Pioneer.	7
	TE031	Roosting Pair	1996/06/05	240805	Roost time = 0630.	7
	TE031	Roosting Pair	1997/06/13	240805	Roost time = 0630	7
	TE031	Roosting Pair	1998/07/09	240805	Roost time = 1635. Roosted by MB&G for Pioneer.	7
Lower Berry Rdg	TE031	Nesting Female, 1 yng	1998/08/11	240805	Nest time=0615. F found w/ 1 juvenile. No M seen. Moused by MB&G for Pnr. Assigned to TE031 by DFW.	0
	TE031	Roosting Pair	1999/06/04	240805	Roost time = 2030. ~ location taken from Strategic Timber records for Pioneer.	7
	TE031	Nesting Pair, 2 yng	2002/07/01	240805	Nest time = 0837. 2 large fledglings. Nest tree may be ~40" DF w/ broke out top.	7
	TE031	Roosting Male	2003/05/22	240805	Roost time = 1121. ~ location from Griffin Crk notes. 240805 SE-NE-NW.	7
	TE031	Roosting Single	2004/04/29	240805	Roost time = 1022. Roost tree = live oak. Preliminary survey. No mice.	7
	TE031	Roosting Single	2004/05/05	240805	Roost time = 0951. NSO likely male.	7
Doll Ridge	TE032	DFG, Reprod. Pair, 3 yng	1992/05/29	231036	DFG Database location. Pair w/ 3 young. MDNF	52
Doll Ridge	TE032	Roosting Male	2002/05/29	231036	Roost time = 0913.	52
Auger Crk Sec17	TE033	DFG, HT, U	1992	240920	DFG Database location. Nighttime response. 1U. CM via Martina-CFA.	34
Auger Crk Sec17	TE033	Roosting Pair	1999/06/01	240917	Roost time = 0730. DB has this as AC, but in 1992 location. Pioneer	34
Auger Crk Sec17	TE033	Roosting Pair	2000/06/07	240917	Roost time = 1330	34
Auger Crk Sec17	TE033	Roosting Male	2002/05/08	240917	Roost time = 1250	34
Upper Auger Crk	TE033	Roosting Pair	2002/05/28	240919	Roost time = 1328.	51
Upper Auger Crk	TE033	Roosting Pair	2008/05/29	240918	Roost time = 0930	51
Auger Crk Sec17	TE033	Roosting Single	2010/06/24	240920	Male; Roost time = 2126	34
Upper Auger Crk	TE033	Roosting Male	2010/07/30	241024	Roost time = 0640; Single adult male	51
Upper Auger Crk	TE033	Nesting Pair, 2 yng	2011/07/11	240919	2 fledglings; Nest time = 1448	51
Upper Auger Crk	TE033	Roosting Single	2012/07/20	240919	Roost time = 0745	51
TE033/TE036(?)	TE033/36	Roosting Male	2002/05/29	240916	Roost time = 1234	50
Upper McClure Ck	TE035	Roosting Pair	1999	240905	~ location. Loc. from mainnsofix TE035 attributes. Could not find 99 CM Heli records. TE072(?)	43
Upper McClure Ck	TE035	DFG, Nesting Pair, 0 yng	1988/04/27	241012	DFG Database location. Nesting pair w/ no young. MDNF.	43
Upper McClure Ck	TE035	Roosting Pair	2001/07/20	240906	Could be TE097, 72, or 35, but closest to and most likely TE035. Roost time = 0730	43
Upper McClure Ck	TE035	Roosting Single	2009/07/08	240907	Roost time = 0710	43
Upper McClure Ck	TE035	Roosting Pair	2010/08/06	241012	Roost time = 0740	43
Upper McClure Ck	TE035	Roosting Pair	2011/06/08	240907	Roost time = 0615	43
Upper McClure Ck	TE035	Roosting Pair	2012/05/16	240907	Roost time = 0630	43
Upper McClure Ck	TE035	Roosting Single	41393	240907	Roost time = 0721, same roost tree as 2012, not interested in mice, not able to gender ID	
Lower Auger Ck	TE036	Reproductive Pair, 1 yng	1993/07/09	240921	1 fledgling. No nest/whitewash found. Roost time = 1030.	25
Lower Auger Ck	TE036	DFG, HT, Pair	1998/07/14	240921	DFG Database location. Nighttime response (0007). Pair. Pioneer.	25
Lower Auger Ck	TE036	Roosting Single	2008/05/28	240931	Roost time = 0830	25
Lower Auger Ck	TE036	Roosting Pair	2011/08/05	240921	Roost time = 1000	25
Lower Auger Ck	TE036	Roosting Male	199807/14	240921	From Pioneer Elk Fork THP. Time = 0724.	25
Flood Creek	TE037	DFG, HT, M	1992/07/29	240913	DFG Database location; Unoccupied for many years. Nighttime response. 1M. MDNF.	2
P98	TE037	Roosting Pair	1998/07/24	240914	Roost time = 0700. Roosted by MB&G for Pioneer.	2
P98	TE037	Roosting Pair	1999/05/25	240914	~ location from Pioneer records.	2
Flood Creek	TE037	Roosting Pair	2007/06/15	240913	Roost time = 0830.	2
Flood Creek	TE037	Roosting Single	2008/05/21	240913	Roost time = 0922	2

Flood Creek	TE037	Reproductive Pair, 2 yng	2009/06/12	240913	Nest time = 0558; 2 fledglings seen but no actual nest found	2
Flood Creek	TE037	Roosting Pair	2010/07/06	240913	Roost time = 0730	2
Flood Creek	TE037	Nesting Pair, 0 yng	2011/05/18	240913	Nest time = 1130	2
Flood Creek	TE037	Roosting Single	2012/05/08	240913	Male; Roost time = 1500	2
Flood Creek	TE037	Roosting Pair	2013/04/15	240913	Roost time = 0821, Pair also roosted 5/28/13, both contacts the owls ate mice, but no nesting behavior observed	
	TE038	Pair	1989	240820	From 1999 Prong THP Pre-Survey Consultation map.	8
	TE038	DFG, HT, Pair	1989/06/07	240820	DFG Database location; Unoccupied for many years. Nighttime response. Pair. Frank Barron.	8
	TE039	DFG, Nesting Pair, 1 yng	1991	240718	DFG Database location. Nesting pair w/ 1 juvenile. Martin-CFA.	46
	TE039	Roosting Male	2002/05/24	240718	Roost time = 0820	46
P98 Sec13	TE039(W)	Roosting Pair	1998	240812	From Pioneer records. Not in DFG DB.	38
P98 Sec13	TE039(W)	Nesting Pair, 0 yng	1999/05/05	240812	Nest time = 0639. No young seen. Could be roosting pair. Not in DFG DB.	38
P98 Sec13	TE039(W)	Roosting Male	2001/06/14	240812	Roost time = 2128. Not in DFG DB.	38
P98 Sec13	TE039(W)	Roosting Single	2002/04/22	240814	Roost time = 0910. Not in DFG DB.	38
P98 Sec13	TE039(W)	Roosting Single	2002/05/15	240812	Roost time = 0821. ~ location. NSO in 36", 25' hollow oak snag. No map w/ follow-up record.	38
	TE040	DFG, HT, M	1985/07/19	231012	DFG Database location. Nighttime response. 1M. MDNF.	0
ForksRdg(LP473)	TE041	DFG, Pair	1994	230932	DFG Database location. Pair. LP.	29
ForksRdg(LP473)	TE041	Roosting Male	1998/07/04	240932	Taken from Pioneer Elk Fork THP. M did not take mouse. Harrassed by passerines. Time = 2047.	29
ForksRdg(LP473)	TE041	Reproductive Pair, 1 yng	1998/07/07	230905	Taken from Pioneer Elk Fork THP. F took mouse to J. Time = 1915.	29
ForksRdg(LP473)	TE041	Roosting Male	2002/05/14	230932	Roost time = 1436	29
UNK	TE042	UNK	1999	230909	From Pioneer owl lyr. UNK info. Likely TE042. Actual date UNK, taken from Log Springs THP date.	15
	TE042	DFG, HT, F	1991/04/25	230909	DFG Database location. Nighttime response. 1F. MDNF. Surveyed 98-99 by CM w/ no results.	15
ForksRdgSec34	TE043	Roosting Pair	1996	240934	~ location from LP records: 240934, NE-SW-SW.	24
ForksRdgSec34	TE043	DFG, Reprod. Pair, 2 yng	1994/08/25	240935	DFG Database location. Pair w/2 young, no nest. LP.	24
ForksRdgSec34	TE043	Roosting Pair	2002/06/24	230903	Roost time = 0843.	24
ForksRdgSec34	TE043	Roosting Pair	2012/05/30	240935	Roost time = 0700	24
ForksRdg	TE043	Roosting Pair	2013/04/09	230903	Roost time = 0812, one owl eats 2 or 3 mice, owls are agitated	
	TE044	DFG, HT, U	1989/06/26	240936	DFG Database location. Nighttime response. 1U. Roy Henson.	0
	TE045	DFG, HT, Pair	1981/05/11	240833	DFG Database location. Nighttime response. Pair. Cordano-Benson.	0
	TE046	DFG, Pair	1991/04/17	230928	DFG Database location. NR, Pair. Surveyed 98-99 by Strategic Timber for Pioneer w/ no results.	11
	TE047	DFG, HT, Pair	1991/04/23	230913	DFG Database location. Nighttime response. Pair at nest w/no young. MDNF.	0
	TE049	DFG, HT, M	1991/04/16	230922	DFG Database location. Nighttime response. 1M. MDNF.	18
LP456	TE050	DFG, Nesting Pair, 0 yng	1996	230820	DFG Database location. Nesting pair w/ no young. LP.	0
LP456	TE050	Pair	1996	230820	~ location from Commander Girl Scout Camp THP. Actual date UNK, date of THP used.	0
LP456	TE050	Nesting Pair, 0 yng	1996/05/31	230820	~ location from LP records: 2300820, SW-SE-NW. Reproductive success unknown.	0
	TE051	DFG, Reprod. Pair, 2 yng	1992	230828	DFG Database location. Pair w/ 2 young. Crane via Martin-CFA.	0
	TE052	Historic Territory, UNK	2002	230731	Moved to this ~location in 2002 after consultation w/ USFWS.	20
	TE052	DFG, HT, U	1991/05/13	230729	DFG Database location. NR, 1U, MDNF. Surveyed in 98-99, 01-02 by CM w/ no results.	20
	TE053	DFG, HT, Pair	1991/07/11	231002	DFG Database location. Nighttime response. Pair. MDNF.	0
	TE072	DFG, HT, Pair	1990/08/01	240905	DFG Database location; Unoccupied for many years. Nighttime response. Pair. CM	43
	TE072	Nesting Pair, 0 yng	1999/07/14	240905	Pair found @ nest site & roosted 300' away w/o fldglng. Nest site had w.wash & fldglng feathers.	43
	TE074	DFG, HT, M	1990/05/24	250932	DFG Database location; Unoccupied for many years. Nighttime response. 1M. Roy Henson.	0
FishCreekBridge	TE075	Single	1989	250829	DFG Database location. Approximate location. Source: Crane Mills Fish THP Pre-Survey Consultation.	36
	TE075	DFG, HT, F	1989/06/09	250829	DG Database location. Nighttime response. 1F. Frank Barron.	36
FshCrkBrg NSO1	TE075	Nesting Pair, 0 yng	1999/05/09	250830		36
FshCrkBrg NSO1	TE075	Roosting Pair	2000/06/30	250830	Roost time = 0511.	36
FshCrkBrg NSO2	TE075	Roosting Male	2001/05/23	250830	Roost time = 0610. Also roosted here on 05/28/01 @ 2030.	39
FshCrkBrg NSO1	TE075	Nesting Pair, 3/4 yng	2001/05/30	250830	Nest time =0545. 3 or 4 fledglings. Took mouse off Mark's head. Nest tree 26" SP, 70' up in fork.	36
FshCrkBrg NSO1	TE075	Nesting Pair, 0 yng	2002/05/10	250830	Roost time = 0730. No young observed. Same location as 2001. Nest tree ~ 36" DF, 40' up on SW.	36
FishCreekBridge	TE075	Nesting Pair, 0 yng	2007/05/18	250831	Nest time = 0945. F on nest in 30" DF, M in small IC adjacent. No young observed.	36
	TE075	Nesting Female, 1 yng	2007/06/13	250830	Nest time = 1140. 5/18 nest abandoned. F & 1 fledgling in DF ~ 200' SE of 5/18 nest. No M.	36
FshCrkBrgNSO1	TE075	Roosting Pair	2009/07/01	240831	Roost time = 0540. Present mouse, no interest. Pair fly off & not relocated.	36
Snake Creek	TE075(?)	Roosting Pair	1997/06/26	250829	Roost time = 2117	45
Snake Creek	TE075(?)	Reproductive Fem, 2 yng	1998/07/10	250829	Roost time = 0900. 2 juveniles roost w/female.	45
Snake Creek	TE075(?)	Roosting Pair	1999/04/30	250829	Roost time = 0745. Pair roosting in ~ same location on 05/06/99.	45
	TE086	DFG, HT, F	1989/06/14	250923	DFG Databse location. Nighttime response. 1F. Roy Henson. DFG Databse location.	0
	TE087	Roosting Male	1998/08/20	250933	Roost time = 0915. Moused by MB&G for Pioneer.	0
	TE087	DFG, Pair	1998/08/20	250933	DFG Database location as of 2-13-13. Pair. Pioneer. Jeff proposed move AC to 2007 location.	0
	TE087	Roosting Pair	2007/06/04	250934	Roost time = 0935. New AC location approved as of 2007.	0
	TE087	Roosting Pair	2009/07/07	250934	Rost time = 0800	0
	TE087	Roosting Single	2012/08/03	250933	Roost time = 0630	0

	TE097	DFG, Reprod. Pair, 3 yng	1992/06/16	241001	DFG Database location; Unoccupied for many years. Pair w/3 young, no nest. MDNF.	0
Berry Ridge	TE101	DFG, HT, Pair	1992/07/02	240806	DFG Database location; Unoccupied for many years. Nighttime response. Pair. Crane via Martin-CFA.	6
Berry Ridge	TE101	Roosting Pair	1997/05/09	240806	Pair not roosted,stopped calling. Time=0730-0840.Point is male location. Female ~625', N20W. Mark P.	6
	TE102	DFG, HT, M	1992/07/16	240932	DFG Database location. Nighttime response. 1M. Crane via Martin-CFA.	0
	TE103	DFG, HT, M	1992/07/16	240933	DFG Database location. Nighttime response. 1M. Crane via Martin-CFA.	0
	TE106	DFG, HT, F	1992/07/02	240809	DFG Database location. Nighttime response. 1F. Crane via Martin-CFA.	5
	TE106	Roosting Male	1997/05/16	240809	Roost time = 0815. Location from actual Berry Ridge 1997 survey notes.	5
	TE106	Nesting Female, 2 yng	2002/07/01	240809	Nest time=0620.2 fledglings.No male seen.~ 100' E of ridgetop.Surveyed by CM in 00-01 w/ no results.	5
	TE106	Roosting Male	2003/05/22	240809	Roost time = 1721. ~ location from Griffin Crk records. 240809 NE-NE-SW.	5
	TE106	Roosting Single	2004/05/05	240809	Roost time = 1411.	5
	TE107	DFG, HT, M	1993/04/26	230816	DFG Database location. Nighttime response. 1M. MDNF. Surveyed by CM in 98/99 w/ no results.	16
	TE108	DFG, HT, M	1993/04/06	230801	DFG Database location. Nighttime response. 1M. Spence-Closson.	0
	TE109	DFG, HT, U	1990/07/23	230821	DFG Database location. Nighttime response. 1U. MDNF.	0
	TE110	DFG, HT, F	1988/07/20	230823	DFG Database location. Nighttime response. 1F. MDNF.	0
LP479	TE111	Roosting Pair	1995	230814	From LP Devil's Basin THP.	19
	TE111	DFG, Nesting Pair, 0 yng	1996/01/01	230823	DFG Database location. Nesting pair w/no young. Pioneer.	19
	TE111	Roosting Female	1998/06/15	230823	No data found. Historic visit(?). MB&G for Pioneer.	19
	TE112	DFG, HT, M	1991/08/05	250806	DFG Database location. ~location of night time detection. 1M. Roy Henson	3
	TE113	DFG, HT, M	1990/01/01	250931	DFG Database location; Unoccupied for many years. Nighttime response. 1M. MDNF.	0
Fish Creek	TE114	DFG, HT, F	1991/05/10	240902	DFG Database location. Nighttime response. 1F. MDNF.	35
Fish Creek	TE114	Roosting Pair	1999/07/07	240911	Roost time = 0710	35
Fish Creek	TE114	Roosting Pair	2000/07/08	240902	Roost time = 0735. Male and fledgling roosted, no nest found.	35
Fish Creek	TE114	Roosting Single	2008/06/04	240911	Roost time = 0715	35
Fish Creek	TE114	Roosting Single	2011/06/13	240911	Male; Roost time = 1315	35
Fish Creek	TE114	Roosting Single	2012/07/09	240911	Roost time = 0800	35
ForksRdgSec30	TE115	DFG, Nesting Pair, 0 yng	1998/07/08	230930	DFG Database location. Nesting pair w/no young. Pioneer.	28
ForksRdgSec30	TE115	Reproductive Pair, 1 yng	1998/07/08	240930	From Pioneer Elk Fork THP. Roosting pair with young.	28
ForksRdgSec30	TE115	Roosting Pair	1999/06/17	240930	~ same location as 1998. From Pioneer records.	28
ForksRdgSec30	TE115	Roosting Pair	2002/05/29	230930	Roost time = 0900.	28
Buttermilk	TE116	Roosting Male	1999/06/10	230915	Roost time = 2008. Strategic Timber for Pioneer. Surveyed in 02 by CM w/ no results.	13
	TE116	DFG, Roosting Male	1999/06/10	230915	DFG Database location. 1M. Pioneer. DFG DB location different than records.	13
	TE117	Roosting Male	1996	250928	~ location from LP records: 250928, NW-SE-SE	0
	TE117	DFG, Roosting Male	1996/01/01	250928	DFG Database location. 1M. LP	0
	TE117	Roosting Pair	2007/05/18	250928	Roost time = 0827.	0
	TE117	Roosting Pair	2007/05/31	250928	Roost time = 0746	0
	TE117	Roosting Single	2012/05/15	250928	Roost time = 0755	0
Thomes Cr Brdge	TE117	Nesting(?)/Roosting Pair	2013/05/13	250928	Roost time =1145,both owls eat total of 6 mice, audio of a 3rd owl 100' apart from pair (young?)	
ForksRdgeSec28	TE118	DFG, Pair	1995/01/01	240928	DFG Database location. Pair. LP.	1
LP417	TE133	Reproductive Pair, 1 yng	1994/06/23	250825	From LP S.F.Elder Creek/Riley Creek THP. Pair w/1 fledgling. No nest located.	12
LP417	TE133	Roosting Male	1996/06/12	250825	Roost time = 0630.	12
LP417	TE133	Roosting Pair	1997/05/08	250825	~ location from LP records: In same area as 1994-1996 location. Roost time = 0650.	12
LP417	TE133	DFG, HT, M	1999/06/07	250825	DFG Database location. 1M. McCall.	12
LP417	TE133	UNK	2002/05/08	250825	NSO called to road. Carried off Mouse2 to SE. No Det. made. Unreliable/Useless NSO location. KWR	12
P98	TE146	DFG, HT, M	1998/07/14	230832	DFG Database location. Nighttime response. 1 AM. Pioneer. Surveyed in 98-99 by CM w/ no results.	17
Pair 2	TE147	Historic Territory, UNK	2002	250814	mainnsofix.shp says RP in 02. N.Elder 2002 TA makes no mention; night responses but no status det.	47
Pair 2	TE147	DFG, Nesting Pair, 1 yng	1999/05/14	250814	DFG Databse location. Nesting pair w/1 young. Pioneer. Questionable location.	47
Pair 2	TE147	Roosting Male	1999/05/14	250814	Roost time = 0825.	47
Pair 2	TE147	Nesting Pair, 1yng	1999/05/20	250814	Nest time = 2030. 1 fledgling seen. Nest tree = 50" cull DF, hollowed out @ schoolmarm 55' up.	47
	TE148	DFG, HT, M	1998/07/29	250902	DFG Database location. Nighttime response. 1 AM. Pioneer.	0
ElkhornCk new	TE149	DFG, U	2007/01/01	260821	DFG Database location. 1U. Crane via USFWS.	0
Mickey & Minnie	TE97/72/35	Nesting Pair, 0 yng	1991/06/12	240906	Nest in 48" DF in witch's broom, 120' up tree. No DB name, moused by Brn-Hnsn-Clark-Williams. 0655	0
NSO#1,2000		Roosting Male	2000	250810	Status determined by 3 daylight responses. Assumed Pair 2 reolcated. Surveyd w/ N.Elder THP.	44
Lucy & Desi	TE025?	Nesting Pair, 0 yng	1991/06/12	250929	Nest in 28" WF w/ broken top, 50' up tree. NO DB name, moused by Barron-Henson-Clark-Williams. 0820	0
P99 (Govt 40)		Nesting Pair, 1 yng	1998/07/04	230825	Nest time = 1101. Single juvenile. MB&G for Pioneer. Surveyed 99, 01-02 by CM w/ no results.	10
RP01(?)/M98		Roosting Single	1998/07/10	240914	Mouse time = 0502. Site is where mouse was taken. Bird not roosted. MB&G for Pioneer.	42
RP01		Roosting Pair	1999/06/07	240922	Roost time = 1200	42
RP01		Roosting Pair	2000/03/24	240922	Roost time = 0930	42
RP01		Roosting Pair	2001/06/07	240915	Roost time = 1518. Not surveyed in 2011-12 due to mairjuana grower activity.	42
RP01		Roosting Male	2002/03/21	240915	Roost time = 1130	42
Dark Canyon 1		Roosting Pair	2001/06/22	240821	Roost time = 1116.	40
Dark Canyon 1		Roosting Male	2002/05/06	240821	Roost time = 0734	40
Slate Creek		Roosting Male	2001/07/26	240731	Roost time = 0745	49
Slate Creek		Roosting Male	2002/06/06	240825	Roost time = 0745	49

HardingSpg new		Roosting Pair	2006/05/24	250902	Roost time = 1330. Preliminary survey, no mousing done - MP.	0
HardingSpg new		Roosting Pair	2006/05/30	250902	Roost time = 1540.	0
HardingSpg new		Roosting Pair	2006/06/09	250902	Roost time = 1245. Roost spot = small grove of regen.	0
Fred & Ethel		Nesting Pair, 0 yng	199106/04	240909	Nest time = 0611.~28" WF w/ multiple tops,nest 50' up. Dead fledgling @ base of nest tree(8/1)	0

OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- CRANE MILLS -
FRANK BARRON, CHIEF FORESTER

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Northern Spotted Owl Conservation and Management on Mendocino Redwood Company Forestlands

February 14, 2014

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INTRODUCTION

The Northern Spotted Owl (*Strix occidentalis caurina*; NSO) was listed as federally threatened in 1990 because of continued timber harvesting throughout its range, uncertainties about its population status, and the absence of any regulatory mechanisms to conserve and manage this species on working landscapes (USDI 1990). Today, despite an increased understanding of its biology and status, the NSO still remains a species of strong scientific interest in the Pacific Northwest (PNW) and is regulated for timber harvest activities on both private and public lands in northwestern California.

In the 24 years since it was listed as federally threatened, the NSO is now the most studied bird of prey in the PNW, and one of the most studied in world. A substantial body of research indicates that the northern spotted owl's population status, habitat associations, natural and anthropogenic disturbances regimes, and preferred prey vary over its range (Forsman et al. 2011; USFWS 2011). Such variation in natural history necessitates framing any discussion of spotted owl biology, including the development of conservation measures, into an appropriate ecological context. Applying inferences across study areas and biophysical provinces may be inappropriate and lead to poor management decisions. Regional differences in spotted owl biology are complex and continue to be a source of conflicting viewpoints among scientists, environmentalists, regulators, and timber communities, especially the degree of owl dependence on old growth forest ecosystems and the environmental factors influencing their populations.

The coast redwood (*Sequoia sempervirens*) belt, ranging from coastal southwest Oregon south to Marin County of northwestern California, comprises only 9% of the northern spotted owl's range and contains relatively little old growth forest due to historical timber harvest activities. Even so, spotted owl nest and roost sites on commercial timberlands within the redwood region are associated with larger trees and structural features associated with older, less disturbed stands relative to their availability on the landscape (Thome et al.1999; Folliard et al. 2000; Douglas unpublished data). Yet, despite the fact that only 5% of the old-growth redwood forest remains (primarily in state and federal reserves) and a substantial percentage of the region is currently managed for commercial timber production, the redwood region has one of the highest densities of northern spotted owls when compared to its entire range (Diller and Thome 1999; California Natural Diversity Database 2013). This often cited "anomaly" is attributed to redwood's rapid growth rate, dense canopy, tendency to form nesting structures from debris accumulations and top breakage, and association with an ameliorating, cool coastal climate.

Regional differences in territory densities and habitat associations are also driven by the composition and availability of prey species. Spotted owls in western Washington and northwestern Oregon predominantly prey on northern flying squirrels (*Glaucomys sabrinus*; Forsman et al. 2001, 2004), which feed on hypogeous fungi commonly associated with mature and late seral forests (Carey 1995). In contrast, diets of spotted owls in southwestern Oregon and northwestern California are largely comprised of woodrats (*Neotoma* spp.), which are abundant in early-seral stands containing a shrub component such as blueblossom (*Ceanothus thyrsiflorus*), manzanita (*Arctostaphylos* spp.) and tanoak (*Notholithocarpus densiflorus*; Carey et al. 1999; Hamm and Diller 2009). A general consequence of prey composition and availability is that spotted owls in the northern part of their range tend to have larger territory sizes and are associated with more mature and old growth forests compared to their extreme southern range, where spotted owls have smaller territories and thrive on landscapes containing a heterogeneous mixture of mature and early seral habitat (Franklin et al. 2000). Therefore, northern spotted owl density and habitat use can be very dependent on both the degree of habitat disturbance and how primary prey species respond to changes in vegetative composition and structure.

A recent meta-analysis of demographic data from 11 study areas indicates the northern spotted owl is declining at an annual rate of 2.9% over its entire range. The strength of this population decline, however, is strongest in the north and weakens southward through the range (Forsman et al. 2011). In northwestern California, results from two of three demographic study areas show consistent pattern of declining fecundity, apparent survival, and finite rate of population change (Forsman et al. 2011). Although the potential causes differ by study area, the only study from the redwood region indicated that declining trends in both apparent survival and fecundity were influenced by the increasing presence of barred owls (*Strix varia*). While the maintenance and growth of habitat is still a key aspect to spotted owl conservation (Dugger et al. 2011), competition from the barred owl has been identified as the single-most pressing threat to the continued existence of the northern spotted owl throughout its entire range (USFWS 2011).

Mendocino Redwood Company, LLC (MRC) forestlands have a rich history of spotted owl surveys and regulatory compliance for timber harvest plans, as well as research and monitoring programs to learn about spotted owl ecology. Although MRC formed in 1998, the Louisiana-Pacific Corporation—MRC's predecessor—initiated and maintained a spotted owl survey and monitoring program when the listing of the NSO appeared to be imminent in 1989. This program continued through to the transfer of title marking the inception of MRC. In total, MRC forestlands have amassed 25 years of spotted owl survey and population monitoring data, spanning 1989-2013. This large dataset provides insight into NSO occupancy and reproduction dynamics during a period when spotted owls have been continuously regulated for timber harvest in California. In addition, several research projects have also been conducted covering spotted owl diet, two telemetry studies documenting home-range size and landscape habitat use, spotted owl demography, and nest-site characteristics.

In this paper, I provide a synopsis of spotted owl distribution, forest management history, conservation measures, survey history, occupancy and reproductive patterns, and emerging and unregulated threats to the spotted owl population on MRC forestlands.

OWNERSHIP

Mendocino Redwood Company forestlands consists of 229,000 acres of coast redwood (*Sequoia sempervirens*) and mixed coniferous forests in Mendocino (220,000 acres) and Sonoma (9,000 acres) counties and are primarily managed for commercial timber (Fig. 1). These forests are dominated by three species of trees (percent by volume): coast redwood (45%), Douglas fir (*Pseudotsuga mensziesii*; 37%), and tanoak (*Notholithocarpus densiflora*; 15%). The remaining 3% of the trees species include hardwoods such as madrone (*Arbutus menzesii*), red alder (*Alnus rubra*), California bay (*Umbellularia californica*), big leaf maple (*Acer macrophyllum*), true oaks (*Quercus* spp.); and shade-tolerant conifer such as grand fir (*Abies grandis*) and western hemlock (*Tsuga heterophylla*). Vegetation patterns vary across the landscape and are the result of an interaction between precipitation gradients, soil type, fire history, past agricultural use, and more significantly—timber harvest.

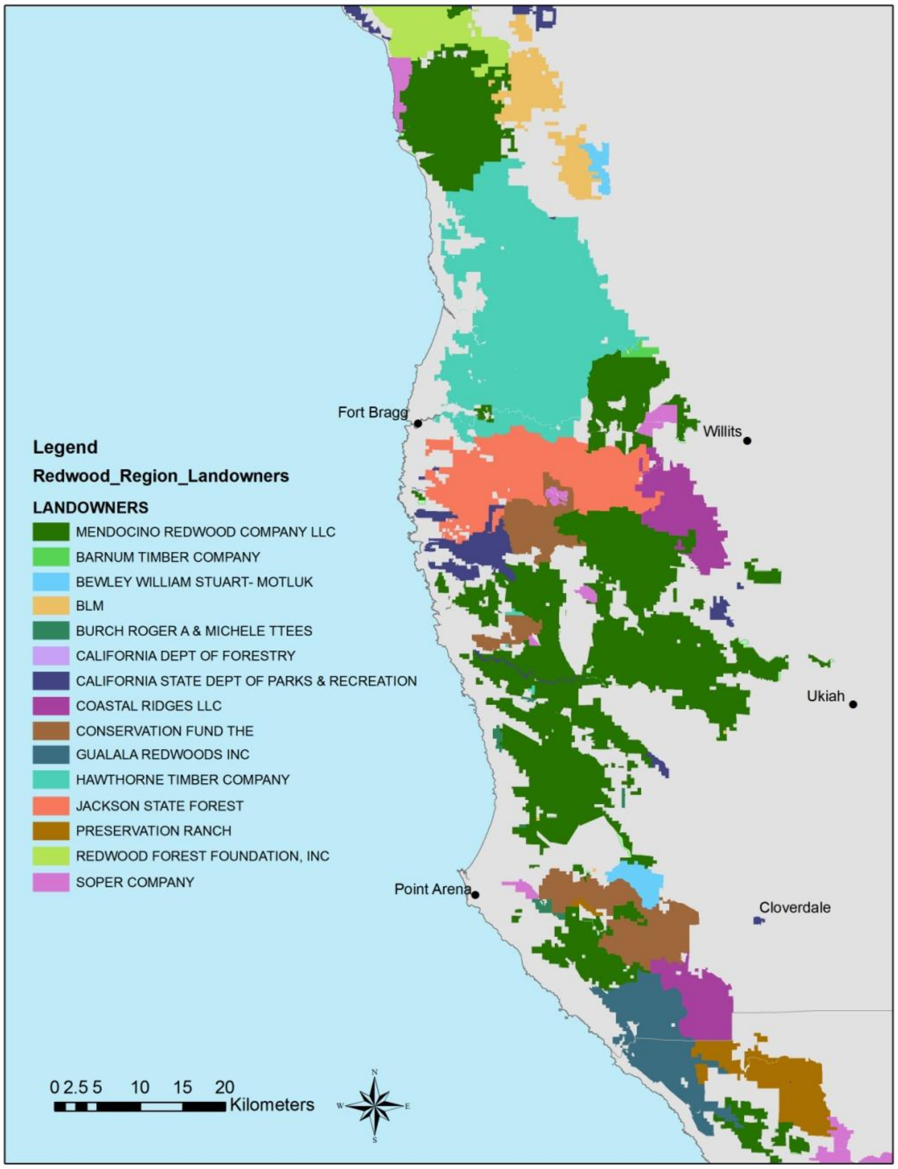

Figure 1. Map showing Mendocino Redwood Company landholdings and other large ownerships in coastal Mendocino and Sonoma counties.

SILVICULTURAL HISTORY

Forest structure patterns on the landscape have been heavily influenced by commercial timber harvests over the past 120 years. These timberlands have experienced at least two harvest entries, and have been shaped by a regimen of clear-cutting and repeated burning that removed most of the old growth forest and large valuable trees.

In the two decades prior to MRC forming, L-P managed these forestlands using a combination of even- and uneven-aged silviculture. A majority of the harvests consisted of shelterwood removal (50-60%), followed by clear-cut (15-25%) and selection (15-25%). The significant amount of overstory removal, combined with a failure to manage for adequate conifer regeneration following harvest entries, resulted in large heterogeneous patches of advanced regeneration dominated by pioneering tanoak that has become today's forest—one which consists of more tanoak than pre-settlement times.

In an effort to restore the conifer species balance on its landscape, MRC is actively working to transition hardwood dominated stands (that were formerly conifer) back to conifer by managing pioneering hardwoods and replanting areas with conifer (primarily redwood) following restoration harvests. The company has also committed to making a full transition to selection-based harvesting systems focusing on single tree or group selection methods, and growing more conifer and larger trees throughout its ownership to not only provide future wood products, but also to improve ecological function for terrestrial and aquatic species across the landscape.

NORTHERN SPOTTED OWL DISTRIBUTION

MRC lands contain about 160 NSO territories on its forest lands (Fig. 2; California Natural Diversity Database 2013). However, because the ownership is spread out into large discontinuous blocks there is a high amount of edge that also support a significant number of nearby territories whose home-ranges overlap with MRC's ownership. When MRC lands are buffered by 1000 feet, the number of territories increases by 70 for a total of 230. Furthermore, there is annual variation in the number territories on MRC property, especially with territories that reside near the property line. Given that spotted owl home-range size and shape may conform to topographic features and habitat distribution, it is likely that MRC lands provide roosting and foraging habitats for even more territories residing further off-property.

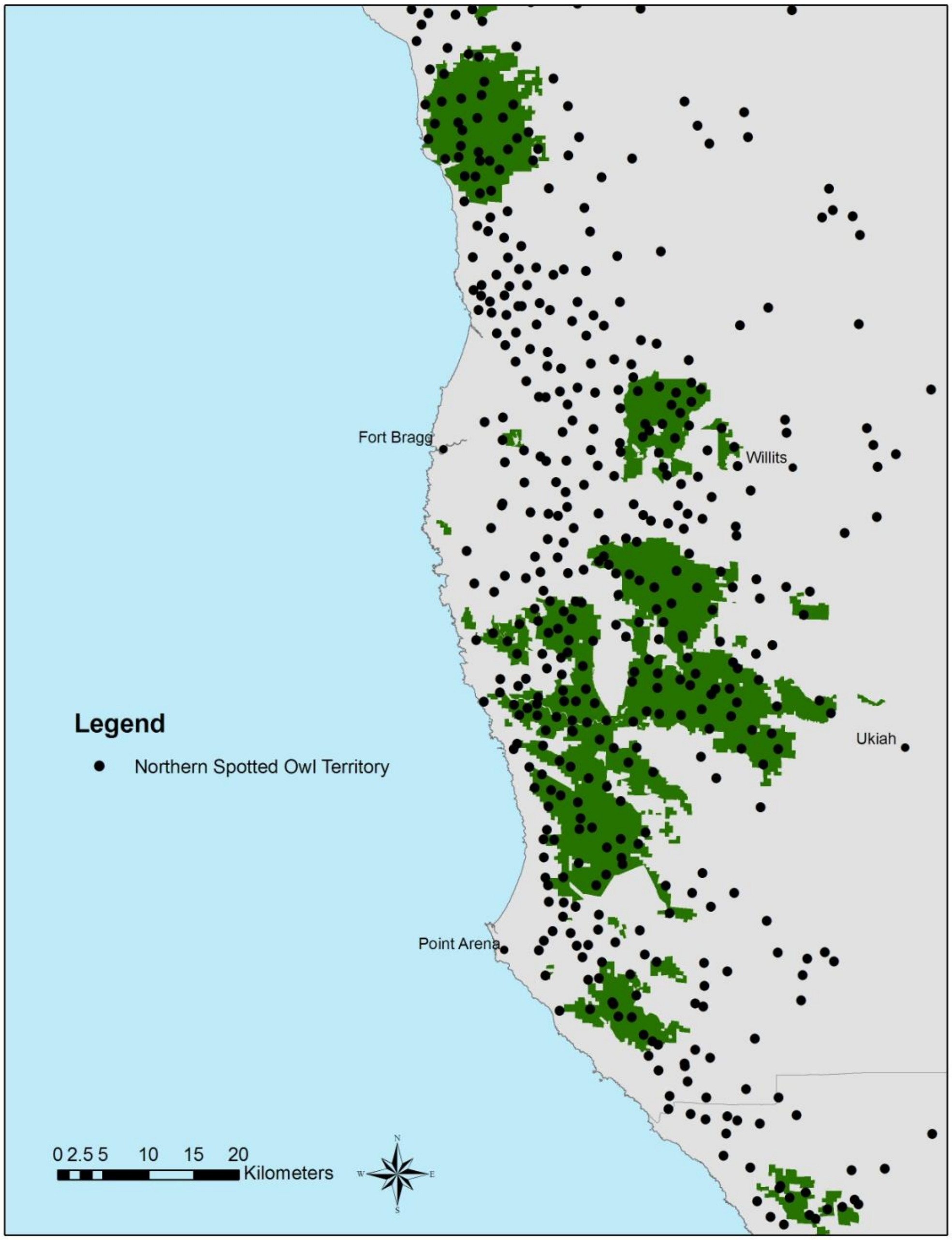

Figure 2. Distribution of northern spotted owl territories in coastal Mendocino and northern Sonoma counties.

REGIONAL REGULATORY HISTORY

The spotted owl has a long history of continuous regulation in California starting with its listing as threatened under the federal Endangered Species Act (ESA) in June 1990. In an effort to be proactive and address the listing, the California Board of Forestry adopted emergency regulations governing harvest activities around NSO sites. These rules were codified into California Forest Practice Rules to ensure NSO issues were addressed in timber harvest plans thereby avoiding claims of violating the federal ESA.

Ted Wooster, biologist from the California Department of Fish and Game (DFG), was responsible for administering the NSO conservation program associated with timber harvest plans in Mendocino and Sonoma counties. He was the agency contact for this program and performed most of the NSO consultations for L-P/MRC lands from 1990-1999 until the program was disbanded due to budget cuts and transferred to the United States Fish and Wildlife Service (USFWS). Ken Hoffman, USFWS biologist based in Arcata, administered the NSO technical assistance program for private timberlands in the redwood region from 1999-2010.

In late 2008, a memorandum was issued by the USFWS stating that their office could no longer financially support the current level of NSO technical assistance being provided to timber harvest plans without an increase in budgetary funding. Consequently, the USFWS gradually reduced its role in providing technical assistance for NSOs associated with timber harvest plans, and transferred this responsibility to CAL FIRE, provided they evaluate THPs using programmatic guidelines issued by the USFWS (i.e. aka, “Attachment A” on the coast, and “Attachment B” inland).

Mendocino Redwood Company relied heavily on the USFWS’ NSO technical assistance program for review of timber harvest plans, and particularly the personal review of harvest proposals by Ken Hoffman. The USFWS also played an integral role in the development of interim conservations measures for the NSO in a Planning Agreement (PA) signed by MRC and DFG. Although the PA deviated from “Attachment A” in several respects, it was necessary to maintain continuity with the standards and habitat definitions used in MRC’s proposed joint federal/state Habitat Conservation Plan (HCP)/Natural Communities Conservation Plan (NCCP), and is a contract required by state law for entities negotiating an NCCP .

Since the USFWS was not a signatory to the PA, CAL FIRE was skeptical they had the legal authority to allow MRC to use its own conservation measures and survey methodology in lieu of “Attachment A” without some written concurrence from the USFWS. Finally, after MRC explained the regulatory complexity it faced with this new process and the need to maintain continuity during the negotiations for the HCP/NCCP, the USFWS agreed to provide technical assistance for a proposed Spotted Owl Resource Plan (SORP), which contains: 1) an explicit survey and monitoring protocol; and 2) measurable standards for NSO protection (i.e. the NSO section of the PA).

On January 15, 2010, the USFWS formally acknowledged in a technical assistance letter (8-14-2010-TA-3742) that the standards and measures used in MRC's SORP are an acceptable alternative to the standards and measures in the USFWS' programmatic guidance document for NSO take avoidance in THPs. Following receipt of this letter from the USFWS, MRC attached the SORP to a THP so that it went through the public review process and it was approved by CAL FIRE. The SORP is now referenced in subsequent THP submittals and is on file with CAL FIRE.

Currently, MRC addresses take avoidance of spotted owls in THPs following the Forest Practice Rules (FPR) § 919.10[939.10] (a), which deals with Spotted Owl Resource Plans (Appendix A).

SPOTTED OWL CONSERVATION PROGRAM

For any conservation program to be effective, it is necessary to employ a survey methodology which has a high probability of detecting the target species so that it can be protected from direct disturbance. Two characteristics of spotted owls make them easy to conserve on working landscapes: 1) they respond readily to vocal imitation or recorded conspecific calls; and 2) they exhibit high site-fidelity to the same general area over successive years (and sometimes generations). These behavioral patterns, combined with knowledge about their regional biology and habitat use, allow foresters and biologists to manage a landscape so that it can support the spotted owl's life-history requirements.

All active spotted owl nest or roost sites receive a minimum, year-round 500-foot no-cut core area, and a 1000-foot breeding season disturbance buffer that can only be lifted after a spotted owl territory is determined to be non-nesting, nest-failed, absent, or the young have fledged and are capable of flight for at least two weeks (Fig. 3). During the breeding season (February 1^{st} through July 31^{st}), the earliest time in which seasonal disturbance buffer can be lifted is after a May 15^{th} survey or status visit which results in one of the above-mentioned outcomes. Limited activities, such use of an existing mainline haul road, may be allowed within these zones during the breeding season, but such allowances are based on the history of occupancy and the amount of historic road use in the area. Roadwork that does not involve vegetative habitat removal or alteration may occur within the seasonal disturbance buffer after July 9^{th}. However, no habitat altering activities are allowed within 1000 feet of an activity center while the seasonal disturbance buffer is in effect.

Topographical core areas which conform to natural landscape features such as ridges, watercourses, and distinct habitat boundaries are favored over the use of circular buffers discussed above (Fig. 3). Usually, topographical core areas are used when operations are proximal to activity centers and there is strong need to ensure maintenance of adequate amounts of nesting/roosting habitat at different spatial scales and facilitate access to nearby timber. Seventy-two acres of nesting/roosting habitat must be retained, at minimum, around spotted owl activity centers. Ideally, a single contiguous block of nesting/roosting habitat would comprise this habitat core. But the reality is that spotted owl activity centers are often surrounded by foraging and unsuitable habitat, not just nesting/roosting. In this case, the habitat core areas would be redrawn to include more nesting/roosting up to the 72-acre amount, and if not, harvesting in nesting/roosting could be restricted, especially if it is deficient within the home-range.

Activity centers are locations where spotted owls have been found in the daytime while roosting or nesting. In the absence of solid daytime locations, repeated nocturnal detections—over the course of a season or multiple years—may represent an activity center. These sites remain active for a minimum of 3-years (assuming consecutive years of surveys continue) and receive disturbance and habitat protections over this time period. In most instances, protecting active locations within the previous 3 years also protects many historical sites older than 3 years within the same general area. Regardless, nest trees for older historic sites that are disjunct from active core areas—or are considered by surveys to be abandoned—must be identified, tagged, and retained along with screen trees in perpetuity.

In 2003, MRC agreed to implement the habitat definitions outlined in its draft HCP/NCCP to address spotted owl take avoidance. Most notably these definitions use a 16-inch minimum average stand diameter limit for classifying nesting/roosting habitat compared to the USFWS's 11-inch minimum. MRC's definition represents a 45% increase in the diameter standard to be considered nesting/roosting habitat. This disparity inflates the number of NSO territories that are deficient in this habitat type at the core area and 0.7-mile scales compared with the USFWS's classification, and results in the application of habitat protection measures which ultimately restrict timber operations in this habitat type. Moreover, MRC has confirmed through analysis of 123 spotted owl nest sites that the 16-inch diameter standard is more appropriate for defining nesting/roosting habitat on its landscape than the standard used by the USFWS.

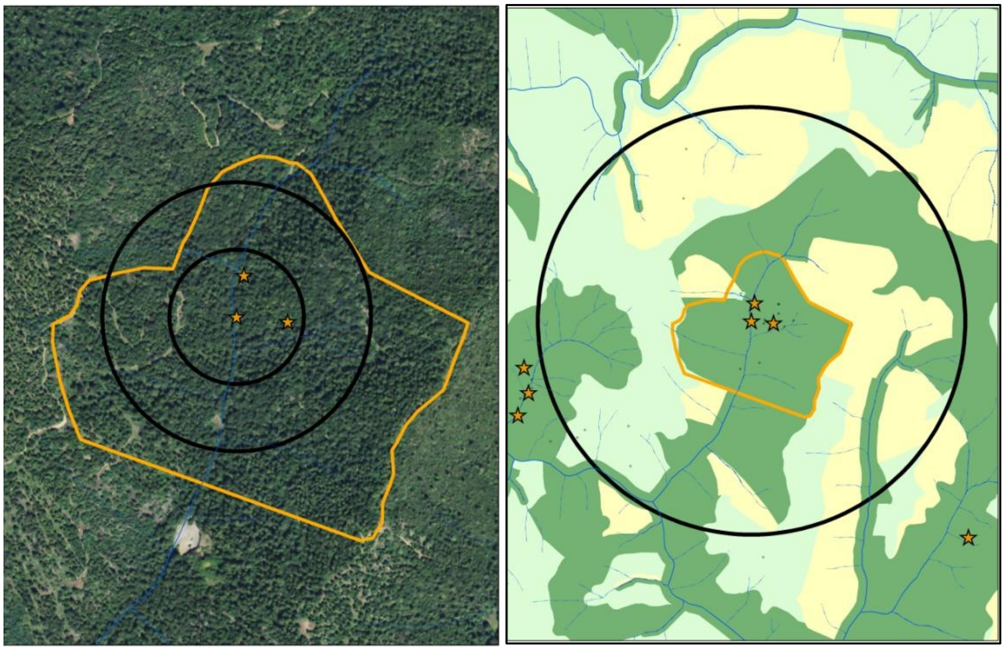

Figure 3. ***Above left,*** **aerial photograph depicting activity centers for MD065 from 2011-2013 with circular buffers of 500 and 1000 feet and a 118-acre topographic core area.** ***Right,*** **northern spotted owl map with 0.7-mile circle categorizing forest structure into nesting/roosting (dark green), foraging (light green), and unsuitable (yellow) habitats.**

Area-wide habitat analysis is conducted at the 0.7-mile scale around spotted owl activity centers. Within this scale, at least 200 acres of nesting/roosting habitat and 500 acres of suitable habitat (i.e. nesting/roosting or foraging habitat) must be maintained (Fig. 3). If a harvest plan will bring nesting/roosting or suitable habitat close to threshold for an owl territory then harvest may be restricted in these habitat types. Also, additional silvicultural standards may apply to nesting/roosting habitat that is contiguous with the core area. For example, if nesting/roosting habitat is approaching 200 acres within 0.7 miles, then at least two-thirds of the pre-harvest basal area must be retained and the stand must average at least 16 inches in diameter post-harvest.

Many other MRC management and conservation practices improve habitat for spotted owls. Because MRC's landscape has undergone intense timber harvesting by its predecessors, a significant amount of its land falls under reserve status. Currently, about 16.7% of MRC lands are off-limits to harvest, which includes forest stands within Watercourse and Lake Protection Zones and occupied marbled murrelet (*Brachyramphus marmoratus*) habitat. If owl core areas are included, the amount of reserve area eclipses 20%. In addition, MRC has numerous policies that specify retention of old growth stands, individual old growth trees, wildlife tree retention, and snag recruitment targets for THPs. When snag targets (i.e. 3 trees per acre with specific characteristics) are not met in a timber harvest plan, green trees must be identified and marked for recruitment to compensate for the deficiency using the same quantitative and qualitative criteria. All of these policies as a whole help to recruit and maintain structural elements of the forest conducive to spotted owl nesting and roosting.

Finally, a policy of sustainable harvest—that is, harvesting less than the annual growth rate—has the added effect of ensuring the existence of more conifer forest and larger conifer trees over time. Although growing more nesting/roosting habitat is not a requirement for take avoidance, MRC has increased the amount of nesting/roosting habitat around spotted owl sites by over an average of 60% from 2004 to 2012 (Fig. 4). Nesting/roosting acreage categories show a reverse "J"-shape distribution in 2004 but are now beginning to normalize (move to the right) with increasing habitat growth. Under the terms of the Planning Agreement, MRC is currently prohibited from engaging in activities resulting in incidental take. MRC's voluntary commitment to sustainable forestry practices is already achieving objectives consistent with an important provision of the draft HCP/NCCP and far exceeds any requirements for take avoidance under Attachment A.

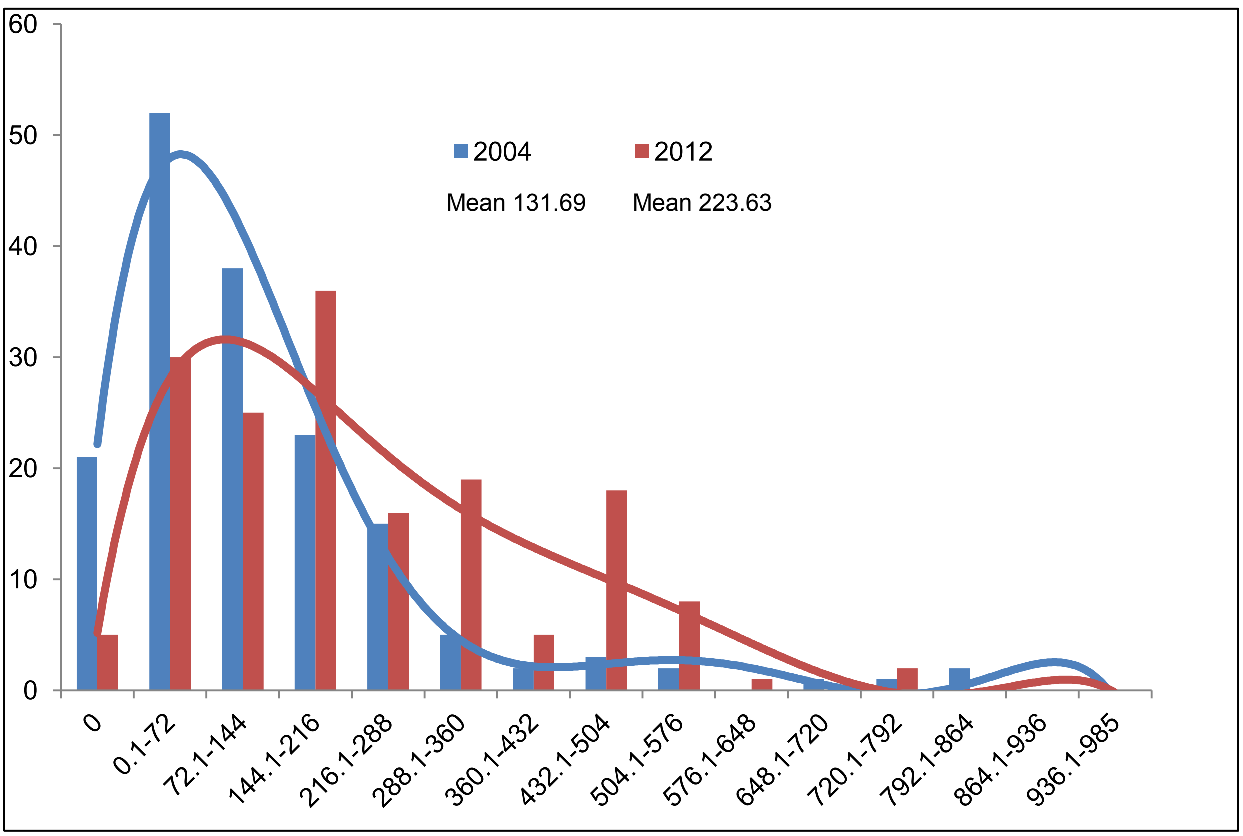

Figure 4. Comparison of nesting/roosting habitat distributions at 0.7 miles around spotted owl territories in 2004 and 2012. Nesting/roosting acreage classes are represented on the x-axis and

frequency is represented on the y-axis. Nesting/roosting acreages have shifted to the right in the 2012 data indicating an increase in this habitat type around spotted owl sites.

SPOTTED OWL SURVEY PROTOCOL

Mendocino Redwood Company follows a modified version of 1992 USFWS-endorsed protocol and relies on a combination of night surveys around project areas and monitoring known owl territories. Most night surveys follow a two-year, three visit protocol; however, in some instances a one-year, six visit protocol may be used. If either the one- or two-year protocol is completed, then a minimum of three surveys are required within 0.7 miles of a project during March, and all historic owl territories within 0.5 miles of a project must be located prior to the commencement of operations during the early part of the breeding season (February 1st—May 15th).

The most current USFWS protocol (2012) mandates a two-year, six visit night survey protocol because of the negative effects the barred owl (*Strix varia*) is having on spotted owl detection rates throughout the range. Although MRC's survey protocol may appear less stringent than the current survey protocol, it requires additional surveys in the form of monitoring visits to historically occupied sites. Monitoring is not required under CEQA, but these additional daytime visits are a necessary option to monitor the health of the NSO population and are beneficial for management because sites are repeatedly visited throughout the breeding season to document any changes in status and location. Moreover, since there is extensive survey history on the property, many sites—including those without any recent detection history—are receiving habitat and disturbance protections.

SPOTTED OWL SURVEY EFFORT

Consideration of survey effort is an important factor when monitoring populations over successive years because it may influence detectability of the target species, and hence, overall variation in observed occupancy patterns. Failing to account for survey effort may result in survey bias (e.g., over- or under-represent true occupancy), which can erroneously lead one to conclude that a species population is doing well when it is not, or vice-versa.

Spotted owl survey effort consists of two elements: 1) the number of visits to a survey station at night or to a spotted owl territory during the day; and 2) the spatial area of survey coverage as represented by the unique number of locations where surveys occurred. Outside of preventing "take", surveys are used to locate spotted owls at historic sites, determine if any have changed location, and/or if there are any new territories. Surveys associated with projects also overlap with owl territories that are regularly monitored. Night surveys offer a fallback method to relocate birds that were not found during daytime site visits, and may on occasion, help identify alternate nest/roost areas in new areas of the landscape.

Over the past 13 years, night survey effort has varied with the number of THPs, road restoration projects, and other disturbance activities being planned at least 3 years in advance (Fig. 5). Notable low points in survey effort occurred both in 2003 and 2009 for night surveys. In 2003, there was a relatively small number of THPs being considered for harvest; and in 2009, the economic recession caused a sudden downsizing in MRC staff, which significantly reduced our ability to conduct night and day surveys at a level seen in prior years. With the exception of 2009, the number of day surveys was somewhat consistent, even in years where night surveys were reduced (Fig. 5).

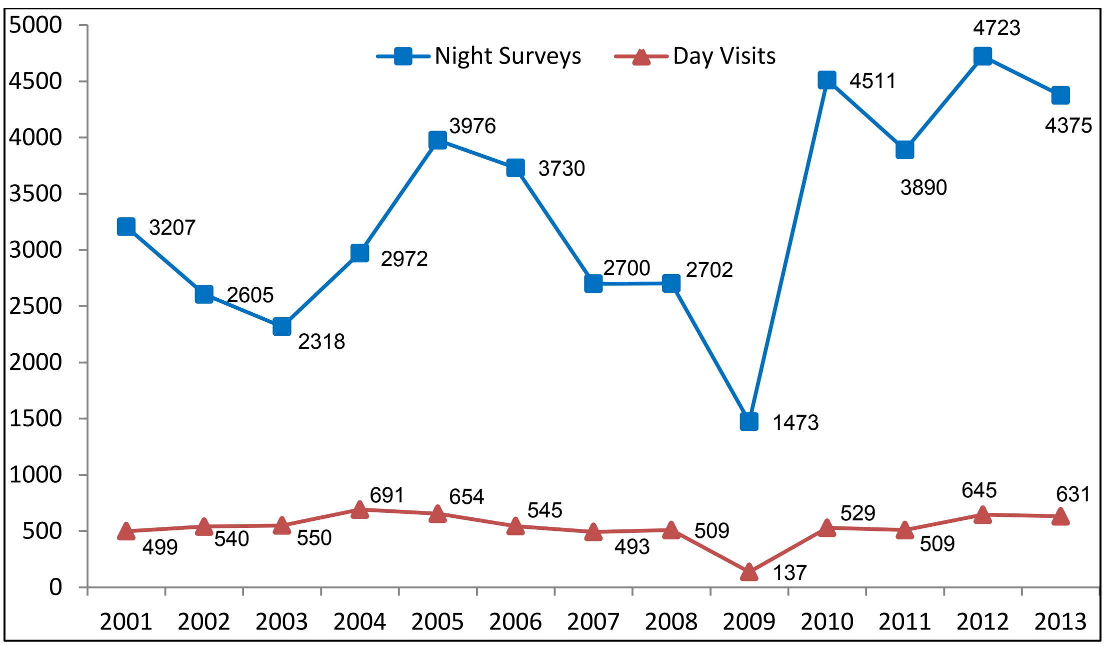

Figure 5. Survey effort by year showing the total number of 10-minute station called at night and the total number of daytime visits to known spotted owl territories and/or follow-up visits to locations where spotted owls were detected at night.

We used 0.5-mile buffers around survey stations and owl sites that were monitored to calculate the spatial amount of survey coverage for each year as a percentage of MRC property. Spatial coverage averaged

75% for the past 13 years and ranged from 60 to 84% (Fig. 6). The greatest consistency in survey effort as seen in both the number of surveys and spatial coverage occurred during the past four years (Figs 5 & 6).

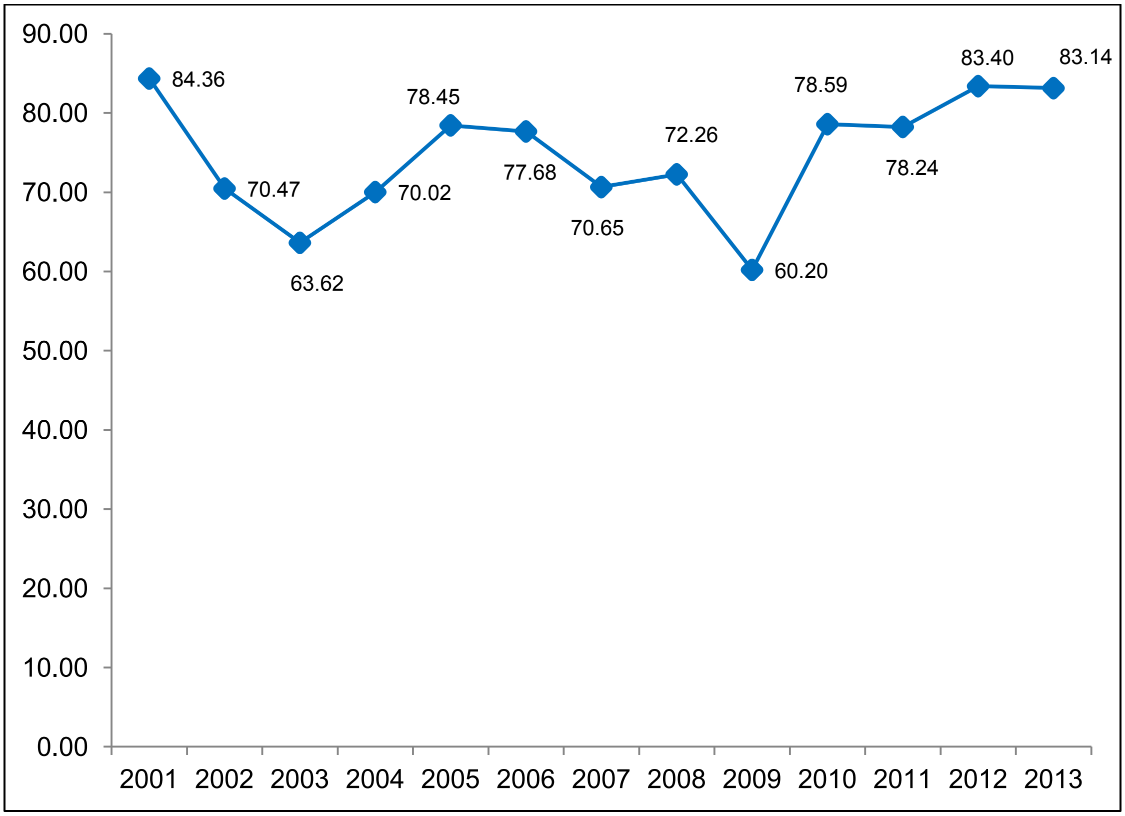

Figure 6. Annual spatial survey coverage percentages of MRC lands from 2001-2013. Percentages are based on 0.5-mile buffers around survey stations and owl sites surveyed during the year and clipped to MRC land.

OCCUPANCY TRENDS

Survey counts of spotted owl territories show a dynamically stable population trend over the past 13 years, with a few dips and spikes in annual numbers of total adult birds, pairs, and singles (Fig. 7). Although the total number of birds was influenced by annual fluctuations in the number of pairs and single birds found during a season, territory occupancy remained relatively constant over this time and increased slightly during past three years (Fig. 7). Fluctuations in the number of pairs and single birds may be affected by the population-level reproductive trends in a given year. Possible reasons for a decrease in occupancy in 2003 may have been due to the cold, wet spring during the spotted owl breeding season, which brought snow to coastal areas in mid-April. In contrast, 2009 was thought to be an above-average reproductive year for spotted owls, but our data show a decline in occupancy because spotted owl survey effort dropped off suddenly in May as a result of employee layoffs precipitated by the national recession. During the past four years nocturnal survey effort has increased slightly and the number of single birds has increased relative to the number of pairs, which have remained stable. Overall spotted owl occupancy patterns show no indication of declining trends over the past 13 years, during which time timber harvest activities have covered approximately 60% of MRC's ownership.

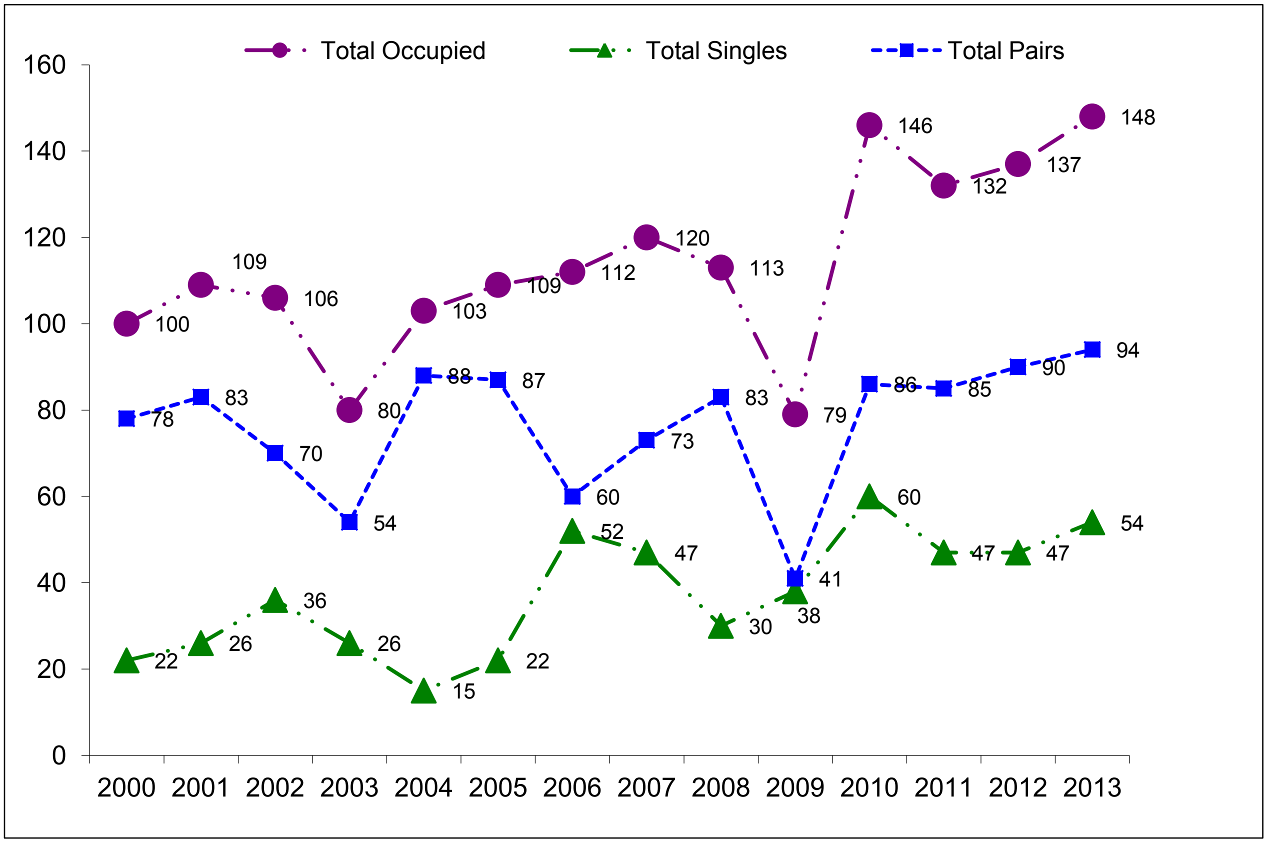

Figure 7. Number of northern spotted owl singles, pairs, and occupied sites by year for Mendocino Redwood Company timberlands, 2000-2012.

Disentangling the potential influence of survey effort on the above results requires scaling the data by considering the total number of sites surveyed or the spatial area covered by surveys. A naïve estimate of occupancy can be calculated as a proportion of the total number of spotted owl sites occupied by either a single bird or pair (Fig 8). The proportion of sites occupied varies annually, has the same characteristic dips seen in the previous graph, and averages 0.69 (or 69%) over the past 13 years (Fig 8). The pattern appears to be dynamically stable around the average and doesn't indicate any precipitous declines. Furthermore, while count data show a slight increase in occupancy over the past four years (Fig. 7), the proportion of sites occupied declined over this time (Fig. 8). This is due to the fact that over the past several years the total number of territories surveyed has increased without a corresponding increase in occupancy.

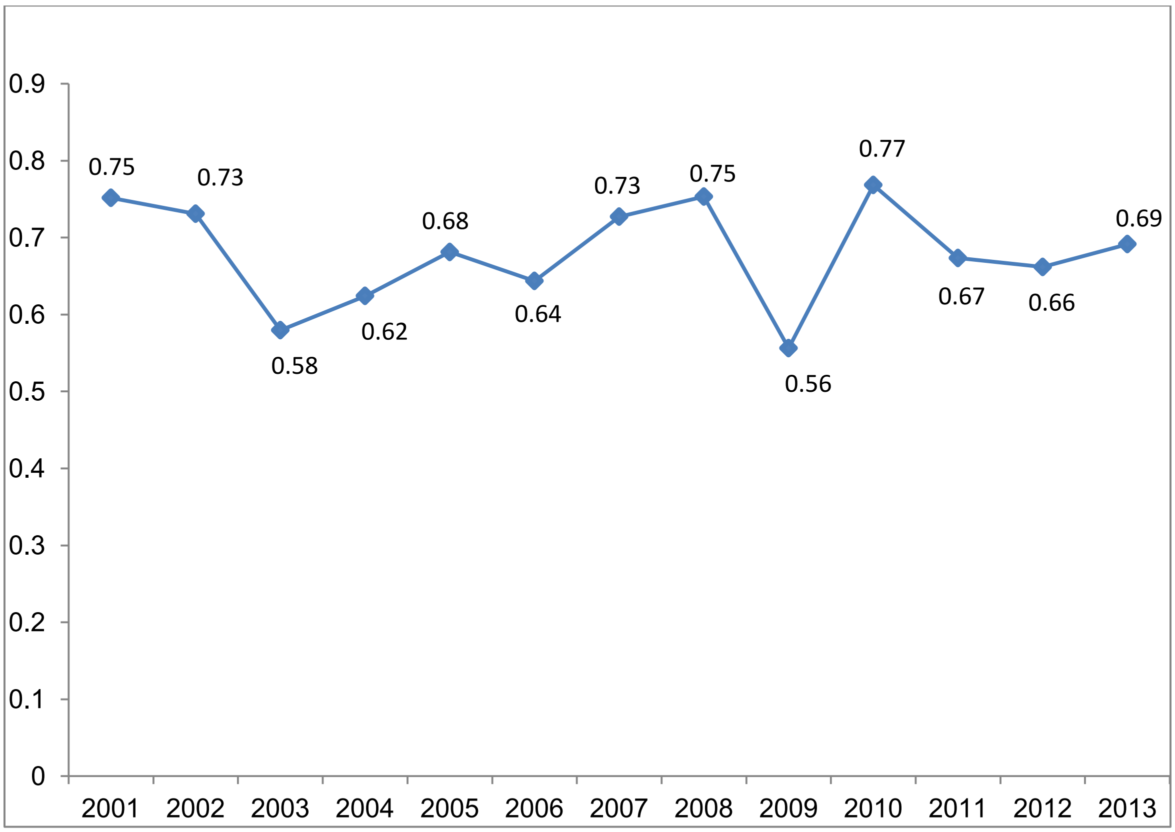

Figure 8. Proportion of occupied northern spotted owl territories on MRC lands, 2001-2013.

Calculating crude density of spotted owls based on the amount of area surveyed is another method that scales the variation in spatial sampling among years. As mentioned previously, the spatial area surveyed varies annually but averages around 75% for the past 13 years. Although crude densities of spotted owl pairs have remained stable, particularly during the past four years, crude densities of individual owls and occupied territories have increased slightly, indicating an increasing trend in the densities of single birds. This trend is seen in the unscaled count data for singles and pairs discussed above (Fig. 9).

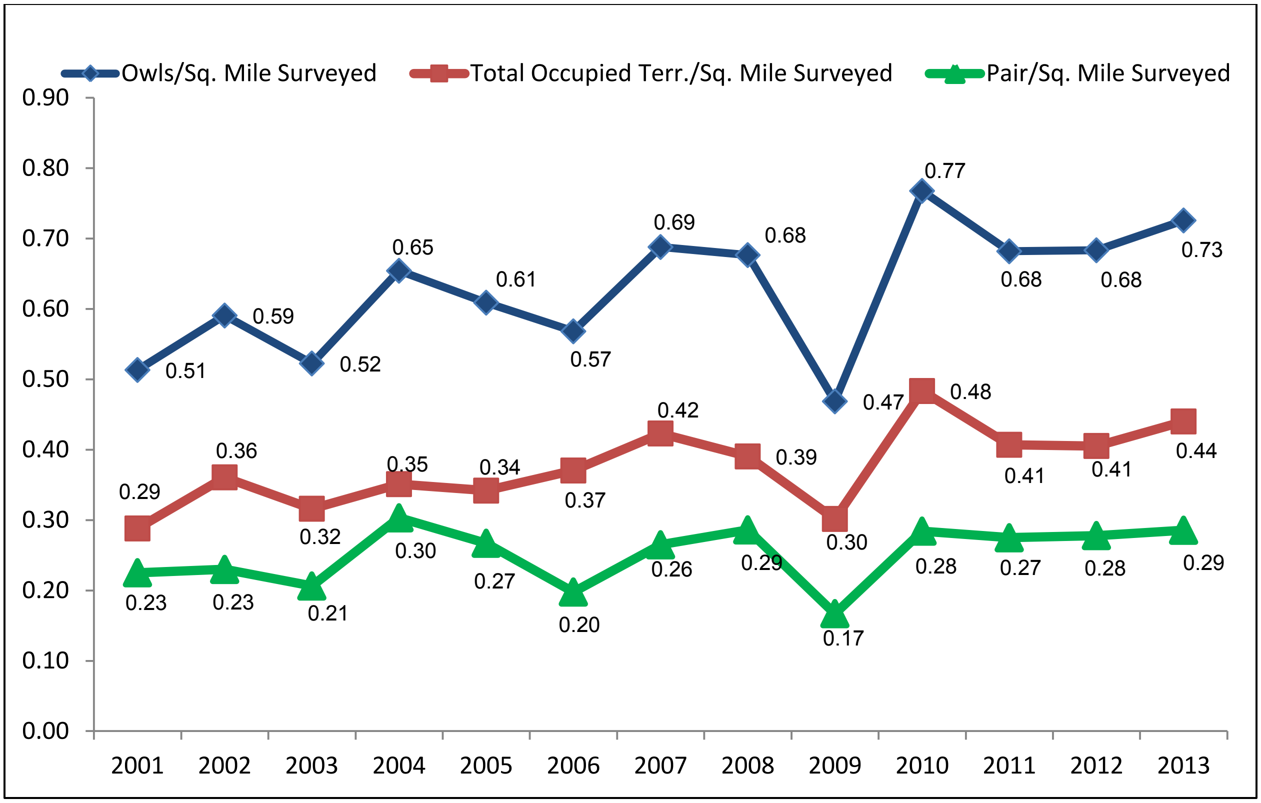

Figure 9. Crude densities of northern spotted owl pairs (*green triangles*), occupied sites (*red squares*), and adult birds (*blue diamonds*).

A major drawback, or criticism, of the methods used here to describe occupancy patterns is that they fail to accurately estimate occupancy because detection probabilities are usually less than one and are not constant over time. This phenomenon was captured in a previous occupancy analysis conducted on survey data from 2001-2008. Results indicated that detection probabilities varied by survey type (night versus day) and from year-to-year (Fig. 10). Failing to account for detection probability generally leads to an underestimation of occupancy—meaning there is a certain percentage of owl sites where birds are present but remain undetected during surveys. Therefore, "naïve" estimates of occupancy represent a conservative—or minimum—estimate of occupancy, whereas consideration of detection probabilities increases this estimate. When occupancy dynamics were modeled for MRC lands from 2001-2008, the top model equilibrated at 0.78, with colonization and extinction probabilities becoming balanced over time (Fig. 11). Occupancy estimates from the modeling exercise exceeded naïve estimates in every year.

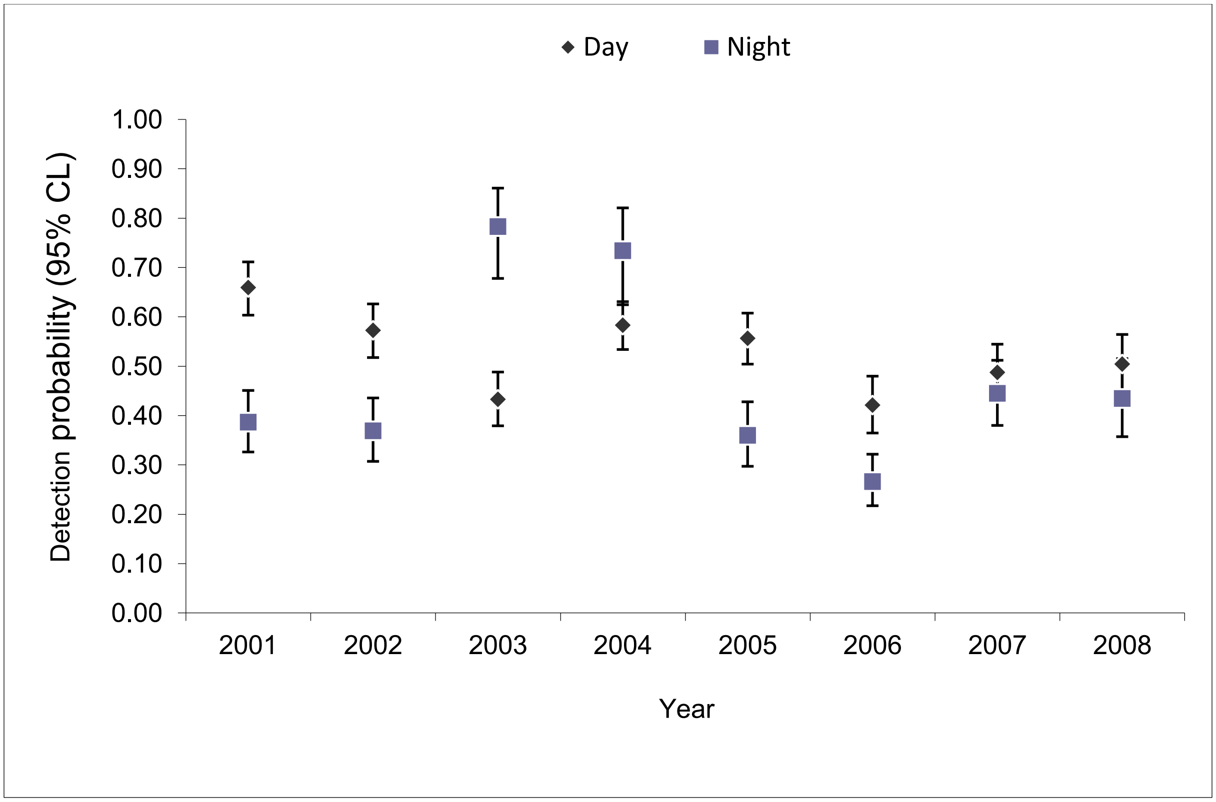

Figure 10. Detection probabilities of northern spotted owl territories based on day (*black diamonds*) and night (*gray squares*), 2001-2008.

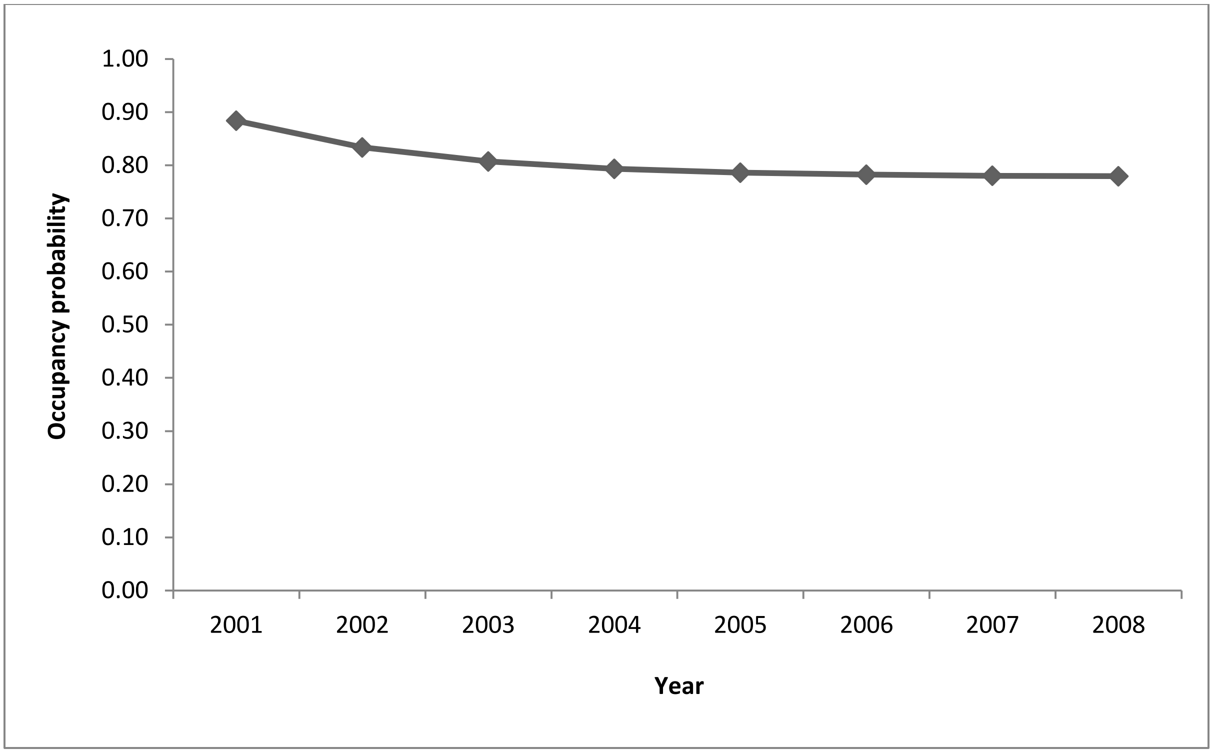

Figure 11. Occupancy probability by year for the top model, 2001-2008. Model includes annual variation in detections probabilities for night and day surveys, constant colonization probability (γ =0.37), and constant extinction probability (ε =0.11).

REPRODUCTIVE TRENDS

Reproductive success is an important metric because owls that successfully reproduce have a higher chance of contributing offspring—and genes—to future generations of spotted owl territory holders if they survive. Successful reproduction is also necessary for generating a surplus pool of non-territorial birds (i.e. “floaters”) available for recruitment when there is territory vacancy. Spotted owl reproduction is sporadic and closely linked to local weather and regional climate patterns, but may also be influenced by habitat, spotted owl breeding experience, prey availability, the presence of barred owls, disease, and chemical exposure. Data for MRC lands further corroborates the view that spotted owl reproduction is cyclic, which has been consistent with other study areas throughout northwestern California over the past 15 years (Fig. 12; See HRC’s white paper). Similar to previous studies, we found that precipitation in the early nesting period (March-April) was the most informative model explaining the negative relationship with reproductive output, particularly in the 1990s (Fig. 13). Although 22% of the variation in reproductive output was explained by precipitation during the early nesting period, we recognize that additional variables not considered here may also explain patterns in spotted owl reproduction.

Nonetheless, the cyclic nature of spotted owl reproductive patterns and their link with climate makes it very difficult to attribute timber harvest activities with declining reproductive rates without a carefully designed study that involves detailed habitat analysis and spotted owl demographic data.

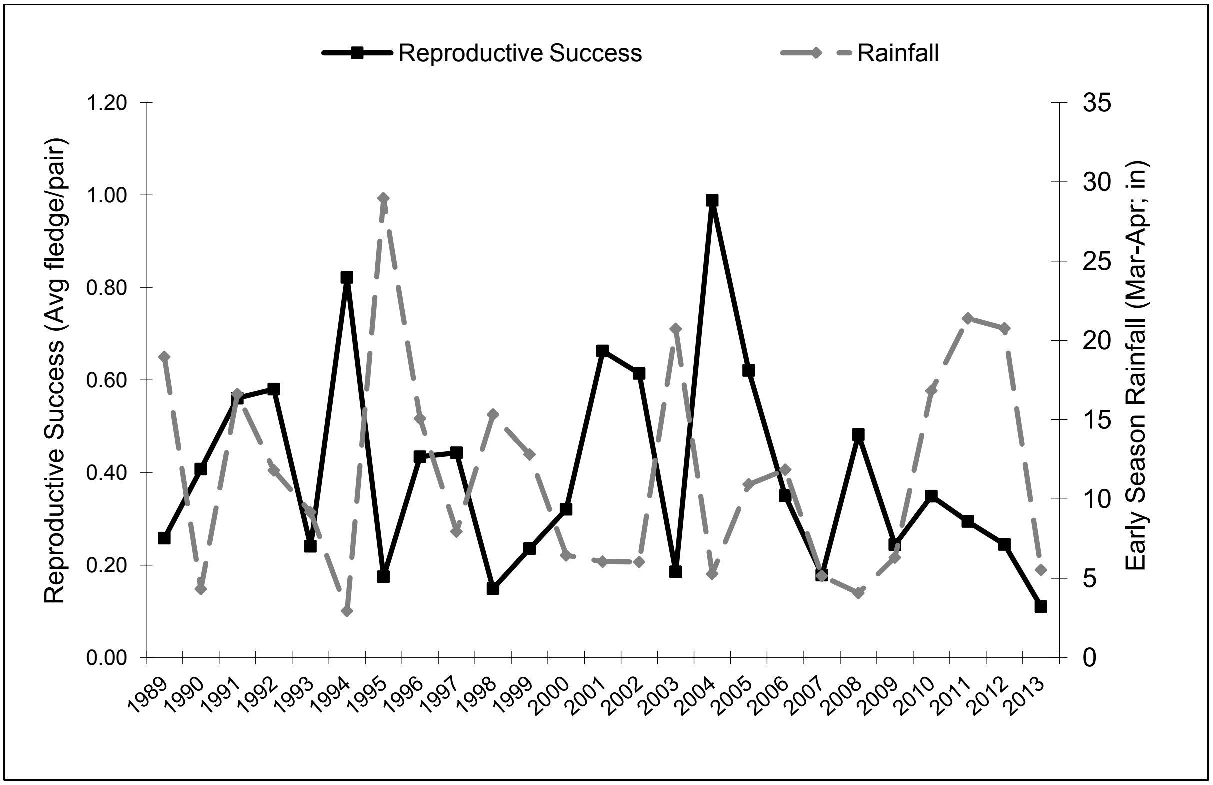

Figure 12. Annual reproductive success (mean number of fledglings/pair) of spotted owls and early season rainfall (inches) by year for Mendocino Redwood Company timberlands, 1989-2013

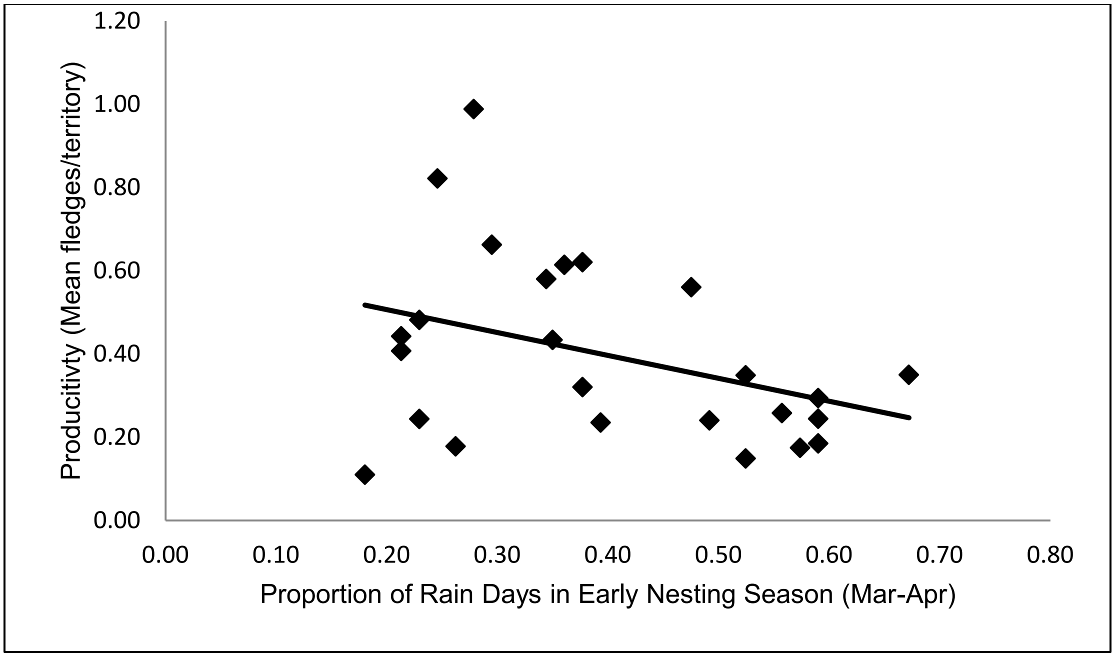

Figure 13. Relationship of the proportion of rain days during the early nesting period (Mar-Apr) to annual productivity (mean number of fledglings/pair) of spotted owls on Mendocino Redwood Company timberlands, 1989-2013.

UNREGULATED THREATS

BARRED OWLS

In recent years, barred owl detections have steadily increased during spotted owl surveys, spawning research into how barred owls affect spotted owls. Barred owl presence may negatively affect spotted owl social behavior, detectability, occupancy, reproduction, and even survival (Kelly et al. 2003; Olson et al. 2005; Crozier et al. 2006; Forsman et al. 2011; Wiens et al. 2011). In some regions of Oregon and Washington, barred owls have increased substantially over the past 25 years and are now displacing spotted owls (Kelly et al. 2003; Pearson and Livezey 2007). These results may explain some of the apparent declines in spotted owl populations seen in several demographic study areas (Anthony et al. 2006; Forsman et al. 2011). In British Columbia, the northern spotted owl was briefly extirpated from the northern-most part of its range by the barred owl but is now being reintroduced to the wild through a captive breeding program (USFWS 2011).

Barred owl presence was initially confirmed in Mendocino County in 1989 when area-wide surveys for spotted owls began. However, barred owls may have been present as early as 1978 (California Natural Diversity Database 2013; Dark et al. 1998). Most historic barred owl detections in Mendocino County were primarily from California State Park lands or other reserve areas, and less so from commercial timberlands (California Natural Diversity Database 2013). Since 2005, the total number of barred owl detections has increased during nocturnal and diurnal surveys for spotted owls on MRC forestlands. In 2013 alone, barred owls were detected within one mile of 47 spotted owl territories (Fig. 14). This raised the total number of spotted owl territories with barred owl detections within one mile to 71 over the past nine years, which represents about 45% of the territories present on MRC land. The number of barred owls detected is probably an underestimate given that surveys were 10 minutes long and consisted of spotted owl calls (with the exception of a few barred owl impacted areas where 20-minute, “Strix-mix” calls were occasionally used). Spotted owls have become more difficult to locate in areas where barred owls have been detected for at least two consecutive seasons; though in 2008, four spotted owl pairs successfully reproduced and fledged young where barred owls were previously detected. Three of these pairs went undetected for most of the breeding season that year, but were later found in July or August with young. Since then, spotted owl detections have ceased altogether at three of these locations because barred owls have established territories and are successful at reproducing.

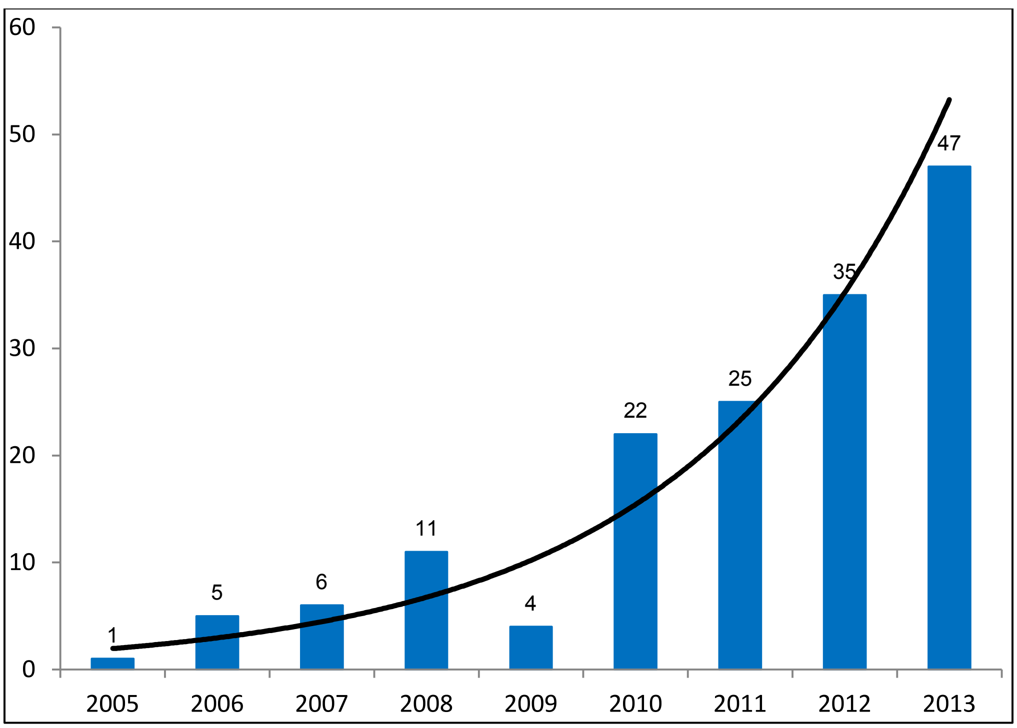

Figure 14.The number of northern spotted owl territories with barred detections within one-mile by year. Since 2005, 71 spotted owl territories have some history of barred owl detections at this distance.

The increasing density of barred owls is a particular concern in northwestern California where several timberland owners have spent millions of dollars and devoted substantial amounts of time negotiating conservation agreements covering the spotted owl (Mendocino Redwood Company 2011; Humboldt Redwood Company 2012). These agreements have explicit spotted owl population objectives (based on occupancy and reproduction) that must be met annually in order for specific management activities to occur. This not only guarantees some level of certainty as to how landowners will be regulated, but also increases spotted owl conservation by focusing on populations across large areas. An increasing population of barred owls on these landscapes could result in a failure to meet population objectives, and thus, unexpectedly trigger additional regulations and costs for landowners, despite an overall higher level of spotted owl protection, habitat retention, and habitat growth. The prospect of such a failure provides impetus for landowners to study this issue before it has the opportunity to undermine the significant effort and long-range planning put into these conservation plans.

RODENTICIDE EXPOSURE

Other unregulated threats to the northern spotted owl include exposure to rodenticides. Concern regarding secondary exposure of wildlife to rodenticides has been mounting as the these compounds are becoming routinely detected in the tissues of raptors and carnivores throughout the world in urban, agricultural, and wildland settings (Stone et al. 1999, 2003; Lambert et al. 2007; McMillin et al. 2008; Gabriel et al. 2012, 2013, Thompson et al. 2013). While initial concern over rodenticide use has been associated with its legal application to control rodents in residential areas and to prevent agricultural crop damage, the ecological impacts of its use are increasingly observed in illicit, trespass marijuana gardens on large tracts of public and private forestlands throughout the western US, including the ranges of the northern and California spotted owl (Gabriel et al. 2013). The scale of the problem in forestlands is largely unknown because marijuana farming is an unregulated, underground industry; and there are limited resources available to conduct thorough aerial surveys, rapid interdiction, and environmental remediation on large expanses of forests. Current knowledge of the problem has been gleaned from observations made by law enforcement, foresters, and biologists studying rare and endangered species affected by toxic exposure to pesticides found that these sites (Gabriel et al. 2013; Thompson et al. 2013).

Second-generation anticoagulant rodenticides have long half-lives (i.e. remain detectable in the body for long periods of time), are more toxic than first-generation rodenticides, and are readily concentrated in the livers of non-target wildlife that either directly consume these baits or consume exposed rodents (Stone et al. 2003). Lethal doses and bioaccumulation of SGAR cause hemorrhaging and affected individuals typically die of internal bleeding. The effects of sub-lethal exposure are less well-understood, but could make exposed individuals more susceptible to injury during normal activities and possibly reduce fecundity. Researchers in northwestern California have recently documented increases in exposure rates and mortality of Pacific fisher (*Pekania pennanti*) due to SGAR used in illicit marijuana gardens. In California, because spotted owls primarily prey on deer mice (*Peromyscus* spp.) and woodrats (*Neotoma* spp.)—the same prey acting as a vehicle for SGAR exposure in fishers—there is a real concern that SGARs may also be impacting their populations. In 2012, a spotted owl that was banded under MRC's Federal Endangered Species Permit was found dead by an adjacent landowner. This bird was sent to UC Davis for a necropsy to determine the cause of death. Although the cause of death was inconclusive, the bird had trace amounts of SGARs in its body, indicating that it was likely secondarily exposed to these compounds via rodent prey. At least 50% of the marijuana gardens found on MRC lands have pesticides present, usually in the form of SGAR (Figs. 15-17).

Figure 15. Common pesticides found at an illegal trespass marijuana garden on Annapolis tract. Chemicals here include an insecticide, molluskicide (metaldehyde), and a second-generation rodenticide (brodificoum).

Figure 16. Second-generation rodenticides dispersed among soil bags where marijuana was being grown on Navarro West.

Figure 17. Dead Stellar's jay (*Cyanocitta stelleri*) on a soil bag. Possibly a victim of rodenticide poisoning.

CONCLUSIONS

Mendocino Redwood Company forestlands have a 25-year history of spotted owl surveys, including detailed population monitoring, research, and conservation. Surveys are conducted to locate and protect spotted owl activity centers from timber operations and other disturbance activities, and to monitor owl occupancy and reproduction patterns over time to assess population health. Results from MRC's long-term monitoring program indicate that spotted owl occupancy has been dynamically stable on a landscape which undergoes annual timber harvests. Maintenance of a healthy owl population is due to MRC's dedication to not only finding and protecting owls, but also due to growing and maintaining habitat element that support northern spotted owl life-history requirements. The fact that spotted owls continue to exist in high numbers across MRC's forestlands is a testament to the company's commitment to sustainable forestry and owl conservation. However, the increasing presence of barred owls and pesticide-laden illicit marijuana gardens are a major concern because MRC has made a substantial financial investment to manage their forestlands in a way that supports a viable and robust population of spotted owls. Declining trends in spotted owl occupancy and reproduction have been attributed to the presence of barred owls in other study areas. But little quantitative information is available regarding the extent of spotted owl exposure to pesticides/rodenticides associated with marijuana gardens frequently observed near spotted owl sites. We strongly believe that the continued influx of barred owls into the redwood region, as well as the increasing presence of illicit pesticide/rodenticide in trespass marijuana gardens, pose a greater threat to the spotted owl than timber harvest. A failure to find a rapid solution to these time-sensitive issues threatens to undermine the intent of sustainable forest management, pending and future conservation agreements, and ultimately, the spotted owl.

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APPENDIX

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Arcata Fish and Wildlife Office
1655 Heindon Road
Arcata, California, 95521
Phone: (707) 822-7201 FAX: (707) 822-8411

In Reply Refer To:
8-14-2010-TA-3742

Mr. Robert B. Douglas
Forest Science Manager
Mendocino Redwood Company, LLC
PO Box 489
Fort Bragg, CA 95437

Subject: Response to Request for Technical Assistance Regarding the Proposed Mendocino Redwood Company Spotted Owl Resource Plan

Dear Mr. Douglas:

This responds to your request for U.S. Fish and Wildlife Service (Service) technical assistance, received in our office on January 8, 2010, on the proposed Mendocino Redwood Company's (MRC) Spotted Owl Resource Plan. At issue in the request is the potential for incidental take of the federally listed northern spotted owl (*Strix occidentalis caurina*) as a result of operations conducted as proposed under MRC's Spotted Owl Resource Plan (SORP). After review of the information pertaining to this request, the Service provides the following technical assistance.

The proposed SORP covers 228,000 acres of MRC property located in Mendocino and Sonoma Counties (see enclosed map). The SORP describes methodologies employed to locate spotted owls and to assess reproductive status, provides a framework for incidental take avoidance by specifying information to be included in individual timber harvest plans, includes habitat definitions, and measurable standards for protecting activity centers and conserving habitat. MRC intends to utilize the SORP until their Habitat Conservation Plan in approved. The Service has determined that MRC's timber harvest operations conducted as proposed under the enclosed SORP would not be likely to incidentally take northern spotted owls. The Service appreciates the high level of professionalism and integrity that you and your staff consistently demonstrate in assisting our efforts to conserve the northern spotted owl.

All maps and data used to provide this technical assistance are on file at this office. If you have questions regarding this response, please contact Mr. Ken Hoffman of my staff at the Arcata Fish and Wildlife Office at (707) 822-7201.

Sincerely,

Randy A. Brown
Acting Field Supervisor

Enclosure

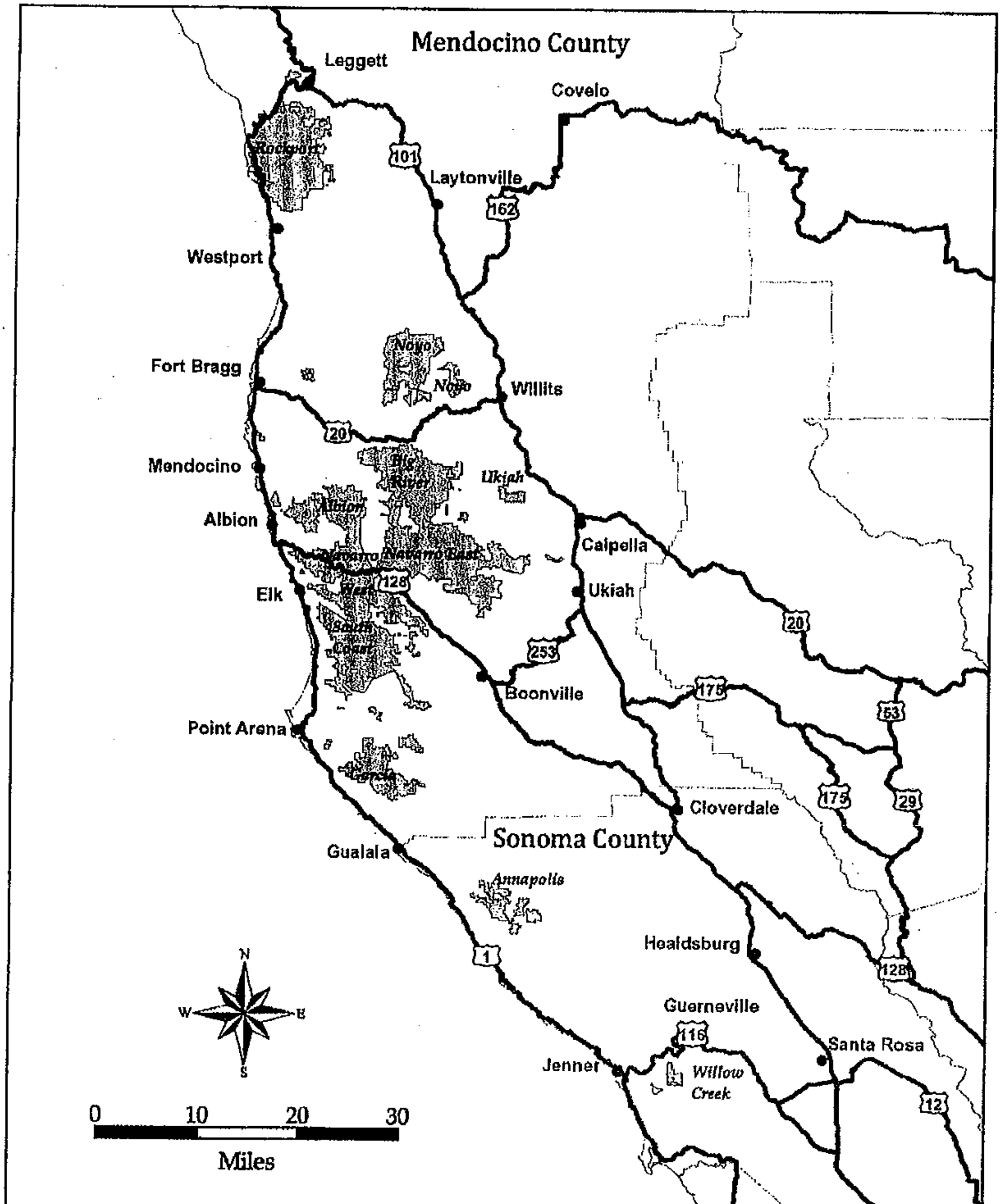

Figure 1: Mendocino Redwood Company forestlands comprising 228,000 acres in Mendocino and Sonoma counties.

Spotted Owl Resource Plan for Mendocino Redwood Company Forestlands

January 15, 2010

SUMMARY

A Spotted Owl Resource Plan (SORP) is intended to offer landowners submitting timber harvest plans a programmatic approach to take avoidance of northern spotted owls (*Strix occidentalis caurina*; NSO). The California Forest Practices Rules defines a "Spotted Owl Resource Plan" as "…an approach to preventing a taking of the northern spotted owl while conducting timber operations[,]" and "…necessarily involves more than one timber harvest plan." A Spotted Owl Resource Plan may be submitted to CAL FIRE for preliminary review, and once approved, can be attached to individual timber harvest plans (THPs) submitted by a landowner under Section 14 CCR 919.9(a).

Currently, however, no example of a SORP exists as none have ever been filed with CAL FIRE. Lacking a template to follow, we combined two documents—Mendocino Redwood Company's (MRC) Spotted Owl Survey Protocol, and a planning agreement signed by MRC and DFG—to function as a SORP covering MRC forestlands in Mendocino and Sonoma counties (Figure 1).

The SORP presented in the following pages describes methodologies employed to locate spotted owls and assess reproductive status, and delineates survey requirements for a range of activities and conditions common to industrial forestlands. In addition to a survey protocol, the SORP also provides a framework for take avoidance by specifying: 1) information to be included in individual timber harvest plans; 2) habitat definitions; and 3) measurable standards for protecting NSO activity centers and conserving NSO habitat.

All documents used in this SORP were generated from discussions with the USFWS and DFG regarding a proposed Habitat Conservation Plan (HCP)/Natural Communities Conservation Plan (NCCP) for MRC forestlands. Mendocino Redwood Company's Spotted Owl Survey Protocol is based on the USFWS-endorsed Spotted Owl Survey Protocol (1992), which was modified to reflect current regulatory and survey standards used in the coastal redwood region, as well as methods used by MRC biologists. The planning agreement is a formal agreement between MRC and DFG that provides explicit standards for addressing and protecting forest resources in timber harvest plans prior to implementation of a HCP/NCCP. Although the planning agreement was signed only by DFG, the USFWS was directly involved in reviewing the protection measures for federally listed wildlife species, including the NSO, to ensure consistency with federal take-avoidance guidelines. Section II of this SORP corresponds with the NSO section of the planning agreement.

Mendocino Redwood Company intends to follow the approved SORP until the HCP/NCCP is implemented. After this time, MRC will address spotted owls in THPs according to an approved incidental take permit (14 CCR 919.9 (d)) for HCP/NCCP-covered lands, but will continue to follow the SORP for THPs submitted in areas of its ownership not covered by the HCP/NCCP.

Overall, the following SORP demonstrates MRC's continued commitment to spotted owl conservation on its forestlands. While the primary function of the SORP is take-avoidance, many elements of this document, including MRC's management practices (e.g., old-growth and wildlife tree protections), go above-and-beyond this basic compliance standard. Mendocino Redwood Company will also continue to monitor spotted owls on its forestlands for both occupancy and

reproductive success. This effort, coupled with a banding program, ensures the collection of high quality data to better assess cumulative effects of timber harvest, barred owl presence, and long-term population trends. With such an investment, MRC hopes that with improved biological knowledge and targeted conservation efforts it can contribute to the eventual recovery of the northern spotted owl.

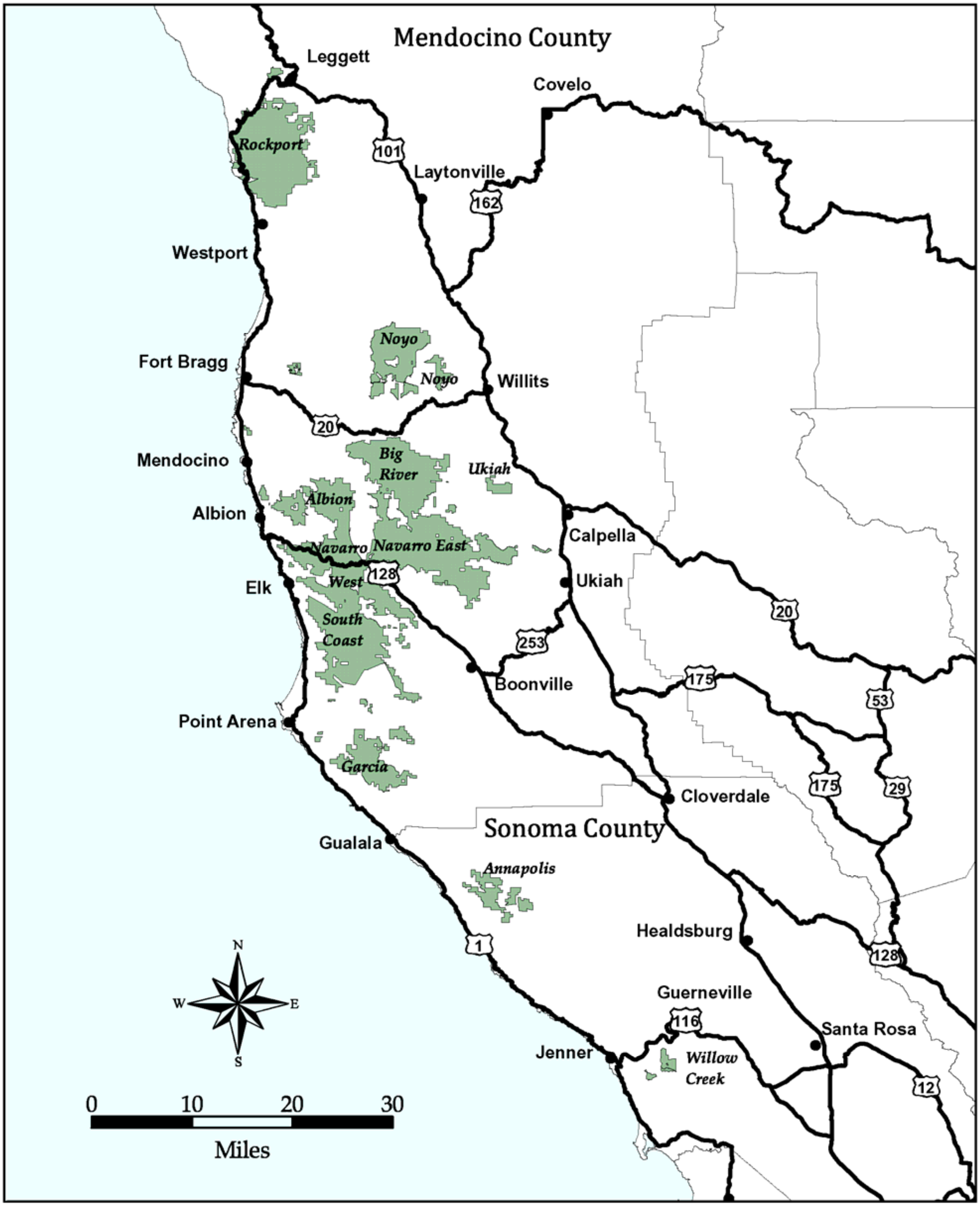

Figure 1: Mendocino Redwood Company forestlands comprising 228,000 acres in Mendocino and Sonoma counties.

I. MENDOCINO REDWOOD COMPANY SPOTTED OWL SURVEY PROTOCOL

1.0 Source and purpose of MRC protocol

MRC developed the following protocol based on the USFWS-endorsed protocol from 1992. Using the latest scientific data on owls and site-specific knowledge, we modified the protocol to better fit our land and harvesting methods. When implemented, the MRC protocol shall:

1. Provide adequate coverage and assessment of an area for the presence of spotted owls.
2. Ensure a high probability of locating resident spotted owls and identifying owl territories that may be affected by a proposed management activity, such as timber harvesting, modification of habitat, or noise disturbance.
3. Identify areas with barred owls and other potential avian predators/competitors.
4. Reduce the likelihood of incidental take.
5. Determine nesting and reproductive success (number of fledged young) of northern spotted owl territories within covered lands.

1.1 Activities requiring surveys

Table 1 indicates all activities that require surveys for spotted owl territories. The subsection immediately following the table clarifies the assessment area for each required survey.

Table 1: Activities Requiring NSO Surveys

Northern Spotted Owl (NSO) Surveys		
Activity	**Survey?**	**Comments**
Commercial harvesting operations	Yes	Needs survey unless there is no suitable NSO habitat within 0.7 miles of boundaries, inclusive of the harvesting operation, and no known activity center within ½ mile.
Vegetation management		
▪ Planting	No	
▪ Manual brush removal	Generally not	Needs survey only for operations using mechanized equipment; see requirements below.
▪ Chainsaw work	Generally not	• Needs survey only if work will result in reduction of NSO habitat during non-breeding season. • Needs survey during breeding season only if conducted within 0.5 mile of a known activity center and off a mainline road. • No requirement for a survey if simply using a chainsaw to clear roads for access.

Northern Spotted Owl (NSO) Surveys		
Activity	**Survey?**	**Comments**
• Heavy equipment	Generally not	Needs survey only if completed during breeding season within 0.5 miles of known NSO activity centers and off a mainline road.
• Prescribed burning	Generally not	Needs survey only if work will result in reduction of NSO habitat or burning during breeding season.
• Slash pile burning	No	
Roads and landings	Generally	Needs survey unless roads are mainline haul routes and landings are directly on mainline roads.
Rockpits, quarries, surface mining	Yes	Needs survey unless rockpits, quarries, or surface mining occurs on mainline roads
Data collection for monitoring	No	
Emergency fire suppression	No	
Habitat improvement/creation	Yes	

1.1.1 Extent of survey area

- If **disturbance only**[1] is proposed:
  - The survey will extend to 0.5 miles beyond a project boundary for a THP.
  - The survey will extend to 0.25 miles (1320 ft) beyond a potential disturbance for a non-THP project.
- If **habitat reduction** is proposed, the survey area will extend to 0.7 miles beyond the project area.
- If **blasting** is proposed, the survey will extend 1 mile beyond the blast site.

1.2 Accuracy of 1-year and 2-year surveys

In preparing its 1991 protocol for northern spotted owls, USFWS analyzed survey data to determine the number of visits needed to detect territorial owls or to conclude that a lack of owl response reflected an absence of spotted owls. Their data analysis provided the basis for the minimum number of visits that MRC requires for our 2-year survey (i.e., 3 visits per year) and 1-year survey (i.e., 6 visits per year). A **complete survey** covers a survey area to the required number of visits or documents activity centers of all spotted owl territories that account for all spotted owl habitat in the project impact area. Surveys over 2 years provide more confidence that the results reflect presence or absence in the current and subsequent year because owls sometimes occupy territories intermittently. Thus, the USFWS prefers the use of a 2-year survey over the 1-year survey to locate spotted owl sites. MRC staff may actually complete

[1] A “disturbance-only THP” is one that does not propose any reduction in habitat.

such surveys before the end of a 1-year or 2-year survey program if: 1) they obtain a response and confirm the status of the owl(s); and 2) there is a sufficient density of confirmed occupied owl sites to preclude additional owl sites within or around the project impact area.

1.2.1 Recertification surveys

Recertification surveys are surveys that deviate from the timing requirements of visits under the 1-year and 2-year survey protocols, and are usually conducted for areas where 2-year surveys have already been completed or where sufficient owl monitoring has located all active owl territories within 0.5-mile of a project impact area in the previous years. Recertification surveys must consist of a minimum of three surveys in March with a minimum 5-day separation between subsequent surveys. Typically, the USFWS allows recertification surveys for early start-up operations only after 2-year surveys have been completed. However, given that MRC forestlands have a substantial survey history spanning 20 years, the USFWS is supportive of MRC using recertification surveys for areas where only the 1-year survey protocol was followed.

1.2.2 The 2-year survey

If a 2-year survey is completed and no responses are obtained, the results fall under recertification status in subsequent years where a minimum of three surveys in March must be conducted. This also assumes that all active NSO territories within 0.5-mile of a THP are located in the current year of harvest operations.

EXAMPLE OF 2-YEAR SURVEY	
Year 1 (March - July)	3 visits with no response.
Year 2 (March - July)	3 visits with no response. Operations may commence after 3rd survey if no response.
Year 3	A minimum of three surveys in March with no responses prior to commencing operations.
Year 4	A minimum of three surveys in March with no responses prior to commencing operations.
Year 5	A minimum of three surveys in March with no responses prior to commencing operations.

1.2.3 The 1-Year survey

If a 1-year survey is completed and no responses are obtained, harvest may occur before the start of the next breeding season. If harvest is not completed within this time period, a minimum of 3 surveys must be conducted prior to harvest in Year 2. If this additional survey produces no responses and harvest will not occur until after Year 2, then recertification surveys will be necessary in subsequent years (at least three surveys in March) prior to early start-up operations. This assumes that all active NSO territories within 0.5-mile of a THP are located in the current year of harvest operations.

EXAMPLE OF 1-YEAR SURVEY	
Year 1 (March - July)	6 visits with no responses.

Year 2	Conduct at minimum 3 surveys in March with no responses prior to commencing operations. If no responses obtained, additional surveys are not needed.
Year 3	A minimum of three surveys in March with no responses prior to commencing operations.
Year 4	A minimum of three surveys in March with no responses prior to commencing operations.
Year 5	A minimum of three surveys in March with no responses prior to commencing operations.

1.2.4 Daytime-only surveys

In cases where the project impact area is either saturated with owl territories or proximal to an owl site (precluding establishment of additional owl territories), daytime-only surveys or site visits to historically occupied sites are acceptable in lieu of nocturnal surveys ONLY when **<u>all active NSO</u>** territories are verified as occupied in the season in which operations are proposed. Available wildlife agencies (USFWS, DFG) and/or CAL FIRE may provide the criteria for such determinations.

1.2.5 Locating nest site or activity center

If a nest site or activity center is located during a survey and the project area is large enough to possibly support more than one site (i.e., there is at least a 0.5 mile radius from the located owl to another site), the remaining potential habitat should be surveyed (Figure 1). Half a mile is a commonly accepted distance for owl territories. Though our minimum inter-territory distance varies from this number, we know, on average, territorial owl activity occurs a half mile or more from other owl territories.

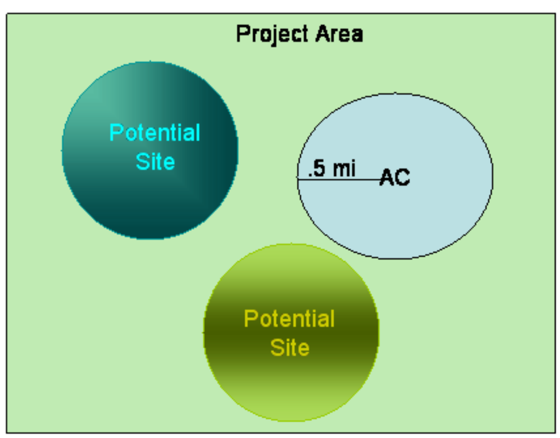

Figure 2 Potential Sites in Project Area

1.3 Area of surveys

MRC will inventory all potential suitable habitat for northern spotted owls in a harvest impact area using current habitat typing. If potentially suitable habitat is located, MRC will conduct surveys. If no potentially suitable habitat is located within the harvest boundary or 0.7 mi. away, no surveys will be required. All areas of suitable habitat within the harvest boundary will be surveyed unless spotted owl territories have been located within 0.5 miles or survey work has adequately covered the area in the current year.

1.3.1 Timing of surveys and operations

MRC will conduct surveys based on the timing of harvest operations. **Ongoing operations** are those in which there is 1 week (i.e. 5 consecutive days) of continuous operations with no breaks prior to February 1st—unless there is a break due to weather or to the requirements of the protection measures.

Ongoing Operations—Option I: Operation may continue from February 1st -March 1st if the following conditions are met:

1. 1-year or 2-year protocol surveys have been completed in the previous year.
2. Operations, other than use of existing roads, are at least a 0.25-mile from a known NSO activity center.

AND

3. Operations are limited to a harvest unit that was started prior to February 1st.

OR

4. All active territories (a) have been located within a 0.5-mile (1 mile if rock-blasting) of the harvest boundary and (b) the operations adhere to breeding disturbance limitations (see Section 2.3.1).

OR

5. Owl territories (a) have been located and either saturate existing habitat or exist in sufficient densities to preclude additional owl sites within 0.5-mile of the harvest boundary and (b) the operations adhere to breeding disturbance limitations (see Section 2.3.1).

Ongoing Operations—Option II: Operations may continue past March 1st if the following conditions are met:

1. 1-year or 2-year protocol surveys have been completed in the previous year.

AND

2. All active territories (a) have been located within a 0.5-mile (1 mile if rock-blasting) of the harvest boundary and (b) the operations adhere to breeding disturbance limitations (see Section 2.3.1).

OR

3. Owl territories (a) have been located and either saturate existing habitat or exist in sufficient densities to preclude additional owl sites within 0.5-mile of the harvest boundary and (b) the operations adhere to breeding disturbance limitations (see Section 2.3.1).

Ongoing Operations—Option III:Felling operations may continue past March 1st if the following conditions are met:

- 1-year or 2-year protocol surveys have been completed in the previous year.
- Falling is limited to completing a harvest unit that was started prior to February 1st and is at least 0.25-miles from a known NSO activity center.

Full Operations—Option I: Full operations can be initiated between March 1st and May 15th if the following conditions are met:

1. 1-year or 2-year protocol surveys have been completed.
2. A minimum of 3 surveys in March have been completed with no NSO detections prior to operation start-up within 0.5 miles of the THP boundary (for projects qualifying for recertification).

AND

3. All active territories (a) have been located within a 0.5-mile (1 mile if rock-blasting) of the harvest boundary and (b) the operations adhere to breeding disturbance limitations (see Section 2.3.1)

OR

4. Owl territories (a) have been located and either saturate existing habitat or exist in sufficient densities to preclude additional owl sites within 0.5-mile of the harvest boundary and (b) the operations adhere to breeding disturbance limitations (see Section 2.3.1).

Full Operations—Option II: Full operations can be initiated between March 1st and May 15th outside of 0.5-mile of any active NSO site if the following conditions are met:

1. 1-year or 2-year protocol surveys have been completed.
2. A minimum of 3 surveys in March have been completed with no NSO detections prior to operation start-up within 0.5 miles of the THP boundary (for projects qualifying for recertification).

Full Operations—Option III: Full operations can be initiated after May 15th if the following conditions are met:

1. 1-year or 2-year protocol surveys have been completed including surveys from the current year.

AND

2. All active territories (a) within a 0.5-mile (1 mile if rock-blasting) of the harvest boundary have been surveyed to protocol and are either located or deemed unoccupied and (b) the operations adhere to disturbance and habitat limitations based on occupancy and reproductive status (see Sections 2.3.1 & 2.3.2).

OR

3. Owl territories (a) have been located and either saturate existing habitat or exist in sufficient densities to preclude additional owl sites within 0.5-mile of the harvest boundary and (b) the operations adhere to breeding disturbance limitations (see Sections 2.3.1 & 2.3.2).

1.4 Protocol for night-calling survey

For survey purposes, northern spotted owl habitat is nesting/roosting or foraging habitat. At a minimum, MRC must survey all nesting/roosting and foraging habitat.

1.4.1 Coordination of information

MRC will avoid common mistakes, such as overlapping visits by more than one survey group, through coordinated planning. When possible, we will also inform adjacent landowners of all surveys near their property. Such surveys could affect their own management and logging operations. Moreover, neighboring landowners may provide information on off-property owls and cooperate in joint surveys.

1.4.2 Survey period

Surveys of proposed management activity areas must take place between March 1st and August 1st, unless proposed operations initiate prior to February 1st. For areas where there is adequate biological information that birds are defending their established territories prior to March 1st, MRC may use earlier dates as a starting time. Positive responses after August 1st are still valid, but negative results after this date do not count as required visits for completing a survey. Positive responses obtained after August 1st also indicate that the area in question should be surveyed the following year.

1.4.3 Establishing the survey area

- Develop transects or calling stations to cover all spotted owl habitat within the delineated survey area, including locations detailed in the Section 1.1.1.

- Establish calling stations and survey routes to achieve complete coverage of the area, preferably from more than 1 calling station. Calling stations should be spaced approximately 0.25 to 0.5 miles apart, depending on topography and background noise levels. Take advantage of prominent points within the survey area when establishing calling stations. If necessary, to ensure complete coverage of the area, supplement the prominent points with intermediate calling stations. Where known spotted owl activity centers exist within the survey area, survey areas may be adjusted to exclude habitat that would be within earshot of the activity center. However, consider the need to survey the known activity center for current status. The intent is to obtain complete coverage of the area where owls will be able to hear the surveyor and the surveyor will be able to hear the owl.

- Record, for each visit, whether results are positive or negative, and include the following information:
  - County
  - Watershed
  - THP or Inventory Block
  - Survey type (point, cruise, or combination)
  - Surveyor(s) name
  - Survey date
  - Brief description of survey route
  - Survey start and finish time
  - Total time of survey
  - Weather conditions (including estimated precipitation level, wind speed, and percent cloud cover)
  - Survey results, i.e., spotted owl detections, including time of response, sex , and age (if possible); type of response (i.e., audio, visual, or both); azimuth of response; estimated distance of response; behavior or vocalization type; For multiple or moving owls, list information and number each response or observation. This will allow more accurate determinations of management centers.

- Record all sightings of or responses by barred owls, great horned owls, northern goshawks, or any other raptor species. The presence of other raptors may affect spotted owl responses.

- Map the following for each visit:
  - Route surveyed and stations called.
  - Spotted owl response or observation locations. For multiple or moving owls, map all response or observation locations and number to correspond with survey results. Again, this will assist in determining activity centers.

1.4.4 Survey methods

There are four types of acceptable surveys: point calling, cruising or leapfrog calling, daytime calling surveys, and territory monitoring (aka site visits). Point calling is the recommended method for nocturnal surveys, and territory monitoring is the recommended method for daytime surveys at historic site centers or nocturnal detection locations (i.e. daytime follow-up visit).

1. **Point calling (nocturnal)**
   Set up a series of calling stations 0.25 to 0.5 miles apart along the road transects. When possible, pick prominent points which cover large areas. Spend at least 10 minutes at each station. If the topography lends itself to fewer, prominent calling stations, spend more time at each station. Be sure the entire survey area is adequately covered.

2. **Cruising or leapfrog surveys (nocturnal)**
   Walk the designated route calling and pausing at prominent points and at regular intervals throughout the area to conduct informal stations of 10-minute duration. If 2 people are involved, you may use a leapfrog method (Forsman 1983).

3. **Daytime calling surveys**
   Set up a series of calling stations at least 600 feet apart along the road transects. When possible, pick prominent points which cover large areas. Spend at least 20 minutes at each station (see section 1.5).

4. **Territory monitoring (site visits)**
   Walk a route through a historically occupied site during the daytime calling at regular intervals and pausing to search the area for sign of spotted owls (i.e. feathers, whitewash, nest structures, roosting birds, etc.,). Once birds are located, note location of birds with GPS unit and assess occupancy status and reproductive status (see sections 1.6 and 1.7). Spend no less than 90 minutes searching a historically occupied site if unable to detect a spotted owl.

1.4.5 Survey instructions

The following instructions apply to either of the methods described above:

- Elicit responses from northern spotted owls with voice calling or the use of a recommended digital wildlife caller. When arriving at a station, the surveyor will record the time and begin voice calling. The surveyor may use a digitally recorded call to elicit a response. Continue this process for at least 10 minutes at each calling station.

- Characterize behavioral observations. Make note of agitated calls, continuous responses, movement (toward you or away from you), or situations where there is only one owl response followed by quiet. Recording this type of information may assist with the identification of activity centers.

- Conduct night surveys between sunset and sunrise. Be sure not to call the same section of a survey route at the same time on each survey effort if possible (i.e., vary the time you start and the section of the route from which you start).

- Do not survey under inclement weather conditions, such as high winds (> 10 mph), heavy rain, heavy fog, or high noise levels (e.g., stream noise, machinery, etc.) which would prevent you from hearing responses. If weather conditions or noise levels are in doubt, be conservative. Survey visits conducted under marginal conditions will reduce the quality of the overall survey effort. Negative results collected under inclement weather conditions may not be adequate for evaluating spotted owl presence or absence. When using an alternate survey point because of stream noise, note this on the survey sheet and re-locate the point in approximately the same survey area. Stream noise is generally a problem during surveys early in the breeding season from March through April.

- Resort to more than one visit, if necessary, to complete a survey. The objective of a complete visit is to conduct a thorough survey of the entire area in one field outing; however, in some cases this may not be possible. A complete visit may be a combination of a day and a night field outing and, in addition, may include a daytime follow-up visit. If reasonable effort was made to cover the area in one outing, but this was not accomplished, then the remaining area should be surveyed in the following field effort. To reduce the chance of owls moving between portions of the survey area and, as a result, being missed, complete the visit on consecutive days as much as possible. The entire area should be covered within 7 days in order to be considered as one complete visit.

- Divide a large project area that cannot be surveyed in 7 days into smaller areas based on available habitat, topography, drainages, and other important factors. Survey areas need to be small enough to be completely surveyed within the specified time period.

- Count as 1 complete visit a night outing and daytime follow-up. If a surveyor goes out at night and does not get a response, a daytime follow-up would not be necessary. In this case, the night outing alone would be considered 1 complete visit. Whether or not owls are heard, the entire area needs to be surveyed to count as a complete visit.

- Space visits at least 5 days apart. For example, assume a visit ends on the 3rd of May. Using a proper 5-day spacing (May 4-8), the next possible visit date would be May 9th.

- Conduct at least 2 of the night visits per year before June 30th for a 2-year survey and at least 4 of the night visits before June 30th for a 1-year survey. One survey must occur after May 15th and before June 30th for a 2-year survey, and two surveys must occur during this same time period for a 1-year survey. Also, survey effort should be spread out over 5 months to avoid efforts concentrated in a short period of time, particularly at the beginning of the survey season. Exceptions to this survey standard apply to recertification surveys where either the 1-year or 2-year survey protocol has been previously met.

- Adjust the survey period when there are season restrictions due to snow, landslides, mud, and bridge failures, etc., and provide documentation to explain the modifications.

- Conduct surveys during the day when there are no roads or foot trails to traverse at night or when there are other safety concerns. Provide documentation on the specific safety concerns.

1.5 Protocol for daytime calling surveys

Permit daytime calling in areas that are not accessible with nocturnal surveys in order to reduce the chance of worker injury while hiking at night. Follow the point method, if possible, when using daytime surveys. Space call points no further than 600 ft apart, if using daytime surveys when calling from discrete points; owls do not respond from long distances during the day as they do at night. Surveyors must conduct all daytime calling for at least 20 minutes at individual survey points. An alternative survey strategy may increase inter-station distance up to a 0.25-mile when conducting a cruise survey between points, but surveyors must spend at least 20 minutes surveying each station.

1.5.1 Owls located during surveys

- Estimate the owl's original and final location. One method is to triangulate on the owl's call, taking compass bearings from 2-3 locations. Make sure compass bearings are taken in as short a time-frame as possible. Record on the survey form the method used to estimate the location.

- Record the location(s) of the owl, preferably on a map or photo attached to the survey form.

- Attempt to confirm the owl(s) location with a daytime follow-up. The intent of triangulation and mapping is to provide a means for verification of the location. Daytime locations are very important in determining more precise activity centers.

- Record a bird response. If no response is heard, proceed to the next calling station. Continue until the survey area is completely covered.

- Return to the same area during the day if a bird responds at night; return within 72 hours to verify status. If weather precludes a return visit, document this.

- Conduct an intensive search during a daytime follow-up to locate spotted owls (pairs or singles) within the general vicinity of the night response. Surveys may begin from roads closest to the night response area. However, if owls do not respond to road surveys, surveyors should conduct walking routes through the area. Surveyors should spend sufficient time within the stand to cover the area well. This may take several hours, depending on the terrain. Observers should watch for owls flying in without responding and for other evidence of occupancy, such as pellets, whitewash, and feathers. Pellets, whitewash, or feathers alone are not sufficient to document spotted owl presence or residency. Mobbing jays are also a potential indicator of owl presence. The follow-up should be completed within 72 hours after presence was detected, as owls are more apt to be located near the previous night's location. A daytime follow-up is only the second part of a complete visit.

- Determine status if a response occurs during daylight hours and there is sufficient time to do so. Use conservative judgment and hoot only as much as needed to determine status. Do not hoot any more than is necessary. By stimulating the owls to move around, you increase their risk of predation. Excessive calling near a nest site may cause harassment by bringing the female off the nest. Excessive use of the agitated call in high owl density areas (e.g., California coastal areas) may also confound survey results by eliciting responses from owls representing multiple territories.

- Complete the survey route to determine pair status once a bird responds at night. To avoid *leading* a spotted owl through calling, go to the other end of the survey route and complete the rest of the survey once an owl responds. If that is not practical, survey only the remaining stations that are beyond the earshot of the responding bird. Beyond earshot is generally over a ridge or at least a 1/2 to 3/4 mile straight-line distance from the owl. Completing the route will provide an opportunity to detect any other owls.

- Continue to call for the duration of the station visit even after other species respond unless the surveyor believes that this will increase the potential for predation, for example, by great horned owls or northern goshawks.

1.5.2 Additional visits

Additional visits may be required if resident status cannot be determined during surveys. These visits should be in the general area of the response (i.e., a 0.5-mile radius around the site). If resident status is determined at any point during the additional visits, no more visits to that particular site are required for the year. The same standards (timing, intervals, weather condition limitations, etc.) apply to additional visits.

In a 2-year survey, MRC will conduct additional visits the same year as the response:

- If the last response occurs on the 1st visit, MRC will conduct 1 additional visit.
- If the last response occurs on the 2nd visit, MRC will conduct 2 additional visits.
- If the last response occurs on the 3rd visit, MRC will conduct 3 additional visits

In a 1-year survey, MRC will conduct additional visits the same year as the response:

- If the last response occurs on the 4th visit, MRC will conduct 1 additional visit.
- If the last response occurs on the 5th visit, MRC will conduct 2 additional visits.
- If the last response occurs on the 6th visit, MRC will conduct 3 additional visits.

If MRC cannot obtain 3 responses even after additional visits, we will not classify the owl as a resident single.

1.6 Protocol for assigning occupancy status

MRC will establish **pair status** if:

1. A male and female are heard or observed (either initially or through their movement) in proximity (< 0.25 mile apart) to each other on the same visit.
2. The male takes a mouse to the female.
3. The female is observed on a nest.
4. One or both adults are observed with young. Young alone do not define a pair because young barred owls look like young spotted owls until late in the summer.

When unidentified calls are heard in the vicinity of a known spotted owl, the surveyor should not assume species identification of the unknown owl. Daytime follow-ups should be used to clarify these situations.

MRC will establish **resident single status** if:

1. There is presence or response of a single owl within the same general area on 3 or more occasions within a breeding season, with no response by an owl of the opposite sex after a complete survey.
2. There are multiple responses over several years (e.g., 2 responses in Year-1 and 1 response in Year-2, from the same general area).

A resident single may represent a succession of single owls within the same general area in single or multiple years. Determining if the responses occur within the same general area should be based on topography and the location of any other owls known for the surrounding area. This should be determined by the wildlife biologist for the particular area. Radio-telemetry and banding data can also be used to aid in determining status of singles.

MRC will establish **status unknown** if there is a response of a male and/or female which does not meet any of the above category definitions.

MRC will establish **unoccupied status** if there are no detections of a spotted owl at a historically occupied site after a minimum three surveys during the breeding season following the timing requirements of a 2-year survey protocol. Night surveys and daytime site visits may be used exclusively or in combination to count towards unoccupied status.

1.7 Protocol for determining reproductive status

Determining reproductive success is not required to avoid "take," if breeding season restrictions are applied to all harvest activity in order to protect owl reproduction during any given year. Restrictions may be dropped if, according to the protocol, surveys reveal that owls are non-nesting or that no young were produced.

Following is MRC protocol for determining reproductive status of spotted owls. Reproduction surveys may provide information on nest tree locations and the most accurate activity center locations. There are 2 stages of reproduction surveys: nesting status and reproductive success.

Nesting Status

- Conduct nesting status surveys between March 11th and July 31st. The start date is based on nest initiation dates. Young identified in July should still confirm nesting.

- Spread the surveys throughout the survey period. Do not conduct all nesting status surveys early in the breeding season.

- Use a standard *mousing* procedure as described below to determine nesting status. However, do not *mouse* birds any more than is necessary to determine nesting status. By stimulating them to move around during the day, you may increase their risk of predation. This applies to hooting as well. Excessive calling near a nest site may cause harassment and endanger eggs or young by bringing the female off the nest.

Mousing

- Locate one or both members of a pair during the day and offer mice or other small prey items.

- Record the *fate* of each prey item (e.g., eaten, cached, or given to female or young) once an owl takes prey or is found with natural prey. The fate of the prey is used to classify nesting status.

- A minimum of four prey items shall be available for determining nesting status, with the exception of a refusal of 2 prey items on a single occasion (see section under *Non-nesting* below).

- Continue to offer additional prey items, if the owl eats the prey, until the owl caches the prey, sits on it for an extended period of time (60 minutes), refuses to take additional prey, or carries the prey away. If the bird flies with the prey, follow and try to determine the final fate of the prey. For more details on mousing procedures, see Forsman (1983).

- Make a concerted effort to get the owl(s) to take mice. Be creative in placing a mouse where the owl can easily see and capture it; offer mice to the mate of an owl.

1.7.1 Classifying sites

MRC will classify a site as nesting, non-nesting, or unknown nesting status based on field observations.

1.7.2 Nesting

MRC will classify owls as nesting if any of the following conditions are observed:

- Two observations, at least 7 days apart, if the first observation occurs before May 15th.
  NOTE

This is necessary because owls may show signs of initiating nesting early in the season. A surveyor may consider them nesting when, in fact, they are not nesting. For instance, a female observed on a nest early in the season may simply be roosting and not incubating eggs.

- One observation, if after May 15th.

Nesting is confirmed if, on 2 visits before May 15th or 1 visit after May 15th, any of the following observations are made:

- The female is observed on a nest.
- Either member of a pair carries natural or observer-provided prey to the nest.
- A female possesses a brood patch when examined in hand during mid-April to mid-June. Only 1 observation is required. Dates may vary with the particular areas. Be careful not to confuse the normal small area of bare skin (apteria) on the abdomen with the much larger brood patch. A fully developed brood patch covers most of the lower abdomen, extending to the base of the wings. Describe the brood patch on the field form, including length, width, color, and texture of the skin, and any evidence of regenerating feathers around the edge. While a scientific research permit is not required by USFWS for calling spotted owls, any capture or handling of spotted owls does require such a permit.
- One or both adults are observed with young. Because young barred owls look like young spotted owls until late in the summer, young alone are not sufficient.

1.7.3 Non-nesting

Non-nesting can be inferred for a NSO territory if, on two visits between March 11th and May 15th, and with at least 3 weeks separating visits, any of the following observations are made:

- The female is observed roosting for 60 minutes, particularly early in the season. Be aware that nesting females with large nestlings often roost outside the nest during warm weather. If in doubt be sure to schedule 1 or more visits in mid-June to check for fledglings.
- The female does not possess a brood patch when examined in hand between mid-April and mid-June.
- Prey are offered to one or both adults and they cache the prey, sit with the prey for an extended period of time (60 minutes), or refuse to take additional prey beyond the minimum of 2 prey items.
- One or both spotted owls refuse to take prey for 60 minutes. **<u>This can only count for one of the two required visits to infer non-nesting</u>**; the other visit must use the procedure outlined above to infer non-nesting status.

Non-nesting can be inferred for a NSO territory if, on two visits between May 15th and August 1st, with at least 7 days separating the visits, any of the following observations are made:

- A pair is located on at least 2 visits.
- Prey are offered to one or both adults and they cache the prey, sit with the prey for an extended period of time (60 minutes), or refuse to take additional prey beyond the minimum of 2 prey items.

OR

- One or both spotted owls refuse to take prey for 60 minutes. **This can only count for one of the two required visits** to infer non-nesting; the other visit must use the procedure outlined above (see March 11th-May 15th) to infer non-nesting status.

1.7.4 Unknown nesting status

Nesting status is unknown if any of the following apply:

- None of the conditions are met for nesting or non-nesting above

1.8 Reproductive success

Once an owl pair is classified as nesting, MRC will conduct reproductive success surveys when the young leave the nest (fledge)—although surveys are more successful in late May to late June. Surveyors may also assess reproductive success through the month of July and even later with positive results. The following process will be used to assess reproductive success:

- Schedule at least 2 visits to a site to locate and count fledged young if 1 or 0 fledglings have been located; time the visits so that the fledged young are observed as soon as possible after they leave the nest to reduce predation.

- Attempt to locate fledged young. Use visual searches and mousing. If young are present, the adults should take at least some of the prey to the young. The sight of an adult with prey will usually stimulate the young to beg, revealing their number and location.

- Record 0 young if the birds take at least 2 prey items and eventually cache, sit with, or refuse further prey without ever taking prey to fledged young—on at least 2 occasions separated by at least 1 week.

- Count the number of fledged young seen or heard on the first successful reproductive visit. If 2 or 3 fledged young are identified, the reproductive status is complete.

- Conduct a minimum of 1 follow-up visit if only 1 fledged young is seen; the visit should be 3-10 days after the fledged young is seen in case some owlets are missed on a single visit.

- Classify the production of young as unknown, if there is no response after at least 2 visits, separated by at least 1 week during the fledging period.

- Classify the number of young as 1+, 2+, etc., if you count young on 1 visit but do not get back for a second visit, or find no owls on the second visit.

Opportunistic mousing late in the season (July 31st) may be useful for providing supplemental information about site productivity. However, mousing efforts late in the season must be considered inconclusive if they fail to provide positive information, because dispersal or mortality may have occurred.

1.9 Protocol for determining activity center

Figure 3 illustrates the decision process that MRC uses every year to select an activity center for each spotted owl territory. In reviewing the decision process, a few points should be noted: (1) MRC may locate an owl pair from auditory input; (2) MRC will use the most-used roost site (based on observations, presence of whitewash, and presence of pellets) in the event of multiple roost sites; and (3) MRC may consult with USFWS and CDFG and/or CAL FIRE to designate an alternate activity center, if the decision flow does not result in the most biologically suitable location.

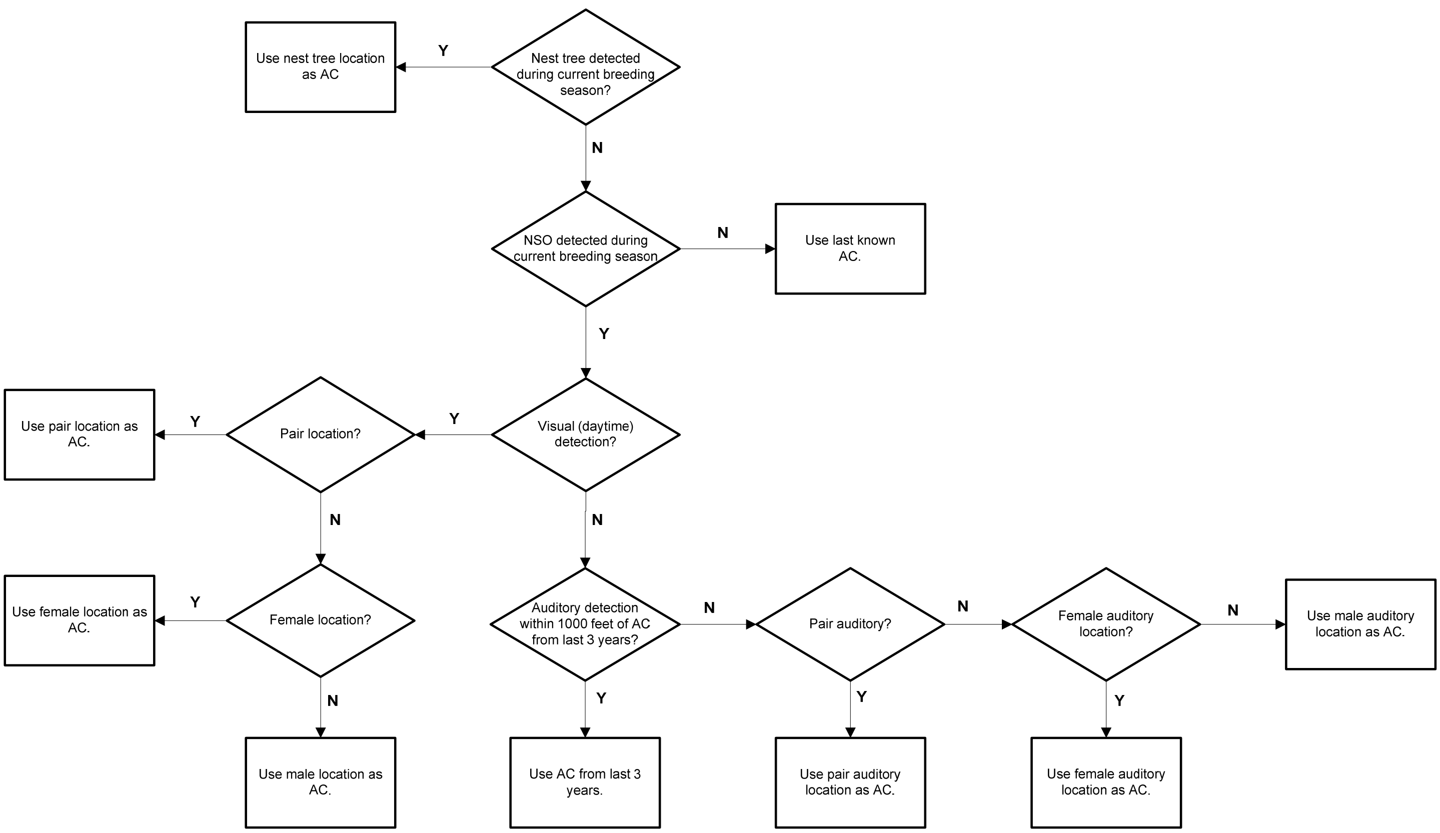

Figure 3: Selecting an Activity Center

II. MENDOCINO REDWOOD COMPANY NORTHERN SPOTTED OWL PROTECTION MEASURES

2. Northern spotted owl habitat definitions

The following guidelines are intended to protect and avoid take of the northern spotted owl. These guidelines prescribe measures that exceed, or are in addition to, the requirements of the FPR and MRC's Option A Report. For purposes of these guidelines, forest structure classes will be categorized as "Foraging" habitat or "Nesting/Roosting" habitat for northern spotted owl, or as "Non-suitable" habitat, as follows:

Structure Class	Tree Type	Dominant Size Class	Min. Canopy	NSO Habitat Type
0	Non-forested	0	0	Non-suitable
1	Mixed Hardwoods	<8"	<40%	Non-suitable
2	Mixed Hardwoods	>16"	<40%	Non-suitable
3	Mixed Hardwoods	8"-16"	>40%	Non-suitable
4	Mixed Hardwoods	>16"	>40%	Foraging
5	Mixed Hardwoods	8"-16"	>60%	Non-suitable
6	Mixed Hardwoods	>16"	>60%	Foraging
7	Mixed Conifer/Hardwoods	8"-16"	<40%	Non-suitable
8	Mixed Conifer/Hardwoods	16-24"	<40%	Non-suitable
9	Mixed Conifer/Hardwoods	8"-16"	>40%	Non-suitable
10	Mixed Conifer/Hardwoods	>16"	>40%	Foraging
11	Mixed Conifer/Hardwoods	<8"	>60%	Non-suitable
12	Mixed Conifer/Hardwoods	16-24"	>60%	Foraging
13	Conifer	8"-16"	<40%	Non-suitable
14	Conifer	16-24"	<40%	Non-suitable
15	Conifer	24-32"	<40%	Non-suitable
16	Conifer	>32"	<40%	Non-suitable
17	Conifer	8"-16"	>40%	Foraging
18	Conifer	16-24"	>40%	Foraging
19	Conifer	24-32"	>40%	Foraging
20	Conifer	>32"	>40%	Foraging
21	Conifer	8"-16"	>60%	Foraging
22	Conifer	16-24"	>60%	Nesting/Roosting
23	Conifer	24-32"	>60%	Nesting/Roosting
24	Conifer	>32"	>60%	Nesting/Roosting

2.1 Take avoidance guidelines.

MRC will continue to follow the procedure prescribed in section 919.9 of the FPR, including providing information to enable CAL FIRE to make no-take determinations and, when applicable, obtaining technical assistance directly from the USFWS or through CAL FIRE prior to implementation of any THP until the NCCP/HCP is finalized and even after the NCCP/HCP is formalized for lands not included in the NCCP/HCP. MRC will include the information below for each THP. MRC acknowledges that the USFWS' provision of technical assistance is subject to the availability of appropriated funds and available staffing.

The technical assistance reflected in this section will apply for so long as the USFWS continues to provide technical assistance to CAL FIRE or MRC. If the USFWS stops providing technical assistance, MRC may elect to stop using these technical assistance guidelines but would remain obligated to comply with the Endangered Species Act and its prohibition against the take of listed species, such as the northern spotted owl.

2.1.1 Activity center map and other information

In each THP, MRC will include one copy of a map of known northern spotted owl activity centers[2] in or near (within 0.7 miles) the THP ("Activity Center Map"). The Activity Center Map will include, at a minimum, all activity centers identified in the previous three years. The Activity Center Map will also include activity centers identified prior to the previous three years, unless the activity center is inactive. "Inactive" means that 1) there are 3 years of negative results to surveys (for a mapped 72-acre core area and assuming no interference competition from barred owls) as described in 2.1.2 below, or 2) based on site-specific conditions identified by MRC, the USFWS concurs that an identified activity center is inactive or otherwise does not warrant designation as an activity center. The Activity Center Map will identify any portion of the THP that is within 0.7 miles of a northern spotted owl activity center. If no portion of the THP is within 0.7 miles of an activity center, the THP will include a statement to that effect, explain the basis for the conclusion that the THP is not within 0.7 miles of an activity center, and describe any surveys or other actions taken to determine that no activity center is present. For the THP area and areas within 0.7 of each activity center, MRC will also provide one copy of each item below in the THP.

A. Pre- and post-harvest habitat maps for the THP.

B. Description of silvicultural acreage for the THP.

C. Pre- and post-harvest northern spotted owl habitat acreages by silviculture and harvest unit, including an estimate of the post-harvest basal area minimums. A pre-harvest basal area assessment must also be provided where timber harvest will occur in Nesting/Roosting habitat that is ~ 500' from the Activity Center or contiguous with the 72-acre core area (see 2.4, below).

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[2] "Northern spotted owl activity center" means a geographical point derived from owl survey data that is used to depict the location of an important functional area of an owl territory for the year of the survey and to locate the application of protection measures. An activity center is identified during the daytime by locating within a northern spotted owl's territory the point or center of the area that for that year is most important biologically to the owl. The factors used to map the activity centers are, in order of importance, the location of: nest sites, non-nesting pairs, single females, single unknowns, and single males. While it is best to locate activity centers during the daytime, it is acceptable to identify an activity center at night if: 1) a pair of northern spotted owls is detected at night (i.e. two birds of the opposite sex ≤ 0.25 miles of each other); 2) an individual owl is detected at night on three separate surveys within a breeding season and the detections are within 0.25-miles of each other; and 3) an individual owl is detected at night in the same area over successive years.

D. Map with the last three consecutive years of northern spotted owl activity centers (all locations within the last three years or the most recent location for old sites not abandoned) within 0.7 miles of the THP boundary. This map must also include the location of the biologically most significant location ("BMSL") from DFG's California Natural Diversity Database ("NDDB") Spotted Owl Viewer and a discussion if it is different from MRC's location of the activity center.

E. For all activity centers within 0.7 miles of the THP area (including territories with disjunct activity centers that are separated by ≥ 1000 feet), a map depicting northern spotted owl habitat distribution at 1000 feet, 0.5-mile, and 0.7-mile scales and a table that quantifies the habitat distribution.

F. Map of all appurtenant roads associated with the THP, identifying existing mainline and seasonal roads.

G. Map identifying any proposed new road construction.

H. DFG NDDB Spotted Owl Viewer reports 1, 2, and 3 for area extending 0.7 miles beyond THP boundary.

I. Color aerial photo coverage of the 0.7 mile area surrounding all activity center(s) associated with THP, including additional color maps with polygons representing stands of differing structure classes and northern spotted owl habitat overlay (i.e., a transparency) using the best available aerial photographs. Any apparent discrepancies between the habitat layer and the aerial photo should be explained. For example, if the aerial photo appears to depict a forest structure class that is categorized in the table above as "Foraging" habitat, and it is identified as non-suitable habitat in the habitat layer, an explanation must be provided.

J. Maps of all timber operations within 0.7 miles of known activity centers that have occurred since the date the aerial photo or equivalent imagery.

K. Maps showing all approved THPs within 0.7 miles of known activity centers.

L. The best available northern spotted owl survey data, which must include: 1) a map of the survey route; 2) a table or spreadsheet that summarizes surveys conducted in the area, including the start and end times of each survey; 3) results of follow-up visits wherever northern spotted owls have been detected; and a map of detection locations for northern spotted owls and barred owls.

M. Because many of the functional habitat designations in the above described analyses are derived from secondary information, a certification from the RPF that he/she has verified NSO functional habitat assignments within the THP and the adjacent 500 feet.

2.1.2. Surveys results

Using the USFWS Arcata Field Office's modified version (8-14-2009TA-3640) of the USFWS endorsed NSO survey protocol (revised March 17, 1992); MRC will conduct northern spotted owl surveys throughout the THP area and all areas within 0.7 miles of the THP. MRC will provide the results of these surveys and survey station layout to CALFIRE in THPs and, if available, in TA requests to the USFWS. MRC may propose an alternative survey regime to CALFIRE and to the USFWS, identifying an appropriate number and location of survey stations. USFWS may review any alternatives and, approve it as proposed, or approve it subject to specific, appropriate modifications needed to achieve equivalent efficiency for detecting northern spotted owls. MRC will conduct the survey and provide the survey results to CALFIRE and, if available to review them, the USFWS. USFWS may review the survey results and inform MRC if a field assessment of the proposed THP area is warranted. If the USFWS issues new NSO survey protocols, MRC, the USFWS and DFG will confer to decide how best to update MRC's survey protocols based on the new USFWS protocols.

2.1.3. Field assessment

If USFWS informs MRC a field assessment is necessary for any reason, USFWS may conduct a field assessment with MRC personnel prior to issuance of a letter of TA.

2.1.4. THPs receiving USFWS technical assistance

Following receipt of the above information and the proposed protection measures for any THP, the USFWS may identify any measures in addition to the NSO Protection Measures below that are necessary to avoid take. The USFWS will include an explanation of its conclusion that implementation of the THP without the additional measure(s) is likely to cause take of a northern spotted owl. The RPF responsible for the THP will include the necessary take avoidance measures, if any, as an enforceable amendment to the THP before timber harvest is initiated.

2.2. Northern spotted owl protection measures

All THPs that occur within 0.7 miles of an activity center identified on the Activity Center Map (see section 2.1.1) or in the surveys described in Section 2.1.2 will include all applicable Protection Measures described in Sections 2.3 to 2.6, unless alternatives are proposed by MRC and accepted by the USFWS. For all activity centers, MRC will include the habitat protection measures in Sections 2.4 to 2.6, below. For *occupied* activity centers, MRC will also implement the disturbance prevention measures in section 2.3, below.

2.3. Disturbance prevention measures

MRC will include the disturbance prevention measures in this Section in all THPs that are within 0.7 miles of any *occupied* activity centers. MRC will stratify northern spotted owl disturbance prevention measures based on the categorization of habitat, breeding season, and non-breeding season. For purposes of these measures, the breeding season for northern spotted owls is February 1-July 31st. The end-date of July 31st will be used unless additional site-specific biological data show that northern spotted owls are absent, are not nesting, have failed to nest successfully, or have fledged young capable of flight, in which case the breeding season for purposes of that THP area will be shortened accordingly.

2.3.1. Breeding season (February 1st-July 31st).

Each THP will include the following measures for occupied activity centers during the northern spotted owl breeding season:

- Only the following operations will be allowed within 1000 feet (305m) of the occupied activity center:
    - Use of mainline haul roads and maintenance of mainline haul roads as designated by maps in the THP. For purposes of this section, "maintenance" does not include the changing the prism of the road or other actions that are considered reconstruction of roads under the California Forest Practice Rules.
    - Use of public roads.
    - Use and maintenance of existing non-mainline haul roads that (1) are located at least the same distance from the current spotted owl activity center as a public road or mainline haul road; or (2) are existing seasonal roads ≥ 500 feet from the activity center and in use throughout the time the spotted owl territory has been active.
    - Use of pickups and ATVs on existing roads.

- Helicopter operations, including service landings, will be prohibited within 2640 feet (805m) of the occupied activity center.

- Falling and yarding within 1000 feet of an activity center may be allowed *only if* the activity center is determined after May 15th to be inactive because owls are absent, non-nesting, or had a nest failure. Falling and yarding shall not occur within a northern spotted owl core area that has fledged young until there is evidence that the fledges have been out of the nest for at least two weeks and are capable of sustained flight.

- Stopping logging vehicles outside of mainline haul roads will be allowed within 1000 feet of an active nest site for safety reasons only.

- Any trees allowed to be felled within a core area for road maintenance will be retained for woody debris.

- Non-habitat disturbing activities, such as road reconstructions and maintenance, and other types of road use, may be allowed after July 9th.

- Stumps at least 425' from an activity center may be used to guy a yarder for yarding ground outside the core area.

2.3.2. Non -breeding season (August 1st-January 31st)

Each THP will include the following measures for occupied activity centers outside of the northern spotted owl breeding season:

- Operations, including use and maintenance of all existing roads and rock pits, may be allowed.

- Only the following operations may be allowed within the nest core area (i.e., within a 500' radius of the occupied activity center):
    - Use of cable corridors and tailholds, provided.
    - Only trees less than 6 inch dbh may be felled for the cable corridor.
    - All trees felled for the cable corridor will be left on the forest floor for woody debris.
    - Exclude nest or screen trees from felling.
    - Use and maintenance of existing roads.

- Helicopter operations—including service landings—that are at least 1000 feet from an activity center may be allowed.

2.4. Activity center protection

All THPs will include a buffer zone around each northern spotted owl activity center-the "core area." A northern spotted owl *core area* is a 72-acre acre area surrounding an activity center, which includes the 18-acre "nest core" area within a fixed 500' radius of the center and the 54-acre "roost protection zone" outside the 500' radius. A core area will ordinarily have a circular radius of 1000 feet from the activity center. However, MRC may deviate from a circular core area by adjusting the boundaries to 1) include Nesting/Roosting habitat instead of Foraging habitat, 2) include contiguous habitat instead of isolated habitat, 3) exclude habitat cut off from the activity center by a topographic divide, such as a ridge, or 4) conform to local landscape attributes such as draws and streamcourses. Core areas must include a minimum of 72 acres and must maximize the amount of retained Nesting/Roosting habitat. All THPs will include the following measures for northern spotted owl core areas.

- MRC shall mark with a "wildlife tree" tag, any tree confirmed to have a northern spotted owl nest in it to enable its retention. No tree or snag previously identified as containing a northern spotted owl nest structure will be felled regardless of the occupancy status of the activity center. Historic spotted owl nest trees in areas unoccupied or abandoned by owls will be provided with screen trees for additional protection.

- Harvest will be prohibited within the nest core area.

- Functional Nesting/Roosting habitat will be retained within the roost protection zone.

- MRC will only be required to protect that portion of a core area that is on its property.

- 72-acres of Nesting/Roosting will be retained in the core area, if possible. If a core area contains less than 72 acres of Nesting/Roosting habitat, the roost protection zone will be modified to maximize the amount of Nesting/Roosting habitat that is contiguous with and outside the nest core (500 foot radius) while conforming to local landscape attributes. If a core area cannot be redrawn to retain 72 contiguous acres of Nesting/Roosting habitat, all Nesting/Roosting habitat within 1000' of the activity center will be retained, and no harvest will be allowed within the 1000' area. If the core area contains at least 72 acres of

Nesting/Roosting, then harvest may be permitted in the roost protection zone (outside of 500' nest core) as long as:

- At least 2/3 of the pre-harvest basal area is retained, comprising at least 100 square feet of basal area with 60% canopy cover and an average stand diameter of at least 16"inches per acre.
- If the above objective cannot he met, then no harvest in the roost protection zone will be allowed.
- All suitable habitat (Nesting/Roosting and Foraging) subject to harvest that is within the roost protection zone (i.e., 500-1000 feet or topographical area around nest core) will be harvested in a way that retains its pre-harvest functional definition. Immediately post-harvest, these areas will maintain or increase pre-harvest mean stand diameter.

2.5. Habitat retention within 0.7 miles of activity centers

All THPs will include the following measures to retain habitat within.7 miles of activity centers.

- At least 500 acres of suitable habitat (Nesting/Roosting and Foraging) will be retained within 0.7 miles of the activity center. If there is less than 500 acres of suitable habitat within 0.7 miles of the activity center, all suitable habitat will be retained. Or no operations within any suitable habitat.

- At least 200 of the 500 acres of suitable habitat will be maintained as Nesting/Roosting.

- At least 100 acres of Nesting/Roosting habitat within 0.7 miles of an activity center will be retained. If a northern spotted owl territory contains ≤ 100 acres of Nesting/Roosting habitat within 0.7 miles of an activity center, then no harvest shall occur in those acres of Nesting/Roosting habitat.

- Harvest may occur in Nesting/Roosting habitat that is between 100 and 200 acres within 0.7 miles of an activity center, provided the Nesting/Roosting habitat is not contiguous with the core area and is maintained with at least a 60% canopy cover of at least 16" dbh trees.

- For northern spotted owl territories[3] containing ≤ 200 acres of Nesting/Roosting habitat within 0.7 miles of an activity center, timber harvest in Nesting/Roosting habitat harvest is permitted only if:
    - contiguous Nesting/Roosting habitat within and extending beyond the core area is retained so that at least 2/3 of the pre-harvest basal area in the NR stand to be harvested is maintained post-harvest, comprising at least 100 square feet of basal area with 60% canopy cover and an average stand diameter of at least 16" inches per acre; and

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[3]A "northern spotted owl territory" is a spatial area that is defended by a single resident or pair of northern spotted owls. Specific northern spotted owl territories refer to generally fixed geographic areas. As a working definition, a territory is that area within 0.7 miles of the AC.

- Nesting/Roosting habitat not contiguous with the core area is maintained with at least a 60% canopy cover of at least 16" dbh trees.

- Before harvesting timber within Nesting/Roosting habitat that is within 0.7 miles of an activity center, where the Nesting/Roosting habitat either comprises < 200 acres or the harvest would reduce the Nesting/Roosting habitat to < 200 acres, MRC staff trained in habitat typing will conduct a field review to confirm the actual acreage of suitable Nesting/Roosting habitat.

- Operations will be limited to ≤ 50% of available suitable habitat within 0.7 miles of a northern spotted owl territory in anyone year.

2.6. Relocation of activity centers and emergence of new northern spotted owl territories

Northern spotted owl activity centers may move over time, or new territories may become established within the area of a THP or within the biological assessment area of the THP after a THP is approved, but before operations under the THP are begun. To ensure take of northern spotted owls is avoided in these circumstances, MRC will update and include in the THP the information required in Section 2.1.1 with regard to any new or relocated activity centers, and will include all applicable measures required in Sections 2.2 to 2.5.

OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- MENDOCINO REDWOOD COMPANY -
NORTHERN SPOTTED OWL CONSERVATION AND MANAGEMENT;
ROBERT B. DOUGLAS, FOREST SCIENCE MANAGER

http://www.calforests.org/wp-content/uploads/2014/01/State_of_the_Spotted_Owl_MRC_2013_Final-DOUGLAS.pptx

Since 1907

Fruit Growers Supply Company Northern Spotted Owl Science Forum Property-Wide Status Review

The purpose of this summary is to provide information on surveys, monitoring, and conservation measures for the Northern Spotted Owl (*Strix occidentalis caurina*, NSO) under the Fruit Growers Supply Company's Habitat Conservation Plan (HCP). This summary provides detail to accompany our presentation given at the NSO Science Forum on October 30, 2013 in Sacramento, CA, and is intended to aid the Department of Fish and Wildlife (DFW) in its consideration of scientific and regulatory factors regarding the potential listing of the NSO as threatened or endangered in California under CESA.

Fruit Growers Supply Company (FGS) owns and manages approximately 328,550 acres of forestlands in northern California, and western Oregon and Washington. Of the 278,860 acres in California, approximately 152,000 acres are affected by the potential listing. These are inland mixed-conifer forests in Siskiyou County, CA (Figure 1). Ownership in Lassen and Shasta counties are essentially outside the range and thus unaffected.

FGS ownership within the range of the NSO has been managed for timber production for over 100 years. Much of the forest was initially harvested under the Ad Valorem tax incentive which promoted harvest of 70% of the mature timber in order to reduce the tax burden. This has left a legacy of second-growth forests of irregular stocking conditions and a mosaic of various age classes. From the 1940s to the 1970s these forests were managed under an uneven-age regime of individual tree selection harvests promoting forest growth. Since the 1980s forest health and forest structure have been the focus of management objectives. As a result approximately 20% of the forest has been regenerated through even-age silviculture contributing to the mosaic of various age classes across the landscape. Currently FGS conducts primarily uneven-age management using selection and group-selection harvest, with the long-term goal of maximizing the sustainable production of high quality forest products while protecting natural resources.

In November 2012 FGS was issued an Incidental Take Permit (ITP) for NSO from the U.S. Fish and Wildlife Service (USFWS). FGS, in consultation with DFW, collaborated with the USFWS and the National Marine Fisheries Service (NMFS) to develop a Multi-species Habitat Conservation Plan (HCP). This HCP includes terrestrial and aquatic conservation programs with specific measures both at the landscape and individual scales to protect various species including the NSO.

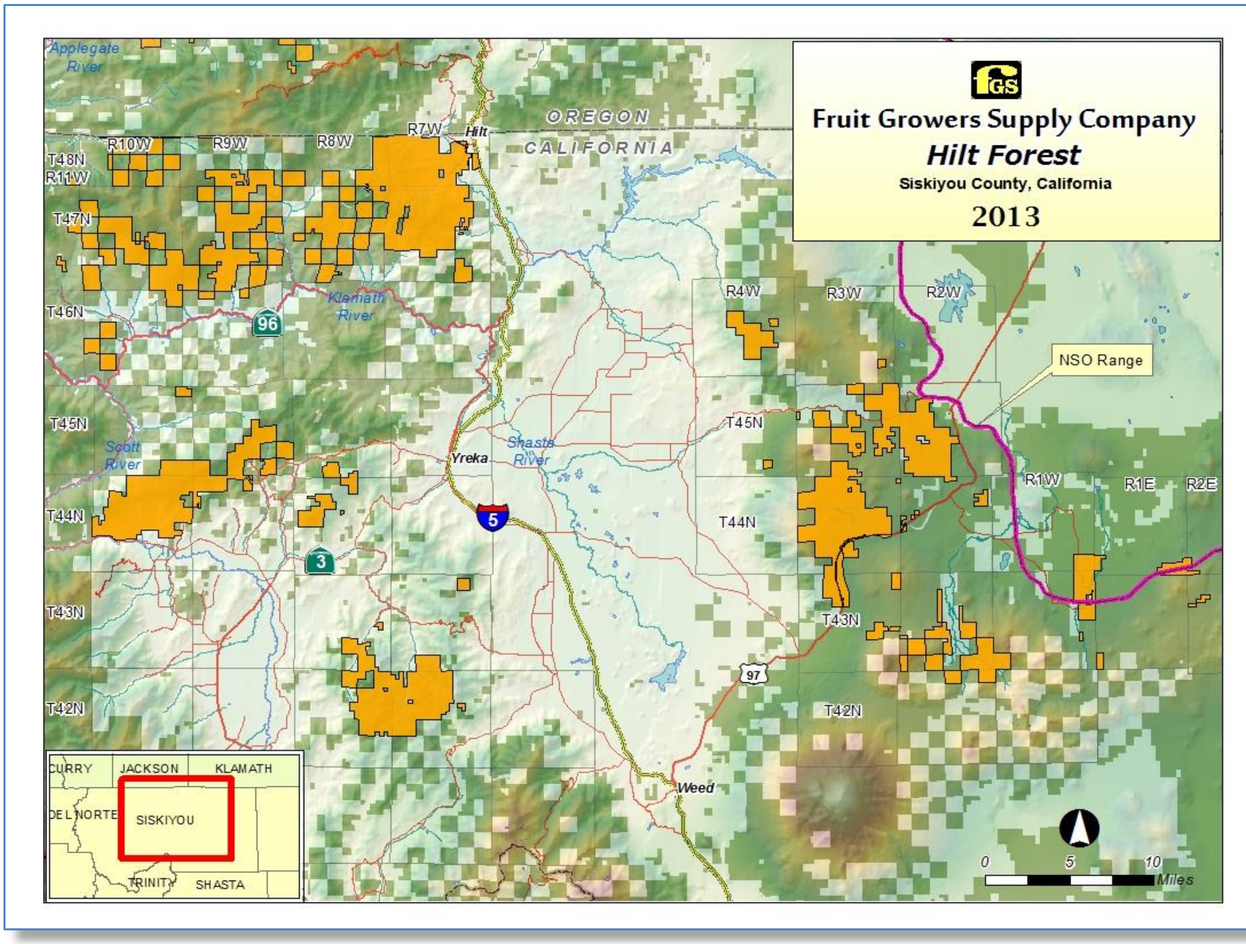

Figure 1. Fruit Growers Supply Company forestlands within the range of the NSO, Siskiyou County, CA.

NSO Surveys and Monitoring

FGS has conducted extensive surveys and monitoring of the NSO since the federal listing of the species in 1990. A wildlife biologist has been maintained on staff to provide training and supervise fieldwork. Survey effort varies from year to year; a summary of efforts from 1990 to the present is as follows:

- 1990 – 1991: Property-wide surveys following USFWS protocol. Results indicated half again as many NSO were located within 1.3 miles of FGS as was previously reported. FGS consulted with DFW on measures to avoid take of NSO during timber harvest operations.
- 1992 – 1997: USFWS survey protocol was used as a basis for NSO survey techniques. THPs contained standard take-avoidance measures and habitat retention standards.
- 1998 – 2002: a Spotted Owl Management Plan was developed in cooperation with the USFWS. The Service's protocol was used as a basis for NSO survey

techniques. The Plan contained standard take-avoidance measures and habitat definitions and retention standards.

- 2003 – 2012: Project level surveys utilizing USFWS protocol and coordinating with adjacent landowners. Standard take-avoidance measures were applied including pre-activity surveys and habitat retention standards.
- 2013: a multi-species HCP currently controls NSO conservation on FGS lands. USFWS protocol is the basis for survey methods, with modifications for annual monitoring, and THP-specific surveys. Surveys take approximately 100 man-days annually. The HCP conservation strategy is a habitat-based approach, with measures applied at the individual NSO territory, and also at the landscape-level.

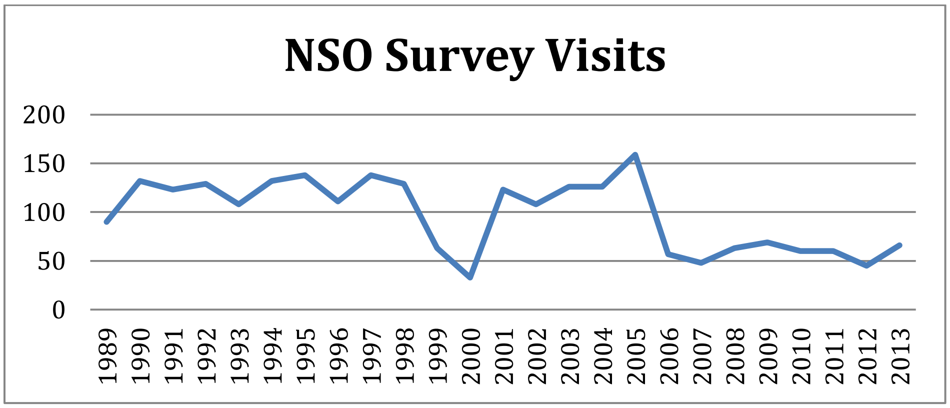

Figure 2. NSO Surveys by FGS, Siskiyou County, CA.

Except for the initial property-wide surveys in 1990 and 1991 and HCP specific surveys in 2013, FGS has surveyed for NSO at the project level, primarily as pre-activity surveys for THPs. As a result population demographics have not been effectively monitored for our area. The survey data, however, can be used to profile some relative trends in the local population of NSO, and to possibly draw some broad observations about NSO in the HCP area.

1. By examining data results for years in which over 50% of the historic sites were surveyed it can be seen that the population varies year to year.

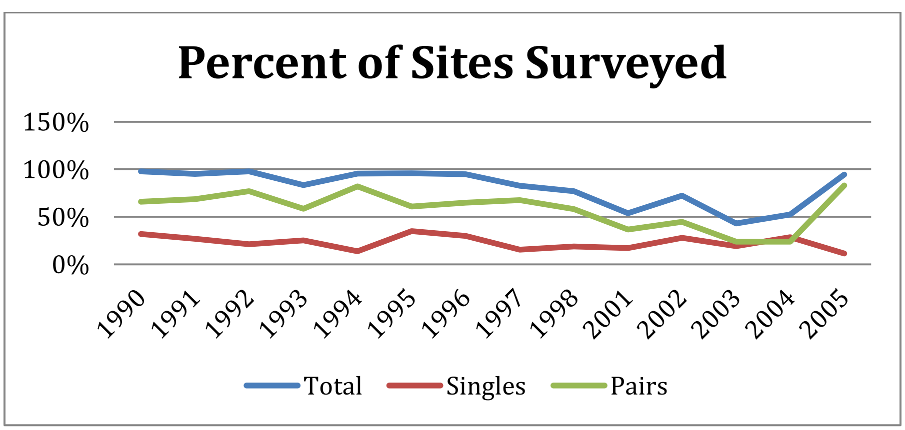

Figure 3. NSO Occupancy ratio of sites surveyed, Siskiyou County, CA.

2. Historic sites are irregularly occupied. Of the 67 historic sites surveyed, 33 have had periods of non-occupancy followed by periods of occupancy.
3. A relatively small proportion of sites are consistently occupied. Of the 67 historic sites surveyed only 11 have not had a no-response survey result.
4. NSO are territorial, but can be opportunistic. Nearly every year since 1990 there is at least one and as many as thirteen sites (out of 67) in which a site was presumably re-occupied based on survey data.
5. Habitat requirements vary by individual and/or locale. There are sites with extremely low quality habitat that have produced young as well as sites with high quality habitat that have not. There are relatively high quality sites that have been abandoned and low quality sites that have been consistently occupied. There are sites with extremely low quality habitat that have been re-occupied with nesting pairs after years of no-response.
6. The variability in occupancy suggests that NSO move around on the landscape. Without a systematic property-wide survey program or a full-scale banding program it is difficult to comprehensively monitor a local population. As many as 8 of the 67 sites were detected after the initial property-wide surveys.
7. The variability in fecundity across the landscape and for individual sites suggests there are a range of variables that affect reproductive capacity. This is also a function of which sites are surveyed.

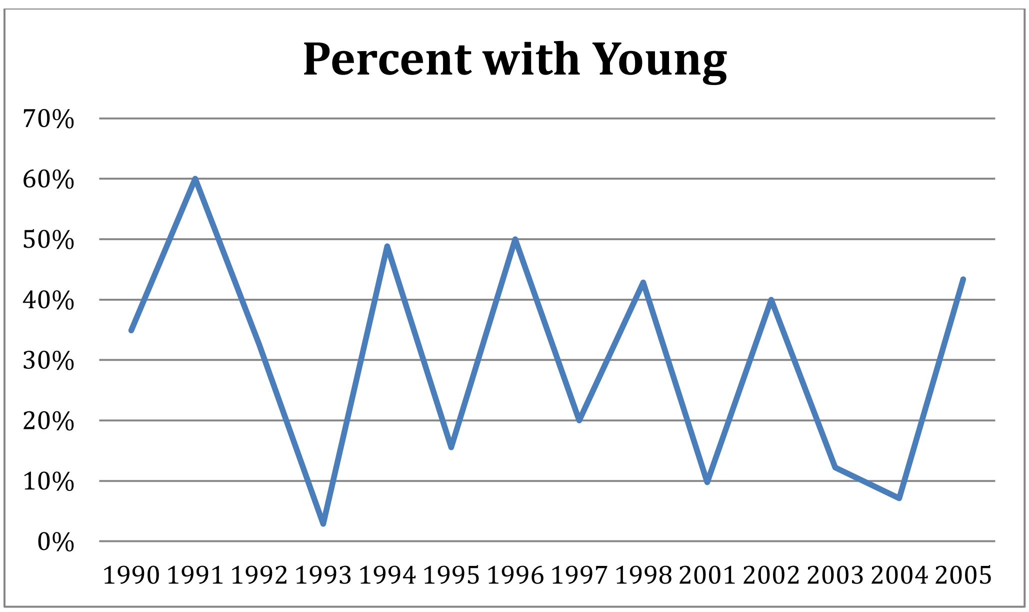

Figure 4. NSO Fecundity rates for sites surveyed, Siskiyou County, CA.

From 1999 to 2002 FGS participated in a National Council for Air and Stream Improvement (NCASI) directed telemetry study of 19 individual NSO located within ten territories. Telemetry data was collected nightly year-round for four years on banded NSO. In addition to habitat use data, some demographic data was obtained in terms of home range size, and a banded young was found dispersed roughly 20 miles away over the Siskiyou Divide.

Data from this study was used to develop a RSF model of habitat used for nocturnal activities, presumably foraging. Relative probability of use was influenced by abiotic and biotic factors including slope position and aspect, species composition, and size and density of overstory trees. The following graph depicts NSO use relative to the availability of habitat on the landscape for a range of habitats. Bars in which the telemetry points exceed the availability are habitats preferred by NSO for nocturnal use. The graph also suggests that NSO use the full range of habitats on FGS forestlands.

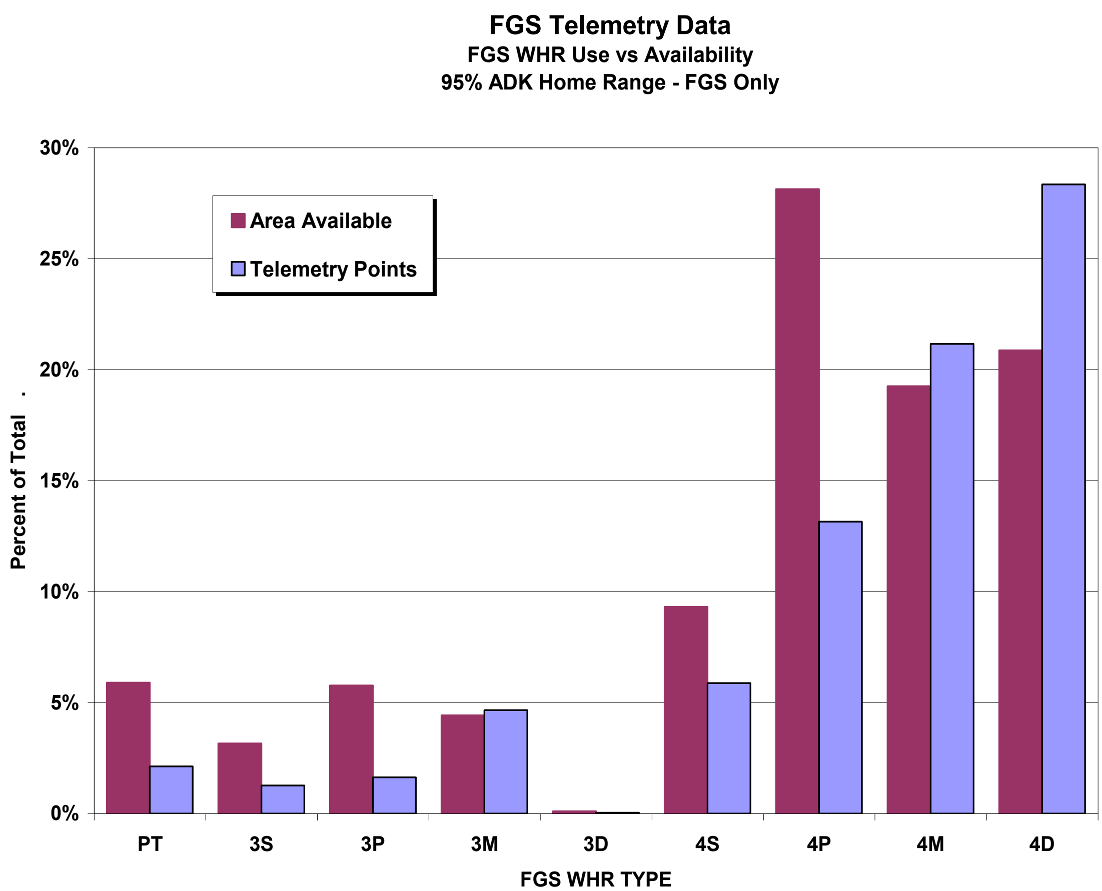

Figure 5. NSO telemetry data by WHR habitat type compared to habitat availability within ten home ranges on Fruit Growers Supply Company forestlands in Siskiyou County, CA.

NSO Conservation

From the time of the federal listing of NSO as threatened under the Endangered Species Act in 1990 to the issuance of a federal Incidental Take Permit in 2012 FGS has maintained the local NSO population under federal No-Take guidance. This has included pre-activity surveys for avoidance, and habitat analysis and retention standards for each NSO located within 1.3 miles of proposed timber operations.

FGS' multi-species HCP, which conserves the habitat of the NSO and 4 other species, was approved in 2012. The term of the HCP is fifty years. The HCP was developed in collaboration with USFWS to contribute directly to the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) by creating habitat reserves on its property adjacent to federally designated Critical Habitat Units, effectively increasing the area of these CHUs. The HCP area is intermixed and surrounded by USDA Forest Service lands which are managed as Late Seral Reserves under the Northwest Forest Plan (USDA, 2004). As a result much of the land surrounding FGS is managed by the federal government specifically to provide nesting opportunities for the NSO. This provides an opportunity for FGS lands to contribute to the recovery of the species by managing its forestlands for foraging and dispersal habitat needs. Currently 20% of the NSO activity centers within 1.3 miles of FGS ownership are located on FGS.

As a habitat based plan, the HCP allows FGS to concentrate its conservation efforts on lands that are most inclined to be occupied by NSO, while freeing up the less desirable habitat for timber management. Over the life of the HCP there is a projected net increase in habitat of approximately 27,000 acres, or an increase from 33% currently to a projected 54% of the forest ownership. FGS also has a conservation strategy for habitat structural components, including retention of snags, snag replacements, large hardwood trees, large down logs, and high value wildlife trees, so that future forest stands will have structures suitable for NSO nesting and roosting.

Conservation and protection measures under the HCP for the NSO are based on five biological objectives:

1. Take Avoidance
    - 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 USFWS. 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' timber harvest plan boundary, FGS will conduct up to three 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 results must be reviewed and approved by the USFWS prior to operations. For activity centers where two consecutive years of protocol surveys indicate the site is not currently occupied, and no northern spotted owls are detected within 0.25-mile of the timber harvest plan boundary, Covered Activities may occur during the breeding season for the following two years without conducting additional surveys. Surveys are not required for Covered Activities occurring outside of the breeding season. *[This measure is currently being amended to include six protocol surveys.]*

- 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 location from DFW, the USFWS, 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 activity center during three consecutive years of protocol-level northern spotted owl surveys, the USFWS will evaluate the habitat quality and quantity within the home range to determine its occupancy status.

2. Demographic Support
   - FGS has established 24 Conservation Support Areas (CSA) 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 (Area of Impact), and whose home ranges overlap with 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 (more 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 including lands owned by others before harvest can occur on its ownership in a CSA.

- 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 USFWS.

- FGS will prioritize conservation efforts on lower elevation, northern-facing slopes near the nest site. 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.

- FGS will monitor home ranges supported by CSAs for habitat and occupancy of NSO as well as barred owl. The USFWS will be notified immediately of barred owls detections.

- FGS will reduce the risk of catastrophic wildfire within home ranges supported by CSAs by maintaining fuel loads within surrounding stands.

3. Riparian Management
    - FGS will establish WLPZs or EEZs along all stream classes, and implement the management prescriptions described in the Aquatic Species Conservation Program over the term of the Permits. 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.

4. Dispersal Habitat
    - Consistent with the USFWS's expectations for conservation efforts on private lands, as stated in the "Revised Recovery Plan for the Northern Spotted Owl *(Strix occidentalis caurina)"* (USFWS 2011), 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.

5. Threat Management
    - FGS will implement the following barred owl control measures:
        - FGS will conduct barred owl monitoring using current USFWS-approved survey protocols every 4 years within the CSAs as long as deemed necessary by the USFWS. 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 USFWS every 4 years.
        - If a barred owl is detected in the Plan Area, FGS will locate and monitor the barred owl and notify the USFWS 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 USFWS.

    - 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 USFWS.
        - 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 USFWS.

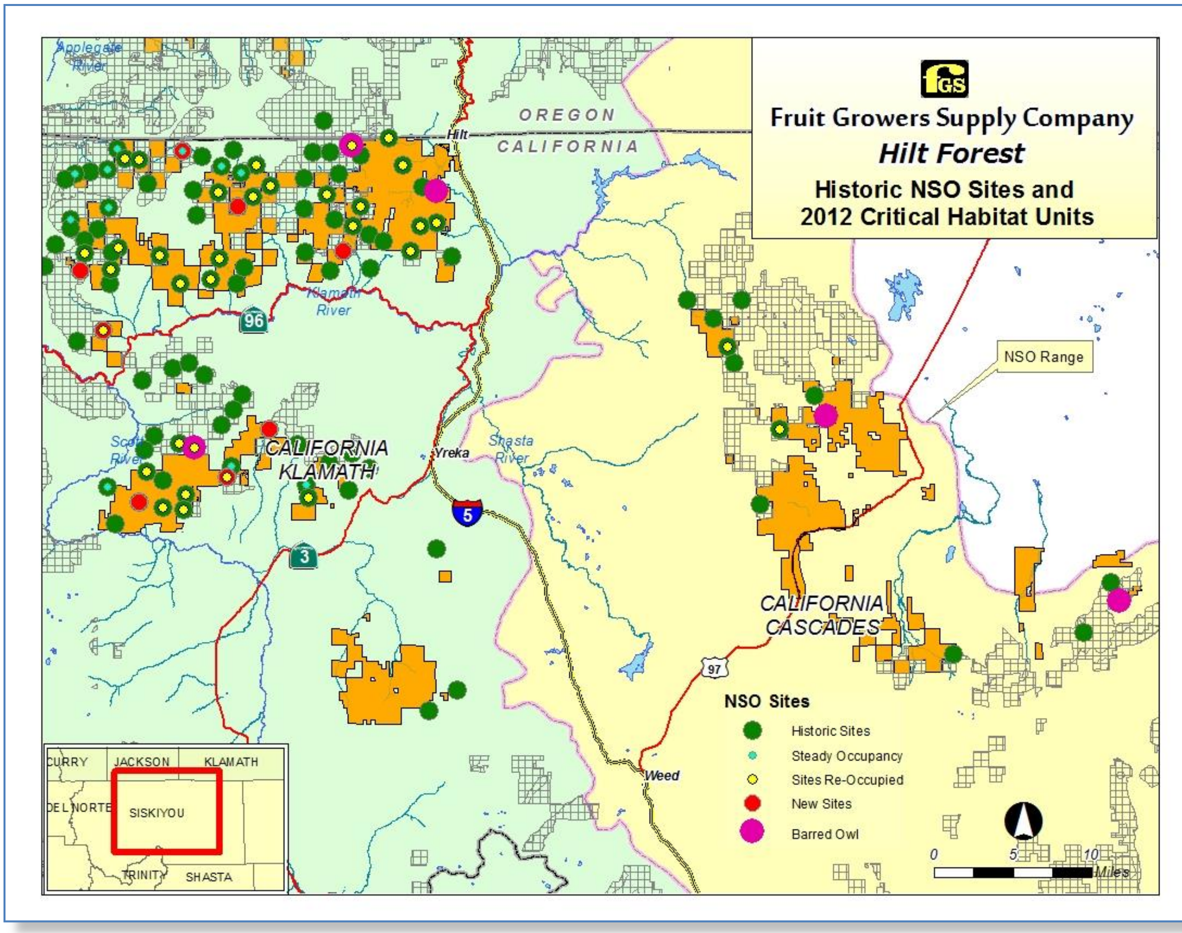

Figure 6. Historic NSO Activity Centers relative to FGS ownership, NSO Physiographic Provinces, and the 2012 USFWS Critical Habitat Unit designations.

Unregulated Threats

Unregulated threats to the NSO population may prove to be a significant problem. Of primary concern is the ongoing barred owl invasion, increasing risk of catastrophic wildfire, and a recently identified threat of possible poisoning due to rodenticides.

FGS has recently detected barred owls at three NSO activity centers and two nearby. Studies have indicated that NSO occupancy, reproduction, and survival declines when barred owls are detected within 0.5-mile of spotted owl activity sites (Kelly et al 2003, Olson et al 2005, Dugger et al 2011). The increasing trend in barred owl detections within 0.5-mile of NSO sites could prove to be significant. For this reason FGS is working with USFWS to obtain a Depredation Permit for barred owls detected as part of our HCP.

Barred owl detections on FGS lands have shown a similar pattern as has been seen elsewhere during the invasion. This may partially explain the decrease in night detections during surveys. For this reason FGS is updating its survey protocol to include as many as six nighttime visits to detect NSO occupancy.

A very significant and large scale threat to NSO is the increasing risk of catastrophic wildfire. Due in part by increases in fuel loading on public lands as a result of the lack of management and vegetation treatment wildfires have grown in size and intensity in recent years. Currently the primary source of habitat loss is catastrophic wildfire, particularly in fire prone provinces such as the Klamath and Cascades (USFWS, 2011). Habitat restoration through vegetation management is one of the four basic steps in the federal recovery strategy. In order to maximize forest growth and minimize mortality, FGS effectively maintains fuel loading on its lands by forest thinning and vegetation management at various ages.

There is growing recognition of the potential for a new threat resulting from possible exposure to anti-coagulant rodenticide poisoning. There is mounting evidence that marijuana growers tend to use copious amounts of rodenticide in an attempt to prevent damage to planted marijuana. In turn, the rodenticides can have both primary and secondary impacts on predators such as fisher (*Martes pennanti pacifica*), and possibly spotted owls (Thompson et al 2013). In the Klamath and Cascades provinces, a primary prey species of NSO includes the dusky-footed woodrat (*Neotoma fuscipes*), which are also prey species of fisher and may be responsible for exposure of fishers to rodenticides used at grow sites (Thompson et al 2013). FGS works closely with local law enforcement to rid the forests of this threat.

Summary

FGS lands have had over 20 years of surveys and monitoring of the local NSO population. Prior to approval of the HCP in 2012, take avoidance strategies were implemented through consultation with either USFWS or CDFW.

FGS currently operates under a multi-species HCP that provides long-term conservation for the NSO. The HCP is a habitat-based approach, with habitat retention requirements associated with selected NSO activity centers, riparian management zones, mass wasting areas of concern, and retention of habitat structural components. The habitat strategy is expected to provide habitat now and through the HCP term. There is a projected net increase in habitat at the end of the HCP term. FGS currently implements policies including uneven-age forest management with selection harvest, retention of wildlife trees, and Sustainable Forest Initiative (SFI) certification.

The current survey strategy includes protection of all active sites during the breeding season, 6 surveys of all THP areas, and monitoring for NSO and barred owl occupancy within home ranges supported by CSAs on a 4-year rotating basis. FGS staff and contractors are regularly trained for NSO and barred owl recognition, habitat, and habitat elements.

Survey results from 1990 – 2013 indicate that there is a variable population of NSO on FGS lands. Survey data is not complete enough to draw comprehensive conclusions about the local NSO population. Occupancy of historic sites as indicated by survey data is highly variable.

The barred owl invasion, the risk of habitat loss by wildfire, and toxics from marijuana cultivation activities are the most significant unregulated threats to the NSO population moving forward. Increasing detections of barred owls near spotted owl activity sites has been shown to reduce occupancy, reproduction and survival of NSO. Unmanaged public forestlands have resulted in over-stocked conditions with increased mortality, high fuel loading, and very low resilience to climate change increasing the risk of large-scale habitat loss. The region-wide increase in illegal marijuana cultivation has resulted in an elevated risk of exposure to toxics. FGS is proactive in reducing these risks on its forestlands.

In conclusion, it is not necessary for the NSO to be listed as threatened or endangered in California because 1) there are effective regulatory and voluntary mechanisms in place that provide short-term protection and long-term conservation of the NSO, and 2) long-term monitoring data indicate that the NSO population is variable, yet stable.

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OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- FRUIT GROWERS SUPPLY COMPANY -
KELLY CONNER, FOREST INVENTORY AND PLANNING MANAGER

http://www.calforests.org/wp-content/uploads/2014/01/NSO_Presentation_CFA_DFW_v2a-CONNER.pdf

Campbell Global, LLC Northern Spotted Owl
Science Forum Status Review for Managed
Timberlands in Northern California

Introduction and Description of Study Areas

The purpose of this report is to provide further description to material presented 29 October, 2013 at the northern spotted owl (*Strix occidentalis caurina)* Science Forum on the status of northern spotted owl (spotted owl) on Campbell Global L.L.C. managed timberlands in California. Campbell Global, L.L.C. (Campbell), manages industrial timberlands owned by the Hawthorne Timber Company, L.L.C. (HTC), Usal Redwood Forest Company (URFC), TCI Shasta, and Bascom Pacific (Figures 1 and 2). The HTC and URFC ownerships are comprised of approximately 115,025 acres (180 mi^2) and 49,600 acres (78 mi^2), respectively, and are located in Mendocino County, California (Figure 1). The TCI Shasta and Bascom Pacific ownerships comprise of approximately 23,600 acres (37 mi^2) and 31,850 acres (50 mi^2) in Shasta and Siskiyou Counties (Figure 2).

The two industrial timberland areas located in Mendocino County encompass approximately 258 mi^2 (671 km^2) stretching from the Humboldt Mendocino County line south to the Noyo River. Most of the two ownership areas are within 11 miles of the Pacific Ocean and are composed of two large, nearly contiguous forested tracts to the north and east of Fort Bragg (Figure 1). The entire study area is located in the Northern California Coast Range Province and is characterized by a highly dissected landscape with moderate topographic relief. Elevations range from near sea level to approximately 3000 feet (914 m). The climate of this region is characterized by cool, wet winters and hot, dry summers (Sawyer et al. 2000). Fog is the most common source of precipitation during the summer months, particularly along the coast and coastal valleys (Sawyer et al. 2000). The plant community is characterized by coast redwood (*Sequoia sempervirens*), with site latitude, physiographic features, anthropogenic land use practices, and proximity to the ocean influencing the occurrence of other conifer species. Important conifer associates are Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*), to the east and west respectively. Minor conifer components include western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*). Tanoak (*Lithocarpus densiflorus*) and Pacific madrone (*Arbutus menziesii*) are the most prevalent hardwood tree species, particularly dominant within interior xeric sites and on higher slopes. Tan oak is especially prevalent on the URFC ownership and in specific watersheds of HTC mainly due to past forest management. In these areas, tan oak may occur in densities of >400 stems per acre (Campbell Global L.L.C; unpublished data).

A variety of timber management and harvesting techniques have been employed by a succession of landowners over the last century. Both even- and uneven-aged silvicultural prescriptions have been applied across the management areas. The varied silvicultural prescriptions have resulted in a heterogeneous forest cover relative to species composition, stand structure, and stand age, especially on the HTC ownership. In Mendocino County, all timber stands in the management areas were harvested at least once in the previous century leading to no late successional forests remaining. However, individual residual trees occur across the landscape in varying densities.

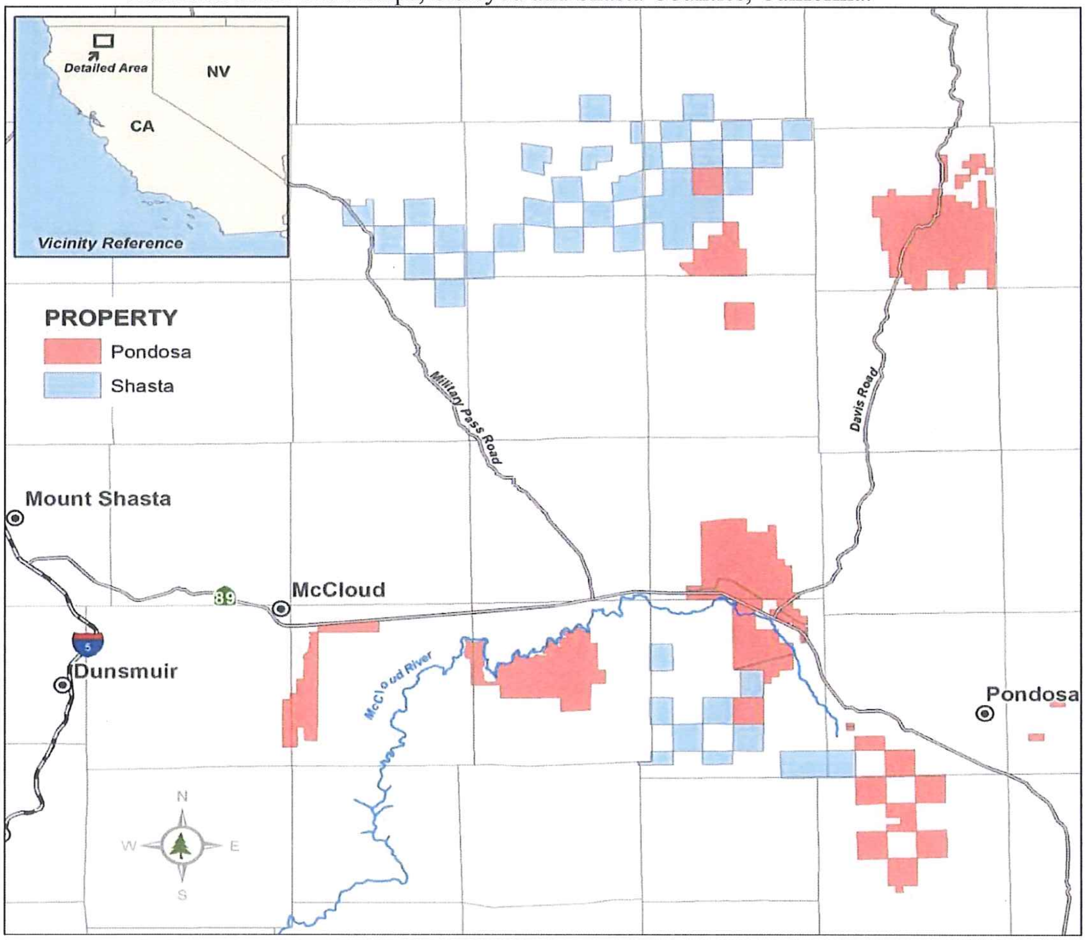
On the Shasta and Siskiyou Counties managed areas, small patches of late successional forests occur at higher elevations and along some watercourses; however, these patches are generally less than 20 acres in size and highly fragmented.

For the Campbell Global, LLC managed landscapes in Mendocino County, continuous annual project level surveys and spotted owl territory monitoring has resulted in twenty-four years of data collected on pair and single spotted owl territory occupancy rates, nesting status, and number of young fledged. In addition, research conducted on spotted owl occupancy dynamics and habitat relationships, as well as banding efforts, has led to further understanding of spotted owl ecology on these highly managed landscapes and may offer an adaptive management approach to spotted owl survey methods and spotted owl conservation.

In Shasta and Trinity Counties, the managed landscape has very few known spotted owl territories, although known territories occur in low densities on adjacent USDA Forest Service lands. Except for a short discussion on regulatory compliance and protection measures, most of this report focuses on the status of spotted owl on the Mendocino County managed ownerships.

Figure 1. Campbell managed areas in the north-central coastal redwood region, comprising the Hawthorne Timber Company (HTC) and Usal Redwood Forest Company (URFC) ownerships, Mendocino County, California.

Figure 2. Campbell managed areas in the California Cascade Province, comprising the TCI Shasta and Bascom Pacific ownerships, Siskiyou and Shasta Counties, California.



Regulatory Compliance

Since the listing of the spotted owl in 1990, the ownerships have operated under various "take avoidance" provisions. Although the agency responsible for review of "take avoidance" has changed over time, all Timber Harvest Plans (THPs) and adjacent suitable habitat within 0.7 mi (1.1 km) were and continue to be surveyed for spotted owl under guidelines set forth by the USFWS protocol (USFS 1992; USFS 2011) and other guidance documents described below. When spotted owls were detected during surveys, follow-up monitoring was initiated and protection/conservation measures for the spotted owl territory (hereafter activity center) were applied. Below outlines the "take avoidance" provision and representative agency conducting the "take avoidance" review during the specified time period.

1990 – 1999: THP consultations with the California Department of Fish and Wildlife were initiated. Protection measures for known Activity centers could vary widely, depending on site specific information and proposed project activities.

2000 – 2008: Campbell acquired management of HTC and URFC in 2000 and the Cascade properties in 2008, and would typically submit THPs under CCR14 919.9(e) with Technical Assistance provided directly by the USFWS.

2008 – Present: Campbell typically submits THPs under CCR14 919.9(e) using USFWS Take Avoidance Scenarios and "Attachment A" (USFWS 2011) for the coast properties and "Attachment B" (CAL FIRE 2008) for the interior properties. These documents provide programmatic guidance by the USWFS for CAL FIRE as a method for CAL FIRE to consistently determine that take avoidance measures have been applied to spotted owls for timber operations as proposed under THPs.

Project Level Surveys and Territory Monitoring

All THPs and their associated assessment areas (0.7 miles coast, 1.3 miles interior) are surveyed according to most recent USFWS Protocol and supplemental USFWS documents (USFWS 2008, USFWS 2011a, 2011b). However, the spotted owl survey strategy on the coastal properties varies slightly as Protocol guidance is to conduct surveys from call points every 0.25 – 0.5 miles apart, depending on topography. Campbell's strategy is to conduct surveys on a sub-watershed basis known as the Watershed Assessment Area (WAA). WAAs are topographically discreet sub-watersheds designated with a 5-digit nomenclature. Call points are established to cover the WAA located with the assessment area. Most of these WAAs are small in size, typically consisting of Class II (non-fish bearing) tributaries to Class I (fish-bearing) main stems. Large watersheds are divided into smaller WAAs, usually by Class II tributaries, change of aspect, and/or ridges lying perpendicular to the main drainage. The placement of survey stations ensures complete coverage of the THP and the surrounding WAAs. When known spotted owl activity centers are located within 0.7 mi of the proposed THP, point calling is conducted in areas topographically separated from the known territory or at an appropriate distance to avoid "calling in" spotted owls associated with that activity center. THP surveys located adjacent to other property owners are coordinated with the neighboring landowners to avoid repetitious calling and harassment of known spotted owls. The interior properties exhibit much less topographic relief than the coastal properties and surveys are conducted in accordance with Protocol guidelines.

All known active spotted owl activity centers occurring on the ownership are surveyed annually to determine occupancy status, nesting/reproductive status, and number of young fledged. Walk-in surveys (also known as stand searches) are also conducted to obtain banding resight/recapture data and to band un-banded spotted owls. Walk-in surveys are done in the spotted owl's historic site center(s) and in areas where spotted owls are detected during point calling surveys. Although surveys at known activity centers can occur from 1 March to 30 August, as spotted owls may disperse later in the breeding season we attempt to fully survey (up to reproductive status) all known territories by 30 July.

From 1990 – 2010, biologists conducted 6717 surveys at 87 known spotted owl activity centers on the Mendocino ownerships; of which 5294 (79%) consisted of night-time survey visits to determine site occupancy prior to daytime site visits. The remaining surveys consisted of daytime walk-in visits used to determine pair status, nesting status, and reproductive success of the spotted owls associated with the activity center. Single spotted owls were detected on 2149 survey visits (32%), similar to spotted owl pairs, detected on 2144 (32%) survey visits.

For the banding program, spotted owls are baited into range with a mouse and then captured with a noose pole or by hand. Once captured, a band is attached to each leg: a blue-anodized aluminum USGS number band and a color/pattern-coded plastic band. For monitoring purposes, band combinations are uniquely assigned to individual adult birds on specific territories. To avoid overlap, band patterns/colors are coordinated with adjacent landowners. Fledglings receive a year-coded (cohort) plastic band, with colors predetermined and standardized throughout the spotted owl's range (Franklin 1995). Once a banded fledgling matured, it is re-captured and the cohort band is replaced with a new 'adult' color-coded band. To assure that the cohort band colors are current, we coordinate with the USFWS, Arcata Fish and Wildlife Office on an annual basis.

In addition to habitat conservation measures, disturbance buffers are also applied to each known activity center occurring within 0.25 miles of proposed management activities. However, topography may also play a role in allowing deviation from the 0.25 mile disturbance buffer. The 0.25 mile disturbance buffer is applied after January 31 and continues until non-nesting status is determined. If spotted owls are determined to be nesting, a final determination of fledgling success is required prior to allowance of management activities within the disturbance buffer.

Spotted Owl Annual Survey Results and Occupancy Dynamics (coastal managed areas only)

Spotted Owl Activity Center Monitoring (2013 results)

A total of 87 spotted owl activity centers occurring on or immediately adjacent to the study areas were monitored in 2013 (Table 1). Seventy-two activity centers (83%) were occupied, while 15 (17%) were determined unoccupied. Of the 15 unoccupied activity centers, 6 were classified as unoccupied in 2012, 7 unoccupied activity centers were occupied in 2012, and 2 unoccupied activity centers were newly monitored activity centers in 2013. Spotted owl pairs occupied 39 (54%) of the occupied activity centers. Single males were detected at 25 activity centers (35%), single females at 6 (8%) activity centers, and single spotted owls of uncertain sex were found at 2 (3%) activity centers. Of the 111 individual adult spotted owls (64 males, 45 females and 2 sex undetermined) located in the managed areas, 87 were located on HTC ownership and 24 were located on the UFRC ownership.

Of the 39 spotted owl pairs, 1 (3%) attempted to nest and this nest eventually failed.

Table 1. Spotted owl monitoring results for 2013, by coastal managed area ownership.

Number of:	HTC (Hawthorne)	URFC (Usal)	Total
Monitored Sites	64	23	87
Active Sites	55	17	72
Inactive Sites	9	6	15
New or Previously Unmonitored Sites	2	1	3
Confirmed Pairs	32	7	39
Sites with Single Males	18	7	25
Sites with Single Females	3	3	6
Sites w/ Single Uncertain Sex	2	0	2
Nests Attempted	1	0	1
Nests Successful	0	0	0
Young Produced	0	0	0

Crude and Ecological Densities

Crude density is simply calculated by dividing the total number of spotted owls by the number of mi^2 encompassing the sampling area. In 2013, crude density across the two managed areas combined was 0.429 spotted owls/mi^2 (0.165 spotted owls/km^2). Crude densities of spotted owls across individual managed areas were 0.483 spotted owls/mi^2 for HTC and 0.304 spotted owls/mi^2 for URFC. Ecological density is the total number of spotted owl divided by the mi^2 of suitable habitat encompassing the sampling area, with suitable habitat defined as per USFWS definitions. For the HTC managed sampling area ecological density was 0.776 spotted owls/mi^2. The ecological density of spotted owl located in the URFC managed sampling area was not calculated; however, ecological density would also be likely higher due to the smaller mi^2 area represented by suitable habitat.

Using plumage characteristics outlined in Forsman (1981), we assign spotted owls to 1 of 3 age classes: juvenile (less than 1 year old), sub-adult (1–2 years old), and adult (3 or more years old). Juvenile spotted owls are not sexed. Call pitch and/or behavior are used to determine the sex of sub-adult and adult spotted owls.

Re-sighting of banded spotted owls during territory site visits allow for the monitoring of individual birds. If a band is present, its color and pattern are identified with the aid of binoculars and high-powered flashlights. Un-banded owls are documented and scheduled for banding once it is determined that they are either non-nesting or their nesting/reproductive cycle is complete.

Since 1990, 287 spotted owls have been banded on the Mendocino ownership with no related spotted owl mortalities.

Spotted Owl Habitat Definitions and Conservation Measures

Spotted owl habitat is defined in accordance with USFWS Attachments A and B (USFWS 2008, USFWS 2011) for the coast and interior, respectively. Habitats types are determined by biologists or foresters using a combination of inventory data, aerial photography, and ground-truthing. All suitable spotted owl habitat located within the THP assessment area are targeted for surveys according to USFWS Protocol (USFWS 2011) prior to timber operations.

For every known activity center occurring on the ownerships, habitat conservation measures are applied using the USFWS Attachment A or B guidelines. These conservation measures include:

Attachment A (USFWS 2011)

- The establishment of a 100 acre core habitat area of the best available habitat (usually Nest/Roost habitat), surrounding the Activity center. The core habitat area is also based on topographic features and locations of past nest trees and/or areas where spotted owls have been located on multiple occasions from past survey effort. Generally, no habitat altering timber operations are conducted within the 100 acre core habitat.
- Within a 0.7 miles radius centered on the activity center, there must be a minimum of 500 acres of habitat consisting of a minimum of 100 acres of Nest/Roost habitat in addition to the core habitat, and the remaining 500 acres of habitat may consist of Foraging habitat. Timber operations are allowed within the 500 acres of habitat if existing habitat types are maintained and if additional habitat over the 500 acre minimum occurs within the 0.7 mile radius assessment area.

Attachment B (USFWS 2008)

- The establishment of 1000 foot radius core area centered on the activity center. No habitat altering timber operations may be conducted within the core habitat area.
- Within a 0.5 mile radius (502 acres) of the activity center there must occur a minimum of 400 acres of suitable habitat consisting of a minimum of 250 acres of Nest/Roost habitat and the remaining acres may consist of Foraging habitat.

If the activity center deviates from the habitat quantities recommended in the USFWS guidelines, no habitat alteration is permitted during timber operations except as allowed through consultation with the USFWS or CAL FIRE biologists.

Spotted Owl Counts and Trends

As mentioned above, all spotted owl activity centers occurring on the coastal managed areas are monitored annually for occupancy status up to reproductive status. Monitoring efforts have been ongoing since 1990, providing opportunities for the examination of spotted owl counts, occupancy dynamics and reproductive rates on these industrial managed landscapes.

Figure 3 below provides a simple analysis of the total number of territories (activity centers) occupied, total number of single spotted owls, total number of spotted owl pairs, and total number of adult spotted owl occurring on the two managed survey areas combined from 2000 – 2013. We used 2000 as the starting year for the analysis as the first decade of surveys from 1990 – 1999 was when new activity centers were still being discovered and this would therefore bias the trend lines shown below. It was likely that most activity centers occurring on the ownership were discovered by 2000 and banding resights suggests that most newly discovered activity centers since 2000 were spotted owl from nearby activity centers establishing new core areas. As shown in Figure 3, we observe annual variation in counts but no steady negative trends in counts.

Figure 3. Total number of territories occupied, total number of single spotted owls, total number of spotted owl pairs, and total number of adult spotted owl occurring on the two coastal managed survey areas combined (2000 – 2013).

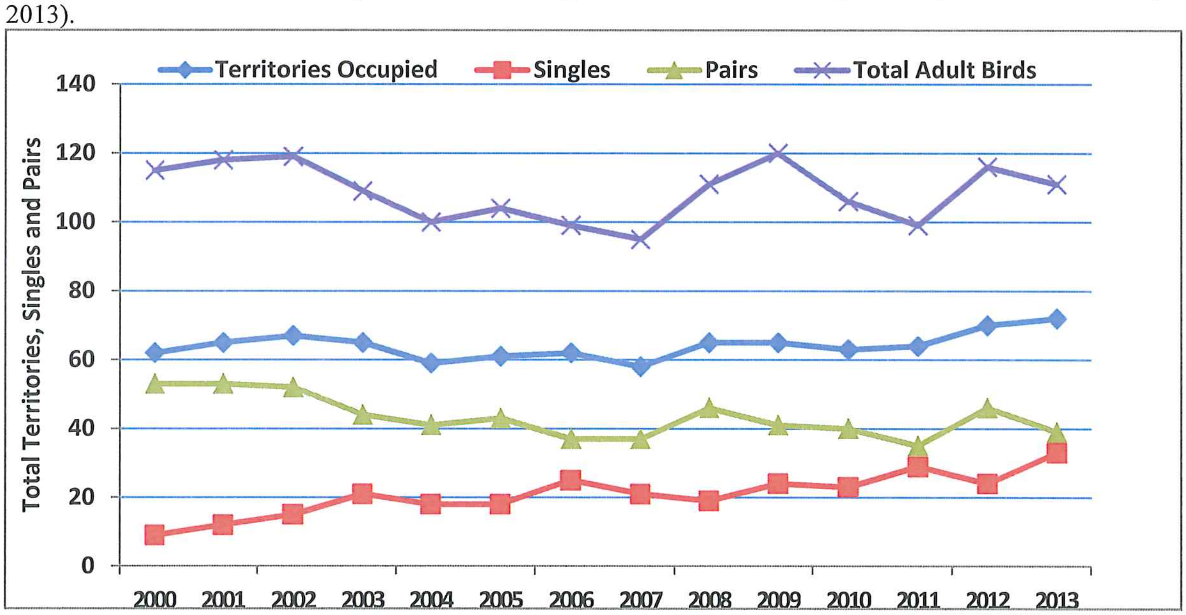
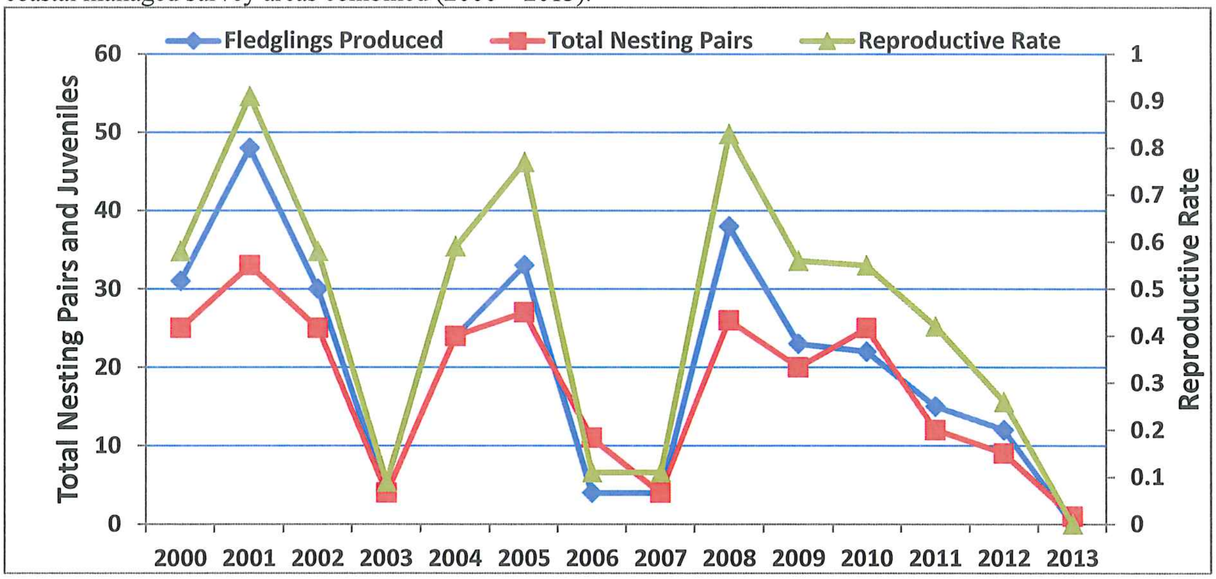


Figure 4 below provides a simple analysis of annual numbers of spotted owl nesting pairs, spotted owl juveniles, and reproductive rates of spotted owl occurring on the two managed survey areas combined from 2000 – 2013. Again, wide annual variations in counts are observed along with noticeable peaks and valleys in annual reproductive counts. Since 2011, we observed a declining trend in reproduction culminating in no reproductive success in 2013. As of mid-April, 2014, we are observing spotted owls nesting on the managed survey areas, but it is still too early in the spotted owl breeding season to assess final reproductive rates in 2014.

The peaks and valleys in reproductive counts closely track other study areas in the coastal redwood region (see other reports; this volume), suggesting some large scale effect, such as climate, on temporal variation in reproduction. In our managed survey areas, the low reproductive counts appear to be correlated to rainfall events during the critical nesting period in March and April (Meekins and Fullerton, 2003), similar to what has been reported by other investigators in the coastal redwood region (see HRC and

MRC reports; this volume). For example, the poor reproductive years observed in 2003, 2006, 2007 and 2011 – 2012 also coincided with high rainfall amounts occurring for long durations during the spotted owl nesting season. For reasons unknown, the 2013 reproductive year was an anomaly where low rainfall amounts occurred during the critical nesting period yet no successful spotted owl reproduction was observed that year.

Figure 4. Total spotted owl nesting pairs, fledglings, and reproductive rates of spotted owl occurring on the two coastal managed survey areas combined (2000 – 2013).



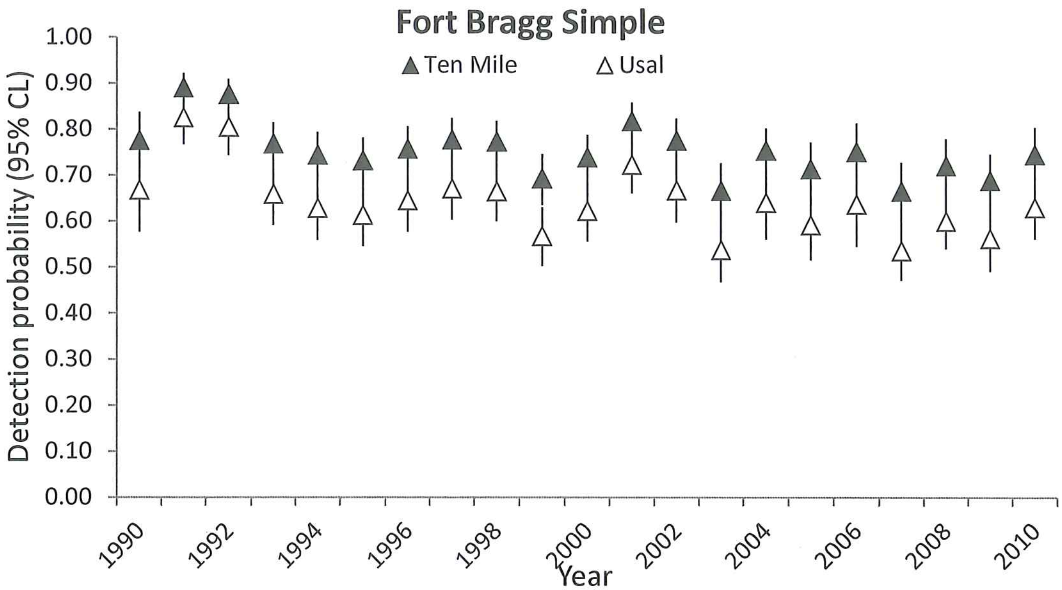
Spotted Owl Detection Probabilities and Site Occupancy Dynamics

In order to investigate spotted owl occupancy dynamics on the HTC and URFC ownerships, we conducted an analysis of detection probabilities and occupancy probabilities of spotted owls using Campbell Global datasets from 1990 – 2010 and following methods described by MacKenzie et al. (2003, 2006) for open populations and specifically used for spotted owls as outlined in Olsen et al. (2005) and Kroll (2010). The analysis included an evaluation of detection probabilities and occupancy probabilities across the two properties combined (HTC represented by the Ten Mile and URFC representing the Usal ownerships) and using an ownership (block) specific covariate. The results presented here should be considered preliminary as a final analysis is currently underway with updated datasets and is not currently available as of this report.

Detection Probabilities

For spotted owls, detection probability is the probability that a spotted owl will be detected, if present, during the sampling (survey) effort. Detection probabilities for single spotted owls on the HTC and URFC managed properties across all years averaged 0.72 (95% CI=0.70-0.73) and 0.62 (95% CI=0.58-0.65) respectively for all years combined and exhibited an unspecified time effect (varied across years) and block effect, where detection probabilities were higher on the HTC managed area and lower in the URFC managed area (Figure 5) (Kroll, A.J. unpublished data). It also included a negative linear seasonal effect where detection probabilities were highest during the early survey period (i.e. March and April) and declined during the course of the survey season. The declining detection probabilities observed over the course of the survey season occurred on both HTC and URFC managed areas and across all years (Kroll, A.J., unpublished data).

Figure 5. Detection probabilities for single spotted owls occurring on the HTC and URFC managed areas from 1990-2010 (from Kroll, A.J., unpublished data). Ten Mile referenced in the figure represents the HTC ownership.

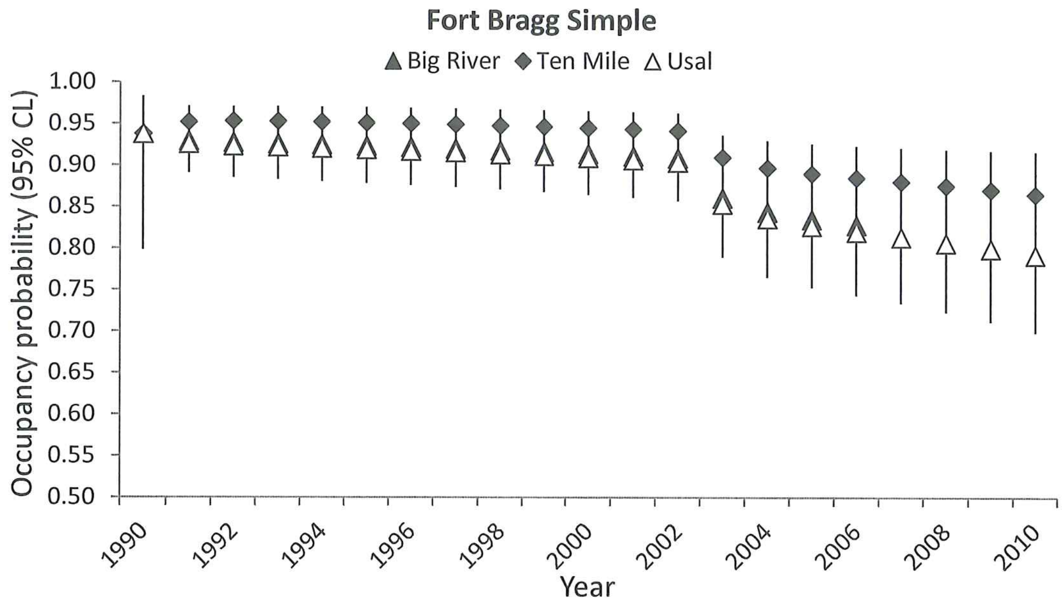


The best model for detection probabilities for spotted owl pairs contained an interaction between survey time (day versus night surveys) and between year and nesting status (effect of nesting status on detection probability varied each year). Detection probabilities were lowest for non-nesting pairs during night surveys and highest for nesting pairs during daytime surveys. In this case, daytime surveys consisted of walk-in surveys within spotted owl core areas. For spotted owl pairs, average detection probabilities for all surveys combined was 0.45 (95% CI-0.44-0.47) while the average detection probabilities across all years were 0.50 (95% CI=0.48 – 0.52) for daytime surveys and 0.21 (95% CI=0.19-0.24) for night surveys.

Occupancy Probabilities

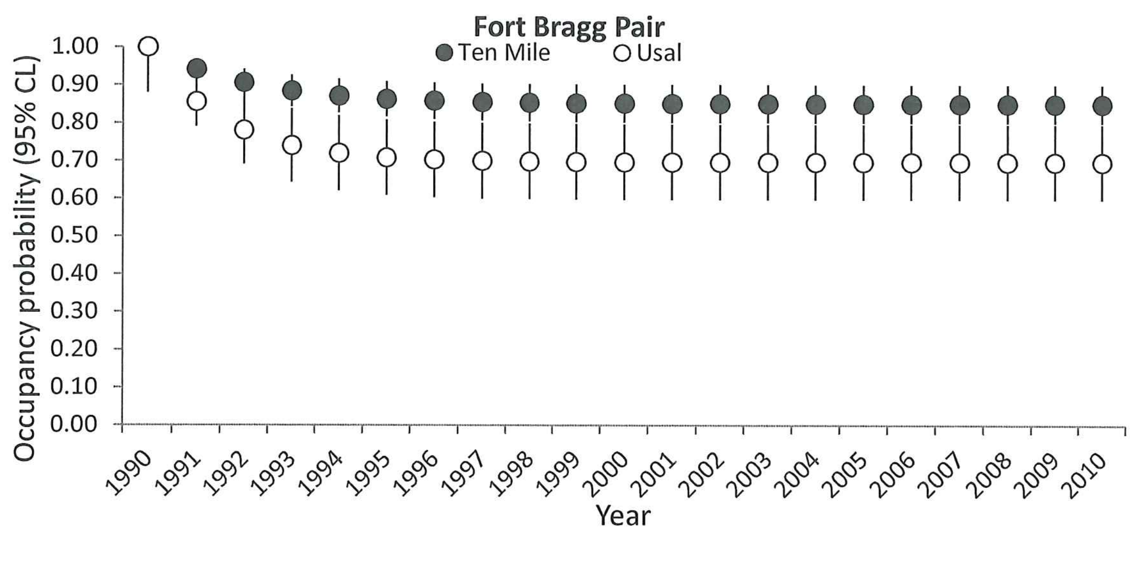
Occupancy probability is the probability that a spotted owl site will be occupied the following year. Estimates of annual single and pair occupancy probabilities were conducted on the HTC and UFRC managed areas from 1990-2010. For single spotted owls, occupancy probabilities were relatively stable until 2003 and then began to decline across both ownership areas (Figure 6)(Kroll, A.J., unpublished data). Future analysis by other investigators in the coastal redwood region may provide further insights as to the scope and potential causes of this decline. However, it should be noted that although single spotted owl occupancy rates appeared to be declining from 2003-2010, occupancy probabilities on both ownership are high. Occupancy rates for single spotted owls were >0.85 and >0.80 for the HTC and URFC ownerships, respectively, in 2010 (Figure 6).

Figure 6. Occupancy probability for single spotted owls occurring on the HTC and URFC managed areas (from Kroll, A.J., unpublished data). Ten Mile referred to in the figure represents the HTC managed area. Campbell disposed of the Big River property in 2006 and this disposed property is not discussed in this report.



For spotted owl pairs, occupancy probability was higher on the HTC ownership than the URFC ownership (Figure 6). Occupancy probabilities declined during the initial years of survey effort in 1990-1997, then pair occupancy probabilities stabilized to a constant occupancy probability of approximately 0.85 and 0.70 for the HTC and URFC ownerships, respectively (Kroll, A.J, unpublished data). The 1990-1997 declines in pair occupancy probabilities may reflect sampling efforts during these first years of surveys when surveyors were attempting to "sort out" the high densities of spotted owls and their associated territories they discovered on the ownerships. During this period, many spotted owls were assigned pair status due to multiple detections in the same and adjacent watersheds that were actually spotted owls from independent territories.

Figure 6. Occupancy probability of spotted owl pairs on the HTC and URFC survey areas from 1990–2010 (from Kroll, A.J., unpublished data). The Ten Mile area referred to in the figure represents the HTC managed property.



Overall, pair occupancy probabilities declined by approximately 16% and 30% on HTC and URFC, respectively, with most of the decline observed occurring during the first seven years of the survey effort, as mentioned above (Kroll, A.J., unpublished data). The stabilized occupancy probabilities observed for spotted owl pairs across the ownerships suggest that spotted owl pairs are at least being maintained over time.

Unregulated Threats

Barred Owls

Several unregulated threats to spotted owls occurring in our region have been identified as potentially negatively influencing spotted owl populations including the continuing invasion of barred owls and the increasing use of rodenticides in illegal large scale marijuana operations occurring on the two managed survey areas.

Barred owls were first detected on Campbell managed landscapes in 1990 with a total of 24 detections occurring from 1990 – 2013, or 0.4% out of the 6717 surveys conducted during this period. Interestingly, 15 out of the 24 (63%) barred owl detections occurred during the first 9 years of survey effort (1990-1998). The majority of these detections were made on the periphery of the managed properties on adjacent landowners in older (>100 years) 2nd growth forests. These older 2nd growth forests do not occur on the HTC and URFC to the extent they occur on adjacent landowners. Although barred owl surveys are not conducted on HTC or URFC ownerships, given that barred owls were first detected over twenty ago, the low number of barred owl detections occurring on the properties from 1990 - 2013, in addition to the continued high detection probabilities of spotted owls suggest that barred owls are not currently a threat to the population of spotted owls occurring on the two ownerships in the coastal redwood region.

The apparent lack of barred owls observed on the two ownerships is in direct contrast to increasing trends of barred owl occurrences observed on other industrial managed landscapes in the coastal redwood region and throughout the range of the spotted owl. It is unknown why we observe an absence of barred owls or increasing trends of barred owl detections on the two ownerships while the population of spotted owls appears stable. Investigators have examined the role that forest structure may play on foraging dynamics of barred owls, especially when forest structure is exemplified by a heavy hardwood component (Irwin et. al., 2013). Irwin et al. (2013) hypothesized that the larger barred owls may be less efficient than spotted owls exploiting prey occurring in these denser, younger forests. We believe this hypothesis is worth further exploration and if substantiated could have implications for future forest management in this region.

Rodenticides

Rodenticide use in illegal marijuana grows are an increasing concern on the two managed properties. In 2011 and 2013 alone, >40,000 and >30,000 plants, respectively, were eradicated from large, organized growing operations on the ownerships, representing a fraction of those likely occurring across these isolated landscapes. Lack of eradication resources leave most large marijuana grows in place along with thousands of pounds of trash, ammonia, fertilizer, and rodenticides/herbicides. MRC (2014; this volume) gives a detailed description of the extent and potential impacts on the rodenticide issue on their managed properties in the coastal redwood region and their summary of the issue applies to the HTC and URFC properties located directly adjacent to MRC lands as well. Although there is little evidence of spotted owl mortality due to secondary exposure to rodenticides, exposure and mortality from rodenticides in Pacific Fisher (*Pekania pennant*) has been well documented. Given that Pacific Fisher and spotted owls exploit similar habitat types and prey, i.e. woodrats (*Neotoma* spp.); it is likely that lethal secondary exposure to rodenticides may impact populations of spotted owls occurring in the coastal redwood region in the future as well.

Summary

Campbell Global, LLC industrial managed lands in California consists of approximately 165,000 acres of coast redwood forests in Mendocino County and approximately 55,000 acres in Shasta and Trinity Counties. In Mendocino County, twenty-four years of continuous survey and monitoring efforts of have occurred on these industrial managed landscapes in addition to continuing research efforts aimed at furthering our understanding of ecology in the region and for adaptive management purposes.

Campbell conducts full spotted owl surveys according to most recent USFWS Protocol in all suitable habitats within 0.7 miles of proposed THPs in Mendocino County and 1.3 miles of THPs in Shasta and Siskiyou Counties, and conducts full AC monitoring at all known ACs occurring on the ownerships regardless whether there are proposed projects occurring nearby. Currently spotted owl take is avoided by utilizing CCR14 919.9(e)/939.9(e) under the USFWS programmatic Take Avoidance Scenarios (Attachments A (coast) and B (interior) but landowners will occasionally utilize 919.9(g)/939.9(g) under consultations with CAL FIRE biologists or the USFWS when special conditions warrant. Attachments A and B provide programmatic guidance on habitat quality and quantities as well as disturbance avoidance measures recommended to avoid take of spotted owl during, or as a result, of timber operations.

Continuous activity center monitoring has provided the opportunity for analysis of activity center status and occupancy dynamics of spotted owls over time, which suggests stable occupancy rates of spotted owl pairs and single spotted owls occurring on these landscapes. Monitoring efforts also suggest that the numbers of pairs and singles have not declined since surveys and monitoring efforts were initiated in 1990 but appear to be dynamic yet stable over this time period. Spotted owl reproduction varies widely on an annual basis and appears to follow a regional pattern. However, reproductive rates appear to have declined over the past three years, culminating in no reproductive attempts in 2013. Similar spotted owl reproductive patterns are widely observed throughout the coastal redwood region and other portion of their range, suggesting a regional effect rather than a local effect on spotted owl reproduction. The effects of climate on spotted owl survival and reproductive rates has been observed in several studies, and going forward it will be extremely important for landowners to continue monitoring their spotted owl populations for reproduction to determine if the trends in lowered reproductive rates in the past few years continue, perhaps due to climatic effects, or some other as yet unidentified cause.

Consistent spotted owl occupancy rates, especially for spotted owl pairs at known Activity centers over the last several decades suggest that the various regulatory mechanisms in use through time have been adequate to avoid take of spotted owls and maintain spotted owl populations on these industrial managed landscapes.

Barred owls have not gained a foothold to date on HTC or URFC ownerships, although several barred owl territories have been located on adjacent ownerships in more mature forests than those occurring on HTC or URFC. Lack of barred owl occurrence on these forests may be due to existing forest structure, exemplified by dense young stands with heavy hardwood components and flight dynamics of the larger barred owls. We believe this hypothesis is worthy of future investigation and has implications for future forest management, at least in our survey areas.

Ultimately, it is our belief that listing the spotted owl under the California Endangered Species Act in California is unwarranted due to 1) effective, existing regulation currently in place and conservation measures applied to known spotted owl activity centers using USFWS guidelines, and 2) decades of full monitoring efforts at known activity centers and analysis of occupancy dynamics of spotted owls occurring on these managed landscapes suggests that spotted owl populations are dynamic as seen from variation in spotted owl counts from year to year, and are also relatively stable, as suggested by high annual occupancy probabilities, especially for spotted owl pairs, observed over time.

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OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- CAMPBELL GLOBAL LLC -
DOUG MEEKINS, WILDLIFE RESOURCE MANAGER

http://www.calforests.org/wp-content/uploads/2014/02/Campbell_Group_NSO_101.pdf

Soper Company

Brief prepared for the CFA NSO Science Forum

October 29 & 30, 2013

Sacramento, California

Soper Company is a family owned tree farm with lands in 10 counties in California. The company's total land base is 98,000. Of these lands, approximately 35,000 acres are located within the range of the Northern Spotted Owl (NSO) in Sonoma, Mendocino and Humboldt counties.

The company started to acquire coastal lands in the mid-1960s' with its acquisition of the Devilbiss Ranch on the Mendocino coast. Other properties have been acquired as the opportunity presented. The result is 13 widely spaced parcels ranging in size from a couple hundred acres to the 12,000 acre Hedgepeth Ranch in Sonoma county.

Most of the properties were acquired in a heavily cut-over condition. A number of the ranch properties had a history of timberland conversion with the intent to improve forage for grazing animals. Accordingly, the company's management practices have focused on reforestation and conservative levels of harvest in order to restore the various properties towards their capacity for timber production.

The company has made significant investments to restore forests that had been previously cleared and to restore conifer forests that had been overrun by tanoak. This patient approach to timberland investment has been the hallmark of the company throughout its nearly 110 year presence in California.

Spotted Owl Surveys & Management

When the NSO was listed as an endangered species, staff foresters were initially charged with performing owl surveys and obtaining no-take determinations from the California Department of Fish & Game. This included surveying various timber harvest projects ranging from the Pedotti Ranch @ Ft. Ross to the DeVilbiss Ranch near Rockport.

After obtaining property in the Pine Creek watershed in Humboldt County in the late 1990's, the company began utilizing the services of consulting wildlife biologists to perform owl surveys and other necessary NSO compliance for timber harvest permitting under the regulatory framework of the California Forest Practice Act. Today we utilize the services of three or more biologists at any one time.

NSO Compliance Program

Given the scattered nature of the company's timberland within the range of the NSO, it has been the policy to obtain NSO compliance on a project by project (THP by THP) basis. In this regard, the company's NSO approval process more resembles the compilation of multiple non-industrial ownerships rather than that of an industrial programmatic approach.

Given the relatively small size of the properties, the fact that they are scattered widely across the landscape and that they represent highly variable forest type and conditions; a programmatic approach wouldn't seem to provide any added efficiencies.

Currently, the company has protocol survey efforts on five of the 13 properties which involve 6 currently approved Timber Harvest Plans and one being readied for submittal to CALFIRE. NSO activity centers are associated with all of these projects.

Landowner Cooperation

As the company hasn't taken a programmatic approach to its owl compliance efforts, NSO statistic haven't been summarized for the ownership. Again, as a result of the relatively small size of the company's timbered properties and the past land management history; the owl activity centers and nests sites that are identified for protection are often located on our neighbor's property.

Determination of pair and nesting status on this owls located on adjacent lands requires permission for entry and/or coordinated survey and data sharing. For instance, a number of our projects in Mendocino County adjoin the lands of the Mendocino Redwood Company and we work cooperatively with their staff to locate and mitigate potential impacts to these owls. Presentation here would in effect double count those owls.

Other company lands adjoin Hoopa Indian Reservation, lands held by The Conservation Fund, and the Jackson State Demonstration Forest. In all of these instances there is good level of cooperation with the land manager's biology staff and our consulting biologists.

Long-term Sustained Yield and Harvest Planning

Since Soper Company has over 50,000 acres of timberland; it is subject to the so-called MSP requirements under Sec. 913.11 and 933.11 of the Forest Practice Rules. Accordingly, Soper Company has prepared two 'Option A' documents, one for its inland properties and one for its lands in the Coast Forest District. Soper's Coastal Option A addresses all of the Company's lands located within the range of the NSO.

The Option A demonstrates how the land owner will balance growth and harvest over time for its ownership within the assessment area. For this effort and detailed forest inventory is gathered. The inventory types or strata are modeled to develop growth projections. Harvest models are applied over time, and a projection of future conditions can be made taking into account growth, harvest and regeneration. For this effort, 13 unique silvicultural regimes are considered.

In the case of Soper's Coastal Option A; modeling is done at the stand level which allows model outputs to be presented spatially. This also affords the opportunity to include spatial constraints to harvest in the analysis and modeling effort. Mitigation requirements that affect yield such as: watercourse protection zones, clearcut adjacency, and habitat retention requirements are then 'hard-wired' spatially into the harvest forecasting effort.

Due to the past management history of Soper's coastal properties; harvest modeling for the next two decades projects harvest levels significantly below current growth rates. Conservative harvest will result in increasing inventory levels, larger tree sizes and in-turn increasing more timber growth across the ownership. This has and will increase the amount of high quality nesting/roosting and foraging habitat for the NSO across Soper's ownership.

OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- SOPER COMPANY -
PAUL VIOLETT, VICE PRESIDENT AND CHIEF FORESTER

http://www.calforests.org/wp-content/uploads/2014/01/NSOPresentation-VIOLETT.pdf

GUALALA REDWOODS

Owl visit success 30

11/05/13

F&G Center	Name	First Contact	Total Visits	Last Contact	Last Contact Response	Last Visit	Last Visit Response
Son0034	Rockpile Cr (Middle)	1990	25	2010	Pair	2010	Pair
Men0153	Hoodoo-McGann	1990	38	2012	Adult 1 juvenile	2012	Adult 1 juvenile
Men0510	NF Gualala (Middle)	1990	21	2013	Pair	2013	Pair
Men0179	Elk Prairie	1990	31	2011	Male	2011	Male
Men0371	No Name	1990	47	2013	Pair	2013	Pair
Son0017	Big Pepperwood	1990	57	2013	Pair	2013	Pair
Son0045	Robinson Flat/Rockpile	1990	58	2013	Male	2013	Male
Son0012	Buckeye Cr	1990	36	2011	Pair	2013	No Contact
Son0009	Wheatfield Fork (Lower)	1990	40	2013	Pair	2013	Pair
Men0212	Doty Cr (Lower)	1991	42	2013	Male	2013	Male
Men0214	Doty Cr (Upper)	1991	14	2013	Male	2013	Male
Son0043	Wheatfield Fork (Upper)	1992	11	2008	Pair	2008	Pair
Son0090	Rockpile Cr (Upper)	1993	11	2009	Pair	2009	Pair
Men0152	Jonny Wooden Ridge	1994	31	2011	Male	2011	Male
Son0082	Switchville	1995	37	2008	Unknown	2013	No Contact
Men0307	NF Gualala (Upper)	1995	4	1997	Unknown	2000	No Contact
Men0412	Upper Pepperwood	2001	22	2013	Male	2013	Male
Son0085	Radke	2003	37	2013	Unknown	2013	Unknown
Men0587	Waterfall	2003	10	2011	Male	2011	Male
Son VC	Valley Crossing	2011	13	2013	Pair	2013	Pair

OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- GUALALA REDWOODS -
HENRY ALDEN, VICE PRESIDENT

http://www.calforests.org/wp-content/uploads/2014/01/Owls-2013-4-ALDEN.pdf

Roseburg Resource Company NSO Summary

Roseburg owns and manages approximately 178,000 acres in Siskiyou and Shasta Counties with approximately 110,000 acres within the range of the NSO. The land was managed through uneven aged practices until the early 2000's when the management regime was changed to mostly even-aged.

Surveys on the property started in 1990. There were very few historic Activity Centers in the NSO Database on or adjacent to RRC ownership. Many of the sites in the database have subsequently been determined by USFWS to be either unoccupied or to not have been a valid activity center to begin with. Surveys have continued on the property in relation to planned timber harvest activities.

Much of Roseburg's ownership is located within the Sacramento River Canyon which is noted for having very few NSO. Currently there are fewer than one dozen occupied Activity Centers on or adjacent to RRC lands (within 1.3 miles). Of these, there are several that have been surveyed and been found to be unoccupied for at least 3-4 years that we are awaiting new site abandonment protocols. Only one Activity Center has been continuously occupied and reproductive over the past decade. This site is in what most would consider marginal or non-habitat, dominated by pine, hardwoods, juniper, brush and some Douglas fir and mixed conifer stands. It has fledged 8 young over the past four years.

Based on the most recent habitat definitions, less than 5% of the ownership is classified as Nesting Roosting or High Quality Nesting Roosting habitat. The huge majority is classified as foraging and low quality foraging habitat. Due to the lack of historic activity centers, NSO and Barred Owl responses over the past 20 years, and a general lack of habitat, the USFWS granted us a survey waiver for most of the ownership within the Sacramento River Canyon. This waiver is based on habitat modeling found in Zabel , et al, 2003 which basically states that in areas with less than 40 acres of nesting roosting the probability of NSO occupying that site is zero.

In areas where suitable nesting roosting habitat is present, either on or adjacent to, proposed THP's we conduct two years of surveys following the most recent USFWS endorsed protocols. Additionally, we conduct Barred Owl surveys in areas where historic NSO are not detected. We have no known Barred Owl activity centers on the property.

Forest Growth Models predict increasing amounts WHR 4D over time. Roseburg is currently FSC certified and so retention policies related to FSC will promote late seral characteristics across the ownership.

In summary, there are very few NSO activity centers on, or adjacent to, Roseburg lands. We continue, however, to conduct NSO surveys in areas where suitable habitat suggests there could be resident NSO.

OCT. 2013 NSO SCIENCE FORUM PRESENTATION:

- ROSEBURG RESOURCE COMPANY -
RICH KLUG, CA WILDLIFE BIOLOGIST

http://www.calforests.org/wp-content/uploads/2014/01/KLUG-NSO_Presentation_RRC.ppsx

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Monitoring Northern Spotted Owls on Federal Lands in Marin County, California

2010–2011 Report

Natural Resource Technical Report NPS/SFAN/NRTR—2012/606

ON THE COVER
Northern spotted owl (*Strix occidentalis caurina)* fledgling.
Photograph by: Taylor Ellis

Monitoring Northern Spotted Owls on Federal Lands in Marin County, California

2010–2011 Report

Natural Resource Technical Report NPS/SFAN/NRTR—2012/606

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July 2012

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado publishes a range of reports that address natural resource topics of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

This report is available from the San Francisco Area Network Inventory and Monitoring website (http://science.nature.nps.gov/im/units/sfan) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

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NPS 641/116038, 112/116038, 612/116038, July 2012

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Abstract

This report provides a summary of results from the 2010 and 2011 field seasons of the National Park Service's (NPS) northern spotted owl (*Strix occidentalis caurina*) monitoring program in Marin County, California. The northern spotted owl has been listed as a federally threatened species since 1990. The Marin County population of spotted owls is of interest because of its isolation from other populations, high density and fecundity, and because only recently has this population been affected by the expansion of barred owls (*Strix varia*). The goals of our northern spotted owl monitoring program are to estimate trends in spotted owl occupancy and fecundity within the NPS legislative boundaries in Marin County.

2010 Summary
A total of 30 known spotted owl territories ("sites") were randomly selected and monitored using standardized methods during the 2010 breeding season. Spotted owl pair occupancy in 2010 was the highest on record, with pairs of spotted owls occupying 28 of the 30 (93%) long-term monitoring sites. Of the 28 pairs, 15 females (54%) are known to have attempted nesting. Six nests failed, and the remaining nine nests yielded a confirmed total of 14 young. A total of 11 non-nesting females were confirmed at the 30 sites. The 2010 fecundity estimate of 0.27 (SE ±0.08) was below the average fecundity of 0.37 (SE ±0.07) measured at monitoring sites from 1999 to 2011.

Unfavorable weather conditions may have contributed to the relatively poor reproductive year. The percentage of pairs that attempted nesting (54%) in 2010 was lower than in both 2008 (77%) and 2009 (73%). The nest failure rate in 2010 (21%) was higher than average (11%)**.** A series of storms that lasted into May might have deterred some spotted owl pairs from nesting, and also may have contributed to the high number of nest failures.

Barred owls were detected at three spotted owl territories in 2010, including an apparent nest near Muir Woods National Monument (MUWO). While the presence of barred owls has been correlated with lower spotted owl detection and occupancy rates in other areas of the spotted owl range, spotted owl occupancy in 2010 remained high.

2011 Summary
A total of 30 known spotted owl sites were randomly selected and monitored using standardized methods during the 2011 breeding season. Pairs of spotted owls occupied 22 of these 30 (73%) long-term monitoring sites. Of the 23 territorial females in 2011, 9 females (39%) attempted nesting. These nine nests were all successful and yielded a confirmed total of 10 young. A total of 13 non-nesting females were confirmed at the 30 sites. No nest failures were documented in 2011, possibly because most of the sites were not monitored until late in the breeding season due to budgetary constraints. Some of the non-nesting females may have actually attempted to nest and failed during the spring before full monitoring was underway. In 2011, the fecundity estimate of 0.23 (SE ±0.06) was well below the average fecundity of 0.37 (SE ±0.07) measured at monitoring sites from 1999 to 2011.

As with 2010, unfavorable weather conditions in 2011 may have contributed to the relatively poor reproductive year. The percentage of pairs that attempted nesting in 2011 (41%) was lower than in 2008 (77%), 2009 (73%), and 2010 (54%). An unusually wet winter and late rains lasting

into June may have deterred some spotted owl pairs from nesting, and could have led to undetected nest failures before our spotted owl monitoring began for the season.

Barred owls were detected at four spotted owl territories in 2011, including a nesting barred owl pair with four fledged young near MUWO. Five of the 30 (17%) randomly selected monitoring sites in 2011 had a history of barred owl detections, while in 2010 only three of the 30 (10%) sites had a history of barred owl detections. By randomly selecting a higher percentage of sites influenced by barred owls for our 2011 monitoring, we may have decreased our chances of recording northern spotted owl pairs at the sites we monitored.

We recommend continued annual monitoring of the spotted owl population, and continuing to share information and work with land managers and county officials to reduce potential adverse impacts of projects on spotted owls. Research focused specifically on barred owls and their impacts on spotted owls in Marin County should be initiated. In addition, studies investigating the effects of Sudden Oak Death on spotted owls also are needed. NPS should continue to provide outreach materials related to spotted owl awareness and recovery.

Acknowledgments

This project has been made possible by funding from the following agencies and organizations: San Francisco Bay Area Network Inventory and Monitoring Program, Point Reyes National Seashore, Golden Gate National Recreation Area, Muir Woods National Monument, Golden Gate National Parks Conservancy, Point Reyes National Seashore Association, and Conservation Corps North Bay. The NPS monitors spotted owls in cooperation with PRBO Conservation Science, Marin Municipal Water District, Marin County Open Space District, and California State Parks.

This project is possible through the assistance of numerous staff members from past years. D. George of NPS designed the monitoring program database and additional field guidance and supervisory contributions have been made by S. Allen, G. Geupel, D. Hatch, M. Koenen, and M. Monroe. We are grateful to Point Reyes Law Enforcement staff for accompanying staff biologists to monitoring sites with safety concerns. Thanks to R. Townsend, M. Saxton, A. Frostholm, and S. Shpak who helped with surveys at both Point Reyes National Seashore and Golden Gate National Recreation Area. Last, but not least, thank you to D, Munton, M, Divens, and R, Johnson for their continued assistance with surveys at Point Reyes National Seashore.

Introduction

The mission of the National Park Service (NPS) is “to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (16 U.S.C. 1). To uphold this goal, Congress approved the the Natural Resource Challenge in 1998 to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (PL 105-391) . The NPS Inventory and Monitoring Program organized 270 parks in the national park system into 32 inventory and monitoring networks. The networks use common methodologies for data comparability, to reduce the level of effort, and to share resources.The San Francisco Bay Area Network (SFAN) includes Eugene O’Neill (EUON), John Muir (JOMU), and Fort Point (FOPO) National Historic Sites, the Presidio of San Francisco (PRES), Muir Woods (MUWO) and Pinnacles (PINN) National Monuments, Point Reyes National Seashore (PORE), and Golden Gate National Recreation Area (GOGA). The network has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent is to monitor a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Northern spotted owls (*Strix occidentalis caurina*) represent a vital sign for SFAN due to their federally threatened status, ecological significance, and high interest to the public (Adams et al. 2006, Press et al. 2010).

Life History

The northern spotted owl has been listed as a federally threatened species under the Endangered Species Act since 1990. Northern spotted owls inhabit forested regions from southern British Columbia through Washington, Oregon, and northwestern California. They reach the southern limit of their range in Marin County, California, north of San Francisco, where they occur on NPS lands (GOGA, MUWO, PORE), and other public and private lands in Marin County.

In the majority of their range, northern spotted owls are typically found in mature coniferous forests (Forsman et al. 1984). In Marin County, they inhabit second growth and old growth Douglas fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), mixed conifer-hardwood, and evergreen hardwood forests. All forest types and ages contain a significant hardwood component. A nest site occurrence model developed in cooperation with PRBO Conservation Science indicated that forest connectivity, areas with more forest cover, less forest edge and urban development, and topographic conditions such as locations lower in the watershed, closer to streams, and more south-facing aspects, were the strongest predictors of spotted owl presence (Stralberg et al. 2009).

Spotted owls in Marin County use a variety of tree species of differing sizes for nesting, and typically nest in platform structures, with relatively few nests in cavities. Platform nesting structures in Marin County have included tree forks, large limbs, broken top trees with lateral branches, old raptor, corvid, squirrel, and woodrat nests, debris piles, poison oak tangles *(Toxicodendron diversilobum*) and dwarf mistletoe infestations (*Arceuthobium* spp.). Cavity nests included both side entry and top entry cavities. Spotted owl nests have been documented in tree species including coast redwood, Douglas fir, bishop pine, California bay (*Umbellularia californica*), tanoak (*Lithocarpus densiflorus*) and coast live oak (*Quercus agrifolia*).

An inventory of most of the forested habitat in Marin County was conducted in 1997 and 1998 (Chow and Allen 1997, Chow 2001), with a second inventory focusing on federal lands in Marin conducted in 2006 (Jensen et al. 2007). Monitoring of the Marin County spotted owl population has occurred from 1999 to 2011 (Hatch et al. 1999, Fehring et al. 2001b, 2002, 2003, 2004, Jensen et al. 2004, 2006, 2008, 2010). The Marin County study area supports one of the highest known densities of northern spotted owls within its range (Blakesley et al. 2004). Based on a recent analysis, the density of spotted owl activity sites was estimated to be 0.52 owls/km^2, which is slightly higher than a previous Marin County estimate due to the discovery of several additional owl sites and the use of a more limited, geographically relevant boundary for the study area (Chow 2001, Stralberg et al. 2009). As part of range-wide demographic analysis, adult survival and fecundity in Marin County were apparently stable from 1998–2003 (Anthony et al. 2006). Out of a total of 14 study sites, fecundity of adult females in Marin County was the second highest and the Marin County adult survival estimates were similar to most other sites (Anthony et al. 2006).

Spotted owls in Marin County forage primarily on dusky-footed woodrats (*Neotoma fuscipes*), which make up over 75% of their diet by weight (Chow and Allen 1997, Fehring 2003). Zabel et al. (1995) found that in areas where the dusky-footed woodrat is the primary prey species, spotted owls tend to have smaller home ranges and higher reproductive rates. This may explain the high density and fecundity estimates of the spotted owl population in Marin County (Chow 2001, Anthony et al. 2006, Jensen et al. 2007). Other prey species taken by spotted owls in Marin includes small mammals such as deer mice (*Peromyscus maniculatus*), California meadow vole (*Microtus californicus*), and brush rabbit (*Sylvilagus bachmani*) as well as a variety of forest-dwelling birds (Chow and Allen 1997, Fehring 2003).

Threats to the Population

In the 2008 Northern Spotted Owl Recovery Plan, the US Fish and Wildlife Service (USFWS)identified three high ranking concerns to the conservation of the spotted owl: (1) declining suitable habitat, (2) isolation of populations, and (3) decline in the population (USFWS 2008). The recovery plan acknowledged that protecting and managing spotted owl habitat alone is not adequate for spotted owl recovery and the USFWS prioritized barred owls (*Strix varia*) as a significant and complex threat (USFWS 2008). The suite of threats present in Marin County mirrors the range-wide concerns and reflects the area's close proximity to the greater San Francisco Bay area. Threats (ranked according to perceived risk level in Marin County) include: (1) interspecific competition due to the continued range expansion of the barred owl, (2) loss of habitat resulting from urban development along open space boundaries and increased risk of catastrophic wildfire, (3) structural changes in forest heterogeneity due to Sudden Oak Death, (4) genetic isolation, (5) disturbance due to intense recreational pressures, and (6) West Nile virus.

The threat from barred owls is of particular concern to the spotted owl population in Marin County (Anthony et al. 2006, Jennings et al. 2011). Barred owls have expanded their range from the eastern United States west across the Canadian Rocky Mountains and down the west coast. Barred owls exploit the same forested habitats and prey species as spotted owls. However, barred owls are slightly larger than spotted owls and can exhibit aggressive behavior toward spotted owls. Temporary and permanent displacement of spotted owl pairs from their historic sites as a result of the spread of barred owls into the spotted owl's range has been documented by biologists in the Pacific Northwest (Gremel 2000) and the sharpest declines in the spotted owl population have occurred in the northern portion of the spotted owl's range where barred owls have been present the longest (Anthony et al. 2006). Evidence of negative effects of barred owls on spotted owls include territorial exclusion (Hamer 1988, Hamer et al. 2007) and declines in site occupancy (Kelly et al. 2003, Olson et al. 2005), reproduction (Olson et al. 2004), and apparent survival (Anthony et al. 2006). Barred owls were first detected in Marin County in 2002, and have been documented as reproducing in 2007, 2008, and 2011. Confrontations and aggressive interactions between barred and spotted owls have been documented at multiple spotted owl sites within Marin County (Jennings et al. 2011).

Small populations at the edges of a species' range have a much higher risk of local extinction, due to environmental and demographic stochasticity (Gilpin and Soulé 1986). The Marin County population is isolated from the spotted owl populations to the north and shows no evidence of hybridization with California spotted owls (*S. o. occidentalis*; Henke et al. 2003, Barrowclough et al. 2005). A break in forested habitat, expansive grasslands and anthropogenic development serve as dispersal barriers and has isolated the Marin County population from its northern counterparts. Barrowclough et al. (2005) indicated that due to the apparent genetic isolation of Marin County's spotted owl population, the population warrants special management attention.

Currently, forests in Marin County are heavily infested by the pathogen Sudden Oak Death (*Phytophthora ramorum*). At several locations within PORE, tanoak mortality has exceeded 95% by basal area (Moritz et al. 2008). The die-off of native coast live oak and tanoak species is locally important because it results in shifts in plant species composition, possible reduction in plant species richness, and potential impacts on forest dynamics. Specifically, the spotted owl's dominant prey item in this area, the dusky-footed woodrat (Chow and Allen 1997, Fehring 2003), use tanoaks for cover and forage (Sakai and Noon 1993). Sudden Oak Death may also amplify fuel load accumulations and increase the potential and severity of fires.

NPS lands in Marin County are situated within the immediate San Francisco Bay Area and receive several million human visitors each year. Spotted owl nest sites in Marin County are generally close to roads and trails**.** This is likely the result of the high density of trails and fire roads located within potential spotted owl habitat and the tendency to locate trails in riparian drainages where owls often nest. As a result, spotted owls in the region have a high potential for interaction with humans. Furthermore, spotted owl territories located on a matrix of public and private lands or near the wildland-urban interface face an increased risk of injury and death due to effects of human related activities including poisoning, domestic animal interactions, nest site disturbance, and collisions with vehicles.

Monitoring Objectives

There are three current monitoring objectives for the SFAN northern spotted owl monitoring program (Press et al. 2010).

1. Monitor long-term trends in northern spotted owl site occupancy rates of territories within the legislated NPS boundaries of Marin County, California.

2. Monitor long-term trends in northern spotted owl fecundity (number of female young per territorial female) within northern spotted owl territories within the legislated NPS boundaries of Marin County, California.

3. Determine long-term trends in northern spotted owl nest site characteristics including nest tree metrics and abiotic and biotic habitat characteristics to evaluate changes in nesting habitat associations within the legislated NPS boundaries of Marin County, California.

Methods

Study Area

Our study area is within a 13,889-hectare (34,320-acre) forested area of Marin County and includes suitable spotted owl habitat inside or within 400 meters (0.25 mile) of the legislative boundaries of GOGA, MUWO, and PORE (Figure 1; Press et al. 2010). California State Park (CSP) lands in Mount Tamalpais State Park and Samuel P. Taylor State Park are included in the study area, but Tomales Bay State Park is outside of the federal boundary; thus, its spotted owl habitat and known territories have been excluded from the study and are not included in the acreage calculation. Also not included in the study area acreage calculation are additional management sites that occurred outside the perimeter of federal lands on CSP, the City of Mill Valley, the Marin Municipal Water District (MMWD), and the Marin County Open Space District (MCOSD) lands.

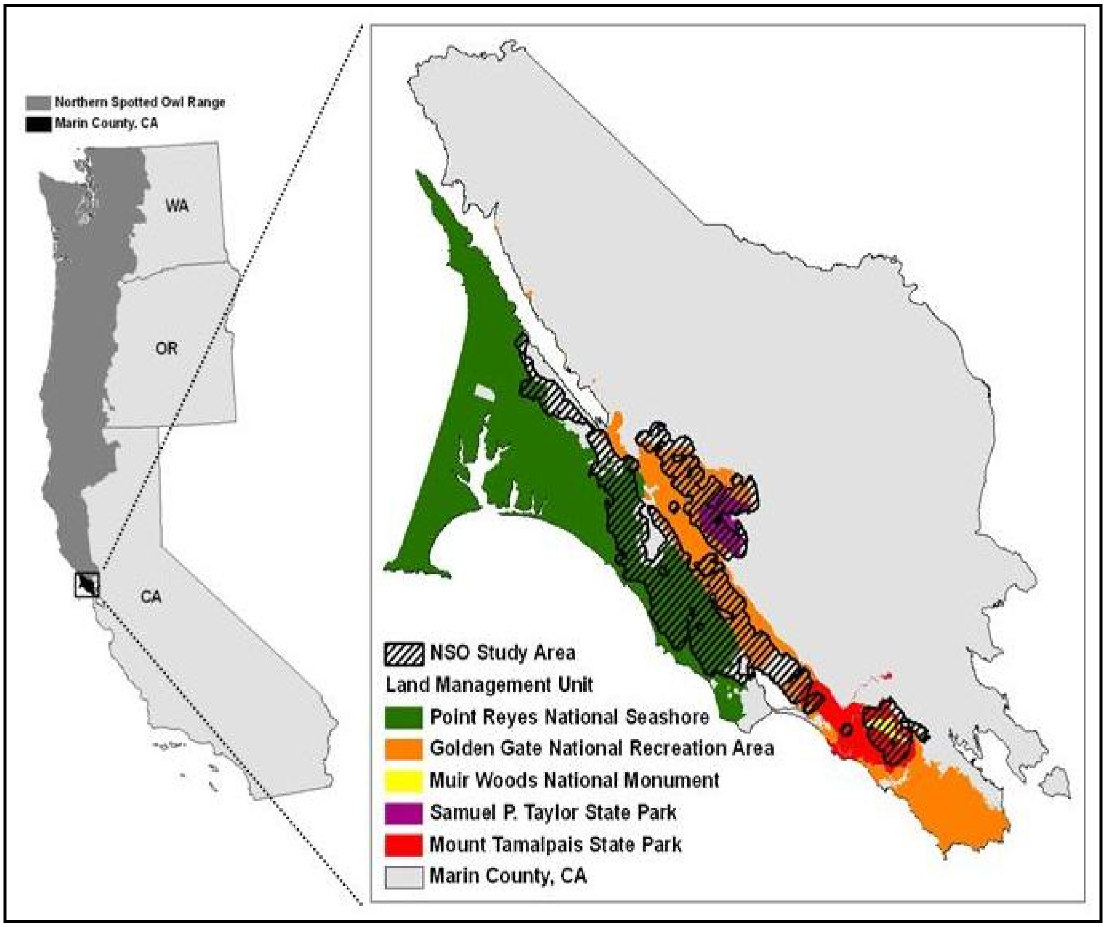

Figure 1. Northern spotted owl range map and Marin County study area. On the left, the dark gray shows the northern spotted owl's range and the black square is centered on Marin County. On the right, land management units included in the Marin County study area are color coded. The study area itself is shaded in black, diagonal lines.

Monitoring History and Study Design

In a 1997–1998 spotted owl inventory study, all evergreen forest habitat located on federal lands within Marin County was thoroughly and systematically surveyed for spotted owl presence using the USFWS protocol (USFWS 1992). Additional surveys on MMWD and MCOSD lands were completed in 1999 (Hatch et al. 1999). A total of 83 spotted owl sites, including 53 pairs, were identified on public lands in Marin County (Hatch et al. 1999, Chow 2001).

Between 1999 and 2005, 46 sites were monitored for occupancy and fecundity and nest site characteristics were collected (Hatch et al. 1999, Fehring et al. 2001b, 2002, 2003, 2004, Jensen et al. 2004, 2006). The sites were chosen to represent a variety of habitat types, ongoing management concerns, accessibility, and funding availability. Due to a non-random selection process, we were concerned that the study design limited our ability to make valid inference across federal lands in Marin County. As a result, we developed a revised study design that allows us to make inferences to all federal lands in Marin County (see Press et al. 2010).

To create a within-subject study design to detect trends toward declines in occupancy and fecundity for all federal lands in Marin County, we first completed a single-year inventory study in 2006 to assess the spotted owl population on all suitable habitat (Jensen et al. 2007). This single-year inventory effort utilized a model that predicted spotted owl nest-site occurrence based on habitat suitability (Stralberg et al. 2009). We applied a 400-meter buffer around the habitat model's boundary and restricted our study area to include buffered lands within 400 meters of the legislative boundary of MUWO, PORE, and GOGA. We used a hybrid of the Marin Modified Protocol (Fehring et al. 2001a) and the USFWS spotted owl monitoring protocol (USFWS 1992) and standardized search procedures (Jensen et al. 2007). As a result, 65 areas, which included 43 known spotted owl territories and 22 other areas with no known established territories, were inventoried for occupancy. At a minimum, a single spotted owl was detected at 59 of the 65 areas, and pairs occupied 43 territories (Jensen et al. 2007).

In 2007, a randomly selected subset of 25 sites was obtained from 47 spotted owl sites that had known pair occupancy in at least one year from 1997–2006 (Jensen et al. 2008). The same 25 sites established in 2007 were monitored in 2008. For the 2009–2011 breeding seasons, we increased our sample size to 30 sites and selected a random set of sites for each year. Sites monitored by NPS staff for management purposes are not included in fecundity analyses because they are not randomly selected.

Field Methods

All long-term monitoring surveys (1999–2005 and 2007–2011) for occupancy and reproductive information follow the Marin Modified Protocol developed for use in areas with high potential owl/human interaction (Fehring et al. 2001a, Press et al. 2010). The "Modified Protocol for Spotted Owl Monitoring and Demographic Studies in Marin County California" (Marin Modified Protocol; Fehring et al. 2001a) is modeled directly from the widely used "Spotted Owl Monitoring Protocols for Demographic Studies" (Forsman 1995). Survey methods include visual surveys of previous activity centers and nest sites, playback calling and hooting both during the day and at night, mousing, visual nest checks, and counts of fledged young.

Standard spotted owl survey protocols may lead to changes in owl behavior due to repeated calling and the feeding of live mice (*Mus domesticus*) to owls (known as "mousing"). Owls habituated to people may be more vulnerable to disturbance and manipulation by park operations and visitors. The Marin Modified Protocol was developed collaboratively between the NPS and PRBO Conservation Science to reduce the number of mice used to obtain the relevant nest site and reproductive information (Fehring et al. 2001a, Press et al. 2010). The ease of access to nest sites and high visibility of nesting structures in Marin County facilitates intensive nest checks and obviates the need to use mice to monitor reproductive status. Consequently, we rely on increased search time, more frequent visits and owl behavioral observations to gather the data.

Spotted owls are sexed based on vocalizations and aged by tail feather shape and coloring (Forsman 1983). Barred owl detections are noted, and reports of barred owls in or around the study area are investigated, but there are no specific methods utilized for monitoring barred owls. An annual breeding status is assigned to the individual spotted owl territories monitored and is determined using criteria in the Marin Modified Protocol.

All owl activity centers (either nest location or major roost site) are recorded in Global Positioning System (GPS) coordinates using a Garmin eTrex Legend or similar GPS unit. Roost sites or nest trees for which GPS satellite access is not available are mapped on topographic maps from compass bearings taken in the field and GPS coordinates are obtained by using ArcGIS 9.3 (ESRI 2009). Each year, at every known nest location, nest tree parameters are measured and surrounding habitat is described using standardized methods found in the monitoring protocol (Press et al. 2010).

Data Management and Distribution

All site search, owl detections, and nest record field data are compiled in a Microsoft Access database maintained at PORE (Press et al. 2010). All areas surveyed are mapped using ArcGIS 9.3 GIS software program and the data layers are made available to agencies involved in land management and planning projects within Marin County, including MCOSD, MMWD, and CSP managers. The 1999 through 2011 spotted owl location data was submitted to the Biogeographic Information and Observation System (BIOS) database which is administered by the California Department of Fish and Game.

Summaries and Reporting

For reporting purposes, in 2008 we established new criteria for inclusion or exclusion of spotted owl sites from annual data summaries. The new criteria were necessary to standardize the reporting process and allow repeatability and robust comparisons among years. In annual reports prior to 2008, data from 1999–2005 was reported for 46 long-term monitoring sites. In 2008, we restricted the inclusion of data from those 46 sites to only data from the 36 sites that fell within our re-designed study area (see Monitoring History and Study Design). Data from 1997 and 1998 were excluded from the summaries due to the difficulty in interpreting the data to determine survey purpose and effort level. Although non-randomly selected, we justified including 12 management sites (number of management sites varied annually) and 14 inventory areas in the analyses if the sites or areas received an adequate level of survey effort for the years 1999–2006. The 2006 data is excluded from the annual summaries for reproductive success and fecundity since the primary purpose of the single year inventory surveys was to determine presence/absence. Each year additional sites may be monitored in order to ensure that park operations and other activities, such as road repairs or trail maintenance, do not impact nesting northern spotted owls. Additional sites monitored in 2007 to 2011 for purposes other than demography (i.e., management sites) were not included in the summaries. Any differences from previously reported results can be attributed to the application of the new criteria to the long-term spotted owl data.

Results

2010 Results

From March 1 to August 17, 2010, the survey teams made 253 visits (mean visits/site = 8.4, range 2–18) to the 30 study sites monitored for the purpose of determining occupancy and fecundity (Table 1). Of the 30 sites monitored, 28 sites were occupied by pairs and 15 of those were nesting pairs; 14 spotted owl young were confirmed in 2010 for an annual fecundity value of 0.27 (Table 1).

Table 1. Summary of the spotted owl monitoring results for the 2010 breeding season.

Number of sites monitored	Number of occupied territories	Number of sites occupied by pairs	Number of sites with known reproductive outcomes	Number of nesting pairs	Number of young produced	Fecundity
30	29	28	26	15	14	0.27

2011 Results

Although monitoring began at some sites in late March, monitoring at the majority of sites did not begin until late May due to budgetary constraints. From March 25 to August 28, 2011, survey teams made a total of 169 visits (mean visits/site = 5.6, range 1–14) to the 30 study sites monitored for the purpose of determining occupancy and fecundity. Of the 30 sites visited in 2011, 22 sites were occupied by pairs and one site was occupied by a resident single female, allowing for the determination of reproductive outcome at 23 sites. In 2011, 29 territories were occupied by spotted owls and 9 nesting pairs confirmed. 10 young were produced in 2011 for an annual fecundity value of 0.23 (Table 2).

Table 2. Summary of the spotted owl monitoring results for the 2011 breeding season.

Number of sites monitored	Number of occupied territories	Number of sites occupied by pairs	Number of sites with known reproductive outcomes	Number of nesting pairs	Number of young produced	Fecundity
30	29	22	23	9	10	0.23

Age and Sex Determination

In other study areas where banding occurs, sexing and aging of spotted owls is easily determined with a re-sighting of the owl's band, but in the Marin County study area only a small proportion of the owls are banded. On numerous occasions when a single owl or pair was located, but without band identification, biologists relied on sexing the owl in view based on vocalizations and aging the owl based on tail feather wear (Forsman 1983). Some owls remained silent during daylight survey hours and only vocalized at night making it impossible to assign ages to the corresponding sex.

In 2010, we positively sexed and aged a total of 50 (26 males and 24 females) spotted owls. Adults constituted 78% or 39 of the 50 spotted owls whose age was identified. Four second-year sub-adults (8%) and five first-year sub-adult (10%) were located. Two sub-adults (4%) in which the age could not be further determined were located. At 24 spotted owl territories, we were able to age both pair members. Seventy percent of the 24 pairs in 2010 were composed of an adult female and male (Figure 2), consistent with the thirteen-year average (Figure 4).

In 2011, we sexed and aged a total of 44 (23 males and 21 females) spotted owls. Adults constituted 84% or 37 of the 44 spotted owls whose age was identified. Six second-year sub-adults (14%) were located. One sub-adult (2%) in which the age could not be further determined was located. At 18 spotted owl territories, we were able to age both pair members. Sixty-seven percent of the 22 pairs were composed of an adult female and male (Figure 3).

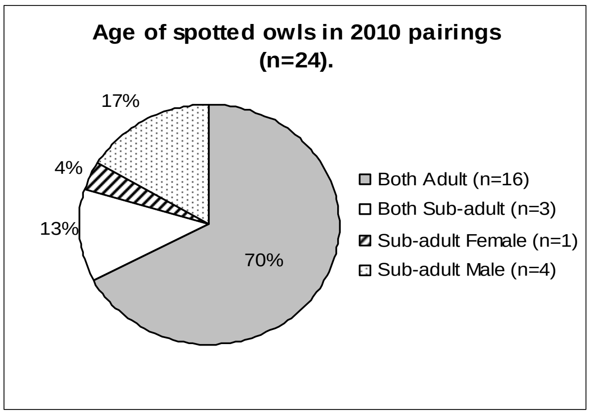

Figure 2. Age of spotted owls in 2010 pairings; n is the number of spotted owl pairs.

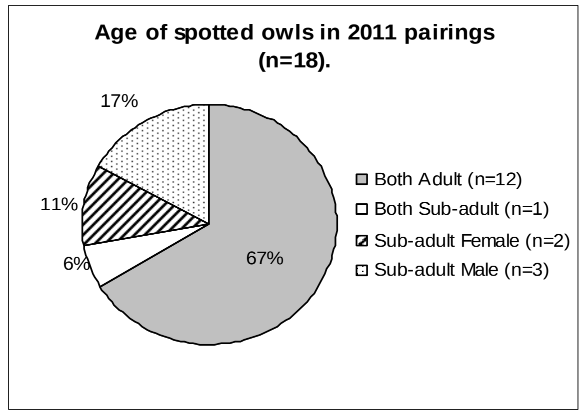

Figure 3. Age of spotted owls in 2011 pairings; n is the number of spotted owl pairs.

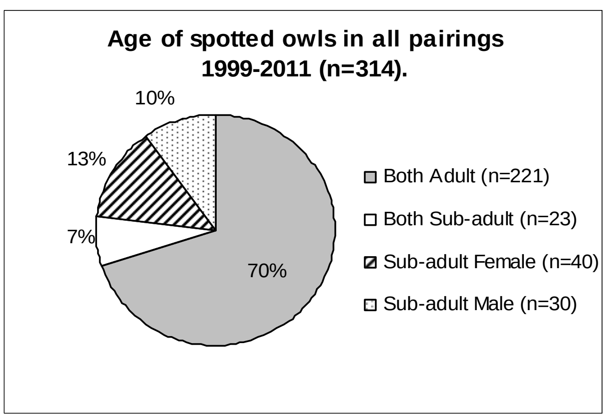

Figure 4. Age of spotted owls in all pairings 1999–2011; n is the number of spotted owl pairs.

Occupancy Status

In 2010, the total percentage of sites occupied by pairs or singles was 97%, with pair occupancy reaching the highest recorded level (93%) in 13 years of monitoring on federal lands in Marin County. Concurrently, the percentage of sites occupied by a single owl (3% in 2010) was one of the lowest recorded. In 2011, 73% of sites were occupied by pairs, and 23% were occupied by single owls, the highest recorded single occupancy rate thus far (Figure 5). The 13-year average for pair occupancy from 1999-2011 was 79%, while the average for occupancy by single owls was 11%.

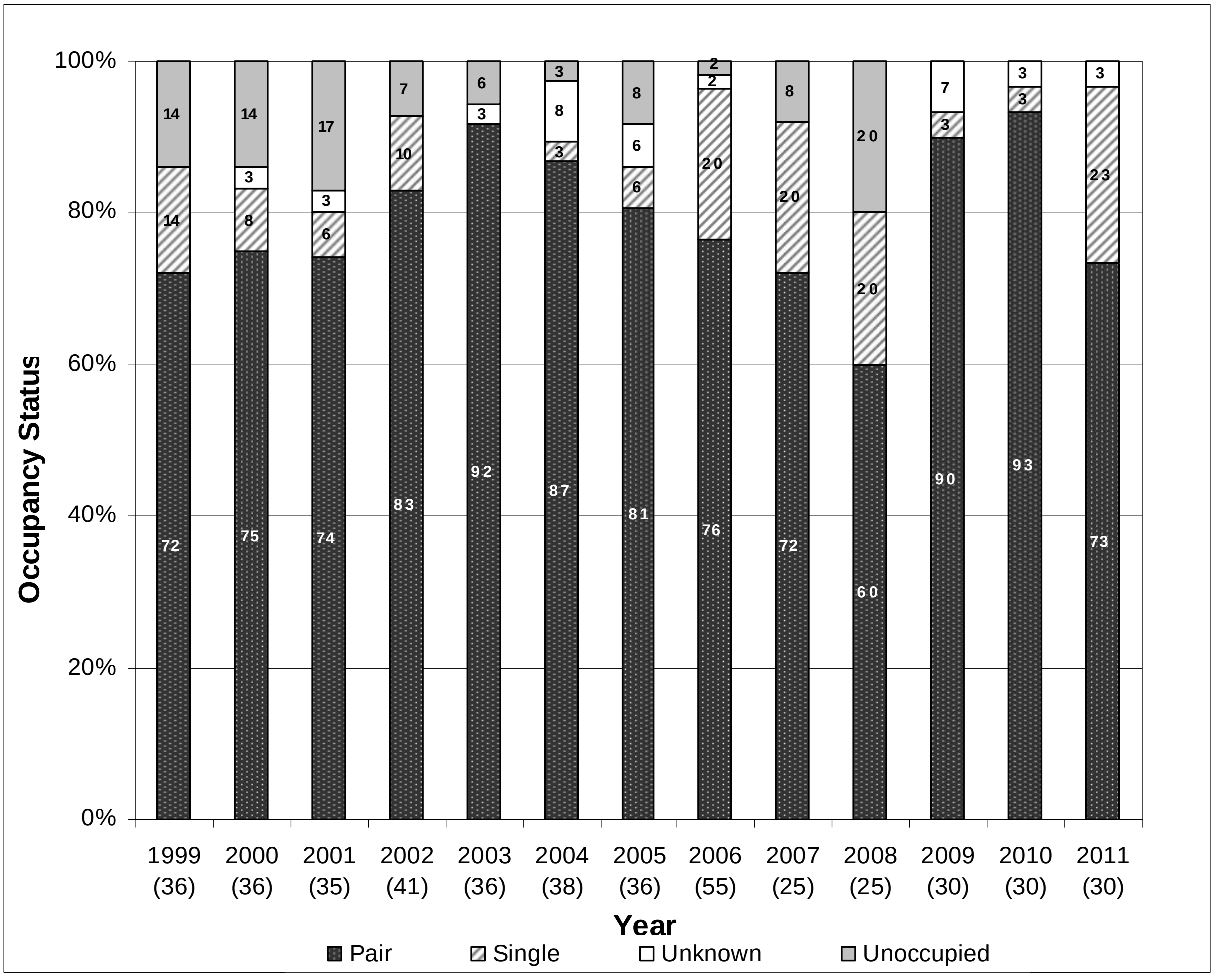

Figure 5. Occupancy status for all study sites (1999–2011). Numbers within the bars are the exact percentage for each status category. Numbers in parentheses are the total number of spotted owl territories monitored per year.

Reproductive Status and Fecundity

In 2010, a total of 28 sites were occupied by a pair of spotted owls. Of the 26 females with known reproductive outcomes, 15 (58%) attempted nesting (Figure 6). Nine females successfully nested yielding a total of 14 young. Eleven non-nesting females and six nest failures were confirmed at the 26 sites with known reproductive status. In 2011, only 22 sites were occupied by pairs of spotted owls. Of the 23 territorial females with known reproductive outcomes, nine (39%) attempted nesting (Figure 6). All nine nests were successful, and yielded a total of 10 young. Thirteen non-nesting females were confirmed at the 23 sites with known reproductive status. No nest failures were recorded in 2011, but due to the delayed start of complete monitoring, pairs with nest failures could have been recorded as non-nesting.

Fecundity, a measure of productivity, is calculated as the average number of female young produced per territorial female, assuming a 50:50 sex ratio of fledglings (Anthony et al. 2006). The mean fecundity for the 2010 breeding season was 0.27 (SE ±0.08). Mean fecundity for the 2011 season was 0.23 (SE±0.06). Both years were below the average fecundity from 1999 to 2011 (0.37, SE ±0.07; Figure 7).

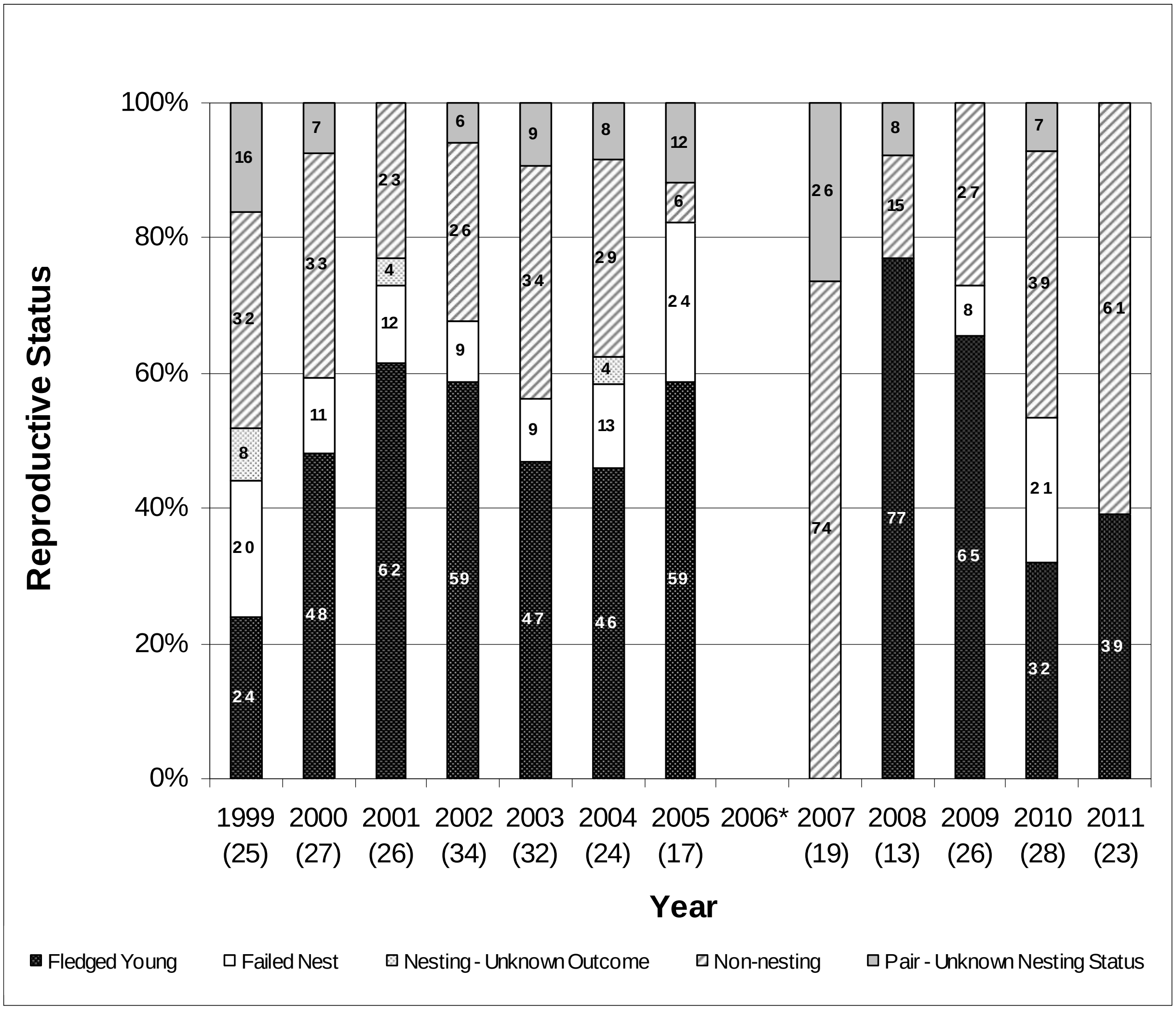

Figure 6. Reproductive status for owl pairs monitored in the NPS study area (1999–2005 and 2007–2011). Numbers within the bars are the exact percentage for each status category. Numbers in parentheses are the total number of spotted owl territories per year. *2006 inventory data was excluded from this analysis.

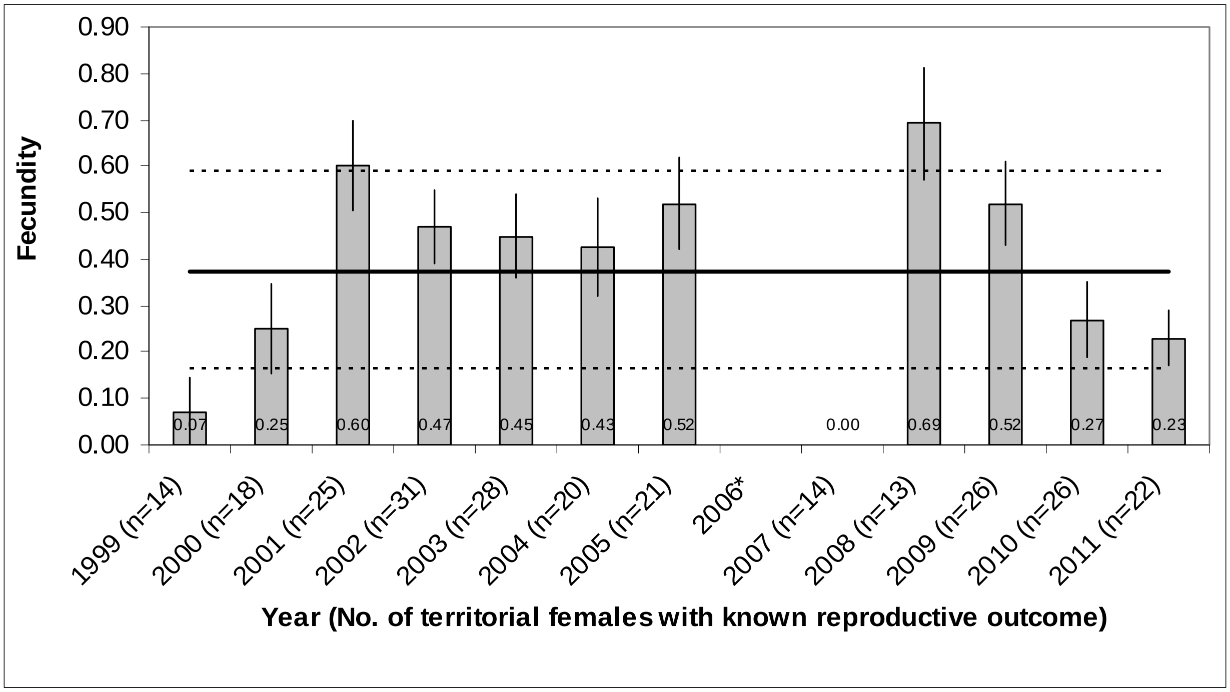

Figure 7. Fecundity for 1999–2005 and 2007–2011. The solid line on the graph is mean fecundity from 1999–2011 (0.37), and the dashed lines are one standard deviation from the mean (0.21). Year error bars indicate ±1 standard error and n is the total number of spotted owl territories. *2006 inventory data was excluded from this analysis.

Nest Measurements

During surveys from 1999 to 2011, spotted owl researchers have located a total of 134 spotted owl nests (Table 2). Of the 134 unique nests, 11 (8%) were in cavities and 123 (92%) were platform nests. This ratio is the opposite of owl nests in older forests where 80–90% of the nests are in cavities, but closely resembles the ratio in other parts of the range where forests are younger (Buchanan and Irwin 1993, Forsman and Griese 1997, LaHaye and Gutierrez 1999). A total of 15 platform nests and two cavity nests were located in 2010, while in 2011 all of the nests (11) were platform nests.

Half (51%) of the documented nests have been in Douglas fir (n=69). The remainder of nest tree species selected include coast redwood (n=45), California bay (n=11), coast live oak (n=7), tanoak (n=1), and bishop pine (n=1). The broad range of species and size of trees selected as nest trees indicate a broader use of forest types and ages in the Marin County study area relative to the northern regions of the spotted owl's range. Although the sample size for cavity nests is small, it appears that cavity nests tend to occur in larger trees (Table 3).

Identifications of Banded Owls

Between 1998 and 2003, 110 spotted owls were captured and color banded at 26 sites within a 9,996-hectare (24,700-acre) area surrounding Bear Valley in PORE. In 2004, the banding aspect of the project was ceased due to logistical constraints and limited sample size. We have continued to identify the presence or absence of color bands on all spotted owls encountered.

Table 3. Average nest measurements for 134 unique nests located within the NPS study area from 1999 to 2011.

	Platform Nests (n=123)		Cavity Nests (n=11)	
	Mean	SE	Mean	SE
dbh (cm)	101.0	±4.58	194.0	±37.71
Nest height (m)	19.0	±0.67	21.4	±3.66
Tree height (m)	35.2	±1.17	42.3	±5.91

Of the 110 spotted owls banded, 50 were banded as juveniles, 23 as subadults, and 37 as adults (Fehring et al. 2004). Of the six band resights in 2010, three were adult females and three were adult males, most of which were banded in 2002. The oldest banded owl observed in 2010 was a 12 year old male which was banded as a second year subadult in 1999. In 2011, only two banded females were observed. Both were observed at sites where they were originally banded. One of the banded females was 9 years old and the other was 11.

Barred Owls

The first barred owl record for Marin County occurred in May 2002 in MUWO, and the first known successful reproduction of barred owls occurred in 2007 also at MUWO. In 2008, biologists documented the first known barred owl nest tree in Marin County and confirmed the successful fledging of two barred owls (Jennings et al. 2011).

At the 30 randomly selected monitoring sites in 2010, there were four barred owl detections at three sites during spotted owl surveys. A single barred owl, suspected to be the same individual, was detected at two spotted owl sites in the lower Olema Valley. Spotted owl pairs occupied both surveyed sites, but neither pair successfully reproduced. NPS biologists detected an apparent barred owl cavity nest while surveying for spotted owls near MUWO. The historic spotted owl territory nearby was unoccupied by spotted owls. The success of the barred owl nest was not determined. Of the 30 randomly selected monitoring sites in 2010, three were known to have a history of more than one barred owl detection.

In 2011, a pair of barred owls successfully fledged four young near MUWO from a cavity used in 2004 by the now displaced northern spotted owl pair. This spotted owl territory, where a spotted owl pair was present this year, appears to have now shifted farther up the canyon from where it was historically located. A single barred owl was detected at two monitoring sites in the lower Olema Valley, which is thought to have been the same individual detected in the area in 2010. An additional barred owl was detected at a monitoring site near PORE’s Bear Valley Headquarters. Of the 30 randomly selected monitoring sites in 2011, five were known to have a history of more than one barred owl detection.

Since barred owls in Marin County are not marked, the exact number of individuals cannot be confirmed. Based on the sex determination, frequency and repetition of barred owl detections, and distance between barred owl detections over the last several years, at least two males and a female are current residents of federal lands within the monitoring study area. Based on detections outside of the study area, there are an additional two or more unknown sex barred owls in Marin County. To date, no spotted/barred owl hybrids have been detected at any of the long term monitoring sites.

Barred owls have been observed hunting signal crayfish (*Pacifastacus leniusculus*) in the Redwood Creek drainage on numerous occasions over multiple years by park visitors and NPS staff (Jennings et al. 2011). On May 7, 2008, biologists watched a male barred owl hunt on the ground for 25 minutes and successfully capture a broad-footed mole (*Scapanus latimanus*). Pellet samples collected at the 2008 barred owl nest site indicate a diet composed of crayfish and small mammals. Relative to spotted owls, barred owl diet plasticity likely provides a competitive advantage over spotted owls (Livezey et al. 2008). An example of this likely competitive advantage was documented on federal lands in Marin County during the 2007 breeding season. There were no spotted owl nesting attempts, nests, or young located on federal lands in 2007; however the only known barred owl pair successfully nested and produced at least two fledglings (Jennings et al. 2011). In contrast to spotted owls, the generalist diet and foraging strategies of barred owls may buffer the species from major fluctuations in reproductive success among years.

Discussion

The percentage of sites occupied by pairs or single owls has remained fairly constant, averaging nearly 90% from 1999 to 2011. The 13-year average for pair occupancy from 1999-2011 was 79%, while the average for occupancy by single owls was 11%.

Northern spotted owl pair occupancy in 2010 was 93%, the highest percentage reported in the past 13 years of monitoring. In 2010, a single owl was detected at only one site (3%), and one site had unknown occupancy. Pair occupancy declined in 2011, with pairs detected at just 22 of the 30 sites (73%). Seven sites were occupied by single owls (23%), a record high for the 13 years of monitoring, and one site had unknown occupancy.

Pair occupancy may have been influenced by our random selection of sites to monitor during the 2010 and 2011 breeding seasons. We randomly selected a set of 30 sites to monitor in 2010, of which only 3 sites (10%) had a history of more than one barred owl detections. Five of the 30 (17%) randomly selected monitoring sites in 2011 had a history of barred owl detections.

Our monitoring history has shown that in the presence of barred owls, northern spotted owls are difficult to detect and pair occupancy rate decreases (Jensen et al. 2007, Jensen et al. 2008, Jensen et al. 2010, Starcevich and Steinhorst 2010). This imperfect detection of spotted owls may indicate the suppression of spotted owl vocalizations or displacement of spotted owls from their territories as a result of barred owl residency.

By randomly selecting a high percentage of sites influenced by barred owls for our 2011 monitoring, we likely decreased our chances of recording northern spotted owl pairs at those sites. Three of the four sites with barred owl detections in 2011 were found to be occupied by single spotted owls. We located one of these single spotted owls on three separate daytime surveys, but in the three nocturnal surveys of that site we did not hear it vocalize, instead detecting a barred owl each time. The fourth site, near MUWO, had a spotted owl pair, but they were found in a new location far from the barred owls. The barred owl pair successfully nested in a 2004 spotted owl nest cavity and produced four fledglings.

Declines in spotted owl site occupancy have been seen in other areas where barred owls are present (Kelly et al. 2003, Olson et al. 2005) and are the most severe in areas where barred owls have been established the longest (Anthony et al. 2006). In reviewing barred owl and spotted owl locations in Oregon between 1974 and 1998, Kelly et al. (2003) found that when barred owls invade spotted owl territories, mean annual occupancy of spotted owls decline when compared to territories without barred owls.

Fecundity estimates of 0.27 (SE ±0.08) in 2010 and 0.23 (SE±0.06) in 2011 were below the average fecundity of 0.37 (SE ±0.07) measured at monitoring sites from 1999 to 2011. Weather and the use of platform nests by spotted owls may have contributed to the low reproductive rates. In the parts of their range where there are older forests, spotted owls predominantly nest in tree cavities. In our study area, the forests are relatively young, and spotted owls predominantly use platform nests. These platform nests are generally more exposed and vulnerable to inclement weather conditions than are cavity nests. In 2010, a series of storms that lasted well into May coincided with the time period when female spotted owls spend most of their time sitting on nests, either on eggs or with chicks. In 2011 a similar pattern occurred, with late rains lasting into June. The exposure to these rains may have made it difficult for these females to stay on their nests and may have contributed both to the low percentages of nesting females and the low fecundity estimates.

Research Activities and Recommendations

Barred Owl Study

There is a great need to study barred owl and spotted owl interactions, to determine the nature of the threat, and identify potential management options to ensure the persistence of spotted owls throughout their historic range (USFWS 2008). The NPS and other agencies are implementing studies across the northern spotted owl's range to gain a better understanding of the interspecific behavior and to learn more about management options to benefit spotted owls in the presence of barred owls. Since the barred owl has only recently invaded the southern extent of the northern spotted owl's range, Marin County offers a unique opportunity to study the early patterns of contact between barred and spotted owls (Jennings et al. 2011). In Marin County, researchers will continue to track barred owl observations and make efforts to color band barred owls to facilitate tracking individual owls. Staff members and volunteers will continue to be made aware of the potential of hybridization and the importance of confirming the species of both pair members. In future years, we will continue to investigate the possibility of implementing a barred owl telemetry study to track barred owl movements, predict areas likely to see barred and spotted owl interactions, and to provide insight to the overlap of diet, habitat use, and interspecific behavior.

Pellet Study

The diet of owls can be identified from the analysis of pellets (casted prey remains). Numerous studies conducted throughout the range of the northern spotted owl have reported the frequency of prey items and the relative biomass of prey items (Forsman et al. 1984). Other studies have provided evidence that prey can have an influence on reproductive success (Zabel et al. 1995, Rosenberg et al. 2003) and home range size (Zabel et al. 1995).

The SFAN spotted owl monitoring program has continued to provide Dr. James Cunningham at Dominican University with spotted owl pellets collected during the 2008, 2009 and 2010 breeding seasons for a prey analysis study. Dr. Cunningham has identified undergraduates who will dissect the pellets and identify the prey remains. Each student will develop a research idea in conjunction with Dr. Cunningham and the National Park Service.

Vocalization Study

During the 2006 through 2010 breeding seasons, spotted owl staff members worked with independent researcher, Rick Johnson, to investigate the potential of identifying individual northern spotted owls through vocalization analysis. Vocal identification has been proven to be an effective tool to distinguish between individuals in the genus *Strix,* specifically the African wood owl (*Strix woodfordii*; Delport et al. 2002). The purpose of the research project was to determine if recordings of owl vocalizations, specifically four-note location calls, can be used to identify individual birds. The use of vocalizations as an alternative to banding for individual identification has been proposed for the Mexican spotted owl (*S. o. lucida*; Kuntz and Stacy 1997).

During spotted owl breeding surveys, unsolicited and solicited male and female spotted owl vocalizations as well as incidental barred owl vocalizations were recorded during day and night surveys. The sounds are studied using spectrograms (Figure 7) and five parameters were selected to evaluate the spectrograms. The timing of the calls, pitch of the fourth note, and shape of the fourth note were used to distinguish individual owls. These quantitative measures are based on previous work on northern spotted owls and California spotted owls (Van Gelder 2003).

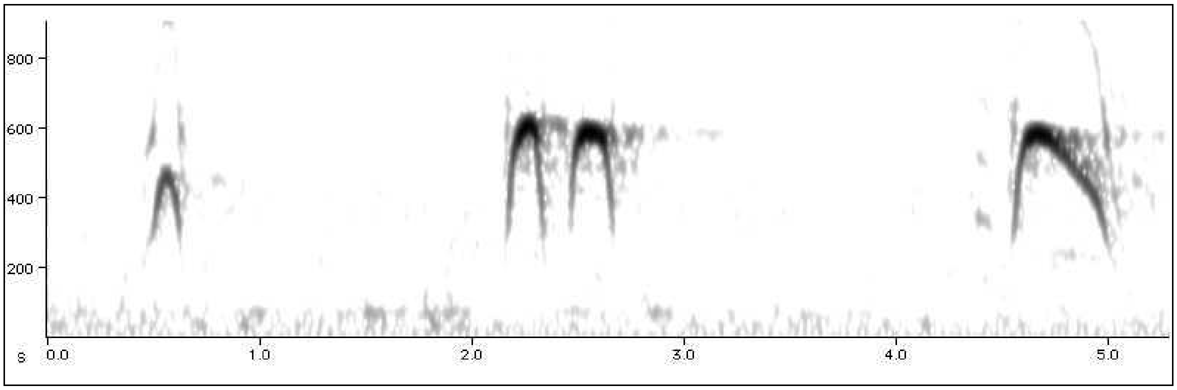

Figure 8. Spectrogram of a spotted owl four-note location call.

Preliminary results indicate that identification of individual spotted owls by vocalization alone is not likely to be an efficient monitoring tool for project staff to utilize in a demographic study. This technique may prove to be appropriate for the identification of a smaller population of barred owl individuals.

Sudden Oak Death

Marin County is one of 14 counties in California affected by the pathogen that causes Sudden Oak Death (SOD). *P. ramorum* is a water mold that acts like a fungus, attacking the trunk of a tree and causing a canker, or wound that eventually cuts off the tree's flow of nutrients. Other secondary decay organisms such as beetles and fungi often move in after the tree is infected. Trees infected with SOD may survive for one to several years as the infection progresses. As the tree finally dies, the leaves may turn from green to brown within a few weeks, hence the appearance of sudden death (Davidson et al. 2003). Tanoaks and coast live oaks are killed by the disease; other species affected are known as "foliar hosts", such as bay laurel (*Umbellularia californica*), because their leaves and twigs may be infected. These foliar hosts can spread the disease, but are only occasionally killed.

The diversity of host species affected by *P. ramorum* indicates potential long-term landscape modifications through changes in the forest canopy, understory, and ground layer (Rizzo and Garbelotto 2003). Moritz et al. (2008) found that nearly every stand of tanoak within PORE is already impacted by SOD and at several locations tanoak mortality was greater than 95% by basal area. Tanoak is currently the most common subcanopy species in coniferous forests within the study area and Moritz et al. (2008) suggest that tanoak will be replaced by redwood in redwood forest and California bay in Douglas fir forests. For comprehensive information regarding SOD and links to current maps visit the California Oak Mortality Task Force website at www.suddenoakdeath.org.

To date, there have been no published studies on the impacts of SOD on northern spotted owls and research is needed. There are many pathways through which SOD could affect spotted owl populations. There could be direct impacts due to the loss of structural complexity of forested owl habitat. Northern spotted owls might also be affected indirectly by SOD through changes in prey species populations. The tanoak and oak species most impacted by *P. ramorum* are abundant acorn producers and are an important forage species for small mammals, such as dusky-footed woodrats, which make up the majority of the spotted owl diet in Marin County (Tappeiner et al. 1990, Chow and Allen 1997, Courtney et al. 2004). Another potential indirect effect of SOD on northern spotted owls is through increased potential for uncharacteristically severe wildfire in diseased forests. Because these owls require mature forest habitat, they could be adversely affected by large, high severity wildfires (Forsman et al. 1984, Verner et al. 1992, Gaines et al. 1997, USFWS 2008).

West Nile Virus

West Nile virus (WNV) is an arbovirus that first appeared in the Western Hemisphere in New York, in the early fall of 1999. Mosquitoes and migratory birds are the main species involved in the spread of WNV. Mosquitoes are the principle vector and avian species are considered the principle host species for WNV. WNV first appeared in California in 2002. By 2004, WNV had spread to all 58 counties of California and a total of 3,232 birds tested positive for WNV. Statewide, the incidence of WNV has continued to decrease annually. On a local level, since reaching a peak in 2004 of 18 birds testing positive for WNV in Marin County, numbers have continued to steadily decline. In both 2010 and 2011, no dead birds tested positive for WNV in Marin County. For historical and current information that is updated weekly visit http://westnile.ca.gov/.

Raptors and owls have been noted to be particularly susceptible to WNV. A northern spotted owl was confirmed to have died from WNV at a captive wildlife facility, indicating that spotted owls are susceptible to WNV. WNV has been detected within other owl species in California. Future efforts will be made to document fatalities potentially resulting from WNV. Carcasses should be tested whenever possible and the population should continue to be monitored for declines due to this threat.

Management Activities and Recommendations

Humans and their activities, including development along the wildland/urban interface, land management practices, and recreation are among the significant sources of impact in Marin County. In addition, the continued range expansion of the barred owl poses a competitive threat to spotted owls throughout their range (USFWS 2008). We recommend that owl occupancy and reproductive monitoring surveys continue, and that land managers use these data to ensure that management activities do not impact the habitat or the productivity of northern spotted owls. We encourage continued communication between land managers and their maintenance crews in planning and executing projects in spotted owl habitat. Information on owl site locations should continue to be made available to all land managers and local city and county planning departments. The central repository for owl detection information in California is the

Biogeographic Information and Observation System (BIOS) database, managed by the California Department of Fish and Game.

Given the mixed ownership patterns in Marin County, several owl home ranges contain both public and private lands. Coordination between park managers and local planners is essential. Loss of owl habitat and owl pairs due to residential land management practices (e.g., rodenticide use) and urban development is a local concern. Due to the fragmented and isolated nature of the Marin County forested habitat, declines along the urban edges may impact overall population health throughout the local range.

Public Outreach

Due to the consistent public interaction with Marin County's northern spotted owl population, the NPS has developed educational resources to inform the public of their role of living and working in areas with spotted owls. Project biologists have worked with MUWO interpretative staff to develop comprehensive spotted owl information on the MUWO website. The goal of the website is to introduce Marin County residents, land owners, and agency managers to basic spotted owl biology, guidelines for protecting spotted owls and owl habitat in this county, and how to minimize potential threats to spotted owls.

Informational materials including executive briefings and past annual reports are made available to the public at the San Francisco Bay Area Network's Inventory and Monitoring website: http://science.nature.nps.gov/im/units/sfan/vital_signs/Spotted_Owl/birds.cfm

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EXPERIENCE YOUR AMERICA ™

Experimental Removal of Barred Owls to Benefit Threatened Northern Spotted Owls

Final
Environmental Impact Statement

Prepared by:

Oregon Fish and Wildlife Office
U.S. Fish and Wildlife Service
Portland, Oregon

July, 2013

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.

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Northern spotted owl would benefit from active management of forests, study says

Tuesday, July 24, 2012

AP
By The Associated Press

The Oregonian
A northern spotted owl takes flight with a mouse offered as bait by BLM biologists conducting an annual check-up on the owl population in old-growth forest of Quines Creek, northeast of Grants Pass June 6, 2000. The red eyes are from the photographer's flash.

CORVALLIS — The northern spotted owl would actually benefit in the long run from active management of the forest lands that form its primary habitat and are increasingly vulnerable to stand-replacing fire, researchers conclude in a recent study announced today by Oregon State University.

Any short-term drawbacks from logging, thinning or other fuel-reduction activities would be more than offset by improved forest health and fire-resistance characteristics, the scientists said, which allow more spotted owl habitat to survive in later decades.

The findings were published in Forest Ecology and Management, a professional journal, by researchers from Oregon State University and Michigan State University.

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Comparative hazard assessment for protected species in a fire-prone landscape

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ABSTRACT

We conducted a comparative hazard assessment for 325,000 ha in a fire-prone area of southwest Oregon, USA. The landscape contains a variety of land ownerships, fire regimes, and management strategies. Our comparative hazard assessment evaluated the effects of two management strategies on crown fire potential and northern spotted owl (*Strix occidentalis* caurina) conservation: (1) no action, and (2) active manipulation of hazardous fuels. Model simulations indicated that active management of sites with high fire hazard was more favorable to spotted owl conservation over the long term (75 years) than no management, given our modeling assumptions. Early in the model simulation, young seral stages were mostly responsible for high fire hazard, and active management in young stands tended to perpetuate that hazard. Later in the simulation, older seral stages accounted for most of the high fire hazard and active management could be used to ameliorate that hazard. At any given time period, ⩽8% of the landscape was identified for treatment. Fire hazard fluctuated over time depending on vegetation regeneration, maturation, and response to treatments. Active management resulted in greater numbers of potential spotted owl territories in lower fire hazard conditions, particularly during later years of our simulation. Our results support the contention that short term risks to protected species from active management can be less than longer term risk of no management in fire-prone landscapes. Thus, a short term, risk averse strategy for protected species in fire-prone landscapes may not be the best long term alternative for conservation. We caution that this finding warrants landscape-level field evaluation and structured adaptive management and monitoring prior to broad scale adoption as environmental policy.

1. Introduction

Decades of grazing, fire exclusion and logging in dry forest landscapes of the Pacific Northwest, USA resulted in vegetation communities that, in many cases, currently contain uncharacteristic fuel conditions (Agee, 1993; Morgan et al., 2001; US General Accounting Office, 2003; Wright and Agee, 2004). Many of these dry forest landscapes currently provide habitat for protected species, including northern spotted owls (*Strix occidentalis* caurina) and several salmonids (Rieman and Clayton, 1997; Rieman et al., 2003; Courtney et al., 2004). Protected species habitat loss and alteration from wildfires in these dry forest landscapes is well documented (Courtney et al., 2004; Lint, 2005; Spies et al., 2006) and partly responsible for Federal legislation and policy that encourages hazardous fuels reduction (e.g., Williams and Hogarth, 2002; HFRA, 2003).

Hazardous fuel reductions through active management on federal lands in the United States (US), particularly those associated with protected species habitats, are influenced by a complex interaction of environmental laws, regulatory agency interpretations, court decisions, and land management policy. Decisions on whether to allow active management are often based on precaution, particularly when compliance with the US Endangered Species Act (ESA) is involved (Mealey et al., 2005). The precautionary principle limits management action that could change the environment unless there is certainty that no immediate harm to protected species will result (Mealey et al., 2005). This implementation framework results in a short term, risk averse resource management strategy that, when combined with the dynamic tendencies of fire-prone landscapes, may put the resources that ESA was intended to protect at increased longer term risk (Irwin and Thomas, 2002; Mealey and Thomas, 2002; Rochelle, 2002; Mealey et al., 2005). Yaffee (1997) noted that this approach to implementing environmental policy results in poor long term direction and piecemeal solutions to complex problems.

Recent environmental laws codified in support of the US National Fire Plan (http://www.forestsandrangelands.gov/NFP/index.shtml) recognize the temporal dimension of risk. Some laws

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and policy call for consideration of short and long term risks during ESA consultation on hazardous fuels reduction projects (e.g., HFRA 2003; Sec 106[c][3]; US Fish and Wildlife Service, 2011). At the national level, evidence suggests that National Fire Plan implementation has not been hindered by regulatory constraints related to ESA (Hayes et al., 2008), but this trend is likely to change as land managers shift their focus to the wildlands, where much of the protected species habitat occurs (e.g., Ager et al., 2007). Explicit recognition that risk has a temporal dimension coupled with a need for tools to aid in implementation of the National Fire Plan brought comparative assessments to the forefront of a nation-wide effort to quantify fire hazards and risks on public lands. Without hazard and risk based assessments land management agencies cannot defend fuel reduction projects or make fully informed decisions about which effects and project alternatives are more desirable (GAO, 2004; Fairbrother and Turnley, 2005).

Comparative hazard assessment is defined as "an analysis and evaluation of the physical, chemical and biological properties of the hazard" (Society for Risk Analysis, 2012). Comparative hazard assessment is recognized as a useful process for fulfilling the legislative requirements of the National Environmental Policy Act and ESA Section 7 consultation regulations issued by the US Fish and Wildlife Service and National Oceanic and Atmospheric Administration-Fisheries Service (US-FWS, 2003).

Several methodologies for conducting comparative hazard and risk assessments on fire and protected species habitats have been published (Hummel and Calkin, 2005; O'Laughlin, 2005; Roloff et al., 2005a,b; Ager et al., 2007). Comparative assessments for hazardous fuels projects involve complex data and models and thus, uncertainty with the outputs is generally high. In uncertain situations, resource managers and decision-makers have historically favored precaution and hence inaction (e.g., Ruhl, 2004; Prato, 2005; Schultz, 2008), even though vigorous trial and error is likely the best way to proceed (Wildavsky, 2000). Indicators of high fire hazard in dry western forests such as uncharacteristic fuel conditions (Graham et al., 2004), a prevalence of insect and disease infestations (Filip et al., 2007; Jenkins et al., 2008), wildfires of greater intensity and extent (Graham et al., 2004), and a warming and drying climate (Westerling et al., 2006; Allen et al. 2010) suggest that the potential for large-scale habitat alteration is increasing. Hence, decisions on acceptable levels of short and long term risks are warranted.

In this paper we present results from a comparative hazard assessment between no management and active fuels management in a fire-prone landscape of western North America. The fire management goal was to reduce hazard where fire risk was high while conserving protected species. Our objectives were to: (1) identify those forest types and seral stages in highest hazard conditions, (2) quantify the short and long term effects of active management and no management to northern spotted owls, and (3) portray our results in the context of current land management policies. Our approach provides a strategic evaluation in that it is coarse, occurs over substantial temporal and spatial scales, and relies on indices of ecosystem responses to management alternatives. Results from our model simulations should be used only as relative indices to evaluate trends in resource conditions.

2. Materials and methods

The data, prescriptions, and processes used for our comparative hazard assessment have been described elsewhere (Roloff et al., 2005a,b; Mealey and Roloff, 2010). Our previous publications described model and data linkages, helped identify quantifiable hazard metrics, revealed some ecological characteristics of our landscape that warranted further scrutiny, and offered preliminary insights into hazards associated with three different management scenarios (Roloff et al., 2005a,b). Here we present an abbreviated study area description, synopsis of the modeling process, and modifications that were unique to the current model simulation.

2.1. Study area

The Southwest Oregon Hazard Demonstration Project Area (SOHDPA) encompasses 336,000 ha, with its southwest boundary located approximately 19 km northeast of Medford, Oregon, USA (Fig. 1). The SOHDPA boundary is based on drainage units (Roloff et al. 2005a) and is located at the southern edge of the Western Cascades ecoregion (McNab and Avers, 1994). Elevations range from 300 to 2200 m above sea level. Precipitation varies depending on elevation and topography. Average annual precipitation near the center of the project area is 107 cm (received mostly during October to June) with average annual temperatures ranging from lows of 2 °C to highs of 19 °C (Western Regional Climate Center, Prospect, Oregon, http://www.wrcc.dri.edu/index.html). Fire is an important disturbance agent in the SOHDPA, with the landscape dominated (59%) by mixed-fire regime plant association groups (PAGS, *sensu* Atzet et al., 1996, Table 1). Frequent-fire regime PAGS (19% of the landscape) occur on lower to mid elevations. Evidence suggests that Native Americans frequently ignited these types to enhance forage production (South Cascades Late Successional Reserve Assessment, 1998). Moist forests or long-fire-regime PAGS (20% of the landscape) tend to occur at the higher elevations where lightning was and continues to be the primary fire ignition source (South Cascades Late Successional Reserve Assessment, 1998). Records of organized fire suppression in the SOHDPA date to 1902 and, coupled with lack of prescribed fire, has allowed the development of conditions suitable for spotted owl occupancy, insect and disease infestations, and large-scale, high intensity wildfires (Campbell and Liegel, 1996; South Cascades Late Successional Reserve Assessment, 1998). Statistics from 16 years (1987–2002) of fires that occurred in our study landscape indicated that ignition probability ranged from 0.03 to 1.51 ignitions/100 ha (Roloff et al. 2005a). We documented 45 large (>2500 ha) fires between 1992 and 2002. In the late 1990s land ownership included 74% federal, 17% private industrial and 9% other. Approximately 97% of the landscape is forested, with the majority (53%) federally reserved or subjected to management restrictions because of northern spotted owls; not all owls are centered on federal lands (Roloff et al., 2005a). Approximately 22% of the forested area is being managed for industrial timber production.

2.2. Comparative hazard model

Our comparative hazard model was based on projecting and managing vegetation states. Each vegetation state contained information on vegetation structure and composition (collectively called vegetation attributes; Roloff et al. 2005a). The vegetation attributes were then used as criteria for implementing management prescriptions and modeling fire and spotted owl responses (Roloff et al. 2005a,b). We developed an ecological land classification that portrayed different vegetation states. A vegetation state was defined by existing vegetation conditions (i.e., dominant tree species, density, and canopy structure as derived from four independent vegetation classifications of satellite imagery) and PAG. Map accuracy was >85% based on field sampling a subset of vegetation states (Roloff et al. 2005a). The resulting classification defined >900 potential vegetation states for mapping (mean patch size = 91 ha, min = 0.09 ha, max = 8796 ha) in our study landscape; at any given time period about 400 states actually occurred. We compiled geo-referenced tree inventory plots (n = 810) to quantify vegetative structure and composition of different vegetation states.

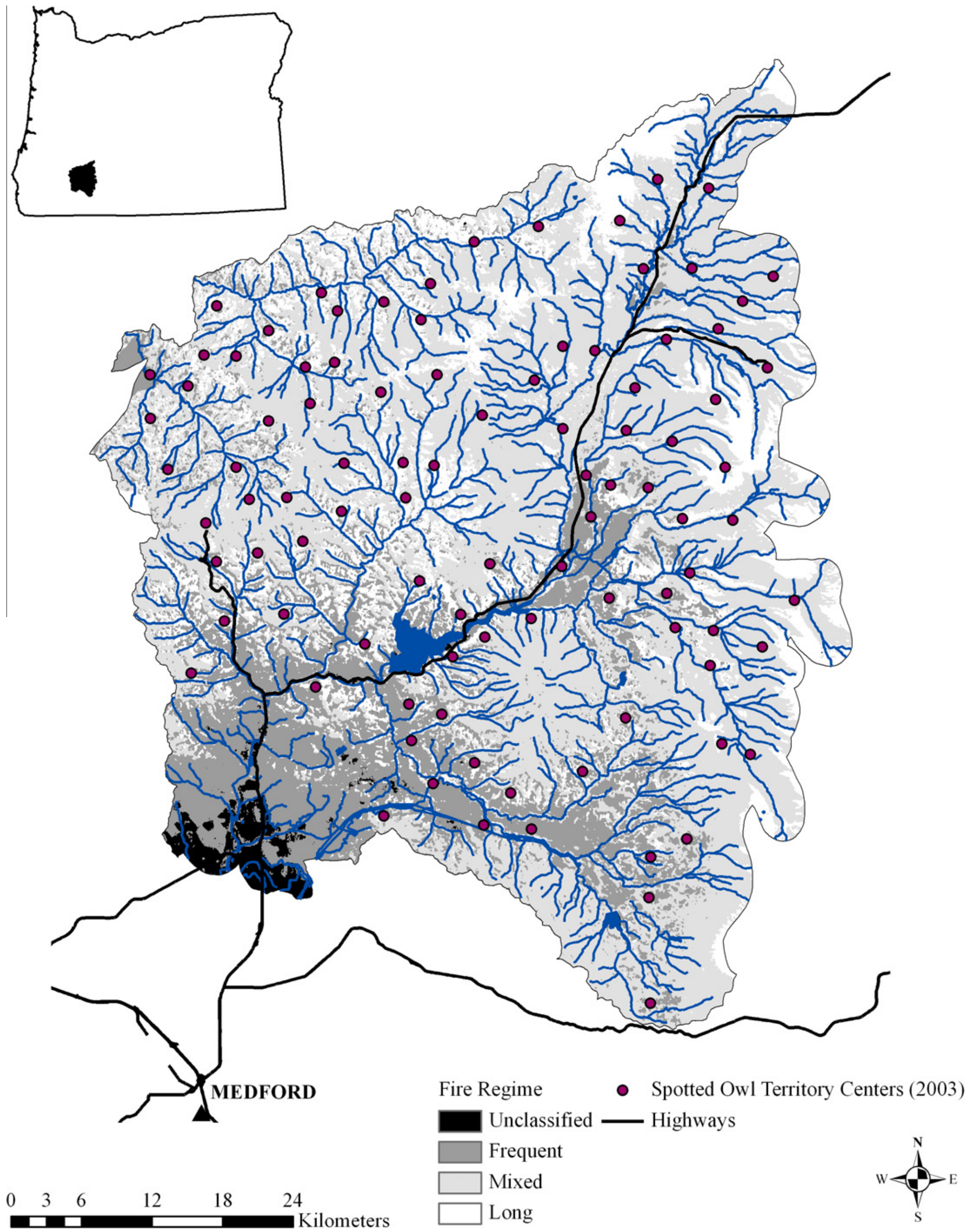

Fig. 1. Study area location, major bodies of water, fire regime (*sensu* Atzet et al. 1996), and modeled northern spotted owl territory centers (2003) for the Southwest Oregon Hazard Demonstration Project.

The number of inventory plots per state ranged from 0 to 4. For those states without an inventory plot, we used the Forest Vegetation Simulator (FVS, West cascades Variant; Keyser 2008) to simulate vegetation dynamics for a plot that occurred in the same PAG. We simulated plot dynamics until the state-specific vegetation criteria were met. The simulated tree list was then assigned to the state. For those states with multiple plots, average vegetation condition (as portrayed by a tree list) was calculated and this average subsequently assigned to a state. State-based tree lists were then used in FVS to implement management prescriptions and project vegetation conditions 75 years into the future at 5-year time intervals. The FVS simulated natural seedling establishment (parameterized from field plots) and tree growth and mortality. The simulator produced an average tree (both live and dead) inventory for each time step and was programmed to assign a corresponding vegetation state from the diameter distribution of live trees.

In our original work (i.e., Roloff et al., 2005a,b) we relied on the US Forest Service's strategic forest planning model (ForPlan; Iverson and Alston, 1986). Our previous results using ForPlan were based on optimizing net present value of timber while reducing fire hazard and protecting spotted owl habitat (Roloff et al., 2005a,b). Using this objective function we found that economic and regulatory constraints on hazardous fuels treatments resulted in an ineffective ForPlan solution for reducing fire hazard (Roloff et al., 2005a), similar to results observed by Hummel and Calkin (2005). In our current model the objective function specifically

Table 1
Fire regime and component plant association groups (PAGS, *sensu* Atzet et al. 1996) used for the Southwest Oregon Risk Demonstration Project.

Fire regime	Plant association group (PAG)
Frequent	Warm, dry Douglas-fir
	Warm, dry white fir-grand fir
Mixed	Warm, moist Douglas-fir
	Warm, moist white fir-grand fir
	Cool white fir-grand fir
	Shasta red Fir
Long	Pacific silver fir
	Western Hemlock
	Mountain Hemlock

emphasized fire hazard reduction without economic or regulatory constraints. Thus, we were willing to sacrifice economic return and potentially some spotted owl territories to provide a less hazardous forest landscape. This rationale is consistent with recommended management direction for fire-prone ecosystems (Irwin and Thomas, 2002). In our revised model we allocated and implemented management prescriptions in ArcGIS 9.2 (Environmental Systems Research Institute, Redlands, California) and not in ForPlan. As vegetation states entered a hazard condition that triggered management, we assigned the appropriate prescription using queries and lookup tables. As a result, ArcGIS 9.2 allowed us to more tightly control the timing and spatial placement of prescriptions, an activity we found critical to produce a working solution (also see Ager et al., 2007, 2010; Finney et al., 2007).

We characterized fire hazard by using the US Forest Service's FlamMap model (Finney, 2006). FlamMap output lends itself to landscape comparisons (e.g., pre- and post-treatment). FlamMap requires data on weather and wind, fuel characteristics for different vegetation states, and topography to predict areas of potential crown fire (Finney, 2006).

FlamMap inputs were generated from tree lists assigned to each vegetation state using existing FVS extensions (e.g., COVER; Moeur, 1985) and some additional programming code. FlamMap inputs included height to base of live tree crown, canopy bulk density, canopy closure and canopy height. Fuel models (13-class; Anderson, 1982) were assigned by conducting field visits to representative states and subsequently extrapolating the field data to unvisited states (Roloff et al., 2005a). This process resulted in fuel characteristics that were mapped (by state) as FlamMap input landscapes. We created FlamMap landscapes immediately following implementation of the active management prescriptions. We assumed that logging debris and understory vegetation were managed to reduce hazard.

We conducted FlamMap simulations using preconditioned fuel moistures and extreme weather and wind conditions compiled from 10 years (1992–2002) of large-fire history data in Oregon. Initial fuel moisture conditions (weight of water/dry weight of fuel) were 5%, 8%, and 12% for 1, 10, and 100 h fuel moistures, respectively; and 30% and 70% for duff and live vegetation, respectively. Weather was portrayed from August 19 to 24, with daily temperature and relative humidity ranging between 19–37 °C and 53–16%, respectively, at average elevation. Wind speeds at 6 m height were modeled at 37 km/h from the northwest (300°).

We verified pre- and post-treatment fuel conditions for each vegetation state by conducting field visits (described in Roloff et al. 2005a) and visually inspecting tree inventory data in Stand Visualization Software (USDA Forest Service, Pacific Northwest Research Station, Portland, OR; see Roloff et al. 2005b: 214). We used the map of potential crown fire activity from FlamMap to identify those portions of the study area with surface or crown fire potential (Scott and Reinhardt, 2001). We were specifically interested in the hazard resulting from the occurrence of crown fire and not the mechanism for fire reaching the tree canopy. Thus we combined passive and active crown fire types into a single crown fire category.

In our current model, fuel reduction activities occurred only on frequent-fire PAGs with the potential for crown fire. Large contiguous areas of frequent-fire PAGS tended to occur at lower elevations in our landscape (Fig. 1). At the mid-elevation interface of frequent-, mixed-, and long-fire return interval PAGS, topographic aspect exerted a strong influence on PAG distribution. Frequent-fire PAGs tended to occur on southerly and westerly aspects at the mid elevations, whereas mixed- and long-fire PAGS occurred on northerly and easterly aspects. Our maps of potential spotted owl territory cores (i.e., the 40–80 ha area likely to contain a nest tree) at lower and mid elevations indicated a consistent positive association with the mixed- and long-fire PAGS on northerly and easterly aspects (Fig. 1). Hence, we hypothesized that hazardous fuels on the frequent-fire PAGS associated with lower and mid elevation spotted owl territories (i.e., the >1134 ha area that contains a core) could be treated and result in negligible negative effects on spotted owl habitat potential.

Vegetation states subjected to fuel reduction activities fell into two categories (1) older, multilayered forests with abundant surface and ladder fuels, and (2) young, dense regenerating forests. Under a typical multilayered forest management scenario, vegetation states were treated using a q-ratio prescription (Bailey and Covington, 2002), with repeated entries every 30 years. A typical prescription in our model was to sustain 10–20 m^2/ha basal area with thinning based on a q-ratio of 1.15 (i.e., 15% more trees in each successively smaller diameter class) over the size distribution ⩽91 cm diameter, retaining fire tolerant species. Trees >91 cm diameter were fully retained. Simulations and field data indicate that this type of prescription can result in forest structures resistant to crown fire (Fulé et al., 2001; Stephens et al., 2009) and may positively contribute to wood fiber markets (Ince et al., 2008). The same q-ratio was applied to regenerating forests but no residual basal area target was identified.

We evaluated hazard to spotted owls by comparing potential crown fire activity to the location of modeled spotted owl territories. Spotted owl territories were mapped by combining a nesting habitat regression model that was developed for northern California (Zabel et al., 2003) with information on foraging habitat use from central and southern Oregon (Zabel et al., 1995; Franklin et al., 2000; Irwin et al., 2000). Nesting and foraging habitats were modeled into viable nesting cores using the process described by Roloff and Haufler (2001). Each nesting core was buffered by 1.9 km to delineate spotted owl territories. Size of these territories approximated the areas around spotted owl site centers subjected to ESA restrictions on forest management. In this restricted area we implemented fuel reduction prescriptions only if the spotted owl territory was in a high hazard condition (as defined below). We did not manage owl habitat with the objective of retaining habitat structure; a strategy that previously failed in our modeling framework (Roloff et al., 2005a). Instead, we focused treatments on reducing fire hazard, accepting the fact that some spotted owl territories may be lost or displaced as a result of management.

Our metric for hazard evaluation was the potential number of spotted owl territories in the frequent-fire portion of the landscape. The number of spotted owls impacted by a management action, not the amount of habitat impacted, is often an important component of judicial decisions (e.g., Oregon Natural Resources v. Allen, 2007). Our model compares the hazards or benefits of management to the hazards or benefits of no management at a particular time step:

$$\text{Management} : (\text{Total Provided}_{Time\ x} - \text{Total in High Hazard}_{Time\ x}) - \text{No Management} : (\text{Total Provided}_{Time\ x} - \text{Total in High Hazard}_{Time\ x}) = \text{Net Hazard or Benefit of Action}_{Time\ x}$$

where Total Provided refers to the total number of spotted owl territories located in our management area of interest. Here, our management area of interest is defined as those territories with >50% frequent fire PAG. High Hazard in our model is defined as those spotted owl territories with substantial crown fire potential (here defined as those territories containing >50% crown fire potential). In our model we used the amount of a spotted owl territory with crown fire potential (>50%) as an index to fire spread potential though more sophisticated modeling approaches exist (e.g., Ager et al., 2007). We focused our definition of high hazard on crown fire because spotted owls have been documented using habitats burned by low to moderate severity fires (reviewed by Bond et al., 2002). Our hazard model assumes that crown fire in >50% of a spotted owl territory will result in loss of that territory.

3. Results

3.1. Forest types in hazardous conditions

Vegetation states on frequent-fire PAGS subjected to no management followed an expected trajectory of fire hazard. Young seral stages (classified as seedling-sapling in our analysis; Table 2) exhibited high crown fire hazard regardless of tree density due to low canopy heights and low heights to live crown. The majority of seedling-sapling seral stages on frequent-fire PAGS transitioned into a lower hazard designation 15 years into the simulation (at year 2018; Table 2), consistent with the relationship between plantation age and fire canopy damage observed by Thompson et al. (2011). As younger seral stages matured into single-storied, closed canopied, taller vegetation states (denoted as Small tree in our analysis) the potential for crown fire from a ground source ignition decreased because height to live crown increased. On some sites, these seral stages again entered a hazardous condition as they entered the Medium tree category in year 2038 (Table 2), likely 40–60 years after plantation establishment. This increase in hazard was associated with tree regeneration in the understories according to our FVS model. This hazardous condition persisted as Medium and Large tree vegetation states for the duration of our model simulation (Table 2). Medium and Large tree vegetation states with high fire hazard were multilayered (through canopy gaps or proliferation of shade-tolerant species) and densely stocked and accumulated abundant ladder fuels over time.

Early in the model simulation active management occurred mostly on seedling-sapling seral stage because these stands were hazardous and occurred on frequent-fire PAGS. In contrast to the no management vegetation trajectories, active management on seedling-saplings perpetuated fire hazard (as multi-storied Small trees) into 2018 (Table 3). The amount of active management in Medium and Large tree vegetation states consistently increased over time (Table 3) as a result of two factors: (1) vegetation states maturing to the stage at which ladder fuels develop under tree canopies, and (2) spotted owl territories exceeded the fire hazard threshold and thus, older vegetation states in those territories were designated for management. In any given time period, ⩽8% of the landscape was identified for active management (Table 3).

For the time steps we evaluated, crown fire potential ranged from 11% (Active Management, Year 2018) to 32% (No Management, Year 2078) of the landscape (Fig. 2). Crown fire potential in Year 2003 was mostly influenced by an abundance (27% of the landscape) of seedling-sapling seral stages. Although our management prescription reduced the stocking density of these young forests, they remained susceptible to crown fire (Table 3). At the landscape scale, actively managed young forests matured into single-storied, taller, closed canopy forests, and canopy fire hazard decreased (Year 2018), even though some of the managed younger forests on frequent-fire PAGS remained hazardous (see Small Tree, Table 3). As forests in the landscape continued to mature, crown fire potential increased from 2018 to 2078, the exception being for active management in 2078 (Fig. 2). For the entire landscape, crown fire potential for no management was higher than active management in all time steps, with differences more pronounced later in the model simulation as treatment of older forests dominated management activities (Fig. 2).

The majority (>58%) of crown fire occurred on frequent-fire PAGS regardless of management scenario (i.e., no management or active management), the exception being in Year 2003 during which >51% of the total crown fire occurred on mixed fire PAGS (Fig. 3). Thus, our decision to focus active management on frequent-fire PAGS was supported by the tendency for crown fire hazard to disproportionately increase on frequent-fire PAGS over time (Fig. 3). Crown fire persisted on frequent-fire PAGs under the active management scenario because fuels in those spotted owl territories designated as low hazard (i.e., ⩽50% of the territory on frequent fire PAGS and ⩽50% crown fire potential) were not being treated.

3.2. Fire hazard to spotted owls

The number of modeled spotted owl territories encompassing >50% frequent-fire PAGs during our 75-year simulation ranged

Table 2
Vegetation states on frequent-fire plant association groups (PAGs) with crown fire potential resulting from no management by time period. Table values represent ha (% of total landscape).

Vegetation state[1]	Simulation year				
	2003	2018	2038	2058	2078
Seedling-sapling	24,313 (7)	22 (<1)	–[2]	–	–
Single and multi-storied					
Small tree	236 (<1)	1 (<1)	–	10 (<1)	–
Medium tree	3219 (1)	5827 (2)	34,226 (10)	35,412 (11)	6831 (2)
Large tree	115 (<1)	640 (<1)	4815 (1)	13,261 (4)	43,447 (13)
X-large tree	65 (<1)	–	–	–	–
Multi-storied					
Old growth	–	–	–	–	–

[1] Seedling-sapling = average quadratic mean diameter (QMD) 1.3–12.7 cm diameter breast height (dbh); Small tree = 12.8–38.1 cm QMD; Medium tree = 38.2–50.8 cm QMD; Large tree = 50.9–76.2 cm QMD; X-large tree = 51.0–127.0 cm QMD; Old Growth = X-large tree size criteria plus trees >127.0 cm dbh with snags, cull trees, and abundant downed wood.
[2] No area identified.

Table 3
Vegetation states on frequent-fire plant association groups (PAGs) with crown fire potential identified for active management by time period. Table values represent ha (% of total landscape) subjected to management in each time period.

Vegetation structure[1]	Simulation year				
	2003	2018	2038	2058	2078
Seedling-sapling	16,396 (5)	30 (<1)	13 (<1)	1 (<1)	–[2]
Single and multi-storied					
Small tree	163 (<1)	14,438 (4)	–	–	–
Medium tree	1623 (<1)	505 (<1)	4428 (1)	6388 (2)	15,287 (5)
Large tree	55 (<1)	65 (<1)	1715 (1)	3943 (1)	11,642 (3)
X-large tree	15 (<1)	54 (<1)	–	–	–
Multi-storied					
Old growth	–	1 (<1)	–	–	–

[1] Seedling-sapling = average quadratic mean diameter (QMD) 1.3–12.7 cm diameter breast height (dbh); Small tree = 12.8–38.1 cm QMD; Medium tree = 38.2–50.8 cm QMD; Large tree = 50.9–76.2 cm QMD; X-large tree = 51.0–127.0 cm QMD; Old Growth = X-large tree size criteria plus trees >127.0 cm dbh with snags, cull trees, and abundant downed wood.
[2] No area identified.

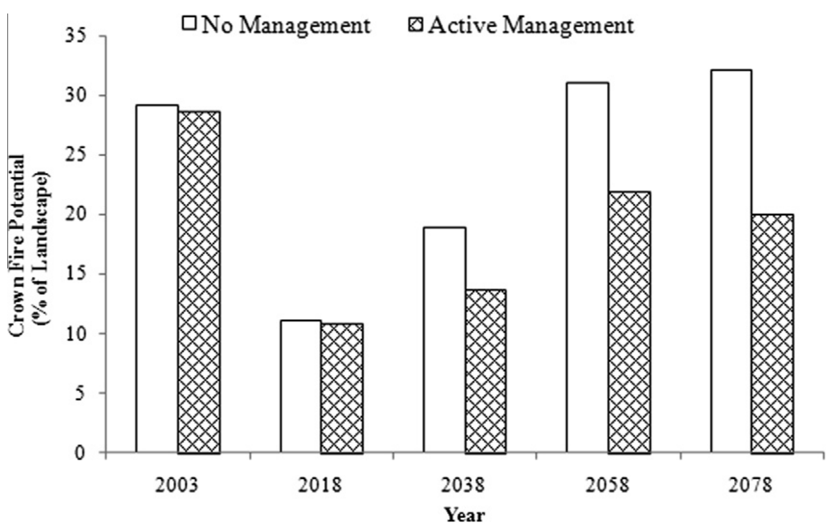

Fig. 2. Crown fire potential (modeled via FlamMap; Finney, 2006) for the Southwest Oregon Hazard Demonstration Project landscape by simulation year for active management and no management scenarios.

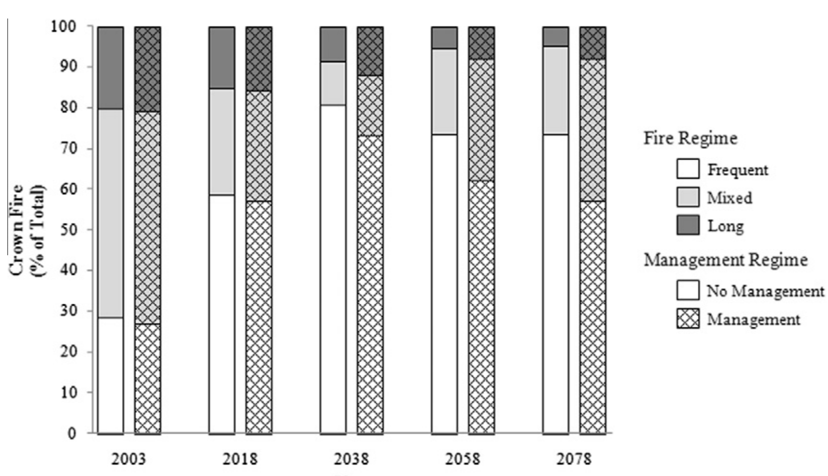

Fig. 3. Association between crown fire potential (modeled via FlamMap; Finney, 2006) and fire regime by simulation year for active management and no management scenarios in the Southwest Oregon Hazard Demonstration Project.

from 21 (No Management, Year 2038) to 7 (No Management, Year 2078) (Fig. 4). During a time period, these territories accounted for <18% of the total spotted owl territories modeled for our entire study area (Fig. 1). Active management occurred within spotted owl territories in 2003 ($n = 3$), 2018 ($n = 1$), and 2078 ($n = 2$). Spotted owl territories averaged 2218 ha in size, and the amount of area managed within a spotted owl territory ranged from 731 ha (Year 2003) to 1372 ha (Year 2078). When owl territories were

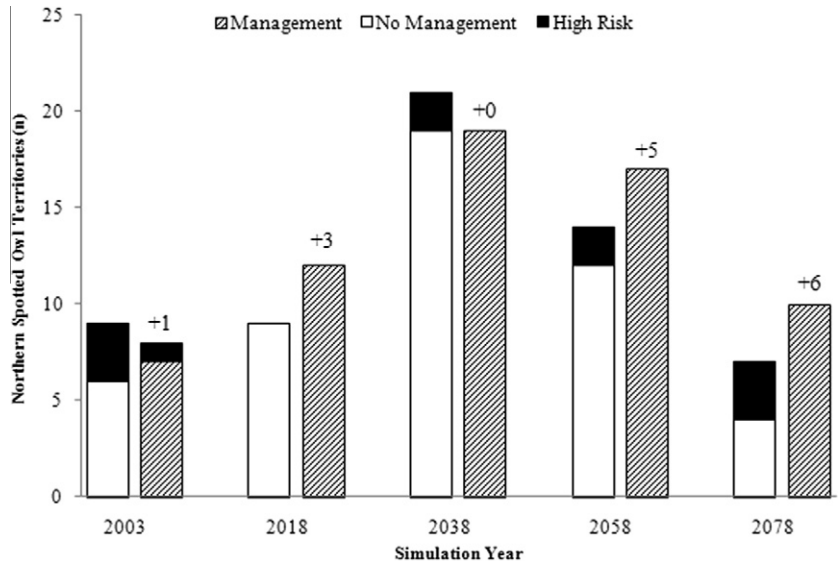

Fig. 4. Modeled northern spotted owl territories and corresponding hazard ranking by simulation year for active management and no management scenarios in the Southwest Oregon Hazard Demonstration Project. Numbers above each management bar denote the net benefit or loss of territories resulting from management.

identified as high hazard, active management was used to treat 33–62% of the territory on average.

We observed a peak in spotted owl territory numbers in 2038, followed by a steady decline (Fig. 4). This declining trend in spotted owl territories during later simulation years seems counter-intuitive in that larger, homogenous areas of older forests are often presumed to provide high quality spotted owl habitat (Forsman et al., 1984; Noon and Blakesly, 2006; Seamans and Gutiérrez, 2007). The decline in spotted owl habitat potential was caused by a reduction of suitable foraging habitat as portrayed by our habitat model. Our foraging habitat model ranked riparian zones and edges as important to spotted owl fitness; a pattern consistent with results from field studies conducted in comparable landscapes (Zabel et al., 1995; Franklin et al., 2000). According to our vegetation state-transition model and our spotted owl habitat model, no management resulted in a more homogenous forest landscape that lacked edges, whereas active management resulted in greater heterogeneity. Heterogeneity in dry forest landscapes of the Pacific Northwest is common (Spies et al., 2006; Kennedy and Wimberly, 2009) and, according to our owl habitat model, increases forage habitat potential.

Our model simulations suggest that active management helped reduce fire hazard without compromising spotted owl habitat potential (Fig. 4). The active management scenario resulted in lower hazard territories in four of the five simulation years; the exception being in 2038 when both management scenarios resulted in the same number of low hazard territories (Fig. 4). The benefits of active management were most pronounced during later simulation years (Fig. 4), as the cumulative effect of the management regime focused on fire-prone older forest types that also tended to support owls (Table 3).

4. Discussion

Active management at appropriate scales can effectively reduce crown fire hazard and not compromise northern spotted owl habitat potential if that management emphasizes fuel reduction and ecosystem restoration (as opposed to financial return) and focuses on those portions of the landscape at greatest hazard to crown fire (also see Gaines et al. 2010). Disagreement exists over the effects of fire on spotted owl population persistence, with some arguing that fires create elements of suitable habitat (Hanson et al., 2009a,b). Our results support the contention that small-scale heterogeneity caused by a patchy distribution of fire intensity (or, in our case, active management) is favorable to spotted owls in disturbance-prone landscapes; consistent with field observations of spotted owls using burned patches for foraging (Bond et al., 2009). However, conclusions from our comparative hazard analysis are based on a different premise and scale, i.e., the potential for large-scale habitat loss (i.e., >50% of a spotted owl territory) caused by extensive crown fire. Our premise is based on the observation that spotted owls will rarely use large areas that burn at high severity (Weatherspoon et al., 1992; MacCracken et al., 1996; Gaines et al., 1997; Bond et al., 2002). Thus, loss of habitat from large-scale crown fire is a primary conservation concern (Courtney et al., 2004).

Young conifer forests are susceptible to high levels of canopy damage from wildfires (Thompson et al. 2011). We contend that a thinning treatment of these younger seral stages actually prolongs the period of crown fire susceptibility because the canopies remain more open thereby encouraging retention of lower branches and the development of herbaceous and shrubby understories. Hence thinning programs should also include understory vegetation control and appropriate slash management. Our simulation results suggest that early seral stages should be encouraged to rapidly develop into closed-canopy forests to reduce understories and raise height to live crown (self-pruning of lower branches). As such, no management and lighter thinning treatments in denser stands appears to be the best option for younger seral stages.

Active management in older forests was effective at reducing crown fire potential, but we caution that logging debris and surface fuels must be managed for this prescription to be effective (e.g., piled and burned or broadcast prescribed fire; Stephens et al., 2009). Hazardous, older forest vegetation conditions are often associated with spotted owl habitat, particularly at lower elevations in fire-prone forests of the western US (Courtney et al., 2004; Ager et al., 2007). Spatial discontinuity of surface, ladder and crown fuels are recommended.

The percentage of landscape treated and positioning of treatments in the landscape are crucial management considerations. In our simulation, active management was implemented on $\leqslant$8% of our study area in any given 15–20 year time period. We reiterate that our approach focused management only on high hazard areas and did not attempt to explicitly influence fire spread or intensity by managing adjacent harvest units, topographic connectivity, and other vegetation states. Simulation modeling suggests that >20% of a fire-prone landscape must be treated to begin altering fire behavior and help reduce the chances of spotted owl habitat loss (Ager et al., 2007). Our results suggest that effective and sustained fire hazard management and spotted owl conservation are compatible, though effective control of fire spread likely requires more tactical treatment.

Fire hazard to spotted owls fluctuates due to changes in fuel structure as vegetation regenerates, matures, and responds to management and natural disturbances. Vegetation dynamics in dry western forests are strongly influenced by disturbance agents like insects and disease (US Fish and Wildlife Service, 2011:III-7) in conjunction with fire (US Fish and Wildlife Service, 2011:III-6; Simard et al. 2011). Although our current results do not incorporate the likelihood for stochastic disturbance agents at different time steps, those capabilities exist (e.g., Roloff et al., 2005b). Based solely on fuel dynamics as vegetation states matured, our model indicated that lower elevation forests in the planning landscape were particularly hazardous in 2003 and 2078 and that hazard was absent in 2018 (Fig. 4). These results underscore the importance of long term assessments with periodic evaluations of hazard when deciding on a management trajectory for large landscapes (Fairbrother and Turnley, 2005; US Fish and Wildlife Service, 2011:III-14). Given the assumptions of our simulation, basing a decision on a short term analysis (i.e., the next 15-years) would lead to the conclusion that no management is the best option for reducing fire hazard to northern spotted owls in SOHDPA. However, a decision based on a longer term analysis (i.e., 75 years) leads to the conclusion that active management is the best option. A hazard profile like that portrayed in Fig. 4 improves the quality of management decisions because it permits a simultaneous evaluation of short, long, and periodic hazard.

We recommend that hazard profiles (e.g., Fig. 4) in dry forest types of the Pacific Northwest include a hazard calculation at least every 20 years and span sufficient time to include at least one forest successional cycle. Based on such a hazard profile, decision-makers can decide whether to subject protected species to no management periods of high potential volatility (e.g., time periods with high hazard conditions; Fig. 4) or to subject those species to management disturbances that result in less volatile conditions over the same time period. Our results confirm that impacts resulting from short term decisions compound and manifest themselves over long time periods with potentially profound consequences on protected species conservation.

4.1. Model limitations

Our findings are based on models that assume vegetation states can be accurately described and mapped, that states are defined at sufficient resolution to assume vegetative homogeneity, and that all areas of a particular state simultaneously transition into a new state (Ravindran et al., 1987). Additionally, we assumed that FVS accurately portrayed vegetation dynamics and that other major disturbances (like wildfire) did not occur. These simplifying assumptions have led some to question the utility of models for portraying vegetation dynamics (Olson et al., 1985). Models like those used in our study have a long history of utility in strategic forest planning and as such are useful for identifying broad vegetation categories for management (Iverson and Alston, 1986). Implementation of our model solution requires scaling down to site level decisions with management activities spread over multiple years.

Outcomes from our model were strongly influenced by our definition of high hazard; >50% of an owl territory occurring on frequent fire PAGS and >50% of the territory in vegetation conditions conducive to crown fire. This definition of high hazard may be conservative in light of recent publications noting increased vulnerability of western forests to uncharacteristic fire because of an increasingly warm and dry climate (Allen et al., 2010; Liu et al., 2010; US Fish and Wildlife Service, 2011:III-6) and high incidence of insects and disease outbreaks (Campbell and Liegel, 1996; US Fish and Wildlife Service, 2011:III-7). Additionally, surface fires may result in loss of spotted owl habitat, depending on fire intensity (Stephens and Finney, 2002; Schwilk et al., 2006). Our comparative hazard model permits future evaluation of alternative hazard definitions that might be more appropriate under changing landscape conditions. For example, if a warmer and drier climate increases the prevalence of insects and diseases, a lower hazard threshold may be warranted. In a different model simulation we demonstrated that the case for active management was even more compelling under a lower hazard threshold (i.e., 40% of an owl territory in crown fire potential; Mealey and Roloff, 2010).

We acknowledge that our model contains uncertainty and untested assumptions. Perhaps most importantly, we did not model vegetation heterogeneity within states (i.e., we assumed a single tree list represented average conditions across the landscape), resulting in a generalized portrayal of hazard and habitat covariates. We also did not include elements of unpredictable environmental stochasticities (e.g., fire, insect outbreaks). Thus, focus should remain on the relative comparisons and not the absolutes generated by our model. Habitat amount and quality thresholds used to portray spotted owl territories remain untested although findings from field studies were compiled to develop our habitat model. Also, we assumed that high hazard was likely to result in habitat loss; an outcome dependent on highly variable weather, climate, and fire factors.

4.2. Model application

Some have questioned the use of predictive models for natural resource planning and management (reviewed by Starfield, 1997); however, modeling is often the only alternative for informing decision-makers on long term impacts (Roloff et al., 2001). Whereas experimentation is recognized as the best approach for understanding the complexities of protected species conservation and fire risk management (Hanson et al., 2009a,b), proliferation of the precautionary principle has limited actual experimentation (Wildavsky, 2000). We emphasize the importance of continuously improving these models for use in natural resources decision-making through critical evaluation of model assumptions, inputs, outputs, and linkages. Additionally, strategic models (like the one presented herein) should be periodically (5–10 year intervals) implemented to incorporate landscapes changes that were not initially accounted for (e.g., large areas of tree mortality from insect outbreaks).

5. Conclusion

Our analysis of the interaction between management regime and northern spotted owl habitat conservation in a dry forest landscape of the Pacific Northwest suggested that active management reduces fire hazard and provides better habitat conditions for spotted owls over the long term. This finding provides specific hypotheses for field testing prior to broad scale implementation, with such testing focused on spotted owl responses to levels of management and fire within territories. A positive association between spotted owl dispersal and habitat alteration has been documented, though questions remain as to population-level impacts (Bond et al., 2002; Seamans and Gutiérrez, 2007; US Fish and Wildlife Service, 2011:III-11). A testable hypothesis is that active management of fuels (i.e., using a q-ratio for thinning), if conducted tactfully, can occur on frequent-fire PAGS without compromising the quality of the spotted owl territory core. Our model simulations suggested that the locations of habitats suitable for spotted owl nesting cores remained relatively stationary over time, but that active management caused spatial shifts in suitable foraging resources within territories. Strategically, this active management strategy for fuels reduction and spotted owl habitat conservation appears to be a better alternative than no management.

Spotted owl habitat in many dry forest landscapes often exists over a mosaic of public and private ownerships as well as vegetation communities and fuel profiles. Ignoring fire hazard is not a socially or economically acceptable option in these mixed ownership landscapes. For example, some industrial forest landowners have questioned the long term value of owning timber assets in high-risk landscapes and, in some instances, these risk perceptions have factored into divestiture decisions. Our results should not be used as an argument for abandoning late successional reserves for spotted owl conservation in mixed ownership, dry forest landscapes. Rather, our results suggest that high risk areas in reserves can be tactfully managed to perpetuate their functionality as spotted owl habitat.

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Research Article

Site Occupancy Dynamics of Northern Spotted Owls in Managed Interior Douglas Fir Forests, California, USA, 1995–2009

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ABSTRACT Northern spotted owls (*Strix occidentalis caurina*) have received intense research and management interest since their listing as a threatened species by the United States Fish and Wildlife Service in 1990. For example, public and private forest managers in the Pacific Northwest, USA, conduct surveys to determine presence or absence of spotted owls prior to timber harvest operations. However, although recently developed statistical methods have been applied to presence–absence data collected during research surveys, the effectiveness of operational surveys for detecting spotted owls and evaluating site occupancy dynamics is not known. We used spotted owl survey data collected from 1995 to 2009 on a study area in interior northern California, USA, to evaluate competing occupancy models from Program PRESENCE using Akaike's Information Criterion (AIC). During 1,282 individual surveys, we recorded 480 spotted owl detections (37.4%) and 13 barred owl (1.0%) detections. Average per visit detection probability (85% CL) for single and paired spotted owls was 0.93 (0.90–0.96) for informed daytime, stand-based searches and 0.47 (0.43–0.51) for nighttime, station-based surveys (estimated from the best model); the average per visit detection probability from the null model was 0.67 (0.64–0.70). Average pair-only detection probabilities were 0.86 (0.81–0.90) for informed daytime, stand-based searches and 0.23 (0.18–0.29) for nighttime, station-based surveys; the average per visit detection probability from the null model was 0.63 (0.58–0.68). Site occupancy for any owl declined from 0.81 (0.59–0.93) in 1995 to 0.50 (0.39–0.60) in 2009; pair occupancy declined from 0.75 (0.56–0.87) to 0.46 (0.31–0.61). Our results suggest that a combination of 1 informed stand and 2 station-based operational surveys can support determinations of spotted owl site status (either a single or a pair) at desired levels of confidence. However, our information was collected in an area where barred owls were rarely detected. Surveys conducted in areas that support well-established barred owl populations are likely to be less effective for determining presence or absence of spotted owls and may require more surveys and/or different survey methods to determine site status with confidence.

KEY WORDS California, colonization, detection probability, local-extinction, managed forests, northern spotted owls, occupancy, operational surveys, *Strix occidentalis caurina*.

The northern spotted owl (*Strix occidentalis caurina*) has been a federally listed threatened species since 1990 and remains the focus of numerous conservation, management, and research programs in the Pacific Northwest, USA. The primary focus of research efforts for spotted owls has been demographic studies that estimate survival, productivity, and changes in population growth rate (Franklin et al. 2000, Anthony et al. 2006), although several efforts have examined site occupancy probabilities and potential sources of variation in these probabilities (Meyer et al. 1998, Swindle et al. 1999). Recent analyses used data collected on demographic monitoring areas, where the main objectives were to monitor adult survival and fecundity (Anthony et al. 2006), to examine northern spotted owl occupancy dynamics (Olson et al. 2005, Kroll et al. 2010, Dugger et al. 2011). Site occupancy probabilities can be useful metrics for monitoring how long-lived, territorial species such as the spotted owl respond to changes in environmental conditions, anthropogenic impacts, and co-occurring species.

Public and private forestland owners in California, Oregon, and Washington conduct presence–absence surveys for spotted owls prior to timber harvest operations to avoid indirect or direct impacts to spotted owls that occur within project areas. These operational surveys are planned and conducted based on widely accepted field methods and recommended United States Fish and Wildlife Service (USFWS) protocol (Forsman 1983, USFWS 1992). However, little information about the effectiveness of these operational surveys is available. For example, available spotted owl detection probabilities have been estimated from information collected in

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long-term research studies that use different methods than operational surveys (Olson et al. 2005, Anthony et al. 2006, Kroll et al. 2010).

In addition, the effectiveness of research surveys has been reduced across a wide portion of the northern spotted owl's distribution by the occurrence of barred owls (*Strix varia*), which have a negative association with spotted owl detection probabilities and may lead to misclassification of site occupancy status (Olson et al. 2005, Kroll et al. 2010). The barred owl has rapidly expanded its range in the Pacific Northwest since 1990 (Taylor and Forsman 1976, Herter and Hicks 2000, Kelly et al. 2003), and the consequences for spotted owl populations have been mostly negative (Kelly et al. 2003, Haig et al. 2004). For example, studies have found that barred owls were negatively associated with spotted owl productivity, adult survival, and occupancy (Olson et al. 2004, 2005; Anthony et al. 2006). However, the density of barred owls varies widely across the range of the northern spotted owl, and barred owls appear to be more numerous in Oregon and Washington than in California (Courtney et al. 2008). Information collected in areas where barred owls occur only infrequently would presumably provide a more accurate understanding of typical variation in detection probabilities and spotted owl population trends, and preclude the need to adjust statistical analyses to account for the influence of barred owls.

Our objectives were to evaluate annual variation and potential temporal trends in detection, local-extinction, colonization, and occupancy probabilities of northern spotted owls on a study area in interior northern California that lacks a well-established population of barred owls. In addition, we evaluated the association of pair nesting status and biological province (Klamath and Cascades) with spotted owl detection and occupancy probabilities.

STUDY AREA

The study area covered approximately 5,850 km^2 of the eastern Klamath and southern Cascade Mountains in Trinity and Siskiyou Counties, California, USA (Fig. 1). The spotted owl territories were located at elevations ranging from 1,000 m to 1,500 m. The study area was characterized by relatively steep mountainous terrain with a Mediterranean climate of warm, dry summers and cool, moist winters, with approximately 80% of the precipitation occurring from November to March. The dominant forest vegetation types in the Klamath Mountains included Klamath mixed conifer, Douglas-fir, and montane hardwood-conifer, whereas the Southern Cascades were dominated by Klamath mixed conifer, white fir, and red fir types (Mayer and Laudenslayer 1988). Coniferous forest stands were composed of Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and white fir (*Abies concolor*), with an understory composed of Oregon white oak (*Quercus garryana*), incense cedar (*Calocedrus decurrens*), snowbrush (*Ceanothus cordulatus*), and dwarf Oregon grape (*Berberis nervosa*; Mayer and Laudenslayer 1988).

We collected data from spotted owl sites located on both private forestland and portions of the Klamath and Shasta-

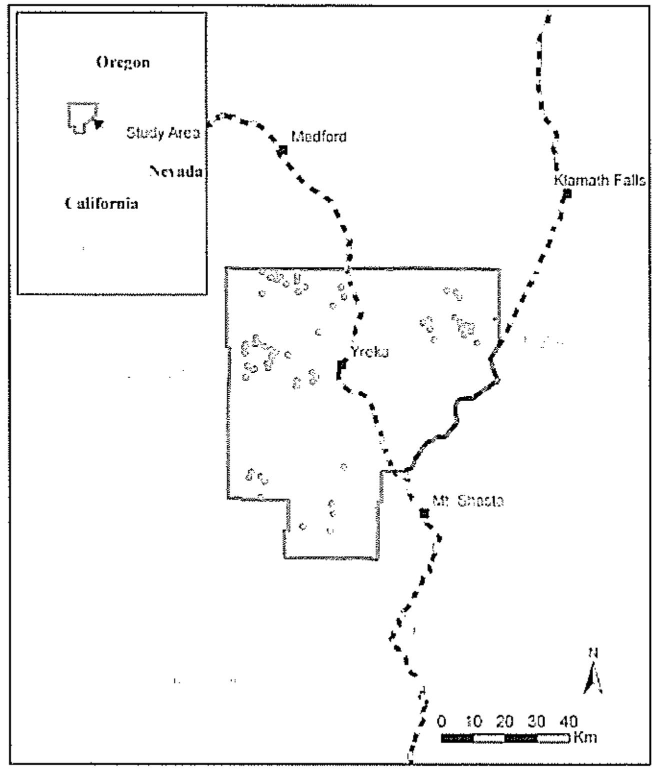

Figure 1. General outline of the northern spotted owl study area, Siskiyou and Trinity Counties, northern California, USA, 1995–2009. Gray dots reference individual northern spotted owl sites.

Trinity National Forests. Private forestland, originated from land grant railway ownership, was typically intermingled with United States Forest Service ownership in a checkerboard pattern. Forest management had occurred on the private forests for over 80 years, resulting in a forest landscape mosaic of young, intermediate, and mature forests (ranging from 80 to 120 years old). During our study period, silvicultural prescriptions on private forests included clearcut-variable retention, shelterwood removal, and commercial thinning. The clearcut-variable retention prescription retained a variety of green tree species, snags, wildlife trees, and large downed woody debris (Hansen et al. 1991, Swanson and Franklin 1992) to increase future stand complexity for species such as northern spotted owls and their prey (Thome et al. 1999, Irwin et al. 2000, Sullivan and Sullivan 2001). Prescriptions on United States Forest Service ownership were implemented to support the Northwest Forest Plan (United States Department of Agriculture 1993) and included stands that were thinned or selectively managed to reduce risk of catastrophic fire as well as late-successional reserves.

METHODS

Field Surveys and Data Preparation

Various public and private monitoring programs have surveyed northern spotted owl sites in the Klamath and Southern Cascades provinces since the late 1980s. The territorial nature of spotted owls allowed for the development of a public database of known owl sites. Our study included data from a portion of the spotted owl sites contained in the public database and we only included data from surveys that were conducted from 1995 to 2009. We did not include data for years prior to 1995 because of an unbalanced and inconsistent survey effort which could have biased our results. Although we did not include pre-1995 data in our analyses, our dataset included spotted owl sites where at least 1 owl had been detected during the March–August breeding season prior to 1995 as well as spotted owl sites where owls were first detected after 1995. We added these new sites if they were within our study area boundaries and if subsequent surveys were consistent and met our criteria described below. We conducted surveys to monitor selected known sites and to evaluate occupancy of sites prior to, and following, timber management activities. We included 63 spotted owl sites that met our criteria in our occupancy analyses. Sixteen of these sites occurred in the Southern Cascades and 47 occurred in the Klamath Mountains province.

We conducted surveys following recommended field methods (Forsman 1983, USFWS 1992). Typically, we conducted surveys (consisting of 3 visits per year) were conducted over 2 years, resulting in a minimum of 6 visits to a survey area to meet the protocol standard. One complete survey visit included a nighttime station survey (hereafter, night survey) and, if necessary, a subsequent stand search during the day to find spotted owls detected the previous night. A night survey consisted of imitating spotted owl vocalizations, by either voice or digital recording, for 10 min at each survey station located within a specific owl site. The spotted owl territory provincial radius, a circle that approximates the annual home range for spotted owls, for the Southern Cascades and Klamath Mountains is 2.1 km (USFWS 1992). For this study, we only included surveys that completely covered, at a minimum, a 1.1-km radius from the defined site center.

In addition, we often conducted an informed daytime stand search (hereafter, informed day search) prior to beginning night surveys. We conducted informed day searches, primarily within spotted owl core use areas (Blakesley et al. 1992, Bingham and Noon 1998, Zabel et al. 2003), by following routes developed by biologists using historical and current biological information gathered at the sites. Historical and current biological knowledge included 1) historic or current location of spotted owl sites; 2) suitable habitat within sites; 3) previous spotted owl detection locations; 4) previous nest and roost locations; and 5) location of abiotically favored suitable habitat (Clark 2002, Underwood et al. 2010). This information was readily available in a spatial database to biologists, survey personnel, and forest managers when planning and conducting surveys. Although we had limited information for some spotted owl sites, we had territory location and suitable habitat maps for all sites. Accordingly, we considered all of our day searches informed relative to naïve surveys (Riddle et al. 2010). In our analysis, we did not consider follow-up stand searches (e.g., conducted after a detection on the previous night) as informed day searches, as this decision would have added a positive bias to our results.

If spotted owls were detected during either the night surveys or informed day searches, we summarized the results into 1 of 4 status categories: single, pair, nesting pair, or reproductive pair (following recommendations in Forsman 1983 and USFWS 1992). We designated detections as single when only an individual spotted owl was detected and made a pair designation when both a male and female were detected within the site. We made a nesting pair designation when, after 15 April, a female spotted owl was observed on a nest or a male owl was observed taking a prey item to a female on a nest. We made a reproductive pair designation when a nesting pair had confirmed fledglings outside the nest structure. We typically conducted surveys prior to forest management operations to determine the occupancy and reproductive status of spotted owls; consequently, surveys did not always determine final nest fate or total number of young fledged. Finally, we did not attempt to detect barred owls using barred owl vocalizations. As a result, we detected barred owls opportunistically during spotted owl surveys.

Spotted owl sites are maintained by either a mated pair or a resident single bird (often a male). To reflect this distinction, we created 2 data sets: 1 data set contained detections of single birds (either M or F) and pairs (simple detections) and the second data set contained detections of pairs only (Olson et al. 2005, Kroll et al. 2010). Occupancy probabilities that we estimated from the former data set are likely to be greater and represent an upper bound of site occupancy. We refer to the analyses based on these 2 data sets as simple and pair, respectively.

Detection and Site Occupancy Modeling and Parameter Estimation

We based our analysis of site occupancy models on methods designed for open populations and described by MacKenzie et al. (2003, 2006) and employed specifically to analyze spotted owl data by Olson et al. (2005), Kroll et al. (2010), and Dugger et al. (2011). The primary sampling occasions were years and the secondary sampling occasions were the 3 individual visits that occurred during the spotted owl nesting season (Mar–Aug) to site-centers (i.e., known nest-sites or areas of concentrated use) or call stations distributed throughout owl territories.

We employed a 2-step process to estimate occupancy parameters. First, we modeled those covariates that we thought would influence detection probabilities. In the second step, we used the best detection model and evaluated combinations of time effects (., T, and TT). We then added a province (either the Klamath or Cascades) or a nesting status covariate (for pairs only) as an additive effect on local-extinction (probability that an occupied site became unoccupied in the following year) and colonization (probability that an unoccupied site became occupied in the following year) to time trend models with the lowest Akaike's Information Criterion with small sample correction (AIC_c) and models with $\Delta AIC_c < 2.0$ (Burnham and Anderson 2002). We calculated year-specific (denoted as *t*) site occupancy probabilities based on estimated local-extinction and colonization probabilities (following MacKenzie et al. 2003). We conducted analyses with Program PRESENCE (PRESENCE Version 3.0 beta, www.mbr-pwrc.usgs.gov/software/doc/presence/presence.html, accessed 1 Apr 2010). We used AIC_c for model selection and considered models with $\Delta AIC_c < 2.0$ as being substantially supported (Burnham and Anderson 2002). We used the logit link function for all models so that parameter estimates and 85% confidence intervals would be constrained to the interval 0–1.

We modeled several temporal structures for within-season detection probabilities, including constant (denoted as [.]), a linear trend (T), a quadratic trend (TT), and an unconstrained model (t). Within-season linear and quadratic time trends are equivalent to evaluating an effect of Julian date. Also, we evaluated year-specific, linear, and quadratic temporal trends across years. We did not consider unspecified within season and annual temporal models simultaneously, as they would have required too many parameters (i.e., a different parameter for each of the 45 visits across the study period).

We did not monitor all spotted owl site centers each year, resulting in different sample sizes in each year. As a result, we used only 3 temporal covariates (., T, and TT) to evaluate models of local-extinction and colonization (i.e., we did not model unspecified annual variation, t). We used the initial occupancy (probability that a site was occupied in 1995) parameterization in PRESENCE but we did not consider any spatial variation in initial occupancy. We added the province and nesting status covariates to the models with the most support (smallest AIC_c and $\Delta AIC_c \leq 2$). We evaluated the nesting status covariate in local-extinction models only. We evaluated whether nesting status in year i might be associated with spotted owl local-extinction in the interval between year i and year $i + 1$. Unlike other studies that investigated occupancy dynamics of spotted owls (Kroll et al. 2010, Dugger et al. 2011), we did not evaluate a barred owl covariate because barred owls were transient and rarely detected during our study. We evaluated effect sizes for covariates by examining parameter estimates and associated 85% confidence intervals; if effect sizes were large and 85% confidence intervals did not include zero, we considered the association to have support from the analysis (Arnold 2010). Finally, we note that spotted owl territories chosen for monitoring were located opportunistically over time, similar to other studies (Olson et al. 2005, Kroll et al. 2010, Dugger et al. 2011). As a result, inference from our study is restricted to spotted owl territories that are either currently occupied or were occupied at some point in the past, rather than all potential spotted owl territories in our study area.

RESULTS

Of the 63 spotted owl sites that met our criteria, 54 were known in a public database prior to 1995 and 9 spotted owl sites were discovered during the study. Sixteen (25%) and 47 (75%) spotted owl sites occurred in the Southern Cascades and Klamath Mountains, respectively. The number of spotted owl detections per site ranged from 0 to 30 ($\bar{x} = 7.6$; 95% CI = 5.5–9.7) from 1995 to 2009; 10 sites had 0 detections during our study period.

Table 1. Regression coefficients and 85% confidence intervals from the top ranked simple and pair spotted owl detection models, northern California, USA, 1995–2009. Night indicates the effect of conducting a nighttime, station-based survey; the intercept includes the effect of conducting a daytime, stand-based search.

Occupancy level	Model term	$\hat{\beta}$	SE	85% CL
Simple	Intercept	2.60	0.259	2.22 to 2.97
	Night	−2.71	0.282	−3.12 to −2.29
Pair	Intercept	1.90	0.223	1.58 to 2.22
	Time	−0.47	0.151	−0.69 to −0.25
	Night	−3.15	0.271	−3.54 to −2.76

One thousand thirty-three of 1,282 surveys (81%) occurred at night. A total of 480 (37.4%) spotted owl detections and 13 (1.0%) barred owl detections occurred during the 1,282 surveys. Barred owls were detected in 6 of 16 sites (38%) in the Southern Cascades and 2 of 47 sites (4%) in the Klamath Mountains province. During our study period, we did not detect barred owls in 1995 and 1996; however, we detected 4 barred owls from 1997 to 2004, 8 barred owls in 2005 and 2006, and 1 barred owl from 2007 to 2009. We detected a barred owl in multiple years on 1 spotted owl site; for the remaining 7 sites, we detected a barred owl in ≤1 year.

Detection Probabilities

The best model for detection probability in the simple analysis contained an effect for search type (informed day search or night survey; Table 1). Survey-specific simple detection probabilities were 0.93 (85% CI = 0.90–0.96) and 0.47 (85% CI = 0.43–0.51) for informed day searches and night surveys, respectively. The best model for detection probability in the pair analysis contained a negative linear annual trend and an effect for search type (Table 1 and Fig. 2). The average pair detection probabilities across all years were 0.86 (85% CI = 0.81–0.90) and 0.23 (85% CI = 0.18–0.29) for informed day searches and night surveys, respectively. Average detection probabilities (for all surveys combined) were 0.67 (85% CI = 0.64–0.70) and

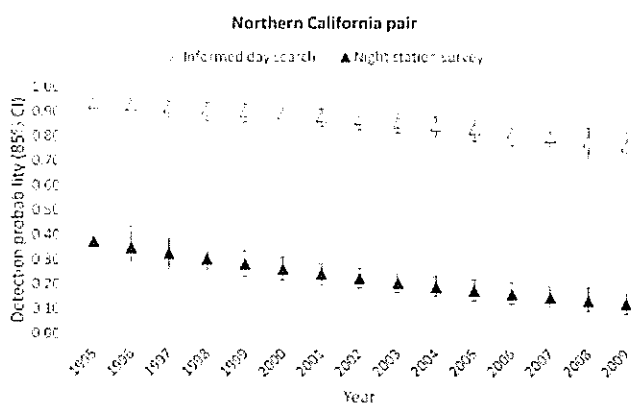

Figure 2. Estimated year-specific northern spotted owl pair detection probabilities and 85% confidence intervals, northern California, USA, 1995–2009. Open and filled diamonds represent estimates for surveys conducted during the day and night, respectively.

0.63 (85% CI = 0.58–0.68) for the simple and pair analyses, respectively (estimated with the null model). We did not find support for a difference in detection probabilities between the Southern Cascades and Klamath Mountains province.

Local-Extinction and Colonization Probabilities

Initial occupancy probabilities were 0.81 (85% CI = 0.59–0.93) and 0.75 (85% CI = 0.56–0.87) for the simple and pair analyses, respectively. The most supported model in the simple analysis included a negative linear trend in colonization probabilities; a model where colonization probability did not change during the study was the most supported in the pair analysis (Table 2). A constant local-extinction model received the most support in both the simple and pair analyses (Tables 2 and 3). Although the model weight indicated support for an effect of province on local-extinction probability in the simple analysis, the 85% confidence interval overlapped 0, suggesting uncertainty about the effect. The same was true for other covariates in both the simple (e.g., a linear trend in local-extinction) and the pair (e.g., an effect of nesting status on local-extinction and an effect of province on colonization) analyses (Table 2).

Local-extinction probabilities (from the best model) were constant across the study period for both the simple (0.09, 85% CI = 0.06–0.12) and pair (0.09, 85% CI = 0.06–0.13) analyses (Table 3). Colonization probabilities declined across the study in the simple analysis (Fig. 3 and Table 3) and remained constant in the pair analysis (0.06, 85% CI = 0.04–0.12).

Site Occupancy Probabilities

We present derived parameter estimates for simple and pair annual site occupancy probabilities for spotted owls based on best model estimates of initial occupancy, local-extinction, and colonization in our study area (Fig. 3). Site occupancy for any owl declined from 0.81 (85% CI = 0.59–0.93) in 1995 to 0.50 (85% CI = 0.39–0.60) in 2009; pair occupancy declined from 0.75 (85% CI = 0.56–0.87) to 0.46 (85% CI = 0.31–0.61). However, the rate of decline slowed for pair occupancy probabilities in the final 5 years of the study.

Table 3. Estimates and 85% confidence intervals for colonization and local-extinction coefficients from the top ranked simple and pair spotted owl occupancy models, northern California, USA, 1995–2009.

Occupancy level	Model term	$\hat{\beta}$	SE	85% CL
Simple	$\text{Intercept}_{\text{Colonization}}$	−2.15	0.33	−2.63 to −1.67
	$\text{Time}_{\text{Colonization}}$	−0.66	0.43	−1.29 to −0.03
	$\text{Intercept}_{\text{Extinction}}$	−2.34	0.24	−2.69 to −1.99
Pair	$\text{Intercept}_{\text{Colonization}}$	−2.59	0.43	−3.21 to −1.96
	$\text{Intercept}_{\text{Extinction}}$	−2.31	0.31	−2.76 to −1.86

DISCUSSION

We found that simple and pair spotted owl occupancy probabilities declined approximately 39% across the 15 years of our study, although the decline in pair occupancy probabilities appeared to slow in the final 5 years of the study. Observed pair declines in our study area were less than those reported for the Wenatchee study area in Washington, which demonstrated declines of 15% and 50% in simple and pair occupancy (Kroll et al. 2010), but greater than those for 3 study areas in western Oregon, only 1 of which demonstrated a decline of >10% (Olson et al. 2005). These declines in site occupancy are consistent with the trend in realized population change for the northwestern California demographic study area, which has been declining since 1992 (Anthony et al. 2006).

We found evidence that changes in simple occupancy probabilities were likely the result of declining colonization probabilities. Kroll et al. (2010) found that simple and pair

Table 2. Best ranked northern spotted owl site occupancy models (cumulative weight ≥0.85), northern California, USA, 1995–2009. For simple occupancy models, the detection probability model was $p_{\text{Day or Night}}$ (detection was a function of either day stand search or night station survey; 2 parameters); for pair occupancy models, the detection probability model was $p_{\text{T, Day or Night}}$ (detection was a function of a linear trend across years and day stand search or night station survey; 3 parameters). Model parameters include ψ (occupancy), γ (colonization), and ε (local-extinction); covariates include linear (T) and quadratic (TT) effects of time, Province (Klamath or Cascades), and Nesting status (whether a pair was nesting during the survey year).

Occupancy level	Model	K[a]	AIC$_c$	ΔAIC$_c$	w_i	Deviance
Simple	ψ(.)γ(T),ε(.)	6	1,153.0	0	0.20	1,141.0
	ψ(.)γ(.),ε(.)	5	1,153.1	0.1	0.19	1,143.1
	ψ(.)γ(.),ε(Province)	6	1,153.1	0.1	0.19	1,141.1
	ψ(.)γ(.),ε(T)	6	1,154.5	1.5	0.09	1,142.5
	ψ(.)γ(T),ε(T)	7	1,155.0	1.9	0.07	1,141.0
	ψ(.)γ(TT),ε(.)	7	1,155.0	2.0	0.07	1,141.0
	ψ(.)γ(Province),ε(.)	6	1,155.1	2.1	0.07	1,143.1
	ψ(.)γ(T),ε(.)	6	1,153.0	3.4	0.04	1,141.0
Pair	ψ(.)γ(.),ε(.)	6	842.5	0	0.21	830.5
	ψ(.)γ(.),ε(Nesting status)	7	843.4	0.9	0.13	829.4
	ψ(.)γ(Province),ε(.)	7	843.7	1.2	0.12	829.7
	ψ(.)γ(T),ε(.)	7	844.0	1.5	0.10	830.0
	ψ(.)γ(.),ε(Province)	7	844.5	2.0	0.08	830.5
	ψ(.)γ(.),ε(T)	7	844.5	2.0	0.08	830.5
	ψ(.)γ(Nesting status),ε(.)	7	844.5	2.0	0.08	830.5
	ψ(.)γ(TT),ε(T)	9	845.3	2.8	0.05	827.3

[a] K = the number of parameters in the model; AIC$_c$ = Akaike's Information Criterion adjusted for small sample sizes; ΔAIC$_c$ = difference in AIC$_c$ between top model and each subsequent model; w_i = Akaike weight; deviance = residual sum of squares.

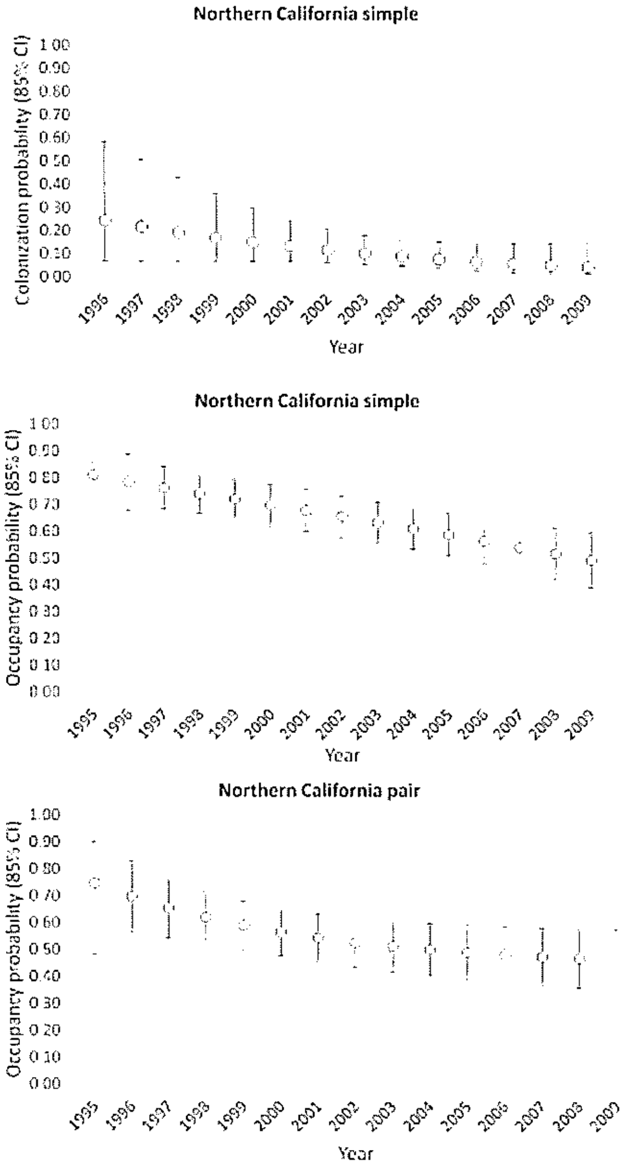

Figure 3. Estimated year-specific simple colonization probabilities and simple and pair occupancy probabilities with 85% confidence intervals for northern spotted owls, northern California, USA, 1995–2009. We calculated occupancy probabilities from the most supported models of initial occupancy, local-extinction, and colonization and using formulae from MacKenzie et al. (2003).

colonization probabilities declined during the 14 years included in their study; in contrast, Olson et al. (2005) found a consistent decline in simple colonization probabilities for only 1 of 3 study areas in Oregon; the other 2 simple colonization probabilities either increased or remained constant through time, while 1 pair colonization probability remained constant through time and 2 declined from initial levels before increasing during the last 6 years of the study. Simple colonization probabilities may have declined in our study area because recruitment declined during the study; as a result, the pool of floaters (individuals prospecting for territories) declined. We did not measure juvenile survival or emigration, so we cannot address this hypothesis. In addition, the estimated probabilities of local-extinction and colonization for both simple and pair spotted owls were small, suggesting relatively low turn-over at individual spotted owl sites.

Barred owls appeared to have occurred only as transients in our study area, suggesting that other factors were responsible for observed declines in site occupancy and corresponding differences in site occupancy estimates between our study area in northern California and results reported for Oregon and Washington (Olson et al. 2005, Kroll et al. 2010, Dugger et al. 2011). Differences in habitat types (dominant tree species and understory vegetation) and disturbance regimes (size and frequency of fires, differences in harvesting practices) are 2 primary sources of spatial variation that we were unable to model in our analysis. Specifically, we were unable to evaluate how much the amount of older forest within each spotted owl site may have influenced site occupancy dynamics. Olson et al. (2005) hypothesized that greater occupancy probabilities on 1 of their 3 study areas was a result of sites on that study area containing a greater proportion of older forest than the other 2 sites. Dugger et al. (2011) found that local-extinction probability was negatively associated with the percentage of old forest ($\geq$100 years of age) in the spotted owl site core (167-ha circle centered on the nest site). We also did not evaluate how the range of management intensity in our study area may have been associated with site occupancy dynamics. Spotted owl sites occurred on federal and private ownerships, portions of which were managed passively or actively. However, we did not have annual habitat data for all of the spotted owl sites that would allow us to model habitat-based variation in local-extinction and colonization probabilities. Collection of detailed habitat data over an extensive period, and with a resolution that accurately quantifies spotted owl habitat characteristics, poses a challenge to managers and researchers, but these attributes are probably critically important for explaining and managing spotted owl occupancy dynamics (Carey et al. 1992, Franklin et al. 2000).

In general, detection probabilities for spotted owls were <1.0 and variable, a result that agrees with other analyses using the same methods (Olson et al. 2005, Kroll et al. 2010). Average detection probabilities (across all years) were similar to detection probabilities reported by Reid et al. (1999) and Olson et al. (2005) as well as some of the years presented by Kroll et al. (2010). We did not find strong associations between province and simple and pair detection probabilities, although low sample sizes in the Cascades ($n = 16$) may have limited our ability to detect differences. Also, we did not find an association between nesting status and pair detection probabilities.

Detection probabilities of spotted owls in both the simple and pair analyses were strongly associated with survey type. Specifically, during night surveys, spotted owl calls were broadcasted from established survey stations; during informed day searches, the best abiotic locations of suitable habitat within territory core areas was surveyed, resulting in greater average detection probabilities compared to night surveys. Varying amounts of information about individual territories could lead to variation in detection probabilities resulting from informed day searches. However, by including only spotted owl sites that received consistent survey effort informed by comparable amounts of site-specific knowledge in our dataset, we attempted to limit this source of variation. We suggest that other landowners consider gathering information on a site-specific basis, as this information can be used to increase survey-specific detection probabilities, thereby limiting the amount of resources dedicated to spotted owl survey programs. For example, because of the high detection probabilities associated with informed day searches (0.93 and 0.86 for simple and pair detections, respectively), including even 1 informed day search per season greatly increases confidence in the determination of spotted owl site occupancy status.

MANAGEMENT IMPLICATIONS

Site occupancy probabilities for spotted owl pairs appeared to have stabilized in the final 5 years of our study, although the continuing decline in simple occupancy probabilities, because of reduced colonization, merits further monitoring attention. In addition, we expect that occupancy probabilities will decline in the future if barred owls become as prevalent in the study area as they have in other portions of the spotted owl's geographic distribution or if habitat quality changes significantly (e.g., after a large wildfire). Based on the large differences in detection probabilities between informed day searches and station-based night surveys, we recommend that survey programs in our study area include at least 1 informed day search, directed by informed knowledge of site conditions, in each survey season to increase confidence in occupancy status. Conducting 1 informed day search along with a 2 visit annual night survey protocol will meet the USFWS standard for confidence in site status for simple spotted owls in the Klamath Mountains and Southern Cascades biogeographic provinces. We did not find support for a relationship between detection probabilities and survey date and suggest that informed day searches can be conducted throughout the survey season (although we recommend that surveys be conducted early in the breeding season to identify both breeding and non-breeding spotted owls). To increase confidence in determination of site occupancy status for spotted owl pairs, given the lower and declining pair detection probabilities, managers should include 2 informed day searches along with a 3 visit annual night survey protocol.

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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 28 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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Electronic Copy

A copy of the Revised Recovery Plan and other related materials can be found at: http://www.fws.gov/species/nso.

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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.

PNW
Pacific Northwest Research Station

Science
FINDINGS

INSIDE

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"Science affects the way we think together."
Lewis Thomas

AN EVOLVING PROCESS: PROTECTING SPOTTED OWL HABITAT THROUGH LANDSCAPE MANAGEMENT

Tom Iraci

Fire, such as the 2003 B&B Fire on the Deschutes National Forest shown above, has replaced logging as the biggest threat to spotted owl habitat east of the Cascades.

IN SUMMARY

A network of late-successional forest reserves is central to the Northwest Forest Plan, the guiding vision for managing federal forests in Washington, Oregon, and northern California within the range of the northern spotted owl. These reserves were created to maintain older forest structure as habitat for the northern spotted owl, marbled murrelet, and other associated species. Since the plan's adoption in 1994, however, scientific thinking has evolved to question the ecological suitability of reserves as the primary recovery strategy for the northern spotted owl in the fire-prone forests of eastern Washington and Oregon.

After a century of fire suppression, forest conditions have emerged that have heightened the threat of insect outbreaks and larger, more intense wildfires than occurred historically. Research by John Lehmkuhl, Paul Hessburg, and colleagues describes how the northern spotted owl habitat is threatened under current conditions of dry forests east of the Cascades. They suggest the owl would be better served by replacing the reserve system on the east side with a whole-landscape-management approach designed to maintain and create habitats in dynamic landscapes, restore natural fire ecology, and maintain populations of species associated with older forests. The researchers are working with land managers and other scientists to address on-the-ground issues of managing for ecological objectives such as fuel reduction and spotted owl habitat.

The more intensely we have protected the forest from fire, insects, and disease, the worse many of our problems have become.
—James Agee

The Northwest Forest Plan was adopted in 1994 to break the legal stalemate over logging versus wildlife habitat protection. Years of controversy had culminated in a court-ordered injunction against federal timber harvests in the region. The plan guides management on federal land within the range of the northern spotted owl in Washington, Oregon, and northern California. The northern spotted owl is a threatened species protected by the Endangered Species Act, and its preferred habitat is old forests. The plan sought to preserve spotted owl habitat by creating a network of late-successional reserves. These reserves are set within a matrix of lands assigned various levels of active management.

After 16 years of conservation efforts through implementation of the Northwest Forest Plan, spotted owl populations continue to decline. Loss of habitat continues to be an issue—but instead of losing it to logging, in dry forests, a significant amount of habitat is being lost to wildfire. Since the plan's inception, some forest managers have questioned if the reserve strategy can address the complex problem of managing dry mixed-conifer forests with high fire danger while maintaining viable populations of northern spotted owls. A century of wildfire suppression, selectively harvesting the largest trees, and the lack of widespread treatments to mimic fire have placed many forests in eastern Washington and Oregon in the highest risk category for uncharacteristically intense wildfire.

John Lehmkuhl, a research wildlife biologist, and Paul Hessburg, a research ecologist, both with the Pacific Northwest Research Station in Wenatchee, Washington, responded to managers questions about reserve strategies with a group of studies that led to a unique, whole-landscape conservation model. "Within the Northwest Forest Plan, there was recognition of the reserve strategy's limitations on the east side of the Cascades because we have such a dynamic fire regime over here," says Lehmkuhl.

The conventional reserve network design, when applied to dynamic landscapes, takes disturbance into account by making many big reserves so that if a few are lost over time, sufficient habitat will still be retained. But the thinking about landscape management and reserves has evolved in the last 16 years.

Lehmkuhl points out that 75 percent of federal forest in the eastern Cascades landscape is already in reserves or wilderness. "You might as well just manage the whole landscape with owls in mind," he says. "It doesn't make sense to have spotted owls and their habitat in the matrix areas within the Northwest Forest Plan where active forest management is allowed. The owls could be eliminated through permitted management or lost from unplanned disturbances. It's better to have a strong vision

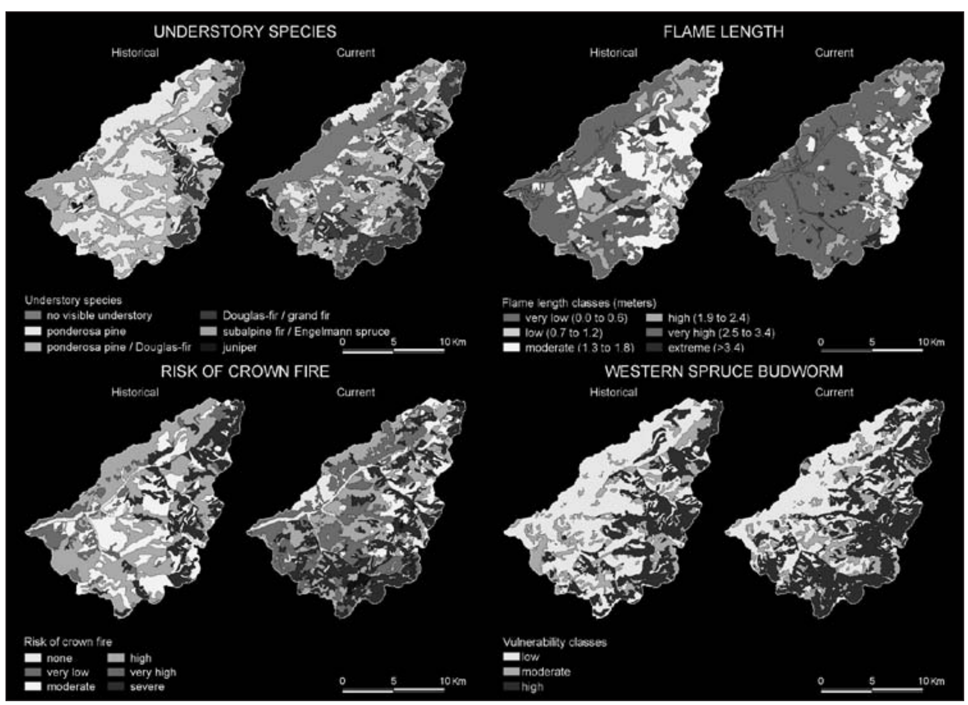
KEY FINDINGS

- Mixed-conifer forest landscapes are dynamic systems where fire, insects, and other disturbances play key roles in shaping patchy and shifting landscape mosaics. Fire suppression and other management activities over the 20th century have created unstable and unpredictable forest conditions.
- A whole-landscape-management approach would help maintain habitats in dynamic landscapes; restore ponderosa pine and mixed-conifer forests; restore natural fire ecology; and maintain populations of species associated with old forests, such as the threatened northern spotted owl, especially given projected climate change scenarios.
- Over the last century, the acreage of 100- to 150-year-old forests in eastern Washington and Oregon has increased, but the condition of these older forests is unsustainable under current fire regimes. Research shows where late-successional and old forest historically persisted and where current old forest can persist if managed in a sustainable landscape context.

of what the entire landscape can support," says Lehmkuhl.

"Reserves may offer part of a strategy in the wet Coast Range and western Cascades forests, and their counterparts on the east side, but they just don't make as much sense in the dry forests of the east side," Hessburg says. "Setting up large areas as hands off to management and saying, this is going to work for 50 years in the face of wildfires and ongoing insect outbreaks—how do you make that work? The processes that can destroy the reserves are contagious. Habitat conditions that are vulnerable to these disturbances are largely contiguous under current conditions." The question becomes, says Hessburg, "How do you maintain landscape patchworks of down logs, snags, forest structure, and composition that are highly useful to spotted owls, while retaining a more natural resistance to large, landscape-altering wildfires?"

To answer this, Lehmkuhl and Hessburg started studying current landscape patterns and reconstructing historical patterns of the same landscapes. "We found that landscapes prior to the fire-suppression era had fairly predictable characteristics," Hessburg explains. "For example, they were dominated by a more fire-tolerant patch structure and composition, and the more fire-vulnerable patches were disconnected spatially from other fire-vulnerable patches. So long fetches of running crown fires were relatively uncommon in the historical landscape where the



Comparisons of presettlement era (historical) and current forest vegetation, fire, and insect vulnerability in a watershed in the Crooked River subbasin, Oregon.

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spotted owls apparently evolved. Instead, stand-replacement patches were less common and more variable in size, most being less than 1,000 acres," Hessburg says.

"More importantly, when we compared historical landscapes to our existing landscapes, we saw that our past management had inadvertently set up a near perfect-storm scenario for wildfires, bark beetles, defoliators, dwarf mistletoes, and root diseases. We are learning that we need to evaluate large landscapes by considering a variety of features and processes, asking how do they currently function and how would they naturally function as landscapes in this or any other future climate? Management can then adjust patterns of forest structure, fuels, and composition accordingly to enhance species and process functionality of entire landscapes," says Hessburg.

"The trouble with large unmanaged reserves on the east side today," Hessburg continues, "is that they're wildfire habitats with a bull's-eye on them. A 10,000-acre reserve has so much edge that fires migrating from many directions can find them. If you want to keep stand-replacing wildfires from spreading over great distances, you have to alter the mosaic of surface and canopy fuels to create a resistance to fire spread and intensification."

Hessburg and Lehmkuhl think that this troubling situation can be addressed by restoring some of the spatial isolation of late-successional forest patches that once characterized the native landscape. This can be done by treating the surface and ladder fuels in between untreated late-successional patches. This reduces the likelihood that fires will spread across the landscape. They theorize that based on reconstructions of historical landscape dynamics, certain landscape patterns of forest structure and composition lessen the ability of fires and insects to move from one stand to another, whereas others actually facilitate their spread.

The scientists base their ideas on key spatial characteristics of the historical dry-forest mosaics. No two mosaics were ever alike, but they exhibited patterns within a particular set of conditions. Their research over the years has attempted to characterize those patterns in terms of the way fire, insects, and even pathogens functioned within them.

U.S. Forest Service

Prescribed burning alone is useful in some stands for reducing surface and ladder fuels.

Yakama Indian Reservation

Thinning may also be used alone or in combination with burning where it is difficult to meet the intent of fuel and habitat management objectives through prescribed burning alone.

THE STRATEGY'S EVOLUTION

The two scientists' theory of whole-landscape management evolved from their collaboration in the early 1990s on ecosystem management projects. Lehmkuhl was examining the influence of landscape changes on habitats and species abundance, while Hessburg was focused on landscape composition, structure, and interactions with fire and other disturbance processes. Hessburg recognized in Lehmkuhl a wildlife biologist who not only understood the habitat dynamics of species of various sizes and mobility, but also the way landscapes worked.

At the time, much research underway at the Wenatchee Forestry Sciences Laboratory focused on fire regimes, fire history, and the condition of the inland Northwest landscape. When the Northwest Forest Plan was adopted, Hessburg, Lehmkuhl, and Richard Everett, a now retired range ecologist, began thinking about managing for ecological objectives across the landscape, regardless of the land's reserve status. They were intrigued by the idea of providing suitable habitat in spatial configurations that worked for wildlife and the species they prey on, in a landscape that was highly dynamic.

Lehmkuhl and Hessburg also saw the similarities between fire and insect as disturbance processes. Both disturbances have the ability to move from one susceptible habitat location to another. To Lehmkuhl and Hessburg, that meant patterns of forest conditions really mattered across the landscape. For example, tree-killing bark beetles seek susceptible, weakened hosts after they emerge from the host trees where they develop and reach maturity. If stands of host trees of adequate size and species are adjacent to each other, beetle populations can keep expanding, and tree mortality expands along with them. The same is true of wildfires. If many adjacent forest stands, including those in reserves, have large accumulations of surface and canopy fuels, severe wildfire can spread among them.

U.S. Forest Service

After decades of selective harvesting, fire suppression, and ingrowth by more shade-tolerant species, this ponderosa pine stand is more vulnerable to fire and insect outbreaks than it would have been under historical conditions. Arrows show two remaining large ponderosa pine after selective harvesting.

"Landscape management is a dynamic problem-solving process where properties of the landscape are continuously emerging over space and time," Hessburg says. "Planning needs to acknowledge this dynamism and work with it." According to Hessburg, landscape management tries to simultaneously influence the behavior of disturbance processes such as insects and fires while providing networks of habitats that can work over space and time. The other virtue of this approach, the scientists say, is that managers do not have to keep the whole forest free from fire. Instead, they can look at the patterns that supported the kind of desired fire behavior and then manage landscapes accordingly.

CHARTING A NEW COURSE

In 2008, the U.S. Fish and Wildlife Service contracted the Sustainable Ecosystems Institute (SEI) in Portland, Oregon, to conduct a third-party science review of written comments from three scientific societies on the Draft Northern Spotted Owl Recovery Plan. The SEI gathered together a panel of recognized scientists, and asked them to assess the comments. In their review, the SEI concluded, that "a simple reserve network is unsustainable in east-side fire-prone habitats. Conservation strategies, to be viable, must be designed and implemented at the landscape level."

The whole-landscape approach would require some management changes. On one hand, it would give land mangers more flexibility and simplify management by eliminating the differing rules and guidelines for reserve and matrix lands. By looking at the bigger picture, rather than treating a particular patch of fire-prone owl habitat and risk losing it in the process, that patch could be protected by treating neighboring patches to prevent fires and insects from migrating to it. Silvicultural treatments could be planned now to provide replacement habitats later—and with plenty of redundancy to allow for fire and nature's unpredictability.

Lehmkuhl and Hessburg have been working with managers and other scientists to address on-the-ground issues of managing for such ecological objectives, particularly how to write silvicultural prescriptions for ecologically functional stands. With several colleagues, Lehmkuhl is working on a computer program called FuelSolve to help land managers decide how much fuel to remove and where treatments would effectively maintain ecological values such as spotted owl habitat. FuelSolve is unique among landscape planning programs because it helps users find a set of optimal solutions that trade-off multiple goals. Other optimization planning programs typically find a single optimal solution for a single goal like fuel reduction, for example. Having a set of solutions, instead of just one solution, gives managers options to achieve their multiple goals for that landscape, and importantly, it makes ecological goals equivalent to fuel reduction, rather than acting as constraints on fuel reduction as with typical optimization planning.

"None of us know the perfect way to realize these multiple goals in the first cut, but we see a path clearly," says Lehmkuhl. He continues, "In terms of a scientific process, we've done a lot of research that indicates that we could accomplish them. We do know a lot about the needs of the spotted owl in terms of habitat, prey, and what kind of stands they use. We also know a lot about vegetation, fire behavior, and stand characteristics. We need to put our minds together and then get started in the spirit of adaptive management, building in ways to assess our methodology and validate and adjust tactics and assumptions systematically along the way."

There's nothing wrong with change, if it is in the right direction
—Winston Churchill

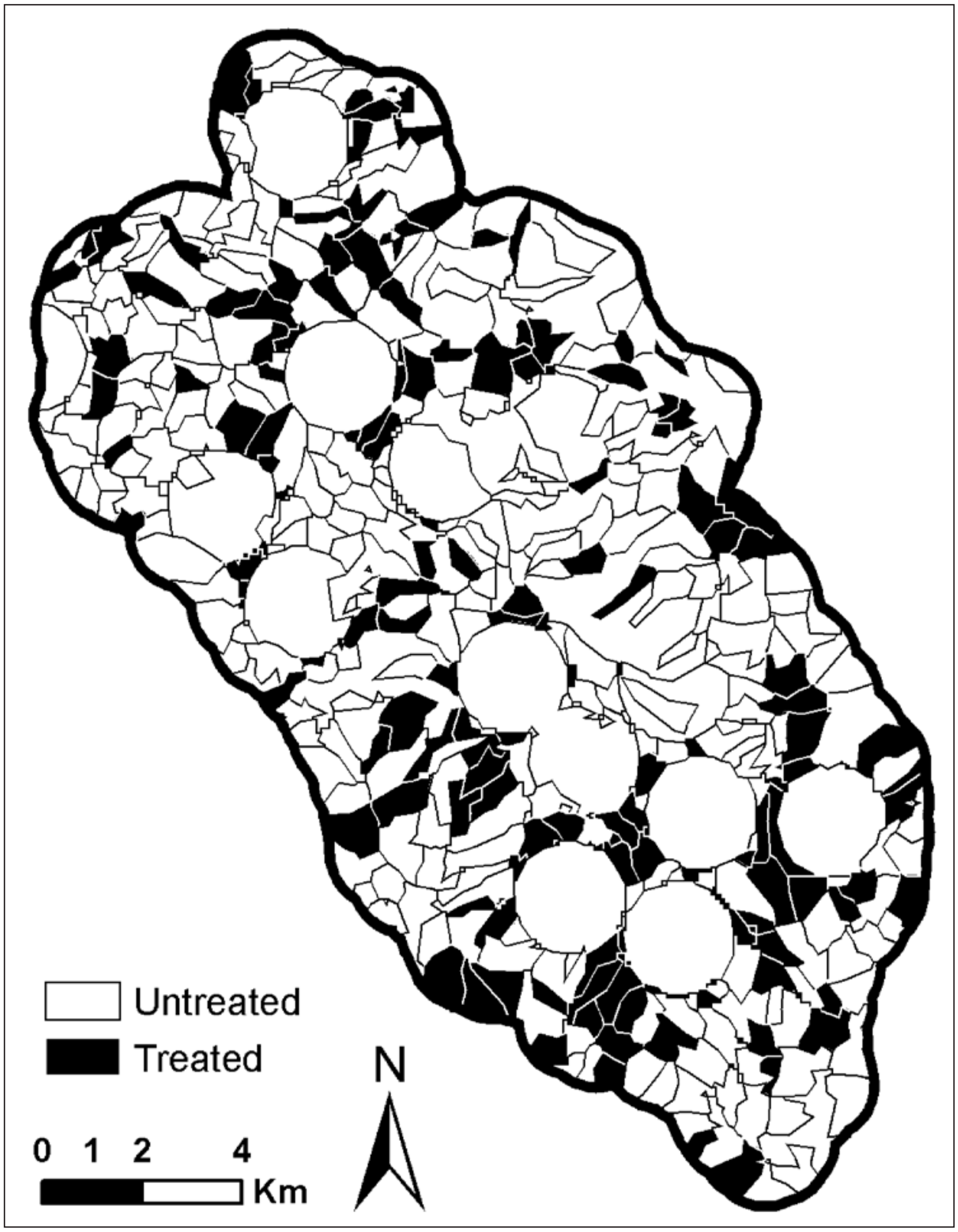
LAND MANAGEMENT IMPLICATIONS

- Under a whole-landscape-management approach, the ecological and regulatory complexity of management could be simplified by a unifying standard and guideline for maintaining ecological integrity.

- Using a whole-landscape-management approach, managers would have more flexibility to manage forests across the landscape to meet both conservation and societal objectives. Conservation would no longer be mostly relegated to reserves. Landscape units would be managed according to their needs and potential, not by arbitrary lines around land allocations.

- The spatial allocation of management across the landscape requires innovative planning solutions, decision-support systems, and an adaptive-management approach.

- New landscape-level silviculture prescriptions would need to be developed to integrate fuels reduction, vegetation management, wildlife habitat networks, and other ecological considerations into management.



An example of optimal allocation of fuel reduction treatments around spotted owl locations on the Mission Creek Drainage, Okanogan-Wenatchee National Forest. To arrive at this solution, the FuelSolve planning tool simultaneously considered the dual goals of minimizing potential fire behavior and maximizing the maintenance of spotted owl habitat. The open round circles are protected habitat around owl nest sites; the black patches are treated stands.

FOR FURTHER READING

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BIOMASS TO ENERGY:

FOREST MANAGEMENT FOR WILDFIRE REDUCTION, ENERGY PRODUCTION, AND OTHER BENEFITS

PIER FINAL PROJECT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
USDA Forest Service
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A full list of team members, research cooperators, and technical and policy advisors is available in Appendix 12.

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Abstract

The Biomass to Energy project models the costs and benefits of generating electricity from forest thinnings[1] over a 40-year period beginning in 2006. The study demonstrates that economic valuation is possible for many, but not all, valued assets[2] on the landscape, and that the impacts and costs of forest disturbance (including thinning operations) can be accurately modeled. The study includes a life cycle assessment[3] of forest operations[4] and energy conversion, measuring three biomass conversion technologies. A test of the model structure was developed on a Northern California forest landscape comprising approximately 2.7 million acres spanning the crest of the Sierra Nevada range and encompassing the Feather River basin. A Reference Case and Test Scenario were developed to test the structure and accuracy of the model using real-life data from Mt. Lassen Power (an existing biomass conversion plant), public and private forestry operations, and historic wildfire ignition patterns. Wildlife habitat impacts and cumulative watershed effects were also modeled. Results of the Test Scenario show that thinning reduces wildfire size and severity — therefore reducing fire-generated greenhouse gas emissions — while producing renewable energy. With appropriate caveats about data resolution and model sensitivity, impacts to wildlife habitat and watershed appeared minimal. The Biomass to Energy project benefits California by contributing to the state's capacity to analyze forest biomass utilization opportunities at the landscape scale.

Keywords: Biomass, renewable energy, forest biomass, forest thinnings, biomass energy conversion, wildfire, greenhouse gas, life cycle assessment, Northern California, Mt. Lassen Power

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[1] Forest thinnings are the material that is generated during forest thinning operations. Forest thinning is the selective removal of trees from a forest or portion of a forest.

[2] Examples of valued assets include structures, infrastructure, recreation resources, agricultural production, water quality, air quality, and biological diversity.

[3] A life cycle assessment is an evaluation performed to compare the full range of environmental and social impacts assignable to a product or service.

[4] Forest operations are the physical actions which change the forest, altering structure, composition, condition, or value in order to meet society's needs for clean air and water, forest products, wildlife, recreation, and other benefits.

Executive Summary

Introduction

The Biomass to Energy (B2E) project breaks new ground by offering a framework for deciding whether biomass energy generation is a suitable investment for a given forest. This study offers a credible way to establish the relative values of converting forest thinnings into energy, as well as the costs (especially wildfires and air pollution) of not doing so. Such a framework updates the debate about structuring financial incentives that correspond to avoided costs.

Biomass has been used as a source of renewable energy for approximately 50 years and currently generates about 1 percent of California's total power. From an engineering perspective, the technology is not the most efficient way to make electricity. Yet biomass conversion offers a unique paired benefit: a way to recycle forest waste into renewable energy while simultaneously decreasing potential fuel for wildfires.

Modern management practices designed to protect forests (for example, restricting thinning or excessive harvesting) have produced increasingly dense vegetation. In recent years, wildfires occurring in overstocked forests consumed brush and smaller trees (*ladder fuels*), growing into larger, more intense fires involving hundreds to thousands of acres. Such catastrophic wildfires produce more air-polluting emissions and cause more devastation to forests, including wildlife habitat and watersheds, than less intense fires.

The B2E project integrates existing U.S. Forest Service models of fire planning and forest ecology with life cycle assessment models of energy use, emissions, and cost. The life cycle assessment portion of the project assesses environmental impacts associated with treating, disposing of, and using forest biomass and producing electricity or biofuels.

In the short time between beginning this project and completing this Final Report, energy costs have jumped beyond anyone's expectations. The research team has not attempted to update cost/revenue numbers to their present dollar worth, as energy price volatility makes such computation a moving target. All cost and revenue numbers reported in these pages are in 2006 dollars.

Purpose and Project Objectives

The B2E project demonstrates the capabilities of a robust and complex modeling structure using real-world data to identify and analyze costs and benefits associated with removing biomass (thinnings and other waste) from the forest and using it to generate electrical power. Environmental benefits associated with removing biomass from forest ecosystems are quantified by the model, including decreased size and severity of wildfires and reductions in life cycle greenhouse gases and other air pollutants. In addition, this project demonstrates that it is possible to build a set of interconnected and interdisciplinary models to represent quantifiable relationships between economic investment, forest vegetation, and wildfire, on the one hand, and impacts on air quality, energy production, wildlife habitat, and other ecosystem effects on the other.

At the core of this study is a life cycle assessment, which examined approximately 2.7 million contiguous acres of Northern California forest (referred to in this study as the beta landscape.) This beta landscape contains public and private lands located at the northern end of the Sierra Nevada range straddling both the Central Valley (to the west) and the Great Basin (to the east.) Forestry operations and biomass power facilities have been part of the economic fabric of this rural region — including parts of five counties and the Feather River basin — for nearly 30 years. The beta landscape was selected to represent high infrastructure and other asset values, high fire risk, and a broad range of economic, social, and ecological diversity.

A decade is the shortest meaningful period for modeling forest vegetation growth. This study projects data over four decades, beginning in 2006, and accommodates the typical life of a power plant, which is 35-40 years. In each decade, the model measures existing forest inventory and allows for vegetation growth over time. For modeling and analysis, the beta landscape was divided into units called grid cells, each measuring 100 square meters.

For this project, the life cycle assessment models two possible conditions in the beta landscape. First, the Reference Case models only the interaction of vegetation growth and wildfires to establish an ecosystem baseline. To establish the fire model, the research team used historical data. Historically, approximately 65,000 acres within the beta landscape burn over a typical decade. Modeled fires were also burned on the landscape consistent with historic ignition patterns.

This no-treatment Reference Case is compared to a Test Scenario in which a complete menu of forest management treatments such as thinning, clear-cutting, and selective harvesting are modeled. Sawlog and biomass removal occurs during all of these treatments. In the Test Scenario, an average of 492,863 acres per decade receive treatments across the beta landscape. The energy use, emissions, costs, and revenues related to these treatments are quantified.

This B2E study used actual data from the Mount Lassen Power plant in Westwood, California, built around 1980. Mount Lassen Power, which has a long history of continuous operations, receives most of its feedstocks from forest thinning operations within a 30-50 mile radius. Mount Lassen Power provided empirical data representative of operating and maintaining a typical biomass power plant. In addition, a technical working group collected empirical data about equipment used in forest harvest operations from forestry experts. This was used to model fuel and lubricating oil consumption, machine-specific emissions, and productive machine hours.

Most landscape models lack a time dynamic. Such models make a statement about a single event or condition. The reality of forest management at a landscape level is that neither treatments nor fires take place all at once; impacts are distributed over space and time. Also, forests are dynamic systems that change and recover from impacts over time. For this reason, the team explored the need for building a time dimension into the study and concluded that sequential treatments and disturbances should be accommodated.

Developing such a conceptual framework to model landscape level changes over 40 years required a kind of daisy-chaining of various scientific models. For example, vegetation models feed into fuel models, which feed into fire models. Looking at the forest in this way presented major computational and database management challenges. Forest inventory datasets (called tree lists) often reached tens of gigabytes while calculating time-dynamic changes.

The total biomass available for energy conversion is calculated by measuring the amount of vegetation (small trees, branches, brush and litter) removed during a treatment. The next modeling steps include processing, transportation (assuming an average haul distance of 30 miles), and energy production. It should be noted that many biomass plants operating in forests use additional fuels (such as agricultural and urban waste) to achieve economic efficiencies. For this study, the model assumes that only forest waste was used to generate energy.

After treatments are modeled, a reduced level of wildfires occur over the four decades in the Test Scenario, where they are fed by post-treatment fuels conditions. Post-fire treatments (such as salvage operations) are also modeled, as are the growth of treated and untreated forest stands as well as burned stands. The model finally reports on vegetation conditions at the end of each decade resulting from treatments or fires as well as the interactions of treatments and fires in places where the two events overlapped.

Project Outcomes

An initial scenario was built to test the model. This Test Scenario — modeling thinning, transporting, and converting biomass into electrical power — yielded the following results when compared to the no-treatment Reference Case:

- $1.58 billion in power revenues, assuming an 8.3-cent per kilowatt-hour price on the wholesale power market. A negligible amount of fossil fuels (approximately 1.3 percent of total energy consumed) is required to produce this power.
- Clear life cycle climate change benefits, including a 65 percent net reduction in greenhouse gas emissions (from 17 million tons of carbon dioxide (CO2) equivalents to 5.9 million tons of CO2 equivalents.)
- A 22 percent reduction in the number of acres burned by wildfires. Even greater reductions can be anticipated by strategically locating thinning projects in areas of high fire hazard.
- A significant economic gap between the cost of biomass fuel delivered to power plants, estimated at $68 per bone dry ton, and the 2006 financial analysis of greenfield power plant development under which maximum fuel costs would have to be less than $8.20 per bone-dry ton in order to build the project.
- A dramatic drop in fire severity. Again, strategic location of thinning treatments would likely enhance this result.
- Savings of $246 million in avoided wildfire damage to assets, including timber, buildings, and infrastructure, as well as $18 million savings in avoided fire suppression costs.

- A substantial offset of fossil fuel consumed to generate the same amount of electricity over the same period (estimated at a life cycle savings of approximately 120 terawatt-hours.)
- Impacts on habitat suitability over the 40-year period from treatments and fires could not be accurately determined.
- Minimal cumulative watershed effects over the 40-year period.

This final report contains detailed explanations of these findings. Further information, including highly detailed and specific analyses, model specifications and model run results can be found in the appendices.

Conclusions and Recommendations

This study offers insights into potential economic, energy, and environmental trade-offs associated with managing forest biomass. By modeling the effects of biomass removal at the landscape level, this forest-based life cycle assessment provides a credible method of measuring the relative values of converting forest biomass to energy as well as the costs of not doing so. Such a framework can inform the debate about structuring financial incentives that correspond to avoided costs. In addition, this study invites future examination of biomass to energy applications stretching beyond the forest landscape.

Instead, the study supports development of scenarios to demonstrate the interactions of multiple benefits and impacts associated with treatments from which biomass is used for energy production. When quantifying the economics of converting forest waste into renewable energy, the net benefits to the environment extend far beyond energy production, as this study demonstrates.

The vegetation data used in the model were well-suited for estimating wildfire behavior and emissions, the economic value of harvested wood products, and power plant operation and emissions. However, these data were not as well-suited to the characterization of disturbance impacts on habitat. The study's conclusion that treatments have minimal impacts on habitat quality for the nearly 120 habitat types modeled must be viewed with caution and may change with additional research and improvements in habitat modeling.

Cumulative effects on watershed appear to be minimal. Watershed effects are highly localized depending on severity of wildfire. High severity wildfire impacts watersheds more than the impacts associated with treatments. The Test Scenario shows reduced wildfire severity, and therefore reduced soil erosion, as a result of forest thinning.

Some items cannot be modeled, such as social choices that impute value to forest ecosystems. The costs of quantifying and modeling social preferences were found to be beyond the scope and capacity of the B2E project. For example, quantification of "healthy forest conditions" proved elusive and subjective. Further research on this topic would be needed to meet the stringent quantification requirements of the life cycle assessment and economics models used in this study.

Benefits to California

The Biomass-to-Energy project has contributed to California's capacity to analyze forest biomass usage opportunities at the landscape scale. Even in draft form, the Secretary of the United States Department of Agriculture has identified the project as a "highly influential scientific assessment," with implications for how the USDA Forest Service would use life cycle assessment to evaluate the benefits of biomass power.

California has approximately 40 million acres of forest lands, nearly half of which are managed by private landowners. The economics of private forest land management historically have constrained opportunities for effective and sustainable management. The B2E project's approach is likely to assist policy makers and landowners in evaluating comprehensive and long-term benefits to the environment, as well as enhancing economic opportunities in forest-dependent communities.

Realization of the benefits of thinning forests and using the waste products for energy production are largely a matter of public choice and policy making. Many of the benefits of managing California's forests — such as reducing wildfire effects, saving fire suppression costs, providing clean air and water and other climate benefits — may be better reflected in future markets and public policy as a result of this project. Biomass power is a rare form of renewable energy in that it provides a broad range of benefits at relatively low cost to the consumer and substantial ancillary benefits to the environment. Further quantification and analysis, building on the work presented by the project, will help California's policy makers and legislators evaluate how forest biomass will contribute to larger societal and environmental goals.

1.0 Introduction and Background

California's forests represent a significant potential resource for generating biofuels and bioenergy. More recently, policy makers and land managers have begun considering the potential for forested landscapes to substantially alter carbon cycling as a mitigation strategy for greenhouse gas reduction. In addition, most of the state's developed water resources depend heavily on California's forests being maintained in healthy and resilient conditions, especially in the light of probable climate changes over the coming century. In short, forests represent a complex and critical resource, providing a broad array of public and private goods and services (Nechodom et al. 2008).

Nearly 40 million acres, or 40 percent of the state's land area, are covered by some kind of forest (USDA Forest Service 2007). The rich variety of forest ecosystems is almost unequalled in the world, with vegetation types ranging from dense coastal redwood to foothill oak woodland to mid-elevation mixed conifer to high alpine fir. California's Sierra Nevada Range hosts some of the world's most productive temperate forests, growing an impressive range of species from giant sequoia to ponderosa pine and Douglas fir to high-elevation white bark pine.

These forests are prone to wildfire. In fact, fire has been such an integral part of their evolution that foresters refer to them as *fire adapted* forests. In the absence of fire, most Western temperate forest ecosystems become vulnerable to drought, disease and catastrophic[5] wildfires. A management policy of excluding wildfires from forest ecosystems over the past century has contributed to an increasing risk of large-scale wildfires that leave forests in worse shape than after fires that burn under less intense conditions. In sum, some of the forest must burn to be healthy, but high-severity fires over large land areas can leave landscapes and ecosystems in unhealthy conditions for a very long time.

Managing California's forests toward a more stable relationship with fire has become a major focus of forest policy and management over the last several years. How to do this has been controversial. Some would prefer to "let nature take its course," leaving fires to burn largely unabated, protecting only relatively small buffer areas around valuable assets and communities, eventually "resetting" the equilibrium of forested landscapes. Others contend that only intensive forest management over very large areas will create forest structures that will be resilient to fires, allow fire suppression resources to deploy safely around communities, and ensure the long-term sustainability of forests that have been allowed to grow in unsustainable ways. Yet another perspective holds that strategically thinning patches in a pattern across the landscape reduces the rapid spread of intense wildfires, encourages fires to burn undergrowth and to thin trees naturally, and reduces the amount of resources required to manage wildfires in the future.

5. Catastrophic fire refers to stand replacement or high intensity fires that cause damage to ecological and/or economic assets and values. The B2E project also refers to these types of fires as uncharacteristically severe wildfires.

Each of these options has both ecological and economic consequences. Some of these outcomes are quantifiable, while other impacts are more elusive and difficult to measure. For example, the costs of thinning are easily measured by accounting for the expenses associated with moving machinery into the forests, removing trees and brush, and moving products with any value to their respective processing facilities and markets. However, the "costs" associated with impacts to streams, air quality, wildlife habitat or other non-market values are far more difficult to quantify. The "benefits" associated with safer forests, beauty and amenity values, or the social value of sustainably managed forests can be even more elusive.

Nonetheless, society decides how to manage public and private forests based on more than economics and cost, or on the measurable and tradable goods that flow from forest management actions. The values that inhere in forests and their management are a complex bundle of market and non-market, measurable and immeasurable, quantitative and qualitative goods and services. In an ideal universe, we would be able to hold all of these competing values against the same measuring stick, and we would be able to compare them and make choices based on a single metric. This is, of course, simply not possible. There are goods and services in our forests that are highly valued by some – and are often at the center of extreme contention – which cannot be compared to tangible goods and services, or impacts or damages to those goods and services.

In this context, a team of researchers, engineers, and forestry professionals undertook a study, funded by the California Energy Commission, to quantify where possible the multiple costs, benefits, and impacts associated with thinning forests in order to reduce wildfire risks. In addition, since management nearly always produces a flow of products, co-products and waste, the project focused on the potential to produce energy from the non-commercial portion of the wood produced. This product stream, which the project calls *wildland biomass*, or simply *biomass*, is the focus of a life cycle analysis, in which various environmental impacts associated with removal, transportation, processing and conversion of biomass to electricity are compared to the impacts associated with other ways of generating electricity.

The research team also took on another dimension of the problem that has never been modeled before in quite the same way. Could a life cycle assessment be developed to analyze the flow of biomass, energy and costs associated with the production of a healthy forest? To answer this question, two parallel life cycle assessments were attempted, one focused on the impacts, costs, benefits, and co-products associated with the production of electricity, and the other focused on the impacts, costs, benefits, and co-products associated with the production of healthy and sustainable forests. There was a risk inherent in this strategy. Defining the end-product of "electricity delivered to the grid" is fairly straightforward. However, clearly defining the end-product of a "healthy and sustainable forest" is fraught with difficulty. The former can be measured against a simple metric, i.e., megawatt-hours generated. The team attempted to measure the latter in acres that have reached a quantifiable state of "health" (which may be defined differently, based on the management objectives of different landowners) without substantially diminished capacity to maintain qualitatively measured multiple ecological benefits. While not entirely successful, this attempt rendered some very useful quantification and analytical techniques as well as modeling insights.

The team took on this challenge because of the persistent difficulties that face decision makers and stakeholders in managing public and private forests. The team tried to respond to a fairly consistent call for an honest accounting of trade-offs, costs and benefits in managing forests for multiple benefits and outcomes. At the most simple level, the driving question is: Can forests be managed sustainably to produce energy and other products while meeting objectives for maintaining healthy forest conditions (which include reducing wildfire risk and severity) as well as deriving other important forest benefits and values?

To address this question, the team set two *primary* objectives for the project, with three *secondary* objectives.

1.1. Project Objectives

The first primary objective of the research was to produce the structural framework for a life cycle assessment (LCA) approach to identify a range of environmental trade-offs and impacts involved in removal of wildland biomass to produce electricity. A second primary objective was to create and analyze a test scenario, using the LCA developed by the team. A Test Scenario was designed to test the structure of the model, to ensure that logical relationships among processes and sub-models had been established, and to allow sensitivity analyses of key modeling parameters.

Three secondary objectives were required in order to build the modeling platform. Each involved reviews and syntheses of key literature and science. First, the team synthesized scientific knowledge in key environmental areas potentially affected by wildland biomass removal, and evaluated data sources and quality for model development. This step involved a thorough review of the ecological production functions and critical ecological processes that were key to the model, and synthesis of the science about those functions and processes.

The next secondary objective was to investigate, synthesize and report the status of knowledge in environmental and resource economics pertaining to the market and non-market valuation of key indicators to be developed for the model.

Finally, since the model represents an attempt to bring disparate disciplines in the natural sciences and economics into quantified relationships with each other, a number of gaps in research were expected to become far more evident as the model was developed. Therefore a final objective was to identify critical research gaps that would allow further development of the prototype model after the first phase of the project.

2.0 Project Approach

The B2E Project was proposed to the Energy Commission in the context of a growing need to consider environmental effects across large landscapes, an approach that has been manifest in federal land management planning over the past several years. Several notable federal and state regional planning efforts have received tremendous investment and public attention in recent years, including the Northwest Forest Plan, the Sierra Nevada Framework, the Southern California Conservation Plan, the Natural Communities Conservation Plan, the San Diego County Multi-species Habitat Conservation Plan, and the Western Riverside County Habitat Conservation Plan. While many of these plans started out as a means to address one or more threatened or endangered species, in each case both scientific analysis and public pressure have resulted in an increasing focus on multiple ecological and economic processes at different scales. Challenges and appeals to federal planning processes have often focused on the "failure to analyze" landscape level processes that interact with one another to produce unintended consequences.

Federal and state public agencies have begun to put greater emphasis on complex scalar and landscape interactions. Recent discussions to improve National Environmental Policy Act (NEPA) and National Forest Management Act (NFMA) disclosure requirements have focused on how to integrate multiple processes at different scales so that the public can evaluate the impacts and trade-offs of management actions. None of this is simple, and all of it requires dramatic increases in public agency personnel, public and private analytical processes, stakeholder involvement, and complex modeling of ecological and economic impacts.

Because of this increasing emphasis on complexity and scale, the team recognized a need to "push the envelope" and attempt to meet what appears to be more frequent demand for accounting for complex interactions at landscape scales. The team recognized early in its project scoping efforts that the architecture of the final product needed to reflect the actual complexity of public and private land management decision making, taking into account the kinds of fragmented decision processes that often happen on the same landscape, with synthetic consequences for resources and values beyond the technical scope of a particular management decision. Hence, for example, the team modeled patterns of private commercial forestry harvesting alongside the landscape level thinning operations of the Forest Service on national forest lands. And these management patterns were subsequently analyzed in the context of protected and reserved areas that have an effect on the total quality of habitat and watershed resources at the landscape scale.

The research team and the technical advisory committee generally agreed that, while the effort could prove burdensome and fraught with errors and disconnections, it was nonetheless important to attempt to capture complex and highly interrelated ecological and economic processes at a scale that continues to confound land managers and decision makers. Trade-offs at a small watershed scale may be relatively easy to identify, especially when only one or two landowners are involved. But the public cares more about how the entire landscape responds, including impacts on key terrestrial and aquatic species, water quality, air quality and other public goods and services. In this spirit, the team developed a comprehensive forest biomass to energy (B2E) model to achieve the project's primary objective of identifying a range of environmental trade-offs and impacts as well as key cost and benefit relationships associated with managing forests and using the biomass generated from managing those forests to produce electrical energy.

The comprehensive B2E Model is actually comprised of a series of interconnected sub-models, which together identify and analyze economic and environmental costs and benefits of using forest biomass to generate electrical power while meeting an array of landowner forest management objectives at a landscape scale. The sub-models were built to analyze the environmental effects of different forest management strategies conducted over a specified time period through two arenas: the wildland landscape and the biomass power production plant. The landscape and power plant arenas are linked by the transport of biomass material from the wildlands to power plant. The landscape provides the surface for exploring how forest management treatments (which generate biomass material for electricity production) affect vegetation and fire behavior. Landscape-scale changes in vegetation and fire behavior ultimately determine many of the benefits associated with forest-based biomass power (including reductions in wildfire impacts on communities, forests, wildlife habitats, and watersheds; improvements in air quality and water quality; protection of human health and welfare; and renewable energy production) and the costs associated with achieving these benefits.

Three existing biomass power plant technologies and two emerging biomass conversion technologies were analyzed by the engineering and life cycle assessment teams for this project. The results of these analyses have been published by Nechodom et al. (2008), and include very early results from a next-generation thermochemical conversion technology that produces both electricity and ethanol. For the purposes of the LCA portion of this study, three of the technologies specific to electricity generation were analyzed and compared in the LCA model, per the scope of the original Energy Commission contract. The comparison of three biomass-to-electricity technologies allowed the LCA team to reveal differences in efficiencies of electricity production, energy use, and emissions impacts associated with different conversion technologies.

Data for three types of biomass power plants (a current generation combustion plant, a current generation integrated gasification/ combustion plant, and a next generation thermochemical conversion plant) were provided by the LCA and engineering teams. Nameplate and net capacity, efficiencies, and stack emissions are presented below. The emissions are supplemented to include CH_4 and N_2O emissions as described by the U.S. EPA (2003). The use of supporting equipment used at the power plant (i.e., a bulldozer, two loaders, a bobcat, a tub grinder, and a natural gas emergency generator) and ancillary grid electricity use were also included. Although the fuel use and emissions of the supporting equipment were deteriorated over time, based on the U.S. EPA's NONROAD2004 Model, the stack emissions and efficiency were held constant throughout the plant life cycle.

Ultimately, the spatial and temporal analytical methods used in the study required separation of the project's modeling processes into different *domains* in order to conduct discrete modeling and analyses. These domains are listed in Table 1 below and described in detail in subsequent sections of this report. Each of the major domain teams has completed a comprehensive report that describes in detail the modeling approaches and findings within that domain. The domain reports are included here as appendices.

Table 1 - B2E project modeling and analysis domains

Domain	Purpose and Modeling Processes
Vegetation	Determine the amount, area, and structure of vegetation across a landscape over time under different scenarios. Interact with the fire modeling domain to reflect changes in vegetation condition before and after modeled fire events. Use Forest Inventory Analysis (FIA) and other vegetation datasets to establish the initial vegetation condition on the landscape. Then use the Forest Vegetation Simulator (FVS) with the Fire and Fuels Extension (FFE) to model changes in the initial vegetation inventory in each time period (decade) due to forest management treatments and/or fires.
Fire	Use inputs from the vegetation domain for each model decade as the initial inventory and condition. Apply a series of representative ignition points and model representative forest fires and report fire effects (fire size and severity) under treated and untreated scenarios.
Equipment Configuration	Establish forest operation equipment options under each scenario. Design a representative configuration of equipment used for each forest management treatment prescription, and scale the equipment configuration to the size, location and distance of the forest treatment operation, including transportation to the conversion facility (sawmill or biomass power plant).
Life Cycle Assessment	Analyze all energy and material inputs and outputs by unit process, beginning with forest management treatments on the landscape and following all operations to terminate with interconnection with the California power grid. Assess environmental impacts, comparing them with those required to produce an equivalent amount of electricity from natural gas.
Economics	Determine economic values associated with changes in natural resource conditions across the landscape. Analyze costs and revenues of forest management and biomass conversion, and integrate these costs and revenues into market transaction and other measurable costs and benefits at the landscape level over time.
Ecosystem Services	Develop a framework for analyzing the non-market values of ecosystem services associated with forest conditions in the landscape. Specify discrete *ecological endpoints* that could be measured in economic terms to determine total system costs and benefits. (This domain remains incomplete due to cost limitations.)
Wildlife Habitat	Evaluate vegetation conditions and other environmental variables to determine effects of forest management treatments and wildfire on wildlife habitat. Assess impacts of treatments and fire on native biological diversity indicators. Integrate key ecosystem services into the habitat suitability indicators matrix for a comprehensive model of sustainable habitat conditions. Use California Wildlife Habitat Relationships (CWHR) as initial model to determine change; develop improved, empirically driven models for specific species to refine initial modeling assumptions.
Cumulative Watershed	Evaluate effects on soil erosion in aquatic systems due to forest management treatments and fire disturbances. Use the Forest Service's Water Erosion Prediction

Domain	Purpose and Modeling Processes
Effects	Project (WEPP) model, a standardized tool for measuring watershed effects, and integrate the Fuel Management Erosion (FuME) extension to determine specific effects of forest treatments on key watershed indicators. Normalize all impacts to a standardized Equivalent Roaded Acre (ERA), used in the Forest Service's Pacific Southwest Region cumulative watershed effects methodology, to compare projected watershed impacts.

2.1. B2E Modeling Domains and Processes

The following sections describe the analytical processes used in the project domains, with the general sequence of process steps outlined in Table 2 below. While the first four process steps were conducted in a sequential manner, subsequent steps were either iterative, interacting with other process steps, such as vegetation and fire modeling, or initiated separately from other processes once treatment plans were in place (for example, equipment configuration). All of the process steps were connected with other process steps, albeit to varying degrees. For example, the wildlife habitat analysis was inherently connected to the vegetation and fire analyses; however, it was independent of the LCA. Both the LCA and economic analyses relied heavily on pre-processing steps in the other domains to provide input to their respective models. Figure 1 graphically depicts the relationships and data flows between the project's various modeling and analysis domains.

Table 2. Sequence of B2E model analytical processes

Process	Domain	Outputs
Establish landscape analysis area.	General: consultation with team and stakeholders	Geographic area of analysis
Select temporal scope.	General: consultation with team and stakeholders	Time frame of analysis
Determine scenarios to be tested.	General: consultation with team and stakeholders	Hypotheses to test; independent variables; landscape goals and objectives identified
Develop vegetation treatment plans.	Vegetation, in consultation with team and stakeholders	Locations, sizes and types of treatments
Track changes in vegetation resulting from the interactions of treatments, fire, and growth over time.	Vegetation Dynamics	Acres treated by prescription and scenario; amount of vegetation removed by treatment; amount of vegetation removed by fire; amount of vegetation retained on site following treatment, fire, and growth
Analyze wildfire behavior.	Fire Behavior	Representative ignition points (following probability and risk analysis); acres burned by severity class in each decade
Calculate emissions from each	Fire Emissions	Emission factors for each type of

Process	Domain	Outputs
type of burn, i.e. wildfire, underburning, or pile burning.		burning; emission quantities for each decade, scenario and type of burn (severity and type of burn)
Determine equipment used for forest treatment operations.	Equipment Configuration	List of all machinery used, including horsepower ratings, operation hours, distances traveled, personnel required; calculation of *sides*[6] required scaled to treatment areas
Characterize power plants or other biomass conversion technologies.	Life Cycle Assessment	Selected technologies to compare; fossil fuel use and other operational materials; energy use, production and waste heat; emissions
Conduct life cycle assessment of in-forest operations and biomass energy conversion facilities.	Life Cycle Assessment; Equipment Configuration	Energy use; emissions; environmental impacts including contribution to global warming potential (GWP), acidification, and smog production
Assess changes in wildlife habitat over time.	Wildlife Habitat	Impacts to key species (requires selection of species matrix)
Conduct ecosystem services assessment.	Ecosystem Services	Impacts to key ecosystem services and ecological endpoints
Analyze cumulative watershed effects.	Cumulative Watershed Effects	Impacts to soil; soil movement
Analyze economic costs and benefits.	Economics	Damage to assets at risk from wildfire; treatment costs and revenues; power plant costs and revenues; fire suppression and rehabilitation costs (on a per acre basis)

6 Side is a common term used by harvest contractors to denote a separate and distinct blend of harvest equipment conducting harvest activities as a separate operation. This is discussed at length in the Equipment Configuration domain section.

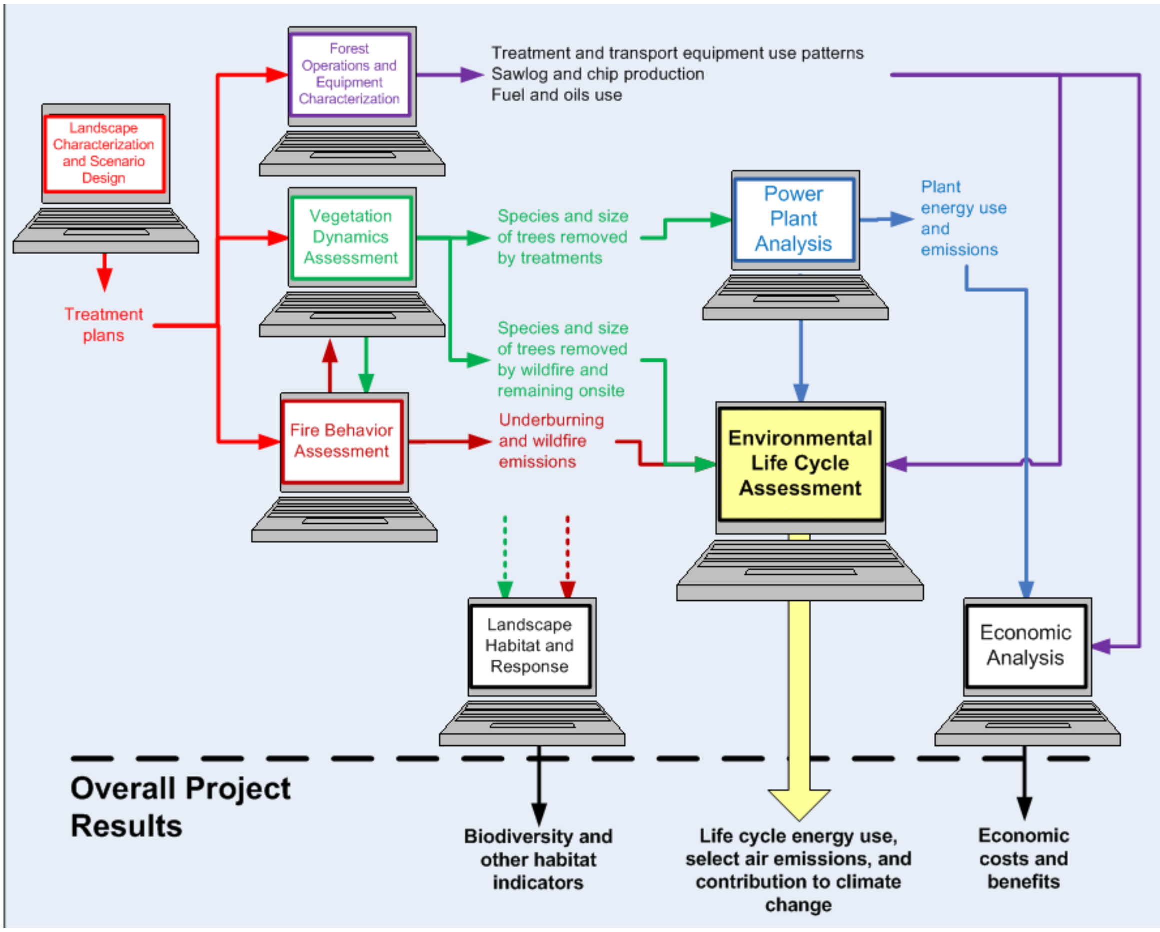

Figure 1. B2E project model

The sections below present the approaches used by each modeling domain. Section 3.0 of this report presents the modeling results in the same logical sequence.

2.2. Selection of Landscape Archetype

In this step, the team worked from an initial Alpha test landscape (1.1 million acres located in the northern Sierra Nevada), expanding to a final landscape archetype, or the Beta landscape, to include more logical regional boundaries. Criteria used to select the Beta landscape archetype included:

- **Hazardous Fuels Conditions:** A significant portion of the landscape has forest conditions that contribute to high risk and hazard for catastrophic wildfire.
- **Ownership Mix:** Given the range of values being measured as a function of changes in resource conditions, the landscape contains multiple ownerships and a range of values.
- **Human Settlement and Capital Assets:** The landscape contains a diversity of infrastructure, structures, and other assets at risk of loss to wildfire.
- **Habitat:** The landscape has a diversity of threatened and endangered species habitats that are at risk of loss from wildfire. (This allows testing the variation in higher-value habitats in the face of disturbance.)

- **Data Quality:** Sufficient data about the attributes to be assessed in each domain exist.
- **Landowner/Agency Interest:** Landowners who have significant data holdings or who are in a position to offer critical review of the data and conclusions regarding the study area are willing to cooperate.
- **Current and Past Management:** The landscape has been actively managed and active management strategies are in place. (This allows testing of the differences between treated and untreated areas. If no management regimes were in place, the project would have to make several broad assumptions about management potential on the landscape.)
- **Geographic Scope and Representative Ecoregion:** The landscape is sufficiently large to capture a diversity of landscape-level ecological processes and to measure changes in ecological endpoints (see ecosystem services model).

2.2.1. The B2E Beta Landscape

The Beta landscape encompasses approximately 2.7 million acres in the northern Sierra Nevada mountain range. The region included parts or all of five counties, a river basin (Feather River) significant for its hydropower resources, as well as other developed water assets, and nearly 180 different vegetation types, ranging from brush and shrub to dense mixed conifer forests. Population in the region was typical of a predominantly rural forested region, and forestry operations and biomass power facilities had been common parts of the economy and landscape for several decades. A growing recreation and amenity industry in the region made it ideal for testing likely changes in value of property, recreation, and other aesthetic changes due to wildfire losses as well as the impacts of fuels treatments.

The study used the following five simplified land ownership categories, stratified in large part by the degree to which lands may be managed to modify wildfire behavior and differences in administrative or policy conditions:

- **Public Multiple Use (PMU):** lands administered and managed by public agencies, specifically the Forest Service (FS) and USDI Bureau of Land Management (BLM). PMU lands do not include areas that are reserved or withdrawn from management (such as wilderness areas, wild and scenic rivers, special management areas, and so forth): such lands are included within the Public Conservation and Recreation category described below.
- **Public Conservation and Recreation (PCR):** lands administered by public agencies that are typically not managed at any significant scale, and therefore assumed to have little or no impacts on wildfire behavior through management.
- **Industrial Private Forests (IPF):** private lands managed primarily for commercial timber production.
- **Non-Industrial Private Forests (NIPF):** private lands managed occasionally for timber values. The project used the California Board of Forestry's definition for NIPF owners:

those who typically own less than 5,000 acres of forest land and do not own a sawmill or other forest products processing facility.

- **Urban and Other (U):** land that is divided into smaller parcels, usually developed with assets, structures or other infrastructure (such as dams, penstocks, landfills, and so forth). These lands are assumed to have little or no management potential in changing wildfire behavior.

Table 3 indicates the distribution of ownerships in the Beta landscape and shows that public lands comprise a significant portion of the landscape.

Table 3. Land ownership categories in the B2E Beta landscape

Land Category	Acres	% of Total
Public Multiple Use	1,374,783	50%
Public Conservation & Recreation	407,776	15%
Industrial Private Forests	457,427	17%
Non Industrial Private Forests	383,008	14%
Urban & Other	112,816	4%
Total	**2,735,809**	**100%**

The 2.7-million acre Beta landscape's location at the northern terminus of the Sierra Nevada Range and its straddling of the Central Valley (to the west) and the Great Basin (to the east) results in representation of a wide range of vegetation types, from hardwood to Jeffrey pine forest types, mixed conifer to pinyon juniper forest types. Table 4 displays the major vegetation types and their respective acreages within the Beta landscape.

Table 4. Major vegetation types in the B2E Beta landscape

Vegetation Type	Acres	% of Total
Alpine	5	nominal
Douglas-fir	4,777	0.2%
Eastside pine	398,401	14.6%
Eastside mixed conifer	579,683	21.2%
Hardwoods (productive)	34,758	1.3%
Hardwoods (non-productive)	67,640	2.5%
Jeffrey pine	10,872	0.4%
Knobcone pine	395	nominal
Lodgepole pine	27,550	1.0%
Westside mixed conifer	519,507	19.0%
Pinion-Juniper	12,209	0.4%
Ponderosa pine	219,552	8.0%
Red fir	101,499	3.7%
Non-forest types	301,392	11.0%
White fir	167,792	6.1%
Shrub types (non-productive)	289,163	10.6%
Total	2,735,195[7]	100%

2.3. Temporal Scope of B2E Modeling Domains

Most landscape models are static. That is, there is no time dynamic in the modeling, which limits the landscape model to statements about a single event or condition. The team explored the need for building a time dimension into the study, and concluded that sequential treatments and disturbances should be accommodated. The reality of forest management at a landscape scale is that neither treatments nor fires take place all at once. Compressing treatments or fire events spatially and temporally onto a landscape renders a distorted view of impacts that are in fact distributed over space and time. This distribution is meaningful in dynamic systems that recover and change over time.

The team analyzed the computational challenges of modeling vegetation changes over time, including the addition of fire and treatment events. In each decade (which is the shortest meaningful time period for modeling forest vegetation growth), the model would need to measure existing forest conditions (forest inventory); apply treatments across the landscape, providing post-treatment fuels conditions for fire modeling; then apply wildfires across the

7 The slight difference in acreage (614 ac.) between the ownership and vegetation classification, in Tables 3 and 4, is due to the methods used to measure vegetation types. Ownership is drawn from actual polygons while vegetation types are measured in 100 square meter grid cells, and a grid cell is counted under a classification only when a majority of the cell is occupied by the vegetation type.

landscape; apply post-fire treatments, under specified conditions; allow for the growth of treated and untreated forest stands as well as burned stands; and finally report on the vegetation conditions at the end of the decade that resulted from treatments and fires alone as well as the interactions of treatments and fires in places where the two events overlapped. For the Beta landscape, a typical scenario resulted in treating approximately 300,000 acres per decade and burning approximately 65,000 acres per decade, across hundreds of discrete polygons, presenting major computational and data management challenges. Forest inventory datasets (called *tree lists*) often reached tens of gigabytes while calculating time-dynamic changes.

Given these computational challenges, the team determined that a 40-year time frame – or four decadal modeling periods – was an appropriate time scale for the B2E Model to show statistically meaningful variation. In addition, this timeframe fits well with the economics that drive timber harvest (scheduled treatments are typically conducted at 20-year intervals) as well as the life cycle of the technology being evaluated (biomass conversion plants typically have a 30 to 40 year life cycle before replacement).

2.4. B2E Scenario Development

Landscape scenarios were developed to test key parameters, assumptions, and ecosystem effects. The key independent variables that could be manipulated to change outcomes and effects were primarily related to the forest management treatments: their size, spatial distribution, and intensity or type of treatment. Secondary independent variables included power plant technology and location. Dependent variables included the kinds of equipment and their configuration chosen to accomplish the treatments; economic values associated with changes in treatment and fire; and other environmental indicators of habitat, watershed, and carbon storage conditions.

The team developed a Reference Case (which modeled no vegetation treatments) and a Test Scenario (which modeled vegetation management regimes on public multiple use (PMU), industrial private (IPF) and non-industrial private (NIPF) forest lands). Table 5 below shows the basic structure and logic of the scenarios used to test the B2E Model.

Table 5. B2E Beta model scenarios

Scenario	Assumptions related to Wildland Fires and Forest Management Treatments	Average acres per decade treated
Reference Case	Baseline wildland fires burn; No treatments.	IPF/NIPF: 0 PMU: 0 Total: 0
Test Scenario (IPF, NIPF and PMU)	Baseline wildland fires burn; Treatments on IPF, NIPF, and PMU lands.	IPF and NIPF lands: 313,416 PMU lands: 179,447 Total: 492,863

The total number of acres treated does not reflect the variation in types, sizes or locations of treatments. These are described in greater detail in the section below on vegetation treatments. It is also important to emphasize that the Reference Case is technically *not a scenario*, but a hypothetical baseline case that allows comparisons with actual management scenarios.

Scenario development is importantly a collaborative process. The team used wide experience and previous analyses to develop the Test Scenario. The main purpose of the Test Scenario was to test the functioning of the B2E Model, particularly the linkages between the series of the Model's interconnected domains. However, it was clear to the team that scenarios are deeply embedded in social and policy preferences. Additional scenarios would need to engage stakeholders or specific clients in extensive discussions about landscape level goals and objectives before designs for size, type, and location of treatments could be developed.

2.5. Vegetation Treatments

As depicted in Figure 1, all of the B2E Project's models require inputs related to assumptions about vegetation treatments. For the Test Scenario, the team used experience and previous analyses to spatially arrange different types of treatments across the Beta landscape over the 40-year time period. Under future model applications, each scenario must have a clearly-defined set of assumptions relative to treatment area designs for each land ownership category and site condition (for example, slope steepness and proximity to streams). The final treatment plan for each scenario should consist of a map displaying the location of each treatment area and a crosswalk assigning a treatment prescription (a series of discrete treatment activities applied over a specified timeframe to a specific piece of ground) to each treatment area. Hence, the key steps in formulating forest treatment plans include: (a) spatially locating treatment areas across the landscape and (b) applying a series of treatment activities over time (i.e. a treatment prescription) to each treatment area.

2.5.1. Locating Treatment Areas and Assigning Forest Management Regimes

Each treatment area's size, location, and forest management regime in the Beta landscape was determined based on land ownership category. On IPF lands, treatments were designed to meet California Forest Practices Act requirements, and the modeled treatments were developed through a collaborative effort involving scientists, forestry professionals, and the team (see the B2E Project Forest Operations and Equipment Configuration Report, Appendix 3). IPF management regimes were based on a roughly evenly distributed representation of the kinds of commercial operations typically found in California. Of the approximately four million acres of commercial forest lands in California, and among the half-dozen or so major commercial operators in fire-prone forested areas, treatment prescriptions range from clear-cutting to selective harvest. In each commercial forestry operation, throughout the cycle of growing trees to maturity and harvest, thinning operations are typically used to enhance growth and reduce impacts from fire, insects, and disease. These are referred to as pre-commercial thinning and commercial thinning, the former removing smaller stems to reduce competition and enhance the growth, and the latter removing merchantable sawlogs to further enhance the growth of the remaining trees.

Similarly, non-industrial private NIPF lands are modeled under different management objectives than many of the IPF lands. Therefore a set of prescriptions must be developed that reflect the average common practices of smaller, non-industrial land management regimes. For the Test Scenario, the team assumed that these lands would be treated using selective harvests intended to continually maintain trees on site, thereby conserving future options, either for timber production or other purposes.

To locate treatments on national forest lands (which comprised most of the PMU lands in the Beta landscape), the team needed an approach that could be used to validate the modeling assumptions and verify the modeling results. Toward this end, the team relied on existing management direction from the *Sierra Nevada Forest Plan Amendment Record of Decision* (USDA Forest Service 2004), which the national forests in the Beta landscape (Plumas, Lassen, and Tahoe National Forests) are currently following to design fuels treatments. Hence, treatment area locations on national forest lands in the Beta landscape were based on a combination of defensible fuels profile zones (DFPZs), or shaded fuelbreaks, and strategically placed area treatments (SPLATs). While these two specific treatment designs were used for the Beta test, the B2E Model is designed to accommodate and test an endless array of prescriptions for management regimes and different treatment designs.

DFPZs were generally located along ridge tops and roads: these are areas where firefighters would make a stand to contain a wildland fire. A DFPZ's width is determined by potential fire behavior based on available fuels, weather, and topography. DFPZs are not designed to stop an oncoming fire, but rather to provide a safe location to facilitate fire suppression efforts. The DFPZs on the Beta landscape were located as mapped for the *Final Environmental Impact Statement for the Herger-Feinstein Quincy Library Group Forest Recovery Act Pilot Project* (USDA Forest Service 1999).

The SPLATs were located using a conceptual herringbone pattern of area treatments distributed across the Beta landscape, based on the premise that disconnected fuel treatment areas overlapping across the general direction of fire spread are theoretically effective in changing fire spread (Finney 2001). For purposes of modeling, each SPLAT was a 150-acre rectangle, oriented according to the prevailing wind direction in order to intercept a spreading fire. The Beta landscape's highly-stylized herringbone pattern of treatment areas was designed to statistically mimic what is often referred to as "the Finney Effect." The pattern has been used as a starting point for landscape-level fuels reduction planning on national forest lands in California. This pattern of treatments starts with the assumption that forest thinning treatments on approximately 30% of the total land area in a given landscape can have a "speed bump" effect by interrupting and slowing the spread of an oncoming wildland fire, ultimately resulting in smaller wildland fires with less severe effects. As the planning process proceeds, more detailed analyses of actual fuel characteristics and likely wildfire behavior allows planners and stakeholders to work collaboratively to adjust the size, location, shape and treatment prescriptions among SPLATS. The full planning process, which the Forest Service refers to as its *Stewardship and Fireshed Assessment* (SFA) process, involves several hundred person-hours of preparatory work, including a series of planning meetings for agency and public stakeholders, before the final pattern and timing of treatments is ready to be applied. The final step for the

Forest Service involves following National Environmental Policy Act (NEPA) environmental analysis before the SPLAT strategy can be implemented. It is a labor- and data-intensive process, resulting ultimately in a highly-refined, landscape-level plan for modifying the behavior, and hence the effects, of large wildland fires, balanced with other values and concerns.

The B2E project did not engage the complete SFA process as used by the Forest Service, largely due to time and resource constraints, but also because the purpose of this study was a more comprehensive landscape analysis, well beyond the boundaries of a national forest. The research team, working with the SFA cadre, did however use most of the modeling approaches used in the SFA process (described in other parts of this "Approach" section), in which vegetation and fire modeling are used to assess likely fire behaviors and outcomes on a landscape.

Approximately 30% of the PMU lands in the Beta landscape were overlaid by SPLATs; the remaining 70% of PMU lands were not assigned treatments over the 40-year time period. This should be kept in mind as further scenario development is considered in later phases of the study or uses of the model. For example, a slight increase in extent or intensivity of management on PMU lands could result in substantial increases in biomass produced, emissions avoided, electricity produced, etc.

2.5.2 Sequencing Treatment Activities over Time

As described above, types of treatment activities on lands in the Beta landscape ranged from thinning, selective harvest, and clearcut harvest on private lands to thinning on national forest lands. Regardless of ownership or type of treatment activity, all treatments were assumed to be followed by prescribed burning (broadcast burning, understory burning, or slash pile burning) to remove the *slash* (woody residues that are generated in the forest from harvesting activities).

It is important to emphasize the distinction between treatment prescriptions and activities in the modeling. *Treatment activities* are discrete management actions or events, such as thinning or understory burning. A *treatment prescription* is a series of management activities applied over the 40-year timeframe to a specific piece of ground. Hence, each treatment area was assigned a prescription sequence consisting of a series of treatment activities for each 10-year time period. In certain time periods, no treatments were assigned and the growth of the vegetation was simply tracked. For example, a regeneration prescription on IPF land would assign an even-aged harvest (clearcut) on a 20-acre treatment area in the first decade (2006), followed by pre-commercial thinning in the second period (2016), and then a commercial thinning 20 years later (2036). The entire 40-year series of management activities is captured in specific coding in the B2E model databases (see the B2E Project Vegetation Dynamics Domain Report, Appendix 1).

2.6. Vegetation Dynamics Modeling

The vegetation domain tracked changes in vegetation and fuels resulting from modeled growth, vegetation management treatments, and fire across the Beta landscape over the 40-year period. The vegetation domain was closely integrated with the Project's fire domain: the condition of the vegetation and surface fuels (combined with topological and weather variables) was used to model fire behavior (as described in the following section), with the resulting fire effects subsequently fed back and used to modify the vegetation.

The analysis assumed a dynamic landscape where vegetation was constantly undergoing change through the processes of growth, treatment, and wildland fire. The vegetation domain spatially tracked these vegetation changes at multiple scales (from a per-acre scale to an entire landscape scale) over time. The outputs from this domain supplied the raw data used by the B2E Project's other domains, which explored how these landscape-scale vegetation changes ultimately affected wildland fire behavior, electricity production, habitat conditions, emissions, carbon cycling, hydrologic conditions, economics, and ecosystem services.

Geographic Information System (GIS) spatial layers for vegetation, ownership, elevation, and slope in the beta landscape provided the foundation for the vegetation domain. This GIS coverage overlaid the entire landscape with 100-meter grid cells, with each cell assigned to a specific vegetation, ownership, elevation, and slope class.

2.6.1. Initial Vegetation Inventory

The starting point for vegetation modeling was the vegetation inventory, which described the existing condition of the vegetation across the Beta landscape in 2006. Over time, this inventory was modified by modeled growth, treatments, and wildland fire. The initial (2006) vegetation inventory consisted of two components: (1) a vegetation map and (2) Forest Inventory Analysis (FIA) plot data (which describe numbers of trees by species and size class) linked to the vegetation polygons delineated on the vegetation map.

The Forest Service periodically collects vegetation inventory data (known as Forest Inventory Analysis (FIA) data) for national forest lands as well as non-national forest lands. FIA data are gathered over a series of plots located across lands within the Beta landscape. The FIA plot data consist of (a) site reference information (plot location, inventory date, slope, aspect, elevation) and (b) the characteristics of each tree sampled (species, size, canopy position, and so forth, collectively referred to as the tree list for each sample plot). The Forest Service Pacific Southwest Region's Remote Sensing Laboratory provided the FIA data for the Beta landscape.

The vegetation domain team linked the FIA plot data to the vegetation map to provide for statistically valid estimates of vegetation change. Vegetation strata labels served as the bridge between the mapped vegetation polygons and the FIA plot data. A strata label can be thought of as each mapped vegetation polygon's address: the strata label is based on the polygon's vegetation type, tree size, and canopy cover in 2006. Each FIA plot was assigned to a specific vegetation stratum, thereby making it possible to aggregate the tree lists from all the plots assigned to that vegetation stratum. Hence, the vegetation inventory for a particular stratum was represented by an aggregated tree list, which was comprised of the individual tree lists from each of its plots added together. Embedded within each mapped vegetation polygon was a set of 100 square meter grid cells. Every grid cell with that stratum label address started through the vegetation modeling with the same aggregated tree list. Over time, treatment, wildland fire, and growth changed each cell's tree list, depending on the prescription sequence assigned to it.

2.6.2. Modeling the Effects of Forest Treatments on Vegetation

As previously described, management prescriptions were comprised of a series of discrete treatment activities applied over the 40-year beta-test timeframe to a specific grid cell. Hence, each grid cell had a prescription sequence consisting of a series of treatment activities assigned by time period. The strata label served as each grid cell's address while the prescription sequence described the treatment activities that occurred at that address over time (for example, thinning followed-up by underburning in the first decade, no treatment in the second decade, a second thinning in the third decade, and no treatment in the fourth decade).

Sawlog and Biomass Material Removed. For each treatment activity, the vegetation dynamics domain team developed specifications for removing trees from the tree lists. (As previously described, the tree lists were linked to the strata labels (addresses) assigned to each grid cell.) These specifications determined the quantities of sawlogs and biomass material removed from the treated stands.

Residual Stand Conditions following Treatments. The specifications for removing trees from the tree lists had a direct impact on residual stand conditions. For example, specifications for pre-commercial thinning were to remove trees from the tree list such that approximately 225 trees per acre were retained following treatment. The specifications also included favoring retention of commercial conifer species, in other words, targeting non-commercial conifers and other tree species for removal from the tree list. The specifications developed for the Beta test are but a small sample of the possible specifications that could be developed in further scenario testing: the B2E Model was designed to accommodate any possible specifications for removing trees from the tree lists (as well as adding seedlings).

2.6.3. Modeling the Effects of Wildland Fires on Vegetation

The fire domain team modeled wildfire behavior and resulting severity as described in the next section. The vegetation domain team then used the fire severity data for each decade to determine the numbers of trees killed and the amount of biomass consumed by fire. The vegetation team used the First Order Fire Effects Model (FOFEM) (Reinhardt and Keane 2003) to estimate tree mortality (in other words, which trees to remove from the tree lists) based on flame lengths associated with different fire severity classes (described in the fire behavior section below). FOFEM predicts fire-caused tree mortality using bark thickness (based on tree species and diameter) and crown volume scorched (based on scorch height, tree height, and canopy base height).

In addition to estimating trees killed and trees consumed by wildfire, the vegetation team also used the wildfire severity data (combined with ownership classification and management regime) to adjust the prescription sequence for treatment areas that burned in wildfire during any of the four time periods. For example, a cell with an initial prescription sequence of thinnings applied in the first and third decades that intersected with a lethal fire in the third decade would have the following prescription sequence assigned: (1) thinning followed-up by underburning in the first decade, (2) no treatment in the second decade, (3) a lethal fire followed by salvage and tree planting in the third decade, and (4) pre-commercial thinning in the fourth decade).

2.6.4. Modeling Vegetation Growth

Vegetation growth was modeled on all grid cells in each decade. To account for growth, the vegetation domain team used the Forest Vegetation Simulator (FVS) Model (Stage 1973), a computer program used to project the development of forest stands. FVS is an individual-tree, distance-independent growth and yield model. It has its structural roots in the Stand Prognosis Model developed by Albert Stage from the Intermountain Research Station. Staff at the Forest Service's Forest Management Service Center in Fort Collins have calibrated many variants of the model to specific geographic areas throughout the United States. For the Beta landscape, growth equations were derived directly from the Inland California Southern Cascades (ICASCA) variant of FVS.

In any given decade, it was possible for a single grid cell to be assigned a treatment, wildfire disturbance (with effects on the vegetation), and subsequent salvage harvest. In these instances, the following sequence of activities (and effects on the vegetation inventory) was tracked in order: treatment, wildfire, and salvage, all of which were assumed to occur in the first year of the decade. Vegetation growth for the grid cell was then modeled for the remainder of the decade.

2.7. Wildfire Behavior and Severity

This section briefly describes how the team modeled the interaction between wildfire and vegetation under treated and untreated conditions. While Table 2 above separates these steps to clarify the overall project's sequencing of processes, in fact the vegetation dynamics and wildfire behavior domains interacted iteratively to produce the final results for vegetation change for the 40-year span of the study.

Wildfire modeling is a complex process, and models are difficult to calibrate. When scientists model wildfire, they are usually modeling what is called *fire line intensity*. That is, rather than modeling the behavior of an entire fire, with all its complex dynamics and internal weather patterns, most fire models attempt to mimic the behavior of flames at the perimeter of the fire as it moves through vegetation. Two major forms of data are used to model fire line intensity: vegetation and weather. The vegetation data tells the model about the structure and condition of fuels that are being burned. The weather data fundamentally tells the model about the amount of oxygen available by applying models of wind behavior and moisture in the air. Between these two factors, scientists are able to predict how high the flames will get (flame length); whether the flames will reach into the crowns of the trees (active or passive crowning), thereby increasing the speed at which the fire will spread; and the number of trees of a particular size that will be killed by the fire (fire severity).

Locating the places where modeled wildland fires would start (ignition points) presented the team with a fundamental challenge. Since the team determined that the B2E modeling effort would be spatially explicit where possible, the locations of wildfire ignition points had to be specified. The fire domain team ran a randomized ignition experiment across the entire landscape, using risk ratings for ignitions and fuel hazard ratings for vegetation fuel conditions (Figure 2).

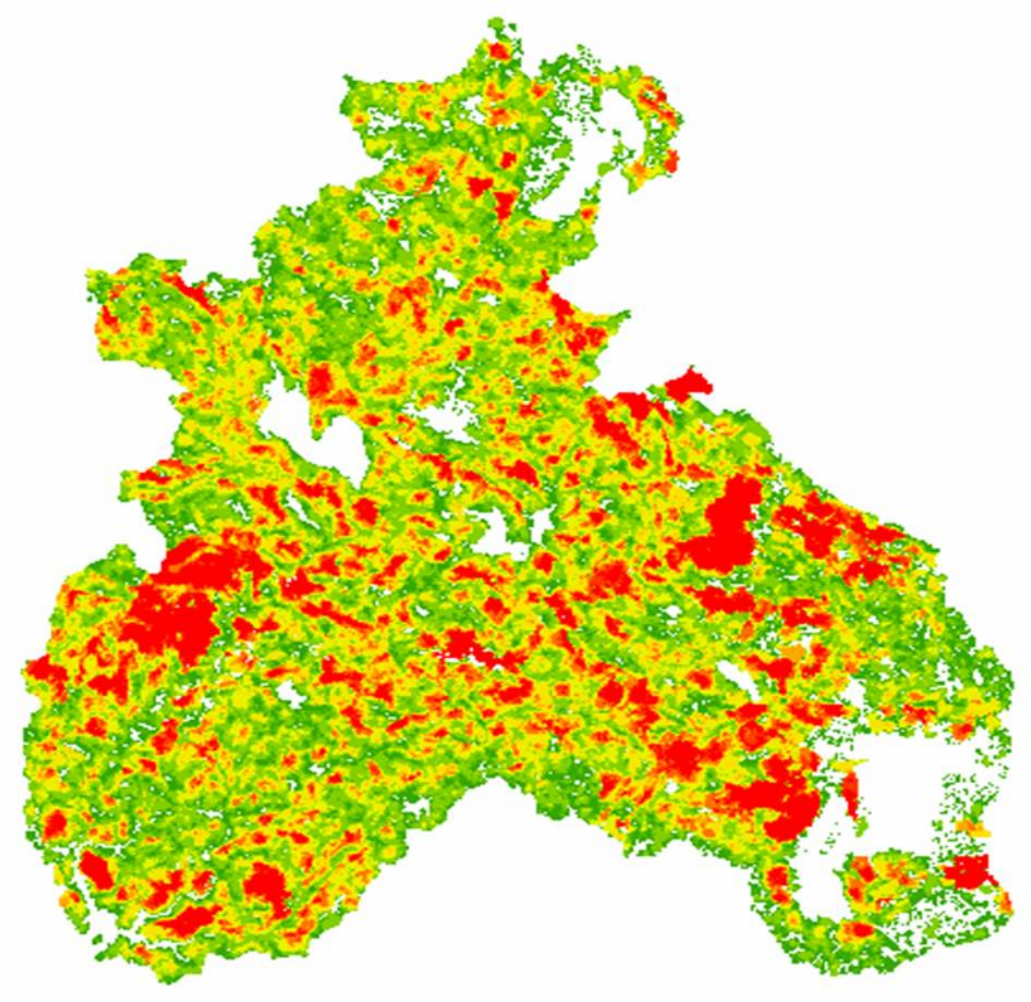

Figure 2. Randomized ignition locations to locate most logical representative ignition points on the B2E Beta landscape.

The randomized ignition map was compared with maps of historical ignition locations from 60 years of fire history. This mapping exercise allowed the team to select discrete ignition points at locations across the Beta landscape, recognizing that demographics, human activities, and climatic conditions would vary with time (Figure 3).

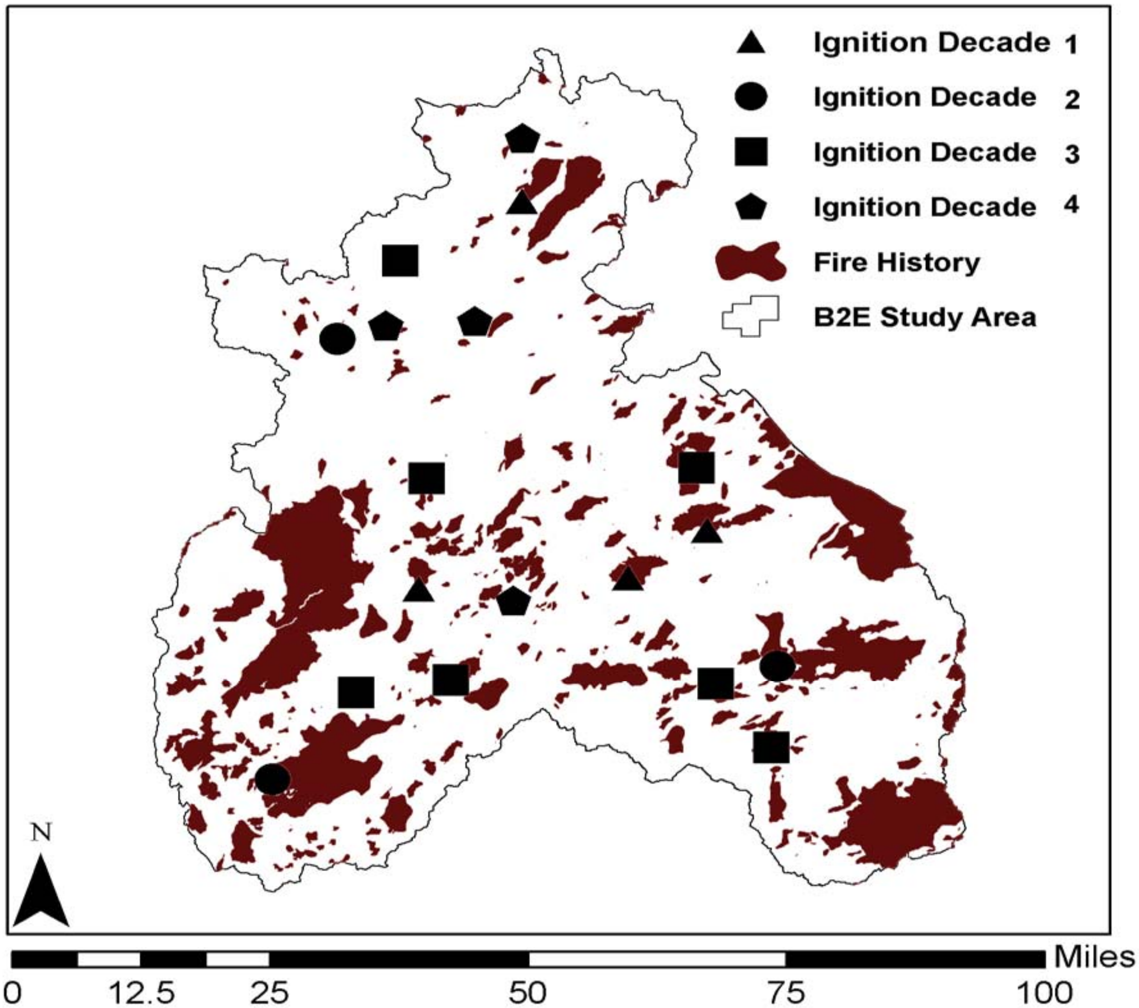

Figure 3. B2E Beta landscape fire history and ignition placement by modeled decade

After the representative ignition points were selected, the wildfire modeling team used the vegetation GIS layers provided by the vegetation dynamics domain team for each decade within the Reference Case and Test Scenario, as inputs to the wildfire model. The wildfire modeling team then tested for change in wildfire severity and the number of acres burned through each decade for the Reference Case and Test Scenario. Modeling outputs included the number of acres burned in three classes of fire severity (lethal, mixed-lethal, and non-lethal fire effects).

Fire behavior was summarized into three classes of severity to distinguish and report changes in wildfire effects across the Beta landscape (Figure 4). Burned areas were classified based on spatially explicit FlamMap Model (Finney, Britten et al. 2006) results of fireline intensity and the crowning behavior of the fires. The severity of wildfire burned on each 100 meter^2 grid cell was assigned to one of three classes (non-lethal, mixed lethal, or lethal effects) depending on its flame length and fire type (ground fire, passive crowning fire, or active crowning fire).

Fire severity was used to determine the numbers of trees killed and the amount of biomass consumed by fire, and these effects were tracked in the vegetation assessment domain. Simulations were performed on a 10-year temporal sequence for 40 years with a series of fires taking place immediately at the beginning of each decade in each management scenario. Note that if a particular grid cell was treated and burned in the same decade, the treatment effects on vegetation were assumed prior to wildfire being modeled on that grid cell. Both treatment and fire (and, in specific instances, salvage) were assumed to occur in the first year of the decade with growth of the modified vegetation modeled for the remaining years of the decade.

Fire Severity Classes		Fire Type (Crown Fire Activity)		
		Ground	Passive Crowning	Active Crowning
Flame Length (feet)	0.00-3.99	N	X	L
	4.00-7.99	X	X	L
	8.00-11.99	X	L	L
	12.00+	L	L	L

Figure 4. Classes of fire severity used in B2E fire modeling: (N) = non-lethal, (X) = mixed lethal, (L) = lethal

The interaction of vegetation and fire is a critical component of any landscape level analysis. In the B2E Project, these two domains constituted the core from which all further modeling domains operated. Once the spatial and temporal scope had been selected and the interaction of vegetation, treatments and wildfire had been modeled, the team was ready to investigate secondary or "downstream" activities. The following sections contribute to analysis of the impacts and effects that follow from the interactions of vegetation and wildfire on a landscape level.

2.8. Fire Emissions Model

After modeling interactions of vegetation and fire on the landscape, the fire emissions domain team was able to characterize emissions from three types of fire: wildfire, underburning, and pile burning. Wildfire burning has been described in detail above. The other two classes of fire are built into the treatment prescriptions analyzed by the vegetation domain team. Under most prescriptions, biomass that is too costly to collect and process is generally piled and burned at the treatment site. Useable biomass was assumed to be removed to the power plant. The vegetation domain report describes each prescription in detail while the equipment configuration domain report describes equipment used to pile slash and burn the piles.

Underburning, the final of the three classes of fire modeled, is used as a treatment follow-up procedure, and was included in the "package" for each treatment prescription, where appropriate. Typically follow-up underburning is conducted within the first one to three years after a treatment is implemented. Since the B2E model has compressed all treatments and fire events to the beginning of each decade for computational efficiency, underburning was assumed to be part of the treatment.

The starting point for calculating fire emissions was determining the amount of woody material the fire (either wildfire or prescribed fire) consumed. Once the amount of material consumed by fire was determined, the corresponding emissions were calculated using vetted relationships between types of forest fuels combustion and corresponding emissions, typically referred to as emission factors.

2.8.1. Fuel Consumption

Wildfire. The vegetation domain team supplied data on amounts of vegetation consumed by wildfire in each decade, based on the CONSUME Model (Ottmar et al. 2001). The CONSUME Model calculates the amount of woody material (in the form of duff, litter, twigs, and foliage) that would be consumed during a low intensity fire (approximating the level of consumption expected in a prescribed underburn). Hence, several adjustments were needed to account for (1) the range of possible wildfire severities, from non-lethal to lethal fires and (2) the full range of vegetation types (including tree stems as well as brush and grass) that could be consumed by modeled wildfires in the Beta landscape.

CONSUME Model vegetation consumption data supplied by the vegetation dynamics domain team was used for all areas affected by modeled non-lethal wildfire. To account for consumption during mixed lethal and lethal fire events, consumption multiplier factors (Table 6) were applied to the vegetation domain consumption data, based on consumption efficiencies measured from actual crown fires in similar forest types (Environment Canada 2007, Taylor and Sherman 1996).

Table 6. CONSUME Multiplier Factors (MFs) for non-lethal, mixed lethal, and lethal fires.

	Fire Severity		
	Non-Lethal	Mixed Lethal	Lethal
Multiplier Factor (MF)	1	1.8285	2.657

The vegetation domain data do not include inventory or consumption values for the grass vegetation type (strata code UGR) or the brush/shrub vegetation type (strata code ZBR) because there are no growth models for these vegetation types in the Forest Vegetation Simulator (FVS). In addition, the vegetation domain's consumption data do not include consumption values for the boles of the trees. The fire emissions domain team applied the following assumptions to first calculate the inventory of grass and shrub types (in bone dry tons, BDTs) (Table 7) and then to calculate wildfire consumption of tree stems and fire events in the grass and brush vegetation types (Table 8).

Table 7. Inventory assumptions for the brush and grass vegetation types

Strata Label	Vegetation Type	Amount of Vegetation (BDT/Acre)
UGR	Grass	4
ZBR	Brush/Shrub	12

Table 8. Combustion efficiencies (combustion factors, CF) for various vegetative components by fire severity class

	Fire Severity		
	Non-lethal	Mixed Lethal	Lethal
Tree Stems	0.02	0.02	0.02
Brush	0.3	0.6	1
Grass	1	1	1

Piling and Burning, Underburning. As previously described, smaller woody material that is left on site following tree removal operations is treated either through piling and burning the material (typically on flat terrain or gentle slopes where mechanized equipment can be used to pile the material) or underburning. The vegetation domain supplied information on the quantities of this material that would be consumed in prescribed fire treatments as follows: small woody material between 0 and 3 inches diameter (reported in cubic feet, converted into BDTs); tops and limbs of all trees removed (BDTs); and brush (BDTs) remaining in treated stands.

2.8.2. Calculating Fire Emissions

Once the quantities of material consumed by fire were determined, the emissions associated with the amount of material burned under specified burning conditions were calculated using emission factors. *Emission factors* (EF) are defined as "the mass of pollutant produced per mass of fuel consumed" (Ottmar 2001). EFs for each of the three fire severities (non-lethal, mixed lethal, and lethal) were provided by the Western Regional Air Partnership (WRAP) Program's Fire Emissions Joint Forum (FEJF) and the Inter-RPO National Wildfire Emission Inventory Project (Air Sciences Inc. 2005; WRAP-FEJF 2006; Randall 2006; Adelman 2004; EPA 2002). The EFs are the result of collaborative research between WRAP and the FEJF, and rely on a point source approach to represent wildland fires, their combustion and emissions within typical western forest types.

Determining the appropriate EF for a particular type of burn first required identification of each burned grid cell's applicable NFDRS (National Fire Danger Rating System) Fuel Model. NFDRS Fuel Models are typically linked to vegetation strata labels. Since the strata labels in the B2E vegetation modeling process served as each grid cell's "permanent address," they did not change from one time period to another. Hence, the emissions domain team used an alternative approach to accommodate changes in the vegetation over time (i.e. succession and growth between time periods). The team constructed a crosswalk based upon expert opinion of both systems (Table 9). This crosswalk links emission factors developed for the NFDRS fuel models (applicable to California vegetation types) to California Wildlife Habitat Relationships (CWHR) types across the Beta landscape. Hence, each CWHR type was linked to a specific NFDRS Fuel Model[8], as shown in Table 9 below.

The first step in developing the crosswalk was to disregard NFDRS fuel models not applicable to California vegetation communities. For example, Fuel Model N was eliminated from consideration because it was constructed specifically for the sawgrass prairies of south Florida. Then the expert reviewed the text accounts and available habitat stages for each CWHR habitat type (California Department of Fish and Game 2002). For each possible CWHR habitat and habitat stage, the NFDRS fuel model that most closely portrayed the typical fuels conditions present in the given habitat and stage was identified. This determination was made through information presented in the CWHR habitat text accounts, and expert knowledge of the various habitats. In some cases, assigning a fuel model code to a given CWHR habitat and stage was difficult due to the relatively few number of models, and the inability of any model to accurately describe the vegetative conditions present in the given habitat and stage. In these cases, expert knowledge was used to select the fuel model that most closely approximated the fuel conditions (rather than vegetative conditions) that would be present within the habitat type and stage.

8 http://www.fs.fed.us/fire/planning/nist/nfdr.htm

Table 9. Example Crosswalk between NFRDS Codes and CWHR Types (partial table)

NFDRS Fuel Model[4]	Vegetation Type	CWHR Vegetation Type	CWHR Tree Size and Canopy Cover	CWHR Tree Size and Canopy Cover
L	Ponderosa Pine	P	1S	Seedling, sparse cover
F	Ponderosa pine	P	2D	Sapling, dense cover
L	Ponderosa pine	P	2M	Sapling, moderate cover
L	Ponderosa pine	P	2P	Sapling, open cover
L	Ponderosa pine	P	2S	Sapling, sparse cover
U	Ponderosa pine	P	3D	Pole-sized tree, dense cover
C	Ponderosa pine	P	3M	Pole-sized tree, moderate cover
F	Ponderosa pine	P	3P	Pole-sized tree, open cover
U	Ponderosa pine	P	4D	Small tree, dense cover
C	Ponderosa pine	P	4M	Small tree, moderate cover
C	Ponderosa pine	P	4P	Small tree, open cover
C	Ponderosa pine	P	4S	Small tree, sparse cover
U	Ponderosa pine	P	5D	Med./large tree, dense cover
C	Ponderosa pine	P	5M	Med./large tree, moderate cover
C	Ponderosa pine	P	5P	Med./large tree, open cover
C	Ponderosa pine	P	5S	Med./large tree, sparse cover
U	Ponderosa pine	P	6	Multilayered canopy, dense cover

Using the NFDRS Code (crosswalked from CWHR type) and the moisture condition for lethal, mixed lethal, or non-lethal fire, the WRAP Emissions Factor Table (Table 10) provided the applicable emissions factors. For all wildfires, a moisture condition of dry was assumed. For underburning a moisture condition of moist was assumed and for pile burning, wet conditions were assumed.

Table 10. Example WRAP Emission Factors (abbreviated and partial table)

NFDRS Code	Moisture Condition (MC)	NFDRS Code, MC	Fire Severity	**PM 2.5 EF** (lbs. emitted per ton of material consumed)	**PM 10 EF** (lbs. emitted per ton of material consumed)
U	2 - Dry	U2	lethal	24.5594	28.98
U	4 - Moist	U4	non-lethal	28.6554	33.8133
U	5 - Wet	U5	non-lethal	27.9954	33.0345

For each fire, the tons of emissions for each pollutant (T_P) were calculated using the following formula:

$$T_P = (BDT_{fire} * P_{ef}) \div 2000$$

Where:

T_P = Tons of Pollutant

BDT_{fire} = Bone-Dry Tons of biomass consumed by fire

P_{ef}= emission factor (*ef*) expressed as pounds of pollutant produced per ton consumed by fire

2.9. Forest Operations and Equipment Configuration

From a modeling perspective, forest management treatments are deterministic events. The activities associated with management of vegetation constitute a realm of actions that, collectively, have energy use, emissions, and costs and revenues that can be quantified. In order to quantify these elements, assumptions must be made about the nature of management activities, including the prescriptions applied and the machinery used, that result in movement of products and co-products from the forest to the processing facility (power plant or sawmill).

The equipment configuration team identified the combinations of equipment that would be representative of an "average" forest treatment operation. Equipment configuration modeling was a collaborative effort, involving members of the team, representatives from the logging industry, forestry academics, and biomass power plant fuel procurement officers. Several iterations of the equipment configuration model were developed, beginning with the Alpha model phase and based on actual field data and experience from the Westwood, California, area and the Mt. Lassen Power biomass plant. The types of equipment used, and how it would be deployed on a given site to implement treatment prescriptions, provided the basis for the next step in the B2E modeling sequence, the life cycle assessment.

The equipment configuration domain team's approach used the expert opinion of harvesting contractors and supervisors currently conducting forest management activities in Northern California. Experts were interviewed regarding specific types and quantities of equipment for each harvest treatment prescription and range of slope conditions. Different equipment configurations were developed that were representative of the kinds of side[9] that would be deployed for each modeling condition. Table 11 provides a summary of slope class, treatment prescription, and equipment configuration code.

9. Side is a common term used by harvest contractors to denote a separate and distinct blend of harvest equipment conducting harvest activities as a separate operation. For example, a large thinning operation (several hundred acres in different locations) on national forest land might use two or three sides deployed separately in order to complete the work within the 120 day operating season. Each side is a complete set of all equipment needed to complete harvest, collection, processing and transportation operations.

Table 11 - Equipment configuration code by slope class and treatment prescription

TREATMENT PRESCRIPTION PER OWNERSHIP TYPE	SLOPE CLASS	EQUIPMENT CONFIGURATION CODE
Clearcut (CC) - Even-aged management. Only occurs on industrial forest lands.		
IPF	Less than 35%	CC <35
IPF	35 to 50%	CC 35-50
Pre-Commercial Thinning (**PCT**) **-** No sawlogs removed. Only biomass fuel removed. Typically in plantations.		
IPF	Less than 35%	PCT <35
IPF	35 to 50%	PCT 35-50
Commercial Thinning (**CT**) - Sawlogs and biomass fuel removed. Typically in plantations.		
IPF	Less than 35%	CT <35
IPF	35 to 50%	CT 35-50
Salvage (SAL) - Assumes that no biomass fuel (3.0 to 9.9 inches diameter at breast height (dbh) or limbs/tops) is recovered.		
IPF	Less than 35%	SAL <35
PMU	35 to 50%	SAL <35 Public
IPF	Less than 35%	SAL 35-50
PMU	35 to 50%	SAL 35-50 Public
Select Harvest (SH) - Uneven-aged management harvest removing high-risk trees in mature stands.		
IPF/PMU	Less than 35%	SH <35
IPF/PMU	35 to 50%	SH 35-50
IPF/PMU	Greater than 50%	SH 50+
Restrictive Thinning (RT) - A light thin, but retain 40% canopy. Public lands only.		
PMU	Less than 35%	RT <35 Public
PMU	35 to 50%	RT 35-50 Public

The blend of equipment is labeled with the equipment configuration code as shown in Table 11, based on slope class (topography) and treatment prescription. The equipment configuration team's analysis also synthesized estimates provided by interviewed experts of average production rates for each side. This approach contrasts with those that use empirical or mechanistic models to calculate production rates as a function of site and stand conditions (such as average tree size and skidding distance). The Project's equipment configuration model can easily generate estimates for an almost unlimited number of scenarios. The B2E approach is considered more realistic and provides more precise values for overall costs and production rates because of the level of detail included. However, this approach suggests that further model development must take into account the need to review equipment configurations that comport with regional and local forestry practices.

For each type of equipment, the equipment configuration team selected one or more representative models used in California or currently available equivalents. The team then collected data on purchase prices, fuel consumption rates, and other parameters. The team's equipment choices do not indicate recommendations or preferences for any particular models. It was not practical, nor did the team consider it necessary, to include the full range of equipment model options in the analysis.

Equipment used for prescribed burning was *not included* in this analysis. Prescribed burning equipment configurations would be more appropriately modeled in another iteration of the B2E Model, as they tend to be more similar to the fire suppression equipment configuration. Fire suppression was not modeled as part of the LCA because of the highly diverse configurations of equipment deployed during fire suppression operations on any given fire.

With the equipment configuration analysis completed, the team was able to proceed to build the LCA model. The LCA required detailed analysis of at least two major categories of activities: in-forest (described here) and power plant operations (described in the next section). In-forest operations included all operational steps from harvest to delivery of biomass to the power plant. The modeling did not include any of the resources or impacts associated with scoping, planning or monitoring of in-forest operations. As with fire suppression, these equipment configurations tend to be highly variable for any given operation, and it was deemed impractical by the team to include even a highly-abstracted version of planning and administrative infrastructure.

To summarize clearly the areas of forest management that are not included in the LCA, but which may have measurable impacts on emissions and forest operations:

1. Equipment configurations appropriate to prescribed fire operations (producing the emissions that are generated by underburning, as is seen in the LCA model);

2. Equipment configurations and impacts associated with fire suppression activities;

3. Administrative operations, such as planning, monitoring or research and analysis.

Given the high degree of variability associated with each of these activities, it would not have been realistic to attempt to build representative operational models for them.

2.10. Biomass Energy Conversion Technology Characterization

As mentioned above, two areas of operation affect total system emissions and energy consumption. The first is in-forest operations, captured by the equipment configuration domain, and the second the types of technologies used to convert biomass to energy. At the outset of this research study, the scope of modeling was restricted to electricity production. However, as the research project progressed, it became clear that other forms of energy production would become important to planners and decision makers. The research team therefore developed the conversion facility modules as independent modeling components. This allows future iterations of B2E Model development to include other bioenergy conversion systems, such as thermochemical conversion to ethanol or hydrogen.

In fact, the full analysis undertaken by the LCA team included engineering studies of five existing or emerging biomass conversion technologies. The results of this analysis have been published in a separate publication (Nechodom et al. 2008), and include very early results from next-generation thermochemical conversion technology that produces both electricity and ethanol. For the purposes of this study, the LCA team included three of the technologies specific to electricity generation, per the scope of the original Energy Commission contract. The comparison of three biomass-to-electricity technologies allowed the LCA team to compare differences in electricity production, energy use, and emissions impacts associated with different conversion technologies.

Data for three types of biomass power plants (a current generation combustion plant, a current generation integrated gasification/ combustion plant, and a next generation thermochemical conversion plant) were provided by the LCA team. Nameplate and net capacity, efficiencies, and stack emissions are presented in Table 12 below, as described in Nechodom et al. (2008). The emissions are supplemented to include CH_4 and N_2O emissions as described by the U.S. EPA (2003). The use of supporting equipment (a dozer, two loaders, a bobcat, a tub grinder, and a natural gas emergency generator) and ancillary grid electricity use were also included. Although the fuel use and emissions of the supporting equipment were deteriorated over time, based on the U.S. EPA's NONROAD2004 Model, the stack emissions and efficiency were held constant throughout the plant life cycle. Data were not found to support a time-scaled deterioration rate for the three technologies reviewed.

The LCA Report (Appendix 4) includes the inventory data used for the biomass power plants. These data take into account the proportions of each major species provided by the forest feedstocks and their relative heating values. Since power plant efficiency is a function of Btus per MWh, it is important to note the significant range of heating values per ton among tree species. For example, ponderosa pine contains a total of 17.2 mmBtus per bone dry ton. In contrast, hardwoods have 16.7 mmBtus per bone dry ton. These differences matter, particularly at larger scales of fuel use where biomass plant managers make daily and hourly decisions about *fuel blends* in order to optimize among Btus per ton and moisture content of fuels in the fuel yard. Nearly all biomass power plants seek out a diversified portfolio of wood fuels, and then blend what goes into the power plant on an hourly basis in order to achieve optimal balances between heating values, moisture content, specific fuels behaviors, and so forth.

For this study, analyzing the heating value by species allows estimation of the net electricity generated and delivered to the grid adjustments for each power plant's efficiency.

Table 12. B2E Project power plant characterization

	Current Generation Biomass Combustion Power Plant	Current Generation Integrated Gasification/ Combustion Power Plant	Next Generation Thermochemical Conversion Power Plant
Plant Size (dry tons per day)	500	500	500
Electricity (kWh/dry ton)	1,000	1,200	1,400
Net Energy Efficiency	20%	22%	28%
Plant Emissions (lbs./mmBtu output)			
NOX	0.329	0.067	0.008
SOX	0.125	0.010	0.002
PM	0.269	0.030	0.032
CO	0.897	0.070	0.042
VOC	0.085	0.018	0.003
CO2	972.000	886.000	694.000
CH4	0.329	0.067	0.008
N2O	0.125	0.010	0.002

2.11. Life Cycle Assessment

The environmental life cycle assessment (LCA) was a core element of the B2E study. The LCA tracked energy use, air emissions, and environmental impacts (in terms of climate change, acidification, and smog formation) associated with removing forest biomass to generate electricity. However, this approach accounted only for the energy use, emissions, and impacts associated with producing a megawatt-hour of electricity. The team was also interested to see if an LCA could provide a way to quantify energy use, emissions, and impacts associated with producing a healthy, resilient forest landscape.

The team spent considerable time and effort attempting to develop a landscape system LCA, at the same time realizing the inherent risk in this strategy. Defining the end-product of "electricity to grid" is fairly straightforward, and LCAs are clearly designed to deal with these types of engineered systems, where flows of materials can be tracked and controlled. Clearly defining and quantifying the end-product of a "healthy and sustainable forest" however is fraught with difficulty. Ideally, the end-product of a "healthy and sustainable forest" could be measured in acres that have reached a quantifiable state of "health" (which may be defined differently, based on the management objectives of different landowners) without substantially diminished capacity to maintain qualitatively measured multiple "ecological benefits."

Differing forest management objectives on different ownerships added complexity, particularly since some objectives operate at the stand scale (for example, sawlog production on private lands, which allows a per acre accounting) while others operate at much larger scales (for example, landscape-scale fire behavior modification on national forest lands, which a simple per-acre accounting will not capture). The multitude of management objectives and desired outcomes at a variety of spatial scales made it difficult to develop a specific, single metric that could be used to indicate that the Beta landscape had "arrived" at a "healthy" condition. Extensive work on this problem yielded the following approach: the LCA could track the energy, emissions, and environmental impacts associated with a 2.7 million-acre landscape of differing management outcomes, as measured by extent and severity of wildfire..

The LCA tracked energy use, emissions, and environmental impacts associated with harvesting, chipping, and transporting woody biomass and converting it into electricity. The LCA's environmental impacts were assessed using the outputs of the following B2E Project sub-models: (1) landscape characterization and scenario design, (2) characterization of forest operations and equipment configurations, (3) vegetation dynamics assessment, (4) fire behavior assessment, and (5) power plant analysis. As depicted previously in Figure 2, the outputs from these five sub-models fed data into the LCA. Development of the LCA portion of the B2E study focused the research team on the structural framework of the LCA itself, as well as on the interconnections between the LCA and the sub-models that provided its inputs.

The LCA estimated the life cycle impacts of harvest, biomass chip transport, and electricity generation. The life cycle begins at resource acquisition (in other words, at the well for mobile fuels and grid electricity generation and in the forest for biomass electricity generation) and extends through fuel combustion or point-of-use. Figure 5 presents the main process flows for the LCA.

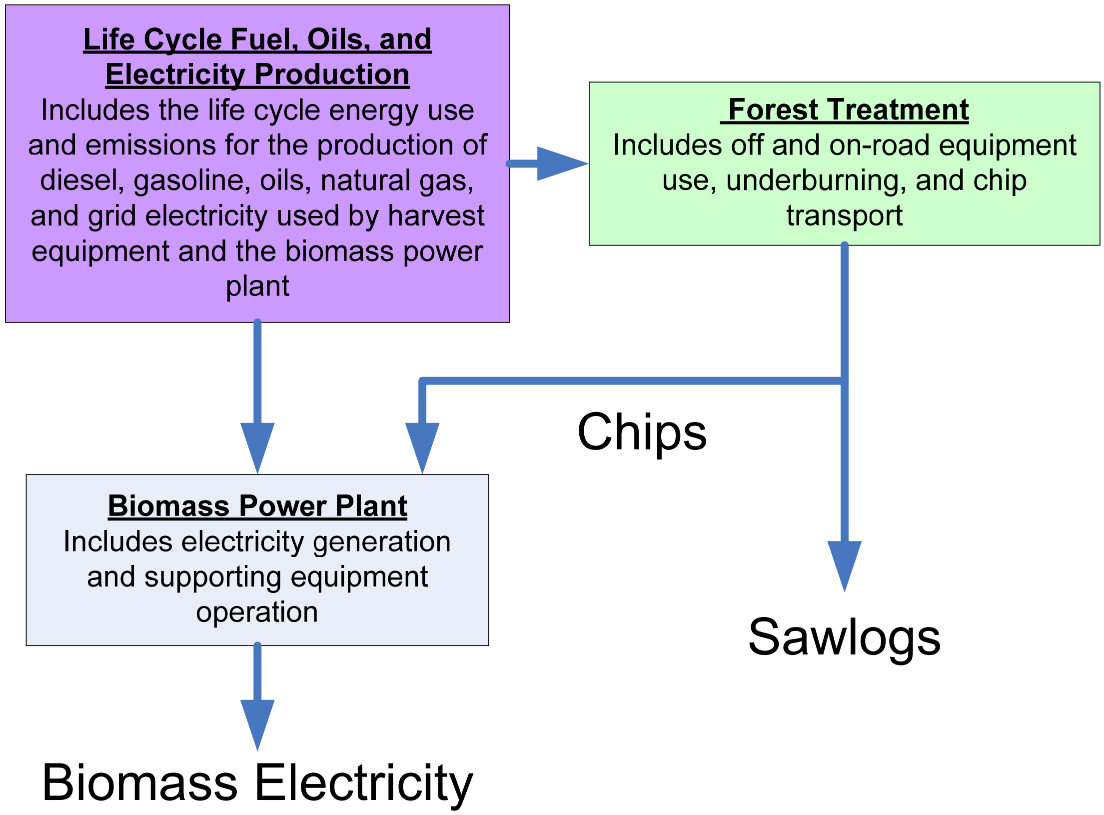

Figure 5. LCA process flows

The LCA included four phases based on the protocol standardized by the International Standards Organization (ISO) [10] and based on the computational structure described in Heijungs and Suh (2002). The four phases, briefly summarized here, are described in detail in the LCA Report for the B2E Project (Appendix 4). The first phase, *goal and scope definition*, described the reasons for carrying out the study, the intended audience, geographic and temporal considerations, system functions and boundaries, impact assessment and interpretation methods[11]. Next, the *inventory assessment* quantified life cycle energy use (total, fossil, and petroleum) and eight air emissions (carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4) nitrous oxide (N_2O), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOCs), particulate matter less than 10 microns in diameter (PM10), and sulfur oxides (SOx)) for acquisition and processing of residual biomass (harvest and chipping

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10 ISO 14040:2006 and ISO 14044:2006 replace the previous standards (ISO 14040:1997, ISO 14041:1999, ISO 14042:2000 and ISO 14043:2000). The new editions have been updated since the development of the goal and scope (Heijungs and Suh 2002) to improve the readability, while leaving the requirements and technical content unaffected, except for errors and inconsistencies (from http://elsmar.com/Forums/showthread.php?t=17459)

11 An extensive literature review of forest product LCAs formed the basis for the development of the project's goal and scope definition document (Cooper et al. 2006).

operations within the forest); transport of chips to a biomass power plant; and conversion of chips into electricity. Third, the *impact assessment* estimated air emissions contributing to global climate change (from CO_2, N_2O, and CH_4) and acidification (from SOx and NOx), and photochemical smog (from CH_4, NOx, CO, and NMVOCs). The final phase, the *interpretation* step, formulated the results in different ways, including an evaluation of alternative biomass electricity generation technologies.

Model interconnection was tested through the development of an LCA that compared the Reference Case (no treatment in the Beta landscape) with a Test Scenario that included a variety of vegetation and fuels treatments in the Beta landscape, designed to meet objectives emphasizing production of wood products on private lands and strategic fuels treatments to enhance suppression capabilities and modify landscape fire behavior on national forest lands. The LCA results in Section 3.0 are presented **in net form, depending on the selected production function,** allowing comparisons between systems that have different levels of sawlog production and electricity generation. The Test Scenario allows us to present different views of energy use, outputs and impacts by placing the focus on which part of the system the user may care about. For example, if one is mostly interested in the use, outputs and impacts associated with the biomass fuel chip production only, the net analysis allows a full assessment based on that primary interest. Examples of how this works are presented below.

2.11.1. Goal and Scope of LCA

In keeping with international standards for life cycle assessment, a complete discussion of the goal and scope of the B2E Project LCA is provided in the LCA Report (Appendix 4). The goal of the LCA was to analyze utilization of forest biomass to generate electricity. The scope of the LCA was based on selected decision categories as defined by the B2E Project's Technical Advisory Committee in June 2005. Table 13 below displays the decision categories and associated impact categories investigated in the LCA for the B2E Project.

Table 13. B2E Project LCA decision and impact categories

Decision Category	Impact Category	Impact Category Description
Infrastructure and Human Use Impacts	Total energy consumption*	Sum of the total energy consumption for the life cycle (as mmBtu***)
	Fossil energy consumption*	Sum of the fossil energy consumption for the life cycle (as mmBtu)
	Petroleum energy consumption*	Sum of the petroleum energy consumption for the life cycle (as mmBtu)
Air Resources Impacts	Contribution to climate change**	Total carbon dioxide equivalents from life cycle air emissions of CO_2, N_2O, & CH_4 (as tons CO_2 equiv)
	Contribution to acidification**	Total hydrogen ion equivalents from life cycle air emissions of SOx & NOx (as tons H^+ equiv)
	Contribution to photochemical smog**	Total nitrogen oxides equivalents from life cycle air emissions of CH_4, NOx, CO, & NMVOCs (as tons NOX equiv)
	PM10 emissions*	Sum of particulate matter emissions (as tons PM10)

* The contribution of the inventory flows was measured by the amount of the inventory flows

** The contribution of the inventory flows was measured using impact equivalency factors

*** mmBtu is 1 million Btu

The LCA evaluated the Reference Case as well as a Test Scenario. Table 14 summarizes the assumptions regarding treatments for the Reference Case and the Test Scenario. The total biomass loading on the landscape ranged from approximately 4 bone dry tons per acre (BDTs/acre) for grasslands to 60 to 80 BDTs/acre for fully stocked forested areas. Treatments were assumed to occur over a 120-day period each year (during the summer months) on both private and public lands. Biomass removed from the landscape not destined for use as sawlogs was assumed to be chipped in the forest and used to generate electricity.

Table 14. Landscape treatment scenarios

Reference Case – No Treatment	No treatment is performed on public or private lands.
Test Scenario - Treatment of Private and Public Multiple Use (PMU) forest lands	Treatments on private forest lands are designed to meet objectives for producing wood products. On industrial private forest (IPF) lands, treatments include regeneration harvest (clearcutting), precommercial thinning, commercial thinning, and underburning. Treatments on non-industrial private forest (NIPF) lands include selective harvesting. Treatments on public multiple use (PMU) lands are aimed at strategically managing fuels and include thinning to create defensible fuels profile zones (DFPZs) as well as strategically placed area treatments (SPLATs). An average of 20 BDT/acre of forest biomass was assumed to be removed after saw timber was harvested.

2.11.2. Gross vs. Net Inventory and Assessment

The Approach and Results sections for the LCA rely heavily on an understanding of the difference between the "gross inventory assessment" and the "net LCA assessment." In the gross assessment, life cycle energy use and emissions for wildfires and all treatment processes are included, with only the Test Scenario producing sawlogs and electricity. The net assessment gives the Test Scenario "credit" (i.e., a subtraction of mass or energy) for producing sawlogs and electricity, so that the Reference Case, the Test Scenario, and conventional electricity generation can be compared.

A gross inventory assessment was undertaken to estimate the life cycle energy use and emissions for the Reference Case and the Test Scenario, representing the management regime as it would occur, including using a current-generation biomass combustion power plant, following the main process flows for the LCA depicted in Figure 5 above. The function of the gross LCA assessment was simply to track management of the Beta landscape over a 40-year period while producing sawlogs and electricity (from the biomass chips). Note that in the LCA, the term "chips" and "chipped forest biomass" are used. This includes tops, limbs, and waste material from the harvested trees, which are processed through a chipper to create wood chips, which can be converted to electricity at a power plant or used for other purposes, such as mulch.

2.11.3. Forest Treatment and Chip Transport Models and Data

The B2E Project's vegetation dynamics modeling (described in Section 2.1.5 of this Report) provided data on the amount of acres treated and quantities of sawlogs and chips generated from the treatments. The forest operations and equipment characterization model (described in Section 2.1.8) provided the data related to the type and quantities of equipment used in harvesting operations and to transport the harvested material to the processing facility (sawmill or biomass power plant). Forest treatment and chip transport included off-road equipment use for biomass harvest, such as the use of feller bunchers, skidders, and chippers, on-road equipment use for harvest equipment mobilization, the use of a water truck for forest road dust control, crew transport, and chip transport at an average distance of 30 miles from the treatment site. The Test Scenario was assumed to be executed based on combinations of six harvest methods (clearcut, pre-commercial thinning, commercial thinning, salvage, selective harvest, and restrictive thinning) for three slope ranges as displayed in Table 15. For each prescription, per-acre production rates for sawlogs and chips were determined via the forest operations and equipment characterization model.

Table 15. Treatments, equipment configuration, and production Rates

Treatment	Description	Slope %	Equipment Configuration	Chips (dry tons/ acre)	Sawlogs (dry tons/ acre)
Clearcut	Even-aged management. Only occurs on Industrial Forest Lands.	<35%	CC <35	30	47
		35 to 50%	CC 35-50	33	48
Pre-Commercial Thinning	No sawlogs removed. Only biomass fuel removed. Typically in plantations.	<35%	PCT <35	5.0	0
		35 to 50%	PCT 35-50	8.3	0
Commercial Thinning	Sawlogs and biomass fuel removed. Typically in plantations.	<35%	CT <35	14	7.5
		35 to 50%	CT 35-50	21	6.7
Salvage	Assumes that no biomass fuel (3"-9.9" diameter at breast height or limbs/tops) was recovered (burned up in wildfire).	<35%	SAL <35	0	11
		35 to 50%	SAL 35-50	0	13
Select Harvest	Uneven-aged management harvest removing individual or small groups of trees.	<35%	SH <35	12	16
		35 to 50%	SH 35-50	13	16
		>50%	SH 50+ (only on Industrial Forest Lands)	14	17
Restrictive Thinning	Thinning aimed at ladder fuel reduction, constrained canopy thinning, and retaining 40% canopy cover.	<35%	RT <35	6.6	12
		35 to 50%	RT 35-50	6.8	17

Data on equipment power, life, and fuel and oil use were combined with the productive machine hours per dry tons of woody material leaving the forest as chips or sawlogs to estimate fuel and oil use. Given the fuel and oil use on a dry-ton basis, total fuel and oil use for the Test Scenario was estimated based on the chips and sawlogs generated per decade (as derived from the vegetation dynamics assessment).

Based on the equipment fuel use, the equipment emissions were estimated based on the U.S. Environmental Protection Agency's NONROAD2004 and MOBILE6 emission inventory models as listed in Table 16. For the application of these models, estimation began with zero-hour or zero-mile emissions and break-specific fuel consumption (BSFC) and was followed by adjustments (where applicable) to account for transient operation, changes in emission factors over time, and technology distributions (for tiered regulatory compliance). For example, emission factors account for changes in regulations on diesel sulfur content. Beginning June 1, 2007, non-road diesel was required to have maximum of 500 ppm sulfur, and beginning June 1, 2012, the sulfur content must be reduced to 15 ppm (US EPA 2004).

Table 16. Harvest and chip transport emissions models

Off-road equipment except chainsaws	NONROAD2004 emission inventory model (technology distributions, zero hour emissions, deterioration factors, transient adjustment factors) [12]; California Statewide Off-Road Fuel Correction Factors [13]
Chainsaws	NONROAD2004 emission inventory model (zero hour emissions, deterioration factors, transient adjustment factors) [14]; Deterioration rates [15]
On-road equipment	MOBILE6 emission inventory model (zero hour emissions, correction factors) [16, 17]; Native road PM emissions [18]

Equipment was assumed to be dedicated to the project, to be new in the first year of the project, and subsequently replaced at the end of its operating life, thus returning the accounting to zero-hour or zero-mile performance (for example, Figure 6 shows that a Morbark Model 30/36 chipper is used for 8,000 hours and then replaced). Machine hours were estimated per decade for the Test Scenario based on the "productive" machine hours and the amounts of sawlogs and chips generated per decade. In addition, average cumulative operating hours per decade were estimated for each piece of equipment. Although emissions were adjusted for transient operation and degraded until the equipment was replaced, fuel and oils use was assumed to be constant over the life of the equipment (to match assumptions made in the project's economic analysis). Finally, PM emissions for on-road equipment traveling on native roads have been calculated and regulated adjustments in fuel sulfur levels have been considered in appropriate years as described in U.S.EPA (1995). The resulting "effective" emission factors are presented in sub-appendix A of the LCA Report (Appendix 4).

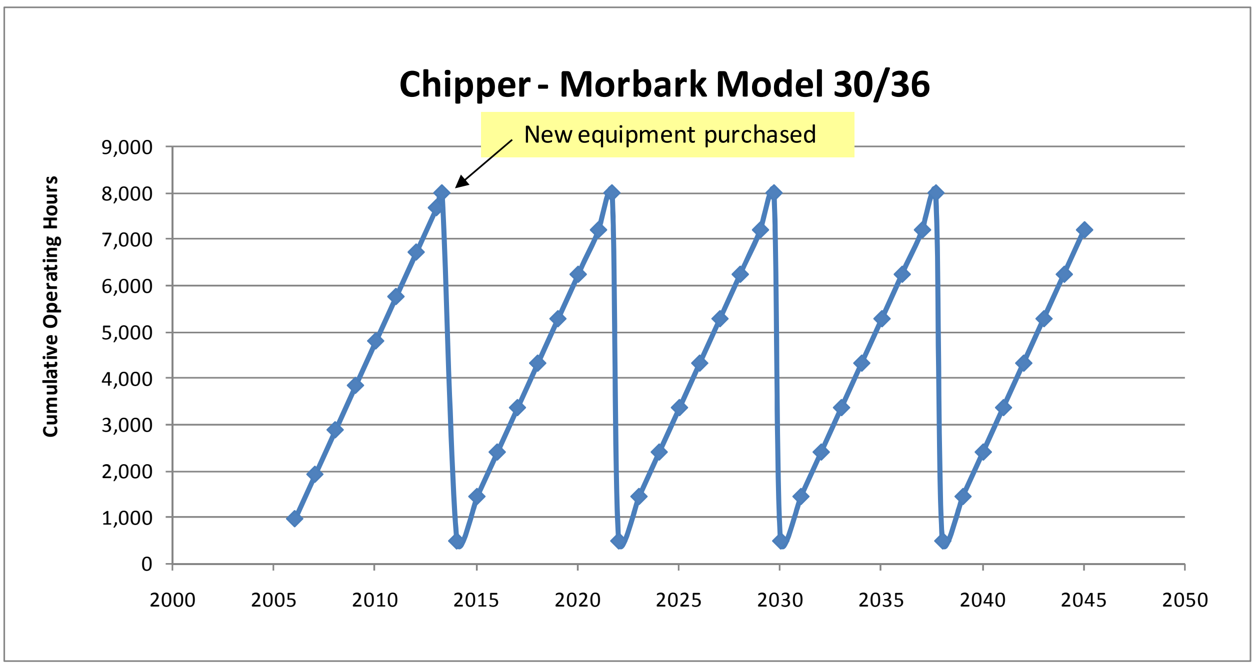

Figure 6. Example of new equipment purchase dates for emissions degradation estimation

2.11.4. Fuel, Oils, and Electricity Production Models and Data

The U.S. Department of Energy (DOE) Argonne National Lab's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model (Version 1.7) was used to estimate the life cycle of diesel and oils production, grid electricity, and natural gas power plants in California. Since GREET Version 1.7 estimates emissions only to the year 2020, energy use and emissions beyond 2020 have been assumed to be at 2020 levels. The data used are presented in sub-appendix B of the LCA Domain Report, essentially representing well-to-point of use values for all fuels, oils, and electricity production processes.

Biomass Power Plant Operation Models and Data

The "Biomass Energy Technology Conversion Characterization" section above describes in detail the biomass power plant operation models and data used in the LCA.

2.11.5. LCA Environmental Impact Assessment

In all assessments, environmental impact was measured in two ways. The first metrics of environmental impacts were based on the amount of inventory flows, such as the amount of energy or the mass of particulate matter emissions, which applied to four of the impact categories specified by the project's Technical Advisory Committee. The second metric used impact equivalency factors (i.e., scoring factors based on fate, transport, and effects models) from the 1996 Intergovernmental Panel on Climate Change values (IPCC 2007) or as compiled in the U.S. Environmental Protection Agency's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts or TRACI model (US EPA 2008). When equivalency factors were used, impacts were measured relative to one of the emissions contributing to the impact. For example, contribution to climate change was measured in "CO_2 equivalents" such that each species of emissions was assumed to have some multiple of the impact of CO_2 (for example, an emission of 1 kg of CH_4 contributes 21 times that of an emission of 1 kg of CO_2). Table 17 lists the equivalency factors used, consistent with the IPCC and the EPA standards.

Table 17. Equivalency factors used (equivalent mass/mass emitted)

Impacts Considered[12]	CH4	CO	CO2	N2O	NMVOC	NOx	PM	SOx
Contribution to Climate Change (CO2 equivalents)	21	0	1	310	0	0	0	0
Contribution to Acidification (H+ equivalents)	0	0	0	0	0	40	0	50.8
Contribution to photochemical smog (NOx equivalents)	0.0030	0.013	0	0	0.78	1	0	0

12 Climate change equivalency factors were for 100-year time horizons and chosen to match the data used in the U.S. EPA's values in the *Draft 2007 Inventory of Greenhouse Gas Emissions and Sinks* (US EPA 2007a). Data were from the most recent version of TRACI (developed in 2006) for the US average condition and available at http://www.epa.gov/nrmrl/std/sab/traci/

Finally, energy consumption, PM10 emissions, and the impact characterization results were normalized by the commensurate California estimates for the 40-year period, presented in Table 18. Energy use projections represented the 40-year sum of annual values forecasted based on linear regressions of 1996-2006 data from the U.S. DOE Annual Energy Review (U.S. Department of Energy 2006) and multiplied by the ratio of the population of California to that of the U.S. from the U.S. Census Bureau (US Census Bureau 2004). Next, and again multiplied by the same population ratio, California PM10 emissions and emissions contributing to acidification and smog formation were estimated from the 40-year sum of 2005 emission estimates from the U.S. Environmental Protection Agency (US EPA 2007b)[13]. Contribution to climate change was estimated as a 40-year sum of the 2004 level for California (CARB 2008). When combined, the normalization factors are intended to allow the life cycle environmental impacts to be placed within the context of their contribution to the overall California condition. Further model development and application would require the same normalization procedure for any given state in which the model was applied. If actual state-level inventory and analysis exist, it is recommended that those data be used for normalization of test landscape contributions.

Table 18. Normalization factors (estimated 40-year California values)

Factor	Result	Units
Total energy consumption	260,000	tera Btu
Fossil fuel consumption	190,000	tera Btu
Petroleum consumption	190,000	tera Btu
Climate change	21,000	million tons CO2 equivalents
Smog formation	150	million tons NOx equivalents
Acidification	6,800	million tons H+ equivalents
PM10 emissions	8.9	million tons

Note that the assessments in this study *did not include* the construction, maintenance, and decommissioning of facilities and capital equipment (in other words, harvest equipment, distribution/ transport equipment, power plant buildings and equipment) and the life cycle of other feedstocks needed to ensure continuous power plant operation.

2.11.6. B2E LCA Interpretation

The B2E Project's approach modeled one Test Scenario; however, the Test Scenario could be compared to other future scenarios, each of which would produce a variation in:

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13 Although the 40-year data could be forecasted from the U.S. Environmental Protection Agency data this method results in negative U.S. emission values as early as 2023. Thus, using the 2005 per capita value was chosen for emissions normalization. Note also that the non-greenhouse gas U.S. emissions data do not include fire and dust.

- the amount of sawlogs produced, and
- the amount of chips used in the production of electricity (and thus the generation of a different amount of electricity).

The B2E Project included developing an LCA framework that would facilitate the comparison of different management scenarios. While the LCA Domain Report (Appendix 4) presents the gross LCA results (which represent the main LCA flows depicted in Figure 5 for a current generation biomass combustion power plant), the gross assessment results do not allow for the comparison between scenarios because they do not account for the variation in sawlogs and chips produced under different scenarios. Hence, the focus of this section is on interpreting the gross LCA results to provide the means for future scenario comparisons. Interpretation of the gross results is done in two steps. First processes, inputs and emissions are allocated to sawlog production and electricity generation. Next variations in the conversion technology (i.e., type of power plant) used to generate electricity are calculated. These steps are described in the Results Section (3.0) to provide context for, and explanation of, the LCA modeling results.

2.12. Landscape Greenhouse Gas Model

The Biomass to Energy project attempted to build an atmospheric carbon flux model based on an interpretation of the data generated by the tree lists and the fire modeling. The Landscape GHG model (LGHG) was developed in order to test assumptions about total fates of carbon dioxide (CO) and methane (CH4) in the atmosphere, and to relate those greenhouse gases to forest growth and biomass removals over the 40 year modeling period.

While the LGHG had promising results, the team determined that the model would need further development in order to fully account for the greenhouse gases associated with post-fire decay and decomposition and the net sequestration from forest growth. The initial version of the model used generalized growth curves for forest mensuration after disturbance, and used assumptions about the sequestration capabilities of broad forest types. Additional assumptions were made about the fate of wood products and biofuels used for energy generation that were consistent with the assumptions used in the life cycle assessment. The LGHG model does not attempt to track all landscape-related carbon flows. Rather, the model is constrained to analyzing the flow of carbon in above-ground live tree biomass into biofuels and sawlogs, and into the atmosphere as a result of wildfire and decomposition.

The LGHG model was tested against a one-year GHG fate model (Morris 1999), developed in order to estimate total CO2 and CH4 burdens and fates in the atmosphere. This original model accommodates a wider variety of biomass fuels (such as sawmill waste, forest treatment residues, agricultural residues, recovered municipal waste and landfill gas). The modules pertaining to in-forest waste and tree growth were compared to the LGHG model in order to test the accuracy of LGHG accounting. The equations used in the B2E application of the original model to account for fire probability and losses, post-fire mortality and decomposition and post-fire growth and sequestration were derived from the tree lists generated through the vegetation and fire analyses presented in Appendices 1 and 2.

2.13. Wildlife Habitat Assessment

Once the analysis of vegetation growth, fire disturbances, and treatments were completed, the habitat domain team subsequently modeled their effects on wildlife habitat and associated values. As most analyses of wildlife habitat depend on data reflecting the structure and condition of vegetation, the habitat domain team used tree list data produced by the vegetation domain team, adapted to allow for habitat quality analysis.

A key reference used for the wildlife habitat analysis was the California Wildlife Habitat Relations (CWHR) model (CDFG 2002). The habitat domain team evaluated vegetation conditions, along with environmental variables (for example, elevation, slope, and precipitation) to evaluate how habitat conditions for wildlife species would be expected to change under different forest management scenarios. The team evaluated the potential effects of the Reference Case and the Test Scenario on biological diversity by evaluating changes in habitat suitability from five perspectives: habitat element specialists, aquatic species, service-providing units, indicator species, and individual species of special interest. Each of the five perspectives addresses concerns regarding the direct and indirect effects of management on biological diversity and the services it provides.

Habitat element specialist guilds represent the effects of forest management on vegetation structure, and in turn, habitat conditions for wildlife species.

Service providing units represent the effects of forest management on ecosystem services by affecting the diversity of service providers and biological diversity as a whole.

Species of special interest are those that are of particular interest or concern based on their current population status or their vulnerability to forest management practices.

Aquatic species use upland habitats to meet a variety of life history needs, including foraging, cover, estivation, and dispersal. Upland conditions and activities can also affect aquatic habitats.

Current vegetation conditions across the Beta landscape were generated from existing Forest Inventory and Analysis (FIA) data. Future vegetation conditions were modeled based on current FIA-based vegetation, Forest Vegetation Simulator (FVS) growth models, and a predetermined array of disturbance events (see vegetation dynamics modeling domain). The Reference Case and Test Scenario each had eight time steps (pre- and post-treatment for each of four decades), with one shared starting condition, providing a total of 17 landscape condition snapshots. Vegetation conditions for each landscape were provided by the vegetation dynamics team.

2.13.1. Habitat Element Specialist Guilds

Species associations with primary habitat features that are likely to change as a result of biomass harvesting were identified to create five habitat specialist element guilds: old forests, early seral conditions, snags, logs, and oaks. Membership in each of the five guilds developed for this analysis was determined based on multiple sources. The old growth associates were derived from Graber's (1996) old growth conifer dependent species for the Sierra Nevada, and included old growth dependent and associated species. Early seral species were those for which early seral stages (open, seedling, or sapling stages) were considered high quality habitat for reproduction, feeding, and cover in the CWHR database. Oak guild membership reflected a combination of species dependent upon oak foothill habitats (Graber 1996), and five additional species for which the CWHR database identified acorns as secondarily essential or essential. Snag and log associates were identified using the CWHR database: species for which snags or logs (large and medium diameter) were considered an essential or secondarily essential were included in these guilds.

Each of the habitat element specialist guilds consisted of representatives from multiple vertebrate classes. The team identified a total of 63 old growth associates, including 2 amphibians, 3 reptiles, 36 birds, and 22 mammals (two of which are currently extirpated). Seventy-nine species were identified as early seral associates, including 9 reptiles, 37 birds, and 33 mammals. Forty-four species were associated with oaks or acorns, including 1 amphibian, 3 reptiles, 30 birds, and 10 mammals. Thirty-four species were associated with snags, including 24 birds and 10 mammals (one extirpated); and 16 species were associated with logs, including 1 amphibian, 3 reptiles, 2 birds, and 10 mammals (one extirpated). Modeling snag and log guilds, particularly the patterns of post-fire mortality and snag and log recruitment, has a degree of uncertainty that should be viewed with caution. The team found that the Test Scenario effects on snag and log dependent species were difficult to quantify, and point to a larger finding that habitat modeling requires more refined vegetation data.

2.13.2. Service Providing Units

Following (Luck et al. 2003), seven service providing units can be identified in similar ecological systems. The habitat domain team identified four categories of service providing units (insect regulators, seed dispersers, decomposition aides, and herbivore regulators) to evaluate the effects of forest management on ecosystem services provided by vertebrate species. Insectivorous animals serve to keep populations of herbivorous insects in check, limiting a variety of undesirable damages associated with outbreaks of these insects, such as stress to native plant species including trees (for example, bark beetles). With an emphasis on aerial insects, the team identified 93 members of the insectivorous service-providing unit, including birds and bats. Seed dispersal is a key service in any ecosystem that is provided by vertebrates, as well as invertebrates (for example, ants). Many species eat and transport seeds; the habitat domain team targeted two groups of species (22 species total): conifer seed dispersers (small mammals), and fruit-bearing plant seed dispersers (frugivorous birds and mammalian omnivores). Snags and logs contribute significantly to soil nutrient availability and nutrient cycling in forested ecosystems. Although other biota, such as bacteria, fungi, and ants, serve the primary role in decomposition, the 13 species of woodpeckers and secondary cavity nesters in the Beta landscape contribute to decomposition in an ecologically significant manner by exposing trees to disease through sapsucker feeding holes, and speeding the breakdown of snags and logs through the creation of cavities for feeding and nesting. Herbivore regulators are carnivores, which serve a regulatory function in ecosystems, keeping populations of lower trophic level species (primarily herbivorous mammals) in check. Finally, the team identified two tiers of herbivore regulators: primary (top carnivores; n = 21) and secondary (n = 9).

2.13.3. Species of Special Interest

The habitat domain team considered species with special status, exotic species, and aquatic species in identifying species of special interest. There were five exotic vertebrate species in the Beta landscape: three birds, one amphibian, and one mammal. The team analyzed the richness of exotic species as a group. The team identified Forest Service Sensitive Species and existing Management Indicator Species for the Plumas and Lassen National Forests as species of special interest, and these included 23 species: 8 aquatic species (4 amphibians, 3 birds, 1 reptile), and 16 terrestrial associates (6 birds, 9 mammals).

To test the sensitivity of the data used, the team evaluated the individual responses of one species, the American marten, as a demonstration of the type of analysis that can be conducted in any landscape where systematic surveys have been conducted. For the American marten, the team developed a predictive model for probability of occurrence based on GIS-based environmental data associated with survey data (detection, non-detection) collected in the study area and adjacent landscapes. In 1999 to 2002, the Forest Service's Pacific Southwest Research Station conducted a survey for mammalian carnivores in the Greater Southern Cascades Region of northeastern California using baited trackplate and camera stations (Barrett 1983; Kirk 2007). The surveyed landscape overlaps the Beta landscape, extending far to the north but not as far east as the Beta landscape. Nonetheless, the surveyed landscape is comprised of vegetation and other environmental conditions typical of the Beta landscape; hence, the predictive models developed for the surveyed landscape could be reliably applied to the Beta landscape.

2.13.4. Aquatic Species

The team then identified 79 non-fish aquatic species that were primarily dependent on aquatic habitats, including 15 amphibians, 58 birds, 4 mammals, and 2 reptiles (Appendix 5). In addition, 38 species of fish were identified as confirmed or likely to occur in the Beta landscape (Appendix 5). Aquatic species were only included in the aquatic guild, and were excluded from the habitat element specialist guilds because of their unique considerations relative to changes in upland conditions. Specific aquatic species were not included in this analysis.

2.14. Ecosystem Services and Ecological Endpoints Analysis

This section describes a framework for analyzing ecosystem services pertinent to the Beta landscape. The habitat team analyzed impacts on key ecosystem functions that were classified as *service-providing units*. However, the B2E research team determined that a broader analysis would be appropriate in a further development of the study beyond Phase 1.

This broader analysis would include quantification of the ecological endpoints identified in this section of the study. Ecological endpoints are characterized as ecological functions that have a directly measurable human welfare function, and that can be quantified in an accounting system that makes them fungible. Forest ecosystems can purify water, reduce flood and fire risks, support recreation, provide beauty, improve nearby agricultural output, sequester carbon, and enhance air quality (Daily 1997). However, the services that connect directly to human welfare functions substantially narrow the field of indicators that needs to be measured to understand changes due to disturbances such as wildfire or management such as fuels treatments.

The methods used in the ecosystem services assessment are innovative in the area of resource economics. While the initial scope of this study had hoped to establish a series of values for non market resources, the team found through its parsing of economic values on the Beta landscape that further analysis would be required before those values could be quantified.

Given that the overall goal of this study was to explore trade-offs among all values associated with disturbance and treatment at the landscape level, the fundamental requirement in meeting that goal would be to quantify or at least normalize values in order to make them comparable. The B2E economic model took into account all values that could be measured with market signals, or at least with reasonable proxies for market signals. However, several other values that in fact drive human choice and behavior on the Beta landscape are clearly importantly affected by treatments and fire. Assigning them fungible values proved frustratingly elusive to the research team.

This section illuminates the problem, and even provides a framework for a potential solution. The longer report (see Appendix 7) on ecological endpoints is an analysis of the historically difficult issues of benefits transfer. And, it offers a recommended strategy for distilling ecological endpoints that can be quantified and measured against other values

The methods employed in the analysis if ecosystems services are still under development. The recommended strategy for development is an additional effort to quantify the values identified in the framework in Appendix 7, and summarized in Table 19.

Table 19. Examples of relationships between benefits and endpoints

Benefits	Endpoints
Scenic, aesthetic enjoyment	Undeveloped landcover, untreated landcover (if visible), burned landcover
Residential water provision	Water quality and availability at intake (wells, POTW sources)
Commercial water provision	Water quality and availability at intake (wells, POTW sources)
Irrigation water provision	Water quality and availability at source
Commercially important soils	Soil availability & quality
Recreational open space, aquatic	Boatable waters area, depth, flow
Recreational open space, terrestrial	Parks and public lands
Active hunting and angling	Target species populations (deer, adult steelhead, ducks)
Passive species observation	Target species (songbirds, elk, deer)
Stewardship	Endangered and threatened species not included in active and passive categories, wilderness
Pollutant reductions – Air	Air quality, particulates
Property damage avoidance – Water	Flood events and flood map
Property damage avoidance – Fire	Fire events and fire map
Property damage avoidance – Pests invasives, pollinator losses	Pest, invasive, and pollinator species populations.

2.14.1. Ecological Production Functions

A production function describes the relationships between inputs and outputs in a system. One of the key limitations of this kind of analysis is the ability to state ecological production functions in ways that can be analytically observed and measured. As Boyd points out in Appendix 7, the production functions on the B2E landscape are well on their way to clear definition, but further analysis and modeling would need to be completed before the ecological economic analysis could be completed.

The current analysis for this study concluded with the following evaluation of the existing and needed tools to support identification and quantification of ecological endpoints:

- Better species models that incorporate the spatial configuration of habitat. Models of reproduction, forage, predation, and migration to better predict the location and timing of populations. Of interest are not just valued populations, but pest and invasive populations as well.
- Better hydrological models to link land cover to aquifer and downstream surface water availability. Forests can prevent 'flashy' runoff and thus protect against flood surges. Dense growth is also thought to reduce groundwater delivery.
- Better water quality modeling to link land cover and land management practices to downstream water quality. Forest-related impacts on nutrient cycling and nutrient loads is an example.

- Better understanding of soil quality effects arising from treatment and hydrological processes.
- Better air quality models to allow for the analysis of human health, ecological, and aesthetic impacts.

2.14.2. Scarcity and Substitution

A common principle of resource economics holds that non-market valuation is fundamentally dependent upon some kind of *stated preference method*[14] being applied at the appropriate scale, surveying an appropriate sample population. However, welfare-significant conclusions can be drawn without knowledge of underlying preferences. This is because economic production obeys certain fundamental properties, or principles. For example, all else equal, the following statements are typical of economic logic, and apply to human evaluation of ecological scarcity and value:

- The scarcer an ecological feature, the greater its value.
- The scarcer are substitutes for an ecological feature, the greater its value.
- The more abundant are complements to an ecological feature, the greater its value.[15]

Note that scarcity can be measured, as well as the abundance of substitutes and complements, without detailed knowledge of underlying preferences. For any of the endpoints found to vary as a result of management, policy, or protection useful things can be said about the social value of the change by exploring the scarcity of what is gained or lost. While stated-preference methods are highly recommended to refine the scarcity analysis approach, for a gross assessment employed at the scale of this study, it is sufficient to detect analytically significant differences among policy scenarios.

For example, a waterbody whose quality is enhanced will – all else equal – be more valuable if it is scarce. Is it the only swimmable lake in the county, or one of many? The same holds true of parks, open space, and wilderness. Are these land uses scarce or plentiful? Knowing the answer to these questions may help decision-makers make more informed choices about impacts and priorities.

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14 Stated preference methods fall into three primary categories: a) contingent valuation, in which the respondent is required to make a comparison of value between the resource value in question and known trade-off values; b) travel-cost analysis, in which travel effort and investment constitutes a proxy for the value of the resource; and c) hedonic pricing, which uses property values as a proxy for the value of the resource as compared with comparable purchase prices. Each has strengths and weaknesses, depending on application. For this study, the team recognized that each method represented fruitful areas of future research to enhance and refine the substitution and "rarity" methods used to determine ranges of values and change due to disturbance and management.

15 Though note that not all ecological inputs require complements to yield a benefit.

Substitutes are also important to analyze. If water flows in a stream are reduced, but there are alternative groundwater sources for irrigation or drinking, the social costs of reduced flows will – all else equal – be lower than if there are no substitutes. The benefits of fire and flood damage are likewise influenced by the availability of averting actions which are a substitute for fire or flood risk reductions. Flood pulse attenuation is less valuable in watersheds where there are built flood controls such as levees, dams, and reservoirs. It is more valuable when those built substitutes are absent.

The scarcity of, substitutes for, and complements to many ecosystem goods and services are relatively easy to assess. In many cases, metrics can be derived from social and biophysical GIS data. (Boyd and Wainger 2002; Boyd and Wainger 2003).

Table 20. Examples of endpoints and relationships to metrics of scarcity and substitution

Endpoint (w/benefit)	Scarcity Metric	Substitute Metric
Undeveloped land in viewshed (Aesthetic enjoyment)	% landcover undeveloped in service zone	% landcover lightly developed land
Water quality (Drinking, Irrigation)	Degree to which consumption constrained by availability	Other water sources Wells, POTWs,
Water availability (Irrigation, Commercial)	Degree to which consumption constrained by availability	Other water sources Wells, POTWs
Boatable waters, depth, flow (Recreation)	Number, size of waters in service zone	n/a
Parks & public lands (Recreation)	Number, size of lands	n/a
Species (Hunting, Subsistence)	Population density	species (bass for trout)
Species (Observation)	Population density in service zone	Substitutable target species
Species (Stewardship)	Global or regional population viability	n/a
Wilderness (Stewardship)	Global or regional wilderness availability	n/a
Fire events (Damage avoidance)	n/a	Protective actions (fire breaks, water)
Flood events (Damage avoidance)	n/a	Protective actions (levees, dams)

Each of the three subsections above are areas for further development. Given the limitations of resources and expertise for this aspect of the project, the B2E team determined that recognition of the issues and a recommendation for further development should be sufficient during this proof-of-concept phase of the project.

2.15. Cumulative Watershed Effects Analysis

Cumulative watershed effects analysis evaluates the impacts of multiple disturbance activities across a landscape over time. The underlying premise for this approach is that watersheds recover over time, and the length and progression of the recovery depends on the type of disturbance involved.

In the northern Sierra Nevada, impacts from vegetation management activities are primarily increased erosion and stream sedimentation resulting from decreased soil infiltration, decreased soil cover, bank and fill failures along roads, and altered runoff patterns. While mass wasting can be a potential problem in localized areas, this process was not analyzed for the Beta landscape.

Watershed impacts are most effectively mitigated using Best Management Practices in designing and locating roads and skid trails, maintaining protective vegetation cover, and limiting the extent and intensity of disturbance (Rice and Berg 1987). MacDonald (1994) states that the effects of present day management activities on water quality are usually transient and rarely severe enough to cause significant damage to fish populations. Exceptions to this conclusion include:

- unstable areas or areas with highly erodible soils,
- the combination of management activities with extreme storm events, and
- downstream deposition areas where there is potential for cumulative effects.

The B2E cumulative effects analysis assumed implementation of Best Management Practices in concert with the modeled treatment prescriptions.

Cumulative watershed effects in the Beta landscape were assessed using the Forest Service Pacific Southwest Region's cumulative watershed effects (CWE) model and verified using WEPP FuME. The CWE model is a disturbance-based model that normalizes all disturbances (treatments, wildfires, and so forth) to an acre of road. WEPP FuME is a web based interface (http://forest.moscowfsl.wsu.edu/cgi-bin/fswepp/fume/fume.pl) that predicts soil erosion associated with vegetation and fuels management practices (prescribed fire, thinning, and a road network) and compares the result with erosion from wildfire.

2.15.1. Cumulative Watershed Effects Model

The CWE model is a non-specific model for modeling disturbance and recovery. It can be designed to model disturbance and recovery related to sediment and soil erosion, or can be modified for other disturbance related processes, such as mass wasting. The model uses equivalent roaded acres (ERAs) to equate all disturbances to one acre of road, and estimates the recovery of the disturbed areas over a specified period of time, based on a recovery curve for the disturbance being modeled. The CWE model can be modified for different disturbance processes by changing the model's ERA coefficients and recovery curves.

For the B2E Project, GIS coverages displaying watershed disturbances were analyzed using a CWE model written in visual basic. The program read each disturbance and disturbance year and, based on the ERA coefficient, recovery curve, and years to recover, computed the ERAs by year for each watershed, as described below.

2.15.2. Watershed Disturbances

The Beta landscape was divided into 122 watersheds, ranging from 2,500 to 46,000 acres (averaging 23,000 acres). Disturbances were quantified using Forest Service corporate GIS layers displaying: (1) past vegetation management activities on national forest lands (from the Forest Service's Activity Tracking System), (2) forest roads, (3) fire history, including burn severity, and (4) the Beta landscape treatments and wildfires modeled for the three time periods of 2006, 2016, and 2026. Past and ongoing timber harvest activities on private lands were modeled using the state's Timber Harvest Plan GIS coverages, which covered only two of the four counties (Lassen and Sierra Counties) in the Beta landscape at the time of the analysis.

2.15.3. ERA Coefficients and Recovery Curves

ERA coefficients were based on the likely effects of management activities on erosion and sedimentation, these two processes being the most likely mechanisms that would result in a cumulative watershed effects in the Beta landscape. ERA values recover over time. To run the cumulative watershed effects model, the watershed team defined a recovery period (years) and assigned a recovery curve (Figure 7) for each type of disturbance. At this broad scale of analysis, sensitive areas, such as highly erodible soils or areas adjacent to streams, were not separated out for customized ERA coefficients and recovery curves.

ERA coefficients and recovery curves were based on erosion and sedimentation studies from the American River Study on the Eldorado National Forest. (MacDonald et al. 2004) The study measured erosion rates from wildfire, logging roads, timber harvest, and prescribed fire, using sediment fences on the American, Cosumnes and Yuba River Basins. Sediment delivery was also examined. The study results are presented in Table 21.

Table 21. Mean sediment by treatment (1999-2000) and proportioned ERA coefficient

Disturbance Type	Mean Sediment Rates\2 Tons/ha	Mean Sediment Rates\2 Kg/M²	Sample Size (n)	ERA Coef\3	Est % Skid trails/landings
Roads Dirt	8.80	0.798	17-55*	1.000	N/A
Roads Gravel or Paved	0.90	0.082	10	0.102	N/A
OHV Trails	3.90	0.354	7	0.443	N/A
Minimally disturbed sites	0.01	0.001	3	0.001	N/A
High Severity Wild Fire	11.00	0.998	3	1.250	N/A
Holland soil skid trail	8.20	0.744	2	0.932	N/A
Other skid trails	0.40	0.036	34	0.045	N/A
Skid Trails (Mean)	0.83	0.076	36	0.095	N/A
Prescribed Fire	0.01	0.001	15	0.001	N/A
Thin Unit (estimated\1)	0.13	0.012		0.014	15%
Regeneration Harvest (estimated\1)	0.23	0.021		0.026	27%

\1 Harvest Units estimated from skid trail erosion rates and minimally disturbed rates. 15 percent of the area in thinnings was assumed to be in skid trails and landings, while 26 percent of regeneration harvest areas were assumed to be in skid trails and landings.

\2 Mean sediment rates taken from the American River Sediment Fence study.

\3 ERA Coefficients: Dirt roads are set to 1 ERA per acre and all other ERAs are calculated based on the amount of sediment per acre relative to roads. For example, the mean skid trail produces 0.83 Tons/ha or about 1/10 that of dirt roads.

In the American River study, sediment rates were highly concentrated, with a relative few sites producing the majority of the sediment from each land use (Table 22). For roads, a few segments, with inadequate road drainage, and road segments that were recently graded, produced a majority of the road sediment. On skid trails most of the erosion came from 2 of 36 segments on the Holland soil type. These outliers were not excluded from the B2E analysis but averaged into the ERA coefficients.

For this analysis, dirt roads were set to 1 ERA per acre. All other ERA values were calculated based on the average sediment yield relative to dirt roads. For example, the average sediment yield on high severity wildfire areas is 11 tons/ha and dirt roads are 8.8 tons/ha. High severity wildfire therefore received an ERA coefficient of 11/8.8 or 1.25.

All disturbances were assigned an ERA coefficient, a recovery curve, and recovery years based on the American River study, other studies, and local expertise. Sample ERA coefficients used in the analysis are listed in Table 21. The complete ERA coefficient tables are listed in the cumulative watershed effects domain report.

Table 22. Beta landscape Equivalent Roaded Acre (ERA) coefficients, recovery years, and recovery curves for different types of disturbances.

Activity Group	Activity Method	ERA's / Acre	Recovery Years	Recovery Curve
Harvest Activity Fuels	Broadcast Burn	0.001	3	Concave
Harvest Activity Fuels	Machine Pile	0.021	8	Concave
Fuel Treat	Thin From Below, Tractor	0.014	8	Concave
Harvest	Clear Cut Tractor	0.026	10	Concave
Harvest	Thin Tractor	0.014	8	Concave
Road	Gravel	0.22	60	Flat
Road	Dirt	1	60	Flat
Wildfire	High Severity with Salvage	1.4	8	Concave
Wildfire	Moderate Severity	0.3	4	Concave

Recovery curves are used in this kind of damage analysis as a variable that can help set management priorities. For example, a convex recovery curve can give a particular area a higher priority for restoration or rehabilitation because of the risks of long-term damage without immediate intervention. Recovery curves are assigned based on the type and severity of disturbance being modeled. For example, since an active road does not recover over time, a flat recovery curve would be assigned. Most sediment recovery can be plotted as a concave curve. Each recovery curve plots a unique pace at which watershed recovery from a specified disturbance is modeled. For example, a concave curve plots a more rapid recovery during the earlier part of the recovery period compared to a linear recovery curve, which plots a constant rate of recovery over the recovery period, as illustrated in Figure 7 below. Recovery curves used for the Beta landscape analysis are shown in Figure 7. Note that Figure 7 shows a 100-year recovery period; however, this period varies depending on the type of disturbance being modeled, as shown in Table 22 above.

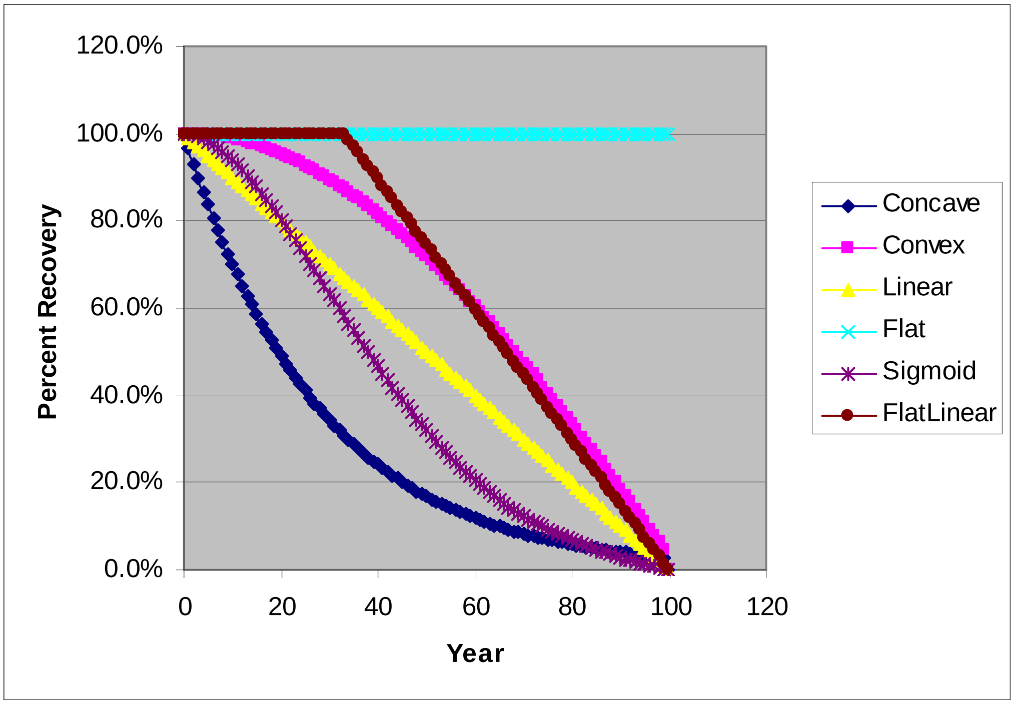

Figure 7. Recovery curves used for B2E Beta landscape cumulative impacts analysis

2.15.4. Watershed Thresholds

The basic area for cumulative watershed effects analysis is a watershed. ERAs are calculated for a watershed over various time periods, and these values are compared to a threshold of concern (TOC) established for the specific watershed. The TOC is expressed as the ERA level that indicates the upper limits of the watershed's tolerance to disturbance. The established TOC is based on the watershed's sensitivity to disturbance and beneficial uses of the water. The TOC does not represent the point at which cumulative watershed effects will occur. Rather, it serves as a "yellow flag" indicator of a particular watershed's increasing susceptibility to potential significant adverse cumulative effects.

The ERA or disturbance threshold for any given watershed is unknown. Thresholds can vary within a watershed based on the intensity and duration of storm events. A very large 100- to 200-year storm event can exceed the threshold of an undisturbed watershed. A relatively small 1 or 2 year storm event may cause debris slides after a wildfire. The amount and severity of disturbances increase the likelihood of a storm event exceeding the watershed threshold.

Thresholds of concern can be estimated based on local knowledge of past events. It is typically a conservative estimate, based on 30- to 100-year storm events. The threshold values used for the B2E analysis were from the Tahoe and Plumas National Forests. Specific thresholds of concern are listed in appendices to the Cumulative Watershed Effects Domain Report (Appendix 6).

2.16. Economic Analysis

The economic analysis focused on determining economic values of changes in resource conditions in the Beta landscape and at the power plant. As such, the analysis necessarily depended on modeling results from most of the Project's other domains, as well as financial data for constructing and operating power plants and the valuation of assets (structures, infrastructure, recreation resources, and agricultural production) at risk to wildfire in the Beta landscape. The analysis, however, was not a comprehensive economic assessment, which would require estimating monetary values for the ecological public goods and services, such as water quality, air quality and biological diversity, supported by the Beta landscape. As discussed in the section on ecosystem services above, prices and quantities were not readily observable for most public goods and services affected by changes in the Beta landscape. (Recreation resources are an exception.) The analysis instead focused on valuating private goods and services (marketable assets, such as timber, structures and power from biomass plants) affected by changes in resource conditions within the Beta landscape and at the power plant. For the most part, data on prices and quantities consumed were available from market transactions to place economic value on these goods.

Different analytical frameworks (Table 23) can be used to present the outputs from economic analyses. Deciding on the appropriate framework often largely depends on the policy questions that need to be answered and the availability of data to conduct the analysis. For example, cost-effectiveness analysis is typically used when a specific project outcome is predetermined and the analytical objective is to determine the least cost way to achieve the objective. Economic costs are derived in terms of the opportunity costs of foregone uses of resources, including any direct costs incurred by implementing agencies. Benefit-cost analysis is a more comprehensive approach to economic analysis, involving equal consideration of economic costs and benefits. Benefits reflect the increased value of market and non-market goods and services (such as recreational, aesthetic, and cultural values).

Table 23. Analytical frameworks for economic analyses

ANALYTICAL FRAMEWORK	PRIMARY OBJECTIVE
Private Investment/Financial Analysis	Identify rate of return on investment
Cost-effectiveness Analysis	Identify least cost program or project
Fiscal Analysis	Identify effect on local government budgets
Local/Regional Economic Impact Analysis	Identify effects on the local economy (jobs, income)
Social/Community Analysis	Identify effects on community well-being
Benefit-Cost Analysis	Identify the net economic value to society

Successfully applying either cost-effectiveness or benefit-cost analysis depends on scientific understanding of the underlying physical and biological processes. The physical changes in environmental and resource conditions are often described by response functions that relate changes in the physical and biological environment to policy actions. The economic analysis attempts to characterize these physical and biological changes in monetary terms. However, if key relationships among the physical and biological processes are not well understood, the economic analysis will mirror (and often compound) the level of uncertainty.

The overarching research question for the B2E Project's economic analysis was as follows: "Do the benefits of removing biomass (both timber and other biomass) from the forest and using it as a fuel source to generate electricity exceed the costs associated with the forest management activities?" The economic analysis focused on estimating the net present value (NPV) of changes in resource conditions associated with the vegetation management treatment scenarios (s1…s3) over a 40-year analysis period (t1…t40). Notationally, the analysis can be expressed as follows:

$$NPV_{s1...1n} = \sum R_{t1...t40} - C_{t1...t40} + EB_{t1...t40} - EC_{t1...t40} + \Delta MAV_{t1...t40}$$

where:

- **R = Revenues:** discounted annual revenues for power generation, biomass co-products (sawlogs), and salvage logs
- **C = Costs:** discounted annual operations, maintenance, and capital costs for forest fuels management, power plant operations, fire suppression, and forest rehabilitation
- **EB = Environmental Benefits:** discounted annual positive changes in the provision of ecosystem services
- **EC = Environmental Costs:** discounted annual negative changes in the provision of ecosystem services
- **ΔMAC = Change in Market Asset Values:** discounted change in market asset values attributable to wildfires, including structures, infrastructure, agricultural lands production, and recreation resources.
- **s = scenario:** comprehensive array of treatments, vegetation changes and wildfire interactions
- **t = time:** annual time period for each change in value

Although the analytical notation includes consideration of environmental benefits and costs as part of a comprehensive economic analysis, research limitations did not allow for monetizing the environmental effects of the treatment scenarios evaluated for the B2E Project. These limitations and ways to address them are discussed above in the section on ecosystem services.

Consistent with requirements for economic efficiency analysis, the economics domain team used a benefit-cost analytical framework to evaluate changes in resource costs and benefits associated with the Reference Case and the Test Scenario. The analysis also included calibrations against the Private Land scenario, developed to test model sensitivity and to show likely marginal impacts and benefits from private land management. Resource costs were measured in terms of opportunity costs, and benefits were evaluated in terms of willingness-to-pay.

The team developed a spreadsheet model to calculate the annual costs and benefits of the no-treatment Reference Case and the Test Scenario over the 40-year analysis period. As a practical matter, costs and benefits that occur beyond 40 years in the future have little or no present value. Costs and benefits are discounted to present value using a 3 percent real discount rate.

2.16.1. Valuation of Assets at Risk to Fire

A primary focus of the economic analysis was on evaluating changes in the economic value of assets at risk to wildland fire. Based on previous research (California Department of Forestry and Fire Protection 2005 and Baerenklau 2006), key assets with established market values that are at risk to fire include agricultural land resources, timberland resources, recreation resources, structures, infrastructure, and mineral resources.

A geographic information system (GIS)-supported approach that allows for considering spatially-explicit relationships was used to conduct the analysis of assets. GIS was used to develop baseline values of assets at risk and to assess how fire affected these values over time. The geographic mapping levels, units of valuation, and basis of valuation for the assets evaluated in the analysis are shown in Table 24.

Table 24. Geographic specification and valuation parameters for the assets at risk analysis

Applicable Assets	Geographic Mapping/Level of Dis-aggregation	Units for Valuation	Basis of Valuation
Agricultural resources	Region-wide, based on designated rangelands (CDF) and irrigated croplands (ag covertype)	Acres	Average rangeland and irrigated cropland values per acre; crop composite values used for specific areas (e.g., Sierra Valley)
Timberland resources	100 square meter grids used for SFA output, by county	Green and salvage volume (thousand board feet) classifications defined by BOE	Average stumpage values from BOE for harvest, treatment (co-products) and salvage
Recreation resources	Region wide, based on CDF designated recreation areas and other important recreation areas	Visitor days	Average net economic value per visitor day
Structures	Parcels, by county	Improvements to real and personal property, by parcel	Assessment value of improvements and other personal property
Infrastructure	Region wide, based on updated CDF data on powerline and facility siting	Improvements to real property and easements	Replacement value
Mining	Region wide, based on designated mining areas	Not valued	Not valued

GIS layers were created for each of the assets considered in this analysis. Baseline values for each asset were calculated by assigning a known or estimated dollar amount to each cell containing an asset. For example, one mile of transmission line was determined to have an average replacement value of $300,000. This value was converted to cost per meter giving each 100-meter cell containing a transmission line a baseline value for that asset. Layers for recreation, agriculture, structures, and infrastructure (power transmission lines) were then compared to modeled fire location and intensity for each 10-year time period in the Reference Case. Fire intensity (flame length) was translated into a damage function appropriate for each asset type. Burned cells containing assets were assigned a percent loss based on the fire intensity in that cell. Asset damages were aggregated within each asset type to determine total asset loss.

2.16.2. Sawlog Valuation

The economic analysis estimated the net revenues from harvesting of conifer sawtimber by species. The economics domain team reviewed potential sources for objective and consistent valuation data and found that the best available source was the California State Board of Equalization (BOE). The BOE sets timber harvest values as the basis for property taxes paid by California forest landowners and purchasers of public timber, per the California Timber Yield Tax Law of 1976. These values reflect net revenues to operators, thereby accounting for production costs.

The BOE values are derived from market analysis conducted by BOE foresters using actual sawtimber transaction data for each of the 11 timber value areas in California. The market analysis provides approximate stumpage[16] values for the timber before it is harvested, processed and transported to the market (i.e. sawmill, paper mill, composite panel facility). Valuation is expressed in dollars per thousand board feet ($/mbf)[17]. The BOE provides timber harvest values for miscellaneous, green and salvage timber respectively. In addition, BOE timber valuation assumes that value for some conifer species, such as ponderosa pine and Douglas fir, is also a function of size. For these tree species, the BOE assumes that the larger the diameter of the sawlog, the more value it has in the marketplace.

2.16.3. Fuels Treatment Costs

Forest management costs for the Test Scenario were estimated using a spreadsheet model developed by the Project’s equipment configuration domain team. Costs were estimated by using the equipment configuration team’s characterization of the type and blend of forest harvest and removal equipment used to perform forest management activities in the Beta landscape. Cost estimation was based on information provided by experts (harvesting contractors and supervisors) currently conducting forest management activities in Northern California.

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16 Stumpage values represent the value of timber as it stands prior to harvesting.

17 Thousand board feet (mbf) represents the volume of a log based upon board foot measure. One board foot represents the amount of wood contained in an unfinished board measuring one inch thick, one foot long, and one foot wide.

Total costs were allocated to the two different products, chips and sawlogs, using the following logic: because a primary intent of the operations is to remove fuel and remediate forest stands, the biomass and sawlogs should share equally, on a per-ton basis, the costs of all activities that handle or process both products. Thus, costs were partitioned by weight over the biomass and sawlogs for activities directly associated with each distinct configuration of harvest equipment. The costs of ancillary activities were also shared on the same basis. Costs allocated solely to biomass included chipping and transport of chips to the power plant. (The analysis did not consider loading and hauling activities associated only with sawlogs.) Finally, capital and operations and maintenance costs were calculated separately on a per-ton unit basis for each product (sawlogs and biomass).

2.16.4. Power Plant Costs and Revenues

Power plant cost estimates developed for the B2E Project were primarily comprised of the following three components:

- initial capital and development costs for the permitting and building of the project,
- cost of financing these up-front costs during construction as well as the operating phases of the project, and
- actual operating and maintenance of the project during its operating life.

Initial capital costs were estimated on the basis of similar-sized plants that are being built on the West Coast, with costs based on the assumption that a new facility would be constructed on land that is rural in nature, and built where permitting for a biomass power plant would be a reasonable financial undertaking. Financing cost was based on the assumption that the project will be a stand-alone entity, and that the equity investors and debt lenders would only have recourse to the project itself. Operating and maintenance costs of the project were based strictly on the experience of the Mt. Lassen Power biomass plant in Westwood, California. Mt. Lassen Power has had a long history of continuous operations, sourcing a majority of its feedstocks from thinning operations within a 30 to 50 mile radius of the power plant, providing empirical data representative of the costs associated with the operations of a typical biomass power plant.

Power plant revenue estimates were developed by multiplying the electricity output of the power plants constructed under each scenario by a price per kWh. The prices incorporated into the revenue estimates were based on information provided by the California Renewable Portfolio Standard Program. This program calls for the California Public Utilities Commission to establish a methodology to determine the market price of electricity for terms corresponding to the length of contracts with renewable generators. The market price must reflect the long-term market price of electricity a utility would need to purchase to meet its capacity and energy needs from conventional fossil fuel resources instead of the renewable resources proposed under the RPS bidding process.

2.16.5. Fire Suppression and Rehabilitation Costs

Fire suppression and rehabilitation costs can vary considerably due to differences in location, terrain, fuel type, proximity to populated areas, weather, fire intensity, and so forth. The team’s review of literature and data concerning fire costs revealed little fire suppression and rehabilitation information specific to the Beta landscape. Therefore, the team used national data and information available for fires in other areas to develop costs for modeling purposes, implicitly acknowledging that costs may differ for fires in the Beta landscape.

To estimate suppression costs on a per acre basis, the economics domain team relied on cost data from the Forest Service (Strategic Issues Panel on Fire Suppression 2004) as well as a study of Colorado fires (Lynch 2004). The Colorado suppression cost data were generally consistent with the Forest Service cost data, indicating that the national suppression cost of $403 per acre was reasonable for estimating suppression costs in the Beta landscape. This cost was adjusted to 2006 dollars using the Employment Cost Index for state and local government workers, resulting in an average fire suppression cost of $465 per acre.

Expenditures on post-fire rehabilitation vary considerably because this spending is more discretionary than is spending on fire suppression. Additionally, variations in locations of fires can play a larger role in costs. For example, a fire that results in erosion that threatens urban water supplies or that increases the chances for major flooding in urban areas may spur significant emergency and long-term rehabilitation spending, whereas a fire in a remote area that does little damage to major watersheds may generate little or no rehabilitation spending. Activities funded by rehabilitation spending can vary from emergency erosion control to multi-year programs that include watershed seeding and tree plantings. The team used data from a Forest Service study that evaluated emergency rehabilitation treatments following 480 fires, primarily on National Forest System lands, from 1973 through 1998 to develop assumptions for average rehabilitation costs for the Beta landscape.

3.0 Project Results

Project results are presented in the following sections in a sequence following the format in the project approach section. Detailed reports for each domain reported are available in the Appendices, along with complete metadata reports for each model and dataset used. The presentation of results in each domain follows the following format (Table 25):

Table 25 - Format for presentation of B2E model results

Domain	Types of results
Vegetation Dynamics	Types, size and location of treatments; general characteristics of the Beta landscape; removal of sawlogs and biomass under each scenario
Wildfire Behavior	Size, severity and locations of fires under each scenario
Life Cycle Assessment	Smoke emissions from each class of fire; energy use and emissions for each equipment configuration; energy use and emissions for each type of biomass powerplant; comparison of biomass energy with California grid and natural gas power plant; total system emissions; environmental impact analysis for climate change, smog formation, acidification and particulate matter
Landscape Greenhouse Gas	
Habitat	Changes in habitat quality due to fire, treatments or both
Cumulative Watershed Effects	Impacts to soil, soil movement, sedimentation in aquatic systems
Economics	Changes in asset values due to fire and treatment; treatment costs and revenues; power plant costs and revenues; fire suppression costs; rehabilitation costs

Note that the results table above does not address several of the other domains and processes identified in the approach section (2.0). The team considered many of the approach processes and domains to be intermediary steps required only to produce model outputs for the domains reported in the results section (3.0).

It is worth emphasizing that the actual numerical and marginal results presented here are the outcomes of the B2E modeling assumptions. The differences in wildfire severity or size, for example, may not be as dramatic in the Test Scenario as one might have hoped. Or the reduction in wildfire greenhouse emissions may not seem significant, given the effort and expense seen in the equipment deployments or economic returns. This is purely an artifact of the modeled scenario assumptions. Future evolutions or applications of the B2E model would include development of additional scenarios that would test the landscape's ability to produce significant changes, perhaps in greenhouse gases, biomass power produced, or other production functions that might be socially preferable. The Test Scenario assumptions were designed to be as close to current practice and experience as possible so as to allow the modeling teams to calibrate model functions and assumptions. In other words, the team chose to test the models as closely to reality as possible, using actual data where possible, in order to assure proper model functioning.

The Test Scenario applied different types of vegetation treatments to account for different landowner objectives, for example, modeled treatments on private industrial forest lands clearly had a sawlog production management objective. PMU modeled treatments accounted for a variety of objectives. For example, most of the treatments on national forest lands in the first decade were focused on the construction of defensible fuels profile zones (DFPZs), which are designed with the objective of providing a place to deploy firefighters in the event of a wildland fire. Firefighters would use DFPZs to make a stand to hold or contain a fire. Treatments on national forest lands during the second model decade focused more on strategically placed area treatments (SPLATs). SPLATs are designed to interrupt the spread of a wildland fire, thereby slowing its spread. DFPZs are a fire suppression enhancement strategy while the objective of SPLATs is landscape-scale fire behavior modification.

The landscape selected for analysis covers approximately 2.7 million acres of both east and west side forest in the northern Sierra Nevada mountains. Figure 8 shows the location of the Beta landscape. The area spans three national forests, five counties and contains parts of Lassen National Park, several state parks, a state game reserve and several thousand acres of commercial forest lands. Table 26 (duplicated from the Approach section) shows a breakout of the types of land ownerships on the Beta landscape.

Table 26. Land ownership categories in the B2E Beta landscape

Land Category	Acres	% of Total
Public Multiple Use	1,374,783	50%
Public Conservation & Recreation	407,776	15%
Industrial Private Forests	457,427	17%
Non Industrial Private Forests	383,008	14%
Urban & Other	112,816	4%
Total	**2,735,809**	**100%**

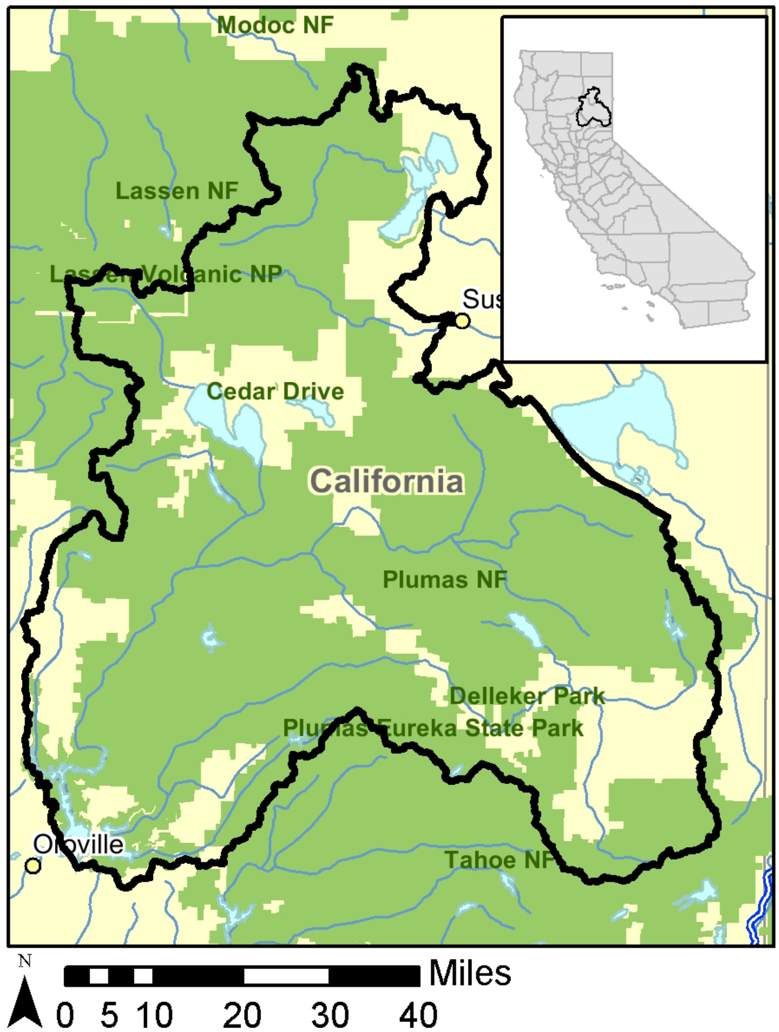

Figure 8 - Location of B2E Beta landscape

The B2E model tracks the changes in vegetation type and condition through four modeling decades for both a Reference Case and Test Scenario. The Beta test of the model assumes a beginning year of 2006, and ends with final conditions stated for 2046. Therefore, changes from fire and treatment are displayed for the years 2006, 2016, 2026 and 2036.

3.1. Vegetation dynamics and change

Vegetation conditions are reported in this section under both the Reference Case and the Test Scenario. Treatments are reported by ownership class and slope condition, so that the reader can appreciate the extent of treatments under each scenario. Scenarios will be compared at the end of the section.

3.1.1. Reference Case and Test Scenario

A Reference Case was developed to compare changes under other scenarios, and is typically characterized as the "no treatment" scenario, in which the model grows and burns trees without any treatments being applied. The primary purpose of this scenario is to establish both the extent of growth on the landscape without intervention and the extent and severity of fires without treatment. It is a totally hypothetical case for reference purposes only.

Vegetation changes in the Reference Case are due exclusively to growth and wildfire, and are reported in the next section on wildfire behavior.

Table 27 - Acres and products from the Beta landscape under the Test Scenario

Acres Treated	1,971,451
Biomass Chips Produced (BDT)	20,804,604
Sawlogs Produced (mbf)	15,682,776

Table 28 - Acres treated by decade per scenario under the Test Scenario

	2006	2016	2026	2036
Test Scenario	525,825	447,478	538,485	459,663

3.2. Wildfire Behavior

Wildfire is one of the most critical variables being tested through the use of the B2E model. Since the key objective of the model was to test the effect of thinning on fire extent and severity, the model needed to show sensitivity to the effects of thinning operations. Table 27 above shows the average BDTs removed per acre during the entire 40-year modeling period. This shows a gross level of change in the fine fuels present, available for burning in wildfire.

The fire behavior domain team modeled wildfire behavior under the Reference Case (no treatment) and the Test Scenario. Under the Reference Case, weighted average biomass levels were 79 bone-dry tons (BDTs) per acre; under the Test Scenario, private land treatments removed an average of 31 BDTs/acre, while SPLATs and DFPZs removed an average of 24 BDTs/acre (Appendix 8, Table 1).

While the ownerships, forest type, density and slope dictated the type of treatment prescriptions, the wildfire modeling found that the spatial arrangement of treatments has a greater impact on their ability to change fire intensity and extent than the prescription applied (see Appendix 8). The Test Scenario fires were modeled with spatial adjustments of treatments to protect sensitive wildlife habitat, reduce negative watershed effects, shape recreational opportunities, and capture timber volume under industrial private forest ownerships. The assumptions used in the spatial distribution of treatments are shown in the treatment allocation rule sets and logic described in the vegetation domain appendix.

The wildfire behavior modeling showed a 22% reduction in extent of wildfire compared to the Reference Case (Table 29). The second decade shows the greatest impact on reducing overall wildfire perimeters (Table 29). One might expect to see a similar trend for reducing fire perimeters across all four decades. However, differences due to modeling assumptions and fire ignition locations may explain the variance from the downward trend in the third and fourth decades under the Test Scenario. The substantial changes in decade two are most likely attributable to the location of the ignitions, higher proportion of private industrial ownership, and the topography within the fire perimeters.

Table 29 - B2E burned areas by scenario and by year

Year	Reference Case	Test Scenario
2006	92,684	80,487
2016	60,153	39,846
2026	69,953	44,385
2036	76,543	67,796
Total Acreage	299,334	232,514
% Change from Reference Case	0%	-22%

As would be expected, the Reference Case generated more acres burned compared to the Test Scenario, with an average of 74,833 acres burned per decade. Ignoring the small fires, the B2E Beta landscape's fire history on record (last 80 years) averaged approximately 65,000 burned acres per decade. Wildfire behavior modeling for the B2E Beta test attempted to mimic the fire history on record, burning 65,000 acres in a variety of fire sizes and intensities.

Evaluations of fire hazard mitigation programs tend to focus primarily on changes in the number of acres burned (since those are easiest to monitor). However, the B2E fire modeling also captured changes in the severity of fires. Across the Reference Case and the Test Scenario, approximately 32 % of the acres burned were characterized as non-lethal, that is, surface fires with flame lengths between one and four feet (Table 30). This acreage corresponds well with the Forest Service's wildfire severity monitoring for the Sierra Nevada (Miller and Fites 2006), in which the authors found that approximately one third of the area of large fires burns in the "non-lethal" severity class.

Table 30 - Fire Severity for Modeled Wildfires Under the Reference Case and Test Scenario

Fire Severity Class	Reference Case	% of acres burned	Test Scenario	% of acres burned
N - nonlethal	81,471	27%	86,586	37%
X - mixed lethal	136,887	46%	98,560	42%
L - lethal	80,976	27%	47,368	20%
Grand Total	299,334	100%	232,514	100%

Fire severity classes are important to the B2E modeling because many of the downstream models evaluate the effects of fuel treatment scenarios based upon the three severity classes. For instance, consumption rates for canopy fuels and resultant wildfire emissions for green house gases are all modeled and calibrated based on fire severity classes.

The percentages of acres with lethal and mixed-lethal fire severity classes were highest in decade two (Table 31). Only decade three showed a decrease in the number of acres in the non-lethal severity class (3,880 acres) but that is due to the dramatic drop in total acres burned from implementing both public and private treatments in this particular decade with a combined reduction of 25,568 acres or a 36.5% reduction from the Reference Case (Table 32).

Table 31. Fire severity results comparing reference to test

		Fire Severity Classes		
	Year	Non-Lethal	Mixed Lethal	Lethal
Reference Case	2006	36,579	33,176	22,929
	2016	19,447	20,947	19,759
	2026	19,296	31,691	18,965
	2036	6,148	51,072	19,324
Test Case	2006	37,889	24,740	17,858
	2016	19,914	15,452	4,480
	2026	15,417	18,496	10,472
	2036	13,366	39,873	14,557

Overall, the results of the vegetation and fire modeling show a reduction in acres burned and the severity with which those acres burned. This demonstrates successful implementation of the interactive vegetation and fire modeling. In terms of treatment efficacy, the modeling confirms increasing experience in the management community as well as empirical measurements in the literature: treatments can have a positive effect on reducing the extent and severity of wildfire at the landscape scale.

3.3. Life Cycle Assessment Results

3.3.1. Gross Inventory Results

The gross inventory assessment estimated the life cycle energy use and emissions for the Reference Case and the Test Scenario assuming use of the current generation biomass combustion power plant and as the treatments would be performed (as described in Section 2.0). The Test Scenario in the gross assessment was assumed to produce different amounts of sawlogs and biomass electricity over the 40 study years (Table 32).

Table 32. Gross assessment system products

	Reference Case: No treatment	Test Scenario: Treatments on IPF , NIPF, and PMU lands
Landscape managed (acres)	2,700,000	2,700,000
Area treated (acres)	0	1,971,451
Sawlogs produced (dry tons)	0	31,000,000
Biomass electricity generation: current generation biomass combustion power plant (MWh)	0	19,000,000
Installed biomass electricity generation capacity (MW)	0	61

Table 33 presents the gross inventory analysis results for the Test Scenario, including the life cycle energy use and emissions for harvest equipment operation (including forest treatment and chip transport), underburning, and power plant operations. Total life cycle energy includes the life cycle for fuels used by harvest equipment and during chip transport and for energy use by the power plant (for example, diesel use for forklifts and use of propane for building heat and plant start up), as well as the energy contained in the chips, minus the energy *generated* by the power plant. Because the power plant was assumed to operate at a20 percent conversion efficiency the energy in the chips dominates total energy consumption.

Table 33 - Gross life cycle inventory results for Test Scenario

		Life Cycle for Harvest Equipment Operation and Chip Transport	In-Forest Underburning	Life Cycle of Power Plant Operation	Total Test Scenario
Total energy consumed	mmBtu	2,924,894	-	291,970,023	294,894,918
Fossil energy consumed	mmBtu	2,861,358	-	809,596	3,670,954
Petroleum energy consumed	mmBtu	1,354,024	-	154,141	1,508,165
NMVOC emissions to air	tons	884	27,789	3,601	32,275
CO emissions to air	tons	3,112	120,892	33,153	157,157
NOx emissions to air	tons	1,750	1,125	14,322	17,197
PM10 emissions to air	tons	356	11,599	9,765	21,719
SOx emissions to air	tons	248	736	1,660	2,644
CH4 emissions to air	tons	1,649	5,690	1,689	9,027
N2O emissions to air	tons	29	150	4,377	4,556
CO2 emissions to air	tons	1,182,172	1,576,269	40,834,701	43,593,142

Beyond the total life cycle energy, life cycle fossil and petroleum consumption for the gross assessment was dominated by fuel use for harvest and chip transport (as expected). For emissions, in-forest underburning becomes important in the Test Scenario for NMVOC and CO emissions. Finally, power plant operations account for approximately 94% to total system emissions in raw tons.

3.3.2. Gross Impact Characterization

Table 34 presents the estimated life cycle contribution to climate change, acidification, and smog formation for the gross assessment of the Test Scenario. These results were based on the inventory results presented in Table 33 above and the equivalency factors described in Section 2.0.

Table 34. Gross assessment of climate impact categories from LCA

Impact Category	Units	Life Cycle for Harvest Equipment Operation and Chip Transport	In-Forest Underburning	Life Cycle of Power Plant Operation
Climate Change	tCO2e	1,200,000	1,700,000	42,000,000
Acidification	tH+e	83,000	82,000	660,000
Smog formation	tNOxe	2,500	2,040,000	18,000

Finally, Table 35 presents the gross assessment energy consumption, PM_{10} emissions, and impact characterization results normalized by the 40-year California contribution to each flow or impact using the normalization factors presented in Section 2.0. As shown, the life cycle total energy is estimated to approach a 0.1 percent increase in the California total for the Test Scenario. Normalized values are less than 0.1 percent of the California totals for fossil and petroleum consumption and contribution to acidification.

Table 35. Gross assessment impact normalization (as percent of California impact)

	Total energy	Fossil energy	Petroleum energy	Climate change	Acidification	Smog formation	PM_{10} emissions
Test Scenario	0.12%	0.0019%	0.00080%	-0.18%	0.023%	0.18%	1.4%

3.3.3. LCA Interpretation

The gross assessment results for the Test Scenario above are not technically comparable to any other possible scenarios for three reasons: (1) different scenarios would produce different amounts of sawlogs, (2) different scenarios would produce different amounts of electricity, and (3) different scenarios result in a 2.7 million-acre landscape characterized by differing management outcomes, as measured by extent and severity of wildfire. In LCA terminology, the systems represented by different scenarios would be multifunctional, and the LCA standards followed in this study provide computational remedies for managing multifunctional systems. In LCA terms, co-products are products produced but not used within the system boundaries. (In the Test Scenario, sawlogs are a co-product.) There are three computational options for the management of co-products in life cycle assessments:

1. system expansion (subtracting from the inventory analysis the life cycle energy use and emissions for an alternative means to produce the co-product),

2. allocation (dividing the energy use and emissions among process products and co-products on the basis of the equipment applied, stoichiometry, or co-product mass, energy, or economic value), or

3. ignoring the co-products (which is essentially what has been done in the gross assessment described in this Section).

System expansion is the preferred method when an alternative means to produce the co-product exists (such as another way to produce electricity or sawlogs), with most LCA practitioners using allocation when system expansion is not feasible.

The importance of these computational remedies cannot be overstated. In order to facilitate a net or comparative assessment (for example, the comparison of ways to produce electricity), credit (or subtraction) must be used for system co-products as needed to model systems that produce only one product. For example, consider the net assessment defined in Table 36, in which the electricity generation system was designed to produce only electricity.

Table 36. Net assessment system characteristics (electricity only)

	Electricity generation systems
Final product	Electricity
Magnitude of service	per MWh
Duration of service	40 years
Expected level of performance	Continuous electricity generation
For comparison to	Electricity generation by conventional means such as using the California grid or a natural gas power plant
What needs to be done computationally	Remove energy use, emissions, and impacts for sawlog production

The assessment of the electricity generation system defined in Table 36 follows below for the comparison of different electricity generation systems. In this net assessment, energy use, emissions, and impacts for sawlog production were removed from the gross assessment results using allocation, because system expansion was deemed infeasible in the absence of a viable process to generate sawlogs only. To remove sawlogs from the assessment, the harvest and chip transport equipment were first grouped as that dedicated to chip production, to sawlog production, or to both. Next, fuel and oil use and emissions for chips were estimated to include that for equipment dedicated to chips and that for equipment dedicated to both chips and sawlogs, with the latter mass allocated to the amount of sawlogs produced. Thus, a combination of process-based and mass allocation was used in the net assessment.

3.3.4. Comparison of biomass electricity generation systems

A comparison of different electricity generation systems follows, using the assessment of the electricity generation system defined in Table 36. In this net assessment, energy use, emissions, and impacts for sawlog production were removed from the gross inventory assessment using an allocation method. A system-expansion method was deemed infeasible in the absence of a viable process model that would show the inputs, processes and emissions for sawlog production only. To remove sawlog-related processes from the assessment, the harvest and chip transport equipment were first grouped as those processes dedicated to chip production, those processes dedicated to sawlog production, or those processes dedicated to both. Next, fuel consumption, oil use and emissions for chip production were estimated for equipment dedicated to chip production and for equipment dedicated to both chips and sawlogs. The latter were mass-allocated to the amount of sawlogs produced. Thus, a combination of process-based and mass-based allocation methods were used in the net assessment.

The comparison of electricity generation systems, detailed in the LCA Domain Report (Appendix 4), offers at least two important insights into the system. First, the effect of the low B2E power plant efficiency on the total life cycle energy consumption is revealed, reflecting the differences in the source-to-point-of-use efficiency of conversion of fuel type to energy output for each system: 35 percent efficiency for the natural gas power plant; 45 percent efficiency for the California grid; and 18 percent efficiency for the Test Scenario. Second, the life cycle consumption of fossil and petroleum fuel and the contribution to acidification for the Test Scenario are estimated to be less than that needed to produce equivalent amounts of electricity using conventional means (i.e., NGPP or the California grid).

Alternative Power Plant Technologies

In Figure 9, life cycle energy is dominated by the difference between the energy embodied in the chips and the biomass electricity generated, again ultimately reflecting the power plant efficiency. Table 37 provides characterizations of a current generation integrated gasification/ combustion power plant and a next generation thermochemical conversion power plant as described in Nechodom et al. (2008). In all cases, the supporting equipment energy use and emissions were assumed to be consistent with that of the current generation combustion plant characterized in Section 2.0 , with the exception of the use of grate grease, which was assumed only to be applicable in operations at the current-generation combustion power plant. The LCA Domain Report in Appendix 4 presents the inventory data used for the biomass power plant, considering the species of trees used and the heating values described in Section 2.0. An 8 percent transmission loss is also assumed when calculating total power plant efficiencies.

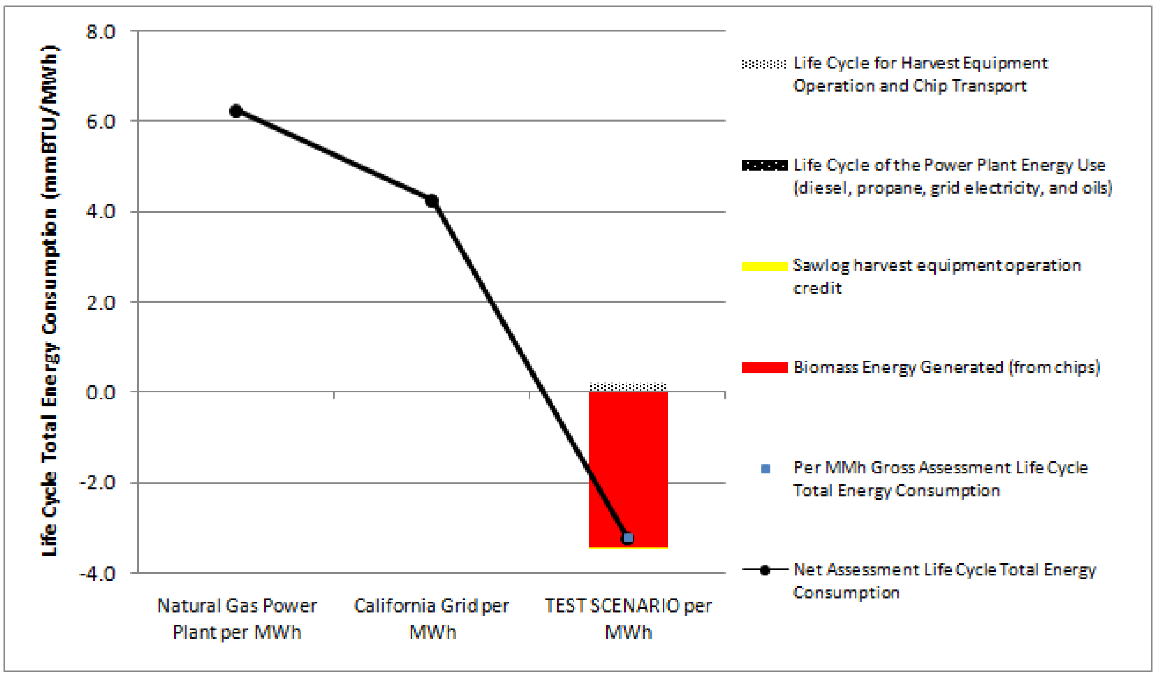

Figure 9 - Life cycle energy consumption net assessment

In order to show the effects of power plant efficiencies, Table 37 presents the two other biomass conversion systems modeled for the final report of the B2E project. These characterizations are important to understand in the context of the net assessment, which compares the assessment impacts depending on which technology is selected. Power plant efficiencies range from 18% for the current generation combustion plant used in the gross assessment to 28% for the thermochemical conversion technology. A complete characterization of all technologies used in the B2E project is available in the LCA Domain Report (Appendix 4) and in Nechodom, et al. (2008).

Table 37. Power plant characterizations for net assessment comparison

	Current Generation Integrated Gasification/ Combustion Power Plant	Next Generation Thermochemical Conversion Power Plant
Electricity (kWh/dry ton)	1,200	1,400
Plant Energy Efficiency	22%	28%
Plant Emissions (lbs/mmBtu output)		
NOX	0.067	0.0084
SOX	0.010	0.0016
PM	0.030	0.032
CO	0.070	0.042
NMVOC	0.018	0.0031
CO_2	890	690
CH_4	19	19
N_2O	0.065	0.065

Table 38 presents the LCA results for all three power plant technologies based on the forest management net assessment, in which the managed acres are held constant in order to compare life cycle impacts from electricity generation.

Table 38. Life cycle impacts of the three modeled B2E power plant technologies

		Current Generation Biomass Combustion Power Plant	Current Generation Integrated Gasification/ Combustion Power Plant	Next Generation Thermochemical Conversion Power Plant
Landscape managed	Acres	2,700,000	2,700,000	2,700,000
Area treated	Acres	1,971,451	1,971,451	1,971,451
Total energy consumed	tera Btu	170	150	99
Fossil energy consumed	tera Btu	(120)	(130)	(160)
Petroleum energy consumed	tera Btu	(0.78)	(0.96)	(1.50)
Climate Change	million tons CO2 equiv	5.90	4.60	0.37
Acidification	million tons H+ equiv	0.47	(0.02)	(0.43)
Smog formation	million tons NOx equiv	0.24	0.23	0.22
PM10 emissions to air	million tons	0.12	0.11	0.11

3.4. Landscape Greenhouse Gas Model

The results from the LGHG model were found to be divergent from the results of the LCA model. However, as a generalized model of GHG fluxes between above ground biomass and the atmosphere, it provides some useful insights. According to the LGHG model, both the Reference Case and the Test Scenario show net increases in carbon in above-ground live biomass. Over the 40-year timeframe of the B2E model, the Reference Case sequesters approximately 100,000 tons of CO2 from the atmosphere, while the Test Scenario removes more than 125,000 tons. Even calculating the release of CO2 from powerplant operations, the net CO2 sequestered in the forest remains positive when compared to the amount of CO2 released by fossil-fuel generation.

The consultant report in Appendix 9 shows a positive relationship between thinning and reduction of CO_2 and CH_4 emissions. When projected over a 100-year timeframe (the commonly accepted time period during which CO_2 "clears" from the atmosphere), Morris shows that the "net biogenic greenhouse gas reduction associated with treatments remains greater than 1 ton of CO_2 equivalents per bdt of treatment removal…".

3.5. Wildlife Habitat Effects

Wildlife habitat effects are measured through changes in vegetative structure. The underlying data for analyzing habitat effects associated with any kind of disturbance, whether wildfire or treatments, are derived from the vegetation dynamics analysis. Data extraction and assumptions are described above in the Approach section, and results are reported here in the following three categories: (1) changes in forest structure; (2) impacts on forest-structure associated species; and (3) changes in service providing units (SPUs). A case study focused on American marten habitat was developed as a complement to the B2E project to test the sensitivity of the B2E habitat modeling against observed marten occupancy data in the Sierra Nevada. Detailed results of effects on American marten habitat from disturbance regimes modeled in the B2E project are reported in Appendix 5.

3.5.1. Forest Structure

Changes in forest structure are measured by two variables: canopy closure and average tree diameter. Prior to treatment, the B2E landscape was predominantly in a high canopy closure condition, with approximately 45% of the landscape characterized by dense canopy closure (greater than 60% or D closure class), and 25% of the landscape characterized by moderate canopy closure (40 to 60% or M closure class). The Reference Case, without treatment, resulted in an increase in the proportion of the landscape with dense canopy closure (D) from 45% to nearly 70% and a decrease in moderate canopy closure (M) to approximately 5%. In contrast, the Test Scenario remained largely unchanged over the duration of the 40 year treatment period. There was a significant difference in the three higher canopy closure classes in the Reference Case, with open (25-40% orP) and moderate (M) canopy closure classes declining and the dense (D) canopy cover class increasing relative to the Reference Case.

Prior to treatment, approximately 50% of the landscape (over 60% of the forested area) was occupied by small diameter forests (average diameter of 12 to 24 inches dbh; diameter class 4), with an additional 20% of the landscape (approximately 35% of the forested area) occupied by medium/large diameter forests (mature forest; average diameter >24 inch dbh; CWHR diameter classes 5 and 6). Pole stands (diameter class 3) occupied less than 3% of the landscape, with the remaining landscape occupied by non-forested habitat conditions.

The Reference Case and Test Scenario differed greatly in the amount of the landscape in small diameter (class 4) and medium/large diameter (class 5/6) forests. In the Reference Case, the proportion of the landscape in small and medium/large diameter forests switched in dominance over the 40-year period, such that at the end of the treatment period, 60% of the forested area was occupied by medium/large diameter trees and 30% occupied by small diameter forest (Figure 10). In the Test Scenario, the proportion of the landscape in small diameter and medium/large diameter forests converged over the course of the modeling period to where each diameter class occupied approximately 35% of the landscape (Figure 11). No change occurred in the number of acres of pole forests (diameter class 3) in the Reference Case or Test Scenario.

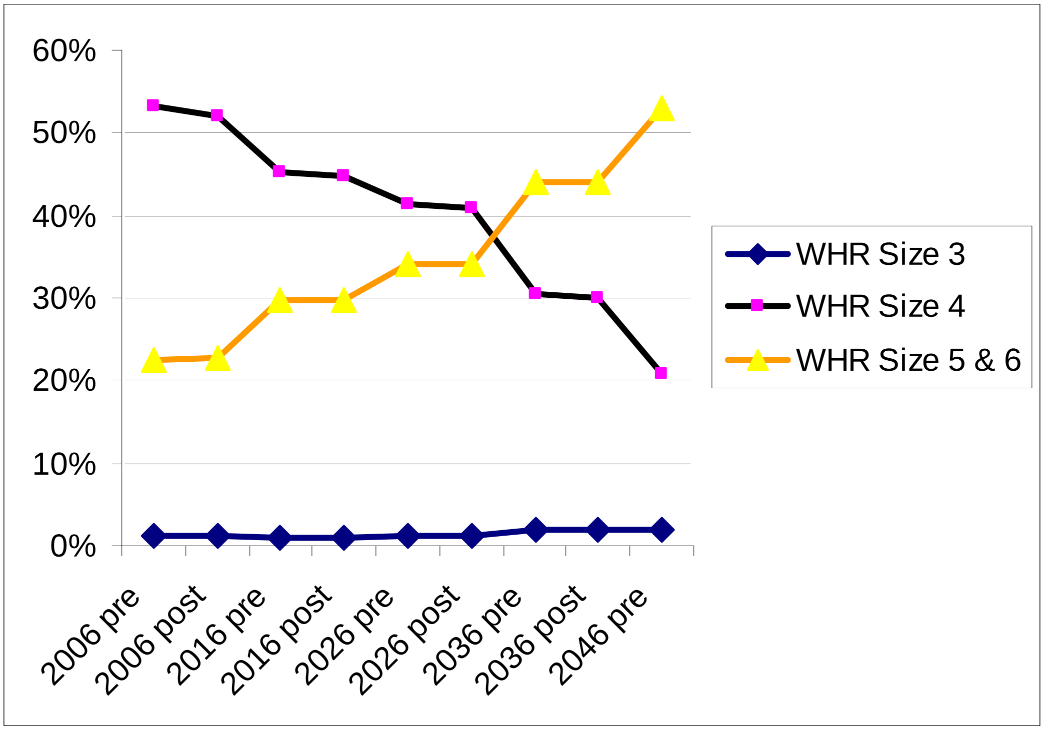

Figure 10 - Changes in Diameter Class, Reference Case Define key.

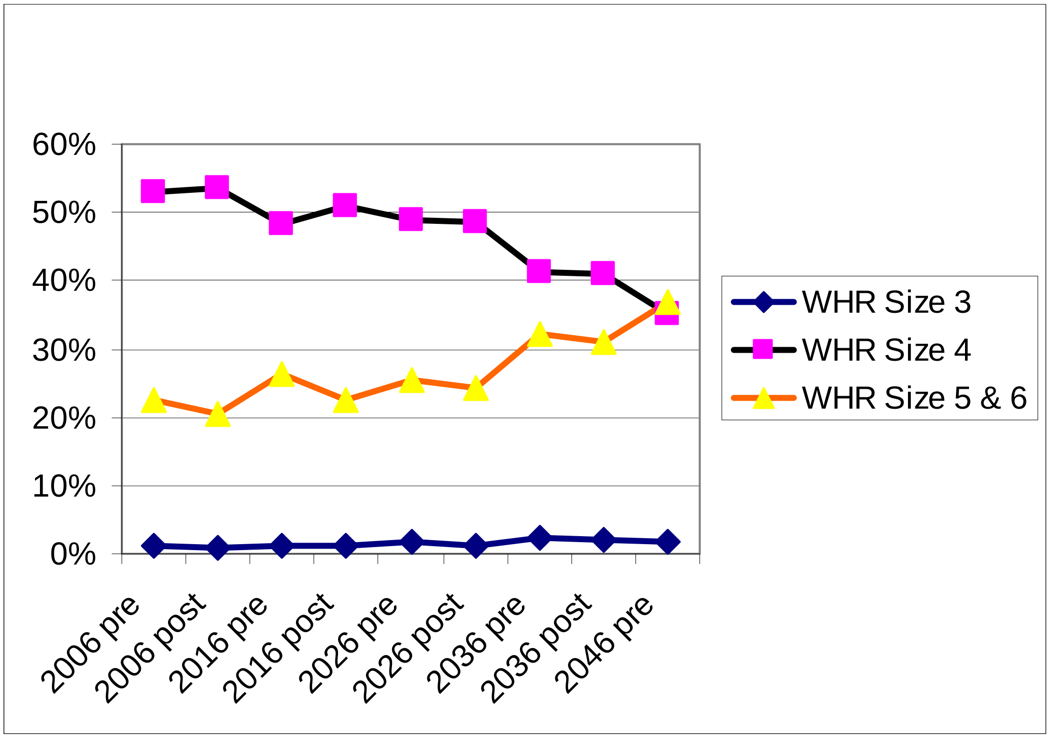

Figure 11 - Changes in Diameter Class, Test Scenario Define Key

CWHR forested habitat types are defined by a combination of vegetation type, canopy closure and average diameter. Prior to treatment, nearly 50% of the landscape was occupied by small diameter forest with higher canopy closure (4MD), typically considered mid-seral conditions, and most of the remaining forested area (20% of the landscape) was medium/large diameter with higher canopy closure (5/6MD), typically considered mature or old forest conditions (Figure 12). Changes in average tree diameter made the greatest difference between the Reference Case and the Test Scenario. In the Reference Case, the landscape was dominated by mid-seral forests (4MD) in the first decades, and changed to an old forest dominated landscape (5/6MD) toward the end of the modeling period (Figure 12). Old forests increased from about 25% of the landscape to about 50% of the landscape, whereas mid-seral forests declined from nearly 50% of the landscape to 20% of the landscape by the end of the 40-year cycle. In the Test Scenario, mid-seral and old forests equalized by the end of the treatment period, indicating that both treatment and fire resulted in a decline in old forest conditions. In addition, open-canopied small diameter forest (4SP) increased slightly to 5 to 10% in the Test scenario.

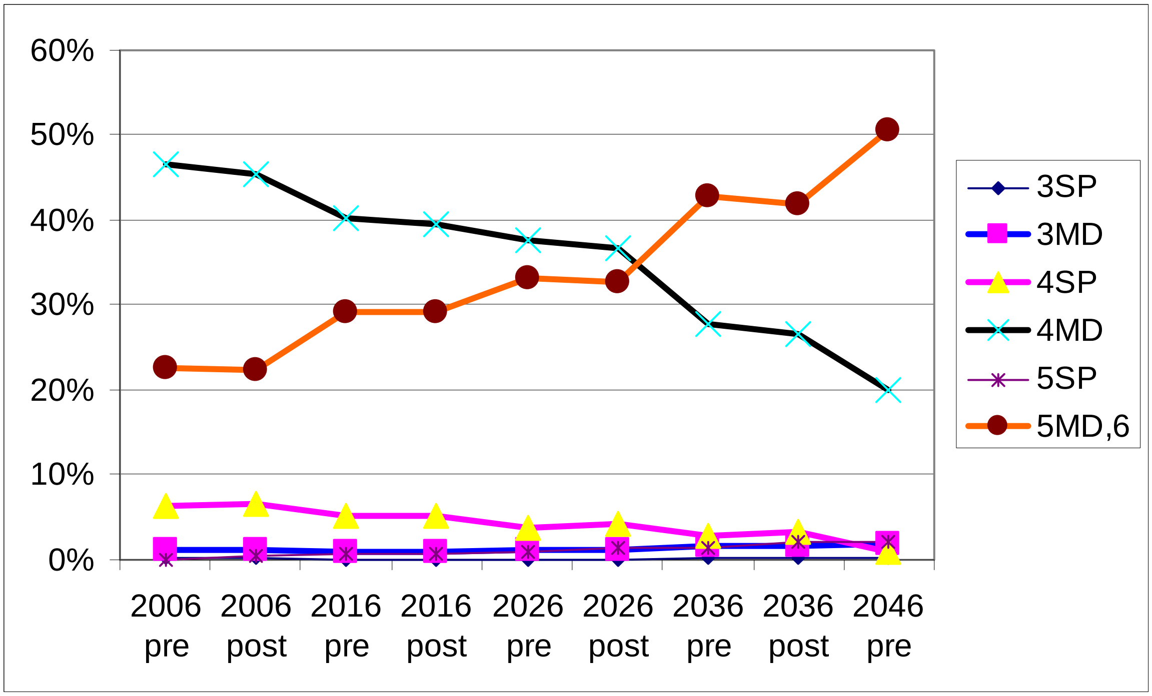

Figure 12 - CWHR Types, Reference Case Define Key

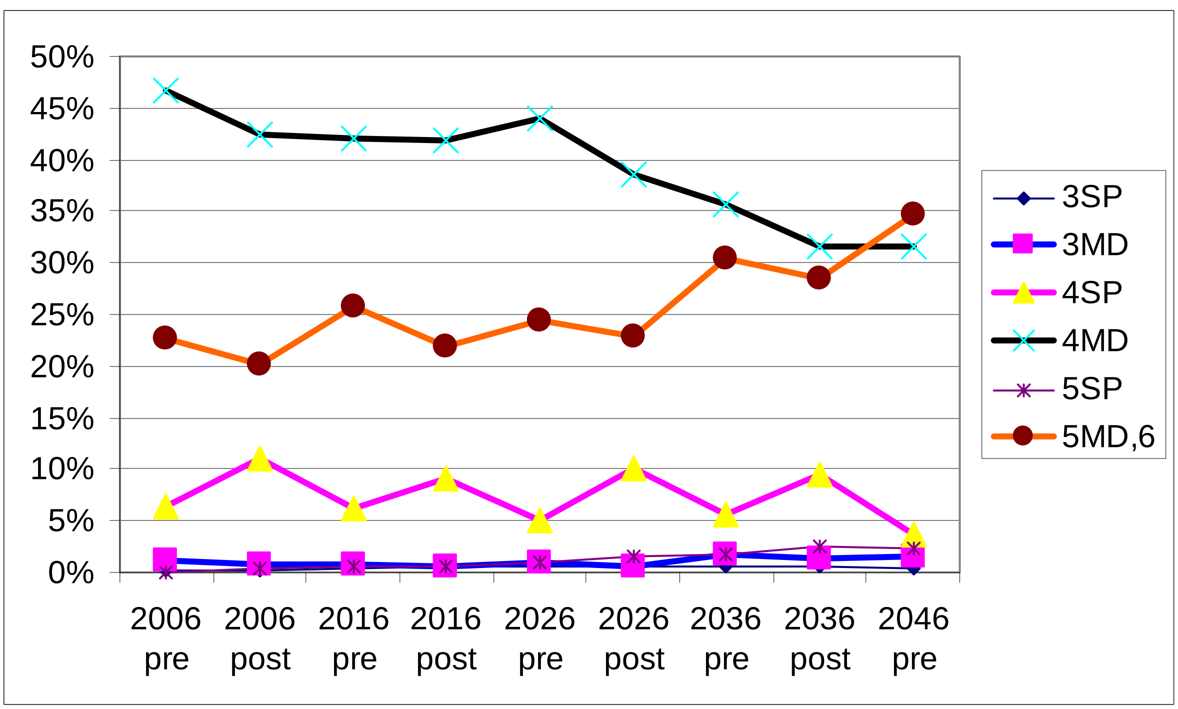

Figure 13 – California Wildlife Habitat Relationships habitat types, Test Scenario

Patterns of change within old forest conditions (5MD,6), revealed that mid-seral forests had approximately half moderate (M) and half dense (D) canopy closure, whereas almost all of old forests had dense (D) canopy closure (Figure 14). Thus, prior to treatment, the landscape was two-thirds mid-seral and one-third old forest conditions (one-third each of 4M, 4D, and 5/6D). In the Reference Case, these three conditions diverged over the course of the modeling period, resulting in old forests with dense canopy closure increasing from 25% to 50% of the landscape, mid-seral with dense closure declining slightly, and mid-seral with a moderate closure nearly declining to zero. In the Test Scenario, the three conditions diverged only slightly, with a slight increase in old forest characteristics with moderate closure.

Within old forests alone, prior to treatment, none of the landscape fell into the medium to large diameter forest classification (diameter class 5) and only a limited amount of medium to large diameter forest remained on the landscape in both the Reference Case and Test Scenario by the end of the modeling period (Figure 15). This reflects the modeling assumption that, as small diameter forests grow, they become multi-layered old forests. In the Test Scenario, it appears treatments in old forests on private lands result in mid-seral conditions, whereas on public lands some remain old forests. This pattern reflects the differences in the types of treatments modeled on public and private lands.

Stand diameter was based on the quadratic mean diameter of the largest 75% of all trees. The use of this approach to determine average diameter is the reason so little of the landscape was classified as pole forests (diameter class 3). It is also likely that this diameter calculation reduced the magnitude of changes observed as a result of biomass removal, which primarily consists of removing smaller diameter understory trees. For example, if primarily smaller diameter trees are removed, then 75% of the remaining trees will consist of fewer small trees with a larger average diameter. Since canopy closure, or the density of tree crowns relative to openings in the forest canopy, is a strong proxy for old-growth forest habitat quality, this method is considered a legitimate means to measure habitat condition. However, it is relatively insensitive to changes in the understory, that is, the conditions created by the smaller trees growing beneath the canopy. Calculation of the quadratic mean diameter of all trees (not just 75% of trees) would likely render a more accurate picture of the effects of fuels treatments on both forest structure and wildfire behavior.

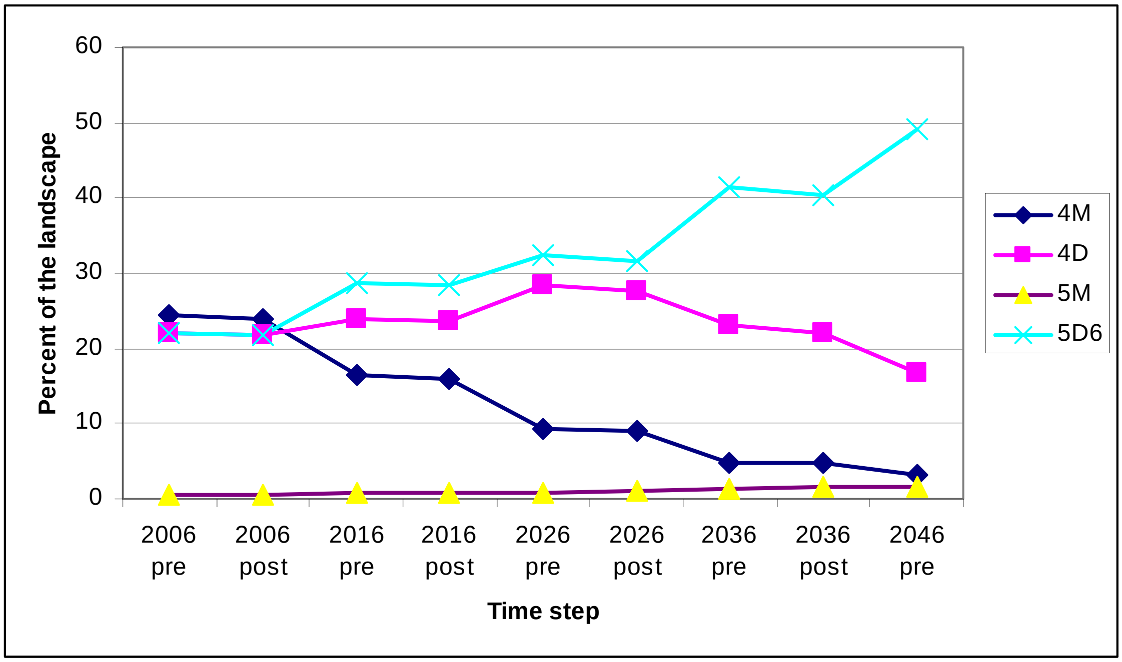

Figure 14 - Mid-seral (diameter class 4) and old forests (diameter class 5/6) with moderate (M; 40-60%) to dense (D, >60%) canopy closure, Reference Case

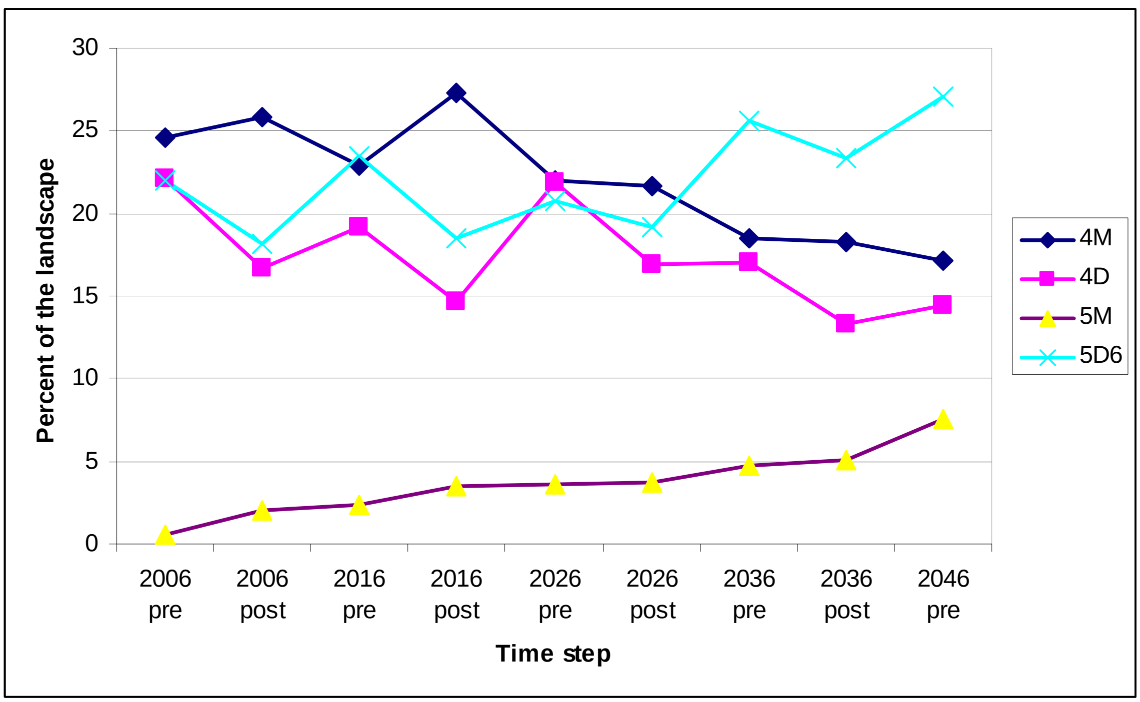

Figure 15 - Mid-seral (diameter class 4) and old forests (diameter class 5/6) with moderate (M; 40-60%) to dense (D, >60%) canopy closure, Test Scenario

3.5.2. *Forest Structure Associated Species*

Habitat guilds showed varied responses to changes in forest structure. Prior to treatment, nearly 70% of the landscape was occupied by 21 to 40 old forest associated species (n = 59 species total), followed by approximately 30% of the landscape occupied by 1 to 20 old forest species (Figure 16). No major changes were observed over time or between the Reference Case and the Test Scenario – in both, the proportion of the landscape with 21 to 40 old forest species declined by around 10%. However, in the Test Scenario the proportion of the landscape with greater than 40 species increased slightly (Figure 17). The team found that, according to CWHR, multi-layered old forests (diameter class 6) were considered to have lower suitability for a number of old forest associated species than single-layered old forests (class 5MD). Thus, as multi-layered forests were replaced by other conditions (e.g., small and medium/large diameter forests), CWHR indicated that habitat conditions improved for some old forest associated species.

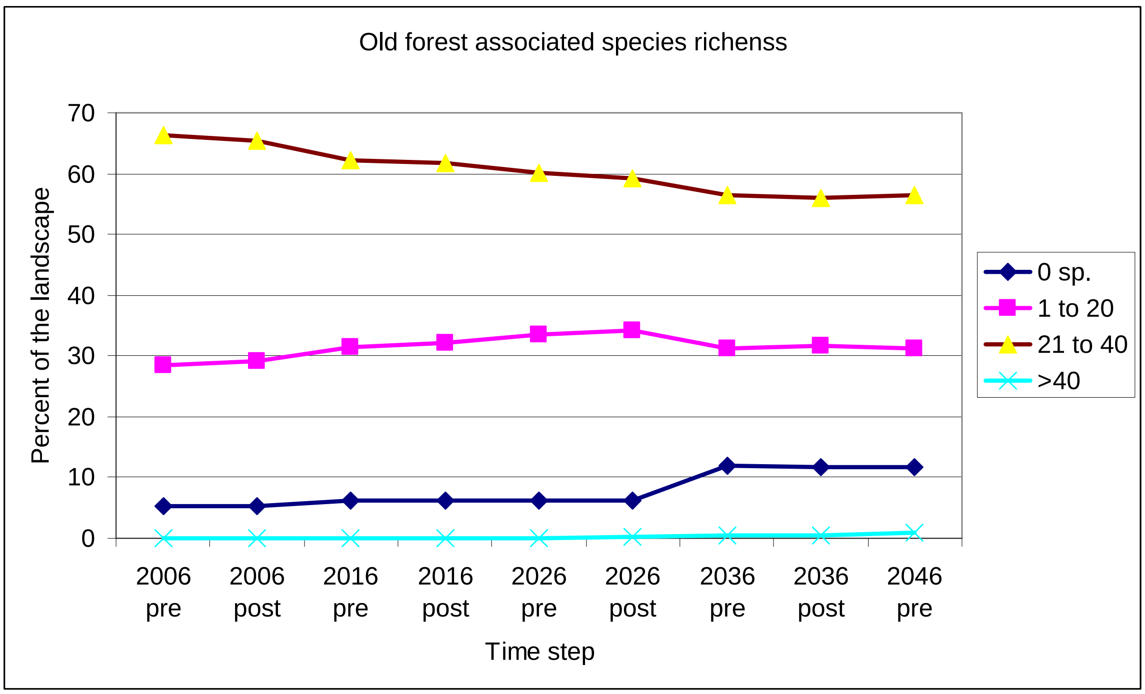

Figure 16 – Richness of old forest associated species (n = 59) supported across the landscape, Reference Case

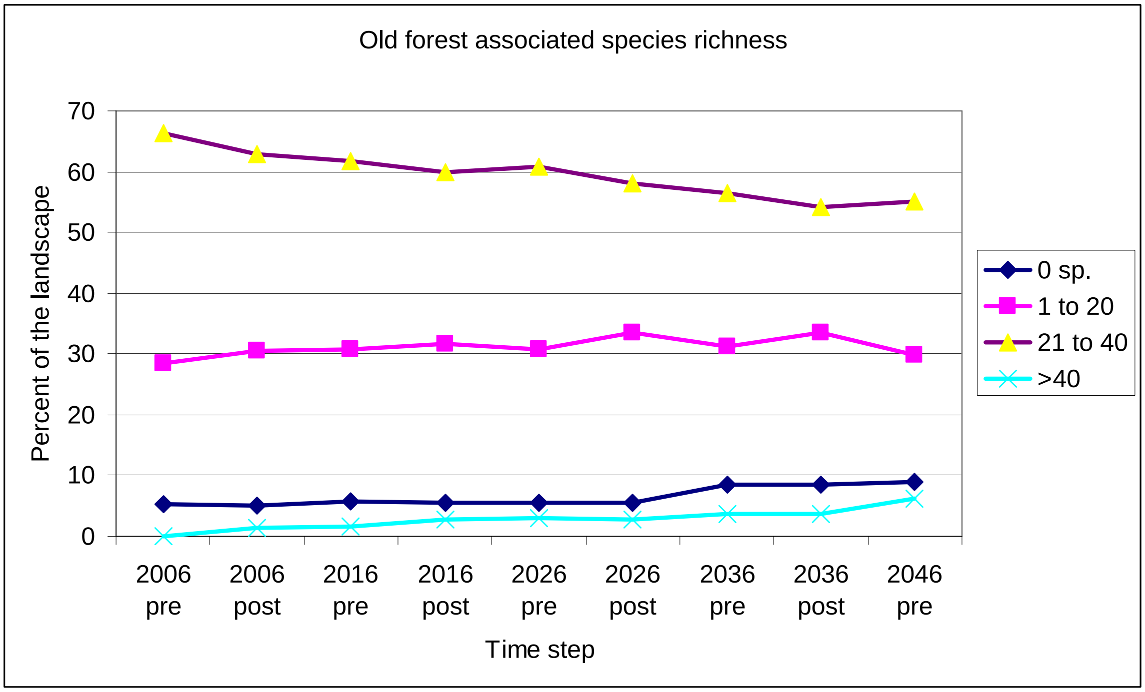

Figure 17 – Richness of old forest associated species (n = 59) supported across the landscape, Test Scenario

Patterns for old forest dependent species (which are a subset of 16 old forest associated species) were evaluated to see if they provided any additional information about the potential effects of harvest treatments on old forest associated species. Prior to treatment, nearly 40% of the landscape was occupied by the highest species richness class (>10 species), with the remaining landscape occupied equivalently (~20% each) by the other three richness classes (i.e., 0, 1-5, 6-10; Figure 18). In the Reference Case, an increasing proportion of the landscape supported high numbers of old forest dependent species, following the pattern seen in the kinds of multi-layered forests mentioned above. In the Test Scenario, the proportion of the landscape occupied by each of the richness classes did not change. However, the treatments in the Test Scenario reduced the species richness index from the highest richness class (>10 species) to the next lower richness class (6-10 species) immediately following treatment, then appearing to recover at the end of the 10-year growth period (Figure 19).

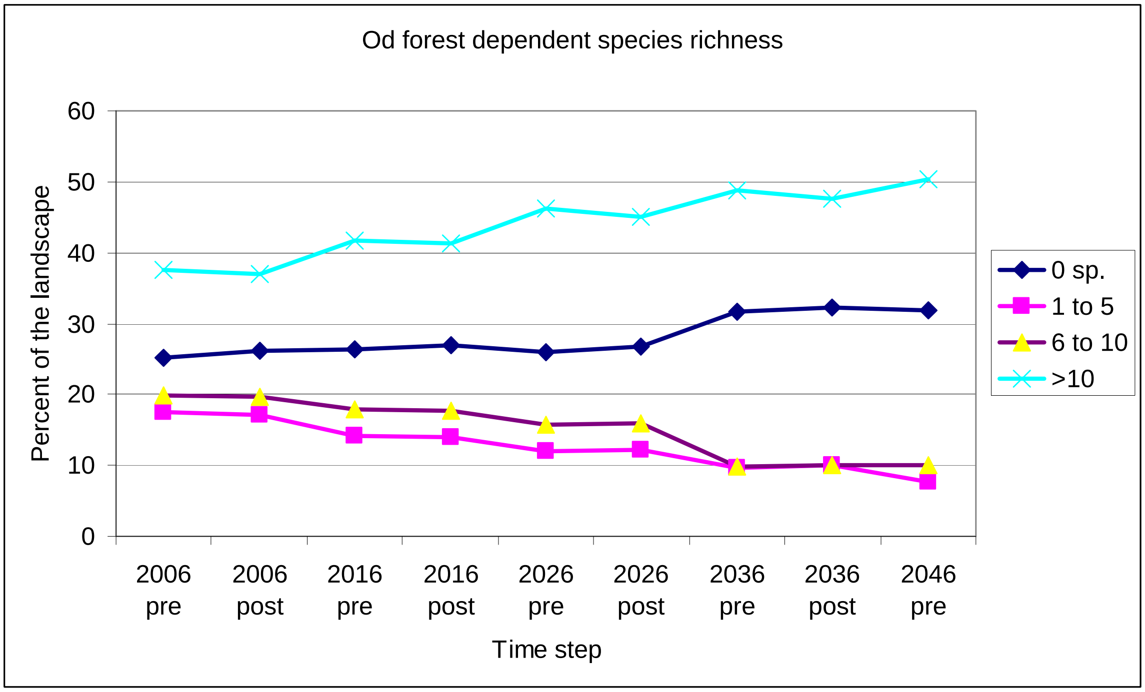

Figure 18 – Richness of old forest dependent species (n = 16) supported across the landscape, Reference Case

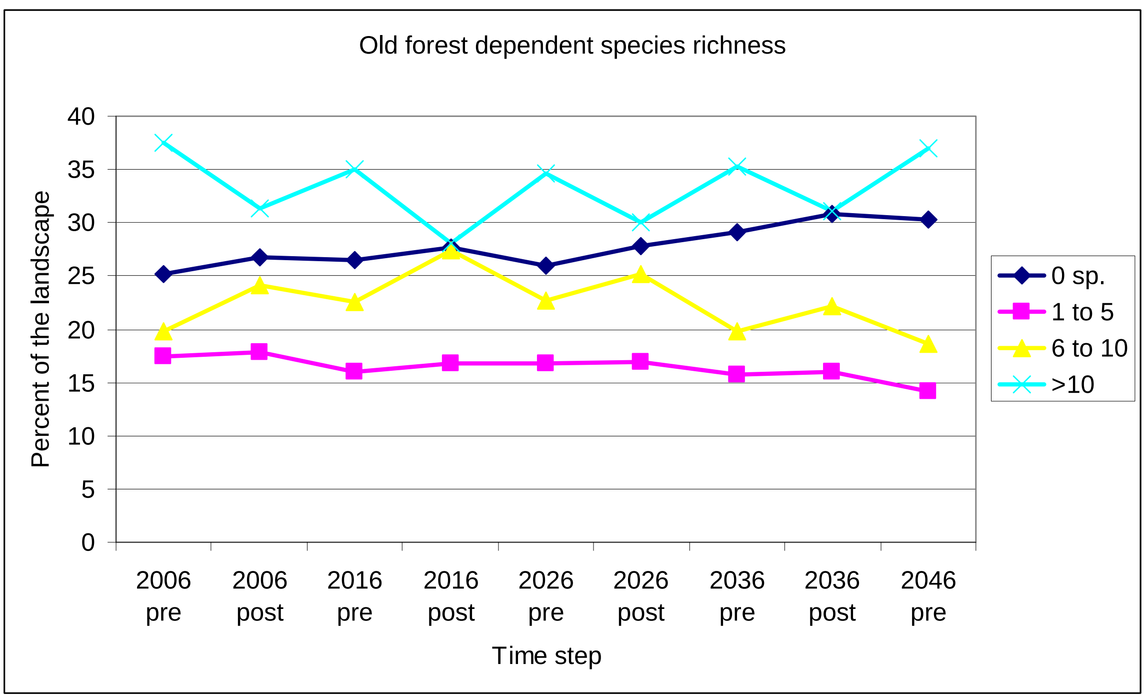

Figure 19 – Richness of old forest dependent species (n = 16) supported across the landscape, Test Scenario

The richness of early-seral associated species, that is, species that are best associated with the early stages of forest growth, (n = 118) followed the same pattern as changes in the prevalence of mid-seral and old forest conditions. Prior to treatment, approximately half the landscape supported 1 to 20 early-seral species, and the other half supported 20 to 40 early-seral species. In the Reference Case, approximately half of the sites supporting 20 to 40 species were reduced to supporting only 1 to 20 species. Little change was observed in the highest (>40 species) and the lowest (0 species) richness classes for early-seral associated species (Figure 20). In the Test Scenario, the richness classes remained relatively constant.

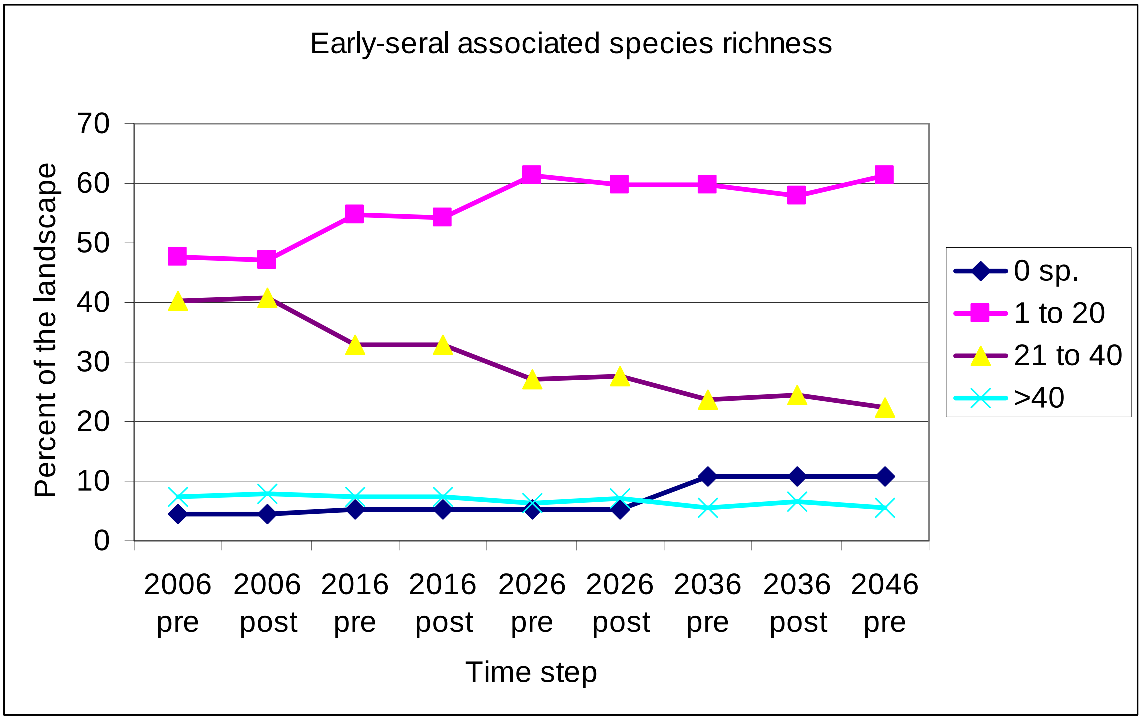

Figure 20 – Richness of early-seral associated species (n = 118) supported across the landscape, Reference Case

The final habitat guild evaluated was the oak and acorn associated species (n = 44). Prior to treatment, nearly 50% of the landscape supported 1 to 5 species, and nearly 30% of the landscape supported 5 to 10 species (Figure 21). In the Reference Case, an increasing proportion of the landscape (approximately 10% more) supported fewer oak associated species (1 to 5 species). However a roughly equal proportion supported the highest species richness class (>10 species) as seen in Figure 21. In contrast, the Test Scenario appeared to slightly improve conditions for oak associated species. Increases in oak associated species were significant with each increment of increasing treatment. The indications of these results would be strengthened if the presence of oaks in conifer forests could have been considered. However, data on the density of oaks was not available at the time of this analysis.

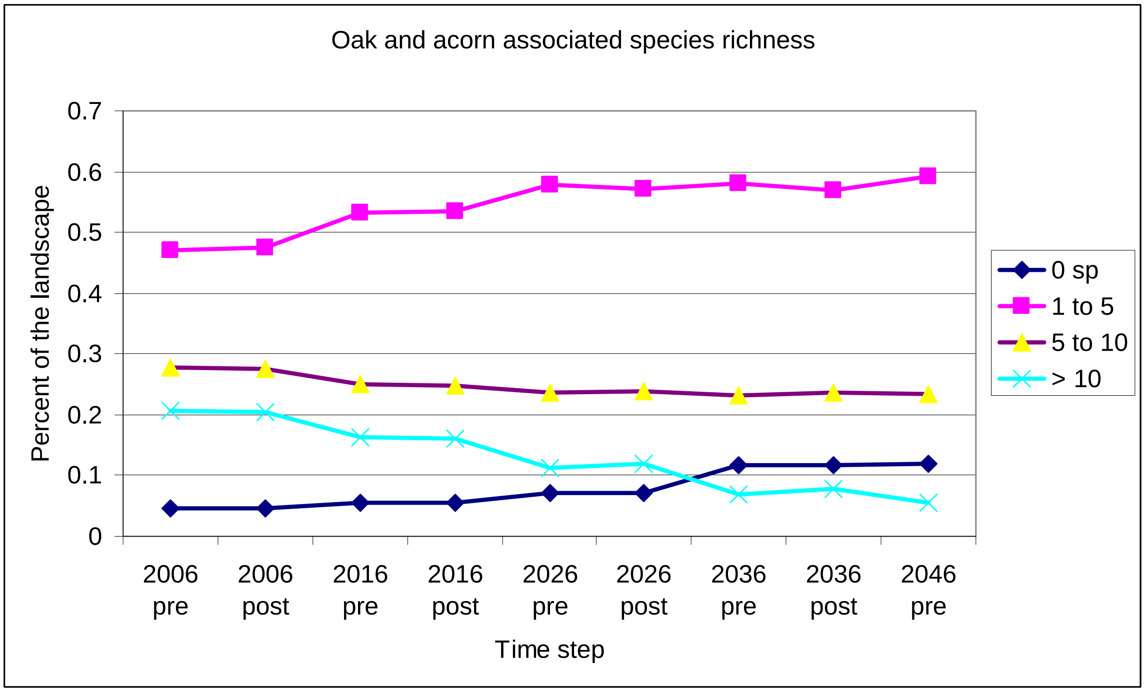

Figure 21 – Richness of oak and acorn-associated species (n = 44) supported across the landscape, Reference Case

The analysis of exotic species richness was not very informative. It simply showed that that proportion of the landscape with one or more exotic species started low (~10%) and did not change over time under the Reference Case or Test Scenario.

3.5.3. Service Providing Units

Seed dispersers (n = 22) and bioturbators (n = 15) had similar patterns of response within and among scenarios as early-seral associated species – as illustrated by the seed dispersers, which declined over time in the Reference Case (Figure 22), but remained at similar or higher levels over time in the Test Scenario (Figure 23).

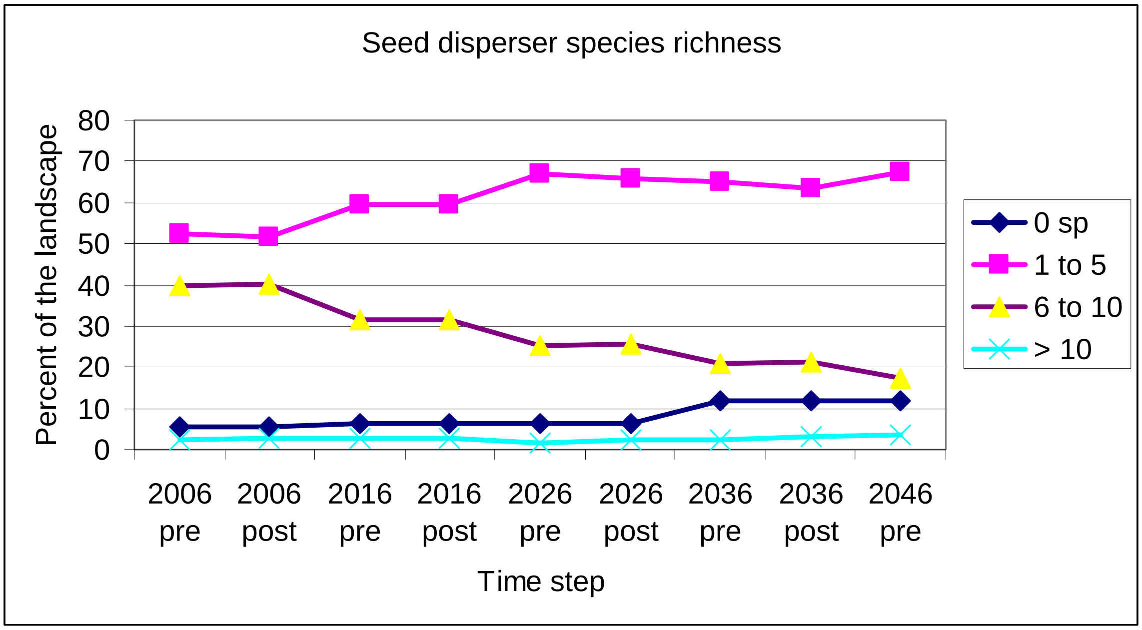

Figure 22 – Richness of seed dispersing species (n = 22) supported across the landscape, Reference Case

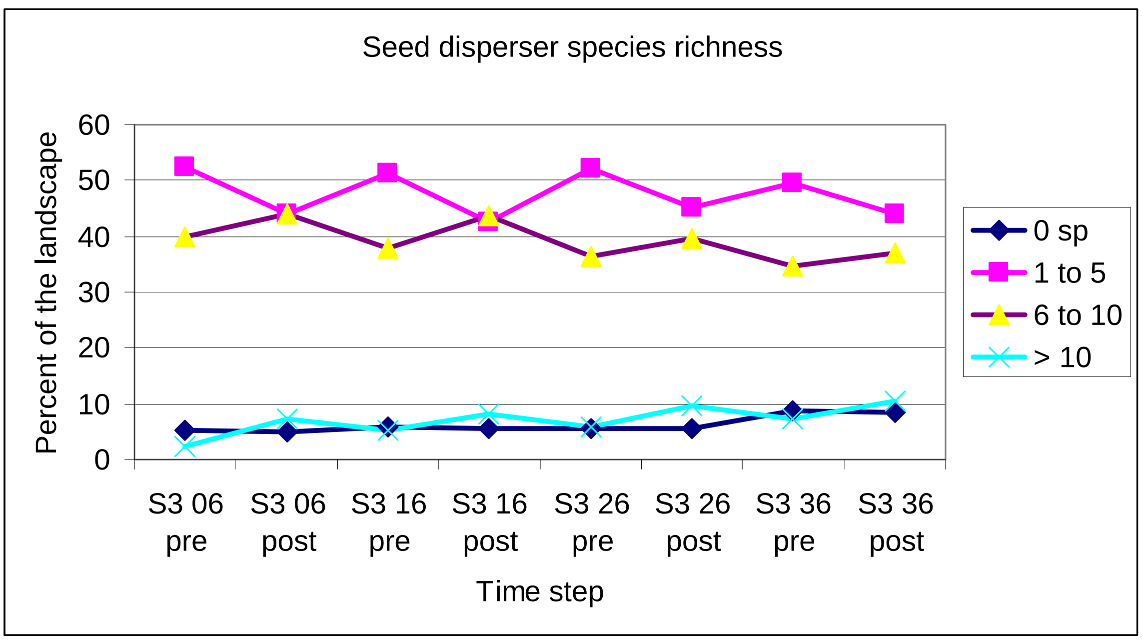

Figure 23 – Richness of seed dispersing species (n = 22) supported across the landscape in the Test Scenario

Pollinators (n = 3) and decomposers (n = 13) showed no substantive change either over the time of the study or between the Reference Case and the Test Scenario. Prior to treatment, less than 10% of the landscape had one or more pollinator species. No change was observed over time in the Reference Case. However the Test Scenario did show a 5% fluctuation in the proportion of the landscape supporting one or more pollinators, varying between 5% and 10%. Prior to treatment, 75% of the landscape supported one or more decomposer species. Both the

Reference Case and the Test Scenario showed about a 5% decline in the proportion of the landscape supporting one or more decomposer species.

Prior to treatment in the Test Scenario, approximately 15% of the landscape supported the highest richness (>40 species) of insect regulators (n = 93) and nearly 60% of the landscape supported 21 to 40 insect regulators, the second to the highest richness class for this guild. In the Reference Case, there was a 10% decline in the proportion of the landscape supporting the greatest richness of insect regulators, with a concomitant increase in areas that supported only 1 to 20 species, indicating a modest decline in the ability of the landscape to support a diversity of insect regulators. In the Test Scenario, the 20-to-40 species richness class declined and the 1-to-20 species richness class increased by about 10% each, indicating a minor decline in the landscape's ability to support a diversity of insect regulators as compared to the Reference Case.

Over 70% of the landscape supported habitat suitable for one or more herbivore regulators (top carnivores; n = 9), with 50% of the landscape providing habitat for 3 or more species (Figure 24). In the Reference Case, the proportion of the landscape supporting the highest species richness (>4 species) declined nearly 20% to 3 to 4 species (Figure 24). In the Test Scenario, only minor changes in species richness were observed and they appeared to balance out to minimal overall change in capacity to support herbivore regulators (Figure 25). No substantive response in the richness of secondary herbivore regulators (n = 21) was discernable over time for either scenario.

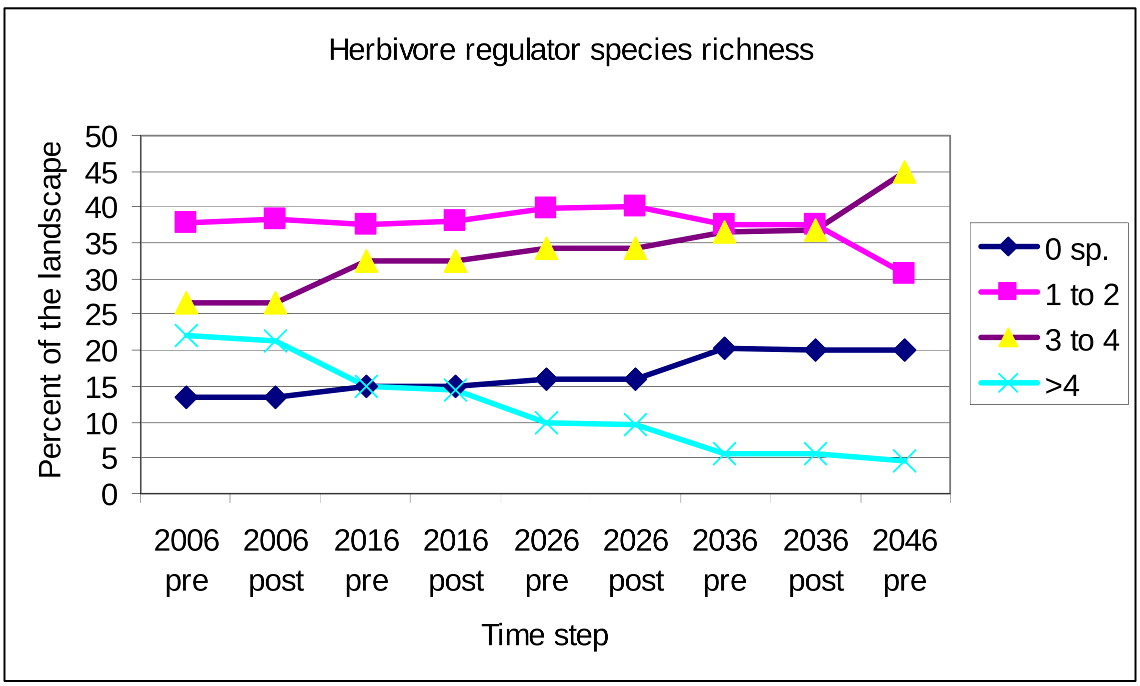

Figure 24 – Richness of herbivore regulating species (n = 9) supported across the landscape in the Reference Case

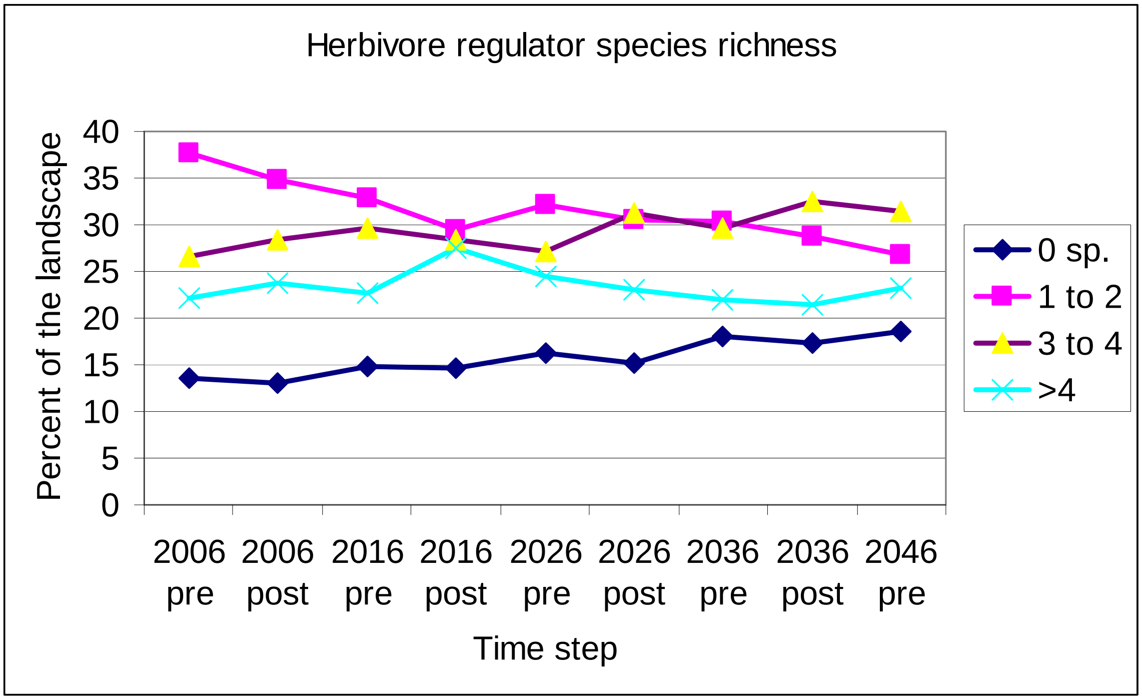

Figure 25 – Richness of herbivore regulating species (n = 9) supported across the landscape in the Test Scenario

3.5.4. American Marten

Surveys of the B2E landscape and a new predictive model were used to evaluate whether the landscape could support reproductive populations of American marten.

This element of the study was developed experimentally as an improvement in habitat modeling methods, comparing the results with the CWHR modeling used for the larger landscape. Field data from the landscape supported the assumption that no suitable habitat for marten occurred below 5,000 feet. Above 5,000 feet, modeling showed that the amount of land in old forest conditions (CWHR diameter classes 5 and 6 and canopy cover classes M and D) was the best predictor of American marten occurrence. Based on these data, the predictive model was used to determine the percent of the landscape in each of four categories of probability of occupancy: none (< 10%), low (10 to 30%), moderate (30-60%) and high (>60%).

The predicted values from vegetation mapping for the B2E project area showed only a small amount (3%) of highly suitable habitat (Figure 26). The majority of the B2E project area (89.9%) was characterized by habitat with low or no probability of occupancy (≤ 30%). The predictive model indicated that the western portion of the B2E project area (south of Lake Almanor) contained relatively little habitat that could support marten reproduction. This finding is consistent with the lack of marten detections by surveys in this region (Tom Kirk, personal communication). The west side was the most likely region to be used by dispersing martens as a corridor between known population centers located to the north and south.

Management scenarios had no appreciable effect on the amount of habitat suitable for marten. The only variable in the model that could be affected by forest management was the amount of old forest conditions (e.g., in CWHR 5M, 5D, and 6 habitat). Old forest habitat (a characteristic of suitable marten habitat) increased more over time in the Reference Case than in the Test Scenario. However, those increases occurred below 5000 feet, the typical lower elevation limit for habitat suitable for the American marten.

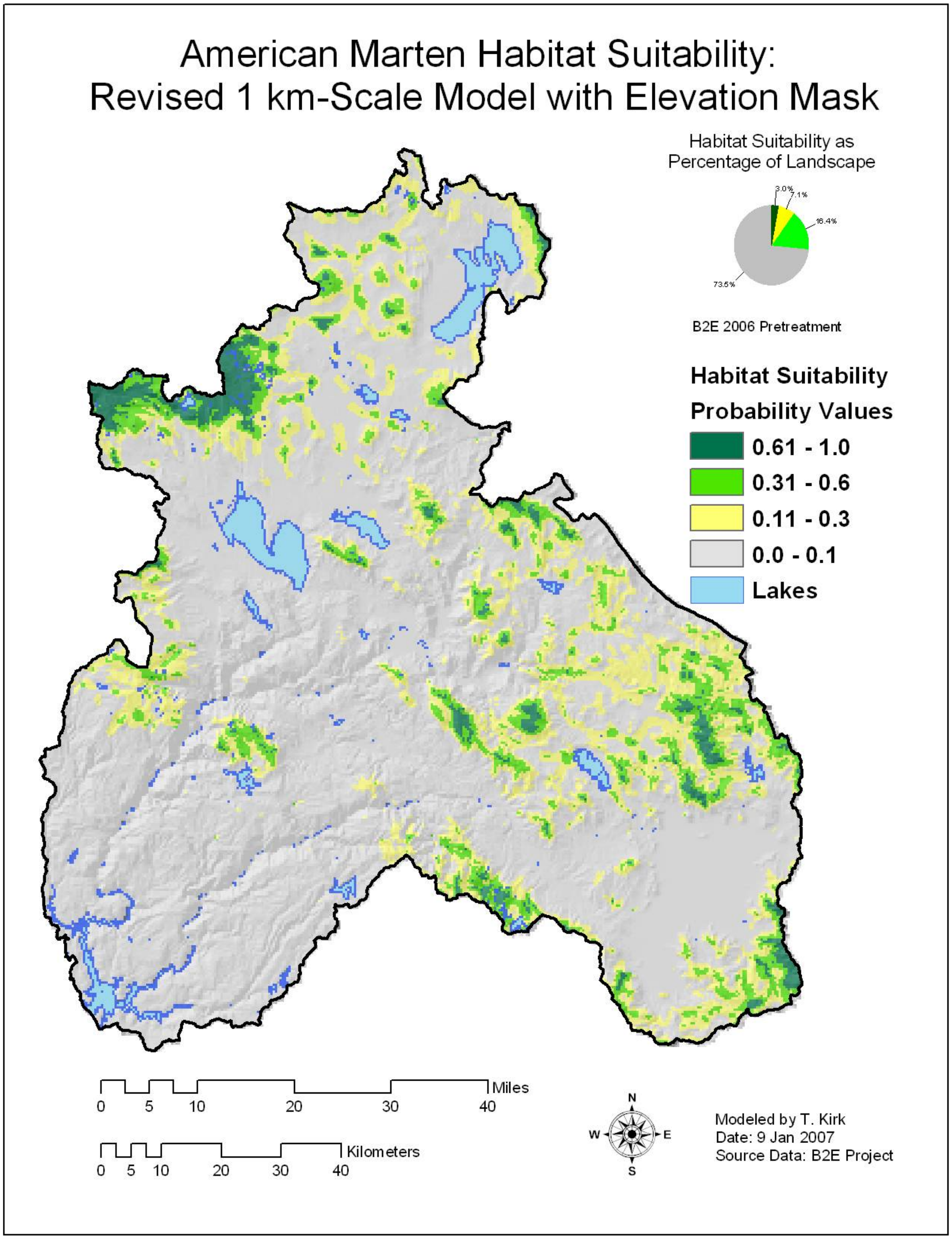

Figure 26 – Probability of occupancy within suitable reproductive habitat for marten (*Martes americana*) in the B2E landscape based on predictive models.

3.6. Cumulative Watershed Effects

Cumulative watershed effects analysis assesses the potential movement of soil and water to approximate synergistic effects at a watershed scale. A watershed may be defined differently, depending on the purpose and scale of the analysis: For the Beta landscape, watershed boundaries were determined by standardized Hydrologic Unit Codes (HUCs) at the 6th order of coding (U.S. Geological Survey 2009), which resulted in analytical units ranging in size from 2,500 to 46,000 acres. As described in the Approach section of this report, the CWE model is a disturbance-based model that normalizes all disturbances (treatments, wildfires, and so forth) to an acre of road. The resulting metric of equivalent roaded acres (ERAs) is compared with its established watershed threshold of concern (TOC) to assess the potential for cumulative watershed effects.

3.6.1. Total Equivalent Roaded Acres (ERAs)

Figure 27 shows the total ERAs for all watersheds in the Beta landscape by year for both the Reference Case and Test Scenario. The Test Scenario produced lower ERAs than the Reference Case, explained by the fact that treatments were effective in reducing the size and intensity of wildfires, as shown in the sections on wildfire and vegetation treatments in this report. Soil erosion, as modeled through ERAs, was reduced accordingly by wildfire reductions. Industrial Private Forestry (IPF) lands are included in the figure as an reference point of some interest, given the ongoing concerns expressed by the public about potential watershed impacts of commercial harvesting. This study shows that the impacts of no treatment under the Reference Case are slightly higher, as measured by ERAs, than IPF commercial treatments.

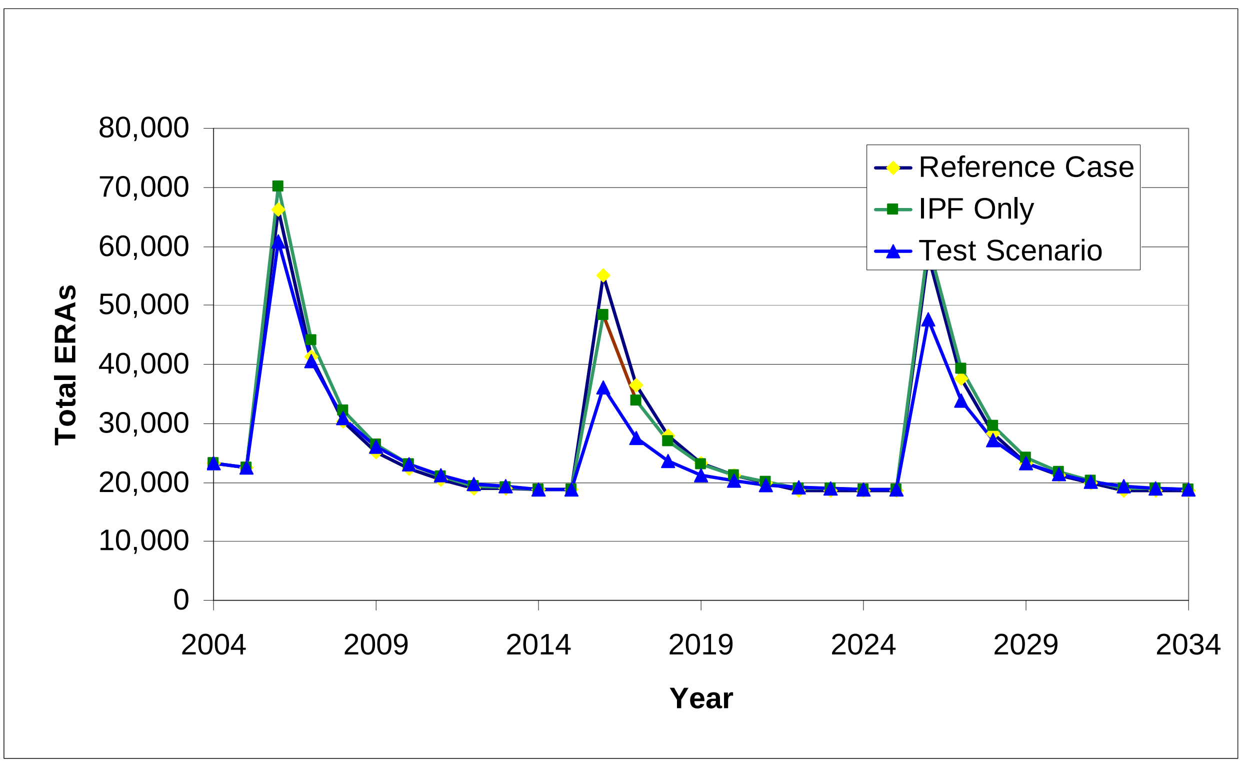

Figure 27 - Total Equivalent Roaded Acres by Year

Figure 28 shows ERAs by scenario, disturbance type and year. The Reference Case scenario has the highest wildfire sediment ERAs and the Test Scenario has the lowest. In the Test Scenario, the reduced ERAs from wildfire still exceed the increase in ERAs from treatment, which constitutes a net reduction. Roads were held constant in both the Reference Case and Test Scenario. IPF treatments and IPF wildfire effects are also shown, as in Figure 28, to give an additional reference point for analysis.

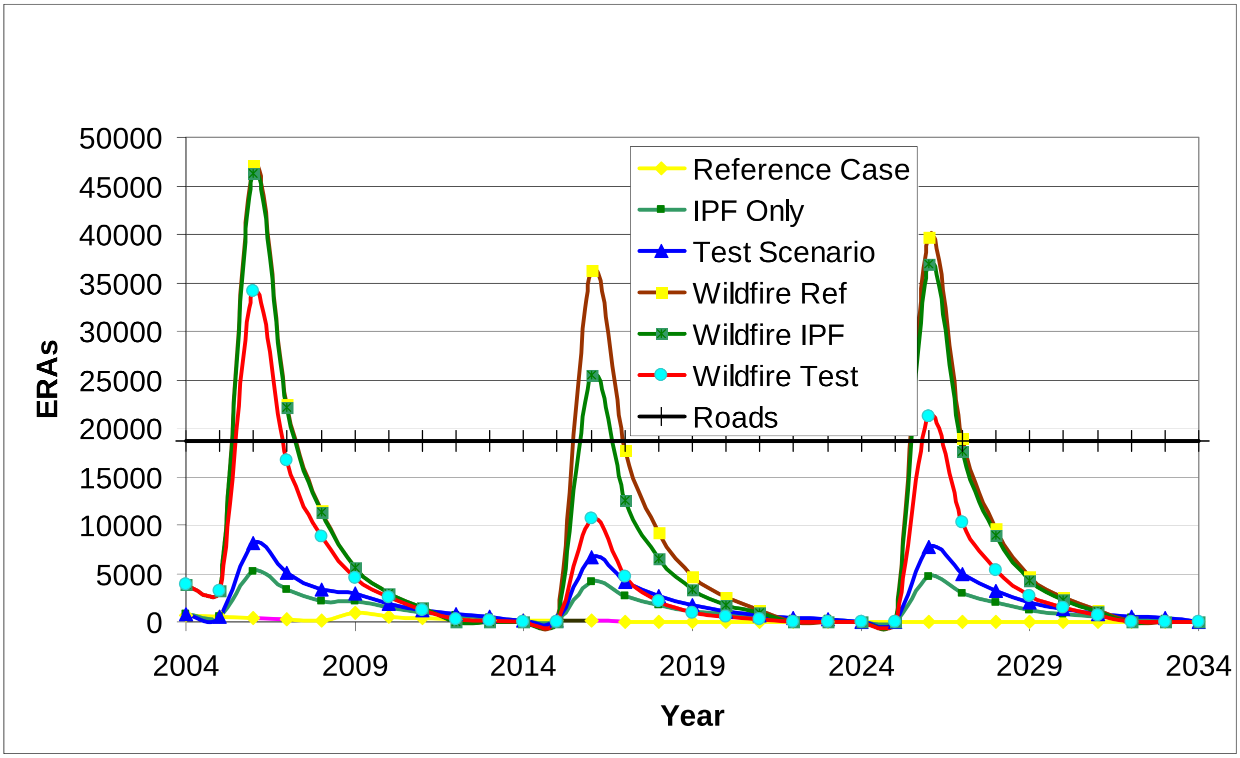

Figure 28 - ERAs by year and disturbance type

3.6.2. Cumulative Watershed Effects Analysis

The findings of the cumulative watershed effects analysis strongly parallel the findings in the wildfire analysis. The study shows that fuels treatments reduce the overall potential for cumulative watershed effects, as measured by ERAs, when compared to the effects of wildfire. Table 39 shows the risk ratios for the Reference Case and Test Scenario for those watersheds over the threshold of concern (TOC) for year 2006, 2016 and 2026. (As described in the "Approach" section, the TOC is based on a watershed's sensitivity to disturbance and the beneficial uses of its water. A watershed exceeds the TOC when the risk ratio exceeds 100.) The Reference Case shows a higher number of HUC6 watersheds over TOC, and by a greater percent, compared to the Test Scenario.

Table 39. Risk ratios for watersheds over threshold by model decade

	Reference Case			Test Scenario		
HUC_NAME	**2006**	**2016**	**2026**	**2006**	**2016**	**2026**
Stoney Creek	490			434		
Lower Last Chance Creek	488			413		
Clarks Creek	275			142		
McClellan Canyon	295			218		
Mc Dermott Creek	270			190		
Middle Last Chance Creek	258			177		
Pineleaf Creek	184			87		
Otis Canyon	122			35		
Lower Pine Creek	114			107		
Upper Red Clover Creek		572			216	
Dixie Creek		297			49	
Big Grizzly Creek		200			74	
Bald Rock Canyon		138			38	
Adams Neck		180			75	
Wild Yankee Creek		112			48	
Last Chance Creek		101			42	
Carman Creek			419			251
Antelope Creek			267			123
Clairville Flat			154			69
Seneca			172			143

In the Test Scenario, the treatments by themselves did not push any of the HUC6 watersheds over TOC. In all cases, the TOC was exceeded due to modeled wildfires. In watersheds that did not have fires modeled in them, there were more disturbances due to treatments and small increases in sediment, but not enough to exceed TOC. The slight increase in sediment runoff by treatments was entirely compensated by the reductions in fire intensity and fire size in watersheds where wildfire was modeled. Recovery from the effects of wildfire commonly happens in a relatively short time period (2 to 4 years). However, the initial adverse watershed effect can be severe if a high intensity rainfall event occurs shortly after the fire. In the Test Scenario, the number of watersheds over TOC dropped from seven to one as a result of the fuel treatments. An example, as seen in Table 39, is the change in the risk ratio of Upper Red Clover Creek, which decreased from 572 to 216 because the fuel treatments reduced modeled wildfire intensity.

The following two Figures (28 and 29) compare watersheds in the B2E Beta landscape by threshold class for the Reference Case and the Test Scenario in model years 2006 and 2016. The fuel treatments moved a few watersheds from one threshold class to the next higher class, but none of the treatments exceeded the watershed threshold. The B2E modeled wildfires moved the watershed well over TOC in most cases. Treatments did not shift any of the study's watersheds over TOC. Eight watersheds were shifted by treatments from over TOC in the Reference Case to under TOC in the Test Scenario in years 2006 and 2016.

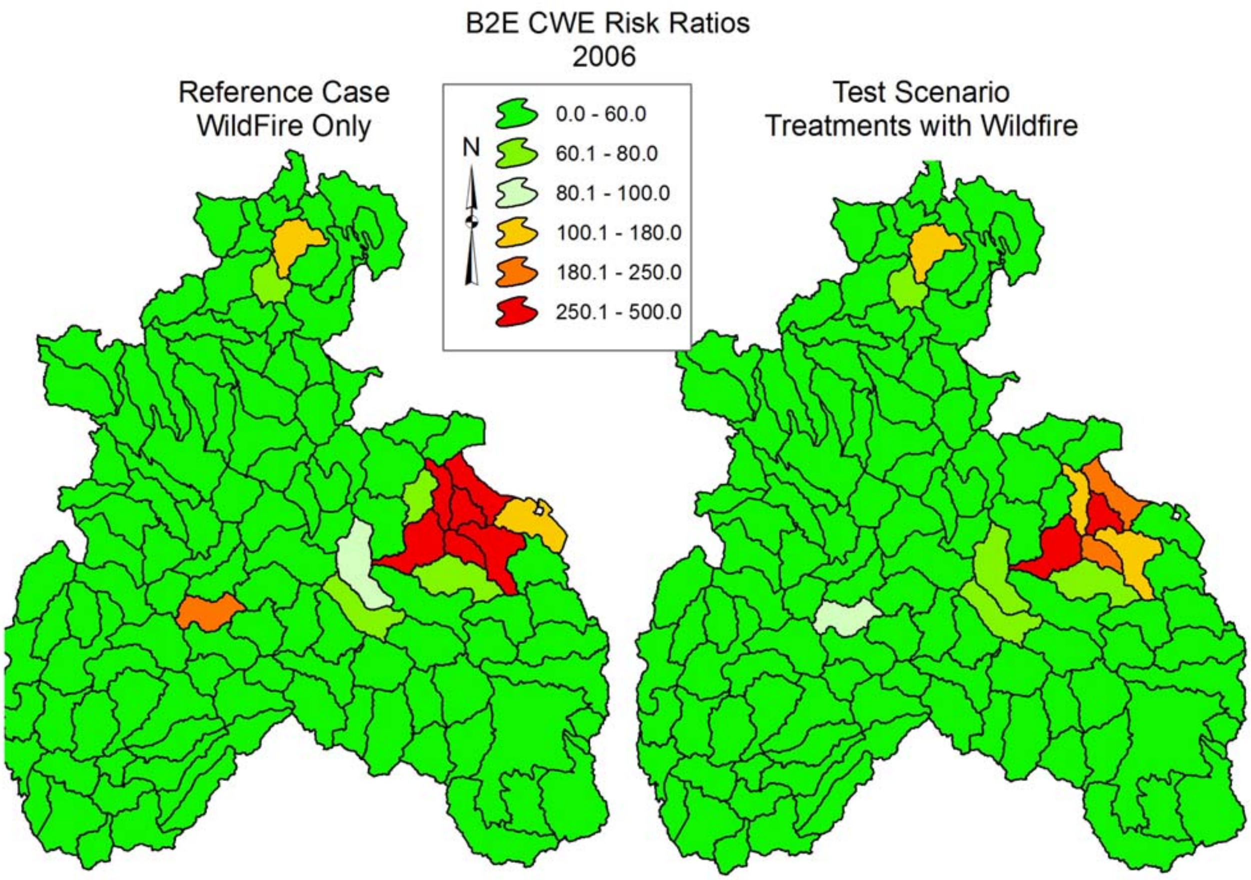

Figure 29. CWE risk assessment by watershed in 2006 model year

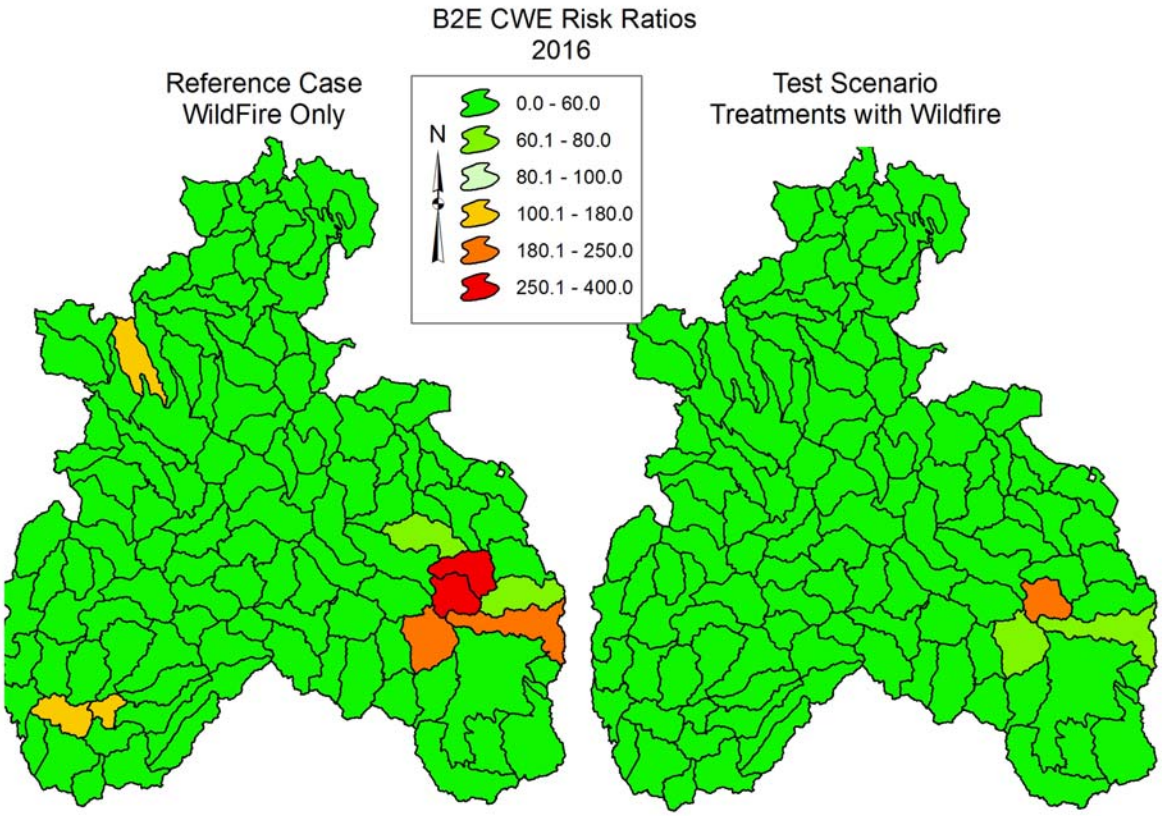

Figure 30. CWE risk assessment by watershed in 2016 model year

3.7. Economic Results

The economic analysis of the B2E project was intended to span all domains wherein costs could be measured. Pricing of non-market values or ecosystem services was used where studies in the peer-reviewed literature were deemed robust enough to warrant reporting in this study. Additional studies to prince non-market ecosystem services were beyond the scope of this analysis. Reasonable attempts were made to capture values, such as recreation damage functions, where possible. The analysis is intended to show benefit-cost relationships, and does not attempt to resolve for economic efficiency.

As with the other domains, the economic analyses were conducted on a Reference Case (with no treatments, but including impacts of wildfire) and a Test Scenario. The detailed economic analysis can be found in Appendix 8. Additionally, a spreadsheet model is available for download, and may be accessed through the Energy Commission's web services.

Table 40 shows estimates of the initial value of assets in the study area at risk to fire damage and fire-related losses (in present value) to these assets over the 40-year analysis period. Of the $20.8 billion in initial value, timberland resources comprise more than $18.1 billion in asset value, followed by structures ($2.4 billion), recreation resources ($117.8 million), infrastructure ($102.3 million), and agricultural lands ($41.3 million).

Table 40 - Study Area Market Asset Value Changes by Treatment Scenario (in millions of 2006 dollars)

Asset Type	Initial Value	Loss in Value Due to Fires	
		Reference Case	Test Scenario
Agricultural lands	$41.3	$3.6	$2.8
Recreation resources	$117.8	$1.7	$0.95
Infrastructure	$102.3	$3.0	$1.9
Structures	$2,364.5	$43.0	$27.2
Timber	$18,144.2	$612.7	$385.6
Total	$20,770.2	$664.1	$418.5

Note: The loss in value for the treatment scenarios represents the accrued present value of the losses from fires over the 40-year project period.

The present value of losses due to fire over the 40-year period is $664.1 million under the Reference Case and $418.5 million under the Test Scenario. The reduction in asset value losses, relative to the Reference Case, is attributable to timber harvest and fuels treatment activities associated with the vegetation management treatments under this scenario.

Table 41 shows the annualized costs and revenues associated with the Reference Case and the Test Scenario. The costs include capital and operations and maintenance (O&M) costs for fuels treatment and power production, and the revenues are those generated from the sale of power and saw logs, both from timber harvest and salvage activities. (Note that the costs of timber harvesting are accounted for in saw log revenues in Table 41, which are revenues net of production costs.) The volume of chips generated by thinning activities are sufficient to fuel seven power plants at an average capacity of 9.8 MW per plant under the Test Scenario.

Table 41 - Annualized Costs and Revenues for No Treatment (Reference Case) and With Treatment (Test Scenario), in millions of 2006 dollars.

Value Category	Reference Case	Test Scenario
Project costs:		
Fuels treatment		
-- Capital costs	N/A	$4.2
-- Operations & maintenance costs	N/A	$15.0
Power Plant Operations		
-- Capital costs	N/A	$15.6
-- Operations & maintenance costs	N/A	$31.9
Fire suppression	$2.05	$1.6
Rehabilitation	N/A	$0.03
Total costs	$2.05	$68.3
Project revenues:		
Power generation	N/A	$27.9
Saw logs from timber harvest	N/A	$72.3
Saw logs from salvage	N/A	$4.2
Total revenues	N/A	$104.4

Fuels treatments under the Test Scenario also produce biomass that would be available for power plant operations. Based on treatment and transportation requirements under this treatment scenario, biomass fuel delivered to power plants would cost an estimated $68 per BDT. Based on the modeling of power plant financials (see Appendix 10) power plant operators can pay up to $8.20 per BDT in order to achieve an acceptable rate of return on investment under the Test Scenario. (The financial model assumed that power plant project investors would require a long-term after-tax return to equity of 14.5 percent to attract investment for a project.) Barring some other source of revenue, such as revenue from steam sales or government grants, constructing and operating biomass power plants would not be feasible at a fuel cost of $68 per BDT.

This last finding, that biomass plant operators may only be able to afford $8.20 per BDT for feedstock, is counterintuitive, and contradicted by the existing evidence of the biomass power industry in California (which typically pays between $25 and $45 per BDT for forest fuels).

However, it must be recognized that the current biomass power industry in California is in large measure dependent upon the subsidies for capacity payments under the federal Public Utility Regulatory Policy Act (PURPA), passed in 1978 in response to the 1973 energy crisis. Among its provisions was to require purchase of renewable power by investor owned utilities. In addition, biomass power plants negotiated prices for power that were typically at least 1.5 to 2 cents above the wholesale price of electricity, under long-term contracts. In California, many of the biomass power facilities built in the late 1980s and early 1990s had retired their debt by 2006, the year in which this analysis begins. The combination of capacity payments and debt-free power sales accounts for the difference between the current (2006) market, and a *greenfield* power plant developed in 2006 without PURPA subsidies.

From a broader societal perspective, subsidies based on the value of avoided asset losses and avoided fire suppression and rehabilitation costs could be offered to power plant operators to offset the relatively high cost of biomass as a feedstock. Under the Test Scenario, the avoided fire damage to assets and reduced fire suppression and rehabilitation costs in the B2E landscape would total about $4.6 million annually. When this asset benefit is incorporated into the power plant financials (by lowering annual O&M costs by $4.6 million), the analysis indicates that a power plant operator could pay up to $54.80 per BDT for biomass fuel, while still achieving the targeted return on investment. Fuel subsidies for biomass power plant operations of up to $46.60 per BDT ($54.80 minus $8.20) would be required in order to achieve break-even based on total costs and benefits.

Although environmental costs and benefits are not monetized and included in the economic analysis, results from evaluating effects of the treatment scenarios on habitat indicate that implementation of the treatment scenarios would likely have an overall beneficial effect that would positively contribute to the net present value of these scenarios. On the other hand, the evaluation of carbon sequestration effects of the treatment scenarios indicate that, in the short term, carbon sequestration of the treated forest would be reduced and greenhouse gases would increase. In the long term, however, the increased productivity and fire resiliency of the treated forest would result in a substantial and prolonged net decrease in the level of atmospheric greenhouse gases. Effects on air quality would vary under the treatment scenarios, with CO and NOx emissions increasing and particulate matter, VOC, and SOx emissions decreasing over the four-decade study period. Overall, it appears that consideration of habitat, carbon, and air quality effects would likely contribute positively to the net economic value of the treatment scenarios.

3.7.1. Conclusions and Key Findings

The Test Scenario, which includes treating public and private lands, generates annualized benefits that exceed estimated costs, indicating that implementing the Test Scenario would incrementally contribute to net economic value.

Vegetation management treatments on public lands in the Beta landscape cost an estimated $5.3 million annually and generate about $4.6 million annually in benefits from avoided asset damage (due to fire) and reduced fire suppression and rehabilitation costs, in addition to $22 million in saw log net revenues. The benefits from vegetation management treatments (i.e., avoided asset damages and reduced fire suppression and rehabilitation costs) are relatively small in the context of total economic benefits of the Test Scenario, which are generated primarily by revenues related to the sale of sawlogs from vegetation treatments. The relatively small effect on avoided fire-related damages to agricultural, recreation, structural, and infrastructure assets from vegetation management treatments reflects the undeveloped and generally rural characteristics of the Beta landscape. Only avoided fire-related damages to timberland assets are significant.

The estimated net operating deficit of power plants that use chips produced from forest biomass in the study area reflects the relatively high cost of producing and delivering chips. Break-even analysis indicates that, under the Test Scenario, the cost of chips for fuel would need to decrease from about $68 per BDT to about $8.20 per BDT for the power plants to be economically viable. Subsidies based on avoided asset damage and reduced fire suppression and rehabilitation costs would need to contribute an estimated $46 per BDT.

Although environmental costs and benefits were not monetized and included in the economic analysis, results from evaluating effects of the treatment scenarios on habitat, carbon sequestration, and air quality suggest that consideration of these effects would likely contribute positively to the net present value of the scenarios

4.0 Conclusions, Observations and Recommendations

Overall conclusions and recommendations of the B2E project can be summarized in four key categories, as briefly described below. The following figure is repeated from the introductory section, as a reminder to the reader of the complex interactions of the processes modeled by the project. Detailed recommendations for further model improvements or development are included in many of the appendices, pertaining to specific components of the B2E project.

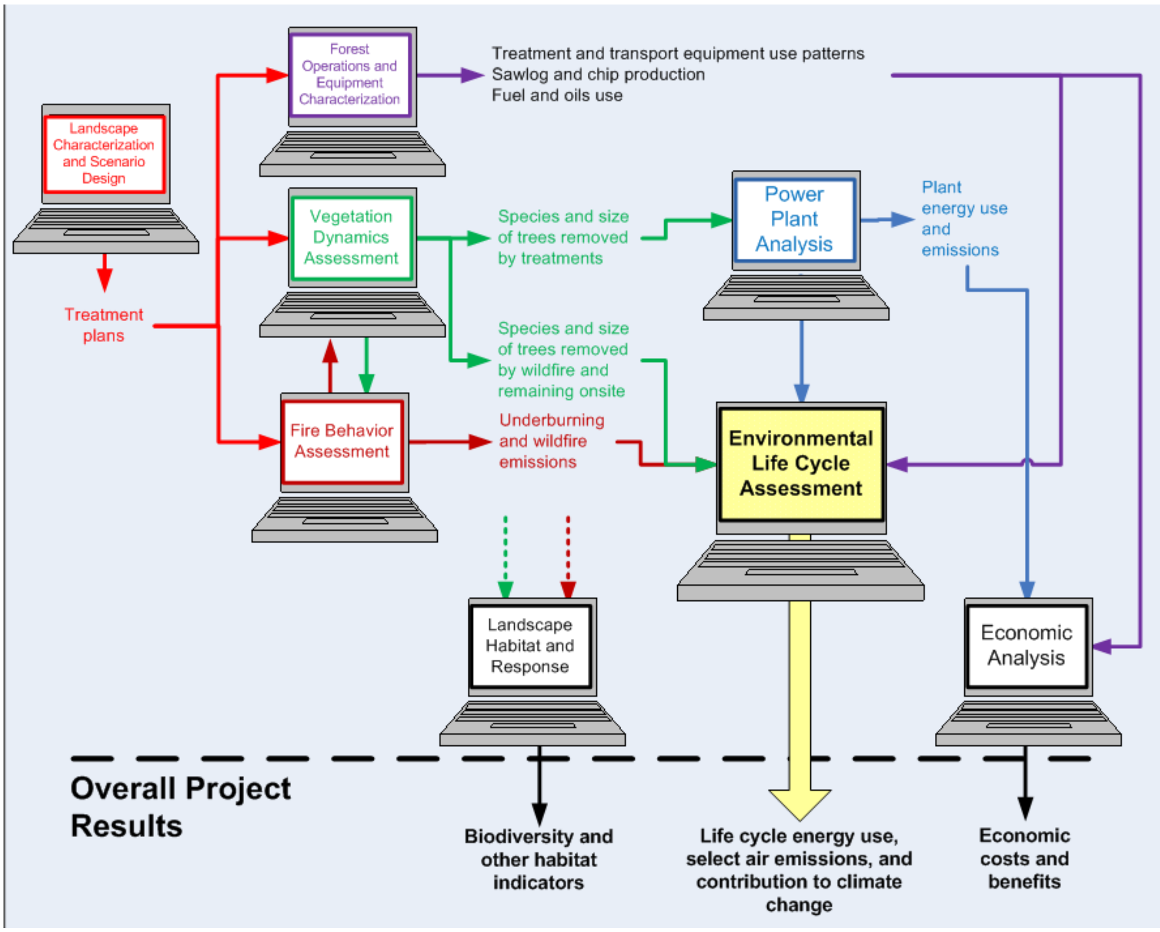

Figure 31 - Review of B2E Process Models and Results

4.1.1. Scenario development recommendations

Further development of the B2E model would include varying the size, spatial distribution, and types of treatments to determine the impacts of pursuing other goals and objectives on the same land base. For example, the research team determined that further model development would include the following scenarios on PMU lands (with private forest land treatments being held constant):

- Natural Disturbance Regime: PMU lands managed to maximize long-term biological diversity and integrity in the face of anticipated climate change dynamics

- Maximum Fire Resilience Regime: PMU lands managed to maximize resilience to natural wildfire regimes, with aggressive reduction of fire severity; heavy thinning in most forest areas not specifically reserved for sensitive species habitat
- Carbon Sequestration Regime: PMU lands managed to maximize in-forest carbon sequestration (i.e., harvested wood products not counted in C sequestration accounting scheme), while reducing risk to wildfire (as threat to Carbon assets)

While these scenarios were not developed fully in the B2E Project analysis, the analytical basis for them has been recorded in treatment prescription specifications on PMU lands. These specifications can be achieved either by application of algorithms to the existing tree lists (i.e., proportional changes in treated strata), or by altogether new runs of altered prescriptions on the original 2006 tree lists, generating new tree lists for each out-year, as was done for the Test Scenario.

4.1.2. Life Cycle Assessment Recommendations

The life cycle assessment for the B2E project has provided important insights on at least two levels: 1) what has been learned about application of LCA principles to complex and multi-objective systems; and 2) the quantifiable life cycle results of the Test Scenario compared with the Reference Case, and what it suggests for further research and development.

On the first level, the team has concluded the following:

1. It is possible to construct a set of interconnected forest operations and equipment characterization, fire behavior assessment, and the power plant analysis models in support of LCA.
2. Data and models are available to represent the life cycle of a range of technologies for developing U.S. forest bioproduct systems. Reliance on the discipline-specific B2E project models (the forest operations and equipment characterization, the vegetative dynamics assessment, the fire behavior assessment, and the power plant analysis) combined with the U.S. EPA NONROAD and MOBILE models and the U.S. DOE's GREET model provided a wealth of data for systems assessments. Similar data availability is expected for technology alternatives, as demonstrated in the assessment of power plant alternatives. However, shortcomings herein included the limited scope (e.g., the small number of impacts assessed, the omission of infrastructure construction models, and the limited number of possible treatment scenarios investigated), lack of uncertainty data for all assessments, and the need to project estimates for all models into the future. These shortcomings do not appear to be insurmountable in the short term, and are recommended for future research.
3. In addition to addressing scope and modeling shortcomings, there are a number of remaining forest bioproduct questions that can be explored with currently available data. For example, investigations of power plant and transfer station citing and optimization of regional utilization of forest residuals, agricultural residuals, and bio-based municipal solid waste could be built around the data presented here.

4. Presentation of results in gross and followed by a variety of computational interpretations provide insights for decision making and a starting place for future assessments.

On the second level, the LCA modeling and assessment work suggestions at least the following:

1. The Test Scenario provides a net benefit for total energy consumption and reduces fossil and petroleum consumption when compared to the Reference Case. Also, whereas the B2E power plant efficiency is critical to the overall energy balance, the consumption of fossil and petroleum fuels during harvest, chip transport, or power plant operation play a less important role.

2. The Test Scenario results show an improvement for NMVOCs, CO, and SOx when compared to the Reference Case. Alternatively, little difference is seen in NOx and PM10 emissions.

3. Forest processes related to photosynthesis, plant respiration, decomposition of litter and soils, despite the uncertainty in estimates, are the most important to understanding whether or not the Reference Case and the Test Scenario contribute to climate change.

Recommendations for future work include the addition of sensitivity analysis to the assessments, comparison of the results to related LCAs, consideration of additional process alternatives throughout the life cycle, and other aspects needed to complete the study as described in the goal and scope document.

4.1.3. Wildlife habitat modeling recommendations

The wildlife habitat modeling team calculated the probability of any given acre having certain structural conditions and being suitable for co-occurring species in a given ecological grouping. Changes in the seral condition of forests were expected and observed to change as a result of forest management. As expected, the starting probability of 23% of any given acre having a large average diameter increased under all scenarios, but increased twice as much in the Reference Case compared to the Test Scenario. Canopy closure was expected to decline in harvested areas, and indeed the probability of a given acre having high canopy cover started at 44% and went from a 50% increase in the Reference Case to a slight decrease in the Test Scenario. The combination of large diameter and high canopy cover represents optimal old forest conditions, and we see the probability of this condition starting at near 20%, more than doubling in the Reference Case, and still increasing a modest 23% in the Test Scenario.

The probability of a given acre supporting a high number (>20; maximum observed = 46) of co-occurring old forest associated species started high (66%), and experienced a minor decline for all the scenarios (see Table 42). This response is attributable to the fact that many species associated with old forests are also associated with earlier seral conditions (e.g. American robin), so some will respond positively to a shift to more early seral conditions, while others will respond negatively. The probability of conditions supporting a high number (>10; maximum observed = 14) of old forest dependent species closely followed that of high canopy cover conditions, with an over 30% increase in probability occurring in the Reference Case, and a decline occurring in the Test Scenario. Approximately half of the existing landscape is estimated to support a high number (>20; maximum observed = 81) of early seral associates. Habitat for early seral associates declined by nearly half in the Reference Case and showed a slight increase in the Test Scenario.

The habitat analysis team examined a number of species groups that have been demonstrated to perform important ecosystem services. Insect regulators consist of invertivores, and the probability of suitability for this group was high (nearly 75%) declined between 10 and 20% across all scenarios. Seed dispersers is one group, and since it is comprised primarily of species associated with early seral conditions, suitability for the majority of these species was nearly identical to early seral associates.

Table 42. Probability that any given acre will support a particular forest condition or suite of species as defined by ecological groupings, and how that probability changes with each scenario

		Reference Case		Test Scenario	
Attribute	Starting point	End point	% change	End point	% change
Large average diameter (>24 in)	0.23	0.53	+134.4	0.37	+63.8
High canopy closure (>60%)	0.44	0.68	+52.5	0.43	-1.4
High canopy closure and large average diameter	0.22	0.49	+123.5	0.27	+23.3
Old forest associates (>20)	0.66	0.57	-13.6	0.62	-7.5
Old forest dependents (>10)	0.38	0.50	+34.1	0.37	-1.3
Early seral associates (>20)	0.48	0.28	-41.7	0.50	+5.5
Insect regulators (>20)	0.73	0.59	-19.7	0.65	-12.1
Seed dispersers (>5)	0.42	0.21	-50.4	0.42	-1.5

4.1.4. Economic analysis limitations and recommendations

Although benefit-cost analysis is widely used in the analysis of regulations and public policy, the approach is based on a number of underlying assumptions that have been challenged over the years. These assumptions include equating changes in income with social well-being, assuming that willingness-to-accept compensation and willingness-to-pay measures are essentially equal and substitutable, and using straight-line discount rates. According to Gowdy (2007), these and other basic assumptions underlying benefit-cost analysis are coming under increasing scrutiny because the assumptions are at odds with observed human behavior.

The successful application of benefit-cost analysis to natural resource policy issues depends on a scientific understanding of underlying physical and biological processes that shape the valuation of environmental costs and benefits. If these processes are not well understood, deriving valid estimates of monetary values is difficult. Boyd (2007) addresses the measurement challenges inherent to valuation of ecosystem services in the B2E study area. The lack of observable data from market transactions greatly increases the challenge to monetizing most of the environmental costs and benefits from the B2E Project.

Although sensitivity analysis was used to test the validity of certain conclusions drawn from the benefit-cost analysis, a more rigorous application is needed to thoroughly evaluate the sensitively of the results to the omission of monetized environmental costs and benefits and to data uncertainties. Conducting a comprehensive economic assessment at the B2E landscape would require a research effort that is an order-of-magnitude greater than this one.

Effects of Population Growth and Future Land Use Development

Although the economic analysis considered costs and benefits over a 40-year analysis period, changes in baseline conditions due to external forces such as population growth, recreation growth, and urban development were not considered. With the exception of tree growth in the supporting vegetation analysis, the economic analysis is considered static and does not account for important dynamic effects that would affect the value of assets at risk to wildfire.

More research is needed to refine the damage functions and asset recovery rates that were incorporated into the benefit-cost model. This is partly responsible for the fact that rehabilitation costs are difficult to capture adequately in the economics model. Rehabilitation costs associated with wildland fires are highly variable. The per acreage rehabilitation cost estimate incorporated into the benefit-cost model likely does not accurately capture probable rehabilitation costs within the study area. Similarly, assumptions built into the benefit-cost model concerning the number of acres that would be rehabilitated under each scenario may have considerable error.

4.2. Benefits to California

The Biomass to Energy project has contributed to California's capacity to analyze forest biomass utilization opportunities at the landscape scale. Even in draft form, the Secretary of the United States Department of Agriculture has identified the project as a "highly influential scientific assessment," with implications for how the USDA Forest Service would use life cycle assessment to evaluate the benefits of biomass power.

California has approximately 40 million acres of forest lands, nearly half of which are managed by private landowners. The economics of private forest land management historically have constrained opportunities for effective and sustainable management. The Biomass to Energy project’s approach is likely to assist policy makers and landowners in evaluating comprehensive and long-term benefits to the environment, as well as enhancing economic opportunities in forest-dependent communities.

The benefits of thinning forests, and using the waste products for energy production, are largely a matter of public choice and policy making. Many of the benefits of managing California’s forests – such as reducing wildfire effects, saving fire suppression costs, providing clean air and water and other climate benefits – may be better reflected in future markets and public policy as a result of this project. Biomass power is a rare form of renewable energy in that it provides a broad range of benefits at relatively low cost to the consumer and substantial ancillary benefits to the environment. Further quantification and analysis, building on the work presented by the project, will help California’s policy makers and legislators evaluate how forest biomass will contribute to larger societal and environmental goals.

Acronym Key

Original Term	Acronym/Abbreviation
Biomass to Energy	B2E
bone dry tons	BDTs
USDI Bureau of Land Management	BLM
California State Board of Equalization	BOE
break-specific fuel consumption	BSFC
British thermal unit, one million Btu, one trillion Btu	Btu, mmBtu, tera Btu
Clearcut	CC
CALFIRE (formerly California Department of Forestry and Fire Protection)	CDF
California Department of Fish and Game	CDFG
methane	CH4
carbon monoxide, carbon dioxide	CO, CO2
Commercial Thinning	CT
Cumulative Watershed Effects	CWE
California Wildlife Habitat Relationships	CWHR
diameter at breast height	dbh
defensible fuels profile zone	DFPZ
emission factors	EF
Equivalent Roaded Acre	ERA
Fire Emissions Joint Forum	FEJF
Fire and Fuels Extension	FFE
Forest Inventory Analysis	FIA
First Order Fire Effects Model	FOFEM
USDA Forest Service	Forest Service/FS
Fuel Management Erosion	FuME
Forest Vegetation Simulator (Model)	FVS
Geographic Information System	GIS
global warming potential	GWP
hydrogen ions	H+
Inland California Southern Cascades	ICASCA
Industrial Private Forests	IPF
International Standards Association	ISO
kilogram	kg
kilowatt hour	kWh
life cycle assessment	LCA

thousand board feet	mbf
moisture condition	MC
mean diameter	MD
Megawatt/megawatt hour	MW/MWh
nitrous oxide	N2O
NFDRS	National Fire Danger Rating System
National Environmental Policy Act	NEPA
National Forest Management Act	NFMA
Non-Industrial Private Forests	NIPF
non-methane volatile organic compounds	NMVOC
non-greenhouse gas	Non-GHG
nitrogen oxides	NOx
Public Conservation and Recreation	PCR
Pre-Commercial Thinning	PCT
particulate matter, particulate matter less than 2.5 microns in diameter, particulate matter less than 10 microns in diameter	PM, PM 2.5, PM10
Public Multiple Use	PMU
Restrictive Thinning	RT
Salvage	SAL
Stewardship and Fireshed Assessment	SFA
Selective Harvest	SH
sulfur dioxide	SOx
strategically placed area treatment	SPLAT
threshold of concern	TOC
Tool for the Reduction and Assessment of Chemicals and Other Environmental Impacts	TRACI
Urban and Other	U
United States Department of Energy	U.S. DOE
United States Environmental Protection Agency	U.S. EPA
volatile organic compounds	VOC
Watershed Erosion Prediction Project	WEPP
Western Regional Air Partnership	WRAP

5.0 Glossary

biomass	non-commercial component of the wood produced in forest harvesting operations
California Wildlife Habitat Relationships (CWHR)	a state-of-the-art information system for California's wildlife. CWHR contains life history, geographic range, habitat relationships, and management information on 692 species of amphibians, reptiles, birds, and mammals known to occur in the state.
catastrophic fire	stand replacement or high intensity fires that cause damage to ecological and/or economic assets and values. The B2E Project also refers to these types of fires as uncharacteristically severe wildfires.
defensible fuels profile zones (DFPZs)	shaded fuelbreaks which are designed with the objective of providing a place to deploy firefighters in the event of a wildland fire. Firefighters use DFPZs to make a stand to hold or contain a fire.
domains	discrete segments of modeling and analysis in the B2E Project
ecological endpoints	ecological functions that have a directly measurable human welfare function, and that can be quantified in an accounting system that makes them fungible
equivalent roaded acre (ERA)	equates all disturbances to one acre of road
fire adapted forests	forests that have evolved with wildfire
fire line intensity	behavior of the flames at the perimeter of the fire as it moves through vegetation
First Order Fire Effects Model (FOFEM)	a computer program developed to predict and plan for fire effects. First order fire effects are those that concern the direct or indirect or immediate consequences of fire. FOFEM provides quantitative fire effects information for tree mortality, fuel consumption mineral soil exposure, smoke and soil heating.
national fire danger rating system (NFDRS) codes	a Forest Service rating system which defines fuel models based on the primary carriers of fire
service providing units	categories of species including insect regulators, seed dispersers, decomposition aides, and herbivore regulators which provide ecological services to forest management
side	common term used by harvest contractors to denote a separate and distinct blend of harvest equipment conducting harvest activities as a separate operation.
slash	woody residues that are generated in the forest from harvesting activities
speciose	relative term for species richness

stated preference method	a classification system for economic analysis. Stated preference methods fall into three primary categories: a) contingent valuation, in which the respondent is required to make a comparison of value between the resource value in question and known trade-off values; b) travel-cost analysis, in which travel effort and investment constitutes a proxy for the value of the resource; and c) hedonic pricing, which uses property values as a proxy for the value of the resource as compared with comparable purchase prices.
strategically placed area treatments (SPLATs)	pattern of treatment areas distributed across a landscape oriented according to the prevailing wind direction in order to intercept a spreading wildfire
thousand board feet (mbf)	volume of the log based upon board foot measure. One board foot represents the amount of wood contained in an unfinished board measuring one inch thick, one foot long, and one foot wide.
treatment activities	discrete management actions or events, such as thinning or understory burning.
treatment prescription	a series of management activities applied over the 40-year timeframe to a specific piece of ground
tree lists, including The Larch	forest inventory datasets which consist of (a) site reference information (plot location, inventory date, slope, aspect, elevation) and (b) the characteristics (species, size, canopy position, and so forth) of the trees sampled, including The Larch.

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7.0 Appendices

General note on appendices: key terminology evolved throughout the course of this project. Most importantly, what became the Reference Case and the Test Scenario had early iterations that were based on separating Industrial Private Forest (IPF) from Public Multiple Use (PMU), creating a "third" interim scenario in order to analyze the impacts of IPF management apart from the broader landscape. Thus, the following notice has been inserted at the beginning of each Appendix.

Notice of Change in Scenario Naming Conventions

Key assumptions, modeling structures and terminology were altered and refined to accommodate new thinking during the course of this study. The reader will observe in the appendices that the scenarios are referred to as "Scenarios 1, 2 and 3" or "S1, S2 and S3."

In both the main text of the Final Report and in the Life Cycle Assessment appendix (Appendix 4), the former Scenario 1 (S1) was renamed to the "Reference Case." Scenario 3 (S3) has been renamed the "Test Scenario." Scenario 2 (S2), focused on the relative contributions and impact of Industrial Private Forestry (IPF) has been eliminated from most of the analyses that make up the entire study. These changes better reflect the focus of the study, which is fundamentally about the landscape level changes in wildfire, habitat, and other dynamics. The modification of terminology do not substantively affect the findings or recommendations of the study.

7.1. Appendix 1: Landscape Vegetation Changes (Barber, Perrot, et al.)

Describes the sources of data and the modeling processes used to establish the inventory and changes in vegetation on the B2E Beta landscape. Approximately 65 pp.

7.2. Appendix 2: B2E Fire Behavior Domain (Ganz, Saah, Barber, et al.)

Explains processes of using vegetation modeling outputs and applying fire behavior models to each of the scenarios during each modeling time period. Approximately 10 pp.

7.3. Appendix 3: Forest Operations and Equipment Configuration (Mason, Hartsough, et al.)

Describes all equipment used in the life cycle assessment and analysis, including variations under different treatment prescriptions and land management regimes. Approximately 10 pp.

7.4. Appendix 4: Life Cycle Assessment of Producing Electricity from California Forest Wildfire Fuels Treatments (Cooper)

Presents a detailed report on the life cycle assessment model developed to integrate life cycle inventory information, calculate impacts and support LCA interpretations. Approximately 78 pp.

7.5. Appendix 5: Wildlife Habitat Evaluation (Manley, et al.)

Reports the methods, data sources and analyses used to assess wildlife habitat conditions under all scenarios. Includes a case study on American Marten, which demonstrates alternatives to using California Wildlife Habitat Relations (CWHR) data and modeling. Approximately 68 pp.

7.6. Appendix 6: Cumulative Watershed Effects Analysis (Wright, Perrot, et al.)

Uses results of vegetation and fire dynamics modeling to model cumulative watershed effects on the B2E beta landscape. Approximately 20 pp.

7.7. Appendix 7: Counting Ecosystem Services: Ecological Endpoints and their Application (Boyd)

Presents an independent consultant report on new methodologies developed for the B2E landscape using “ecological endpoints” as a means to focus and narrow the description and valuation of ecosystem services. This appendix is not technically a part of the Energy Commission contract; the research and writing was funded separately by USDA Forest Service, Pacific Southwest and Pacific Northwest Research Stations. Approximately 55 pp.

7.8. Appendix 8: Project Economic Analysis (Wegge, Trott and Barnett)

Presents methods, applications and results of the economic analysis, including data derived from the Excel spreadsheet model developed for the B2E project. Approximately 57 pp.

7.9. Appendix 9: Landscape Carbon Model (Morris)

Describes in an independent consultant report forest landscape level greenhouse gas changes through wildfire, treatment and forest decay over the 40 year modeling period of the B2E project. Approximately 23 pp.

7.10. Appendix 10: Power Plant Analysis for Conversion of Forest Remediation Biomass to Renewable Fuels and Electricity (Schuetzle, Tamblyn, Tornatore, et al.)

Analyzes five powerplant technologies for the B2E project, three of which are included in the life cycle assessment domain. Two additional technologies included options for ethanol or other liquid fuel production, and were not directly used in the life cycle assessment because of the differences in outputs. The additional technologies were analyzed in anticipation of further work stemming from the B2E project that would include a life cycle assessment for transportation fuels. Approximately 6 pp.

7.11. Appendix 11: Synthesis of Economic Valuation Studies of Forest Landscape Disturbances (Berkenklau)

Synthesizes in an independent consultant report the broad range of research on the economic valuation of disturbance on forested landscapes. Approximately 12 pp.

7.12. Appendix 12: Biomass to Energy Project Team, Committee Members, and Project Advisors

Lists the members of the research team, the Technical Advisory Committee and the Policy Advisory Committee.

California's Forests and Rangelands:
2010 ASSESSMENT

CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION

FIRE AND RESOURCE ASSESSMENT PROGRAM

2.1 Wildfire Threats to Ecosystem Health and Community Safety

CHAPTER OVERVIEW

California is a complex wildfire-prone and fire-adapted landscape. Natural wildfire has supported and is critical to maintaining the structure and function of California's ecosystems. As such, the ability to use wildfire, or to mimic its impact by other management techniques, is a critical management tool and policy issue. Simultaneously, wildfire poses a significant threat to life, public health, infrastructure and other property, and natural resources.

Data suggests a trend of increasing acres burned statewide, with particular increases in conifer vegetation types. This is supported in part by the fact that the three largest fire years since 1950 have all occurred this decade. Wildfire related impacts are likely to increase in the future based on trends in increased investment in fire protection, increased fire severity, fire costs and losses, and research indicating the influence of climate change on wildfire activity.

Developing coherent strategies involves collaborative planning, given the unique and disparate audience for dealing with the threat (i.e., numerous individual landowners). In terms of protecting communities, this is discussed in detail in Chapter 3.3: Planning for and Reducing Wildfire Risks to Communities.

This chapter contains three unique spatial analyses that generate priority landscapes:

1. Preventing Wildfire Threats to Maintain Ecosystem Health
2. Restoring Wildfire-Impacted Areas to Maintain Ecosystem Health
3. Preventing Wildfire Threats for Community Safety

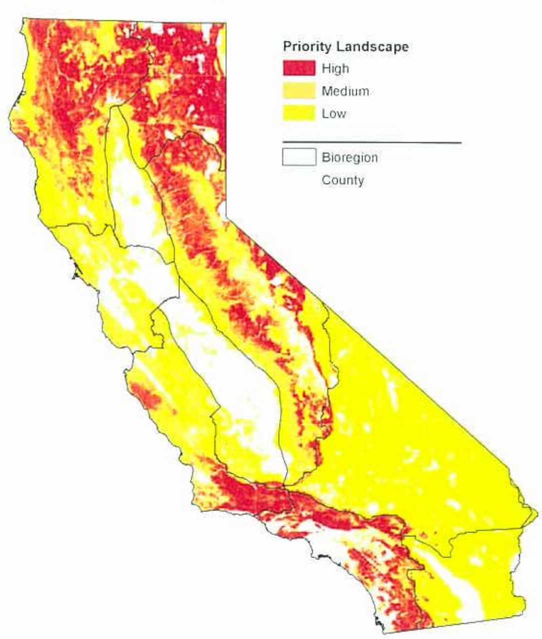
ANALYSIS: PREVENTING WILDFIRE THREATS TO MAINTAIN ECOSYSTEM HEALTH

Key Findings

- Over 21 million acres statewide are viewed as high priority ecosystems for protection from threats from wildfires, with large concentrations in the South Coast, Sierra, and Modoc bioregions, and the northern interior portions of the Klamath/North Coast.
- Key ecosystems at risk include conifer types such as Klamath and Sierran Mixed Conifer and Douglas-fir; shrub systems at risk include Sagebrush, Mixed Chaparral, and Coastal Scrub.
- Managing these risks requires understanding the specific mechanisms of disruption of the natural fire regimes that once formed the ecological stability of the ecosystem, and determining actions that best mimic and or restore these natural processes in manners that are appropriate for different types of land ownership and management. As such, tools must be tailored to the specific ecosystem.

High priority landscape acres by ownership	
USFS	10,980,000
BLM	1,980,000
DOD	130,000
Tribal	230,000
NPS	370,000
Other Federal	60,000
Other Gov.	640,000
Private	6,890,000
NGO	50,000

Priority Landscapes



This analysis identifies priority landscapes where unique ecosystems have high levels of threat of damage from future fires, and should be viewed as a basic assessment of need for strategies and adoption of tools to protect these key areas in the future.

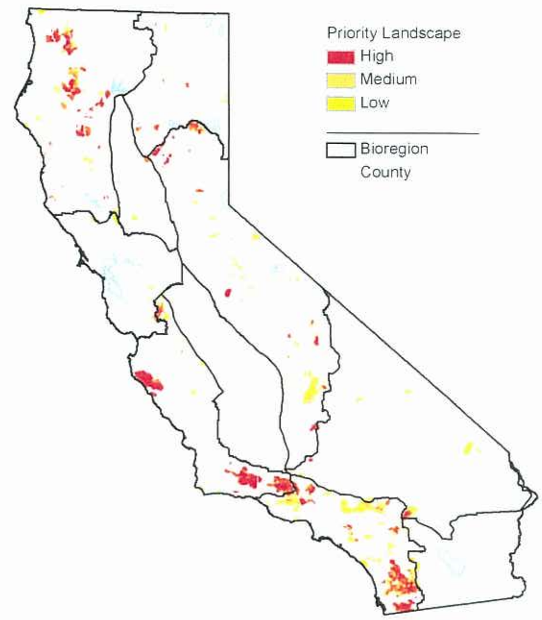
ANALYSIS: RESTORING WILDFIRE-IMPACTED AREAS TO MAINTAN ECOSYSTEM HEALTH

Key Findings

- A total of 2.35 million acres are in high priority for restoration statewide.
- In the northern portion of the state, high priority landscapes include the Klamath, Trinity, and Feather River water basins, and highlight the fire-restoration issue in conifer ecosystems adapted to a frequent, low-severity fire regime, but burning under a less-frequent, more severe modern era regime.
- A total of 445,000 acres in Douglas-fir, Klamath Mixed Conifer, and Sierran Mixed Conifer are in high priority for restoration.
- In the southern portion of the state, a large area of Mixed Chaparral is in high priority status (over 700,000 acres) highlighting direct impacts on soils and watersheds due to fire's typical high intensity/high severity nature in this habitat type, as well as some areas suffering repeated burning and associated type-conversion.
- Similarly, the 200,000 acres of Coastal Scrub in high priority landscapes deserve special attention due to loss of key ecosystem components, and the apparent trend in increased fire frequency, increased non-native invasive dominance, and loss of ecosystems due to land use practices.
- Priority for restoration efforts reflect areas recently burned in wildfire, and will require more resources than have historically been available due to the large area burned in recent fires.

High priority landscape acres by ownership	
USFS	1,440,000
BLM	120,000
DOD	20,000
Tribal	40,000
NPS	30,000
Other Federal	20,000
Other Gov.	150,000
Private	530,000
NGO	10,000

Priority Landscapes



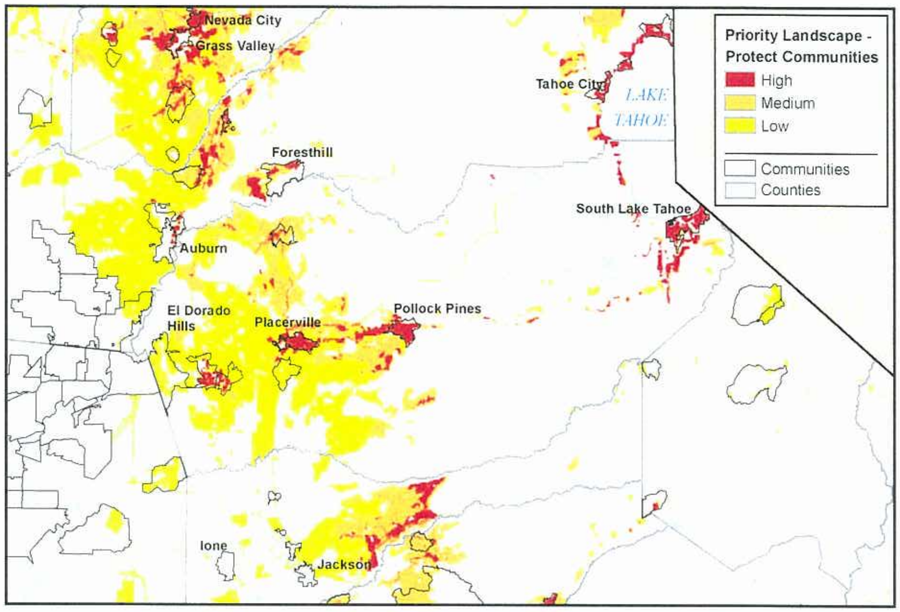
This analysis focuses on restoring fire damaged lands by prioritizing areas that have recently burned in wildfires, especially where a majority of entire ecosystems are impacted. The objective is to define areas in need of activities designed to facilitate recovery of key ecosystem components.

ANALYSIS: PREVENTING WILDFIRE THREATS FOR COMMUNITY SAFETY

Key Findings

- Community areas of high and medium priority are scattered throughout the state, occurring in at least modest (500 acres) abundance in 46 of 58 counties statewide.
- Areas of high priority landscape concentration occur in the South Coast and Sierra bioregions, and other isolated urban areas near significant wildfire high threat areas, such as the East Bay and Redding.
- The cities of San Diego and Los Angeles are by far the largest communities in terms of high priority landscapes. Urban populations of San Bernardino, Riverside, Orange and Ventura counties also have extensive high priority areas. Many of these densely populated areas require coordinated fuel management across significant amounts of adjacent areas to be effective.
- Many rural counties have significant numbers of communities and acreage in medium priority landscapes – a result of extensive low density housing areas in high threat landscapes. These are areas where individual homeowner vegetation management can make a large difference.
- A total of 404 communities meet a basic asset-area threshold for significance, and many more lands not captured within the community layer represent significant areas of risk from wildfires.

Priority Landscapes



This analysis derives priority landscapes as the convergence of areas with high wildfire threat and human infrastructure assets. This is summarized using indicators for prioritizing communities in terms of investments to prevent likely wildfire events that would create the most severe public safety hazards.

Map depicts an example priority landscape for the western Sierra Nevada/Lake Tahoe region, where high wildfire threat converges with high infrastructure assets. Priority landscapes were derived for the entire state.

Population of top counties with high priority landscapes	
Los Angeles	813,000
San Diego	432,000
Orange	235,000
Ventura	174,000
San Bernardino	120,000
Riverside	93,000
El Dorado	67,000
Alameda	65,000
Contra Costa	42,000
Nevada	39,000
Butte	38,000
Shasta	37,000

Abundance and Habitat Associations of Dusky-Footed Woodrats in Managed Redwood and Douglas-fir Forests[1]

Keith A. Hamm,[2] Lowell V. Diller,[2] and Kevin D. Hughes[3]

Simpson Resource Company (formerly Simpson Timber) initiated studies on dusky-footed woodrats *(Neotoma fuscipes)* in 1992 on its approximate 450,000-acre ownership in Humboldt and Del Norte Counties, California. This land base is comprised of second and third growth forests primarily managed under an even-aged (clearcut harvest) silviculture technique. Interest in abundance and habitat associations of woodrats was driven by its importance as a primary prey item for the federally threatened northern spotted owl *(Strix occidentalis caurina)*. Simpson's studies of spotted owls have shown that woodrats comprise approximately 45 percent frequency and 70 percent biomass of prey consumed by spotted owls.

Research projects on dusky-footed woodrats have consisted of two master's thesis projects at Humboldt State University and one "in-house" study. In the 1992 to 1993 master's study, we live-trapped woodrats on 1.2 ha grids located in 24 forested stands from four age classes of redwood *(Sequoia sempervirens)*/Douglas-fir *(Pseudotsuga menziesii)* forest. Age classes were: five to nine years, 10 to 20 years, 21 to 60 years, and 61 to 80 years. We live-trapped each stand for five nights with Tomahawk (model #201) traps. In the 1999 "in-house" study, we live-trapped woodrats in 15 redwood/Douglas-fir stands ranging from young regeneration nine to 15 years old to mature second growth forest 50 to 70 years old that had varying levels of commercial thinning harvest. Thinning existed on a continuum of basal area removed, but for the purposes of sampling we placed stands into light, medium and heavy thinning categories. Vegetation was measured in 0.04 ha circular plots within trapping grids. Akaike's Information Criterion (AIC) was used to identify the top models predicting woodrat occurrence. During 2000 and 2001, an HSU graduate student sampled 29 stands of Douglas-fir/tanoak *(Lithocarpus densiflorus)* forests for woodrats through the use of live-trapping techniques. Stands were stratified into four age classes: five to 20; 21 to 40; 41 to 60; 61 plus years. Two transects were randomly located within each stand and 25 Tomahawk live traps were placed at 15 m intervals along each transect. Trapping was conducted for five nights. Captured woodrats were marked and released. Vegetation was measured in 0.04 ha circular plots along trap lines. The top models for predicting woodrat occurrence were ranked according to AIC values. In addition, this study compared woodrat house centered vegetation plots and randomly chosen plots to investigate the influence of habitat variables on nest site (house) selection.

During 1992 to 1993 we found woodrats were most abundant in young stands

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1 An expanded version of this paper was presented at the Redwood Science Symposium: What does the future hold? March 15-17, 2004, Rohnert Park, California.

2 Simpson Resource Company, Korbel, CA 95550, (707) 668-4437. email: khamm@simpson.com

3 Dept. of Biology, Montana Tech University, Butte, MT 59701.

from five to 20 years of age. Density estimates were ≥31 woodrats/ha in stands five to 20 years old and ≤2 woodrats/ha in stands 21 to 80 years old. In 1999, woodrats trapped in clearcut areas <15 years of age were found in similar abundance to clear-cuts trapped in 1992 to 1993. Abundance in clearcuts was significantly greater than thinned stands ($\chi^2 = 12.54$, $P = 0.006$). In thinned stands, woodrats were associated with increasing understory cover, increasing amounts of redwood shrub cover, and decreasing amounts of Pacific rhododendron *(Rhododendron macrophylum)* and salal *(Gaultheria shallon)* cover. Woodrats were negatively associated with conifer stems >45.7 cm dbh. A Poisson regression indicated that woodrats began responding to thinning when stand basal area approached a lower limit of 28 m^2/ha. During 2000 to 2001, 207 different woodrats were captured among the four age classes of Douglas-fir forest. Woodrat abundance differed among the four age classes of Douglas-fir forest ($\chi^2 = 13.27$, $P = 0.004$) and woodrat abundance was negatively related to stand age ($r_s = -0.68$). The top model predicting woodrat abundance indicated a negative association with stand age, a positive association with shrub hardwood cover and a negative association with percent Douglas-fir in the shrub layer. The top model predicting woodrat house occurrence showed positive associations with ground cover of tanoak, percent tanoak in the shrub layer and density of understory tanoak.

All three studies indicate that in the redwood/Douglas-fir zone of Simpson's ownership, woodrats are in greatest abundance in young stands <20 years of age. Use of uneven-aged silviculture techniques such as commercial thinning or selection is not likely to enhance woodrat abundance because these practices generally encourage the proliferation of shade tolerant understory species that are not palatable forage for woodrats. Silviculture practices that promote a dense and diverse shrub layer of heliophilic species that are more palatable should promote woodrat abundance. However, woodrats also require suitable substrate in the form of redwood or tanoak stump sprouts, logs, and other down material for construction of their houses.

Because woodrats are the primary prey species of spotted owls *(Strix occidentalis caurina)* in northern California, forest management practices that influence woodrat abundance have implications to management of populations of threatened spotted owls. Thinning of mature stands is not likely to enhance the primary prey base for spotted owls in this region. The management strategies for threatened populations of spotted owls must take into consideration the habitat needs of the species itself and that of its primary prey.

AN ESTIMATE OF THE TOTAL POPULATION OF NORTHERN SPOTTED OWLS IN CALIFORNIA

Robert J. Taylor
California Forestry Association
1311 I Street, Suite 100
Sacramento, CA 95814

May 10, 1993

California Forestry Association Technical Report No. 13

Several attempts have been made to project surveys of spotted owls to estimates of a total population. These have all suffered from the fact that the sampling effort to date has been geographically biased, in some cases toward suitable habitat when owls were sought, in other cases away from suitable habitat when the land was reserved from management.

The first effort to deal explicitly with these biases was made by McDonald, et al. (1991) for the Mexican spotted owl. Their calculations derived from the observation that while the currently known number of owl territories was biased low, a simple extrapolation of known densities to all suitable habitat was probably biased high. The procedure they adopted for circumventing these errors was probably the best that could have been done given the limited data for this subspecies but is flawed in several respects.

The northern spotted owl in California has been surveyed a great deal more intensively than the Mexican spotted owl, and the resultant data allow a more sophisticated approach to projecting the total population. This report outlines such an approach and uses it to make a preliminary estimate of the number of owl sites, pairs, and territory-holding birds in California.

I. Partitioning the Klamath Province

The landscape the owl occupies in California is quite diverse. Since any projection requires an estimate of the amount of suitable habitat, it is first necessary to partition the

Klamath Province into relatively homogeneous subregions. This can be done a variety of ways. I chose to divide the area into a coastal zone, the national forests, and the interior private zone. This decision was driven partly by differences in the forest types and partly by the availability of estimates in the SAT Report (Thomas et al. 1993) of the percentage of land surveyed in the national forests. This is not a satisfactory partitioning scheme, since the national forests vary greatly in suitability from east to west, but it is sufficient to start with. Table 1 lists the acreages in each ownership category for the Klamath Province.

Table 1: Acreages by ownership category[1]

Ownership Category	Area (acres)
National forests	6,771,428
Other government lands	1,201,414
Industrial private forests	2,799,027
Non-industrial private lands	5,752,571
Total	16,524,440

[1] Data from T.A.C. (1990).

II. Fraction of Land Surveyed

This part of the estimation process poses the greatest uncertainty. The task was approached by dividing the coast and interior regions into ownership subsets and collecting as much data as could be found about each subset. The majority of non-forested lands are in the category of non-industrial private. These were subtracted from the amounts in Table 1; the remaining non-industrial forested lands appear in Tables 2-4.

The percentage of suitable habitat in each subregion was estimated conservatively high. The brief history of claims about what comprises suitable habitat for northern spotted owls in California is a sequence of overstatements about the size and density of trees required. By the standards of suitability advocated as recently as four years ago, more than half the owls in the 1992 population live on "unsuitable" land. Information on the amounts of suitable land and the percentages of suitable land already surveyed for owls was obtained from telephone surveys of major owners, from a combination of GIS analysis and state Timber Harvest Plan data for non-industrial private owners, and from the SAT Report for the national forests. There remain a couple of seat-of-the-pants estimates in these tables. The percentage of USFS land estimated to be suitable was judged to be 80%. The percentage of industrial and non-industrial forest land estimated to be suitable was 100%, except for areas recently burned. The state and national parks and other government lands were estimated to be all suitable.

Table 2: The coastal subregion

Ownership	Total Land	Suitable Land	Surveyed Suitable Land	% Suitable Surveyed for Owls
Industrial Private (inc.JSDF)	1,449,416	1,319,687	1,067,860	80.9
Non-ind. Private (Timbered)	2,087,000	2,087,000	834,800	40
Other Government	901,000	901,000	450,500	50
Total Coast	4,437,416	4,307,687	2,353,160	55

Table 3: The national forests

	Total Land	Suitable Land	Surveyed Land	% Suitable Surveyed for Owls
All Forests	6,771,428	5,417,142	2,708,571	50[1]

[1] The SAT Report estimates that 44% of suitable habitat on the California national forests was surveyed between 1987 and 1991. Since the Cal Fish & Game spotted-owl database contains a large number of observations made on national forests before 1987, I have adjusted this number upward to 50%.

Table 4: The interior subregion

Ownership	Total Land	Suitable Land	Surveyed Land	% Suitable Surveyed for Owls
Industrial Private	1,340,000	1,054,253	709,060	67.3
Non-ind. Private (Timbered)	231,000	231,600	92,640	40
Other Government	240,283	100,000	50,000	50
Total Interior	1,811,963	1,385,853	851,700	61.5

III. Estimate of total owl sites

The CF&G/CFA database currently holds 2178 known owl sites. With the percentages in Section II, these can be combined to yield the following estimates of the total number of sites:

Table 5: Estimated total owl sites

Subregion	Known Sites	% Land Surveyed	Estimated Sites
Coast	839	55	1525
National Forests	984	50	1968
Interior	355[1]	62	573
Total	2178		4066

[1] Because of checkerboard ownership patterns, attribution of a site in the interior to an owner is difficult. A small number of the sites on private land may prove with further analysis to lie on USFS land.

IV. Estimate of total occupied sites

Not all sites are occupied every year. To factor this into the total estimate, the USFWS (McDonald, et al. 1991) calculated for the Mexican spotted owl the fraction of sites which were occupied in any given year. This is an unreliable statistic for the northern spotted owl in California since it varies with the intensity and location of surveying. A preferable approach, given existing data, is to calculate the occupancy rates for all known sites and then average them for a subregion. The CF&G/CFA database was examined to assess the number of years that each site was found to be occupied and the number that the site was surveyed. The ratios of these two numbers were averaged for all sites within a subregion (Table 6).

Table 6: Estimated total occupied sites

Subregion	Estimated Total Sites	Proportion Occupied	Estimated Occupied Sites
Coast	1525	0.89	1357
National Forests	1968	0.78	1535
Interior	573	0.86	493
Total	4066		3385

V. Estimate of total breeding pairs

Each occupied site was examined for evidence of a breeding pair for the years 1989-1992. The proportion of sites supporting a pair was calculated for each year (Table 7),

Table 7: Proportions of occupied sites with a confirmed breeding pair.

	1989	1990	1991	1992	Average
Coast	0.46	0.62	0.69	0.75	0.64
National Forests	0.43	0.43	0.4	0.41	0.42
Interior	0.36	0.52	0.58	0.66	0.53

The averages from Table 7 were entered into Table 8 to estimate the total number of breeding pairs.

Table 8: Estimated total pairs

Subregion	Estimated Occupied Sites	Pairs per Occupied Site	Estimated No. of Pairs
Coast	1357	0.64	868
National Forests	1535	0.42	645
Interior	493	0.53	261
Total	3385		1774

VI. Estimated total owl population

The total number of territory-holding owls is twice the number of pairs plus the number of singles. For the years 1989 to 1992 this averages to 5159. This number is probably conservative in that it does not include those territorial owls that chose not to respond to survey efforts. The total owl population is the sum of this number plus the number of non-territorial or floater owls; however, nobody has figured out how to estimate the floating subpopulation.

VII. Comparison of the National Forests to Other Lands

Since the Klamath Province divides roughly into half national forests and half in other ownerships, mostly private, a comparison of the two categories of land ownership is instructive. The table below is derived from the preceding tables. It indicates that the national forests hold less than half the owls, by any measure, and that their density of territory-holding owls is lower than on other forested lands.

Table 9: Comparison of the owl population living on the national forests to owls living on other lands in the Klamath Province.

	Total Sites	Occupied Sites	Pairs	Total Owls	Density (owls/sq mi)[1]
National Forests	48%	45%	36%	42%	.26
Other	52%	55%	64%	58%	.33

[1] The base is suitable land (Table 2).

VIII. Discussion

If the patterns revealed here prove stable, then they raise serious questions about federal management planning for the northern spotted owl. Primary among these is that restriction of management attention to public lands alone, as recommended by the ISC strategy, basically writes off a majority of the owl population in California. This is particularly dangerous because for some reason the national forests may provide less suitable habitat for owls, as reflected by lower occupancy and pair occupancy rates. This suggests that the national forests may quite possibly be population sinks for northern spotted owls and that the better habitats lie on private and other lands to the east and west.

The primary purpose of this exercise is to elevate the discussion of the population status of northern spotted owls in California from a focus solely on the number actually surveyed, a number which is acknowledged to be biased in several respects, to efforts to find a reasonably unbiased method of estimating the total population. The particular projection method used here rests, as does any projection, upon assumptions. Several of these require immediate attention, primary among them being the amount of suitable habitat in each of the subregions and the percentage of nonindustrial private land that has been surveyed. Future work might be directed at splitting Forest Service land into subregions and at discovering why both occupancy and the proportion of pairs are so much lower on the national forests.

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A PETITION TO REMOVE THE CALIFORNIA POPULATION OF THE NORTHERN SPOTTED OWL FROM THE FEDERAL LIST OF THREATENED SPECIES

A PETITION TO REMOVE THE NORTHERN SPOTTED OWL IN CALIFORNIA FROM THE LIST OF THREATENED SPECIES

California Forestry Association
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The California Forestry Association hereby petitions the U.S. Fish and Wildlife Service under 50 C.F.R. § 424.14 to remove the Northern Spotted Owl (Strix occidentalis caurina) in California from the federal list of threatened species. The basis of this petition is 50 CFR § 424.11(d)(3), "subsequent investigations may show that the best scientific or commercial data available when the species was listed, or the interpretation of such data, were in error".

In this petition we shall demonstrate the following:

1. the northern spotted owl in California is a delistable unit;

2. the population is large and well-distributed;

3. the habitat used by the population is stable and likely to increase;

4. models used to analyze trends at the time of listing are oversimplified and misleading; and

5. a detailed, spatially explicit model of the population in California predicts that the population is stable and the forests of northern California are completely packed with owl territories.

The northern spotted owl in California is a delistable unit.

Since the beginning of the process that led to the current listing, biologists have recognized that the ecological circumstances of the owl differ in various portions of its range. In comments written in 1989 on the proposal to list the owl, the Interagency Spotted Owl Scientific Committee wrote the following:

> Northern spotted owl numbers, population densities, and the current condition and amount of habitat vary widely across the range of the species. The condition of the population and habitat on the Olympic Penninsula [sic], the Coast Range

of Oregon, northwest Oregon and southwest Washington in terms of owl densities and the amount of suitable habitat are decidedly different from those in the Cascades and Klamath Province. It may be appropriate that the status of the northern spotted owl be evaluated according to the status of "sub-populations" and their habitats by province and land ownership, including such considerations as amounts of northern spotted owl habitat, the degree of fragmentation of that habitat, numbers of owls, etc. These "subpopulations" may be considered by province, by ownership, by political subdivision, or by any classification that has influence on the biological or management situation. (comment #78)

The Recovery Plan for the Northern Spotted Owl - Draft (USDI 1992) agreed with this position by recommending the following:

> Delisting may be considered for all or part of the range. The borders of the area being considered for delisting should follow the borders of the physiographic provinces shown in Figure 2.2. (p. 95)

This petition applies to the collective borders of three provinces identified in the Draft Recovery Plan, the California Coast Province, the California Klamath Province, and the California Cascades Province. These areas will be referred to collectively as the Klamath Province.

We also assert that the northern spotted owl in California qualifies as a distinct population segment under the Endangered Species Act (16 U.S.C. 1531 et seq.). Since the U.S. Fish and Wildlife Service has not adopted a rule defining a distinct population segment, we base this assertion on a prior decision. The marbled murrelet was listed over a portion of its range delimited by a political boundary.[1]

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[1] The California Forestry Association is a plaintiff in litigation challenging the validity of the listing of the marbled murrelet on the grounds that only geographically separate, reproductively isolated populations are eligible for listing under the ESA as "distinct population segments," not populations merely separated by political boundaries (Northwest Forest Resource Council et al. v. Babbitt (Civil No. 93-1579 (D.D.C.)) August 1, 1993). The Association maintains, however, that as long as the U.S. Fish and Wildlife Service adheres to its policy of listing populations separated by political boundaries, it must also apply the same policy in reviewing and approving delisting petitions.

In supporting that decision, Richard N. Smith, Deputy Director of the U.S. Fish and Wildlife Service, submitted a declaration to the Ninth Circuit (Appendix A) that suggests that a population segment be recognized as distinct when it meets at least one of four criteria. Number 4 on that list was

> It can be defined by geo-political boundaries that delineate an area representing a significant portion of the species' or subspecies' range where existing legal protection is inadequate to ensure its survival.

The California population of northern spotted owls is defined by a geo-political boundary, and that boundary delineates a significant portion of the subspecies' range. By this standard the only question remaining to be answered is whether existing legal protection, absent the federal Endangered Species Act, is adequate to ensure its survival. We believe that the California Forest Practice Rules provide this protection on private land, and other arguments presented answer that question on federal lands.

By all criteria previously identified by the Interagency Spotted Owl Committee, the Recovery Plan, the Endangered Species Act itself, and existing interpretation of that Act, the California Klamath Province population of the northern spotted owl is a delistable unit.

<u>The size of the population is large.</u>

The California Forestry Association has compiled all existing survey data through the 1992 field season, an analysis of which is included as Appendix B. The results reveal a total of 2262 known northern spotted owl territories from surveys of between 50% and 60% of the coniferous forest. Figure 1 displays the known territories on a map of the coniferous forest. The population is well distributed; with few exceptions, areas of coniferous forest on Figure 1 showing few northern spotted owls are either high elevation or are unsurveyed.

Because our compilation included an estimate of the land area surveyed by ownership class, we can project this sample to a total population. That population is 4200 territories, about 3500 of which will be occupied in any one year by a population of approximately 1800 pairs and 1700 singles. This leads to a total projected territory-holding population of 5300 birds, to which must be added an unknown number of floaters. Sources of error in this estimate, discussed in Appendix B, lead to a projected range in the number of adult northern spotted owls of a minimum of 4450 and a maximum of 8500.

The history of known northern spotted owl sites in California

(Figure 2) shows that the population was dramatically underestimated at the time of listing. The ISC Team (Thomas, J. W. et al. 1990. A conservation strategy for the northern spotted owl.) speculated that in the three-state region "...the true number lies somewhere between 3000 and 4000 pairs." p. 64. Either this estimate is much too small or fully half of the total population lives in California.

The size of the population is much greater than was known, or even suspected, at the time of the original listing, suggesting that estimates of viability at that time were unduly pessimistic.

<u>The habitat used by northern spotted owls is not declining.</u>

Figure 3 displays known northern spotted owl sites on a map of California that highlights publicly owned land. About half of all land in the Klamath Province is privately owned (Appendix B), and about half of known northern spotted owl sites are on private land. The persistence of owl habitat on state and federal land is assured by existing state regulations and by federal practices in effect at the time of the listing. For the purposes of this petition the critical question is the future of habitat on private land.

Beginning in 1989, the forest products industry began an intensive program of surveying for northern spotted owls. The most significant result of that program is that northern spotted owls were found in high densities in second-growth commercial forests. The question to be answered is what is the nature of that second-growth forest?

To answer that question, the California Forestry Association developed a description of nesting habitat on private lands on the coast and in the interior. The focus on private land was motivated by two concerns. The first is the need for accurate information on northern spotted owl nesting and nest locations. The second is the need to address specific concerns for the reliability of private land in providing northern spotted owl habitat. Private forest land is widely and correctly held to contain very little old-growth forest. To the extent that it supports northern spotted owls, it provides a clue to the broader range of conditions under which this forest owl can survive and reproduce. The details of this habitat description are provided in Appendix C.

The findings are that northern spotted owl nests are found in association with stands of large trees, but these stands extend no farther than 18-72 acres around the nest. Nests are not associated with very dense stands (>60% canopy closure), but they are associated with stands showing 40%-60% canopy closure. Again this effect does not extend beyond the 18-72 acres around the nest. These findings agree precisely with prior descriptions of owl habitat on federal lands. The habitat study leads to two conclusions. While owls may require large trees with moderate canopy closure for nest sites, they do not require large amounts of that forest type. And private industrial forests provide enough of the desired habitat to maintain a well-distributed and dense northern spotted owl population.

For the last twenty years California's Z'Berg-Nejedly Forest Practices Act has been widely regarded as the strictest regulation of forestry on private land of any state. Forest landowners operating under this law before the owl was listed produced habitat suitable for supporting the existing large population. No additional federal regulation is necessary to ensure the northern spotted owl's persistence indefinitely.

California is about to acquire a set of much stricter rules. Appendix D provides a detailed view of how the current rules are being changed. To summarize, rule changes are being made in three areas, sensitive watersheds, late-seral forests, and silvicultural rules. The first two rule packages have been adopted by the California State Board of Forestry. The third is scheduled for final consideration in November, 1993. All three are expected to be in force by March 1, 1994.

The sensitive watershed package provides a process to identify watersheds with resources at risk. Provision is made to identify the special needs of these watersheds and to make rules to address those needs.

The late-seral forest package identifies late seral forests as California WHR classes 5M, 5D, and 6 forests. Before timber harvest can occur in these stands, the owner must assess the impacts of that activity on the wildlife community.

The silvicultural package is a large, complex set of rules that defines and imposes limitations on all silvicultural practices, both even-aged and uneven-aged. For example, clearcuts must normally be limited to 20 acres if they are tractor logged or 30 acres if they are cable logged. Under special circumstances, clearcuts may be enlarged to a maximum of 40 acres. Planning for sustained yield must be demonstrated either at the level of the individual timber harvest plan or in long-term landscape-level sustained yield plans.

Given the flexible nature of the habitats used by northern spotted owls in California, the fact that commercial forestry produced a range of acceptable habitats before it was aware that northern spotted owls occupied its land, and the current restrictive forest practice rules, the continued existence of the current acreage of suitable northern spotted owl habitat is assured.

Existing models of population trends are misleading.

Discovery of a large population living in a diverse array of habitats is insufficient evidence from which to conclude that the population is secure. To draw that inference, one needs to know the trend of the population, i.e. is it increasing, stable, or declining. Because of the long life of this species, its low density, and its cryptic habits, such trends cannot practically be discovered by repeated censuses. The only practical method is to employ a model that uses known life history parameters to project the owl's numbers into the future. Viability modeling is a new and relatively undeveloped field in conservation biology. As such it should come as no surprise if its initial efforts are immature and misleading. We suggest that this is the case for the simplistic demographic models originally employed to discover trends in northern spotted owl numbers.

An as-yet-unpublished manuscript of a theoretical study by Goldwasser, Groom, and Kareiva at the University of Washington is included as Appendix D of this petition. This simulation study evaluated the extent to which the demographic approach described correctly population trends of model owl populations in variable environments. In this study the parameters used in the demographic approach were assumed to have been estimated without error; yet even with this generous assumption, estimates of the rate of population change were routinely wrong. For example,

> ..., we found that our models can by chance alone yield [lambdas] that are far from our simulated realized values, even when using estimates of variability reported by Anderson and Burnham (1991),

and

> ..., our caveat that no model consistently predicts the actual [lambda] seems robust across a range of plausible patterns of environmental variability.

Goldwasser, et al. discovered that the probability of observing a monotonic decline in survivorship over a five-year period was quite low unless the population were in fact declining. The single demographic study area in California, the Willow Creek Area, does not display such a monotonic trend in survivorship (Franklin, A. 1993).

The conclusion we reach from a careful reading of Appendix D is that the interpretation of existing data which led to the inference that the owl was declining in numbers in California was erroneous. The projection of a population trend requires a more precise, mechanistic model of owl population dynamics.

A detailed model of the California population shows that its numbers are stable.

The population of northern spotted owls in California has a trend, whether or not standard demographic models are capable of revealing it. To discover that trend, we developed the most detailed model of owl population dynamics in existence (Appendix F).

In brief the model, known by the acronym COPS (California Owl Population Simulator), predicts that the number of northern spotted owls is not declining. It predicts that the dynamics of northern spotted owls in California are determined by density-dependent processes associated with territory formation and that those processes generate a stable equilibrium population level that falls within the estimated range of the number of northern spotted owls present today. The population, in short, is probably as large now as it can get.

COPS shares with all models vulnerability to the charge that it oversimplifies the environment. It simplifies to less of an extent than any other owl model, but it does simplify. Those simplifications warrant examination by the scientific community. We present COPS in this petition not because we believe it represents absolute truth but because we regard it as the most sophisticated modeling effort to date. As such, it has value in analyzing the consequences of alternative policy actions, and it also represents a counter-example to the assertion that the conclusions of the older demographic approach are robust.

A detailed, spatially explicit model does not support the premise that the population is declining or that it can increase. The model develops a picture, instead, of a healthy stable population fully utilizing its current range.

CONCLUSIONS

The five factors that must be evaluated in a decision to list or delist a species are

1. the present or threatened destruction, modification, or curtailment of its habitat or range;

2. overutilization for commercial, recreational, scientific, or educational purposes;

3. disease or predation;

4. the inadequacy of existing regulatory mechanisms; or

5. other natural or manmade factors affecting its continued existence (50 C.F.R. § 424.11(c)).

We evaluate these factors for the northern spotted owl in California as follows:

1. <u>The present or threatened destruction, modification, or curtailment of its habitat or range</u>

   What can be said about the availability of habitat for this species? The northern spotted owl is a species of the coniferous forest. The conversion of land from forests to agricultural and other uses in the nineteenth century undoubtedly reduced the available habitat. As commercial forestry arose, this tendency to convert land diminished. We do not anticipate a significant change in the acreage of coniferous forest in northern California in the foreseeable future. The shifting of old growth forests on private land to second growth is all but complete, with no measurable consequences for the northern spotted owl. Past practices on the four national forests in the northern spotted owl's range, in combination with the current policy to minimize clearcutting, make it unlikely that any reduction in northern spotted owl habitat will occur. All of this suggests that available habitat for the northern spotted owl is not being reduced or even threatened.

   The facts that federal, state, and private definitions of northern spotted owl habitat in California are similar, if not identical, and that owls flourish in managed forest land strongly suggest that owl habitat is not undergoing fragmentation throughout the majority of the Klamath Province. The range of the northern spotted owl becomes patchy only at its extreme southern and eastern boundaries. Since the coniferous forest also becomes patchy at these boundaries, for ecological reasons, this pattern in the owl's distribution should be considered normal. Given the demonstrated compatibility of the northern spotted owl with commercial forestry as practiced in California, we see no special concerns for maintaining genetic linkage with the California spotted owl population in the Sierras.

2. <u>Overutilization for commercial, recreational, scientific, or educational purposes</u>

   This is not an important concern with this species.

3. Disease or predation

Any wildlife species runs a gantlet of threats to its survival. The critical question is whether disease and predation pose threats to the continued maintenance of the population. We see no evidence of this.

4. The inadequacy of existing regulatory mechanisms

California's forest practices rules are the strictest in the nation. A careful reading of these rules and federal regulations suggests that the amount of suitable forest habitat on both ownerships will increase, not decrease, in the future.

5. Other natural or manmade factors affecting its continued existence

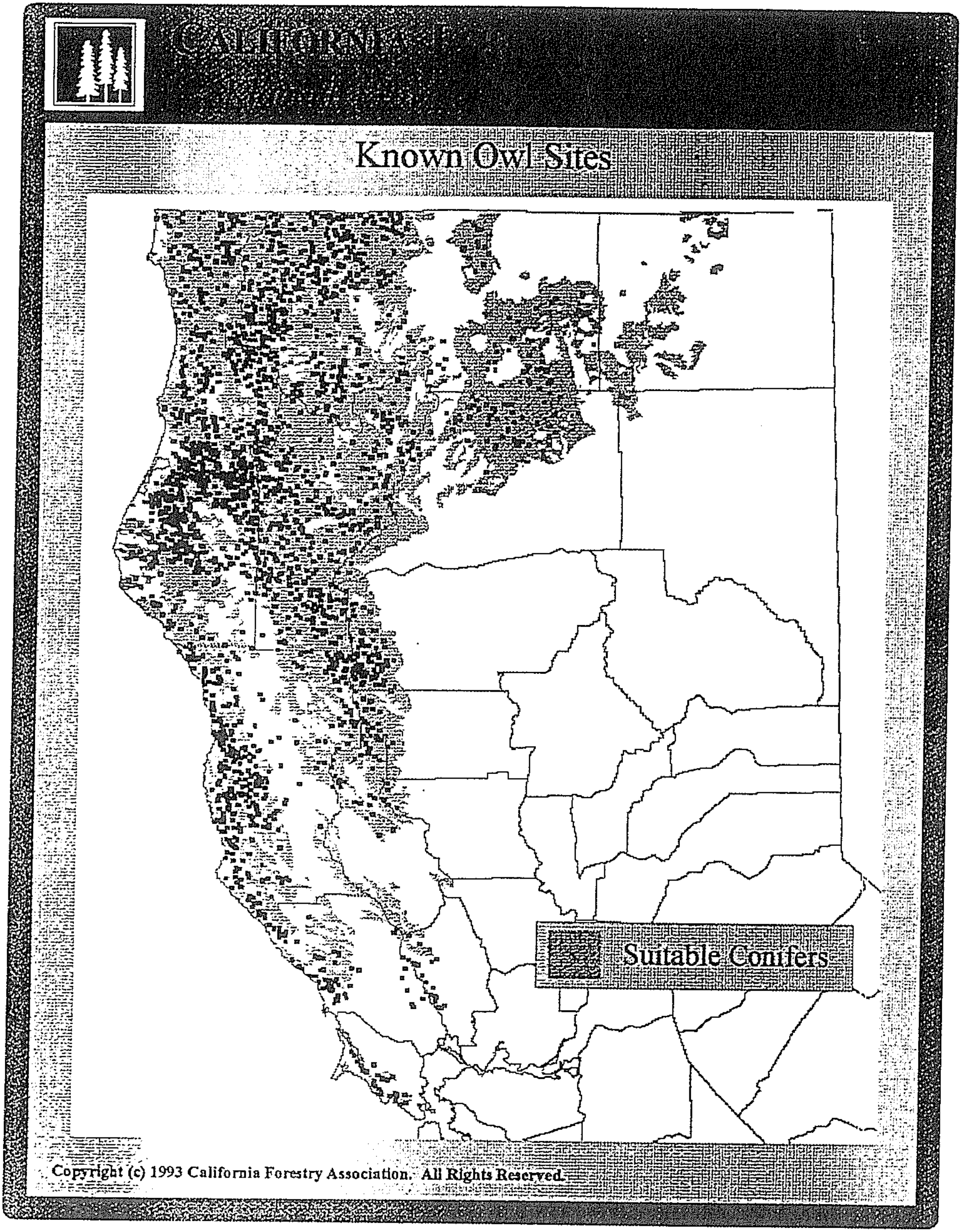
The primary local threat to the northern spotted owl's existence is the wholesale destruction of the coniferous forest by wildfire, insects, and disease. The risks of these destructive forces should be diminished by responsible forest management. We call it a local threat because it is extraordinarily unlikely that the interval between catastrophic events will ever be so short as to reduce to unsuitable a substantial fraction of the habitat in the Klamath Province.

In summary, the Klamath Province of California is not losing northern spotted owl habitat. The population of northern spotted owls is large and stable. It cannot increase beyond its current level because owls do not tolerate crowding. Nothing needs to be done by the federal government to ensure that this subspecies will not be a candidate for threatened status for the foreseeable future. For these reasons, we respectfully submit this petition to the U.S. Fish and Wildlife Service to remove the northern spotted owl (Strix occidentalis caurina) in California from the list of threatened species.

William N. Dennison

William N. Dennison, President

FIGURE 1


Known Owl Sites
Suitable Conifers
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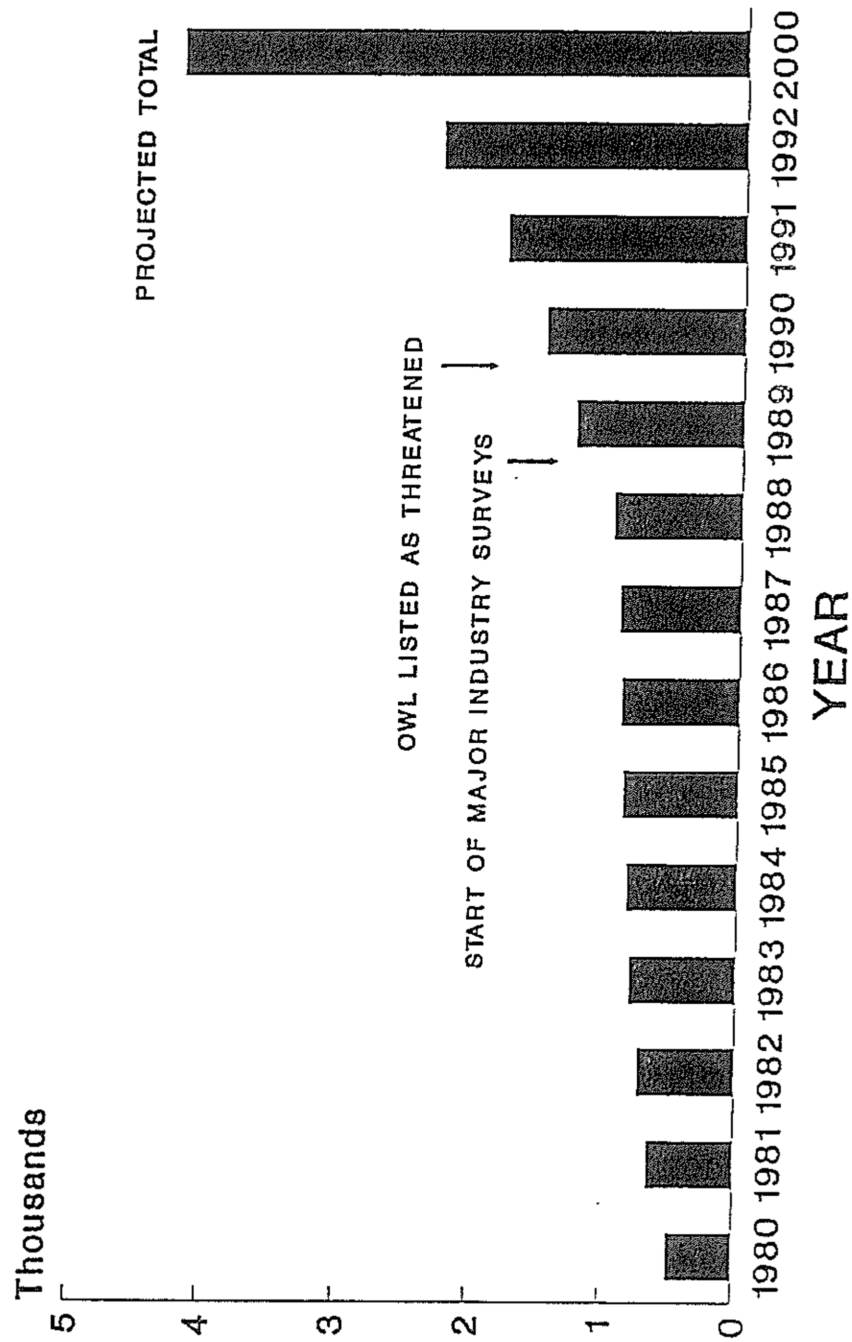
NORTHERN SPOTTED OWL TERRITORIES DISCOVERED IN CALIFORNIA



50% to 60% of suitable forest land in California has been surveyed.

Recovery Plan for the Northern Spotted Owl - DRAFT

April, 1992

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Secretary of the Interior

Donald R. Knowles
Secretary's Representative, Team Coordinator

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Craig Partridge; Nancy Pollot; Fred Seavey, Raul Tuazon.

This recovery plan is not intended to provide precise details on all aspects of northern spotted owl management. The recovery plan outlines steps necessary to bring about recovery of the species. The recovery plan is not a "decision document" as defined by the National Environmental Policy Act (NEPA). It does not allocate resources on public lands. The implementation of the recovery plan is the responsibility of federal and state management agencies in areas where the species occurs. Implementation is done through incorporation of appropriate portions of the recovery plan in agency decision documents such as forest plans, park management plans, and state game management plans. Such documents are then subject to the NEPA process of public review and selection of alternatives.

Management Guidelines for Federal Forestlands Outside Designated Conservation Areas

The draft recovery plan recommends guidelines for the maintenance of sufficient habitat conditions on federal lands outside DCAs to allow dispersal of owls among DCAs. Movement among DCAs is necessary to maintain population levels and prevent genetic deterioration of the population. These guidelines also contain several recommendations for supplementing the DCA network in specific parts of the owl's range where conditions currently do not allow full implementation of the DCA network guidelines. This would be done by providing habitat for additional owl pairs and territorial single owls outside DCAs. In some areas, the draft recovery plan recommends management of these areas to reduce the risk of fire and insect damage. In total, these matrix areas in combination with the DCAs will provide for approximately 1,300 currently known pairs of owls on federal lands. This represents about 53 percent of all pairs currently known to occur on federal lands.

Suggestions for Management of Nonfederal Forestlands

The draft recovery plan relies first on federal lands for recovery of northern spotted owls. However, it also recognizes the role of nonfederal lands in recovery, particularly in areas where federal lands are not adequate to fully achieve the recovery objective. The recovery plan recommends specific contributions from nonfederal lands which will complement federal efforts. These recommendations reflect the varied conditions within individual provinces, the authorities of the three states involved, and the potential for enhanced cooperation with the private sector. They provide a framework for development and implementation of creative efforts to help achieve recovery.

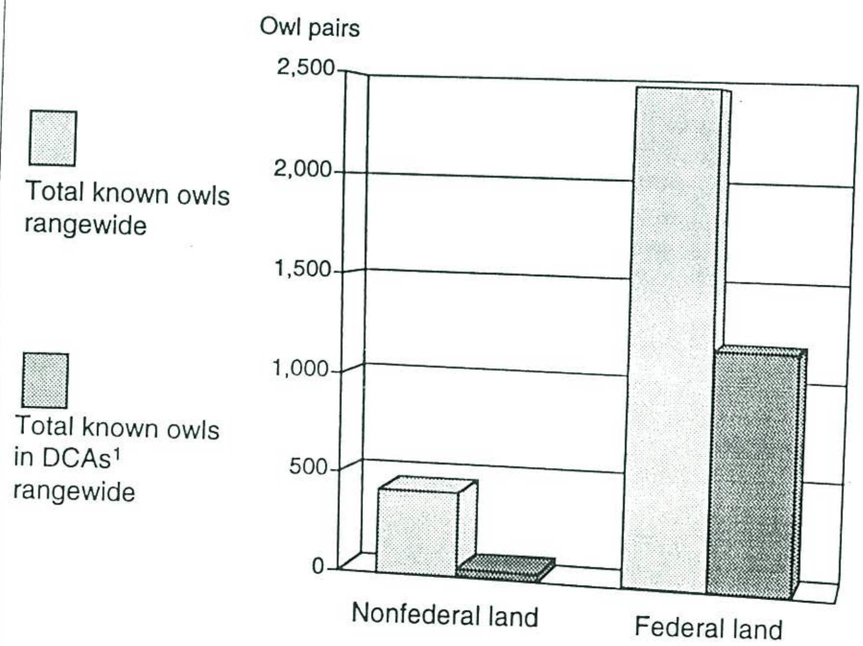

Figure ES.2. Total known owl pairs rangewide and in DCAs.
[1]DCA = designated conservation area.

Delisting Criteria

The primary threat to the northern spotted owl leading to its designation as a threatened species is the reduction and fragmentation of its habitat in forests in Washington, Oregon, and northern California. Northern spotted owls use old-growth forests and other forests with similar characteristics for nesting, breeding, and rearing young. As timber harvesting has proceeded in the Pacific Northwest, the amount of habitat suitable for spotted owls has declined and remaining habitat areas have become smaller and more isolated from each other, particularly during the last 50 years. As a result, the population of spotted owls declined, in some areas rather sharply.

The objective of the draft recovery plan is to reduce the threats to the spotted owl so that it can be removed from the list of threatened species anywhere in its range. The decision to remove the spotted owl from the list of threatened species can be made on an incremental basis for individual areas, called provinces, or for groups of provinces. The range of the spotted owl has been divided into 11 provinces.

Four criteria must be met before delisting is considered: (1) A scientifically credible plan for monitoring owl populations and owl habitat must have been in effect for at least 8 years; (2) the population must have been stable or increasing, as indicated by both density and demographic estimates, for at least 8 years; (3) regulatory mechanisms or land management commitments must have been implemented that provide for adequate protection of breeding, foraging, and dispersal habitat, and (4) analyses must indicate that the population in unlikely to need protection under the Endangered Species Act during the foreseeable future. The draft recovery plan emphasizes that all of these criteria must be satisfied before delisting is considered.

Designated Conservation Areas

As the primary means for achieving recovery, the draft plan recommends establishing 196 designated conservation areas (DCAs) to provide approximately 7.5 million acres of federal forestland as the primary habitat for the northern spotted owl population. These DCAs include approximately 48 percent of the total remaining spotted owl nesting, roosting, and foraging habitat on federal lands (Figure ES.1.). The largest DCAs are designed to support a population of 20 or more pairs of owls in habitat conditions that allow successful breeding and rearing of young. They are located to allow owls to disperse from one DCA to another. Each DCA contains areas of currently existing owl habitat combined with areas of younger forests. These younger stands will be protected so they can mature into owl habitat. The DCAs contain approximately 1,180 known owl pairs on federal lands. This represents about 48 percent of the total pairs currently known on all federal lands (Figure ES.2.). When the DCAs become fully developed owl habitat, they will support a population of approximately 2,320 pairs of owls.

DCAs are located to take advantage of other forestland containing owl habitat that will not be harvested or will be harvested in a manner that does not reduce habitat value. Such areas include parks, wilderness areas, and certain administratively reserved areas. DCAs also are located in a pattern to reduce the risk to the owl population from natural threats such as fire, disease, and insects.

A Conservation Strategy for the Northern Spotted Owl

Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl

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Summary

The Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl (hereafter the Committee) was established under the authority of an interagency agreement between the, USDA Forest Service, USDI Bureau of Land Management, USDI Fish and Wildlife Service, and USDI National Park Service. The Committee's charter was signed by the agency heads and subsequently incorporated into Section 318 of Public Law 101-121 in October 1989. The Committee was asked to develop a scientifically credible conservation strategy for the northern spotted owl in the United States.

Since that time, the Committee has reviewed the literature on the northern spotted owl, heard presentations from most of the scientists doing research on spotted owls, considered the concerns of numerous interest groups, and conducted field trips in Washington, Oregon, and northern California to examine the owl's habitat. We have also interviewed dozens of biologists and land managers.

Much of the attention directed toward this bird stems from a growing debate over managing old-growth forests on Federal lands, and from a concern about protecting biodiversity. We understand the significance of these larger issues, but we have kept to our mandate to develop a conservation strategy specifically for the northern spotted owl.

We have concluded that the owl is imperiled over significant portions of its range because of continuing losses of habitat from logging and natural disturbances. Current management strategies are inadequate to ensure its viability. Moreover, in some portions of the owl's range, few options for managing habitat remain open, and available alternatives are steadily declining throughout the bird's range. For these reasons, delay in implementing a conservation strategy cannot be justified on the basis of inadequate knowledge.

Owl Habitat and Population Trends

The Committee reviewed all available studies dealing with spotted owl habitat, the relative abundance of owls related to stand age, and the relative abundance of owls in relation to various proportions of successional growth stages in the general landscape.

Habitats selected by northern spotted owls typically exhibit moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; a high incidence of large trees with large cavities, broken tops, and other indications of decadence; numerous large snags; heavy accumulations of logs and other woody debris on the forest floor; and considerable open space within and beneath the canopy. These attributes are usually found in old growth, but they are sometimes found in younger forests, especially those that contain remnant large trees or patches of large trees from earlier stands. In younger forests that support breeding owls, the nest and major roost sites are usually found where large trees from the earlier, older stands remain.

We evaluated the coastal redwood forests of northwestern California, where numerous owls live in stands that are mostly 50 to 80 years old. We believe their presence is attributable to the region's unique set of conditions, including a rapidly growing tree species that sprouts from stumps; intrusion of other conifer and hardwood species into the understory; relatively high rainfall; a long growing season; and abundant prey. Under these conditions, the structural attributes that are usually associated with the presence of owls develop at an accelerated rate. We caution strongly against extrapolating these results to other parts of the owl's range.

Silvicultural prescriptions might be developed that would yield significant volumes of wood products while maintaining suitable habitat for spotted owls, but we find no clear evidence that such prescriptions currently exist. Until they do, the prudent approach to ensuring the viability of the owl is to protect an adequate distribution and amount of existing habitat. Nonetheless, examining younger forests where spotted owls reproduce successfully should yield valuable insights into silvicultural techniques that could produce both wood products and owls.

For at least the past century, loss of spotted owl habitat has exceeded recruitment. By some estimates (perhaps conservative), spotted owl habitat has been reduced by about 60% since 1800. The current total population of the owl is likely to be far less than once existed. The loss of habitat has not been distributed evenly across the range of the subspecies.

Owl habitat is also being fragmented, a process that isolates some populations of owls. Fragmentation in the home ranges of individual birds may expose owls to greater risks of predation and competition. It may also result in habitat loss when trees blow down in high winds, and as stands suffer other impacts associated with forest edges.

Determining the number of northern spotted owls in existence has drawn considerable attention. Current data do not permit a statistically reliable population estimate. The approximately 2000 pairs located during the past 5 years or reconfirmed from pre-1985 surveys represent an unknown fraction of the total population. More significantly, demographic studies from the Klamath Mountains in California and the Coast Range in Oregon indicate that populations in these study areas are declining.

The Conservation Strategy

We propose a two-part conservation strategy. The first stage, prescribes and implements the steps needed to protect habitat in amounts and distribution that will adequately ensure the owl's long-term survival. The second stage calls for research and monitoring to test the adequacy of the strategy and to seek ways to produce and sustain suitable owl habitat in managed forests. Insights gained in this second stage can be used to alter or replace habitat conservation areas prescribed in the first stage, but only if the modified strategy can be clearly demonstrated to provide adequately for the long-term viability of the owl.

Our strategy largely abandons the current and, we believe, flawed system of one- to three-pair spotted owl habitat areas (SOHAs), in favor of protecting larger blocks of habitat—which we term Habitat Conservation Areas, or HCAs.

Large blocks of habitat capable of supporting multiple pairs of owls, and spaced closely enough to facilitate dispersal between blocks, are far more likely to ensure a viable population than the current SOHA system. Owls in an HCA containing multiple pairs will benefit from internal dispersal of juvenile owls as well as recruitment of dispersing birds from other HCAs. Owls in HCAs containing multiple pairs are less vulnerable to random fluctuations in birth and death rates. Large HCAs reduce the impacts of habitat fragmentation and edges, and they are more resistant than SOHAs to small-scale natural disturbances.

The Committee has delineated and mapped a network of HCAs necessary to ensure a viable, well-distributed population of owls. Wherever possible, each HCA contains a minimum of 20 pairs of owls. The maximum distance between these HCAs is 12 miles. Our 20-pair criterion is based on models of population persistence and empirical studies of bird populations. We have chosen 12 miles as the maximum distance between HCAs because this value is within the known dispersal distance of about two-thirds of all radio-marked juveniles studied.

The HCA concept applies primarily to BLM, FS, and NPS lands, as delineated in the enclosed maps. The Committee strongly recommends that HCAs be established on State lands in certain key areas (as shown on the maps) to assure population connectivity. We also recommend that resource managers of other State lands, tribal lands, other Federal lands, and private lands use forestry and silvicultural techniques and practices that maintain or enhance habitat characteristics associated with spotted owls.

In several regions, current habitat conditions and owl densities do not allow us to follow this approach. The Committee has modified the guidelines for these regions. For example, in portions of the Oregon Coast Range, habitat is currently insufficient to fully stock 20-pair HCAs with owls. We have delineated 20-pair HCAs for this area, but they will be not be capable of supporting 20 pairs of owls for many years. In the meantime, individual-pair HCAs are prescribed around all known or future pairs to reach the 20-pair target.

A variety of strategies was used in other areas of special concern to help meet the intent of this strategy. Portions of the Cascade Range of northern Washington contain insufficient habitat capable of supporting 20-pair HCAs over the long term because of inherent landscape patterns. In these areas, we delineated a network of smaller HCAs but shortened the maximum distance between them to 7 miles, to facilitate dispersal.

In portions of the eastern Cascade Range in Washington and Oregon, and northeast of Mount Shasta in California, relatively little owl habitat exists and spotted owls occur at low densities. We prescribe individual-pair HCAs around all known pairs and pairs located in the future.

Spotted owls on the Olympic Peninsula are probably demographically isolated from other populations by more than 60 miles of intensively managed State and private forest lands. We have established a large HCA on National Forest lands, but we also prescribe individual-pair HCAs around all known pairs outside the HCA and recommend smaller HCAs for State lands. Our hope is that connectivity can be restored by using a combination of HCAs and applying innovative silvicultural techniques on State and private lands.

Land ownership patterns in the Coast Range of California limit our ability to establish 20-pair HCAs. We have tried to do so wherever possible, but we encourage California to work with private land owners to apply innovative silvicultural techniques to maintain or develop additional owl habitat for dispersal and breeding. We encourage Oregon and Washington to do the same.

Logging (including salvage operations) and other silvicultural activities (with the exception of stand regeneration) should cease within HCAs. The Committee recognizes that allowances will have to be made for timber sales already planned and under contract in HCAs, such as sales necessary to meet Section 318 of Public Law 101-121.

We considered dedicating corridors of forests between HCAs to facilitate dispersal by juvenile owls, but decided corridors were unnecessary, provided at least 50% of the forest landbase outside of HCAs is maintained in stands of timber with an average d.b.h. of 11 inches or greater and at least 40% canopy closure. We also rely on lands currently allocated to such uses as riparian corridors, streamside management zones, and special management areas for pileated woodpeckers and pine martens to provide additional habitat for dispersing spotted owls.

We recommend retaining at least 80 acres of suitable owl habitat around the activity centers of all known pairs of owls in the managed forest, up to a total of seven per township. These centers will serve as older forest nuclei that could become core areas for future breeding pairs of spotted owls as the surrounding forest matures. If healthy populations of northern spotted owls can be sustained in the managed forest, HCAs will no longer be necessary. Timber harvests that affect owl pairs outside the conservation areas are therefore viewed as experiments in managing for spotted owl habitat.

Consequences for the Northern Spotted Owl

The Committee believes this conservation strategy, if faithfully implemented, has a high probability of retaining a viable, well-distributed population of northern spotted owls over the next 100 years. The HCAs on Federal lands contain 925 known pairs of owls, and we estimate the actual number to be about 1465 pairs. Regeneration of younger stands within HCAs on Federal lands should enable the spotted owl population to increase to about 1759 pairs. These numbers are important, but only up to a point; the amount and spacing of habitat are as critical to the viability of the subspecies as the actual numbers.

Under a worst-case scenario, even with this conservation strategy fully implemented, a short-term loss of a significant portion of the existing population of northern spotted owls is likely. We do not take this loss lightly, but we believe the subspecies can withstand a reduction provided our strategy is followed. Even under the most stringent scenarios of habitat protection, a similar reduction in the number of existing pairs over time seems likely because many pairs of owls live in highly fragmented and marginal habitats isolated from other pairs.

Implementing the Conservation Strategy

Implementing a comprehensive strategy for the spotted owl requires a well-coordinated program of research, monitoring, and habitat management by State and Federal agencies and private landowners. Much room for improvement exists. So far as we can determine, for example, no plans have been made within or among agencies to determine what changes in population size or habitat conditions would trigger a review of, and possible changes in management actions needed to ensure the welfare of the owl.

Assessment of Impacts

We urge that a coordinator and interagency staff (State and Federal) be assigned to oversee the conduct of the conservation strategy. The coordinating group would have the additional duty of recommending alterations to our conservation strategy. The plan put together by our Committee, however, is a strategy for the entire U.S. range of the northern spotted owl. No part of the strategy was designed to stand alone, and proposed changes must be considered in that light.

Our assignment was to develop a scientifically credible conservation strategy for the northern spotted owl. We recognize that the impacts of the strategy we propose will be analyzed by others. The immediate response, we expect, will be to focus almost solely on the short-term economic and social impacts of implementing the strategy as it affects the availability of timber. This assessment is critically important. Adoption of the conservation strategy, however, has significant ramifications for other natural resources, including water quality, fisheries, soils, stream flows, wildlife, biodiversity, and outdoor recreation. All of these aspects must be considered when evaluating the conservation strategy. The issue is more complex than spotted owls and timber supply—it always has been.

Appendix C: Current Situation

Over 90% of the known pairs of owls have been observed on federally managed lands—68% on FS lands and 22% on BLM lands. The distribution of these pairs varies widely by land ownership, State, and physiographic province (see table C1). Distribution is particularly important in California, where up to 40% of the habitat could occur on private lands. Although inventories are less complete in California, about 30% of the habitat and population of spotted owls may occur in the Coast Range (Gould, pers. comm.; Self, pers. comm.).

Observations of spotted owl pairs have accumulated for almost 20 years. These counts have been cumulatively tallied over this period as additional and more intensive surveys have been done, particularly in the past 3 years. Censusing is not complete because not all suitable habitat has been fully surveyed. In addition, counts have not accounted for differing inventory intensities, sites lost through habitat reduction or conversion, loss and recolonization of sites by new or displaced pairs, new sites found through recent inventories, or double counting the same pairs in different sites. This type of information is not a good indicator of true population size or trend.

Cumulative numbers of owl pairs observed over their range during the past 5 years (table C1) include estimates of both breeding and nonbreeding pairs. The past 5-year period (1985 to 1989) was chosen because we consider it to be a more reliable estimate of actual numbers than a longer cumulative period or any single-year count, given the current habitat situation. It is the period with the most intense inventories, and it is within the average life span of the species (about 8 years), so it should provide a reasonable balance between how recent habitat loss has affected owl survival and occupancy of sites, and an attempt to report a correct count of pairs, given some of the problems noted above.

A total population estimate was not made. Data from the inventories done during the 5-year period indicate a total of about 2000 known pairs of spotted owls in Washington, Oregon, and northern California. This number is a minimum estimate of the true population size. We suspect the true number lies somewhere between 3000 and 4000 pairs.

Population size is primarily a function of the total amount, distribution, and suitability of habitat available to sustain successfully reproducing owl pairs through time. Present analyses indicate that the population of spotted owls is declining because of habitat loss and modification, and the rate is similar to the decline of suitable habitat (see appendix L).

Table C1—Estimated spotted owl habitat and number of pairs of spotted owls located in the last 5 years on all lands in Washington, Oregon, and California (NA = reliable estimates not available)

Land owner or agency[a]	Estimated acres of spotted owl habitat timber capability				Owl pairs		
	Reserved[b]	Unsuitable[c]	Suitable	Total acres	Reproducing	Not reproducing	Total
FS, WA	433,000	384,000	818,000	1,635,000	166	151	317
FS, OR	438,000	241,000	1,909,000	2,588,000	274	393	667
FS, CA	151,000	209,000	474,000	834,000	169	234	403
BLM, WA	NA	NA	NA	—	—	—	—
BLM, OR	158,000[d]	—	701,000	859,000	224	207	431
BLM, CA	13,000	—	6,000	19,000	7	7	14
NPS, WA	480,000	0	0	480,000	10	10	20
NPS, OR	50,000	0	0	50,000	2	3	5
NPS, CA	40,000	0	0	40,000	1	2	3
Tribal lands, WA	42,000	NA	24,000	66,000	2	3	5
Tribal lands, OR	NA	NA	NA	54,000[e]	1	0	1
Tribal lands, CA	NA	NA	NA	NA	NA	NA	NA
FWS, WA	1,700	NA	5,000	6,700	0	1	1
FWS, OR	4,100	NA	NA	4,100	0	0	0
WDNR, WA	NA	NA	NA	NA	4	9	13
WDW, WA	0	NA	5,000	5,000	0	0	0
State Parks, WA	2,000	0	0	2,000	0	0	0
Cities of Seattle, Tacoma	0	0	1,500[f]	1,500	0	0	0
ODF	2,000	NA	78,000	80,000	1	2	3
State Parks, OR	8,000	0	0	8,000	1	0	1
Counties and cities, OR	NA	NA	NA	NA	1	0	1
CDF	NA	NA	NA	NA	0	3	3
State Parks, CA	56,000	0	0	56,000	5	3	8
State Lands Comm., CA	NA	NA	NA	NA	NA	NA	NA
BLM/TNC, CA	6,500	0	0	6,500	0	2	2
NAS, CA	600	0	0	600	0	1	1
Private, CA	NA	NA	NA	NA	36	63	99
Private, OR	NA	NA	NA	NA	NA	NA	20
Private, WA	NA	NA	NA	NA	2	2	4
Totals	1,885,900	834,000	4,021,500	6,795,400	906	1,096	2,022

[a] See text for sources of above information.
[b] Withdrawn from timber harvest (that is, Wilderness and Research Natural Areas).
[c] Lands unsuited for timber production because of allocation to other uses by land management plans, or technically unsuited for timber production because of soils problems or difficulty of regeneration.