California Department of Fish and Wildlife

Conservation Plan for Gray Wolves in California
Part II

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Charlton H. Bonham, Director

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CHAPTER 1 WOLF LIFE HISTORY AND BACKGROUND

A. Wolf Biology and Ecology

Physical Characteristics

The gray wolf is the largest wild member of the dog family (*Canidae*). Depending upon subspecies, the range of sizes in both sexes is widely variable. Throughout their range, female adult gray wolves weigh from 40 to 120 pounds (18 to 55 kg), and measure from 4.5 to 6 feet (1.37 to 1.52 m) in total length. Adult males, which are generally slightly heavier and larger than females, vary in weight from 45 to 175 pounds (20 to 80 kg) and in total length from 5 to 6.5 feet (1.27 to 1.64 m). Shoulder height ranges from 27 to 32 inches (700 to 800 mm) (Mech 1974; Paradiso and Nowak 1982). Typical weights for adult female gray wolves in Montana are 80 to 100 pounds, and for adult males are 90 to 110 pounds (Smith et al. 2000).

As with all canids, wolves' feet are digitigrade, such that when they walk only the toes touch the ground. The forefoot has five toes, the first of which is reduced to a well-developed dewclaw, and the hind foot has four toes. Because the claws are non-retractable they are usually visible in wolves' tracks (Paquet and Carbyn 2003). Front foot tracks from wolves in Alaska, Minnesota, and Nova Scotia averaged 5.0 inches (116.7 mm) in length (Harris and Ream 1983).

The fur of gray wolves is most often grizzled gray, but varies from white to coal black (Young 1944). Coloration of gray and black wolves may lighten over time to a silver or silvery-gray due to age, physiological stress, and genetics (Gipson et al. 2002). Long, coarse guard hairs measuring approximately 2.4 to 3.9 inches (60 to 100 mm) long overlay a short, thick undercoat. Wolves tend to molt over a long period during late spring when the previous year's coat is shed at the same time that the new coat is growing in (Paquet and Carbyn 2003).

Similar Species

The coyote is typically smaller than the gray wolf, but in some locations there may be slight overlap in overall size (Bekoff 1977). Gray wolves on average weigh about twice as much as coyotes (Dixon 1916). Wolf facial features are generally less "pointed" than those of coyotes: their ears are relatively shorter and more rounded, their muzzles are broader (Young 1944), and their nose pad is larger (Bekoff 1977). Paradiso and Nowak (1971) compared *C. lupus*, *C. rufus*, and *C. latrans* skull measurements, and found no overlap in zygomatic breadth, greatest length of skull, or bite ratio between the largest coyote and the smallest gray wolf, suggesting that these can be very useful indices for differentiating skulls of the two species (Figure 1.1). Both the track and the stride length of the gray wolf are longer than those of the coyote (Bekoff 1977).

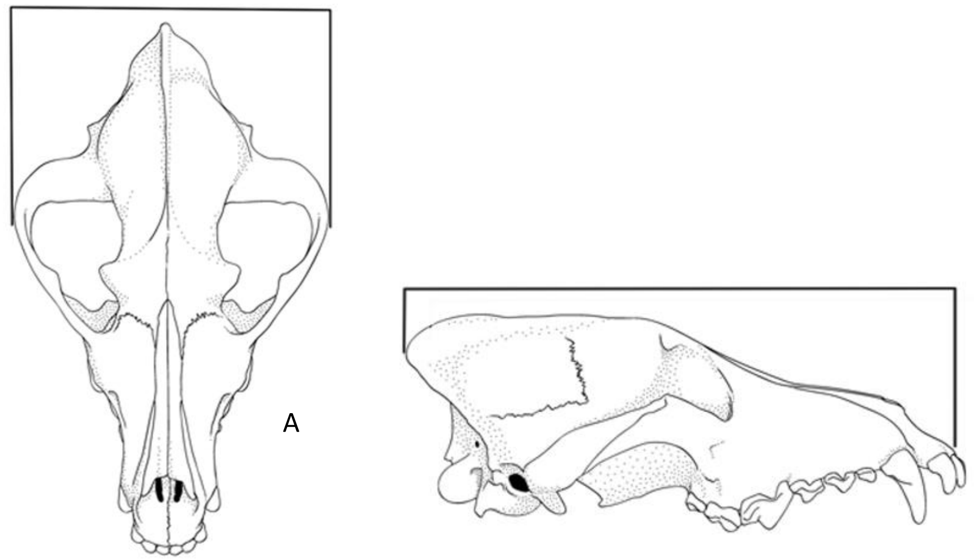

Figure 1.1 Canid skulls displaying zygomatic breadth (A) and greatest length of skull (B) measurements used in species identifications. Both measurements are greater in gray wolf than in coyote. Adapted from Paquet and Carbyn 2003.

As compared to dogs (*C. l. familiaris*) of similar size, wolves have relatively longer legs, larger feet, and a narrower chest (Banfield et al. 1974). The wolf's face is distinct from the dog's due in part to its "mane" – the wide tufts of hair that project out around the ears, neck, and upper back (Mech 1970). In addition, the orbital angle of a wolf skull is 40 to 45 degrees, as compared to 53 to 60 degrees in dogs, which explains the broader head shape in wolves (Figure 1.2) (Mech 1974). Compared to dog tracks, wolf tracks are generally more elongated, and the two front toes tend to be held closer together and have more prominent toenail marks (Young 1944). In contrast to many domestic dogs, wolves have straight tails that do not curl up over the back; a wolf tends to carry its tail slightly below the level of the back, though this varies when at play or frightened (Young 1944).

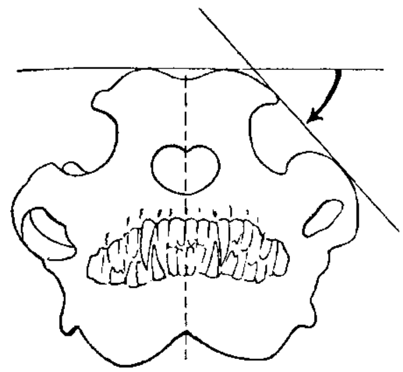

Figure 1.2. Anterior view of wolf skull showing the orbital angle. This measurement is 40° to 45° in wolves as opposed to over 53° in dogs (Iljin 1941). Borrowed from Mech 1974.

Social Ecology

Wolves are social animals. The most fundamental unit in wolf society is the mated pair (Mech and Boitani 2003a). Where wolves occur in low densities, mated pairs tend to be unrelated and monogamous (Smith et al. 1997). Pairs typically form when a male and a female from different packs disperse into a wolf-free area, find each other, and pair up. Where wolf density is high, the chances of establishing a new family is low, since areas containing suitable habitat may be saturated (Packard and Mech 1980).

Mech and Boitani (2003a) define a wolf pack as "some variation on a mated pair." The most typical pack is comprised of the mated pair associated with one or more generations of their offspring. Offspring have been recorded remaining with their parents for one to four years (Gese and Mech 1991; Mech et al. 1998). In the typical wolf pack, the mated pair and their previous years' offspring deliver food to pups, defend them from intruders, and otherwise attend to them (Packard et al. 1992). Pack social structure is generally adaptable and resilient. Breeding members can be replaced from within or outside the pack, and pups can be reared by another pack member should they become orphaned (Packard 2003; Brainerd et al. 2008). In rare cases more than one female in a pack has produced pups, especially after the death of one or both of the original breeding pair (Packard et al. 1983).

A possible explanation for why wolves live in packs is the variation in time to reproductive maturity of young wolves. While some are capable of reproduction as early as 10 months old, many are not completely mature until as late as five years old (Mech and Boitani 2003a). By remaining with their parents for a longer time, maturing wolves benefit by learning hunting and pup-rearing strategies they may not learn on their own. Parents benefit from, among other things, the potential increase in survival of their young into which they have both energetic and genetic investments (Eaton 1970; Peterson et al. 1984).

Average pack size can vary from three to 11 animals but much larger packs sometimes occur (Fuller et al. 2003; USFWS 2003). Ecological theory states that carnivore pack size should vary with prey body mass up to some optimal number that provides the greatest energy return for the least energy expended (MacDonald 1983). This relationship can vary when influenced by harvest or other control measures. Pack size is largest just after pups are born in spring. Through summer, as some pups and adults die, pack size declines. Adult mortality peaks in fall and winter, coinciding with major dispersal, thus further diminishing pack size (Fuller et al. 2003). However during this time, some packs gain new members by picking up "adoptees," young, typically male wolves that are unexplainably permitted to remain for days, weeks, or even months (Mech and Boitani 2003a). Many of these are from the pool of "lone wolves," non-residents in a population that are either temporarily or permanently dispersed from their packs (Fuller et al. 2003). Packs are smallest in early spring, just before litters are born, so this is the most appropriate time to estimate minimum population size (M. Jimenez, pers. comm.).

Communication

Wolves use vocalizations, scents, and visual forms of communication. From birth, wolf pups moan, scream, squeal, yelp, whine, and bark in competition with their littermates, and to elicit a response from their mother. As they mature their vocalizations change to incorporate more adult-like sounds. Most wolf vocalizations are used at close range in conjunction with other forms of communication, thus allowing for subtle differences in meaning. The principle form of long-distance vocalization is the howl. Wolves use both solo and chorus howling, but the functions of each remain speculative (Harrington and Asa 2003). Wolves are believed to howl to reinforce social bonds within the pack, sound alarm, locate pack members, and warn other wolves to stay out of their territory (Paquet and Carbyn 2003).

Smell is probably a wolf's most acute sense. Sources of odor that wolves use in communication with one another include skin glands, feet, ears, anal sacs, saliva, feces, and especially urine. Odors from these sources may provide information on individual identity, gender, breeding condition, social status, and diet. Because scents are relatively long-lasting, they permit wolves to gather and provide information over a longer time period than do vocalizations (Harrington and Asa 2003). Most research agrees that spacing is the primary function of scent-marking by mammals (Ralls 1971; Harrington and Asa 2003). Wolves mark more frequently when they encounter the scents of other wolves (Peters and Mech 1975), which occurs most frequently on the boundaries of territories with other wolves (Mech and Boitani 2003a).

Visual communication between wolves occurs through changes in facial features, tail position, and body posture (Schenkel 1947; Fox and Cohen 1977). Aggressive or assertive posturing is characterized by high body posture, raised hackles, stiff legs, slow, deliberate movements, and often bared teeth. Submissive posturing includes reducing one's apparent size by carrying the body low, sleeking the fur, and lowering the ears and tail (Harrington and Asa 2003).

Territories

Wolf packs live within territories that they defend from other wolves. In areas with a well-established wolf population, a mosaic of territories occurs. Packs compete with their neighbors for space and resources through widespread, regular travel, during which they scent-mark as a means of maintaining their territorial boundaries. Howling at specific locations serves to reinforce these scent-marks (Mech and Boitani 2003a).

Territory size is a function of interdependent factors. Wolf pack size; prey size, abundance, migration patterns, and vulnerability[1]; habitat type; and latitude are all factors that have been recognized as influencing the size of wolf territories (Mech and Boitani 2003a). The smallest recorded territory was 13 m^2 (34 km^2) in northeastern Minnesota, defended by a pack of six wolves (Mech and Tracy 2004). The largest territory on record, defended by a pack of 10, was 2,450 m^2 (6,272 km^2) in Alaska (Mech and Boitani 2003a from Burkholder 1959). Wolf territories in the Northern Rocky Mountains population (NRM) typically range from 200 to 400 m^2 (322 to 644 km^2; USFWS 2003).

Wolf territories are not stable configurations of a pack's home range. In saturated populations, packs are in constant competition with their neighbors at territorial borders, and those borders therefore shift. In areas of newly colonizing wolf populations, this shifting is accentuated (Mech and Boitani 2003a). Newly colonizing regions saw packs shift their territories over large areas. One pack in Montana, unconstrained because of a lack of neighbors, shifted the core of its territory 30 miles (50 km) south (Ream et al. 1991). In these newly colonizing areas territories tend to be exclusive initially, but may overlap with other territories as the region becomes saturated (Hayes 1995). In general, as areas become saturated with wolf territories, the boundaries may shift but the cores tend to remain approximately the same (Mech and Boitani 2003a). In some areas wolf prey is migratory so wolves must also migrate. For example, elk or moose (*Alces alces*) may spend the summer in the high country, migrating to lower elevations for the winter, in which case wolf packs remain territorial, simply shifting their territories to match their prey's movements (Cowan 1947; Carbyn 1974; Ballard et al. 1997; Ream et al. 1991). In Algonquin Provincial Park, where white-tailed deer are the preferred winter prey, wolves made numerous extraterritorial excursions and migrations following deer (Cook et al. 1999).

[1] Prey vulnerability is influenced by many factors, including a prey animal's age, the ruggedness of the terrain, and weather and other habitat conditions that affect the health of prey.

Intraterritorial Movements

The two primary functions of wolf travel within the territory are foraging and territory maintenance (i.e. boundary maintenance via scent-marking), of which they apparently do both simultaneously (Mech and Boitani 2003a). Wolves tend to use well-established trails, sometimes referred to as “runways” (Young 1944), and travel in single-file, especially in deep snow (Mech and Boitani 2003a). Within-territory movements differ between pup-rearing season and the rest of the year (Mech et al. 1998). While pups are confined to the den or other rendezvous sites, movements of adults radiate out from and back to that core position (Murie 1944). Once pups are able to travel with the adults, movements become more nomadic throughout the territory (Burkholder 1959; Musiani et al. 1998). Wolves travel over large areas to hunt, and may cover as much as 30 miles in a day (Paquet and Carbyn 2003).

Diet

Wolves belong to a family of carnivores whose members are adapted to feeding on a diverse array of foods. As generalist carnivores, wolves can and do hunt prey that range in size from ground squirrels to bison (*Bison bison*), depending upon season and geographic location (Peterson and Ciucci 2003). In North America, wolves’ winter diet is dominated by ungulates, which are vulnerable to snow accumulation, and juveniles are the most common age class killed (Mech and Peterson 2003). In summer, North American wolves are able to consume a more diverse diet, and are often found to consume beavers (*Castor canadensis*), ground squirrels, coyotes, salmon (*Oncorhynchus* sp.), and to a very small extent, insects and plant matter (Smith 1998; Peterson and Ciucci 2003; Darimont et al. 2004), although ungulates still represent most of the biomass consumed (Ballard et al. 1987; Fuller 1989b).

Based on studies of wolf predation in Alberta, Canada, in mixed-prey complexes wolf predation on deer equaled that of elk (42% each); however, considering the food biomass consumed, elk contributed 56% compared to 20% each for deer and moose (Weaver 1994). In British Columbia, black-tailed deer (*O. h. columbianus*) are the most common prey along coastal areas, and moose constitutes much of wolf prey in the more southern areas (Darimont et al. 2009; Mowat unpublished data, referenced in Wiles et al. 2011). In the northern and central Rocky Mountains, elk are frequently the most important prey of wolves, but deer and moose take precedence in some areas (Huggard 1993; Boyd et al. 1994; Mack and Laudon 1998; Arjo et al. 2002; Husseman et al. 2003; Kunkel et al. 2004; Smith et al. 2004; Atwood et al. 2007). In areas where wolves, humans, and livestock live in close proximity, wolves have been known to kill domestic animals, including sheep, cattle, goats, horses, llamas, livestock guard dogs, and domestic pets (Bangs and Shivik 2001) in addition to their native ungulate prey. Wolf interactions with domestic animals will be discussed in more depth in Chapter 4: *Wolf and Domestic Dog Interactions*, and in Chapter 7: *Effects of Wolves on Livestock and Herding/Guard Dogs*.

Reproduction and Pup Rearing

Most gray wolf packs, even those that include two or more fully adult females, produce only a single litter of pups each year (Harrington et al. 1982; Packard et al. 1983), although some multiple litters have been reported (Murie 1944; Ballard et al. 1987; Mech et al. 1998). Some canids, such as Ethiopian wolves (*Canis simensis*), showed signs of physiological suppression in which dominant females had elevated hormone levels in fecal samples, whereas subordinates had no such increased reproductive hormones (van Kesteren et al. 2013). There is no current evidence that non-breeding adult gray wolf females are physiologically suppressed by the dominant female (Packard et al. 1985). Captive subordinate gray wolves all showed hormonal cycles typical of reproductive individuals (Packard 2003) and therefore were capable of reproduction (Packard et al. 1983, 1985). The failure of reproductively capable but subordinate female gray wolves from producing pups has to date been attributed to social suppression (Packard et al. 1983, 1985) and incest avoidance (Smith et al. 1997). The ability to reproduce physiologically by subordinate females may give them the ability to respond quickly to changes in opportunity should the dominant female in the pack die or lose status (Harrington and Asa 2003), or in years of unusually abundant food (Mech et al. 1998).

All pack members contribute to preparing for pups. Den digging may begin as early as fall (Thiel et al. 1997), and as the pregnancy progresses, provisioning the female becomes an important activity (Fentress and Ryon 1982). Wolf dens tend to be located centrally within the territory to avoid potential hostile encounters with neighboring packs (Ballard and Dau 1983; Fuller 1989a). Den characteristics vary by location and availability of adequate sites, but most tend to be located near water (Mech 1970). A den can occur in a rock crevice, hollow log, or under the roots of trees (Mech et al. 1998). Each home range may contain several dens, each of which may or may not be reused across years (Ballard and Dau 1983; Mech et al. 1998).

The gestation period for wolves is 60-65 days (Seal et al. 1975). Litters average six, with a range of from one to 13 pups (Gavrin and Donaurov 1954; Mech 1970; Hayssen et al. 1993). Pups depend on their mother’s milk for the first month, but are gradually weaned and fed regurgitated meat brought by pack members. As pups age, the adults may move them to alternate locations known as rendezvous sites, where they wait, often accompanied by an adult attendant, while other adult pack members forage (Paquet and Carbyn 2003). As early as four months of age, but more typically at about six months, the pups may begin traveling with the adults on hunts. By seven to eight months, young wolves may be as tall as some adults, but are not as muscular (M. Jimenez, pers. comm.). Most pups disperse from their natal pack between the ages of nine and 36 months (Packard 2003).

Dispersal

Some wolves remain with their natal packs for multiple years, but most eventually disperse. The rare occasions when a young wolf assumes a breeding position in its natal pack is the exception to this rule. Some dispersing wolves conduct temporary forays, returning one to six times before finally dispersing permanently (Fritts and Mech 1981; Van Ballenberghe 1983; Gese and Mech 1991), while others disperse once, never to return (Mech 1987; Mech et al. 1998).

Few differences have been detected between the sexes in terms of dispersal characteristics. In some areas or years, males may disperse farther than females (Pullainen 1965; Peterson et al. 1984), but at other times or locations, females disperse farther (Fritts 1983; Ballard et al. 1987), so the average dispersal distance is about the same for both sexes (Mech and Boitani 2003a). Wolves disperse throughout the year, with fall and spring tending to be the peak periods. Dispersal primarily during these periods suggests that social competition may be a trigger. In spring during pupping, aggression from the breeding adults may be occurring (Rabb et al. 1967; Zimen 1976), and in fall when pups are traveling with adults, food competition may be at its peak (Mech 1970; Mech and Boitani 2003a).

Although the average dispersing distance of NRM wolves is about 60 miles, some animals disperse very long distances. Individual NRM wolves have dispersed more than 550 miles from their natal pack, with actual travel distances, documented through global positioning system (GPS) technology, exceeding 3,000 miles (USFWS et al. 2011). Data suggest that in general, younger wolves disperse farther than older wolves (Wydeven et al. 1995). This is possibly explained by older dispersers having more familiarity with the local terrain, and hence perceiving greater opportunity locally, whereas younger, more naive dispersers wander farther seeking security in areas not already inhabited by hostile wolves (Mech and Boitani 2003a). There is some evidence that when wolves do travel long distances, they move in a manner that seems goal-directed (Mech and Frenzel 1971). Unable to establish a territory locally, the animal may be predisposed to travel in a certain direction for some distance or time before settling where conflict with established wolves is minimized (Mech and Boitani 2003a).

In recent years, dispersing wolves from British Columbia, Montana, and likely Idaho have established packs in Washington, and dispersers from Idaho have established in northeastern Oregon. A radio-collared male wolf from the Imnaha pack in northeastern Oregon dispersed hundreds of miles and entered California in December, 2011. After three years of moving back and forth between Oregon and California, this animal, known as OR7, found a mate and raised litters on a territory in southern Oregon. Other wolves from northeastern Oregon were discovered to have reproduced in California in 2016.

Population Dynamics

Studies of wolf population dynamics are generally concerned with the factors that affect their distribution, density, and population growth rates. Some research (Fuller 1989b, 1995; Fuller et al. 2003) suggests that three key factors affect wolf population dynamics: food, people, and source populations, all of which can influence whether a population increases or decreases. For example, food availability affects wolf nutritional levels and consequently wolf reproduction and survival rates (Mech 1970; Zimen 1976; Packard and Mech 1980; Keith 1983; Mech et al. 1998); human behaviors can result in direct or indirect killing of wolves, which may influence wolf presence and population growth; and source populations are critical to the establishment of new populations, and to the maintenance of harvested or controlled populations (e.g. where humans intentionally keep wolf numbers below some threshold; Fuller et al. 2003).

Wolf populations have the capacity to increase rapidly. Such increase is most notable where wolves have recently colonized, or where they are rebounding after a disease outbreak, or deliberate removal or harvest (Ballard et al. 1987; Boertje et al. 1996; Ballard et al. 1997; Hayes and Harestad 2000a). Oregon's newly colonizing wolf population has increased annually by 37%, on average, since 2011 (ODFW 2012, 2013a, 2014a, 2015, 2016).The wolf population naturally recolonizing the Upper Peninsula of Michigan increased at a mean rate of 19% per year from 1994 through 2007. That growth rate is showing signs of slowing, averaging 12% from 2003-2007, and population estimates have not changed significantly since 2011 (MDNR 2008, 2015).

Distribution and Density

On a large scale, wolves are very adaptable and can occupy any habitat in the Northern Hemisphere, as long as it contains large ungulates. Little correlation to vegetation type has been found, as wolves inhabit deserts, tundra, swamps, forests, prairies, and even barren lands, at all elevations (Fuller et al. 2003).

On a more local scale, wolf distribution is limited by the amount of land that contains enough prey to support at least one pack (Fuller et al 2003). Fuller et al. (2003) suggested that even at the highest prey densities (prey biomass equivalent to 39 deer/mi^2), a pack of four wolves would require a territory of at least 30 mi^2 (75 km^2) to meet its members' nutritional needs, although few territories that small have been recorded. Actual wolf territories with very high prey densities (biomass equivalent of 18-26 deer/mi^2) were measured at 39 to 78 mi^2 (100-200 km^2). In areas with very low prey densities, wolf territories averaged over 386 mi^2 (1,000 km^2; Mech 1988a; Mech et al. 1998).

Wolf densities vary widely. In Alaska and the Yukon it is not uncommon to record population densities as low as five wolves per 386 mi^2 (1,000 km^2) (Meier et al. 1995; Ballard et al. 1987; Hayes and Harestad 2000a, 2000b). At the other extreme, densities on Isle Royale, Michigan reached 92 wolves per 386 mi^2 (1,000 km^2) (Peterson and Page 1983). More commonly, maximum midwinter densities averaged about 24 wolves per 386 mi^2 (1,000 km^2) (see Table 6.2 in Fuller et al. 2003). Based on a large number of studies in North America, many wolf researchers have concluded that the ultimate limit on wolf density is imposed by food availability (Figure 1.3), although this relationship may vary some between migratory versus nonmigratory prey. Cariappa et al. (2011) provided some evidence of naturally occurring populations (in the absence of hunting) that may be limited by density-dependent, intrinsic regulatory mechanisms (e.g., social strife, territoriality, disease) when ungulate densities are high, and by prey availability when ungulate densities are low. However, McRoberts and Mech (2014) reanalyzed the data for this study utilizing weighted as opposed to unweighted regression, and concluded that these data actually provide further support for the hypothesis that wolf density is regulated by prey biomass. The ratio is highest in heavily exploited or newly protected wolf populations (Fritts and Mech 1981; Berg and Kuehn 1982; Peterson et al. 1984; Ballard et al. 1987; Hayes and Harestad 2000a, 2000b). This suggests that newly protected and/or establishing wolf populations have the potential to grow quickly until food becomes limiting (Fuller et al. 2003).

While it is well-documented that wolf density is strongly correlated with prey density, the ratio of wolf/ungulate density may vary through time in a given area, or between areas at the same time (Peterson et al. 1984). As with other cyclic predator-prey systems, wolf densities may lag behind changes in ungulate densities, especially in single-prey systems (McLaren and Peterson 1994). This effect is reduced in multi-prey systems in which wolves can switch to alternative prey (Mech et al. 1998; Garrott et al. 2007). Prey type may also affect wolf densities. Even when comparing areas with similar total prey biomass, wolf territory size has varied, leading to variation in wolf density. This effect may be due to variation in the amount of effort required to successfully capture different prey. If, for example, elk are more difficult to capture than deer, then a wolf pack subsisting primarily on elk may require relatively more biomass then a pack of the same size subsisting on deer, and would therefore require a relatively larger territory (Fuller et al. 2003) leading to regionally lower wolf density.

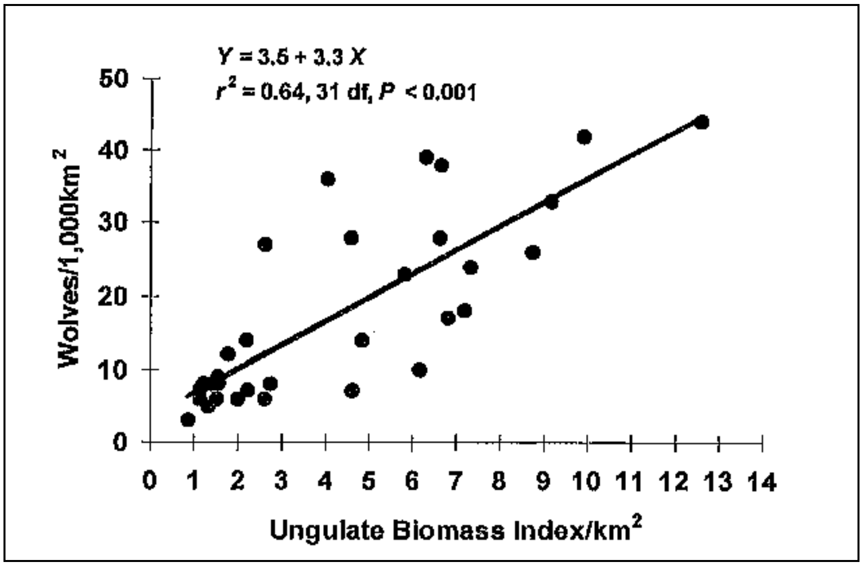

Figure 1.3. Relationship between ungulate biomass index and wolf density, plotted by Fuller et al. (2003), from data in their Table 6.2, as adapted from Keith (1983) and Fuller (1989b).

Reproduction and Pup Survival

Under favorable conditions, female wolves are capable of producing pups every year (Harrington et al. 1982; Packard et al. 1983). On rare occasions, especially when all pack females are young, multiple females may reproduce (Murie 1944; Ballard et al. 1987; Hillis and Mallory 1996). More commonly, in packs with more than two females over two years old, only one female reproduces. A population of larger packs therefore contains a lower proportion of breeders than one with smaller packs. Where wolves are subject to heavy harvest or depredation pressures, their populations may be comprised of more but smaller packs with a relatively higher proportion of breeding females, which may increase the rate of pup production in the population (Peterson et al. 1984; Fuller et al. 2003).

The earliest age at first breeding that has been documented unequivocally for wolves in the wild is two years (Rausch 1967; Peterson et al. 1984) however, some young wolves do not reach reproductive maturity until as late as four years (Mech and Seal 1987; Mech et al. 1998). This range of age at first reproduction can affect rates of population change. For example, in areas with low wolf densities such as in newly recolonized areas, or in areas with heavy wolf control measures in place, and especially when prey is abundant, wolves may reproduce at younger ages (Fuller et al. 2003), potentially increasing the proportion of reproductive animals in the population. Longer reproductive life of females can also affect population growth. Wolves in the wild on average do not live more than four to five years (Fuller et al. 2003), however an 11 year-old female was known to reproduce in the wild (Mech 1988b). In populations with mature, established breeding adults and little or no wolf control, reproductive longevity tends to stabilize population growth.

The single largest age class in a wolf population is the young-of-the-year. Thus, the annual change in pack or population size is most attributable to pup survival. For example in northern Minnesota, annual wolf population change was strongly correlated with the average number of pups per pack the previous year (Fuller 1989b). As with other aspects of wolf population dynamics, litter size and pup survival are attributed to prey availability (Mech 1970; Zimen 1976; Packard and Mech 1980; Keith 1983; Mech et al. 1998). Boertje and Stephenson (1992) found an average 31% increase in litter size with a six fold increase in ungulate biomass per wolf, and summer pup survival almost doubled where per capita ungulate biomass was quadrupled (Ballard et al. 1987; Fuller 1989b). Fall measures are less strongly correlated, likely due to increased pup food requirements and decreased prey supply at that time of year (Van Ballenberghe and Mech 1975; Fuller et al. 2003). Winter pup survival varies, as compared to adult and yearling survival within the same geographic area. Malnutrition was the primary factor in lower winter pup survival as compared to adults, whereas intraspecific strife[2] and human-caused mortality of adults were implicated in higher winter pup survival over older wolves (Ballard et al. 1987; Potvin 1988; Gogan et al. 2000; Mech 1977; Peterson et al. 1984; Fuller 1989b; Hayes et al. 1991).

Immigration

Immigration from reproductively active wolf populations in surrounding areas can be an important element leading to population increases. In areas experiencing intensive wolf controls, dispersing animals from adjacent populations have resupplied breeders which then produce large litters, quickly recolonizing areas where wolves had been previously eradicated (Gasaway et al. 1983; Ballard et al. 1987; Potvin et al. 1992; Hayes and Harestad 2000a).

Mortality

Wolves die from a variety of causes that are classified as either natural- or human-caused. Natural causes of death in wolves can result from starvation; accidents (e.g. avalanche); injuries sustained during traveling, hunting, or territorial conflicts with neighboring wolves; conflicts with other species (e.g. bears); old age; and disease. On Isle Royale, where wolves are protected from human-caused mortality, natural annual mortality averaged 23.5% (± 3.3 SE[3]) (Peterson et al. 1998). In populations where human-caused mortality varied from 4% to 68%, average annual natural mortality varied from 0% to 24% (average = 11% ± 2% SE) (Fuller et al. 2003).

[2] Conflict between members of the same species. In wolves this usually occurs between members of different packs, or between pack members and lone dispersers.
[3] In statistics, the standard error of the mean (SE) provides an estimate of how close the mean of a sample is to the true mean.

Wolves are susceptible to infection by a number of parasitic, viral, and bacterial organisms, none of which appear to have had significant long-term effects on wolf population viability. Internal parasites that have been recorded in wolves include protozoans, trematodes (flukes), cestodes (tapeworms), and nematodes (roundworms). A variety of fleas, ticks, lice, and mites can infest wolves, but probably the most harmful external parasite of wolves is the mange mite *Sarcoptes scabiei*. Chapter 2: *Diseases and Wolves* provide a detailed account of the various infections to which wolves are susceptible.

In the wolf populations of Montana, Idaho, and Wyoming, outside of YNP, human-caused mortality represented 71% to 87% of total wolf mortality between 1979 and 2005 (Mitchell et al. 2008), and 98% of total wolf mortality after the initiation of public harvest in the region (USFWS et al. 2014). Human-caused deaths occur by accident, as in car strikes, or deliberately due to legal and illegal hunting, and control measures to resolve conflicts (Fuller et al. 2003). Many of the human-caused deaths that occur in areas where wolves are protected result from livestock depredations (Fritts et al. 2003). These intentional wolf kills occur legally by government officials or permitted private citizens, as well as illegally by private citizens attempting to protect livestock and pets (Fritts and Mech 1981; Berg and Kuehn 1982; Fuller 1989b). Wolves are also killed from auto and train collisions, unintentionally in traps or snares intended to capture other species, or by mistaking them for coyotes (Berg and Kuehn 1982; Fuller 1989b).

Peterson et al (1984) indicated that human-caused mortality exceeding 30-40% resulted in decreased wolf density on the Kenai National Wildlife Refuge during a five year period, and it was later predicted that newly established and protected wolf populations within Yellowstone National Park (YNP) and central Idaho could increase at rates of 28-35% per year so long as human caused mortality did not exceed this 30—40% amount (USFWS 1994). In actuality these populations increased 22% despite natural mortality and lethal control losses for livestock depredation and/or public safety, during the expansion phase within the NRM (Ed Bangs, pers. comm.). Further, in Montana in 2013, wolves experienced human-caused mortality of 34%, with no change in their population (USFWS 2014).

Habitat Requirements

Wolves have historically occupied diverse habitats in North America, including tundra, forests, grasslands, and deserts (Mech 1970). As a consequence, and because they travel long distances and require large home ranges, wolves are considered habitat generalists (Paquet and Carbyn 2003). Populations, however, may become specialized to the use of local conditions regarding climate, den sites, foraging habitats, geography, and possibly prey selection (Fritts et al. 1995; Mladenoff et al. 1995, 1997, 1999; Callaghan 2002; Mech and Peterson 2003; Geffen et al. 2004; Pilot et al. 2006). Factors affecting wolves' use of their habitat include availability and abundance of prey, snow conditions, protected and public land-ownership, absence or occurrence of livestock, road density, human presence, human conflicts, and topography (Paquet and Carbyn 2003).

Community and Ecosystem Dynamics

Wolves are apex predators - those at the tops of food chains, having few to no predators of their own. In some cases apex predators may have substantial influence on their communities beyond the direct effects on the species they prey upon (Hairston et al. 1960; Estes et al. 2004; Beschta and Ripple 2009; Hebblewhite and Smith 2010). According to trophic cascade theory, removal of an apex predator leads to an increase in herbivores, which then consume larger amounts of vegetation, leading to decreased plant biomass (Hairston et al. 1960, Paine 1980). Conversely, restoring the apex predator leads to reduced herbivore abundance. This in turn results in decreased pressure on plants, allowing them to increase (Hairston et al. 1960, Paine 1980).

Wolves may cause structural changes in prey age and sex composition, and changes in prey behavior and distribution (Schmitz et al. 2000; Mech and Boitani 2003b). Because wolves disproportionately kill undernourished, injured, oldest, and youngest individuals, ungulate herds in wolf systems tend to be composed of animals in prime age, condition, and health, and are therefore more productive (i.e. produce more offspring; Mech 1966; Bubenik 1972; Schwartz et al. 1992). Anti-predator behavior in ungulates affects their movements and distributions. In the Greater Yellowstone ecosystem for example, this behavior may have caused elk to increase their use of forest, and bighorn sheep (*Ovis canadensis*) to abandon less extreme slopes in favor of greater cover, and therefore potentially reduced predation risk (Singer and Mack 1999; Creel et al. 2005; Mao et al. 2005). Middleton et al. (2013) did detect increased movement and vigilance by elk in the presence of wolves, but were unable to find effects on elk body fat or pregnancy rates as a result of those behavioral changes.

It is also likely that wolves directly affect the abundance of their prey, but to what extent remains uncertain (Mech and Boitani 2003b). There are some documented cases of wolf predation leading to reduced prey abundance (Ripple and Beschta 2012). For example, in Banff National Park (BNP), Canada, wolves recolonized the Bow Valley via dispersal after a 30-year absence. This allowed researchers to compare the effects of wolf predation on elk before and after wolves returned to the area. Among the parameters measured were elk calf recruitment[4], adult female elk survival, and elk population growth rate. During early recolonization, adult elk survival and calf recruitment rates were high (approximately 90%), resulting in 20% population growth (λ=1.21). After wolf recolonization adult elk survival had declined by 30%, calf recruitment was 40% lower, and the population was in decline (λ=0.73). Multivariate analysis revealed that these changes were the result of a combination of factors including wolf predation and winter severity (Hebblewhite and Smith 2010).

[4] Recruitment is generally defined as the number of offspring reaching the adult age class in a given year.

Changes in prey abundance and/or distribution, whether influenced by predation or some other factor, are likely to affect the structure of the plant communities these ungulates feed on. Within the Greater Yellowstone ecosystem, patchy recovery of woody browse species was detected in riparian areas after the reintroduction of wolves is believed to have caused elk to shift to more forested areas (Creel et al. 2005; Beschta and Ripple 2009). Studies from Wisconsin conducted outside of a protected national park are also informative. As compared with areas without wolves, plants growing in areas where wolves had been reestablished for 12-13 years showed greater recovery than plants growing where wolves did not occur, or had occurred for a shorter time period (Bouchard et al. 2013). Similarly, sites with high wolf occupancy had a more diverse understory community with complex vertical structure, as compared to low wolf occupancy sites which had limited herbaceous understory and little woody browse (Callan et al. 2013).

In addition to effects on herbivore abundance and behavior, apex predators may also influence the abundance and behavior of subordinate predator species. These meso-predators are mid-trophic level predators, examples of which include coyotes, foxes, bobcats (*Lynx rufus*), raccoons (*Procyon lotor*), fishers (*Pekania pennanti)*, martens (*Martes americana*), and ringtails (*Bassariscus astutus*) (Prugh et al. 2009). When apex predators are removed from a system, some meso-predators may become more abundant. This specific form of trophic cascade, referred to as “meso-predator release,” has led to declines in some prey populations, sometimes destabilizing communities. As with the herbivores in a system, the reestablishment of the apex predator(s) may lead to changes in meso-predator abundance directly through predation, or indirectly through behavioral avoidance, with resulting changes in lower trophic levels (Prugh et al. 2009). This topic is discussed in greater depth in Chapter 5: *Wolf Interactions with Other Wildlife Species*.

Recent studies have highlighted the importance of these types of interactions in shaping communities (Estes et al. 2004; Bascompte et al. 2005), and they must certainly be considered when attempting to understand the effects of wolf reestablishment (Hebblewhite and Smith 2010). However there is scientific debate over the trophic cascade theory regarding wolves (S. Wilson, pers. comm.; Mech 2012). Published studies of gray wolves and trophic cascades are limited, and were primarily conducted on national park lands (e.g. Banff and Yellowstone) which comprise less than 10% of the current wolf range in the lower 48 states, and therefore likely do not reflect conditions elsewhere (Mech 2012). Eisenberg et al. (2013) and Peterson et al. (2014) stressed caution in generalizing the ecological effects of wolves’ natural communities, especially outside of national parks, where spatial heterogeneity, nonequilibrium dynamics, and influences from humans likely confound any effects from wolves. The effects of wolves on ecosystems are complex and are further complicated by interactions with humans (i.e. via wolf harvest and land ownership), with other predators, where alternate prey species are available, and by effects on habitat conditions for prey species due to weather, fire, fire suppression, etc. These factors must all be considered before any predictions can be made about the effects of wolves on prey and mesocarnivore populations (Mech and Peterson 2003; Prugh et al. 2009) as well as wolf effects on ecosystems (Mech 2012).

B. Taxonomy

The history of gray wolf taxonomy is complex (USFWS 2013a). As many as 24 subspecies were once recognized in North America (Hall 1981), although Mech (1974) believed that too many had been identified based on an insignificant sample size. In the western U.S., Nowak (1995) recognized four subspecies, and Chambers et al. (2012) found support for three, conferring full subspecies status for the Mexican wolf (*C. l. baileyi*), the northern timber wolf (*C. l. occidentalis*), and the plains wolf (*C. l. nubilis*) (Table 1.1). Cronin et al's. (2014) study found some differences in the frequencies of nuclear DNA (SNP)[5] alleles, and mitochondrial DNA[6] (mtDNA) haplotypes between different populations of North American wolves. However neither the nuclear alleles, nor the mtDNA haplotypes of Mexican wolves were unique, thereby questioning the validity of the *C.l. baileyi* designation.

In its 2013 Proposed Rule to delist the gray wolf, the USFWS followed the Chambers et al. (2012) interpretation for western gray wolf taxonomy. Genetic and taxonomic experts convened to act as scientific peer reviewers of the 2013 USFWS Proposed Rule, have disputed the merits of the approach used by Chambers et al. (2012) which "relies heavily on a pre-established taxonomy based on morphology" (as presented by Nowak 1995), and fails to discuss the newest information which suggests that gray wolf populations may be genetically differentiated based on ecological factors. The debate over wolf taxonomy will no doubt continue into the future. With respect to planning for management of wolves in California at this time, the CDFW considers *Canis lupus* at the full species level.

[5] 123,801 single nucleotide polymorphic (SNP) loci were compared. A SNP (pronounced *snip*) is a single nucleotide site in a nucleotide sequence of DNA where more than one nucleotide (A, T, G, or C) is present in a population. SNPs are the most common type of genetic variation among individuals, and are inherited by offspring. These genetic markers can be used for multiple purposes including comparing the relationships of different populations of a species, identifying individuals, and estimating an individual's relatedness to other individuals.

[6] Mitochondrial DNA is genetic material found in mitochondria rather than in the nucleus of a cell. These organelles are inherited strictly from the female parent by both male and female offspring. mtDNA sequences can thus be used to trace maternal lineages which provide information about the evolutionary history of a population or species.

Table 1.1. Gray wolf subspecies in the western U.S. as proposed by the most recent authors. The trend in gray wolf taxonomy has been toward merging subspecies. Advances in genetic capabilities will likely further refine interpretation of the taxonomy (USFWS 2013a).

Western U.S. Subspecies	Nowak (1995)	Chambers et al. (2012)
C. l. arctos	*	
C. l. baileyi	*	*
C. l. nubilis	*	*
C. l. occidentalis	*	*

C. Wolf Distribution in North America

Wolves were once widespread in North America (Figure 1.4). During the 18th and 19th centuries, as the human population expanded westward, habitat alterations, declining prey availability, and long-standing human-wolf conflicts resulted in declining wolf populations throughout most of the species' range in the United States (Young 1944; USFWS 1978). By the mid-20th century, predator control programs consisting primarily of poisoning campaigns completed the extirpation of gray wolves in all of the contiguous United States except for parts of the northern Great Lakes region, and possibly parts of Montana, Wyoming, and Idaho (USFWS 1978).

<u>Northern Rocky Mountains and Pacific Northwest</u>

For 50 years prior to 1986, no gray wolf reproduction was documented in the northern Rocky Mountains, although it is likely that gray wolves periodically crossed into northern Idaho and Montana from Canada. In 1986, a wolf den was discovered in Glacier National Park in northern Montana. That population steadily grew and by 1994, it included approximately 65 wolves in northwestern Montana (USFWS 1994b). In 1995 – 1996 as part of the USFWS recovery efforts for gray wolf, 66 wolves were captured in Alberta and British Columbia, Canada; of these, 35 were released into central Idaho and 31 were released into YNP in Wyoming. Today those populations have expanded such that the 2014 annual state monitoring reports provided the following statistics (Table 1.2).

Table 1.2. Minimum population estimates for NRM and Pacific Northwest wolves for the 2015 state annual reports (USFWS 2016).

State	Min. # Wolf Packs	Min. Breeding Pairs	Min. Total Wolf Population
Idaho	108	33	786
Montana	126	32	536
Wyoming	48	30	382
Washington	18	8	90
Oregon	16	11	110

Washington

Throughout most of Washington, wolves were common to abundant through the mid-1800s, in spite of an active fur trade by the Hudson's Bay Company and other trapping outfits (Wilkes 1844; Heath 1979; Laufer and Jenkins 1989; Wiles et al. 2011). As Euro-American settlement increased in the latter half of the 19th century, so did efforts to control wolves. High prices were set for wolf skins (Heath 1979; Gibson 1985), and bounties were established in some areas (Young 1946; Laufer and Jenkins 1989). By the early 1900s the wolf population was severely reduced in most areas, and only the most remote regions of the state held wolves by the 1930s. Wolves remained in the southern Cascades until approximately 1941 (Young 1944), in the region of Mt. Rainier until the 1920s (Taylor and Shaw 1927, 1929), and in the northern Cascades into the 1940s (Hansen 1986). Reported sightings in the Olympic Mountains occurred as late as the early 1950s (Johnson and Johnson 1952). From 1991 through 1995, 20 confirmed sightings were reported in the state. Most of these sightings were in the Cascade Mountains and northeastern Washington, and were primarily of single animals (Almack and Fitkin 1998; Wiles et al. 2011). The first documented breeding pair in the state was recorded in 2008. Wolves from British Columbia and Idaho have dispersed into the state such that by 2015 the minimum estimated population was 90 wolves in 18 packs with eight breeding pairs, distributed in the northern Cascades and eastern Washington (USFWS 2016). Washington also shares wolves in the southeast with at least one of Oregon's northeastern packs.

Oregon

In Oregon, wolf distribution patterns over time followed a course similar to Washington and other western states. Historical records indicate that wolves were widely distributed, with abundance varying locally (ODFW 2010). Bailey (1936) reported on wolf occurrences on the Deschutes River, along the Columbia River near The Dalles, and in the southern Cascades during the 19th century; and in the Umpqua National Forest, near Crescent Lake, and in Douglas and Lane counties in the early 1930s. Gray wolves from Oregon are represented in museum collections from throughout the Cascades, including Josephine, Douglas, Lane, Linn, Clackamas, Multnomah Lake, and Klamath counties (Verts and Carraway 1998). As the human population increased in Oregon, wild prey species decreased, and stock raisers used depredation to control the wolves that had turned to preying on livestock (ODFW 2010). Effective predator control programs contributed to wolf declines, and by 1972, the species was considered extirpated in Oregon, as no wolf had been taken since the last bounty was paid in 1946 (Verts and Carraway 1998). After an absence of nearly 60 years, the first recorded wolf in the state was documented in 1999. This disperser from the Idaho experimental population, known as Wolf B-45, was captured and returned to Idaho (ODFW 2010). In the ensuing years additional wolves dispersed into Oregon, established packs, and initiated breeding, such that, by the time of the state's 2015 annual report, the state held a minimum of 110 wolves, with 11 breeding pairs in 16 packs (USFWS 2016). In 2015 the Oregon wolf population in the East Wolf Management Zone reached the conservation objective of four breeding pairs for three consecutive years, and ODFW therefore began managing wolves under Phase II guidelines in that portion of the state. Wolves in the western half of Oregon are still being managed under Phase I guidelines (USFWS 2016). Also in 2015, ODFW recommended to the Fish and Wildlife Commission to delist wolves from the state Endangered Species list because the population had met delisting criteria. The Oregon Fish and Wildlife Commission voted to delist in November, 2015.

Southwest

The historic range of the Mexican wolf is believed to have been throughout substantial portions of Arizona, New Mexico, Texas, and Mexico. As with other regions of the country, as human settlement intensified into the early 1900s, conflicts between humans and wolves increased. Extermination programs conducted by private, state, and federal agencies led to the near eradication of wolves throughout the region. In the late 1970s the U.S. and Mexico established a bi-national captive breeding program with the plan of eventually reintroducing wolves into the wild. The Final Environmental Impact Statement on *Reintroduction of the Mexican Wolf Within Its Historic Range in the Southwestern United States* was completed in 1996, and the USFWS published its Final Rule in 1998, leading to the establishment of a nonessential experimental population in Arizona and New Mexico. In 1998, 11 captive-reared Mexican wolves were released into the Blue Range Wolf Recovery Area (USFWS 2013a). At the end of 2015 the minimum population estimate for Mexican wolves in the reintroduction area was 97 wolves and seven breeding pairs (USFWS 2016).

Distribution and Abundance in California

While it is certain that gray wolves once inhabited California, their former distribution and abundance in the state are unclear (Schmidt 1991). Published maps for North America vary in their depictions of wolf distribution within California, but none indicate the presence of wolves in the San Joaquin Valley, central or southern Coast Mountains, or the state's southern desert region (Young 1944; Seton 1953; Hall 1981; Nowak 2002). Because very little verifiable information exists for California, these maps likely do not depict an accurate historical gray wolf distribution for the state (Shelton and Weckerly 2007).

The lack of credible, verifiable information makes estimating wolves' former distribution in the state difficult (Shelton and Weckerly 2007). Based on the many anecdotal reports of wolves in California, researchers have generally reported gray wolf range to include the Sierra Nevada, southern Cascades, Modoc Plateau, Klamath Mountains, and the North Coast Ranges (Stephens 1906; Grinnell et al. 1937; Hall 1981; Paquet and Carbyn 2003). Schmidt (1991) concluded that wolves also "probably occurred in the Central Valley, the western slope of the Sierra Nevada foothills and mountains, and the Coast Ranges of California until the early 1800s, although their population size is unknown and may have been small." To date, no evidence of wolves occurring in the San Francisco Bay Area or Sacramento Delta has been discovered. Interments and disarticulated remains from midden deposits in the region, some of which were previously classified as wolf, have been determined by ancient DNA analysis to be dogs (Byrd et al. 2013; B. Sacks pers. comm. Nov. 2013).

CDFW has used previously published habitat suitability models to make broad predictions about where wolves might eventually occur in California. The three regions most likely to support wolf populations include: 1) the Klamath Mountains and portions of the Northern California Coast Ranges; 2) the southern Cascades and portions of the Modoc Plateau and Warner Mountains; and 3) the Sierra Nevada. Oregon is the most likely source of immigrating wolves in the near term, so it is most likely that wolves will first establish in the Klamath/North Coast and southern Cascades/Modoc Plateau areas.

While wolves could readily travel in the northern Sierra Nevada (as evidenced by OR7's movements in the summer and fall of 2012), establishment in the central and southern Sierra is not anticipated in the near term. Wolves dispersing southward would encounter increasing road (California Department of Transportation 2010) and human population densities (California Department of Finance 2010) in the vicinity of Nevada, Placer, and El Dorado counties. Wolves dispersing southward toward the central and southern Sierra would also need to cross Interstates 50 and 80, which appear to be difficult for many wildlife species (Diamond et al. 2013). Wolves have successfully crossed interstate highways in several states however, including Oregon (Merrill and Mech 2000; GPS data for wolf OR-7 from ODFW).

Anecdotal information may be used to approximate the historical distribution of wolves in California, but their former abundance is more difficult to estimate. Statements in explorers' journals such as "wolves…were frequent during the day…" (Fremont 1887) constitute the majority of such references. It is unlikely that we will be able to ascertain true historic gray wolf distribution and abundance, and will instead base goals for wolf conservation on contemporary habitat constraints.

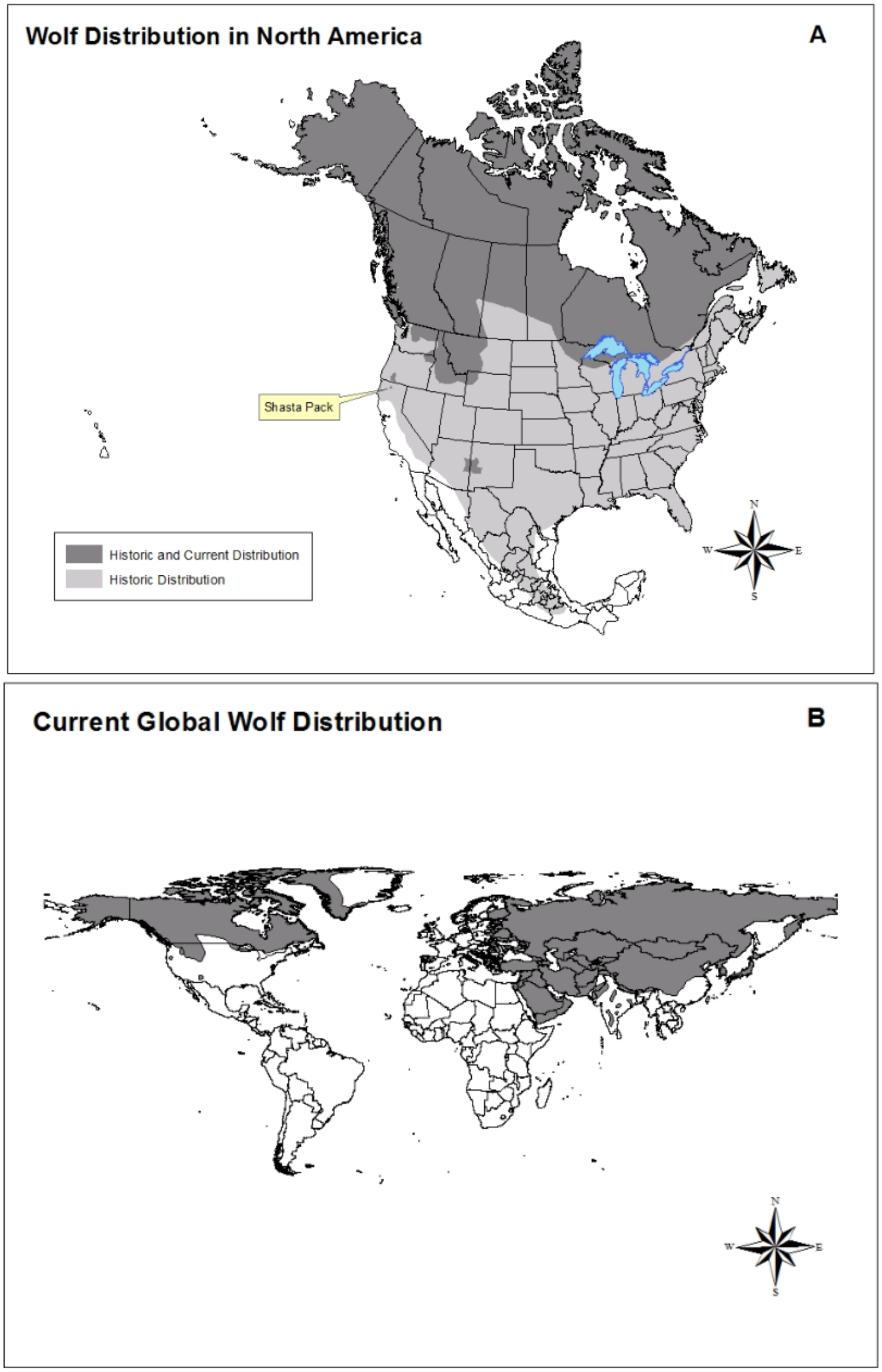

Figure 1.4. (A) Former (pre-European; Musiani and Paquet 2004) and current (IUCN 2012; IDFG 2015; MFWP 2015; ODFW 2015; WDFW 2015; WGFD 2015) distribution of gray wolves in North America. (B) Current distribution of gray wolves worldwide.

Museum Specimens

Dixon (1916) described fruitless efforts to obtain wolf specimens for the University of California: “For several years past the Museum of Vertebrate Zoology…has endeavored to corroborate reported occurrences of timber wolves in California, but without obtaining a single specimen. Several quite convincing reports of such captures have reached the Museum from time to time, but whenever the skin or skull was secured, the animal always proved to be a large mountain coyote…”

CDFW is aware of only two verified specimens of putatively naturally-occurring wolves from California. Both are housed in the Museum of Vertebrate Zoology (MVZ) at the University of California, Berkeley (Jurek 1994). The first specimen was collected in the Providence Mountains, San Bernardino County, in 1922 (Johnson et al. 1948). The animal weighed roughly 100 pounds and apparently was caught in a steel trap, “while pursuing a mountain sheep” (Grinnell, et al. 1937) although other information suggests that this animal was trapped on a homestead in an effort to remove coyotes that had killed domestic goats (Casebier 1987). Johnson et al. (1948) noted “This is the only record known to us of the occurrence of wolves in the Providence Mountains area, or, for that matter, anywhere in southeastern California.” Based on an examination of the skull and the systematics of wolves at the time, Grinnell, et al. (1937) classified this animal as a plains wolf, *C. lycaon nubilis.* Using the same criteria, Johnson et al. (1948) concluded that the animal belonged to the southern Rocky Mountains subspecies *C. l. youngi.* DNA from this specimen was genotyped at UCLA in 2012 and its haplotype was determined to be most consistent with that of a Mexican gray wolf. The other verified specimen at the MVZ was collected in 1924 near Litchfield, in Lassen County. The animal was fairly old, missing a portion of a hind leg, and emaciated. Though it weighed only 56 pounds, it was estimated that in good condition it would have weighed approximately 85 to 90 pounds (Grinnell, et al. 1937). Grinnell, et al. (1937) speculated that this animal was a “straggler” from Oregon or northern Nevada. DNA from this specimen was also genotyped at UCLA in 2012, and its haplotype found to be most consistent with that of “common North American wolf” (subspecies not specified).

In 1962, a putative wolf was killed near Woodlake, in Tulare County. This was an adult male weighing only 56 pounds. Since wolves had not been documented in California for nearly 40 years, this incident generated considerable interest, and the suggestion that a small resident population may still have existed in California (Ingles 1963). Measurements of the skull of this wolf were found to be more similar to those of wolves found in Korea, than to those of the California specimens held at the MVZ, or any other North American wolf subspecies, leading to the conclusion that this animal was introduced into California (McCullough 1967). This animal’s DNA was found to match wolves from central Alaska and Inuvik (subspecies not specified), so CDFW has concluded that this animal was probably imported from elsewhere and released.

Finally, the CDFW is inquiring about a reported wolf having been killed in 1959 in California near the town of Verdi, Nevada. As of this writing, there is no conclusive evidence on the species of animal taken in that instance.

Anecdotal Observations

Given the scant verifiable evidence for historical wolf distribution and abundance in California, the Department has researched additional sources for documentation of the species. It is important to stress here that the following sources are considered anecdotal only, and therefore cannot be assumed to provide a reasonable expectation of accuracy. The information is provided solely to demonstrate the extent to which the Department has investigated the history of wolf presence in California.

Early California explorers, settlers, and naturalists documented encounters with "wolves" in their journals and diaries. These references rarely provided enough detail to indicate whether the animals in question were indeed wolves or coyotes (*C. latrans*). During the 1800s and early 1900s coyotes were referred to variously as wolves, yellow wolves, prairie wolves, and other equally misleading names (Grinnell et al.1937, Bruff 1949). Coyotes in the Sierra Nevada, southern Cascades, and Klamath Mountains were frequently misidentified as gray wolves or timber wolves (Grinnell et al. 1937). An example of an early account is found in an 1827 journal entry describing life near the San Gabriel Mission: "Still at the Mission...Myself and Mr. McCoy went up into the mountains to see if we could find some dear [sic]; I saw two and wounded one, killed a wolf and two ducks..." (Rogers 1918). Since no description of the "wolf" is presented, and no evidence from other parts of the journal indicates the author was familiar with coyotes, it is impossible to determine if he was referring to *C. lupus* or *C. latrans*. As a consequence of these uncertainties there is little credibility in many of these documents. The anecdotal observations described in early writings must be treated with skepticism except for those cases in which authors specifically mentioned both wolves and coyotes, or provided additional information suggesting their wolf observations were authentic.

Additional anecdotal sources that provide some evidence for wolf occurrence in California derive from the languages, tales, practices, and ceremonies of California's native people. For example, early ethnographic researchers of California's native people identified distinct words for wolf, coyote, and dog in many of the approximately 80 native languages, suggesting recognition of the distinctness of the three species among those people (Kroeber 1910; Curtis 1924; Cambra et al. 1996; Geddes-Osborne and Margolin 2001).

California's ancestral native people were primarily animists meaning that they believed that animate and inanimate objects have spirits (Jones 2009). The extent to which the wolf is incorporated into the traditions of native peoples may indicate the importance of this species regionally. For example, the Yurok, Karuk, and Hoopa tribes of California's northwest region share beliefs and ceremonies that indicate regional importance to wolves. All three of these distinct tribes engage in a ceremonial dance in which participants wear a “blinder” made from pieces of wolf tail attached to a deerskin band (Geddes-Osborne and Margolin 2001). Symbolic inclusion of the wolf in rituals may be an indication of this species’ significance to these peoples.

Native peoples from other areas in California also seem to have had some knowledge of wolf existence. The wolf plays minor roles in tales told in a number of California tribes from the Pomo of Lake County, to the Mono of Madera County (Gifford and Block 1930), implying some knowledge and possibly historic presence of wolves in those regions. In other parts of California, the wolf may have been rare or absent as it seems to play little or no role in native peoples’ stories as compared to some other species such as raven, hawk, grizzly bear, and especially coyote.

Summary of California Distribution and Abundance

The limited available information suggests that wolves occurred in California, but their distribution and abundance are unknown. Some of the anecdotal observations are ambiguous as to whether the observer was reporting a wolf or a coyote and physical specimens are very few in number. Most California native peoples had a word for wolf in their vocabularies, as well as coyote and dog, and some incorporated wolves into their stories and rituals. This information is consistent with a hypothesis that wolves occurred in the state but to what extent is merely speculative.

CHAPTER 2 DISEASES AND WOLVES

Like all wildlife, wolves are exposed to a variety of diseases caused by viruses, bacteria, and parasites. Not all of these disease-causing agents, protozoa, result in illness or death. In fact, the impact of disease on individuals and populations depends on a multitude of dynamic factors associated with the host (age, immunity and nutritional status, population density, species susceptibility, social structure, previous exposure), the pathogen itself (infectious dose, strain, life cycle), and the environment (transmission from other species, climatic determinants, environmental degradation). Accordingly, the study of wildlife diseases and pathogen transmission among wildlife, domesticated animals and people is inherently complex.

If wolves naturally disperse to and recolonize California, questions may arise from diverse stakeholders as to the potential for novel disease introduction or changes in pathogen transmission dynamics that could impact other wildlife, domesticated animals, or people. As indicated in previous chapter discussions and throughout this plan, wolf reestablishment in the United States brings a wealth of controversy. While there is ample scientific information that has been published regarding wolf diseases and disease transmission, there is also a prevalence of misinformation available to the general public on this topic. Consequently, CDFW made the decision to provide a distinct chapter discussion on diseases and wolves.

With regards to conservation, a different set of questions emerge, such as which diseases could have the potential to threaten the wolf population itself. Accordingly, this chapter is intended to review the scientific knowledge to date about diseases that may impact wolf populations and that may be transmitted from wolves to other species (including wildlife, domesticated animals, and humans), and to objectively evaluate potential impacts to other species and conservation. This chapter is focused on diseases of relevance to California and is not intended to be a comprehensive review of diseases that have been documented in North American wolves; for this the reader is referred to other literature (Brand et al. 1995; Kreeger 2003; Gillin and Hunter 2010).

A. Viruses

Rabies

Rabies is a viral disease of mammals normally transmitted between animals by saliva transfer from the bite of an infected animal. The virus infects the central nervous system causing an acute and usually fatal inflammation of the brain and spinal cord (encephalomyelitis) (Rupprecht et al. 2001). Rabies has potential to impact wolf populations, but reports are infrequent compared to other carnivores. Rabies has been reported in free-ranging wolves from Alaska and the Canadian Great Lakes region. In a monitored wolf population in northeast Alaska in 1985, rabies was confirmed to have caused the death of five wolves and suspected to have killed four additional individuals whose carcasses were not suitable for laboratory testing (Weiler et al. 1995). Altered annual den use patterns were observed during the rabies outbreak period, but density and fall population counts remained stable suggesting that the outbreak did not decrease population size (Weiler et al. 1995). In contrast, a rabies outbreak affecting several packs in northwest Alaska was associated with a local population decline (Ballard and Krausman 1997). In general, the spread of rabies by wolves is contained within individual packs (Chapman 1978), but inter-pack transmission can occur when infected animals contact members of adjacent packs at their territory boundaries or via dispersing individuals.

North American wolves are not considered reservoirs of rabies virus (Kreeger 2003). In published cases, wolves were suspected of contracting the disease from other canid species that are known reservoirs for the virus, including red foxes and arctic foxes (*Alopex lagopus*) (Rausch 1973 and Ritter 1981 as cited in Kreeger 2003; Theberge et al. 1994). A review of available literature, including gray wolf information for other states and the USFWS through 2014, did not identify any documentation of rabies in free-ranging wolves in the lower 48 states since reintroduction of wolves in 1995-96. The lack of reported cases is likely due to key differences in species reservoirs and interactions between wolves and reservoir species at lower latitudes.

In California, the reservoirs for rabies virus are bats (various species) and striped skunks (*Mephitis mephitis*) (California Department of Public Health 2014), thus the risk of rabies is considered low for wolves in the state. With regards to public health, wolves, like other infected mammals, can transmit rabies to a person through a bite. Although rabies should be always considered as a possible cause if a wolf is observed behaving abnormally or aggressively, in the United States and Canada, interactions involving rabid wolves and humans have rarely occurred (Linnell et al. 2002; McNay 2002b).

Canine Distemper

Canine distemper is a contagious viral disease of wild carnivores and domestic dogs capable of causing significant population declines. Signs of distemper can vary depending on the species infected and virus strain, but respiratory (bronchopneumonia) and nervous system disease (encephalitis) are most common. Infections and mortalities occur most often in pups, but all-age die-offs have been documented (Williams 2001; Timm et al. 2009). Distemper has largely been controlled in domestic dogs in North America through vaccination, and despite being widespread in wild carnivore populations, mortality from canine distemper virus (CDV) has only been documented in wild wolves in Canada (Carbyn 1982a) and Alaska (Peterson et al. 1984).

Exposure, as diagnosed by the presence of antibodies in the blood of an animal, to CDV in North American wolves is variable over time and among populations. Studies from Canada and Alaska suggested that approximately 17% of wolves were exposed to CDV (Choquette and Kuyt 1974; Stephenson et al. 1982; Zarnke and Ballard 1987; Bailey et al. 1995; Brand et al. 1995). Exposure to distemper has increased over time in

Montana's wolf population from 2007 through 2013, becoming quite prevalent (Sime et al. 2011; Bradley et al. 2013, 2014). Monitoring data from YNP showed that in contrast to other viruses to which wolves were constantly and commonly exposed, the number of sampled wolves exposed to CDV varied greatly over time and that high CDV exposure prevalence in wolf pups was correlated with years having poor pup survival (Almberg et al. 2009). Although the findings suggest that CDV may have contributed to pup mortality in YNP, mortalities due to CDV were not confirmed during the study period and the number of wolf pups sampled each year was small. It is not known if wolves maintain CDV within their population or whether the periodic peaks in exposure are due to spillover transmission of the virus from other carnivore hosts in the YNP ecosystem (Almberg et al. 2009).

Distemper is present in wild carnivores throughout the state of California, with mortalities commonly reported in raccoons, gray foxes and striped skunks (D. Clifford, CDFW, unpubl. data). Wolves inhabiting the state would have potential to be infected from sympatric carnivores. Although it is unclear if distemper would result in mortalities meaningful at the population level, because of distemper's documented impacts in other carnivore species, most wolf management programs conduct surveillance for the disease by examining carcasses and testing for antibodies in animals that are captured for other research and management purposes.

Canine Paroviral Enteritis

Canine parvovirus (CPV) was first detected in domestic dogs in 1978 and quickly spread worldwide (Hoskins 1998). Parvovirus can cause a debilitating gastroenteritis resulting in diarrhea, vomiting, dehydration, and eventually death. Similar to distemper, parvovirus most commonly causes illness and death in young animals. The virus is shed in the feces and persists for long periods in the environment. CPV likely entered wild coyote and wolf populations in North America about the same time it was discovered in domestic dogs (Barker et al. 1983; Muneer et al. 1988) and possibly as early as 1973 (Goyal et al. 1986; Mech et al. 2008).

Parvovirus may limit some wolf populations through pup mortality. A decline in the wolf population of Isle Royale National Park, Michigan in the 1980s coincided with an outbreak of CPV among dogs in the region, and the subsequent appearance of antibodies against CPV in sampled wolves indicated exposure to the virus (Peterson 1995 as cited in Kreeger 2003). However, Mech (2011) noted that the evidence for a CPV caused decline was sparse and that malnutrition and intra-specific strife offered a more cogent explanation for the decline (Mech, 2011; Peterson and Page 1988). A correlation between increased antibody levels indicative of exposure and fewer pups over a 30-year period suggested that CPV limited growth of a Minnesota wolf population through pup mortality (Mech et al. 2008). Re-examination of 35 years of data in this population indicated that the effect of CPV on pup survival waned after seven years, despite continued high prevalence of antibodies, suggesting that once CPV became endemic and produced its peak effect on the study population, that population developed enough immunity to withstand the disease (Mech and Goyal, 2013). Exposure to CPV in young and adult wolves in YNP was 100% with no evidence of any correlation with pup mortality (Almberg et al. 2009).

Three wolf mortalities have been directly attributed to CPV infection: a 9-month-old female from Minnesota in 1993 (Mech et al. 1997), and a yearling female and male pup from the same pack in Oregon in 2013 (ODFW 2014). Monitoring of the affected Oregon pack has not revealed additional CPV deaths (ODFW 2014). These deaths demonstrate that CPV can also kill older wild wolves, not just pups.

Canine parvovirus is widespread in domestic dogs and wildlife throughout California. Similar to distemper, CPV can cause mortality of individuals and impact pup survival, thus most wolf management programs in other states conduct surveillance for CPV by examining carcasses and testing for antibodies in animals that are captured for other research and management purposes.

Additional viral diseases

Exposure to canine adenovirus (CAV; cause of infectious canine hepatitis) and canine herpesvirus (CHV) are common in wild wolf populations, but have not been identified as a cause of mortality (Zarnke et al. 2004; Almberg et al. 2009; Sime et al. 2011). Both viruses also infect domestic dogs and other carnivore species. Vaccinations for rabies, CDV, CPV, CAV, and CHV are widely available and commonly used in standard preventive veterinary care for domestic dogs. All five of these viruses are already present in California in both domestic dogs and wild carnivores; the presence of wolves in the state would not be significant in terms of disease risk to these species.

Although foot and mouth disease (FMD) was eradicated in the United States in 1929, it still occurs in other countries and is included here due to stakeholder concerns regarding the potential for wolves to spread disease. FMD is a debilitating viral disease affecting all cloven-hoofed animals, including cattle, pigs, sheep, goats, camels and deer (Ekboir 1999). Clinical signs include drooling, lip smacking, and lameness, caused by blisters (vesicles) on the tongue, dental pad and feet. Although FMD infrequently causes death and is not a human health concern, the virus is transmitted rapidly among ruminants and causes significant economic losses to livestock producers from animal illness and trade restrictions (USDA APHIS Veterinary Services 2013)

While Graves (2014) states that FMD is one of 50 diseases wolves may carry, no primary literature documenting the spread of FMD by wolves was identified. If an outbreak of FMD were to occur in California, rapid agency response to control and eliminate infections would occur (USDA APHIS Veterinary Services 2013). Although wild carnivores (including wolves) could potentially mechanically move virus during an outbreak, the risk of this route of spread is negligible and it is unlikely that wolf populations would increase the risk beyond other existing mechanical vectors including birds and vehicles.

B. Bacteria

Bovine Tuberculosis

Bovine tuberculosis (BTB) is caused by *Mycobacterium bovis*, and primarily affects the respiratory system of domestic cattle and wild ungulates. Humans can contract BTB through the consumption of raw milk and dairy products. Due to its human health risk and negative impact on cattle productivity, BTB has largely been eliminated in domestic cattle in the United States, but focal areas of infected herds are occasionally detected. Currently, Michigan is the only state where BTB is present and self-sustaining in free-ranging white-tailed deer (*O. virginianus*). The source of initial infection for deer was likely infected cattle, then high deer densities coupled with the practice of deer baiting, which concentrates deer into focal areas, enhanced transmission (Schmitt et al. 2002). In Michigan, a small number of BTB cases have occurred in coyote, black bear, bobcat, raccoon, and red fox, but no cases have been reported in Michigan's wolves (Schmitt et al. 2002). Although California does not have white-tailed deer, the fact that BTB is present in the primary prey species for wolves in another state, and that wolves apparently have not been infected, suggests that it will not be a concern in California. Carnivores that consume infected ungulate carcasses can get BTB, but usually do not subsequently spread the bacteria to other animals. A focal study examining coyotes in Michigan concluded infection of coyotes likely occurred through ingestion of infected deer carcasses and not from interaction with conspecifics[7] (Berentsen et al. 2011). The only report of BTB infection in wolves is from Canada, where two pups were found dead and the bacteria was successfully cultured from one carcass (Carbyn 1982b as cited in Kreeger 2003).

BTB cases have been sporadically detected in dairy cattle herds located in the southern portion of the Central Valley and Southern California (California Department of Food and Agriculture 2014a). There have been no cases reported in deer in California (P. Swift, CDFW, unpublished data). In short, BTB is a very low risk disease to wolves as they are extremely unlikely to be exposed given the disease has not been found in wild ungulates in California and the sporadic cases reported in dairy cattle occur well outside of the anticipated areas that wolves would inhabit. Moreover, even if exposed, it is unlikely wolves would efficiently transmit the disease to other species.

Brucellosis

There are multiple species of *Brucella* bacteria that infect ungulates and carnivores. Canine brucellosis, caused by *Brucella canis,* causes abortion in domestic dogs, but has not been reported in wolves (Kreeger 2003). Rangiferine brucellosis, caused by *Brucella suis* biotype 4, infects caribou and reindeer[8] (*Rangifer tarandus*). Wolves most likely become infected when they consume infected prey (Kreeger 2003). Two pregnant

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[7] Defined as belonging to the same species.

[8] Reindeer and caribou are different names for the same species. In North America the species is most commonly called caribou.

female wolves experimentally infected with *Brucella suis* type 4 showed no clinical signs of infection, however all eight pups born to these infected females died within 24 hours of birth. Although these deaths could not be directly attributed to *Brucella* infection, *B. suis* type 4 bacteria was cultured from organs in both the adults and pups, thereby demonstrating wolves could be infected (Neiland and Miller 1981). Antibodies to *Brucella* have been documented in free-ranging wolves living sympatric with caribou and reindeer in Alaska (Neiland 1975; Zarnke and Ballard 1987), Canada (Brand et al. 1995), and Russia (Pinigin and Zabrodin 1970 and Grekova and Gorban 1978 as cited in Kreeger 2003). Swine brucellosis in domestic and feral pigs is caused by different *Brucella suis* biotypes (1 and 3) in the U.S. (Drew et al. 1992; Pedersen et al. 2014); swine brucellosis is present in feral pigs in California (see below). Infections in wolves have not been documented.

Bovine brucellosis, caused by *Brucella abortus*, can cause abortions, retained placentas, male reproductive tract lesions, arthritis, and lameness in both domestic and wild bovids and cervids. The disease can be transmitted to people through direct contact with infected tissues or raw milk consumption and cause recurrent fever, night sweats, joint and back pain, other influenza-like symptoms, and arthritis (Godfroid 2002). Brucellosis has mostly been eliminated in domestic cattle in the United States through aggressive vaccination and control programs, but persists in the Greater Yellowstone ecosystem where bison and elk are also infected (Rhyan et al. 2013). Wolves and other canids can be infected with *B. abortus* when they scavenge on contaminated fetuses, placentas, and possibly carcasses; however, the subsequent transmission from infected wolves to cattle or other wildlife is very unlikely (Thorne 2001). Transmission of *B. abortus* from coyote to cattle was documented, but only under experimental conditions where both species were kept in proximity and at densities that would not occur in nature (Davis et al. 1988). The feces of wolves that were experimentally infected with *B. abortus* sporadically contained the bacteria, but the number of bacteria present in the wolf feces were far below the number required to cause infection in cattle (Tessaro and Forbes 2004). To date, sampled wolves in Montana have not shown evidence of exposure to *B. abortus.* There may be a low risk of wild carnivores transporting contaminated ungulate materials to other areas, but conversely, wild canids may actually reduce brucellosis transmission in ungulates by consuming contaminated materials and thereby eliminating them from the environment (Cheville et al. 1998). Cross et al. (2010) also postulated that wolf predation could potentially reduce the prevalence of brucellosis in elk by reducing elk numbers and group sizes.

California has been free of *Brucella abortus* since 1997 (California Department of Food and Agriculture 2015) and the disease is also not present in wild deer (Roug et al. 2012). Accordingly there is low risk for wolves to contract brucellosis or transmit the disease. *Brucella suis* biotype 4 does not exist in California as the state lacks the natural ungulate hosts. California is free of swine brucellosis in commercial swine; however, *B. suis* antibodies are present in feral pigs in some areas of California (Drew et al. 1992; California Department of Food and Agriculture 2014b). Given that brucellosis is not common in California wildlife and that transmission of *Brucella* species bacteria from wolves to ungulate hosts is extremely unlikely, brucellosis poses very low conservation threat or risk of spillover from wolves to livestock.

Additional bacterial diseases

Lyme disease (*Borrelia burgdorferi*), leptospirosis (*Leptospira interrogans* serovars), tularemia (*Francisella tularensis*), and plague (*Yersinia pestis*) are all present in California. Lyme disease and plague are spread through the bite of infected ectoparasites – ticks are the vector for Lyme, and fleas can transmit plague. Other diseases are passed primarily through the exposure to, or consumption of infected mammalian prey. Leptospires (the spirochete bacteria that cause leptospirosis) are shed in urine, thus transmission can also occur from ingestion of contaminated water sources. Studies show that North American wolves have been exposed to leptospirosis and tularemia but no mortalities have been documented from any of these diseases (Zarnke and Ballard 1987; Khan et al. 1991; Sime et al. 2011). In an area of Minnesota where leptospirosis regularly occurred in livestock, Khan et al. (1991) documented that wolves living in closer proximity to farms were more likely to have antibodies to the bacteria. This finding suggested wolves were exposed from drinking contaminated recreational waters, ponds, and farm waters. Many wildlife reservoirs of leptospirosis already exist in California, thus the addition of wolves onto the landscape is unlikely to change the transmission dynamics of this disease.

One potential novel disease threat to wolves entering California is salmon poisoning disease (SPD), a highly fatal helminth-transmitted rickettsial disease that has been documented in domestic dogs, coyotes, and red foxes (Foreyt 2001). SPD is caused by a rickettsia bacterium called *Neorickettsia helminthoeca* that is carried by a parasitic trematode (fluke) which has a complicated life cycle infecting both snails and salmonid fish. The fluke harbors the bacteria throughout its life including immature fluke stages that are released from the snails and then infect fish. The immature flukes encyst in salmonid fish (and some non-salmonid fish and Pacific giant salamanders) and are then consumed by fish-eating mammals or birds (Headley 2011). Wild and domestic canids become severely ill after consumption of infected fish. The developed and mature fluke releases the bacteria into the dog's intestine and the disease is spread to lymph nodes, spleen, liver, thymus, and brain (Foreyt 2001; ODFW 2010). The disease is primarily restricted to the range of the snail intermediate host which is west of the Cascade Mountains from northern California through west-central Washington. If wolves occupy suitable habitat where the disease is found in northern California, this disease could cause clinical signs, illness, and death in wolves that consume infected salmon.

Anthrax is a potentially fatal disease of all warm-blooded animals, including humans. It is caused by the spore-forming bacterium *Bacillus anthracis*. Herbivores are considered highly susceptible to anthrax, often rapidly dying from infection, while carnivores are considered less susceptible and birds highly resistant (Gates et al. 2001). Herbivores are most commonly infected by ingesting spores in the soil while grazing or on contaminated feed, while carnivores and birds are often exposed when scavenging a carcass. Anthrax often persists in focal geographic areas because the bacterium spores can survive for extremely long periods (decades) in the soil. When a contaminated carcass is opened during scavenging (or other activity), the bacteria are released from the body and transform into the soil-resistant spore form (Gates et al. 2001).

Anthrax outbreaks in the United States occur sporadically in the West and Midwest (Mongoh et al. 2008). A single wolf carcass was suspected of anthrax during a plains bison outbreak in Canada in 2008 (Shury et al. 2009), but anthrax was recovered from two plains bison cows killed by wolves in Montana without associated wolf mortality in July 2010 (Blackburn et al. 2014). Anthrax spores ingested by carnivores may pass through the feces and contaminate other areas (Gates et al. 2001), but evidence of this has not been documented in wolves. Anthrax outbreaks occur infrequently in California, with cattle being the most common species affected (Kirk and Hamlen 2000). Due to the localized geographic distribution and sporadic frequency of anthrax cases in California, and lack of evidence to date that wolves have increased anthrax occurrence in other states, wolves in California would likely have a negligible to nonexistent role in the transmission of this disease.

C. Parasites

Ectoparasites

Various ectoparasites including ticks, fleas, biting flies (Itamies,1979, as cited in ODFW 2010), lice, and mange mites have been reported on wolves (Table 7.8 in Kreeger 2003). The two ectoparasites that can cause illness and mortality in wolves are lice and mange mites.

Infestation with the dog louse (*Trichodectes canis*) can cause illness in wolves but there is little evidence that the parasite causes negative effects on populations (Schwartz et al. 1983; Mech et al. 1985; Jimenez et al. 2010a).The louse is transmitted by direct contact between infected and uninfected animals. Infected animals show varying degrees of hair loss, skin infection, and inflammation that causes severe itching of the skin (pruritis). An outbreak of lice occurred in Alaskan wolves from 1981-1983, with affected wolves having hair loss (alopecia) and seborrhea (crusts and oily skin resulting from excessive sebaceous gland discharge) present on up to 75% of their body surface (Schwartz et al. 1983; Taylor and Spraker 1983; Zarnke and Spraker 1985). Lice have also caused clinical disease in individual wolves in Idaho and Montana (Jimenez et al. 2010a).

Sarcoptic mange (scabies) is a highly contagious skin disease caused by the mite *Sarcoptes scabiei*. Burrowing into the epidermis by mites and the subsequent allergic response by the host to excretions from the mites causes intense itching (pruritis), leading to progressive skin damage as the infested animal bites, scratches, and rubs the affected areas. Infested animals can suffer from alopecia, abnormal thickening of the skin (hyperkeratosis), excessive discharge of sebum from sebaceous glands in the skin (seborrhea), scabs, and ulcerations. Severe infestations can affect the animal's entire body, leading to emaciation, poor body condition, and death from secondary infections or the inability to maintain normal body temperature in winter due to hair loss (Bornstein et al. 2001). Mites are transmitted by direct contact between infested and non-infected individuals, contact with mite-contaminated denning and bedding areas, and contact with contaminated rubbing or scratching objects.

Sarcoptic mange can result in high mortality, especially in pups and may have a role in reducing local population numbers (Todd et al. 1981 and Pence and Custer 1981 as cited in Kreeger 2003; Jimenez et al. 2010b). Between 1991 and 1996, 27% of live-trapped Wisconsin wolves exhibited symptoms of mange. During the winter of 1992-93, 58 percent showed symptoms and a concurrent decline in the Wisconsin wolf population was attributed to mange-induced mortality (Wisconsin Department of Natural Resources 1999). During that same period, mange was the third-most common cause of death in Wisconsin wolves, behind trauma (usually vehicle collisions) and shooting (Wisconsin Department of Natural Resources 1999). Sarcoptic mange was confirmed in 16 wolves in Montana and six wolves in Wyoming from 2002 through 2008, and clinical signs were observed in an additional 40 wolves in Montana and 30 wolves in Wyoming (Jimenez et al. 2010b). Mange-infested wolves continue to be documented in southwest Montana and in at least one pack in Wyoming (Bradley et al. 2014; Wyoming Game and Fish Department et al. 2014).

Sarcoptic mange is already present in multiple carnivore species in California, including coyotes, red fox (non-native origin), and recently San Joaquin kit foxes (Westall et al. 2014). More cases are reported in the southern portion of the state, but mange in coyotes occurs throughout the state (D. Clifford, CDFW, unpublished), thus wolves would most likely be at risk from spillover of infection from sympatric coyotes. Given that mange could have potential to impact wolves when populations are small and localized, the occurrence of mange in California wolves should be monitored and intervention considered if an outbreak of mange threatens population persistence.

D. Endoparasites with Life-Cycles that Include Canids and Ungulates

Echinococcus granulosus

Echinococcus granulosus is a parasitic tapeworm that requires two hosts to complete its life cycle. The adult tapeworms live in the intestine of the definitive host, which is a canid (domestic dogs, coyotes, wolves, or foxes). The adult tapeworms produce eggs, which are then excreted onto the ground in the feces of the canid host. The intermediate host, typically deer, elk, moose, and domestic sheep, goats, and cows, become infected by ingesting eggs while grazing, where the eggs hatch and develop into larvae. Once ingested, the eggs hatch in the digestive tract of the intermediate host, then enter the blood stream and are carried to the major organs (most often the lungs) where they develop into hydatid cysts that contain the immature form of the parasite. The parasite's life cycle is completed when a canid consumes the organs of the ungulate intermediate host containing the parasite cysts with infective larvae (Jones and Pybus 2001).

Humans are not a natural host of the parasite, but can be infected by ingesting tapeworm eggs from canid feces. Eggs could be ingested while consuming vegetation or drinking water that has been contaminated with infected feces. Humans may also become infected after handling contaminated canine scat or fur, and then transferring eggs to the mouth by touching the face or eating before adequate hand washing. In people, hydatid cysts usually develop in the liver or lungs, and there are several treatments for the disease (Gottstein 1992; Brunetti et al. 2010; Bristow et al. 2012). Throughout the world, most human cases occur in indigenous people with close contact with infected dogs. Humans cannot contract *E. granulosus* by consuming cysts in tissues of the ungulate intermediate host.

E. granulosus has a worldwide distribution (Gottstein 1992). There are two recognized biotypes of the parasite – the northern or sylvatic biotype that circulates between canids (wolf, dog) and cervids (moose, caribou, reindeer, deer, and elk) and is present above 45th parallel which passes through northern Oregon, bisects Montana and Wyoming, and roughly corresponds to the border with Canada across the Midwest and eastern United States. The northern biotype does not appear to cross-infect domestic livestock (Rausch 1986 as cited in Drew 2010). The southern or domestic biotype is comprised of at least nine different strains and circulates between domestic dogs and domestic ungulates, especially sheep (Jones and Pybus 2001). The southern biotype is endemic (i.e. regularly found) in most sheep raising areas of the world including the southwestern United States, specifically Arizona, California, New Mexico, and Utah (Schwabe et al. 1971; Foreyt et al. 2009).

Occurrence in Wolves

In North America, *E. granulosus* in wolves has been reported previously from Alaska, and Minnesota in the United States, and, Alberta, British Columbia, Northwest Territories, Ontario, and Yukon Territory in Canada (Jones and Pybus 2001). From 2006-2008 adult tapeworms were detected in 39 of 63 wolves (62%) collected in Idaho, and 38 of 60 wolves (63%) collected in Montana (Foreyt et al. 2009). The parasite has also been detected in the feces of wolves living in Oregon (ODFW, unpublished data).

Occurrence in Domestic Animals and Wildlife in California

An *E. granulosus* domestic dog-sheep transmission cycle was discovered in the late 1960s when hydatid cysts were found in 5% of 22,720 slaughtered sheep in California from herds that originated from within California, Idaho, and Utah (Sawyer et al. 1969). Follow-up investigations revealed infected sheepherding dogs at three of four ranches, establishing a local origin definitive host and the existence of the domestic life cycle

(Sawyer et al. 1969). Epidemiological investigations involving tracebacks of infected farms and hospital record searches revealed human infections, most of which were in people whose livelihood was sheepherding and farming (Schwabe et al. 1971; Araujo et al. 1975).

In addition to a domestic transmission cycle, adult *E. granulosus* tapeworms were recovered from coyotes in Tehama, Madera, and Mariposa counties (Liu et al. 1970; Crellin and Harmon 1980). Hydatid cysts were also detected in deer from Tehama County in areas with and without livestock. The presence of the tapeworm in coyotes and deer in an area without livestock activity suggested that the parasite might also have established a sylvatic (wild animal) transmission cycle (Romano et al. 1974).

Wildlife populations in California are not routinely tested for the presence of *E. granulosus*. Sporadic observations of cysts in deer are reported by hunters (P. Swift, CDFW, pers. comm.) but it is not known if cysts were due to *E. granulosus* or the more common *Taenia* spp. tapeworms. Monthly hydatid disease reporting in livestock is required of state diagnostic labs (California Department of Food and Agriculture 2014c). Review of records from 2010-2014 showed that there were no cases of hydatid disease in cattle, sheep, goats, horses or pigs reported to the California Department of Food and Agriculture (CDFA) (K. Fowler and A. Jones, pers. comm.). Nine hydatid disease human fatalities were reported in California from 1990-2007; these cases predominately occurred in foreign-born residents and males that have some association with livestock exposure (Bristow et al. 2012). Echinococcus hydatid disease in humans is not classified as a reportable disease in California.

Significance of Echinococcus granulosus to wildlife and livestock

Based on available information, the health risks associated with *E. granulosus* to wildlife and livestock is low. Heavy infections in wildlife may be related to poor body condition. In ungulates, the presence of large numbers of hydatid cysts in the lungs can lead to respiratory difficulty. The presence of hydatid cysts in livestock at slaughter is generally not of concern, and if present, is trimmed from the carcass. *E. granulosus* already exists in both wild and domestic species in California, thus recolonization of the state by wolves would not introduce the disease to California. Only people who have close contact with feces or fur of infected wolves without taking any prevention measures (i.e. wearing gloves, not washing hands after working) would be at risk of *E. granulosus* infection. Despite the parasite being present in wolves, no reports could be found of humans being infected by *E. granulosus* contracted from wolves in the contiguous 48 states.

Prevention of hydatid disease

Control of parasite infections in wild animals is difficult to unfeasible. However, because most human infections are associated with infected domestic dogs, not wildlife, regular deworming treatment of domestic dogs and good hygienic practices by humans in contact with dogs are the best methods of control and prevention. Dog owners should not allow their dog to consume uncooked meat or organs from wild or domestic ungulates or to touch or disturb wolf, coyote, or fox scat. Hunters should wear gloves when field dressing a canid carcass, and wash any body part that may have come into contact with feces or contaminated fur.

Echinococcus multilocularis

Echinococcus multilocularis, a closely related tapeworm to *E. granulosus*, utilizes slightly different hosts for its life cycle. The most common definitive hosts (which consume cysts in the infected intermediate hosts and can shed the tapeworm eggs in feces) are small carnivores (coyotes and *Vulpes* spp. foxes) (Jones and Pybus 2001). Domestic dogs and cats may also serve as definitive hosts, especially in areas where the parasite is present in urban/suburban fox and coyote populations (Eckert 2004; Catalano et al. 2012). Instead of ruminants (as in *E. granulosus*), a wide variety of small mammals serve as intermediate hosts including voles, mice, lemmings, shrews, and muskrats (Jones and Pybus 2001). In North America *E. multilocularis* is found primarily in the north central region from eastern Montana to central Ohio, as well as Alaska and Canada (Centers for Disease Control and Prevention 2012; Catalano et al. 2012). Natural *E. multilocularis* infection was recently documented in wolves from Canada (Schurer et al. 2014), but has not been reported in wolves from the U.S. *E. multilocularis* can cause alveolar (vacuolated) cysts in the tissues of people that accidentally ingest the tapeworm eggs (Moro and Schantz 2009). Although rare, alveolar hydatid infection can be severe in people and measures to prevent human infections are similar to those for *E. granulosus* (Moro and Schantz 2009). *E. multilocularis* has not been reported in the western United States (Centers for Disease Control and Prevention 2012), thus natural recolonization of California of wolves from Oregon should not pose a risk for introduction.

Neospora caninum

The single-celled protozoal parasite *Neospora caninum* can cause severe clinical disease in dogs, cattle, and other animals (Dubey 2003; Dubey and Thulliez 2005). The most common clinical sign associated with neosporosis in cattle is abortion. Dogs, coyotes and wolves are definitive hosts: when they consume ungulate tissues contaminated with *N. caninum*, the parasite reproduces in their intestines and then environmentally resistant eggs are shed in the feces (Gondim et al. 2004; Dubey et al. 2011). Cattle become infected via the ingestion of feed contaminated with oocysts or eggs shed transiently in the feces of acutely infected dogs (Barber et al. 1997). Other species including deer and raccoons can be infected with *N. caninum* and may play an important role in the disease’s spread and sylvatic cycle (Woods et al. 1994; Lindsay et al. 2001; Gondim 2006). Similar to *Echinococus, N. caninum* has a domestic dog-cow transmission cycle and most likely a sylvatic transmission cycle involving coyotes and/or wolves and native ungulates (mostly deer) (Gondim et al. 2004).

Neosporosis was first recognized as a major cause of abortion in dairy cattle in 1991 (Anderson et al. 1991). The first documentation of neosporosis in a wildlife species was in a black-tailed deer from California in 1993 (Woods et al. 1994). Since then the parasite has not been identified as causing any population level impacts in California deer (L. Woods and P. Swift, pers. comm.). Antibodies to *N. caninum* have been detected in wolves from Montana (Sime et al. 2011). Although, it is possible that wolves recolonizing California may carry and shed *N. caninum*, the risk of infection from wolves to cattle in California is low compared to the risk of infection from farm dogs and coyotes that more frequently inhabit areas in close proximity to cattle operations.

E. Summary

In general, diseases in carnivores have minimal impact on humans or domestic livestock. Most occurrences of important diseases in carnivores are associated with carnivore-specific pathogens including viruses like rabies, canine parvovirus, and canine distemper. These events usually involve public health concerns or carnivore population effects. Although concerns have been raised regarding the introduction and spread of disease as a consequence of wolves recolonizing California and elsewhere, studies to date from other states where wolf populations have re-established clearly do not demonstrate this impact. Additionally, the pathogens with transmission cycles involving canids and domestic or wild ungulates most often mentioned as concerns are already present in California.

Table 2.1 summarizes disease ecology and qualitatively assesses the risk to wolf conservation, livestock, and people from infected wolves for each disease presented in this chapter. Even though risk of disease impacts are low, a comprehensive wolf conservation and management program should include resources to investigate the causes of wolf mortality, conduct surveillance for diseases of importance to wolf conservation and interspecies transmission, and provide education regarding disease risk and appropriate prevention strategies.

Table 2.1. Summary of disease ecology data and qualitative assessment of the risk to wolf conservation, livestock, and people from infected wolves for each disease presented in this chapter. Risk is described as None, Negligible (extremely rare/unlikely when compared to other sources of infection), Very Low, Low, and Medium.

Disease (causative agent)	Disease Ecology						Risk Assessment			
	Individual wolf mortality documented	Population level effects documented	Trans-mission cycle includes other wildlife	Trans-mission cycle can include livestock	Can be transmitted to people (zoonotic)	Already present in CA	Risk to wolves	Risk to other wildlife	Risk to livestock	Risk to people
VIRUSES										
Rabies (rabies virus)	Yes (usually fatal disease)	Localized population reduction through mortality possible	Yes – primarily carnivore bats but can infect any mammal	Yes, but rare	Yes, but rare	Yes	Med	Med	Very Low	Very Low
Distemper (canine distemper virus)	Yes	Possibly reduces pup survival	Yes - carnivore	No	No	Yes, widespread	Med	Med	None	None
Canine Parvoviral Enteritis (canine parvovirus)	Yes	Possibly reduces pup survival	Yes- carnivore	No	No	Yes, wide-spread	Med	Med	None	None
Infectious Canine Hepatitis (canine adenovirus)	No	No	Yes	No	No	Yes	Low	Low	None	None
Canine Herpes Virus	No	No	Yes	No	No	Yes	Low	Low	None	None
Foot and Mouth Disease (foot and mouth disease virus)	No	No	No	Yes, primary livestock disease	No	No, eradicated from USA in 1929	None	None	None, no reports of FMD spread by wolf	None

Disease (causative agent)	Disease Ecology						Risk Assessment			
	Individual wolf mortality documented	**Population level effects documented**	**Trans-mission cycle includes other wildlife**	**Trans-mission cycle can include livestock**	**Can be transmitted to people (zoonotic)**	**Already present in CA**	**Risk to wolves**	**Risk to other wildlife**	**Risk to livestock**	**Risk to people**
BACTERIA										
Bovine Tuberculosis (*Mycobacterium bovis)*	Yes, rare	No	Yes, primarily deer	Yes, primary cattle disease	Yes, primarily from ungulate	Rare cases in dairy cattle in So. CA	Very Low	Very Low	Negligible from wolves, primary risk from cattle	Negligible from wolves, primary risk from deer /cattle
Canine Brucellosis (*Brucella canis*)	No	No	Yes, other canids	No	No	Likely occurs, but little data	Low	None	None	Yes, primary risk from dogs
Bovine Brucellosis (*Brucella abortus*)	No	No	Yes, but not in USA	Yes, primary cattle disease	Yes, primarily from cattle	No, eradicated	Very Low	Low, risk is from cattle	Negligible from wolf; primary risk from cattle	Negligible from wolf; primary risk from cattle
Swine brucellosis (*Brucella suis*)	No	No	Yes, feral swine	Yes, primary swine disease	Yes, from swine	Eradicated commercial swine, present in feral swine	Very Low	Low, risk from feral swine	Negligible from wolf; primary risk from swine	Negligible from wolf; primary risk from swine
Salmon Poisoning Disease (*Neorickettsia helminthoeca*)	No	No	Yes, complex multi-stage life cycle	No	Unknown, possibly transmitted by eating raw/ under-cooked fish	Yes, but local in north part of state	Low, may cause death of individu als	Negligible from wolf, risk is from fish	None	None from wolf, potential risk from fish
Lyme Disease (*Borrelia burgdorferi*)	No	No	Yes, tick borne disease	Yes, but primarily wildlife cycle	Yes, from tick bite	Yes	None	None from wolf, tick-borne	None from wolf, tick borne	None from wolf, risk is from tick

Disease (causative agent)	Disease Ecology						Risk Assessment			
	Individual wolf mortality documented	**Population level effects documented**	**Trans-mission cycle includes other wildlife**	**Trans-mission cycle can include livestock**	**Can be transmitted to people (zoonotic)**	**Already present in CA**	**Risk to wolves**	**Risk to other wildlife**	**Risk to livestock**	**Risk to people**
BACTERIA										
Leptospirosis *(Leptospira interrogans* serovars)	No	No	Yes, many wildlife reservoirs	Yes,	Yes, from contaminated water or urine	Yes, many water sources	Negligible	Negligible	None	None
Tularemia (*Francisella tularensis*)	No	No	Yes, mainly rabbits	No	Yes, from tick or other vector	Yes, in localized areas	None	None	None	None, risk is from vector
Plague (*Yersinia pestis*)	No	No	Yes, mainly rodents, squirrels	No	Yes, from fleas or fluids of infected animal	Yes, in localized areas	Very Low	None	None	Negligible
Anthrax (*Bacillus anthracis)*	Possible, single mortality suspected	No	Yes, ungulates primarily	Yes, primarily cattle	Yes, from exposure to infective stage of bacteria	Yes, in very localized areas	Negligible	Negligible	Negligible, primary exposure from other sources	Negligible, primary exposure from other sources
PARASITES										
Dog Louse (*Trichodectes canis*)	No	No	Yes, other canids	No	No	Yes	Very Low	Negligible	None	None
Sarcoptic Mange (*Sarcoptes scabiei*)	Yes	May reduce local populations	Yes, primarily other canids	Yes, but not common	Yes	Yes, many species, especially coyotes	Med (higher if small numbers)	Med	Negligible	Very Low, risk from handling infected animals

Disease (causative agent)	Disease Ecology						Risk Assessment			
	Individual wolf mortality documented	Population level effects documented	Trans-mission cycle includes other wildlife	Trans-mission cycle can include livestock	Can be transmitted to people (zoonotic)	Already present in CA	Risk to wolves	Risk to other wildlife	Risk to livestock	Risk to people
PARASITES										
Hydatid Cyst Disease (*Echinococcus granulosus*)	No	No	Yes, ungulate intermediate host	Yes, can include livestock	Yes, from ingestion of infected feces or fecal-contaminated materials	Yes, uncommon but has occurred in livestock and wildlife	None	Low	Low	Low-Very Low if protective steps taken handling carcasses
Alveolar Hydatid Disease (*Echinococcus multilocularis*)	No	No	Yes, small mammals are inter-mediate hosts	No, livestock are not intermed. host	Yes, from ingestion of infected feces or fecal-contaminated materials	Yes	None	None	None	Low-Very Low if protective steps taken handling carcasses
PROTOZOA										
Neosporosis (*Neosporum caninum*)	No	No	Yes, wild canids, raccoon, deer	Yes, cattle and dogs	No	Yes	None	None	Low, risk higher from dogs / coyotes	None

CHAPTER 3 HUMAN INTERACTIONS AND CURRENT PERCEPTIONS OF WOLVES

Because wolves have been largely absent from parts of the landscape in the lower 48 states, most people are unfamiliar with wolves and wolf behavior. Providing information on wolf behavior and addressing public safety concerns are important steps in achieving conservation for this species in California (also see *Public Information and Education section*).

Wolf-human interactions can take many forms. This chapter will address interactions other than human-caused mortality of gray wolves (depredation, vehicle collisions, regulated sport take, illegal take, etc.) that are discussed elsewhere in this document. Specifically, this chapter provides:

- Background on human safety
- Interactions with the public on both public and private lands
- Human attitudes towards wolves
- Strategies to address wolf-human interactions

Fritts et al. (2003) state that "Whereas wolves in some areas of Canada, Alaska, and Russia might never see, smell, or hear a human, most of the world's wolves live somewhere near people. They encounter the sights, sounds, and scents of civilization in their daily travels." For example, OR7, the dispersing male gray wolf that traveled extensively from northeastern Oregon beginning in late 2011 to northern California to eventually settle in south-central Oregon in early 2014 found a mate, denned, and now forms the breeding pair called the Rogue Pack through the recruitment of three pups by the end of 2014. Because this animal was collared by the ODFW with both Very High Frequency (VHF) and GPS capability, it is known that his travels were mostly within remote locations with little human presence.

Gray wolves worldwide are habitat generalists and highly mobile, and historically they have been limited only by prey availability and persistence (See Figure 9.1). Consequently, they have long resided in proximity to humans, particularly as humans and wolves have utilized the same native wild prey base or habitats that support domestic livestock that share resources with native ungulates or have replaced native ungulates on the landscape.

How wolves react to human presence may well depend on their experience with people. McNay (2002b) suggested that learned responses lead to behavior changes through time such that wolves in human-settled areas of Labrador, Canada in the 1970s and 1980s subject to hunting were more wary than wolves in more remote locations. It was noted that wolves on the American Great Plains were often unafraid of humans; however, after later encounters with firearms, they became secretive and elusive (Fritts et al. 2003).

A. Human Safety

Wild wolves generally fear people and rarely pose a threat to human safety. Attacks on humans by wolves are quite rare compared to other species (Wiles et al. 2011). A review worldwide of wolf attacks from 1950 up to early 2000 reviewed by Linnell et al. (2002) identified only eight records of non-rabid wolves in Europe and Russia combined involved in human fatalities. The wolf population in Europe and Russia is estimated at 50,000 animals (The Wildlife Society 2012). This is not to discount attacks from rabid wolves on humans have occurred (Linnell et al. 2002; McNay 2002b) or attacks by wolves on humans resulting from starvation, health-related conditions, human guarding of livestock where conditions have deprived wolves of wild prey (notably India), defense of territory and den sites typically from domestic dogs, wolf habituation to humans and defense behavior associated with food source, when cornered or trapped (Butler et al. 2011; Fritts et al. 2003; Krithivasan et al. 2009; Linnell et al. 2002; McNay 2002a)

This pattern is also consistent in North America with wolf populations in Canada and Alaska estimated at 70,000 animals and over 6,200 wolves in the lower 48 states (McNay 2002a; 2002b; Linnell, et al, 2002; The Wildlife Society 2012). An overview and review of 80 specific instances in Alaska and Canada from 1900-2000 is provided in McNay (2002a, 2002b).

In North America attacks on humans by wolves are very rare despite the presence of 70,000 wolves in Canada and Alaska and over 6,200 wolves in the contiguous United States (McNay 2002a; 2002b; Linnell, et al, 2002; The Wildlife Society 2012). McNay (2002b) compiled 80 documented wolf-human encounters in Alaska and Canada from 1900 to1996 with one unprovoked instance of wolf aggression between 1900 to 1969, but 18 instances of unprovoked wolf-human encounters during 1969 to 2000. The author identified increases in wolf protection; along with increases in wolf numbers and increases in human activity in wolf habitat to coincide with the rise in unprovoked attacks. An overview and review of 80 specific instances in Alaska and Canada is provided in McNay (2002a, 2002b).

Schmidt and Timm (2007) note that five wolf attacks on humans occurred in Algonquin Provincial Park, Ontario, Canada between 1987 and 2000, a location that previously had never reported such attacks. The four healthy adult wolves involved were all seen in and around campgrounds for weeks or months prior to the attacks, where they likely became habituated quickly as a result of human-provided food resources. Since 2000, the Algonquin Provincial Park has had procedures to deal with fearless wolves including monitoring, posting warnings, aggressive aversive conditioning, and, if necessary, dispatching habituated wolves (R. Stronks, pers. comm.). Although no further serious attacks have been reported, the Park has had individual wolves or packs of wolves that have displayed habituated behavior.

In 2001, two wolves were involved in a human attack at Pacific Rim National Park Reserve in British Columbia. Both wolves were lethally removed. This park is an area of high human visitation and this uncommon wolf behavior was determined to have been associated with food conditioning, park visitors not scaring away wolves when they approach close, and domestic dogs being allowed off leash resulting in an average of six dog attacks per year (T. Windle, June 2016). The park employed visitor outreach to recommend aversive conditioning to park visitors including the use of air horns, leashing dogs, yelling at wolves, etc. Additional measures including injurious harassment by park staff are employed where nessary. While one food conditioned wolf was removed since 2001, no further attacks on park visitors have occurred.

Banff National Park is another public area with wolves in proximity to high human use. Lethal wolf removal was also employed as a result of food conditioning. However, according to park staff, when wolves became conditioned to seeking out humans for a food reward rather than seeking out human food sources directly such as garbage collection sites (Bill Hunt, Banff National Park June 2016), it was clear that wolves were comfortable (fearless) in the presence of humans and the likelihood for reconditioning of these specific animals to be wary of humans was poor.

Since the early 2000s, there have been two instances in North America where attacks have resulted in human death. On November 8, 2005, a 22-year-old man in northern Saskatchewan was killed by gray wolves (Alaska Department of Fish & Game 2008). While the official investigation could not determine whether gray wolves or black bear were responsible, further evidence led a coroner's jury inquest in 2007 to determine the fatality was caused by wolves which were known to be feeding/scavenging at an unregulated garbage dump (Patterson 2007; Creative Commons 2015).

On March 8, 2010 a 32-year-old woman in Chignik Lake, Alaska was attacked and killed while jogging along a road. An exhaustive investigation by the Alaska Department of Fish and Game (Butler et al. 2011) concluded that four to six wolves were responsible for this fatality. There was no evidence indicating that wolves had become habituated or were defending a food resource prior to the attack. Of the eight wolves that were lethally taken in the vicinity, one healthy wolf was confirmed to have been involved in this attack based on DNA evidence gathered at the scene. Six of the eight wolves were in good to excellent condition and all tested negative for rabies and distemper.

In August 2013, a teenager camping in Minnesota was bitten in the head by a wolf, requiring stitches. The injuries were not life-threatening. After wildlife officials killed the wolf, which had been reported hanging around the campground in the weeks preceding the encounter, a necropsy was performed. The one-and-a-half year-old wolf had only fish spines and scales in its stomach and had severe facial deformities and dental abnormalities (likely caused by traumatic injury as a pup), and brain damage caused by infection, prompting wildlife officials to speculate that these malformations predisposed it to be less wary of people and human activities than what is normally observed in healthy wild wolves and also affected its ability to effectively capture wild prey (Minnesota Department of Natural Resources 2013).

As part of the Mexican wolf reintroduction effort within the Blue Range Wolf Recovery Area (BRWRA) of the Apache Sitgreaves and Gila National Forests (in Arizona and New Mexico respectively), a comprehensive effort has been made to monitor and document human-wolf encounters (AMOC and IFT 2005). Three categories were selected to describe and quantify these events (after McNay 2002a):

- Investigative search (wolf ignored humans or human activity)
- Investigative approach (wolf moved toward people in an inquisitive, non-threatening manner)
- Aggressive charge (wolf moved toward people rapidly)

During the time period 1998 to 2003 within the BRWRA, 33 cases of wolf-human interactions were documented (USFWS 2010). Of those, 64% were considered investigative searches where wolves ignored human presence and 27% were considered investigative approaches where wolves approached humans in a non-threatening manner. Nine percent (three reports) documented instances where wolves displayed aggressive behavior (charging) towards humans; however, domestic dogs were present and were the focus of the aggression during these encounters. Most of the investigative search and approach events also involved dogs. As a majority of these events involved wolves within three months of initial release or translocation, it was suspected that wolves recently released from captivity as part of Mexican wolf recovery efforts may have been more prone to initial fearless behavior towards humans (USFWS 2010). Adverse conditioning (e.g. cracker shells, bean bags rounds, paintballs, and rubber bullets) and/or removal of these animals in 20 of the 33 cases were used in an attempt to prevent recurrence of the behavior (AMOC and IFT 2005).

While wolves can live in proximity to humans, some have suggested that large-bodied species, including wolves, should probably be negatively (adversely) conditioned when in proximity to humans, so that an association with humans is a painful or unpleasant experience (Geist 2007). This negative conditioning, also known as injurious harassment, could include measures such as the above-mentioned use of rubber bullets or bean bags fired as projectiles. This is not to suggest however, that this action would be appropriate for all wolves wherever they may potentially occur in the California landscape.

B. Interactions with the Public

As discussed elsewhere in this Plan, wolf and human interactions can take many forms. It is reasonable to say that given the foreseeable expansion of gray wolves into California, the location of predicted wolf habitat, and experiences from other western states, these interactions and the frequency of these interactions will likely occur on both public and private lands. Wolves are fearful of humans and typical wolf reaction to humans is avoidance. As with any wild animal, reaction can vary and may depend on an animal’s prior experience with people.

In California, activities in which humans are more likely to interact with wolves include recreation (camping, hiking, hunting, fishing, wildlife viewing, etc.), revenue-generating actions that rely on use of natural resources (e.g., timber harvesting, forest fuel reductions, livestock grazing), rural agricultural activities, and vacation/residential homes on or near public lands.

In some situations the fact that wolves have followed migrating ungulate herds which wolves rely on for food could mean that wolf presence may change seasonally on the California landscape. However, it is difficult to predict whether wolves in California would exhibit this behavior. Further, it is expected that most interactions between wolves and the general public will consist of only observations. However, a smaller number of negative interactions are likely in a particular area. These are expected to be localized based on the behavior of individual wolves or wolf packs.

Public Lands

As wolf populations expand in the western United States, increases in human-wolf encounters are predictable especially where the general public may seek out these encounters on public lands.

Public land within wolf habitat is principally US Forest Service (USFS) and Bureau of Land Management (BLM) lands and, to a lesser degree due to lower acreages in California, National Park Service, USFWS, and CDFW holdings (see Figure 9.1). These areas offer the public many opportunities for recreation (fishing, hunting, camping, hiking, etc.), as well as commercial activities (livestock grazing, fuel reductions, timber harvest, etc.). Human activity is higher during the summer when favorable weather conditions coincide with most school vacations. This may increase again during the late summer/ early fall coinciding with hunting and fishing seasons. However, many public lands in California have some public use throughout the year.

Livestock grazing on public lands is generally associated with the summer months (although some grazing may occur during the spring and fall). Those people associated with the permitted use of livestock grazing allotments on public lands are expected to be present for longer time periods on these areas than those people who are present for other uses. Consequently, these individuals may have a greater potential to come into contact with wolves. This may include wolf observations but could include interactions or wolf conflict with herding and/or livestock protection dogs.

The frequency of the public's interactions with wolves outside of livestock grazing situations is hard to predict but would be expected to be low and include principally observations. While it is reasonable to expect deer and elk hunters would have greater opportunity for interacting with wolves (i.e. concentrating on the same prey), again it would be expected to be low and include principally observations. There is a greater potential for conflict if recreationists are accompanied by either hunting or companion dogs. Wolves may investigate or exhibit aggressive behavior towards other canids (e.g.

domestic dogs). Wolves are highly territorial and the presence of other canids within a wolf territory may illicit territorial defense by one or more wolves, leading to threats or attacks against hunting or companion dogs. It is expected that these events would be infrequent or rare. It is recommended that people who are recreating with dogs in wolf-occupied public lands take precautions to keep their dogs close and under control.

Other activities where the public may come into contact with wolves on public land could include timber harvesting actions involving private contractors conducting these operations. It is anticipated that timber harvesting and fuel reduction activities on public lands would take place outside seasons marked by inclement weather (i.e. rain and snow). Conversely, activities associated with prescribed fire would likely take place during the times where inclement weather is more likely to occur and prescribed fire can be done with less risk of fire escape. These are temporal public land activities and would be expected to occur on some public lands but not within the same watersheds yearly. Observations of wolves would be expected to increase with greater presence of humans on the landscape but such instances are still expected to be low.

Private Lands

Private lands comprised of commercial timberlands and/or rangelands located in proximity to public lands supporting ungulate habitat would be predicted to support wolf populations. While human activities on private timberlands are expected to be temporal (i.e. timber harvesting practices will be conducted somewhere on the landscape during portions of the year) and regularly change location, private rangelands are typically under management year-round. It would be expected that wolf-human interactions on private lands would be similar to those on public lands (i.e. observations) and potential conflicts with wolves would consist of interactions between wolves and companion, hunting, herding, and/or livestock protection dogs. It is also anticipated that conflicts would include wolf-livestock interactions and some depredation, even when non-lethal conflict-deterrence measures are in place.

Most potential wolf occupancy on both public and private lands may never involve interactions with people other than observations. A smaller number of negative interactions may occur in localized areas based on the behavior of individual wolves or wolf packs.

C. Human Perceptions and Attitudes towards Wolves

Human attitudes toward wolves vary from reverence to hatred, and are the result of a long history of interactions dating to prehistoric times (Fritts et al. 2003). Negative attitudes toward wolves may be deeply ingrained, both as a result of adaptive "biophobic" responses to wildlife with potential to cause us harm (Ulrich 1993), as well as concern over the negative impacts that wolf depredation of livestock can have on agricultural producers and rural economies. Competition for native ungulate prey also induces negative attitudes toward wolves from hunter groups (Fritts et al. 2003).

Cultural and historical associations can influence public attitudes and beliefs regarding large carnivores and many of our current perceptions about predators are based almost exclusively on the Euro-American viewpoint (Kellert et al. 1996). Common perceptions however, do not always correlate with actual wolf behavior (Fritts et al. 2003; Kellert et al.1996; MacMillan 1998).

Figari and Skogen (2011) sought to determine how wolves in Norway are perceived and whether this cultural perception could lead to a greater understanding of conflicts that often follow recovery and expansion of this species. One aspect of the study was the underlying perception regarding the natural physical environment. Farmers and hunters viewed the natural environment as a "landscape for sustainable use, as productive areas for logging, grazing, hunting and berry picking…" Those from urban environments viewed the same area as "untouched nature, or wilderness" where it represented both an actual place and an essence far removed from the developed cities where "human bonds with nature are lost". This is consistent with results from other studies (Kellert et al. 1996). It was concluded that the conflicts over wolves were not necessarily between the positive and negative images of wolves but the result of a conflict between social representations of the wolf and representations of other phenomena.

Researchers have conducted a number of surveys to measure human attitudes towards wolves (ranging from positive to negative) or wolf restoration, to gauge public support for such activities. Most of these efforts were conducted prior to wolf restoration and very few occurred post wolf occupancy. Williams et al. (2002) reviewed 39 surveys (from a list of 83 research papers) that contained quantitative data collected between 1972 to 2000, to assess whether attitudes towards wolves differed across social groups, differed across geographical regions, and/or have changed over time. The studies reviewed took place in North America, Scandinavia and Western Europe. The authors also indicate that attitude studies "…are episodic, usually accompanying some political crisis, such as the Yellowstone introduction."

Generally, Williams et al. (2002) determined that positive attitudes toward wolves have not increased over this period but remained stable over the last 30 years. The authors also attribute positive attitude changes in the United States occurring between the 1930s and 1970s to be a result of greater awareness and support of environmental protection nationwide. Other studies conducted in Utah in 1994 and later in 2003 (Bruskotter et al. 2007) supported this conclusion. Average support for wolves was higher among members of the public who did not live in an area with wolves than among people who lived near wolves. The authors also suggest that attitudes where wolves are returning may become more negative as people experience and interact with wolves (Bruskotter et al. 2007). For example, in Sweden, where wolves have recovered in some areas, the general public and hunters both who expressed support for wolves “are still positive, but not as positive as they were more than 20 years ago pre-wolf” (Ericsson and Herberlein 2001).

Other research indicates that attitudinal changes for those publics not supportive of wolves and wolf restoration are resistant to change even with educational campaigns (Kellert et al. 1996; MacMillian 1998). The people most likely directly affected by wolf restoration (farmers, livestock owners and rural residents) may hold the perception that wolves are likely to affect economic interests or are a symbol of urban dominance (Ericsson and Herberlein 2001; Zimmerman et al. 2001; Rodriquez et al., 2003; Lynn 2010). Further, Williams et al. (2002) suggest that members of the public with the most positive attitudes toward wolves typically have the least experience with them. MacMillian (1998) concluded that after wolf reestablishment in southern Tuscany, Italy, the “clearest predictor” of human attitudes towards the wolf “was their degree of connection to the locale affected by predation.” In this particular case, wolves prey on domestic sheep. A series of public attitude surveys (conducted from late December 2007 to the fall of 2009) that queried respondents about natural resource management (and included questions about wolves) were conducted in Washington and are summarized in the Washington Wolf Conservation and Management Plan (Wiles et al. 2011). Surveyed individuals included residents 18 years old and older in January 2008 (Duda et al. 2008a), hunters 12 years old and older from December 2007 to February 2008 (Duda et al. 2008b), and residents in the fall of 2009 (Dietsch et al. 2011). It should be mentioned that the number of wolves in Washington during this time period included one wolf pack in 2008 (unknown number of wolves) to two wolf packs in 2009 (minimum number of five wolves). At the end of 2014, at least 68 wolves and 16 wolf packs reside in Washington (Becker et al. 2015). While not an exhaustive list of all the results, these survey results include: 1) the majority (74%) of respondents were supportive of wolves in Washington; 2) residents who lived in urban/suburban areas were more supportive of wolf recovery; 3) residents who lived in rural areas including ranches and farms were more likely to oppose wolf recovery; 4) most residents support some level of lethal wolf control to protect at-risk livestock; 5) when the stipulation is put on wolf recovery resulting in localized declines in Washington elk and deer populations, support for wolves declines; 6) more residents thought that the state’s wolf population should not be allowed to impact deer and elk numbers to the point that public hunting of these ungulate species becomes more restricted; 7) more residents thought that the most effective method for managing wolves is to educate the public about how to live with wolves; 8) somewhat more residents believed that wolves should be managed by hunting; 9) and most residents favored using state tax funds to manage wolves.

In Wisconsin, researchers investigated possible changes in the public’s attitudes about wolves in 2001, 2003, and later in 2009, targeting those who resided in areas occupied by wolves (Treves et al. 2013). The authors concluded that over this time period (and with increasing wolf abundance in Wisconsin from 257 to 655 animals) there was a decline in tolerance for wolves as a response to fear for personal safety and effects on deer populations. This decline in tolerance for wolves occurred in spite of livestock depredation by wolves declining in that state by one third. The same group of public participants were resampled in 2013 to detect changes in public attitudes after Wisconsin conducted its first regulated wolf hunt (Hogberg et al. 2013). Reported tolerance for wolves did not increase but demonstrated a decrease among males residing in wolf range. To date, these four quantitative survey efforts conducted from 2001 to 2013 represents a measurable collection of a subset of Wisconsin resident's attitudes towards wolves in this state; however they encompass a relatively short period of time in wolf recovery and only one year post-legal harvest of wolves. Other research suggests that changes in human attitudes may take many years (Treves and Martin 2011).

Another Wisconsin study delving further into the perceptions of three affected stakeholder groups (i.e. livestock producers, deer hunters, and bear hunters who use hounds) was more revealing as to the basis for their respective viewpoints (Browne-Nunez et al. 2012). The groups were surveyed twice: early 2011 and late 2012. Within two of the groups (livestock producers and bear hunters) all participants within the study had experienced damage to livestock or injury or death of hunting dogs[9] and consequently had less tolerance for wolves than deer hunters. Other basis for their views involved an unclear understanding of Wisconsin's wolf management/population goals, public safety, fearlessness of wolves, lack of empowerment in dealing with wolves, tolerance of illegal take of wolves, a lack of confidence in successful non-lethal measures, and lethal take. Information gathered from these types of studies, which use both quantitative and qualitative methods, may lend greater insight for future efforts by state agencies to address wolf tolerance. While each state will respond to similar wolf tolerance (or intolerance) issues, it should also be noted that these studies may not be generally applicable to other states where comparable data is limited (Williams et al. 2002).

It remains to be seen whether other areas of the western U.S. (Utah, Colorado, and California), that currently have no or few wolves, will see similar changes in public attitudes. Nevertheless, this provides reasons for cautionary management actions (or inactions) regarding wolf reestablishment, and points to the need to regularly gather scientifically credible information on public attitudes.

While understanding the public's attitude about wolves is important for wolf conservation, other authors have recognized that cultural history (and perceptions) and political symbolism are the best context for understanding wolf politics and political decision making in wolf management and restoration (Nie 2001).

[9] A significant portion of dog depredation incidents in Wisconsin involved hounds and/or hound training in the field. Based on the Annual Wolf Damage Summary from 1985-2014 (http://dnr.wi.gov/topic/wildlifehabitat/wolf/documents/WolfDamagePayments.pdf), 318 verified claims were reported for dogs killed (267) or injured (91). Seventy-five percent involved hound-type hunting dogs.

CHAPTER 4 WOLF AND DOMESTIC DOG INTERACTIONS

As discussed previously, wolves are from the canid family, which in North America also includes coyotes, foxes and domestic dogs. Canids may share many similar traits such as social ecology (pack and pair behavior), food habitats (eating meat), territoriality, and communication.

Domestic dogs (*Canis familiaris*) have a long history and close association with humans for a variety of reasons. These include dogs as companion animals (pets) and guard dogs, as well as working dogs that include hunting and retrieval activities, herding, livestock protection, law enforcement, search and rescue, and service animals. For purposes of this chapter, wolf and domestic dog interactions include livestock protection dogs, herding dogs, hunting and retrieval dogs, and companion dogs.

Wolf biology suggests that packs are highly territorial and protective around active dens, rendezvous sites (during pup rearing), and feeding locations. Other canids that compete for prey and/or other wolves from one pack that cross territorial boundaries can be attacked and/or killed by pack members within that different territory. Thus, domestic dogs may elicit an attack by wolves defending their territory or pups. Wolves have been documented to attack dogs accompanying people, and also to approach and/or follow people with dogs (McNay 2002, Alaska Department of Fish & Game 2008).

Wolves and domestic dogs have the potential to come into contact with each other through human activity in rural or remote landscapes where wolves have reestablished in other western states or are likely to reestablish in California. Although most wolf-dog altercations in the western states have occurred in remote locations, wolves have occasionally fought with dogs near homes, even when people were nearby (Wiles et al. 2011).

Hunting dogs, such as those used to take furbearers, will likely be at the greatest risk when hunting in wooded areas where they are relatively far from and out of sight of their owners. Conditions favoring such circumstances are common in the Klamath Mountains, southern Cascades, and Sierra Nevada. Livestock protection dogs are commonly used to protect sheep, and thus will likely be at greatest risk in those areas where sheep are most common. Companion dogs will likely be at greatest risk in rural-residential areas abutting suitable wolf habitat.

Depredation on domestic dogs by wolves has included losses and injuries throughout the United States where wolves have expanded their range (e.g., Wisconsin, Michigan, and Montana). These numbers vary by state from zero annually to more than a dozen (25 reported in 1998 in Minnesota). In Idaho, Montana, and Wyoming, 169 dogs were confirmed as killed by wolves from 1987-2014 (USFWS et al. 2015). Dog depredation has increased with increasing wolf abundance (Figure 4.1). Fewer domestic dog deaths/injuries are reported in western states (as compared to the Great Lakes region); specifically Oregon and Washington combined have reported five confirmed dog injuries and no confirmed dog fatalities since recent wolf reestablishment.

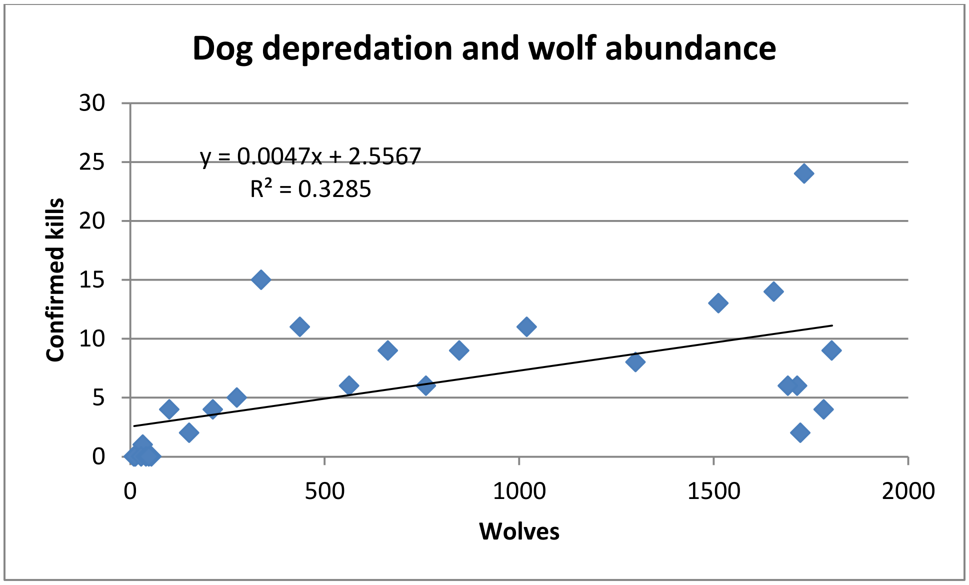

Figure 4.1. The relationship between confirmed domestic dog depredation and wolf abundance in the NRM DPS, 1987-2014. Data from USFWS et al. 2015.

A. Livestock Protection and Herding Dogs

Livestock protection dogs are commonly employed in rural or remote landscapes to protect sheep from predators such as mountain lions, coyotes, and bears. Success of livestock protection dogs has varied when employed for protection against wolves, although there is ongoing research to determine if some larger European dog breeds may be more effective than more commonly used breeds in the western United States (USDA/APHIS Wildlife Services 2014).

Other locations where livestock protection and herding dogs are used include the rural-residential landscape where property sizes tend to be smaller. In California, livestock in these areas tend to include cattle, sheep, goats, horses, donkeys, and llamas. In addition, these rural-residential landscapes are often located between more developed residential features (subdivisions, highways) and larger property sizes supporting agriculture as a primary economic activity, and/or next to public lands that support deer and elk.

B. Hunting Dogs

Hunting dogs include those used to assist the hunter in locating birds or game and retrieval of downed birds such as waterfowl, grouse, pheasant, chukar, etc. Dog types typically include retriever, pointer, and flushing breeds. These kinds of activities are with one to two dogs usually in close proximity to the hunter/owner where the dogs are largely silent during hunting and/or retrieval efforts.

Other types of hunting dogs (e.g., hound breeds) include those used for finding and "treeing" game. These dogs fix on scent or sight of game, pursue, and with some breeds, tree game species until the hunter/owner can catch up with the hounds (generally two or more dogs) at the "treed" location. This is accompanied with constant vocalization (aka baying) by hounds. In general, these types of hunting efforts are not within the general proximity of the hunter/owner. For legally hunted game species such as bear and bobcat, the use of hounds for hunting is not legal in California. Other game species (raccoons, gray foxes, a variety of upland birds, etc.) can still be hunted with the aid of hunting dogs.

In review of the various reports available by state, Wisconsin by far has the highest level of wolf depredation on domestic dogs. A significant portion of dog depredation incidents in Wisconsin involved hounds and/or hound training in the field. Based on the Annual Wolf Damage Summary from 1985-2014 (http://dnr.wi.gov/topic/wildlifehabitat/wolf/documents/WolfDamagePayments.pdf), 318 verified claims were reported for dogs killed (267) or injured (91). Seventy-five percent involved hound-type hunting dogs. Oregon has to date two unconfirmed wolf-dog incidents that were not reported but were brought to the attention of the ODFW (Russ Morgan, pers. comm.) and two confirmed dogs injured in 2014 (ODFW 2015). Washington has confirmed 5 dog injuries since 2011 (Becker et al. 2015).

C. Companion Dogs

Companion dogs include pets associated with households, which are not working dogs per se. These dogs may come into contact with wolves as a result of hiking or camping with their owners in wolf-occupied habitats. Although these dogs are not always leashed when traveling with their owners while hiking, they are more likely to be near their owners in some fashion. Hikers and campers with companion dogs within known wolf territory should minimize distance between dogs and owners, ideally leashing their dog(s) for protection during sudden encounters with wolves and/or other wildlife.

Wolves may come into contact with companion dogs near residences within the rural and rural-residential landscape of California. Outside of California, wolves have been known to attack and kill domestic dogs near ranches and rural homesites. While difficult to predict, it would be expected for this to occur infrequently as wolves generally avoid humans and developed areas.

D. Wolf-Dog Hybrids

The California Code of Regulations Title 14 section §671[10] (c)(2)(K) identifies wolves as a "restricted species" subject to permit for possession and regulated by CDFW. "Wolf hybrids; those animals composed of wolf *Canis lupus* x domestic dog *Canis familiaris* are considered F1 generation[11] wolf hybrids and are also restricted." The law provides that the progeny or offspring of F1 generation wolf hybrids do not require a state permit but cities and counties may prohibit possession or require a permit (Title 14 §671 (c)(2)(K) 2.a.i.). These animals are considered domestic dogs and are regulated by local city and county government.

Sources for advertised wolf-dog hybrids are readily available nationwide, where many states including Oregon, Washington, Colorado, Montana, and New Mexico, regulate them as domestic dogs although some local governments have the ability to regulate or prohibit possession (and some jurisdictions within Oregon and Washington have recently done so). How much crossing of wolf and domestic dog these animals possess is likely unknown. An estimated 10,000 wolf-dog hybrids existed in Washington in the late 1990s (Wiles et al. 2011).

Linnell et al. (2002) reported that pet wolves and wolf-hybrids killed at least 13 children and injured at least 43 in North America from 1981 to 1999. This illustrates why these animals do not make good pets. Depending on the amount of back crossing with domestic dogs, in general, hybrids and pet wolves possess physical strength, a lack of shyness, and predatory instincts that may make their behavior unpredictable in many situations (Fritts et al. 2003). This is not to discount or compare injuries and fatalities to humans from domestic dogs, merely to illustrate why in California possession of wolves and F1 generation hybrids are restricted.

Hybridization between wild wolves and domestic dogs is possible, but rarely has been documented in the western states and to date has not been a factor in wolf recovery (USFWS 2013a). Releases or abandonment of wolf-dog hybrids in the wild has occurred but the survival of these animals is poor. These animals are likely to resort to depredation on livestock and associate more closely with humans than wild wolves (Idaho Legislative Wolf Oversight Committee 2002). Some humans may even release wolf-dog hybrids into the wild in a misguided attempt to reestablish wolves to their historical range (Ed Bangs, pers. comm. 2010).

[10] California Code of Regulations, Title 14. Natural Resources Division 1. Fish and Game Commission-Department of Fish and Wildlife

[11] F1 generation is identified as the offspring (first generation) of a pure wolf crossed with a pure domestic dog.

Reports have been received of encounters with these free-roaming wolf-dog hybrids in the wild in California including animals on or off leashes, or abandoned and free roaming (Chris Brennan, pers. comm. 2011). Reports from USDA/APHIS Wildlife Services (Chris Brennan, pers. comm. 2011) in northern coastal California indicate that incidents involving wolf-dog hybrids increased in the early 2000s, with numerous animals taken as a result of livestock damage. It was reported that these animals appeared to be, or allegedly were, malamute-wolf or pit bull-wolf crosses, could roam 10-15 miles in a day, and were inefficient predators. These hybrids were, however, easily removed by livestock owners or USDA/APHIS Wildlife Services personnel.

There have been three confirmed wolf-domestic hybridizations between Mexican wolves and dogs since 1998 when reintroduction began in the southwest of central Arizona and New Mexico. The pups that ensued from these matings were humanely euthanized, with the exception of one pup the status of which remains unknown (USFWS 2013a).

Since the wolf reintroductions within the Northern Rocky Mountain region in the mid-1990s, only one breeding of a domestic dog with a wild wolf was confirmed in the state of Idaho. These pups were similarly humanely euthanized (M. Jimenez, pers. comm.). In 2014 in Washington, however, a large Great Pyrenees was seen in the company of the Ruby Creek wolf pack in January and February. This pack has no male wolves. It was suspected that one of the female wolves had mated with this domestic dog. The state agency captured the wolf, discovered it was pregnant, had it spayed, and returned it to the wild (Washington Department of Fish and Wildlife 2014a). The wolf was later hit by a vehicle and killed (Washington Department of Fish and Wildlife 2014b). There was never any DNA confirmation of the pups and the dog, but Washington believed the wolf and the dog bred (M. Jimenez, pers. comm.).

Similarly, a recent hybridization between a wolf and domestic dog on Vancouver Island, British Columbia was believed to be a result of the small size of the wolf population and lack of available mates when wolves were recolonizing (Wiles et al. 2011).

E. Avoiding Wolf and Domestic Dog Conflicts

In general, wolves will avoid domestic dogs in the presence of humans, as most attacks occur away from human presence (Bangs et al. 2005). Even after initiating an attack, wolves will curtail aggressive behavior and leave in the presence of humans. As a consequence, domestic dogs far removed from owners (i.e. hounds used in hunting, dogs allowed to roam freely without human oversight, and unattended livestock protection dogs guarding livestock) are at greater risk where wolves are present. Hounds may be at additional risk due to constant vocalization that may attract territorial wolves.

Except where noted, listed below are strategies to avoid wolf and domestic dog conflicts excerpted and modified slightly from the Washington Wolf Conservation and Management Plan (Wiles et al. 2011) in areas occupied by wolves. Many of these steps are similar to what the Department recommends to avoid conflict with a variety of other wildlife species, including bears and mountain lions.

Livestock protection and herding dogs

- Working dogs associated with livestock appear to be more effective and less at risk from wolf interactions when an adequate number of dogs per herd are present with the presence of trained herders. Working dogs and trained herders may be more effective for protecting sheep flocks than cattle (ODFW 2005).

Hunting dogs (hound breeds)

- Avoid releases in areas with fresh evidence of wolves.
- Release hounds only on fresh sign of the target species to avoid long chases.
- Yell or make noise when releasing hounds and going to tree.
- Reach hounds at trees as quickly as possible so they are not unattended for long periods.
- Leash dogs at trees to control them.
- Place bells or beeper collars on hounds.

Hunting dogs (retriever, pointer, and flushing breeds)

- Keep dogs within sight.
- Place bells or beeper collars on dog(s).
- Bring a leash to restrain dogs if wolves or wolf sign are encountered.
- Use a whistle and talk loudly to dog(s) and other hunters.

Companion dogs

- Do not leave dogs outside overnight unless they are kept in a sturdy kennel.
- Avoid letting dogs outside for bathroom breaks after dark except in areas with good lighting or fencing.
- Keep dogs on a leash or in visual/auditory range on walks and vocalize regularly including the use of whistles.
- Do not allow dogs to roam at large. Dogs running loose may attract wolves.
- Train dogs not to chase or approach wildlife, and to return on command.
- Do not leave dog food outside at night.
- Avoid feeding wildlife near one’s home.

When hiking or camping in areas occupied by wolves:

- Consider leaving dogs at home.
- Bring a leash to restrain dogs if wolves or wolf sign are encountered.
- Keep dogs on a leash when walking/hiking in known wolf habitat.
- Consider placing a bell on the dog’s collar.

If hikers/campers encounter a wolf:

- Bring the dogs to heel at your side or put them on leash as quickly as possible.
- Pick up small dogs to minimize potential contact.
- Stand between the dogs and the wolf, which often ends the encounter.
- Do not attempt to break up a fight between a wolf and a dog, which could result in injury to you.

CHAPTER 5 WOLF INTERACTIONS WITH OTHER WILDLIFE SPECIES

Available historical information on wolf related to distribution, abundance and ecological role for California is nonexistent or extremely limited. The impacts discussed here are based on information gleaned from studies from other locations that have uncertain or limited application to current and future conditions in California. Therefore, this information is included as a preliminary assessment that will be revised once we have data specific to California that has greater predictive value. This chapter includes a discussion of potential wolf interactions with other non-prey species, with an emphasis on those most likely to be affected by wolves in California, including coyote, mountain lion, and black bear. Potential interactions with scavenging species that may take advantage of wolf kills and California species identified as threatened, endangered, and special concern are also presented.

A. Wolves and Other Carnivores

Gray wolves coevolved with a variety of other carnivores in many different habitats. In Washington state, recently recolonized wolves are known to occupy habitat with mountain lions, coyotes, black bears, grizzly bears (*Ursus arctos horribilis*), bobcats, lynxes (*Lynx canadensis*), red foxes, river otters (*Lutra canadensis*), wolverines (*Gulo gulo*), American badgers (*Taxidea taxus*), fishers, American martens, minks (*Mustela vison*), long- and short-tailed weasels (*Mustela frenata; M.erminea*), spotted and striped skunks (*Spilogale gracilis; Mephitis mephitis*), and raccoons (*Procyon lotor*) (Wiles et al. 2011). How wolves interact with other carnivores depends upon the habitat, environmental conditions, degree of dietary overlap, and other factors (Ballard et al. 2003; Wiles et al. 2011).

The arrival of recolonizing wolves creates several potential forms of competition with existing predators: interference competition (competing predator species kill each other) and exploitative competition (predator species consume the same prey species) (Ballard et al. 2003, Wiles et al. 2011). However, sympatric predators that consume similar prey generally partition this resource via different hunting strategies (e.g. coursing or ambush or opportunistic), and predator number (i.e. single vs. pack), prey size (age, season), and habitat preferences. Wolves can coexist with other native predator species, although the presence of wolves may change the relative abundance of smaller predators (Crooks and Soule 1999). In California, wolves would likely occupy habitats supporting a variety of medium- and large-sized carnivores including black bear, mountain lion, bobcat, coyote, badger, fisher, red fox and gray fox.

Wolves, as apex predators, may substantially influence the composition of the communities they occur in, well beyond the direct effects on competing predators and the species they prey upon (Hebblewhite and Smith 2010). The effects of competition between wolves and smaller native predators on prey species and vegetative communities are complex and may be dramatic (Prugh et al. 2009). As mentioned previously, researchers have studied theorized trophic cascades (changes at multiple levels of a community's food web) caused by recolonizing wolves where wolf predation reduces herbivore density, which in turn releases plants from herbivory (Prugh et al. 2009). The theory suggests that changes to vegetative communities indirectly brought about by the presence of wolves could affect many native California wildlife species that wolves would not be expected to directly interact with. Mech (2012) cautioned that the cascading effects of wolves on ecosystems has largely been studied inside national parks in the United States and Canada and believes those observations likely have little relevance to the rest of the wolf's range (for example the NRM) because of the overriding anthropogenic (human-caused) influences on wolves, their prey, vegetation, and other parts of the ecosystem outside of national parks. Hebblewhite and Smith (2010) indicate the effects of wolves on other species observed in Parks may be dependent on wolves being allowed to build populations to some minimum saturation wolf density where pack territories are contiguous. These densities may not be realized in California. As such, it is impossible to predict the effects that wolves recolonizing California will have on other native wildlife**.** Wolves share their environments with many animals besides those they prey on, and can impact the communities they live in beyond the obvious effects on their prey (Hebblewhite and Smith 2002). However, to date, the majority of wolf-related research in North America has centered on the interactions between wolves and their prey. Information on wolf interactions with non-prey species is largely limited to anecdotal information (Ballard et al. 2003).

While the presence of a new apex predator in California will assuredly affect the existing predator community, evolutionary theory suggests that native predators in communities co-evolved by occupying different ecological niches (i.e. partitioning the available resources of the ecosystem through different anatomical and behavioral specializations) (Ricklefs 1990). Interference competition is most common between species that are moderately different in size and less common between species that are very similar or very different in size (Donadio and Buskirk 2006). For wolves in North America, the strongest interference competition has been documented with coyotes and mountain lions (Ballard et al. 2003), presumably due to the relative sizes of the species. Exploitative competition for resources can be mitigated through shifts in habitat use and time, and through behavioral changes, such as forming groups, which may be better able to fend off larger predators than individuals alone (Palomares and Caro 1999).

Wolves and Other Canids

Strong interspecific competition between wolves and coyotes has been documented and expected due to the morphological similarity of the species, dietary overlap, and the fact that wolves are roughly two to five times larger than coyotes (Ripple et al. 2013). In North America, wolf-coyote interactions vary from wolf-mediated coyote extinction (e.g. Isle Royale, Michigan), to co-existence with minimal competition (Kenai, Alaska), to increased numbers of coyotes from scavenging wolf kills (Manitoba) (Gese 2006). The potential effects on coyotes from the presence of wolves in California are unknown, and will likely vary from location to location.

Crabtree and Sheldon (1999) reviewed several studies of sympatric canid species throughout the world and hypothesized that canid co-existence is primarily a function of avoiding fatal encounters with other species while simultaneously securing and defending adequate prey to survive and successfully reproduce. The authors found that communities with three canid predators (one large, one intermediate, and one small) are common throughout the world's ecosystems (e.g., wolf, coyote, and red fox in much of North America). Sympatric canids use a variety of behaviors to that end, including:

- Spatial Avoidance**:** The disproportionate relationship between body size and territory size (i.e. slightly larger species have much larger territories), allows for the interspersion of small species home ranges between and on the edges of the home ranges of larger species (e.g., red fox home ranges between coyote and wolf home ranges). Additionally the probability of an individual of a smaller species encountering an individual of a larger species is low due to the large amount of area within the larger species' home range.
- Behavioral Avoidance**:** Smaller species make use of visual, olfactory, and auditory cues to avoid potentially fatal encounters with larger species. This may include using different temporal activity periods in the same area or using different spatial areas.
- Scavenger Potential**:** Very large ungulate prey items may require multiple feeding bouts separated by periods of rest and digestion for large canids (e.g. wolves) to consume. This allows opportunities between feeding bouts for smaller canids (e.g., coyotes and red foxes) to scavenge in relative safety.
- Effective Group Size**:** Smaller canids can achieve some security from attacks by larger species and defend food resources to some degree by forming groups. In YNP all observed fatal wolf attacks on coyotes involved a solitary coyote, although there is anecdotal information of a pair of wolves which in the presence of three adult coyotes dug out a coyote den and killed two coyote pups (http://www.thewildlifenews.com/2014/07/14/lynch-july2014/)
- Groups of coyotes have been observed attacking single wolves and usurping their kills.

Notwithstanding their ability to coexist in the same locations, the historical elimination of wolves from parts of North America had a great impact on coyotes and red foxes. Based on our understanding of pre-European conditions, coyotes and red foxes have each greatly increased their range in North America as the wolf range has decreased (Crabtree and Sheldon 1999). Coyotes are now found in most habitats although they are best adapted to arid and open shrub-grasslands. For example, pre-1890 records from the YNP area indicate coyote sightings were rare while wolf and fox sightings were common. By 1927 trapping records indicate coyotes vastly outnumbered wolves (Crabtree and Sheldon 1999).

Where wolves are absent in the western United States, reported coyote densities range from 0.7-1.3 coyotes per square mile (0.27-0.5/km^2.) in rural and wild environments, and up to 7.8 coyotes per square mile (3/km^2) in urban environments. Conversely, where coyotes and wolves coexist in the Yukon, densities ranged from 0.036-0.233 coyotes per square mile (0.014 – 0.09/km^2) (Ripple et al. 2013).

Coyote numbers were documented to decline in the Lamar Valley of YNP following wolf reintroduction from wolves directly killing coyotes, and presumably from wolves displacing coyotes from areas occupied by wolves (Gese 2006). Several phenomena were noted by Gese (2006) when wolves arrived in the Lamar Valley of YNP following reintroduction, including: a decrease in the mean coyote pack size, coyotes killed by wolves at wolf kill sites, increased coyote use of ungulate carcasses, and less time spent by coyotes resting and more time spent traveling. In documented observations from YNP, wolves dominated in 121 of 145 encounters with coyotes, with coyotes only chasing wolves away in four instances, all four of which involved at least as many coyotes as wolves (Ballard et al. 2003). Ballard et al. (2003) speculated that coyotes may be excluded by wolves in areas where deer are the primary prey of wolves because wolves are able to consume an entire deer carcass after killing it, leaving no food behind for scavengers. Where larger prey like elk and moose are wolves' primary prey, the two species may coexist because coyotes can scavenge carcasses. Lastly, Arjo et al. (2002) concluded that wolves and coyotes may efficiently partition shared resources by using food items differentially (e.g. selecting for different age classes or sizes of similar prey species depending on season and prey encounter rates).

The interactions between wolves and coyotes may have important ramifications for prey species. For example, Berger et al. (2008) found a chain of community interactions in the YNP area whereby the presence of wolves reduced coyote densities and pronghorn fawn survival rates increased to four times that of the survival rate in areas without wolves. The change was attributed to reduced coyote predation on neonate pronghorn. Similar interactions may occur with other species heavily preyed upon by coyotes.

The observed decline in coyote numbers and density in YNP shortly after the arrival of colonizing wolves appears to have been a temporary phenomenon. Prior to the arrival of wolves in the Lamar Valley of YNP there were 11 coyote packs in the valley. The number of packs declined to six after wolves arrived, but later increased to 12 (R.L. Crabtree and J. Sheldon, pers. comm. *in* Hebblewhite and Smith 2010). Recent research (Berger et al. 2008) has revealed that where wolves are present in the greater YNP area, resident coyote densities are similar to areas where wolves are absent; however, the number of transient coyotes is significantly lower. No resident coyotes were observed to be killed by wolves during their four-year study while more than 50% of transient coyote mortality was attributed to wolves.

CDFW has observed the presence of three coyotes in proximity to OR7 in Modoc County, California in early May 2012. There was no obvious coyote displacement during this brief encounter; however, it may illustrate the uncertainty regarding wild canid behavior during these interactions, particularly where coyotes have no prior association with wolves, coupled with the behavior of a single dispersing wolf in these situations. There was speculation that the presence of a coyote den nearby may have contributed to the wariness of the attending coyotes.

Several studies verify interference competition between wolves, coyotes, and red foxes, including fighting, killing, direct displacement, and relegation to inferior habitats, yet the three species persist in sympatry in many areas of North America (Crabtree and Sheldon 1999). Although wolves have been observed killing red foxes (usually near wolf kill sites) (Ballard et al. 2003), the aggressive interactions are normally wolf on coyote and coyote on fox. Levi and Wilmers (2012) found strong correlational evidence that the renewed presence of wolves in Minnesota reduced the number of coyotes, which in turn increased the number of red foxes. They speculate that wolves are more likely to kill coyotes than red foxes because wolves perceive coyotes as more direct competitors due to similarity of diet and larger size.

Evidence of red fox avoidance of coyotes is widespread. In a study in Maine, red foxes established territories at edges of coyote territory boundaries or between coyote territories, thereby avoiding overlap and potentially adverse interactions (Harrison et al. 1989). Further, a later study conducted in Illinois (Gosselink et al. 2003) found urban red foxes spatially avoided coyotes by using human-associated habitats such as abandoned farms and rural residential areas. In Wood Buffalo National Park, Alberta, and the Kenai Peninsula of Alaska there is evidence of red fox population increases following the arrival of wolves (Ballard et al. 2003). The authors believe that on the whole, the recolonization of wolves is thought to have benefitted red foxes because wolves kill coyotes more frequently than they kill foxes, and wolf kills provide scavenging opportunities for foxes (Ballard et al. 2003).

Gese (2006) expected the number of red foxes to increase in the Lamar Valley of YNP with the arrival of reintroduced wolves due to reductions and displacement of coyotes. Further, due to increased fox numbers, a decrease in small mammal numbers was also expected. However, Gese's (2006) prediction regarding the population of red foxes in the Lamar Valley has not been rigorously studied, and YNP biologists have not observed signs of a significant increase or decrease in the Lamar Valley red fox population during the period following the colonization of wolves (D. Smith, pers. comm. August 2014).

In Saskatchewan, Canada (where wolves were present) and Manitoba, Canada (where wolves were absent), Newsome and Ripple (2014) compared harvested pelts from coyotes and red fox as a measure of population density of those species. Their results suggest that in areas with wolves, red fox outnumber coyotes and inversely, where wolves are absent, coyotes outnumber red fox. The authors caution, however, that wolves would need to occupy large continuous areas (at effective densities) to facilitate this effect (Newsome and Ripple 2014).

Much of California is home to native and introduced red fox and gray fox, with desert areas occupied by San Joaquin and desert kit fox. How wolf-coyote-fox interactions manifest in California with recolonizing wolves remains to be seen, but information from other areas indicates there is at least the potential for reduced coyote and increased fox populations. Implications of potentially increasing sensitive fox populations are discussed below.

Wolves and Mountain Lions

Information on sympatric wolves and mountain lions (also known as cougars) suggests that the interactions of these two species are variable. Although the hunting strategies of wolves (long distance pursuit) and mountain lions (ambush and short pursuit) are markedly different, Kunkel et al. (1999) found little evidence of differences in prey species selection in their study of the two species in Glacier National Park (GNP). In the study area deer greatly outnumbered elk, and both predator species were selecting deer over elk and were killing deer of similar age, sex, and body condition. The authors speculate that the apparent lack of prey specialization was a function of the location, topography, thick vegetative cover (which precluded the normal coursing behavior of hunting wolves), concentrations of vulnerable wintering deer, and extremely high prey densities (i.e. the availability of prey in the study area was so great that the level of competition between wolves and mountain lions for food resources was quite low). Other studies of the hunting habits of these two species have shown that wolves will select elk over deer given equal encounter rates (Atwood et al. 2007). Kunkel et al. (1999) suggest that wolves and mountain lions will exhibit greater prey specialization in landscapes with greater habitat heterogeneity than their study site which includes ungulate habitats in California. However, California does not currently have high population densities for either deer or elk.

Hebblewhite and Smith (2010, page 86) summarized the interactions of wolves and mountain lions (cougars) in BNP following wolf recolonization:

"…wolf recolonization in BNP negatively affected cougars asymmetrically through both interference competition (direct mortality) and exploitative competition through kleptoparasitism[12] by wolves of cougar kills. Cougars appeared to respond by shifting their diet from elk to deer and sheep."

The authors predict that competition between wolves and mountain lions for prey will result in reduced mountain lion numbers in YNP within 10 years (Hebblewhite and Smith 2010). Kortello et al. (2007) observed wolves killing mountain lions (17% of documented mountain lion mortality in the study area), and usurping mountain lion kills in Banff NP, but did not observe lions killing wolves or usurping wolf kills. It is clear that where mountain lion and wolf ranges overlap where sympatric, lions avoid wolves (Ruth

[12] Literally "parasitism by theft." A form of feeding in which one animal takes prey from the animal that had actually caught the prey.

2004a, Ruth 2004b; Kortello et al. 2007; Ruth and Buotte 2007; Lendrum et al. 2014). As wolves recolonize an area, resulting mountain lion home range shifts will likely destabilize mountain lion social structure, and subsequently spatial organization (Maletzke et al. 2014), which will likely result in negative demographic effects on mountain lion populations (Ruth et al. 2011).

In GNP, Kunkel et al. (1999) found little evidence that interference competition between wolves and mountain lions had reduced lion numbers (only two of 40 study mountain lions were killed by wolves); however, starvation killed several lions, suggesting the possibility that exploitation competition exists between the two species. In addition, Ruth et al. (2011) recorded that mountain lion kitten survival was directly related to elk calf biomass, which can be reduced in the presence of wolves, further suggesting exploitation competition exists between wolves and mountain lions.

Bartnick et al. (2013) studied changes in the foraging habits of mountain lions in the greater Yellowstone area during wolf colonization and establishment. The authors found that mountain lions avoided areas occupied by wolves, thereby reducing the extent of available lion foraging habitat. Theoretically, reduced foraging opportunities should translate to reduce lion carrying capacity and a reduced lion population. Lions shifted foraging locations to higher elevations, more northerly slopes, and more rugged terrain. These shifts to higher and more rugged terrain are expected to lead to more encounters with mule deer in Yellowstone, and possibly to higher predation rates on mule deer (Bartnick et al. 2013).

Although the majority of published scientific literature points to a one-direction interaction, with wolves dominating lions, recent information from Washington, Idaho and Montana indicates that in some instances mountain lions will kill solitary wolves. In Washington, biologists found three wolves killed by lions (as determined by diagnostic bite patterns, tracks, caching behavior, and presence of lion scat) in early 2014 (WDFW 2014; D. Martorello pers. comm. June 2014). The lion-killed wolves were distributed over a broad area of the state indicating that the three kills were made by different lions. In each case the wolf was believed to be solitary, and in two instances the wolf was a dispersing young wolf (D. Martorello, pers. comm. June 2014). In one case, snow on the ground allowed biologists to determine that the lion was also solitary (D. Martorello, pers. comm. June 2014). Other recent unpublished reports of lions killing wolves include a freshly killed wolf found by hunters under a lion that had been treed by hounds in Idaho (http://gothunts.com/mountain-lion-kills-wolf accessed 6/19/2014), and a collared female lion with kittens near Jackson Hole, Wyoming that killed and consumed a yearling wolf (http://www.jhnewsandguide.com/news/environmental/this-lion-doesn-t-run-instead-kills-eats-wolf/article_bdf4e68b-49d2-52b7-af68-302a559a9361 accessed 6/19/2014). Jimenez et al. (2008) reported on three other instances in the Rocky Mountains of the U.S. and Canada where radio-collared wolves were killed by lions, including one instance where one of two wolves traveling as a pair was apparently chased, killed, and consumed by a lion and her kitten or kittens (as determined by tracks in snow, blood, and other evidence at the scene). With the exception of this case involving a pair of wolves, all available reports indicate that only solitary wolves are vulnerable to lion attacks. It has become apparent that the killing of wolves by mountain lions is a regular, though infrequent behavior. The killing of solitary dispersing wolves may occasionally prevent or delay the expansion of occupied wolf range; however, the impact of occasional wolf kills by mountains lions on wolf populations is likely negligible.

The presence of wolves can indirectly affect mountain lions by causing changes to prey species numbers and behavior. Atwood et al. (2007) studied predation patterns of wolves and mountain lions in Montana and discovered elk changed their habitat use patterns rapidly (<1 year) following wolf reintroduction. Elk shifted to heavier cover areas to escape wolf predation. In heavier cover they were more susceptible to mountain lions, and consequently the prevalence of elk in mountain lion diets is increasing. As a consequence, predation pressure on mule deer, the lions' primary prey, was found to decline with the introduction of wolves. Similarly, Ballard et al. (2003) speculated that wolves usurping mountain lion kills may significantly increase lion kill rates of prey such as elk and deer. Other studies provide evidence that mule deer predation increased under similar circumstances (Kortelo et al. 2007; Bartnick et al. 2013).

Allen et al. (2014) studied the interaction between mountain lions, black-tailed deer, and black bears in northwestern California. They speculated that black bear kleptoparasitism of mountain lion kills may lead to increased lion predation on deer during the summer and autumn when black bears are most active. Seasonally increased lion predation could be further exacerbated by wolves usurping lion kills and caches.

<u>Wolves and Black Bears</u>

Black bears in California feed primarily on herbaceous matter and insects, with mammalian prey composing a relatively small portion of the diet. The majority of native mammalian prey appears to be deer fawns and deer carrion (Graber and White 1983). Therefore strong direct competitive interactions between wolves and bears would not be anticipated, although interference competition may occur between wolves and bears at kill sites.

Ballard et al. (2003) summarized the known interactions between wolves and black bears in North America. Wolves killed black bears in nine out of 26 recorded encounters. In six of the nine fatal encounters, wolves actively sought out black bears in their dens and in one of the 26 recorded encounters a bear killed a wolf. Although adult black bears are larger than wolves, wolves usually outnumbered black bears and were therefore able to dominate the interaction, including usurping bear kills. However, wolves have also been observed in communal feeding situations with black bears. Ballard et al. (2003) was aware of no reported black bear – Mexican wolf interactions.

Other Carnivores

As mentioned previously, other carnivores that come into contact or may be affected by wolves include; wolverines, badgers, bobcats, river otters, fishers, martens, weasels, skunks, raccoons, and some raptor and corvid bird species.

Information regarding the interactions between wolves and other carnivores is largely limited to anecdotes. Wolves have been reported killing river otters, striped skunks, and martens; chasing a weasel, killing golden eagles (*Aquila chrysaetos*) at kill sites, and attacking badgers (Ballard et al. 2003). Although most records of wolves interacting with non-prey species are antagonistic, wolves have been observed in communal feeding situations with bears, coyotes, foxes, and ravens (*Corax corax*), presumably because the wolves present were satiated and resting between feeding bouts and not because they were truly tolerant of the other species (Ballard et al. 2003). Additionally, many other carnivores have been observed scavenging wolf kills.

Gese (2006) concluded smaller mesopredators like red foxes, bobcats, and lynxes may benefit from wolf reintroduction through decreased competition and mortality from coyotes. The author states the potential effects of wolf reintroduction to YNP on badgers, raccoons, fishers, martens, and wolverines are unknown, though they may benefit from reduced competition with coyotes and more available carrion (Gese 2006). Wolves and wolverine exhibit especially strong interference competition (Ballard et al. 2003) and in many of the reported cases, a wolverine was killed. Other encounters resulted in wolves chasing wolverines until the wolverines were able to escape into trees or caves (Ballard et al. 2003). These documented encounters notwithstanding, Inman et al. (2012), suggest the presence of additional, year-round large ungulate carrion resulting from wolves would be expected to benefit wolverines.

In Wisconsin, a wolf has reportedly killed at least one fisher, and fisher abundance has declined in areas of the state occupied by wolves (A.P. Wydeven pers. comm. in Wiles et al. 2011). Although martens use densely forested habitat and coyotes use more open habitat, reductions in coyote numbers following wolf introduction could benefit martens by reducing competition for prey species (Gese 2006) and may also be the case for fisher as well. Ballard et al. (2003) were unaware of any reported interactions between wolves and bobcats, although bobcats may benefit from scavenging wolf kills.

B. Wolves and Scavengers

The production of carrion may be one of the most important community effects of wolves in the ecosystem (Hebblewhite and Smith 2010). Studies in YNP and BNP demonstrated no other species generated as much carrion over such a consistent temporal scale as wolves (Wilmers et al. 2003, Hebblewhite and Smith 2010). CDFW recognizes (and discussed elsewhere in the Plan) that study results conducted on large national parks may not be directly comparable outside of the parks where wolves establish (Mech 2012). As such, if wolves fully establish a population in California, their principal prey is likely to be elk and deer, which in the case of deer are readily consumed in their entirety by two or more wolves, and therefore unlikely to result in a significant benefit to scavenging species.

Wolves have been reported to benefit scavenging species by changing the availability of large ungulate carcasses that seasonally increase due to winter mortality (characteristic of communities without wolves), to a relatively constant, year-round supply of large carcasses for scavengers (Wilmers et al. 2013). However, the presence of wolves in a community may reduce the total available biomass available to scavengers if they reduce the numbers of prey species (Hebblewhite and Smith 2010). Additionally, wolves generally consume 75-100% of prey items before relinquishing them to scavengers, while animals that die absent predation provide most of their biomass to scavengers (Mech 2012). More specifically, Zimmermann et al. (2014) suggest that surplus killing (killing more prey than can reasonably be consumed) by non-breeding wolf pairs may be an optimal foraging strategy in some locations. That is, if securing prey comes at a relatively low cost in energy and risk, it is favorable to consume only the most nutritious part of the food. This strategy has the side effect of making more kill biomass available to carcass scavengers. The same authors further suggest that smaller wolf packs may be subject to greater losses of biomass from kills to scavengers than packs of larger sizes. Studies to date have not addressed whether the net effect of the change in seasonal availability and total biomass of carcasses is beneficial or detrimental to scavenging species, nor whether the changes effect scavenger survival and reproduction (Mech 2012).

Twenty species of scavengers were observed scavenging wolf kills in BNP by Hebblewhite and Smith (2010), including, most frequently, the common raven, coyote, and black-billed magpie (*Pica hudsonia*). Also observed were the grizzly bear, mountain lion, lynx, wolverine, marten, long- and short- tailed weasels, mink, masked shrew (*Sorex cinerus*), bald eagle (*Haliaeetus leucocephalus*), golden eagle, great gray owl (*Strix nebulosa*), gray jay (Perisoreus candadensis), Clarke's nutcracker (*Nucifraga columbiana*), and boreal and mountain chickadees (*Parus spp*.).

In YNP, Wilmers et al. (2003) recorded 12 different scavengers at wolf kills, with five (coyotes, ravens, magpies, golden and bald eagles) at nearly every kill. The most common species wolves interact with are ravens scavenging kills. The two species usually coexist, but wolves have been observed killing ravens (Ballard et al. 2003).

A Yukon study determined ravens removed up to 81lbs (37kg) a day from 16 ungulate carcasses set out in the winter. Ravens may remove up to 66% of an individual wolf's kill, but only 10% of a pack's kill because a pack can consume a carcass much faster than an individual. Therefore, the presence of ravens can significantly increase wolf kill rates (Promberger 1992 in Ballard et al. 2003). Vucetich et al. (2004) propose that the rapid depletion of individual wolf kills by scavenging ravens may have been a significant selective pressure favoring the evolution of pack forming behavior in wolves.

C. Wolves, Small Mammals, and Special Status Species

Although wolves feed primarily on large ungulates, they will also feed on many different small prey species including mice, squirrels, muskrats (*Ondatra zibethicus*), grouse, and songbirds, especially in the summer when ungulates are less available. But small prey never comprises a significant portion of the diet (Wiles et al. 2011). Wolf effects on small animals are more likely to occur through changes to the predator community brought about by wolves killing and displacing mesopredators. The theory of "meso-predator release" occurs when small predator populations irrupt following the removal of larger predators (Crooks and Soule 1999). Mesopredators are any mid-trophic level predator in a natural community. Some species may act as mesopredators in one community and apex predators in another. For example, coyotes are mesopredators when coexisting with wolves, and apex predators absent wolves and mountain lions (Prugh et al. 2009). Meso-predator releases can often lead to declining prey populations, sometimes destabilizing communities and driving local extinctions (Prugh et al. 2009). Predator-mediated extinctions are often the result of apparent competition - an indirect interaction between prey species through a shared predator (DeCesare et al. 2010). In some cases, apparent competition may drive one species to extinction - usually when the predator is subsidized by an abundant alternate prey species while simultaneously driving another species to extinction (DeCesare et al. 2010). The effects of apparent competition on endangered species are often compounded by other impacts, such as habitat fragmentation and introduced species (DeCesare et al. 2010). Prugh et al. (2009) determined that the likelihood of meso-predator release occurring following the removal of an apex predator is greater in more productive ecosystems and greater where existing predator diversity is low.

Although some studies have failed to find evidence of meso-predator release following the removal of an apex predator, the weight of evidence suggests meso-predator release is a common result of the loss of an apex predator throughout the world (Prugh et al. 2009). In the past 200 years in North America, 60% of meso-predator species ranges have expanded while all apex predator ranges have contracted (Prugh et al. 2009). However, current information suggests that large carnivores are expanding and occupying former range (LaRue et al. 2012; Pyare et al. 2004; USFWS et al. 2015). Crooks and Soule (1999) affirmed the phenomenon of meso-predator release in fragmented southern California sage-scrub communities by demonstrating that coyote presence was the strongest indicator of bird species diversity in habitat patches, even when controlling for co-variables. The absence of coyotes correlated with increased numbers of smaller mesopredators including grey fox, domestic cat (*Felis catus*), opossum (*Didelphis virginiana*), and raccoon - predators better adapted to bird predation. Henke and Bryant (1999), in their study of the effects of coyote removal on the faunal community of western Texas found that within nine months of the initiation of coyote removal, the relative abundance of the smaller mesocarnivores (badgers, bobcats, and gray foxes) increased in treatment (coyote removal) sites.

As discussed above, wolves appear to be capable of reducing coyote populations, at least for a short period following recolonization. The interactions between wolves and coyotes will likely have a greater impact on sensitive species in California than direct interactions between wolves and sensitive species. Coyotes have been described as a major predator of a number of federally threatened and endangered vertebrate species, including rodents, leporids (rabbits, hares, and pikas), ungulates, carnivores, and birds (Ripple et al. 2013). Ripple et al. (2013) implicate the dramatic expansion of coyote populations in the wake of wolf extirpation in the apparent precipitous decline of rabbit and hare species in the west, including cottontails (*Sylvilagus spp*.) in Arizona, pygmy rabbits (*Brachylagus idahoensis*), white-tailed hares (*Lepus townsendii*), black-tailed hares (*Lepus californicus*), and snowshoe hares (*Lepus americanus*), although the evidence is circumstantial.

The diet diversity of coyotes allows them to keep some species of prey at extremely low densities because the coyote population is sustained by alternative prey sources. For example, coyotes were found to be a significant source of predation on threatened desert tortoise (*Xerobates agassizii*), particularly when they were subsidized by anthropogenic food sources (Esque et al. 2010; Ripple et al. 2013).

Levi and Wilmers (2012) speculate that the suppression of coyotes by wolves will likely result in increased populations of other small predators, and in turn changes to prey communities. Therefore the presence of wolves in the community is expected to result in fewer coyotes, in turn resulting in more foxes, and a higher predation rate on small mammals. Additionally, the authors write that the suppression of coyotes by wolves would be expected to reduce the predation pressure on the medium-sized prey preferred by coyotes, such as lagomorphs (rabbits and hares), squirrels, and ungulate neonates. Evidence of coyote effects on medium size prey was found from Minnesota in the period following wolf extirpation where expanding coyote populations correlated with declining white-tailed hare populations (Levi and Wilmers 2012). However, Hebblewhite and Smith (2010) noted the reduction of coyote packs in YNP from 11 to six packs after wolf reintroduction, later returned to 12 coyote packs possibly due to a short-term decline in wolf numbers. Mech (2012) also notes that a release of smaller predators (meso-predator release) has yet to be confirmed in YNP.

Gese (2006) predicts the number of red foxes will increase in the Lamar Valley of YNP with the arrival of reintroduced wolves due to reductions and displacement of coyotes. Due to increased fox numbers, a decrease in small mammal numbers is also expected. For the same reasons, bobcat numbers are expected to increase. The predicted effect of wolf reintroduction on badger, lynx, raccoon, marten and wolverine are less clear, although reductions in coyote numbers could be beneficial to most of these mesocarnivores due to less interference competition and less indirect competition for prey resources.

Miller et al. (2012) found that on plots within 1.8 mi (3 km) of wolf dens in Grand Teton National Park, rodent numbers, particularly voles (*Microtus spp*.), were significantly higher than on other plots. They attributed this phenomenon to decreased predation by coyotes that were avoiding wolf den sites. As denning is a temporary condition, smaller predators may not have had adequate time to respond to the increased rodent resource.

Sovada et al. (1995) reported that the presence of coyotes correlated to lower red fox density and increased duck nest success. Although it is unlikely that gray wolves or Mexican wolves will colonize the range of the endangered San Joaquin kit fox in the near term, the presence of wolves could prove beneficial to kit foxes through a reduction in coyote numbers. Ralls and White (1995) found that 78% of all San Joaquin kit fox mortality on the Carrizo Plain resulted from interactions with larger canids, with 15 from coyotes, two from non-native red foxes, and one from a domestic dog.

Should Mexican wolves eventually colonize California, they may have a beneficial effect on desert tortoise populations by reducing or displacing coyote populations. Coyotes are commonly implicated in deaths of adult tortoises. However, the population-level effects of coyote predation on desert tortoise populations is unknown, and except for extreme predation events brought on by unusual circumstances, predation by native predators alone would not be expected to cause dramatic population declines (USFWS 2011).

The presence of wolves in an ecosystem may also impact sensitive species through indirect influences on the vegetative community. Hebblewhite and Smith (2010) noted that wolf predation on ungulates can directly affect plant communities by reducing the number of herbivores in the community, and indirectly through herbivore behavior modification. Small, herbivorous vertebrates may benefit from reduced herbivory by wild ungulates brought about by predation and changes in ungulate distribution and habitat use from recolonizing wolves. Reduced ungulate herbivory would provide more vegetative forage and more herbaceous cover to small mammalian herbivores (Ripple et al. 2013). Resulting changes in small mammal species numbers may provide more prey for small mammalian carnivores and raptors (Miller et al. 2012). The dual effects of reduced coyote interference competition and increased small mammal prey availability may significantly increase small predator numbers (Miller et al. 2012).

Bighorn Sheep

Two populations of bighorn sheep in California have special legal status, the state and federally endangered Sierra Nevada bighorn (*O. c. sierrae*), and the state threatened and federally endangered peninsular bighorn sheep (*O. c. nelsoni*). In other parts of the North American wolf range, wolves are known to prey directly on bighorn sheep. White et al. (2008) studied the relationship between reintroduced wolves and bighorn sheep in YNP from 1995 to 2005. In that period the population of wolves increased from 21 to a maximum of 106. Counts of bighorn sheep during the same period sharply declined during a severe winter in 1997, but then increased by 7% annually for the remainder of the study period. The authors speculate that reduced competition between bighorn sheep and elk (which declined by 50% during the same period) for food benefitted the sheep. The authors strongly caution that observed correlation between wolf-mediated elk reductions and the increasing bighorn sheep population should be interpreted cautiously due to the short period of study and lack of significant correlation between elk population and bighorn sheep population growth (White et al. 2008).

Sawyer and Lindzey (2002), in their literature review of predation on bighorn sheep, concluded that bighorn sheep predation is primarily caused by mountain lions and coyotes, although reports exist of predation by golden eagles, lynxes, bobcats, gray foxes, wolves, and bears as well. Herding behavior and the use of steep terrain appear to be effective adaptations by bighorn sheep to avoid predation by coursing predators like wolves and coyotes (Sawyer and Lindzey 2002).

In California, mountain lions are the primary predator of adult bighorn sheep, and predation appears to occur primarily where wintering mule deer herds (mountain lion's primary prey) overlap with wintering bighorn sheep (which mountain lions take opportunistically) (Johnson et al. 2013). Because wolves and bighorn sheep generally use different habitats, impacts of recolonizing wolves would most likely occur through changes in mountain lion populations and spatial use (i.e. higher elevations and steeper terrain favored by bighorn sheep).

Wehausen (1996), and Schaefer et al. (2000), found that mountain lions are an important cause of bighorn sheep mortality in California and may cause changes in bighorn distribution, but appear to be restricted to areas where sheep and mule deer are sympatric, such as wintering grounds (Hayes et al. 2000; Wehausen 1996). The presence of mule deer supports mountain lion that may opportunistically take bighorn sheep. However, without the alternative prey source of mule deer, mountain lions do not appear able to subsist on bighorn sheep alone.

Although in California Johnson et al. (2013) demonstrated that predator-mediated apparent competition may limit some bighorn sheep populations, the authors caution that it is not the primary factor limiting all populations, the population dynamics of each herd being highly idiosyncratic. Mountain lion predation was found to constrain bighorn sheep herd population growth in some herds, but not in others. How the information gleaned from studies in other locations will transfer to California is impossible to predict. California ecosystems are generally highly productive and already host complex predator communities.

Potentially Impacted Special Status Species

Species are listed along with the anticipated trajectory of the species population (+ or -) in the presence of recolonizing wolves in Table 5.1. This information was gathered from studies from other locations that have uncertain or limited application to current and future conditions in California. It is included as a preliminary assessment that will be revised once data in California has been collected and analyzed.

Table 5.1. List of special status species potentially affected by wolves although this remains largely uncertain as information used to provide this assessment were gathered from other sources outside of California.

Species Name	Status[13]	Potential influences on species by wolves (positive or negative)	
Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*)	CE/FE	wolf predation on wintering grounds, changes in mesopredator community affecting lamb predation, changes in wintering mule deer spatial distribution could reduce mountain lion predation	**+/-**
Peninsular bighorn sheep (*Ovis Canadensis* nelsoni)	ST/FE	Mexican wolves not likely to occupy mountainous sheep habitat but could change mule deer spatial use patterns causing changes in mountain lion predation	**+/-**
Gray-headed pika (*Ochotona princeps*)	SSC	possible reduction of coyotes leading to increase in weasels, red fox, and other small predators more likely to prey on pikas	**-**
Pygmy rabbit (*Brachylagus idahoensis*)	SSC	possible reduction in coyote numbers or change in distribution could reduce predation on this species and other lagomorphs	**+**
Oregon snowshoe hare (*Lepus americanus klamathensis*)	SSC	possible reduction in coyote numbers or change in distribution could reduce predation on this species and other lagomorphs	**+**
Sierra Nevada snowshoe hare (*Lepus americanus tahoensis*)	SSC	possible reduction in coyote numbers or change in distribution could reduce predation on this species and other lagomorphs	**+**
Western white-tailed jackrabbit (*Lepus townsendii townsendii*)	SSC	possible reduction in coyote numbers or change in distribution could reduce predation on this species and other lagomorphs although direct wolf predation on jackrabbits could reduce numbers	**+/-**
Mohave ground squirrel (*Xerospermophilus mohavensis*)	ST	possible future arrival of Mexican wolves could reduce coyote numbers and benefit species, effects of other changes in mesocarnivore community difficult to predict	**+/-**
Armagosa vole (*Microtus californicus scirpensis*)	SE/FE	possible future arrival of Mexican wolves could change mesopredator community resulting in increased predation from small predators	
Pacific fisher (*Pekania pennanti*)	CC/FPT	direct wolf predation/interference competition could reduce population, changing mesocarnivore community could reduce population and increase competition for small prey, for example bobcats, the primary predator of fisher in southern Sierra Nevada, may increase if wolves reduce coyote numbers	**-**
Humboldt marten (*Martes americana humboldtensis*)	SCC	possible, but likely insignificant wolf predation, changes in mesocarnivore community with unpredictable effects on marten	**+/-**
Sierra marten (*Martes americana sierra*)	SCC	possible, but likely insignificant wolf predation, changes in mesocarnivore community with unpredictable effects on marten	**+/-**

[13] CE- California endangered, ST- California threatened, CC- California candidate for listing, SSC- California species of special concern, FPT-federally proposed threatened, FE-federally endangered.

Species Name	Status[13]	Potential influences on species by wolves (positive or negative)	
Sierra Nevada red fox (*Vulpes vulpes necator*)	ST	wolf predation/interference competition, potential for positive impact from wolf-mediated coyote reduction/displacement	**+/-**
North American wolverine (*Gulo gulo luscus*)	ST/ FPT	wolf predation/interference competition, although wolves unlikely to occupy alpine wolverine habitat, changes in mesopredator community, potential reduction in total ungulate carcass biomass and change in seasonal availability of carcasses	**+/-**
American badger (*Taxidea taxus*)	SSC	wolf predation/interference competition, changes in the mesopredator community could have unpredictable effects	**+/-**
Bald eagle (*Haliaeetus leucocephalus*)	SE	changes in scavenged food availability	**+**
California condor (*Gymnogyps californicus*)	SE/FE	changes in ungulate carcass total biomass (elk specific) and seasonal availability	**+**
Northern harrier (*Circus cyaneus*)	SSC	could be impacted by changes in ground nest predation resulting from mesocarnivores community changes principally in the northeastern California	**-**
Short-eared owl (*Asio flammeus*)	SSC	could be impacted by changes in ground nest predation resulting from mesocarnivores community changes principally in the northeastern California	**-**
Greater sandhill crane (*Grus canadensis tabida*)	ST	wolf predation on adults and young, mesocarnivore community changes could affect predation of young and eggs	**-**
American white pelican (*Pelecanus erythrorhynchos*)	SSC	Only remaining CA nesting area is in Klamath Basin where nesting colonies are susceptible to ground predators (including coyotes) during drought years when nesting islands are connected to the mainland	**+/-**
California black rail (*Latterallus jamaicensis coturniculus*)	ST	mesopredator community changes could favor effective predators	**-**
Yellow rail (*Coturnicops noveboracensis*)	SSC	recently re-discovered during breeding season in meadows/marshes of NE California and predation on nest success completely unknown	**+/-**
Black tern (*Chlidonias niger*)	SSC	vulnerable to increases in ground predation from changed mesopredator communities	**-**
Greater sage-grouse (*Centrocercus urophasianus*)	FPT	wolf predation, changing mesocarnivore community and predation on birds, young, and eggs	**+/-**
Desert tortoise (*Xerobates agassizii*)	ST/FT	wolf predation, reduction in coyote predation on tortoises	**+/-**

CHAPTER 6 WOLF INTERACTIONS WITH UNGULATES

This chapter provides background on California's native ungulate species including descriptions of their estimated abundances, distributions, habitats, mortality factors, and general status. This information is followed by a more detailed description of deer and elk habitat requirements, factors that affect their habitats, information on wolf predation of ungulates, wolf influences on ungulate populations, predicted levels of wolf predation of ungulates in California and how the CDFW intends to monitor ungulates for impacts from wolves. Finally, the chapter concludes with a discussion of the tools and strategies available for managing wolf-ungulate interactions in California.

A. Introduction

Healthy and abundant prey populations will be necessary to sustain wolf populations in California. The state is home to a number of large ungulates[14] including native elk, mule deer, pronghorn, and bighorn sheep, as well as feral horse (*Equus ferus caballus*), burro (*Equus asinus*), and feral pig (*Sus scrofa*), all of which are potential prey for gray wolves. Wolves establishing in California will require sufficient numbers of such large prey to meet their energetic requirements. They will encounter competition for prey with other carnivores. The effects of an additional predator species on California's native ungulates are difficult to predict, even given information available from other locations where reintroduced or recolonized wolves are once again part of the carnivore guild. Localized differences in climate, topography, habitat conditions, ungulate abundances, relative predator abundances, ungulate harvest strategies, and other sources of ungulate mortality may all influence the relationship between wolves and California's native ungulates. However, information from other western states, particularly Oregon and Washington, can provide some useful insight into the potential impacts of wolves on California's ungulates.

California's native ungulates are among our most visible wildlife species, inhabiting much of the wildlands in the state. Consequently, their value as representatives of California's wildlife resources is high. Ungulates are enjoyed for viewing in such places as the mountain meadows of Yosemite National Park (mule deer), the woodlands and forests of the Coast Mountains (elk and black-tailed deer), and the sagebrush flats of northeastern California (pronghorn antelope). They also represent an integral link in the food chain, from their roles as herbivores of wildland plants to their roles as prey of California's top carnivores. Most of these ungulates are popular game animals, collectively attracting thousands of hunters annually. An expected challenge to the Department will be determining how to maintain or improve ungulate populations at levels capable of supporting wolves and other predators while maintaining viable

[14] Ungulate is defined as a hoofed, typically herbivorous four-legged mammal. For the purposes of this plan, ungulates will refer to native elk, deer, pronghorn and bighorn sheep.

ungulate populations capable of providing public use opportunities such as hunting and wildlife viewing.

Native ungulates occupy habitats that comprise a mosaic of vegetation for their forage and cover needs. Forage is primarily found in early seral stages[15] such as grasses, forbs[16], and younger shrubs and trees, which are more abundant, nutritious, succulent, and palatable than more mature plants found in late seral stages. Cover is a necessary habitat element for predator avoidance, and thermal refuge for both adult and young ungulates, and is provided by denser and more mature vegetation.

Wolves are generalist carnivores adapted to feeding on diverse prey. They can effectively hunt prey ranging in size from hares to bison. Throughout their range, wolf diets are highly variable. Wolves on Ellesmere Island (Canadian territory of Nunavut), have been documented consuming Arctic hare in large numbers (Mech 1988), while those in coastal Alaska and British Columbia may consume large amounts of salmon (Mech et al. 1998; Darimont et al. 2008) as well as waterfowl (Stephenson and Van Ballenberghe 1995). Flexibility and opportunism drive wolves' foraging behavior (Peterson and Ciucci 2003). Ungulates are by far wolves' main prey. Although the ungulate species present may vary considerably in size, behavior, and habitat use, some form of hoofed mammal occurs throughout the wolf's range (Mech and Peterson 2003). Table 6.1 illustrates the variety of wolves' prey in various locations in North America. In the Northern Rocky Mountains, wolves rely on elk as their primary prey in many areas, with white-tailed deer and moose important in some locations. Moose are important wolf prey in inland British Columbia, with black-tailed deer becoming more important in coastal areas. Bighorn sheep however, are not a common prey species because of the lack of significant habitat overlap with wolf distribution. In Alaska, wolves prey on Dall's sheep but are generally not considered to be an important limiting factor (Sawyer and Lindzey 2002).

In some locations, wolves have access to numerous large ungulate prey species, which is not what CDFW believes wolves will encounter in California. In northern California, mule deer, black-tailed deer, Roosevelt elk, and Rocky Mountain elk are the primary ungulate species present. To a lesser extent pronghorn, feral horses, burros, and wild pig could be potential prey for wolves. Mule deer are more abundant than Rocky Mountain elk in northeastern California and may therefore represent the majority of the wolf diet in that region. In northwestern California, black-tailed deer and Roosevelt elk would comprise most of the potential prey for wolves. Prey selection by wolves in California, as in other areas, will reflect a combination of capture efficiency (or optimal foraging) versus risk. Wolves will prey on species that are most vulnerable to capture, and that give them the greatest reward for their effort. This behavior does not necessarily reflect the most common species in an area (Mech and Peterson 2003).

[15] A seral stage is a phase in the sequential development of plant communities. An early seral stage is one that exists in the early period after a disturbance, such as wildfire or logging, which opens canopies and allows for grass, forb, and new shrub growth to occur.
[16] Forbs are herbaceous flowering plants that are not grasses.

Table 6.1. Prey selection by wolves at various locations in the central and northern Rocky Mountains of the United States and Canada, and coastal British Columbia. Adapted from Wiles et al. 2011.

		Prey Species (% of diet[1])								
Location	**Season[2]**	**Elk**	**White-tailed deer**	**Mule deer**	**Black-tailed deer**	**Moose**	**Bison**	**Bighorn Sheep**	**Other[3]**	**Source[4]**
Glacier Natl Park	w	30	60	3	-	7	-	-	-	1
Glacier Natl Park area (Camas pack)	w	14	83	-	-	3	-	-	-	2
Glacier Natl Park area (Spruce pack)	w	35	4	-	-	61	-	-	-	2
Northwest Montana	y	23	49[5]	-[5]	-	12	-	-	15	3
Madison Range, sw Montana	w, sp	70	26	4	-	-	-	-	-	4
Idaho	su	53	42[5]	-[5]	-	-	-	-	5	5
Salmon River Mtns, Idaho	w	77	-	23	-	-	-	-	-	6
Yellowstone Natl Park	w	92	2[5]	-[5]	-	3	3	-	-	7
Yellowstone Natl Park	y	83	3[5]	-[5]	-	<1	5	<1	7	8
Banff Natl Park	w, su	78	7[5]	-[5]	-	10	-	2	3	9
N. Columbia Mtns, se British Columbia	sp, su, f	-	3[5]	-[5]	-	95	-	-	2	10
Apache and Gila Natl. Forests Arizona/New Mexico	y	73	11[5]	-[5]	-	-	-	-	7	11
Vancouver Island	y	28	-	-	71	-	-	-	1	12
Vancouver Island	w, su	38	-	-	56	-	-	-	7	13
Coastal British Columbia	sp. su, f	-	-	-	70	-	-	-	30	14

[1]Reported as percent of total kills or frequency of occurrence based on stable isotope analysis of hair
[2]Season: w = winter; y = year-round; sp = spring; su = summer; f = fall
[3]Includes other wildlife such as mountain goats, beaver, pronghorn, mountain caribou, small mammals, birds, salmon, harbor seals, and unknown
[4]Sources: 1 = Boyd et al. (1994); 2 = Kunkel et al. (2004); 3 = Arjo et al. (2002); 4 = Atwood et al. (2007); 5 = Mack and Laudon (1998); 6 = Husseman et al. (2003); 7 = Smith et al. (2004); 8 = USFWS et al. (2007, 2008, 2009, 2010; results presented as the mean of those studies); 9 = Huggard (1993); 10 = Stotyn (2008); 11 = Reed et al. (2006); 12 = Scott and Shackleton (1980); 13 = Milne, et al. (1989); 14 = Darimont et al. (2008). [5]Use of white-tailed deer and mule deer combined.

Ungulates sustain their populations through the survival to reproductive age of their healthiest, most fit members. The removal of the more vulnerable, less fit individuals from the population means that surviving members are left with greater proportions of the natural resources on which they depend. Wolves and most other predators contribute to this effect on prey populations by removing those unhealthy or less fit individuals through predation of old, newborn, weak, diseased, or injured animals (Mech and Peterson 2003). In California, expanding elk populations are not limited by natural resources and removal of individuals could prevent further expansion or reduce distribution within currently occupied areas. In some areas, wolves have been known to prey on adult bull elk. This may be due to the relatively poor condition of bulls after the rut, as well as the bull's choice of habitat during winter (Atwood et al. 2007; Winnie and Creel, 2007; Hamlin and Cunningham 2009). Wolf predation success fluctuates throughout the year and between years as weather events and other environmental factors that affect prey vulnerability change. Severe winter conditions with deep snow leave elk and deer vulnerable to predation because deep snow limits their movement more than it does wolf movement (Nelson and Mech 1986; Del Giudice et al. 2002, 2006). As wolves chase their prey over long distances, they continually test and evaluate individuals to determine which animals will require the least amount of energy to capture, and will present the lowest risk of injury to pack members (MacNulty et al. 2009). Elk in vulnerable habitats or snow may suffer heavy mortality through wolf predation (Garrott et al. 2008).

B. Influence of Wolves on Prey Populations

The impact of wolves on prey abundance is widely debated, and the variety of outcomes from studies in different systems has not helped to settle the question (see Klein 1995; Peterson et al. 1998; White et al. 2011; Creel et al. 2011 for examples). Wolves have been seen to dramatically reduce some prey species in some locations (Mech and Karns 1977; Garrott et al. 2008), and in other locations only compensate for other mortality (Ballard et al. 1987). Important determinants of wolf effects on ungulate populations include the availability of multiple prey species and their densities relative to wolf densities, the presence and abundances of other predators, the densities of prey relative to the carrying capacity of the ecosystem, the functional and numerical responses of wolf and prey to prey density (Messier 1994), and environmental factors such as winter severity or disease. Any of these factors may impact the rate of increase or decrease of prey, the number of wolves that can be sustained, and the kill rate of wolves on prey (Mech and Peterson 2003). Mech and Peterson (2003) suggested three reasons why scientists have been unable to reach agreement regarding the significance of wolf predation on prey populations. These are: 1) each predator-prey system studied had unique ecological conditions; 2) wolf-prey systems are inherently complex; and 3) population data for wolves and their prey are imprecise and predation rates are variable.

The question of whether mortality caused by wolves is considered "compensatory" or "additive" has generated additional debate among researchers. Predation is considered compensatory when it takes the place of other mortality factors, such as when wolves kill prey that would have died anyway from starvation or disease. Additive mortality occurs when wolves kill prey not necessarily destined to die of other causes in the short term. In all likelihood, wolf predation is a combination of both additive and compensatory (Mech and Peterson 2003). Analyses from the Greater Yellowstone Area are contradictory on this topic. Vucetich et al. (2005) reported that wolf predation of elk in Yellowstone was primarily compensatory in the first decade after wolf reestablishment, replacing mortality that would have been caused by hunting and severe winter weather, but noted that wolf predation could become more additive in the future as circumstances (e.g., weather patterns, overall rates of predation) change. Others have concluded that take of female elk by wolves and hunters are probably additive because of the high survival rates of adult females in the absence of hunting and major predators (White et al. 2003; White and Garrott 2005).

In multi-predator ecosystems, where species such as mountain lions, bears, and coyotes are present, the reestablishment of wolves could potentially result in declines in other predators in which case wolf predation could be compensatory. However, under recent conditions at Yellowstone, predation (primarily by both grizzly and black bears, but also including that by wolves and coyotes) on elk calves was believed to be mainly additive mortality (Barber-Meyer et al. 2008). At Glacier National Park, Kunkel and Pletscher (1999) reported that prey losses from wolves were largely additive to those from other predators. One major influence on the conclusions of such studies is whether or not the prey population occurred at or below carrying capacity. Wolf predation is often determined to be compensatory for prey populations at or near carrying capacity, but additive for those below carrying capacity. For example, wolf predation may be a source of compensatory mortality in white-tailed deer relative to starvation if deer numbers are beyond the carrying capacity of their range during winters of higher severity (DelGiudice et al. 2002).

In a recent study conducted in Alberta, Canada, Webb et al. (2009) suggested that the numerical response of wolves to increases in white-tailed deer may intensify the effects of wolf predation on secondary prey such as elk. They reported that whether elk were actually limited by wolf predation depends on many factors, several of which they did not address in their study (Webb et al. 2009). If wolves in California do numerically increase based on the availability of prey such as black-tailed deer or mule deer, then predation on elk may increase and limit the potential for the elk population to expand and increase. It seems likely this would particularly affect small elk herds that have only recently been reestablished through translocation or natural movements.

For example, prior to the reintroduction of Mexican wolves in the Southwest (Arizona and New Mexico), the elk population within the BRWRA was estimated at 15,800 (average density over 1.4/mi^2 or 0.54/km^2). Mule and white-tailed deer populations were over three times higher estimated at 57,170 (average density over 5/mi^2 or 1.93/km^2; USFWS 1996). Although prey densities for the entire BRWRA were not available, wolf activity was believed to be in areas of high elk density with no evidence of food shortages observed (AMOC and IFT 2005). Analysis of scat in the BRWRA suggests that wolves are concentrating on elk that is the largest-sized native prey available (Reed et al. 2006; Carrera et al. 2008) even though deer populations and densities were significantly higher.

In comparison, Northern California deer densities in the B, C, and X zones north of Lake Tahoe are estimated from 0.21-2.2 per mi^2 (0.34-3.50 per km^2), elk densities in northern California range from 0.02-0.04 per mi^2 (0.03 to 0.70 per $km^{2)}$); and pronghorn antelope densities are estimated between 0.01-0.20 per mi^2 (0.02 and 0.32 per km^2) (Figure 6.1) (CDFW 2012; 2014b). These numbers are considerably lower than in Oregon and other western states where wolves are increasing and expanding. Consequently, in California there is higher potential compared to other states for wolves to limit elk expansion or reduce elk populations in California based on the availability of alternate prey (deer). Because of the concern for California's native ungulate populations, initially, the following thresholds (presumed to be influenced by wolf predation) will indicate significant impacts to ungulate populations and trigger management considerations by the CDFW:

- Reduction in survival of adult females below 90% and 80% for elk and deer, respectively, or

- 25% or more population reduction in deer or elk herds in a three-year monitoring period, or

- Elk calf:cow ratios fall below 20:100 or deer fawn:doe ratios fall below 30:100 in a three-year monitoring period, or

- Allocated big game tags must be reduced below current levels in areas occupied by wolves.

An elk calf:cow ratio below 20:100, or a deer fawn:doe ratio below 30:100 in a management unit for three consecutive years may indicate a declining population and management actions may be needed once the cause of the decline is determined. (If poor ungulate habitat conditions are identified, actions by CDFW are limited as these are within other public land agency control and/or private ownership).

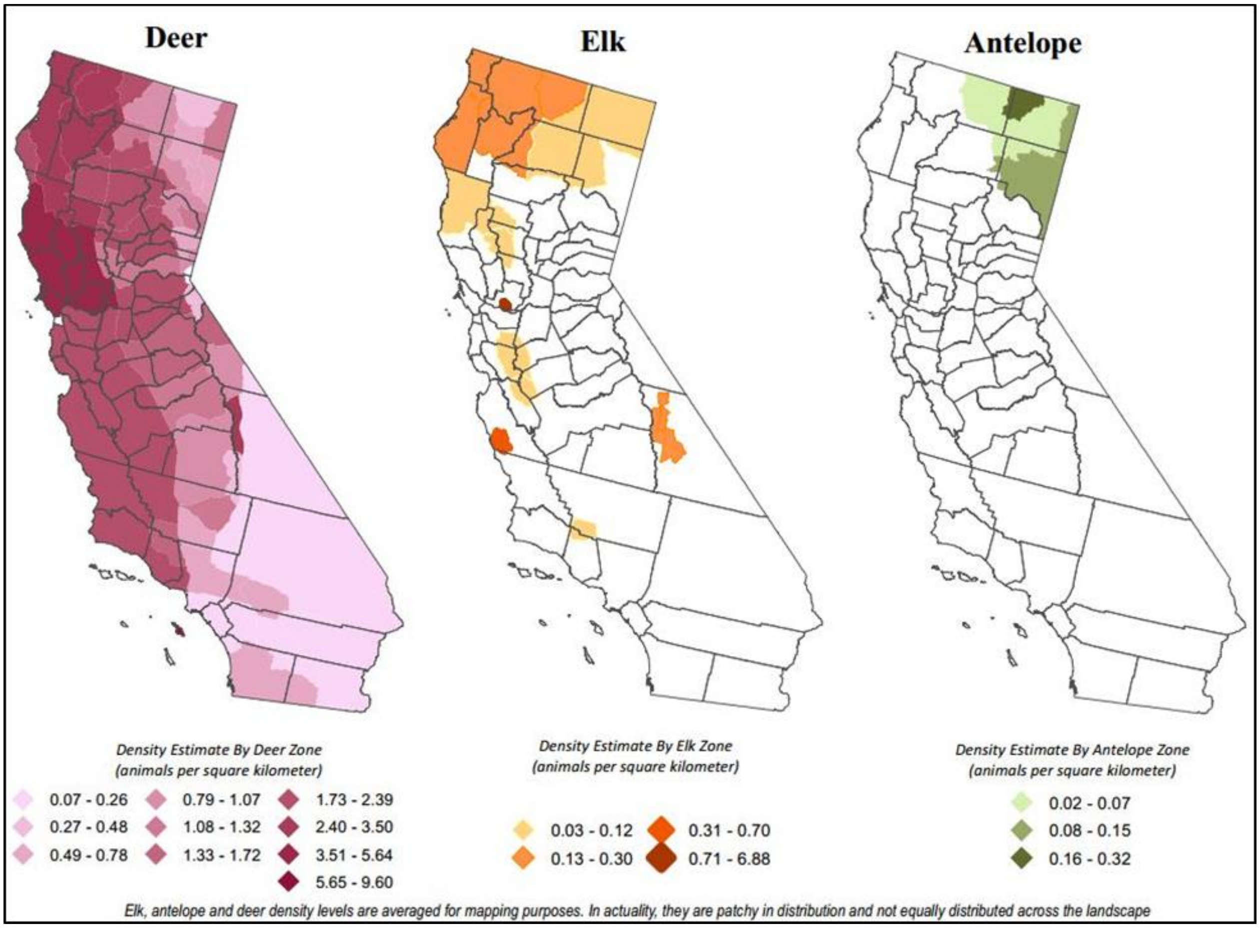

Figure 6.1. Density estimates for deer, elk, and pronghorn antelope by zone in California (see CDFW 2012; 2015a; Appendix C). Note that these species are not equally distributed across the landscape, and presence is often irregular and concentrated over the extent of the distribution.

C. Ungulates in California

This section provides information on the history, distribution, status, habitat and mortality factors for the ungulates likely to serve as prey for wolves in California. Because elk and deer are expected to be the primary prey species, additional information is provided regarding their conservation and management. The state's ability to achieve management goals for deer and elk will be enhanced if the Plan is considered in conjunction with management goals for these important species.

CDFW determines management objectives for elk and deer based on numerous factors including land ownership, private landowner tolerance of elk and deer property damage, winter range, carrying capacity, population trends, occupied available habitat, public access, public viewing, and hunter harvest. The effects of these factors on the final management objectives vary for each species and the unique circumstances of each management unit. CDFW is currently updating the statewide deer management plan and finalizing a statewide elk management plan, both of which incorporate population objectives that consider the previously mentioned factors.

1. Elk

History and Background

California is home to three subspecies of elk: Roosevelt elk (*C. e. roosevelti*), tule elk (*C. e. nannodes*), and Rocky Mountain elk (*C. e. nelsoni*) (Figure 6.2) (O'Gara and Dundass 2002). Roosevelt elk once occupied the Cascade and Coast mountain ranges as far south as San Francisco (Harper et al. 1967), and eastward to Mount Shasta (Murie 1951). Tule elk, native only to California, were distributed throughout the Central Valley and the grasslands and woodlands of the Central California Coast Range (McCullough 1969). Museum specimens of elk collected from northeastern California have been attributed to Rocky Mountain elk (McCullough 1969), but Murie (1951), and Bryant and Maser (1982), suggested that the Great Basin, Sierra Nevada range, and Cascade range presented a boundary to this subspecies western extent. Despite the disagreement over which subspecies occurred there historically, both Murie (1951) and McCullough (1969) included portions of Shasta, Siskiyou, and Modoc counties within the historic range of elk in California.

By the late 1800s Roosevelt elk were extirpated throughout much of their historic California range. Barnes (1925a, 1925b) reported that by 1925, Roosevelt elk occupied range in California was reduced to one small area in Humboldt and Del Norte counties. Mining, logging, agriculture, and market hunting were factors that contributed to the decimation of Roosevelt elk in much of California. Reintroduction efforts, natural expansion from Oregon, public ownership of large tracts of land with suitable elk habitat, and various congressional mandates to maintain wildlife habitats have resulted in substantial increases in Roosevelt elk populations (CDFG 2010, CDFW 2015a).

Accounts from journals and diaries of early European settlers and explorers indicate that approximately 500,000 tule elk inhabited much of the oak-woodland and oak-grassland habitat types in California (McCullough 1969). Native Americans and early Spanish explorers likely had little impact on the elk populations in California. However, other early explorers were responsible for the introduction of exotic annual grasses and domestic livestock, both of which continue to have long-term deleterious impacts on California's elk populations. By the late 1860s, tule elk were extirpated from all but one small locale in the southern San Joaquin Valley (McCullough 1969). It is from this population that a series of relocation efforts began during the 20th century. Largely through CDFW's efforts, approximately 1,250 tule elk have been successfully relocated.

Recent Elk Population Trend and Distribution

Most elk populations in California are considered to be slowly increasing (Figure 6.3) although there are large areas within historic elk range that are not currently occupied by elk. There are an estimated 5,100 tule elk throughout California, in 22 separate herds; and four populations of Rocky Mountain elk totaling 1,500-2,000 animals that occur in portions of Modoc, Kern, San Luis Obispo, Lassen, Shasta, and Siskiyou counties. These populations were established through natural immigration from Oregon, CDFW translocation efforts, and various historical relocation projects (CDFW 2014). Figure 6.3 suggests a static population for Rocky Mountain elk although systematic surveys for elk in northern California have not been implemented. Roosevelt elk populations currently exist in areas of Del Norte, Humboldt, Mendocino, and Shasta counties, as well as within the Cascade and Klamath mountains in Siskiyou and Trinity counties. CDFW currently estimates the Roosevelt elk population at 5,000-6,000 (CDFW 2015a, Appendix C).

Habitat

Elk habitat in California is diverse. They inhabit emergent wetlands in the Central Valley, oak woodlands in the Coast Range, dense conifer forests in the northwest, juniper grasslands in the northeast, and many other habitats. Available forage conditions on most elk ranges are the result of forest and range management under the control of the public land management agencies, especially the USFS and BLM, as well as private landowners. Although the CDFW does not manage activities on these lands it does provide recommendations for wildlife habitat needs (see Chapter 8 *Coordination with Other States and Federal Agencies)*. CDFW has direct management authority over only a small fraction of habitat within current elk range including Grizzly Island Wildlife Area in Solano County, South Valley Ecological Reserve in Santa Clara County, Cache Creek Wildlife Area in Lake County, Lake Earl Wildlife Area in Del Norte County, and the Carrizo Plains Ecological Reserve in San Luis Obispo County.

Elk habitat consists of an assortment of forest cover and large open areas. Forest habitat provides escape cover from various types of human disturbance and natural predators, and forest corridors provide pathways among seasonal habitats. Open areas provide forage in the form of grass and forbs. Tule elk find suitable foraging and protective cover in various coastal regions of California. Due to the lack of severe weather patterns (no deep snow) in these regions, tule elk do not seasonally migrate. Many Roosevelt and Rocky Mountain elk herds migrate from one area to another according to season and weather conditions. These two subspecies occupy mountain forests and meadows, valleys, foothills, bottomland woodlands, and open plains throughout the year. Adequate winter habitat in the form of lowland forest cover is important for elk survival. Preserving and managing forests and open areas with elk in mind can assist land agencies and private landowners in supporting elk populations.

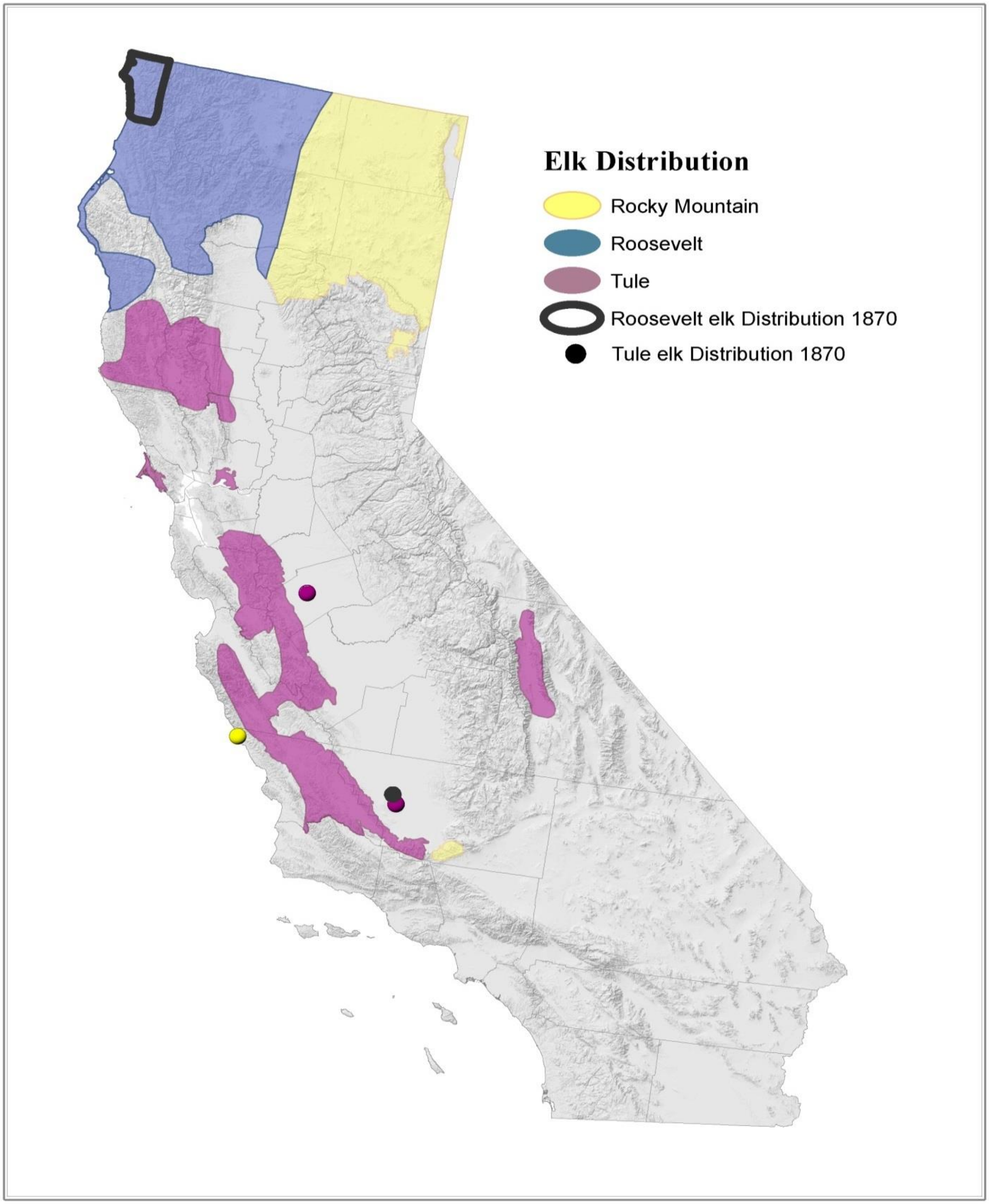

Figure 6.2. Estimated current elk distribution by subspecies within California, 2015.

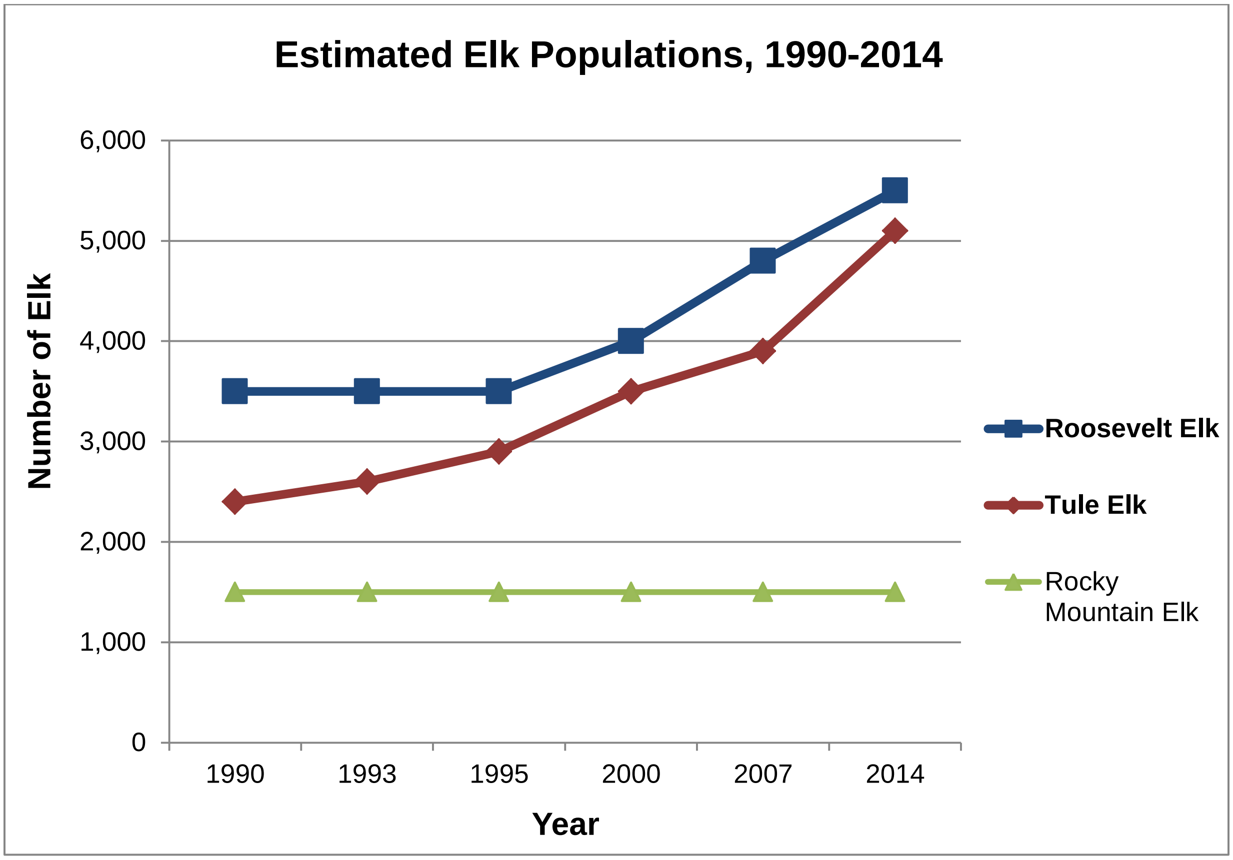

Figure 6.3. California elk population estimates since 1990 (CDFW 2014). Rocky Mountain elk estimates are only for Northern California.

Elk diets consist of a wide seasonal variety of green and dried grasses, forbs, and woody plants. As summer progresses, more forbs and woody browse, such as shrub twigs and branches are consumed. Dry grasses and browse are consumed heavily in autumn. Elk are opportunistic feeders, and will eat a variety of plant species when available. However, elk seek to consume a mixture of grasses, forbs, and shrubs in winter to ensure proper intake of nitrogen (Kufeld 1973; Peek 2003; Christianson and Creel 2009).

Mortality

Elk are fairly long-lived animals with harvest-reported ages in California up to 19 years for Roosevelt elk, 14 years for Rocky Mountain elk, and 18 years for tule elk. Most natural mortality in tule elk populations appears to be of calves due to the difference between observed pregnancy rates in spring and the ratio of calves to cows later in summer and fall (Fowler 1985). Although cause-specific mortality has not been studied in California's elk, in some areas a large portion of adult tule elk mortality is believed to be human-related. Legal hunting may be the largest single source of mortality for some of the tule elk herds (such as Grizzly Island Wildlife Area, Solano County), but at the current level of regulated elk hunting[17] in California the herds have continued to expand. Illegal killing of elk has also been implicated as a source of mortality by both commercial and non-commercial[18] poachers in California, but the level of poaching is disputed (Hansen 1994). Elk poaching incidents have been recorded in several of California's herds. Hanson and Willison (1983) reported that poaching was found to be the cause of a complete failure of one tule elk translocation when nearly all the animals were poached. As recently as 2013 the California Deer Association offered a reward for information related to the killing of three tule elk bulls that were shot and left behind (Romans 2013). Very few citations have been issued for poaching elk in California, although Hansen (1994) suggests such crimes are seriously underreported. However neither legal nor illegal killing of elk are considered to be limiting established elk herds because they continue to expand. Other human-related mortalities include vehicle collisions and entanglement in fences and other structures. Diseases and parasites are not believed to limit elk populations in California, and few have been documented (CDFW 2015a).

Throughout their range in North America, elk are susceptible to predation by numerous carnivores. Wolves and mountains lions are both successful predators of adult elk, as has been documented in various studies (Zager et al. 2007; White et al. 2010), and mountain lions are believed to be the only established major predator in California capable of killing a healthy adult elk. In YNP, grizzlies and black bears are efficient predators of elk calves; and coyotes, wolves, and mountain lions will also occasionally kill calves (YNP 2014). An ongoing study in Idaho has revealed higher than expected predation of calves by black bears (Barber et al. 2005; White et al. 2010), and in California's Mendocino County, black bears have been observed stalking and killing them. Under specific conditions black bears may exert high predation pressure on elk calves (Barber et al. 2005; White et al. 2010). The overall impact from black bear, coyote, and mountain lion predation on elk in California is not fully known. Predation rates on elk likely vary among herds, but the CDFW does not consider current levels to be a limiting factor because most elk populations are increasing.

Current Elk Conservation and Management Planning

California is divided into 22 Elk Management Units (EMUs; Figure 6.4) each of which has established management or population objectives. CDFW considers numerous factors when setting population objectives that can include current elk population size, distribution, available habitat, existing and potential conflicts with private landowners, and amount of private and public land.

[17] Elk tags are issued annually at less than 5% of the estimated statewide population.
[18] Non-commercial poachers are those who take wildlife illegally for their own consumption, whereas commercial poachers do so for the sale of meat, hides, and other animal parts.

These objectives may be adjusted as CDFW obtains new information on elk population levels, composition, distribution, depredation, and other factors.

As of August 2015, the Shasta Pack of wolves was generally within the range of the northeastern and Siskiyou EMUs. For greater understanding of elk management by the CDFW, see Appendix C.

2. Deer

History and Background

There are two generally recognized subspecies of deer in California, the mule deer and the Columbian black-tailed deer[19]. Both are widespread in the state with slight overlap and inhabit about 75 percent of California's wildlands in a wide variety of habitats. Most deer ranges are administered as public land by the federal government (e.g., USFS, BLM, National Park Service, and Military) or is privately owned (e.g. commercial timber holdings and ranches). Because of this diverse ownership, legal mandates for uses on public lands, and varying objectives of each landowner (both public and private), improving deer habitat conditions may not be a high priority in many areas.

As it relates to deer management, the California Gold Rush of 1849 was the beginning of dramatic changes in California. The greatest initial impact on deer was from market hunting to supply venison for mining camps (Longhurst et al. 1952; Leopold et al. 1951). This impact was accompanied well into the 1900s by exploitative timber harvesting, slash fires, and wildfires that greatly altered the forests, resulting in widespread increases in plant communities capable of supporting an abundant deer population. The forest's carrying capacity was increased by creating more early successional vegetation that set the stage for an increase in the deer population. However, habitat changes benefiting deer (Leopold 1950) were not immediately followed by increases in deer populations, likely because of continued heavy unregulated hunting and other factors such as heavy livestock grazing. Some of these changes to the landscape ultimately benefited deer, but the short-term result was a decrease in deer numbers. As the demand for meat exhausted the game supply, livestock grazing increased rapidly throughout California in the second half of the 1800s. An estimated six million head of sheep occupied California by 1876 and there were equally impressive numbers of cattle and horses. The increase in livestock numbers resulted in severe overgrazing in some areas, which caused a decrease in carrying capacity for both deer and livestock and subsequent decline in deer populations (Longhurst et al. 1952).

Because of these dramatic declines in deer and other wildlife species populations, California became a pioneer state in passing wildlife conservation legislation during the

[19] For purposes of this document, the term "mule deer" refers to all deer in California unless a subspecies is specified.

late 19th and early 20th centuries. Deer numbers increased dramatically as a result of improved habitat conditions through continued disturbance, enactment of restrictive hunting regulations, enforcement of game laws, control of predators, and possibly mild weather patterns between 1900 and the 1950s (Mackie et al. 1982). As a result of land use changes (primarily reductions in grazing and increased logging), high quality deer range was created in areas that historically had not supported large numbers of deer and subsequently deer numbers peaked in the 1950s and 1960s. While this was considered to be the "heyday" for deer populations, it was accompanied by severe over-browsing by large numbers of deer.

Deer numbers began to decline in California and across the western United States during the 1960s and that trend continues into current times (Ballard et al. 2001; Heffelfinger and Messmer 2003; Mule Deer Working Group 2003; Andelt et al. 2004). Efforts have been made to correlate this decline with factors such as habitat loss and deterioration, increased predation, competition with livestock, severe winters, drought, and competition with elk (Stewart et al. 2002; de Vos et al. 2003; Wasley 2004; Monteith et al. 2010; Brown and Conover 2011; Anderson et al. 2012). However, none of these factors individually can explain the population declines in all areas in which they occurred (Gill et al. 2001; Andelt el al. 2004; Forrester and Wittmer 2013).

Recent Deer Population Trend and Distribution in Northern California

California deer are no exception to the decline in mule deer numbers that has occurred in the western states since the mid-1900s. More recently, combined deer population estimates for the deer hunt zones in the areas of potential wolf occupation range have been in a declining trend. Figure 6.5 illustrates the collective estimated deer population trend in that region from 1990 to 2014. However, distinct bioregions within this area each responded differently to the extremely harsh winter of 1992-93 that resulted in a high rate of overwinter loss for deer herds in areas with winter snow. Deer numbers in the X deer hunt zones (Figure 6.6) declined precipitously during the severe winter of 1992-93, and then remained somewhat stable from the mid-1990s to the present. In contrast, B zone populations did not decline as quickly, but show a more gradual decline over the last 25 years. The population trend of the C zones has been intermediate between that of the B and X zones, mirroring the statewide trend shown in Figure 6.3. Overall deer harvest in the areas likely to support early wolf occupation increased during 1992 and 1993 because of weather conditions during hunting season. Early winter weather often causes deer movement to different ranges, and this activity makes them more vulnerable to hunter harvest.

Figure 6.4. Elk Management Units in California. These are regulatory boundary descriptions and may not have elk equally distributed within each EMU (see Figure 6.2).

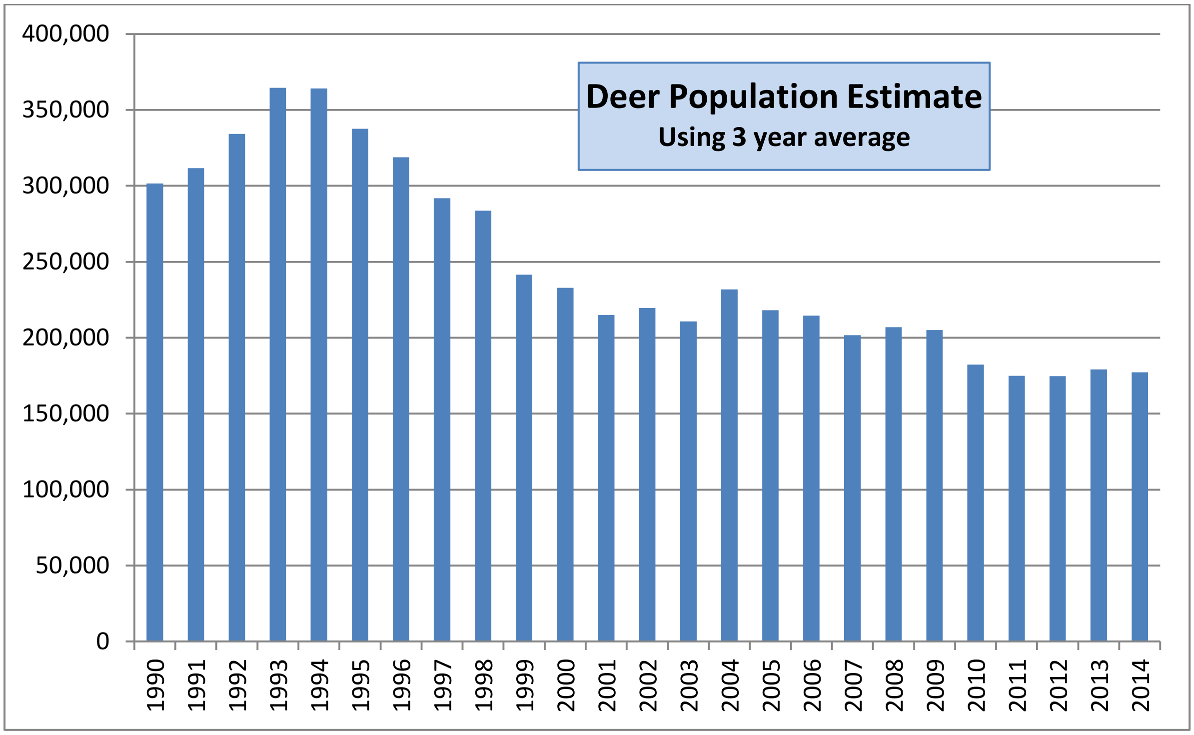

Figure 6.5. Deer population estimates for the early potential wolf occupation range (Deer Hunting Zones B, C, and X) over the past 25 years. This graph is based on the average of each year plus the year before and the year after (except for 1990 and 2014 which are two year averages). This approach provides a smoothing effect on the annual variation of the modeled estimates to show a more realistic trend line.

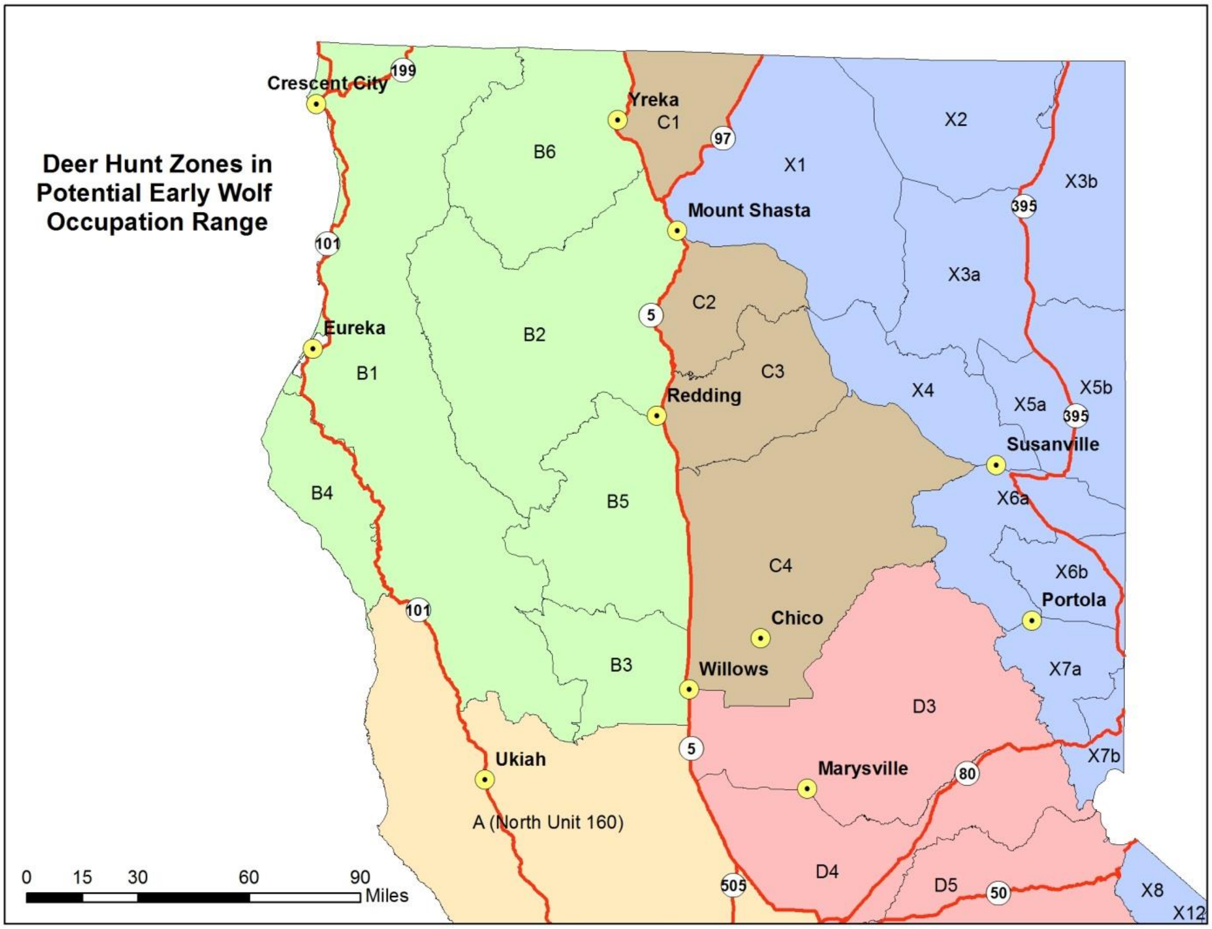

Figure 6.6. Deer hunt zones that are located in areas anticipated to be early potential wolf occupation range. The area of potential early wolf occupation range primarily includes all of the B zones, the C zones, and the X zones north of Lake Tahoe (X1-X7B). Portions of zones A and D3 occur on the southern boundary of the estimated wolf range.

Habitat

Deer are generally thought to be limited by the quantity and quality of their habitat (Mule Deer Working Group 2004), although it is recognized that other environmental factors such as weather also play important roles in the dynamics of deer populations (deVos et al. 2003; Wasley 2004; deVos and McKinney 2007; Brown and Conover 2011). Habitat includes a combination of food, water, cover, and space arranged in a way that meets the needs of a species. Changes in deer habitat quantity and quality combined with impacts from a growing human population of over 38 million have reduced California's carrying capacity for deer and other wildlife species in recent decades. For example oak woodlands, occurring primarily in the foothills of the Sierra Nevada, Cascade, and Coast mountains, play a critical role for most of the state's migratory deer herds, providing them with an important food resource in the form of acorns during fall and early winter.

These woodlands have declined in the 200 years since the arrival of Euro-Americans. The vast majority of California's oak woodlands are privately owned (approximately 80%), and many occur in suburban and semi-rural areas that are most at risk of being developed as the state's human population continues to grow (Pavlik et al. 1991; UCANR 2014a).

A significant portion of deer range in California is public land managed by the USFS and management of those lands has changed greatly over time. From the gold rush days until the mid-1900s, extensive burning, logging, and livestock grazing significantly altered California's vegetation communities, converting vast acreages to earlier successional vegetation (Gruell 2001). In general these activities benefitted deer and led to the extremely high population levels observed in the 1950s and early 1960s. Over time forest management practices changed, significantly decreasing the amount of early successional vegetation on federal lands (Lutz et al. 2003). Much of this is due to improved efficiency in fire suppression techniques leading to increased tree densities and a decline in shrub species. Shrubs that are present tend to be mature individuals, and the young, more nutritious plants that benefit deer are rare (Kucera and Mayer 1999). As early as the 1970s, the USFS began to recognize that fire suppression was resulting in an increase in both dead and standing wood (fuels) buildup in the forests, and a new regime of managing rather than controlling fires was started (Gruell 2001). This strategy recognizes the ecological role of fire in increasing forest heterogeneity (hence maintaining early seral habitat on the forest landscape), but is not yet universally embraced (North et al. 2009). While the USFS is working to bring fire into management of their lands, it will take time to reverse the results of decades of fire suppression.

The BLM is another major landowner in deer range, generally in areas of lower precipitation such as the sagebrush dominated Great Basin habitats east of the Sierra Nevada and Cascade Range. There are several issues currently impacting the habitat quality of Great Basin rangelands. Due to a history of fire suppression and excessive livestock grazing, many Great Basin shrublands have become decadent (Gruell 1996). These habitats are mainly comprised of dense, old-age shrubs containing a high proportion of dead wood and little available browse, and cannot supply the nutrition for deer that plants of an earlier successional stage do. Rather than resetting shrub succession, fuel buildup supports high intensity fires that typically convert the remaining shrublands to vegetation communities dominated by annual grasses such as non-native cheatgrass (*Bromus tectorum*), that holds very little nutritional value for ungulates. In other areas vegetation communities continue to be threatened by the encroachment of western juniper (*Juniperus occidentalis*) into sagebrush-grasslands (BLM 2007). Juniper encroachment into sagebrush and bitterbrush habitats has further reduced the capability for supporting deer by competing with more desirable forage species (Cox et al. 2009).

In addition, California is inhabited by free roaming feral horse and burro herds on an estimated 9.4 million acres statewide principally on BLM lands. Many herds occur within the potential early California wolf occupation range in Modoc, Siskiyou, and Lassen counties. BLM manages these herds in accordance with the federal Wild Free Roaming

Horse and Burro Act of 1971 and BLM has identified California's Appropriate Management Level (AML) at 1,746 horses and 453 burros. Recent population estimates (March 2014) by BLM indicate populations for California greatly exceed this amount with 4,086 wild horses and 1,922 burros. (http://www.blm.gov/wo/st/en/prog/whbprogram/history_and_facts/quick_facts.html). When populations exceed AML levels, the BLM develops a "gather" plan to remove excess animals, and places these animals for adoption (BLM California 2014). However, constraints for BLM on removal of animals exceeding AML thresholds, leads to additional competition for available forage and water with deer. This further exacerbates poor habitat conditions leading to reduced capacity to support native ungulates.

Mortality

Deer mortality may be influenced by a long list of factors including weather, food supply, disease, predation, and human influences (e.g. habitat conversion to development and changes of rangeland to other more intensive agriculture, such as vineyards, orchards, or other row crops). Other human-caused mortality factors such as vehicular collisions (although locally can be significant), fence entanglement, and illegal kill generally make up a small percentage of ungulate losses due to their geographically limited nature. However, in some cases these factors can impact local ungulate populations.

The significance of each factor affecting mortality rates within a deer population changes constantly, making identification of limiting factors difficult. Populations at carrying capacity are at the maximum density that the habitat can support without detriment, and are more vulnerable to severe fluctuations as environmental conditions change (Connolly 1981). Studies designed to identify causes and relative contribution to overall deer mortality have been infrequent in California, and further investigation is needed to understand the level of significance of wolf predation.

Mule deer are susceptible to predation by a number of carnivores. A review of 48 published studies found that predation was the primary proximate cause of mortality for all mule deer (including black-tailed deer) age classes in North America. Important predator species included coyotes, mountain lions, bobcats, wolves, and black bears (Forrester and Wittmer 2013). In California, mountain lions are the primary non-human predator of adult mule deer. In eastern California, mountain lions were the primary cause of death among migratory mule deer in an intensively studied population (Bleich and Taylor 1998), consistent with findings from other parts of western North America (Hornocker 1970; Nicholson et al. 1997). Coyotes also prey on mule deer, particularly young-of-the year (Knowlton 1976; Bowyer 1987). In eastern California, coyotes were responsible for 22% of deer mortality (Clark 1996). Black bears are also known to prey on fawns to varying degrees in California. Bears were the principal cause of mortality west of the Sierra crest, whereas coyotes and mountain lions represented the highest cause of fawn mortality in the Eastern Sierra (Monteith et al. 2014). Bobcats are capable of killing mule deer and are known to do so (Garner et al. 1976; Epstein et al.

1983); however, predation by bobcats probably occurs infrequently when compared to predation by mountain lions and coyotes. Bobcats prey primarily on young mule deer, as is the case with white-tailed deer (Boulay 1992; Labisky and Boulay 1998), but they are known to kill adults (Labisky and Boulay 1998).

Deer in California are affected by disease and parasites, but rarely to a significant extent. Occasional outbreaks of hemorrhagic diseases[20] occur, but are generally short-lived and localized. Chronic Wasting Disease (CWD)[21] does not occur in California or adjacent states, and strict regulations on importation of carcasses from other states and game farm restrictions aim to prevent CWD from entering the state. In recent years, Deer Hair Loss Syndrome has been identified in various parts of California, including within the potential early wolf occupation range. This condition is believed to have spread from deer in Oregon and Washington, and appears to be a hypersensitivity to lice, causing itching and rubbing, resulting in hair loss (ODFW 2014c). Little is known about this syndrome, and research projects are ongoing in California to find out more about the condition and determine impacts to deer populations.

Current Deer Conservation and Management Planning

Currently the state is divided into 44 Deer Management Units (DMUs) equivalent to the 44 general deer hunt zones. Management strategies have traditionally focused on obtaining information needed to allocate hunting tags that are almost exclusively for bucks only. As harvest is 98% bucks, and huntable bucks typically comprise fewer than 20 percent of California deer populations, a less rigorous data collection protocol is needed than if CDFW were managing the entire population. CDFW is currently completing a significant update to deer conservation and management planning. This planning effort includes an updated strategy for maintaining sustainable deer populations in the state (see Appendix D).

3. Pronghorn

History and Background

Prior to the early 1800s pronghorn numbers are estimated to have been as high as 500,000 in California, and they inhabited most parts of the state except for the higher mountain ranges and the north coast (CDFG 1982). At that time the greatest densities of pronghorn were found in the San Joaquin Valley (Yoakum 2004a). A dramatic decline in pronghorn numbers began with the California gold rush of 1849 and associated market hunting, and continued with agricultural and urban development. By 1923 only

[20] A hemorrhagic disease is an infectious viral disease transmitted by small biting flies during the fall season. It is not transmitted by direct contact and can result in mortality.
[21] CWD is a fatal neurological disease affecting deer and elk in North America. It is not known exactly how CWD is transmitted but is believed that the infectious agents are passed directly and indirectly through feces, urine, or saliva. For more information see http://www.dfg.ca.gov/wildlife/WIL/disease/cwd/.

about 1,000 pronghorn remained in California. Between 1923 and 1982, due in large part to protection from overhunting, decreased livestock grazing, and the emergence of wildlife management based on science (Yoakum 2004a), the pronghorn population increased to nearly 8,000 animals, with the majority (>90%) of the animals occupying the arid sagebrush/grasslands of northeastern California (Figure 6.7). At this population level private property damage by pronghorn entering and consuming agricultural crops was leading to increasing conflicts with the region's agricultural producers. To mitigate this damage[22] CDFW significantly increased the tag quota for northeastern California for the 1990 through 1992 hunting seasons in an effort to reduce the population from over 7,500 to within a range of 5,600-7,000. Despite tag quotas that were more than double those of previous years, the northeastern California pronghorn population did not decline until the winter of 1992-93 when extremely harsh weather conditions resulted in large over-winter losses (CDFG 2004). The population did not rebound after the heavy loss, possibly indicating the herds had been above carrying capacity of the range, or that unknown factors such as disease, land use changes, or predation are playing an increased role in population demographics.

Current Distribution and Status

Pronghorn antelope range in numbers from over 4,000 animals in northeastern California, where the majority of the state's population resides, to small remnant groups such as in San Benito County (Figure 6.7) where pronghorn antelope were released but have slowly declined in number until they are on the brink of extirpation. Two interstate herds are shared with Nevada, one in Surprise Valley, Modoc County and a small isolated herd of approximately 150 animals in the Bodie Hills area, Mono County. There is also an interstate herd that winters in the Clear Lake area of Modoc County, California and summers in Oregon. Due to an aggressive translocation effort during 1987-1990 prompted by crop depredation issues in northeastern California (O'Gara and Morrison 2004) several small herds exist in various locations throughout the state. The reintroduction efforts were successful in establishing pronghorn antelope in historical ranges where no animals had existed for decades. Currently each of these herds contains no more than 50 animals, several far less.

The northeastern portion of the state currently supports a population of approximately 4,500 animals that occur primarily in Modoc, Lassen, Siskiyou, and Shasta counties. While there was a sharp decline in numbers (from 7,000 to 8,000 in 1992 to about 5,000 in 1993) resulting from the winter of 1992-1993, the overall population level has been fairly stable for the last 15 years (Figure 6.8).

CDFW's objectives as stated in the 2004 Environmental Document for Pronghorn Antelope Hunting are: "to maintain a healthy pronghorn antelope population statewide and provide biologically appropriate public hunting opportunities. CDFW desires to

[22] It is a policy of the Department to alleviate economic losses caused by wildlife to the people of the state in a manner designed to bring the problem within tolerable limits (California Fish and Code Section 1802(g))

maintain a population of 5,600-7,000 animals in northeastern California, 300 animals within the Carrizo Plains area, and a minimum of 100 animals within the Tejon Ranch area" (CDFG 2004).

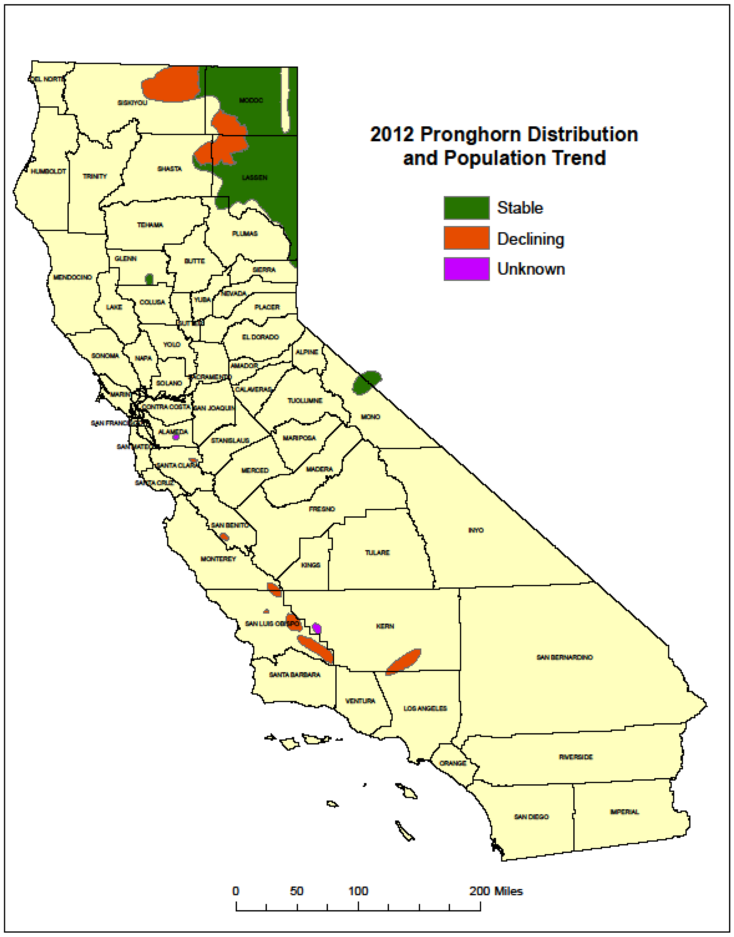

Figure 6.7. Pronghorn distribution and population trend in California (CDFG 2012).

The population estimates derived from annual winter surveys provide the basis for setting tag quotas for hunting pronghorn antelope in northeastern California. Hunting strategies are designed to achieve and maintain specific herd goals. The harvest strategy for northeastern California is calculated to allow the take of 5% to 6% of the population estimate based on the winter survey, and is intended to result in a post-hunt ratio of at least 24 buck antelope per 100 does (female antelope). This is a very conservative harvest compared to most western states which harvest 10% to 25% of their entire population annually with no significant adverse effects (CDFG 2004b). California has harvested a small percentage of the estimated population annually (Figure 6.8).

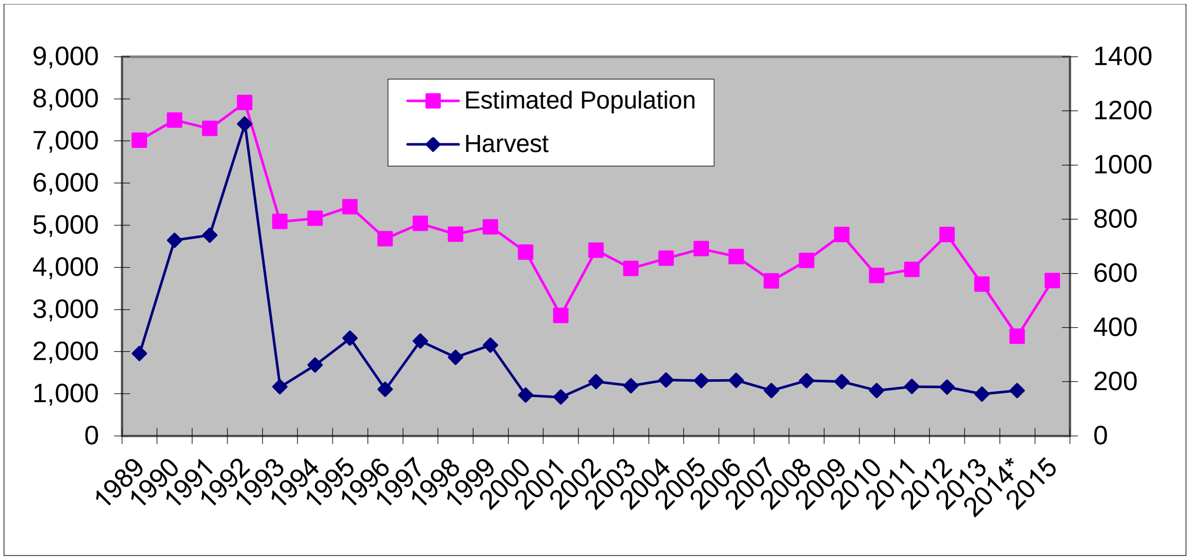

Figure 6.8. Population estimates for pronghorn in California. The population appears to have been relatively stable since declines due to the severe winter of 1993-1994, with an average of 4,385 animals estimated since 1994. *CDFW suspects the drought reduced our ability to detect pronghorn because of their apparent absence from traditional winter ranges.

Habitat

Autenrieth et al. (2006) describe pronghorn antelope as selective, opportunistic foragers that feed on the most palatable grasses, forbs, shrubs, and trees available. They favor habitats containing a mixture of vegetation that satisfy forage requirements and provide adequate fawn bedding cover (Yoakum 2004b). In northeastern California forbs and shrubs comprise the majority of the diet. Forbs are used at any time of year they are available, however summer is a critical time for forb consumption because does are nursing fawns and are in need of additional nutrients (CDFG 1982; Autenrieth et al. 2006). Shrubs are also often consumed throughout the year, although their nutritional value is generally better in the fall and winter. This is the time of year when pronghorn antelope use of shrubs is greatest. In addition, shrubs are often available even with deep snow and during years of drought. In these conditions lesser-preferred shrubs are more often used because other more nutritional forage is scarce (CDFG 1982; Autenrieth et al. 2006). Grass is consumed most when it is young, green, and highly nutritious, but gets little use when it is dry (Autenrieth et al. 2006).

Northeastern California pronghorn antelope winter range is primarily sage habitat, with low sagebrush (*Artemisia arbuscula*) and big sage (*Artemisia tridentata*) serving as the predominant shrubs, and bitterbrush (*Purshia tridentata*) occurs in limited amounts. Other common plant species are rabbitbrush (*Chrysothamnus nauseosus*), saltbush (*Atriplex* spp.), tumbling mustard (*Sisymbrium altissimum*), and cheatgrass. Some perennial grasses that occur in smaller amounts are squirrel-tail (*Elymus elymoides*), bluebunch wheatgrass (*Pseudoroegneria spicata*), and fescue (*Festuca* spp.). Summer range varies and may include dry meadow habitat with perennial grasses, sedges (*Carex* spp.), annual forbs, and sage (*Artemisia* spp.). Other summer ranges consist of juniper/sage, sage/grassland, wet meadows, large vernal ponds, grass/forb habitats, and some cultivated crops, such as alfalfa (CDFG 1982). Plant productivity and resultant carrying capacity for pronghorn antelope and other wildlife can vary significantly from one year to the next as a result of climatic conditions (CDFG 2004b).

Mortality

On areas where habitat quality is marginal and water availability and distribution is limited, predation can play an important role in suppressing populations from expanding (Smith et al. 1986). Domestic livestock such as cattle, sheep, and horses are the primary livestock species sharing rangelands with pronghorn, and approximately 99% of pronghorn share rangelands with livestock at some time during the year (Yoakum and O'Gara 1990). Although those animals have coexisted with pronghorn for centuries, there can be specific situations that are cause for concern. The abundance of forbs and grasses during late gestation and early lactation is a major factor in pronghorn fawn survival. Reduced availability of that forage component due to consumption by livestock in some habitats can result in reduced carrying capacity for pronghorns. On rangelands in good ecological condition, competition for forage is not generally a significant factor. Cattle can have a positive effect on pronghorn in areas dominated by grasses by removing the grasses and increasing the availability of forbs and shrubs preferred by pronghorn. Several researchers have observed competition between sheep and pronghorn for forbs and shrubs (Yoakum and O'Gara 1990).

Generally, coyotes, bobcats, and golden eagles are the most common predators of pronghorn in western North America (O'Gara and Shaw 2004). However, Barnowe-Meyer et al. (2009) found that within YNP, coyotes accounted for 56% of adult predation and up to 79% of fawn predation with mountain lions and wolves accounting for additional predation of adults, while mountain lions, black bears, and golden eagles killed fawns on rare occasions. Other carnivore species recorded preying on pronghorn include domestic dogs, badgers, and red foxes (O'Gara and Shaw 2004).

Pronghorn are susceptible to several viral diseases such as bluetongue and epizootic hemorrhagic disease (EHD). Epizootic outbreaks of bluetongue and EHD across the pronghorn's North America range generally occur during late summer and early autumn, and all sex and age classes may be affected. The most important vectors for bluetongue and EHD are no-see-um gnats of the genus *Culicoides*, and die-offs can be expected to terminate shortly after temperatures drop below freezing. Die-offs due to EHD are not well documented, largely due to the difficulty in distinguishing it from bluetongue, but losses to the disease were suspected in several western states and Canadian provinces (O'Gara 2004).

4. Bighorn Sheep

History and Distribution

California supports two subspecies of bighorn sheep: the Sierra Nevada, and the desert bighorn sheep. Sierra Nevada bighorn occupy the mountains of the Sierra Nevada range. They use habitats ranging from alpine to sagebrush scrub at elevations from 13,120 feet in summer, to 4,760 feet in winter (USFWS 2007). Historically, Sierra Nevada bighorn sheep were distributed along the crest of the Sierra Nevada in California from Sonora Pass in the north to Olancha Peak in the south. The Sierra Nevada bighorn sheep population was severely reduced during the 19th and 20th centuries due to diseases contracted from domestic sheep, forage competition with domestic livestock, and market hunting, such that by the late 1970s, Sierra Nevada bighorn sheep were only found near Mts. Baxter and Williamson, with a combined population of 250. Recovery efforts via translocation were thwarted by another major population decline during the 1990s, attributed primarily to mountain lion predation and drought. By 1995 only about 100 animals remained in the Sierra Nevada. Sierra Nevada bighorn sheep have been listed under the California Endangered Species Act (CESA) since 1974, but were upgraded from threatened to endangered in 1999. In the same year, the USFWS temporarily listed the subspecies as endangered on an emergency basis under ESA, with final ESA listing as endangered occurring in 2000 (CDFW 2014b).

Desert bighorn sheep are found in the drier desert mountains throughout southeastern California. Peninsular desert bighorn sheep occupy the Peninsular Ranges in San Diego, Riverside, and Imperial counties. This population, which ranges from the San Jacinto Mountains south to the U.S.-Mexico border, is listed as endangered under ESA. Although once considered a separate subspecies, bighorn sheep of the Peninsular Ranges have recently been combined with desert bighorn sheep in the subspecies *O. c. nelsoni* (USFWS 2000). The majority of desert bighorn in California is not endangered and occupies mountain ranges throughout the Sonoran, Mojave, and Great Basin deserts from the Mexican border to Mono County.

The population of Sierra Nevada bighorn sheep currently numbers just over 600 animals (T. Stephenson, pers. comm. 2015). Peninsular bighorn sheep number around 1000 individuals (R. Botta, pers. comm. 2015). The remaining desert bighorn sheep are found in more than 50 mountain ranges and the population likely exceeds 4000 animals (Abella et al. 2011).

Habitat

Two adaptations of bighorn sheep define their basic habitat requirements. The first is their agility on precipitous rocky slopes, which is their primary means of evading predators. Short legs and a stocky build provide a low center of gravity and allow agility on steep, rocky slopes, but preclude the fleetness necessary to outrun coursing predators in less rocky terrain. The second is their keen eyesight, which is their primary sense for detecting predators. Consequently, bighorn sheep select mostly visually open areas that allow detection of predators at sufficient distances to permit time to reach the safety of precipitous terrain. Optimal bighorn sheep habitat is therefore visually open and contains steep, generally rocky, slopes. Large expanses lacking precipitous escape terrain can represent substantial barriers to movement, so bighorn sheep habitat is discontinuous and their population structure is one of natural fragmentation (Bleich et al. 1990a).

Bighorn sheep are ruminant herbivores that possess a large rumen and reticulum relative to body weight (Krausman et al. 1993). This permits flexibility in plants consumed and, notably, allows the digestion of graminoids (grasses, sedges, and rushes) in all phenological stages (Hanley 1982). This flexibility in food consumption, in turn, allows flexibility in habitats utilized for feeding. Bighorn sheep select the most nutritious forage from what is available, with the result that the species composition of their diet varies greatly seasonally and regionally and can range from grasses, forbs, and flowers to shrubby browse (Krausman et al. 1989).

Mortality

Bighorn sheep die from a variety of causes including disease, predation, and accidents. Bighorn sheep are particularly susceptible to diseases transferred by domestic sheep and goats, and this susceptibility was one factor for listing Sierra Nevada bighorn. Pneumonia, which can be caused by numerous pathogens, is the most significant disease threat for bighorn sheep (Bunch et al. 1999). Diseases transferred from domestic sheep are believed to have led to several bighorn sheep die-offs in the Sierra Nevada beginning in the mid-19th century, and currently domestic sheep are still grazed on both public and private lands adjacent to Sierra Nevada bighorn sheep subpopulations (USFWS 2007; Lawrence et al. 2010; The Wildlife Society 2014).

Various predators kill wild sheep in North America, including mountain lions, coyotes, bears, wolves, bobcats, wolverines, and eagles (Kelly 1980; Berger 1991; Nichols and Bunnell 1999; Bleich 1999). Where bighorn sheep populations neighbor elk or deer populations, mountain lions tend to be the primary predator of bighorn sheep (Ross et al.1997). Mountain lions account for 96% of predation-related mortalities of bighorn sheep in the Sierra (USFWS 2007), and up to 100% in the Peninsular Ranges (USFWS 2000). Large populations of mule deer occur in the vicinity of two important bighorn sheep herds, Mount Baxter in the Southern Recovery Unit, and Wheeler Ridge in the Central Recovery Unit, used for translocation stock for CDFW’s reintroduction program. These herds have experienced strong predation pressure from mountain lions, leading to decreased survival in adult females in some years (A. Few pers. comm.). The characteristics of bighorn sheep habitat and their attachment to escape terrain make predation of bighorn sheep by wolves unlikely, except possibly in winter when the sheep are at lower elevations or when snow conditions are extreme (Sawyer and Lindzey 2002). Coyote predation may be important but is likely restricted to lambs Arthur and

Prugh 2010). In several studies of Sierra Nevada bighorn sheep, coyotes represented 1.4% of the known mortalities (USFWS 2007).

While wolves, coyotes, and mountain lions are all predators of wild sheep, mountain lions appear to be the only predators capable of affecting bighorn sheep populations (Sawyer and Lindzey 2002). Mountain lion predation is suspected as the cause of a marked decrease in winter range use by bighorn sheep in the Sierra Nevada, with subsequent population declines resulting (USFWS 2007). Conversely, evidence from Yellowstone's northern range suggests that an increasing wolf population did not prevent the bighorn sheep population from increasing slowly during the post-wolf reintroduction decade. The authors hypothesized that the strong selection of elk by wolves in this region explained these results. The relatively small bighorn sheep population in California, occurring in steep, rugged terrain, may mostly escape attention by wolves (White et al. 2008).

5. Feral Horses, Burros, and Pigs

Little is known about the extent to which wolves may rely on feral horses and burros in North America. However in Mongolia, wolves represent the main cause of mortality of wild Przewalski foals in an area with significant elk and livestock populations (Van Duyne et al. 2009).

The feral pig in California is a potential source of food for wolves. The majority of California's feral pigs occur at low to mid-elevation in the Coast Ranges from Humboldt County south through Santa Barbara County, with scattered populations in the foothills of the Sierra Nevada Mountains from Lassen County in the north to Kern County in the south. The European wild boar represents an important component of wolves' diet in many regions of Europe (Jedrzejewski et al. 2012; M. Hebblewhite, pers. comm.), and feral pigs may serve a similar function for wolves in California.

Monitoring Ungulates for Change

Currently elk and deer population estimates in northern California are modeled based on harvest rates, age, composition data (fawn:doe:buck and calf:cow:bull), and regional biologists' expert opinions. This method is not sufficient to detect future herd- or population-level changes that may occur as a result of wolf activity or presence. To detect such impacts from wolves CDFW will need to begin conducting more intensive monitoring to determine what environmental factors are currently influencing deer and elk populations. Important parameters to estimate will include deer and elk abundance and distribution, habitat resource selection, fertility and birth rates, population growth rates, adult survival, deer fawn:doe and elk calf:cow ratios, predation sources and rates, and overall mortality sources and rates. Collecting data on these attributes will inform CDFW about whether current habitat conditions are adequately supporting ungulate populations, which predator(s) may be affecting ungulate population growth, if deer fawns and elk calves are surviving into adulthood at rates sufficient to permit population growth or stability, and importantly, which sources of mortality other than predation may be affecting ungulate populations. In addition, CDFW will need to estimate abundances, densities, and distributions of important ungulate predator species such as black bear, mountain lion, and coyote. Such data will facilitate understanding how wolves may affect the dynamics of these species and whether wolf predation on deer and elk will be additive or compensatory. Data collection on ungulates and predators will continue after wolf reestablishment commences in order to detect potential changes.

D. California Deer and Elk Habitat Needs

In spring and summer, deer and elk both depend on young shrubs, grasses, and forbs for forage (Leopold 1950, deVos et al. 2003, CDFG 2006). These habitat elements are most available in early successional plant communities, which are not as stable as mature communities, and which rely on fire or some other type of disturbance for their continued existence. When left undisturbed, they eventually transition to more stable plant communities dominated by mature trees and large shrubs. Habitat quality for deer and elk is therefore enhanced by periodic disturbance (CDFG et al. 1998). However, some undisturbed areas are also valuable as cover. Deer and elk populations are typically at their highest densities in areas with a diverse mix of forage and cover habitats.

Oak woodlands provide critical habitat elements for ungulates in California, especially deer. Acorns are an important food source in late summer, autumn, and early winter, comprising 40% to 50% of deer diets from September through December (Taber 1956; Longhurst et al. 1979; Bertram 1984). Migratory deer in Tehama County have been known to move to their winter range earlier in years of good acorn production, and to delay movement in years of acorn failure (Leach and Hiehle 1957).

Fire

Fire suppression has had a substantial impact on habitats in many deer and elk ranges, particularly in conifer forests. Long-term fire suppression often results in adverse impacts to habitat through the loss of forage and edge habitats (Nelson et al. 2008). Gruell (2001) suggests that within the Sierra Nevada and prior to European settlement, repeated, low intensity surface fires set by indigenous people maintained a more open forest canopy with early successional stages of shrub and herbaceous vegetation and small patches of young trees. Effective fire suppression has led to forest conditions favoring dense closed canopy stands of trees, shrub fields too dense for deer to move through, and aging forage species that are less palatable (Gruell 2001). As a consequence, California's deer and elk habitats have become less diverse with less representation of varied successional communities, in part due to fire suppression efforts.

However, not all habitats benefit from fire. In the Great Basin, fire has largely negative effects by killing the shrubs that are the predominant vegetation in this habitat. Recently burned areas provide no browse, thermal cover, or hiding cover for wintering deer (Loft and Menke 1990), and it is common for nonnative cheatgrass to invade these shrublands after catastrophic wildfire*.* Even in conifer-dominated habitats where fire once maintained mosaics of multiple-stage successional vegetation, the current increased fuel load caused by long-term fire suppression and prolonged drought conditions now often sustain large, high intensity fires that scorch vast areas and require significant time to recover (SBFFP and CDFFP 2010). The 2010 Strategic Fire Plan for California indicates a trend of increasing acres burned statewide, as shown in Figure 6.9. Fire acreages for shrublands and coniferous forests in particular exhibit a large spike during the 2000s (SBFFP and CDFFP 2010).

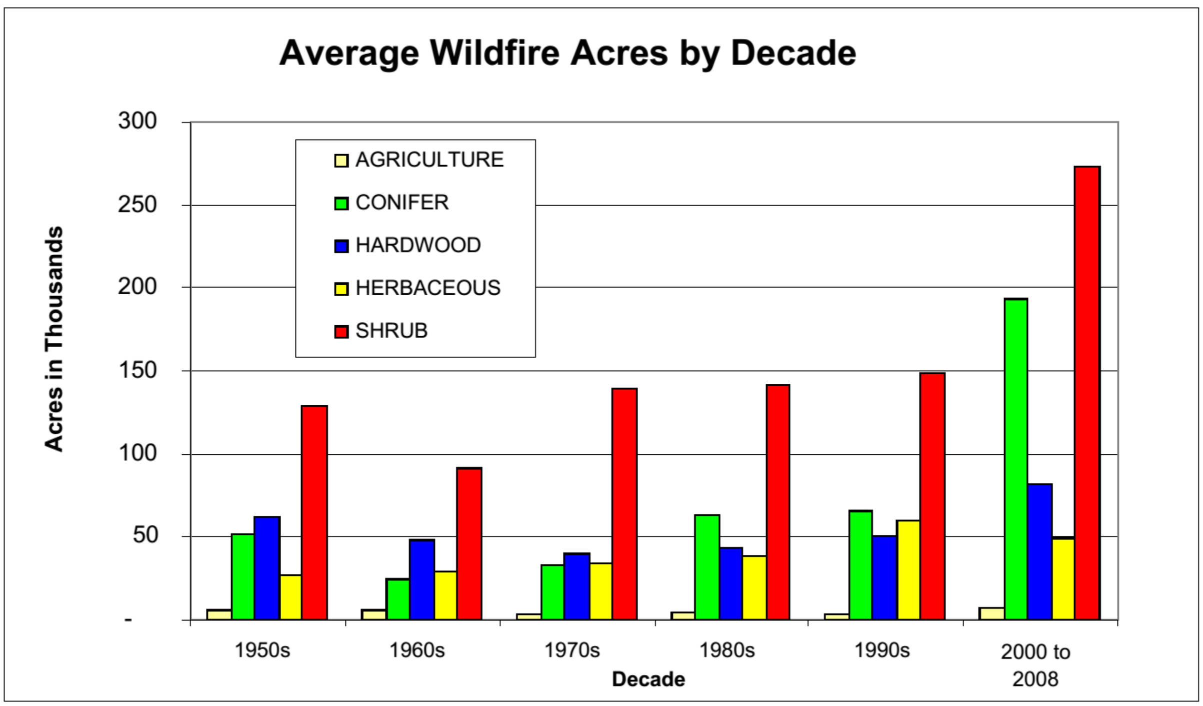

Figure 6.9. Annual acres burned by decade and by life form, 1950 – 2008. Source: State Board of Forestry and Fire Protection and California Department of Forestry and Fire Protection, 2010 Strategic Fire Plan for California.

Timber Harvest

In many cases logging activities can provide a source of disturbance to reset vegetation to early seral stages in forested habitats in California. The trend on both public- and privately-owned land has been a reduction in timber harvest volume through time (Figure 6.10), however the rate of decrease has been much greater on public land than on private land. Between 1978 and 1988 there was 1.4 times greater volume (board feet) of timber removed from private than public lands. In contrast, between 2003 and 2013 this difference was 8.3 times (CBOE 2014). This suggests that reset of conifer dominated habitats to early seral stages is greater on private compared to public lands. There are many other factors that affect habitat quality from timber harvest such as type of harvest (clear cut versus selective harvest) and pre- and post-harvest treatment types (such as herbicide application), but Figure 6.10 exemplifies a general trend over time.

Several other factors affect the ability of deer and elk to meet their habitat needs. Historical livestock use degraded many riparian areas, and reduced forage and cover vegetation. Oak woodlands, which serve as important winter habitat, have been declining in California for decades. As a result of residential-commercial development and clearing for firewood and range improvement, 16 counties in California have experienced decreases in oak woodlands of greater than 21% (UCANR 2014b).

Private land in many respects is more productive (from an ungulate perspective) due to successional reset from logging and other management actions. In many instances private land contains better soils, more water sources, and better forage. In several areas of Humboldt and Del Norte counties elk numbers have increased and the increases appears to disproportionally favor private property over adjacent public lands that CDFW believes is due to habitat availability and quality (CDFW 2015a).

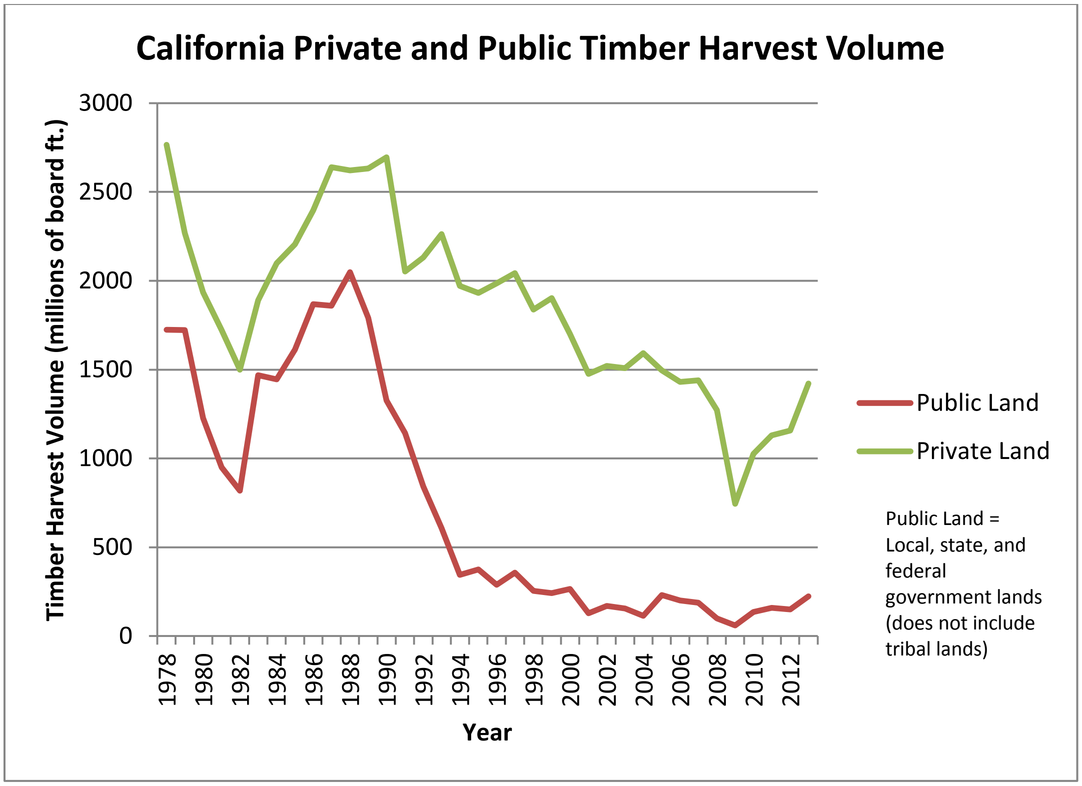

Figure 6.10. Timber harvested from public and private forests in California from 1978 to 2013 (CBOE 2014).

Climate Change Impacts on Ungulates

Atmospheric concentrations of greenhouse gases, especially carbon dioxide (CO_2) are the primary factors affecting global temperature (Weart 2003). These concentrations have increased rapidly over the past 200 years, which is expected to result in marked changes in climate throughout the world, particularly in the form of rising average temperatures (Hansen et al. 2006). Predicted physical and climatic changes due to continued warming include increased frequency and severity of wildfires, increased frequency of extreme weather events, and changes in rainfall and snowfall patterns. Because of their strong association with climate, plant communities are expected to respond to these changes through generally northward latitudinal and upward elevational shifts. These shifts are expected to affect the abundance, distribution, and structure of natural communities (deVos and McKinney 2007).

Potential effects of climate change on specific plant communities are difficult to predict; however, some regional predictions have been made for western North America. Models indicate that drier forests containing juniper, ponderosa pine (*Pinus ponderosa*), and arid hardwood species such as blue oak (*Quercus douglasii*) and interior live oak

(*Q. wislizenii*) will expand in distribution; temporal rain forests containing conifers such as western hemlock (*Tsuga heterophylla*) and Sitka spruce (*Picea sitchensis*) will decrease west of the Cascade Range, but may expand in the interior; subalpine conifers may contract substantially; and big sagebrush is expected to shift from the U.S. into Canada, and be replaced by such species as creosote bush (*Larrea tridentata*), which currently occurs in the desert southwest (Hansen and Dale 2001). Because winter range is a crucial but limited and declining resource, particularly for mule deer in California (Mule Deer Working Group 2005), these shifts in plant communities may lead to further declines in the size and quality of winter range in California (deVos and McKinney 2007). DeVos and McKinney (2007) suggested that elk abundance may actually increase in the short term due to their ability to utilize a wider array of low to moderate quality forage, but in the long term both mule deer and elk will likely decline as a result of increasing drought conditions expected in California.

In addition to shifts in plant communities resulting from climate change, increased atmospheric CO_2 concentrations benefit the growth of trees more than shrubs, with the least benefit to grasses. In some locations this has led to the replacement of slower-growing species by faster-growing species, thereby altering plant species composition (Jones et al. 1998; Prichard et al. 2000). These faster growing plants tend to have lower nutritional value and are frequently less palatable for herbivores (Nowak et al. 2004). Both mule deer and elk are sensitive to environmental conditions (Mule Deer Working Group 2003); however differences in digestion efficiency may lead to disproportionate effects on mule deer as a consequence of these changes in forage quality. Elk are better suited to utilize lower quality forage from a wider variety of grasses, shrubs, and trees, whereas mule deer have a less diverse diet and require higher quality forage from forbs and shrub leaves and young stems (Wakeling and Bender 2003).

Although research specific to ungulate responses to climate change is limited, existing information suggests both adverse and beneficial effects, depending on a variety of local/regional factors such as latitude, elevation, topography, and aspect. For example, in Rocky Mountain National Park where snow accumulation currently limits elk winter range, computer simulations suggest a reduction in future snow accumulations of up to 25% to 40%. An expansion of winter range would serve to increase over-winter survival and recruitment of juveniles into the adult population, leading to an increase of the overall elk population in that area (Hobbs et al. 2006). Conversely, research in BNP, Canada indicates climate change will result in colder winter temperatures, increased snowfall, and a higher frequency of winter storms (Hebblewhite, 2005). These factors would result in a decrease in over-winter survival and recruitment, leading to an overall reduction of the elk population for that area.

CHAPTER 7 EFFECTS OF WOLVES ON LIVESTOCK AND HERDING/GUARD DOGS

A. Effects of Wolves on Livestock

Gray wolves may adversely affect livestock[23] directly, by killing or injuring individual animals,[24] or indirectly, by modifying livestock behavior and physiological processes. While direct effects are generally easier to quantify and have received the bulk of scientific and public attention, recent research suggests that indirect effects also contribute to the total economic impact of gray wolves upon livestock producers (Muhly et al. 2010a; Laporte et al. 2010; Ramler et al. 2014). As in other western states with wolf populations, some livestock producers[25] in California will be affected financially due to direct losses or indirect effects from wolf depredations on livestock including the acquisition and installation of materials (or other measures) to avoid and/or minimize wolf conflicts. Others will experience no losses or effects. Whether, where, and when depredations occur will depend on many factors, including the abundance and distribution of both ungulates and wolves (Imbert, et al. 2015), the abundance and distribution of livestock in areas occupied by wolves, and the livestock husbandry and protection methods utilized by producers. At the state level, wolf depredation is likely to represent a very small portion of all livestock mortality and a relatively small portion of overall livestock depredation. However, the economic impacts of gray wolves to individual producers could be significant.

1. Direct Effects

Wolf-caused livestock depredation has been documented in all western states with established gray wolf packs (Idaho, Montana, Oregon, Washington, and Wyoming).[26] In those states, wolves have preyed upon cattle, sheep, goats, horses, llamas, miniature horses, Shetland ponies, and domestic bison (Sime et al. 2007, USFWS et al. 2013). However, cattle and sheep comprise the great majority of depredated livestock, respectively comprising 32% and 67% of all confirmed[27] wolf depredations (USFWS 2014).[28]

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[23] Livestock is used here to refer to domesticated animals raised and/or kept for their economic value or other use.
[24] Property damage caused by wildlife, including the killing or injuring of livestock and pets, is generally referred to by CDFW and in this document as “depredation”.
[25] As used in this chapter, the term “livestock producer” refers to all owners and managers of livestock and includes those engaged in commercial and non-commercial livestock production.
[26] Hereafter in this chapter these states are referred to as the “western states.”
[27] Depending on the state, staff from the state wildlife management agency and/or USDA/APHIS Wildlife Services investigates all reported wolf depredation events. In each state the same or very similar criteria is utilized to confirm wolf depredation. Investigations result in a conclusion of “confirmed”, “probable”,

Most wolf attacks on cattle involve one or two individual animals (Muhly and Musiani 2009), and wolves prey on calves more frequently than adult cattle (Dorrance 1982; Fritts et al. 1992; USFWS 1996; Sime et al. 2007; Sommers et al. 2010). The significant size difference between calves and adult cattle likely makes calves much easier for wolves to kill. In 2010, livestock producers in the western states reported that wolves killed over three times as many calves as adult cattle (USDA-NASS 2011).[29] Wolves may also select the youngest calves available. Oakleaf et al. (2003) found that calves in Idaho born one month later than others on the same range were four times more likely to be depredated by wolves.

Multiple sheep are often attacked during wolf depredation incidents (Sime et al. 2007), and wolves sometimes kill them in excess of their immediate food requirements. Sheep of all ages are likely easy prey for wolves due to their relatively small size and lack of effective defense mechanisms. Muhly and Musiani (2009) found that wolves in Idaho, Montana, and Wyoming, killed an average of nearly nine sheep per incident. Additionally, a smaller proportion of the edible sheep biomass was typically consumed than was consumed in cattle depredation incidents (Muhly and Musiani 2009). Wolves are sometimes involved in incidents where large numbers of sheep (40+) are killed or injured. In six out of seven such incidents in Idaho since 1995, wolves had bitten all the wounded or killed sheep. However, in one 2013 wolf attack nearly all the 176 sheep that died perished from panic-induced trampling and suffocation (T. Grimm, USDA/APHIS Wildlife Services, pers. comm. April 2014).

Depredation numbers and trends

Estimated numbers of wolf-livestock depredation events are often considerably larger than confirmed depredations. For example, in 2010 the USDA/APHIS National Agricultural Statistics Service (USDA-NASS) estimated that wolves killed 4,763 cattle in the western states (USDA-NASS 2011). In contrast, the interagency Northern Rocky Mountain Wolf Recovery Program (NRMWRP) reported only 199 confirmed cattle kills during the same period in the same area (USFWS et al. 2013). This more than twenty-fold difference stems primarily from the data-gathering techniques used to derive estimates and the logistical challenges of promptly locating missing animals and conducting detailed assessments of the cause of death. The USDA-NASS estimate was derived from a random survey of cattle producers. However, many of the losses and causes of loss reported by the surveyed producers may not have otherwise been

"possible/unknown", or "other" (or similar terms). Most confirmed depredations include bite marks from wolves with pre-mortem hemorrhaging and tissue damage on the livestock carcass affirming that wolves were directly responsible. Incidents deemed "probable" are not included in the depredation numbers presented here.

[28] Cattle and sheep are the most common livestock in western states, and they are also frequently, but not always, grazed in areas relatively far from human habitations (e.g., in open range environments or in very large pastures).

[29] For the NASS survey all cattle weighing less than 500 pounds were considered calves and those weighing over 500 pounds were considered cattle.

reported to or investigated by agency staff.[30] The NRMWRP statistics only include those incidents where an agency staff confirmed a reported wolf depredation. Many investigations of a reported wolf depredation result in a finding that wolves did not cause the reported livestock injury or mortality or that the cause of damage cannot be conclusively determined. ODFW investigated 41 potential wolf depredation events in 2013. Thirteen of these (32%) incidents were confirmed as wolf-caused and two (5%) were found to be probable wolf-caused depredations (ODFW 2014a). During a 10-year period in Montana, about 50% of annual wolf damage complaints were confirmed (Sime et al. 2007). In summary, because many incidents of reported wolf-livestock damage are not confirmed when investigated, and because the USDA-NASS estimates likely include many incidents that were not investigated, those estimates are likely to overestimate wolf-livestock kills.

It is also very likely that confirmed depredation counts underestimate wolf-livestock kills. The carcasses of some wolf-killed animals are never located or are found in such incomplete condition or so long after death that determining the cause of mortality is not possible. These outcomes are most likely where livestock are grazed in extensive, rugged, and/or remote areas and monitored infrequently. In a mountainous, densely forested USFS grazing allotment in Idaho, only 12.5% of estimated wolf kills and 8.7% of estimated non-predation deaths were located by ranchers (Oakleaf et al. 2003). However, the authors speculated that the detection rate might be much higher in less densely forested or rugged environments. In a 74,000+ ac (30,000 ha) “steep and rugged” USFS allotment in the range of the Mexican gray wolf, the livestock producer located 27 of 34 calves killed by predators (79%) and all three calves killed by wolves (Breck et al. 2011). The authors credited the high detection rate to near-daily monitoring of cattle by experienced staff and the use of dogs for locating cattle.

Regardless of the method used to estimate depredation, at the state level, wolf depredation generally represents a very small proportion of all livestock mortality and a relatively small proportion of livestock depredation. Most cattle and sheep deaths result from digestive or respiratory ailments, calving problems, weather, and other factors not related to depredation, and most depredations are by coyotes (USDA-NASS 2011, 2012b, 2013, 2014). In 2010, wolf depredations in states comprising the NRM DPS[31] likely represented less than 1.4% of all cattle mortality and between 1% and 20% of all cattle depredation (Table 7.1). In 2011, survey of sheep producers indicated that wolves

[30] For example, in 2010, the USDA-NASS statistics estimate that 1,293 cattle were killed by wolves in Montana. Yet only 190 wolf-livestock incidents were reported to USDA Wildlife Services in Montana during Fiscal Year 2010 (which included the last three months of 2009 and the first nine months of 2010) (Sime et al. 2011).

[31] The Northern Rocky Mountains Distinct Population Segment is a geographic area containing the states of Idaho, Montana, Wyoming and portions of eastern Washington, eastern Oregon, and northern Utah.

were responsible for less than 1.2% of all sheep mortality and 4.2% of sheep depredation in Idaho, Montana, and Wyoming (Table 7.2).[32]

Although the contribution of wolf depredation to livestock loss at the scale of individual states is relatively small, wolves are not equally distributed across states or large landscapes, and evidence from Idaho suggests that individual wolves may be much more likely to prey on livestock than individuals of other large predator species (Collinge 2008). Additionally, depredating packs tend to repeat the behavior (Bradley 2004; ODFW 2014b; WDFW undated a, undated b). Wolf depredation is thus often concentrated in certain areas, and as a result, the economic impacts of wolf depredation can be substantial for some livestock producers (Fritts 1982; Muhly and Musiani 2009) while others experience no depredations or impacts. From 1987-2006, 162 livestock producers in Montana experienced confirmed damage due to wolf depredations. Of those 162 producers, 38% experienced multiple damage incidents (Sime et al. 2007).

Table 7.1. Wolf depredation as a percentage of all cattle mortality and cattle depredation in the western states, derived from two different 2010 datasets. Datasets are a) confirmed cattle depredations (Northern Rocky Mountain Wolf Recovery Program [NRMWRP]) and b) estimates derived from cattle producer survey reporting (National Agricultural Statistics Service [NASS]). Total cattle mortality and depredation figures from NASS; 2010 is the most recent year for which nationwide results are available.

State	Wolf kill as a percent of all cattle mortality		Wolf kill as a percent of all cattle depredation	
	NRMWRP	NASS	NRMWRP	NASS
Montana	0.1%	1.6%	1.7%	24.9%
Wyoming	0.1%	1.4%	0.7%	15.0%
Idaho	0.1%	2.8%	1.2%	42.0%
Oregon	0.0%	0.4%	0.2%	6.5%
Washington	0.0%	0.1%	0.0%	2.1%
Utah	0.0%	0.1%	0.1%	1.6%
Western states combined	0.1%	1.4%	0.9%	20.4%

Confirmed[33] cattle depredation by wolves in the NRM DPS increased substantially between the mid-1990s and 2005 (Figures 7.1 and 7.2).[34] From 2006 to 2012, the

[32] Cattle and sheep depredation are not presented for the same years or specific geographic areas due to data limitations. NASS only publishes detailed sheep predation statistics for some states and only publishes detailed cattle predation statistics periodically.
[33] The "confirmed" data are used here because the NRM Wolf Recovery Program produces annual reports tallying confirmed cattle and sheep mortality. These data provide a year-to-year index of trends in wolf depredation. The NASS generally publishes detailed nationwide cattle and sheep mortality estimates every five years.

annual number of confirmed cattle kills was relatively stable and averaged 194 deaths per year. Cattle depredation declined in 2013 and 2014, averaging 142 deaths per year. Confirmed annual sheep depredation in the NRM DPS has also increased since 1996, although annual sheep depredation numbers tend to vary to a much greater extent than those for cattle (Figures 7.3 and 7.4).

Table 7.2. Wolf kill as a percentage of a) all sheep mortality and b) sheep depredation in 2011 in Idaho, Montana, and Wyoming. Data from USDA National Agricultural Statistics Service 2012b, 2013, 2014.

State	Wolf kill as a percent of all sheep mortality	Wolf kill as a percent of all sheep depredation
Idaho	4.1%	17.6%
Montana	0.4%	1.5%
Wyoming*	<0.20%	<0.60%
Combined	1.1 - 1.2%	3.9 - 4.2%

* Wyoming reported fewer than 100 sheep killed by wolves, but did not provide an exact number. The results are thus presented simply as less than the percentage that would have resulted from 100 kills. For the combined analysis, the range is the result of the Wyoming kill number falling somewhere between 0 and 100 sheep.

The Washington Department of Fish and Wildlife (WDFW) estimated potential future confirmed livestock losses in Washington for various wolf population scenarios (Wiles et al. 2011). Its analysis was based on the relationship between wolf abundance and confirmed depredations in Idaho, Montana, and Wyoming. As it did not consider any factors specific to Washington, the analysis may also be useful for predicting potential losses in California (Table 7.3). However, the assumptions and caveats of the original analysis remain the same: livestock losses to wolves in California may not occur at the same rates as in other states, as many variables differ between states, including livestock numbers and density, husbandry methods, availability of natural prey, land use, road density, and human density.

[34] Although wolves began recolonizing parts of the NRM DPS in the late 1980s, the population expanded rapidly after wolves were reintroduced to YNP and parts of Idaho in 1995 and 1996.

Table 7.3. Predicted estimates of confirmed depredations for four different future wolf population scenarios. Analysis conducted by WDFW using 1987-2010 confirmed loss data from Idaho, Montana, and Wyoming (Giles et al. 2011).

Wolf population size	Estimated annual number of confirmed losses		
	Cattle	Sheep	Dogs
50	1-6	7-16	1-2
100	2-12	14-35	2
200	6-28	20-60	2-3
300	12-67	22-92	2-4

The WDFW analysis predicted two to 12 annual confirmed cattle deaths and 14 to 35 annual confirmed sheep deaths would result from a wolf population of 100 animals. To date, confirmed losses in Washington have been largely consistent with these predictions[35]. Actual kill numbers would likely be higher, as confirmed depredations are likely to represent only a portion of actual wolf-caused mortality. Nonetheless, if losses to wolves in California are similar to these predictions for Washington, wolf kills would comprise only a small fraction of the current overall annual cattle and sheep loss to predators in the state[36]. At the statewide scale, the economic effects of additional losses caused by wolves would be insignificant. However, because most wolf-caused losses would likely occur in areas of individual pack activity, economic impacts of additional livestock mortalities would likely be borne by a small number of livestock producers. Any indirect effects on livestock value resulting from wolf presence or depredation would also be borne by the producers in the same wolf-occupied areas.

Factors influencing depredation

Numerous factors may affect the amount of wolf depredation on livestock, including seasonality, pasture size, pasture vegetation, terrain complexity, proximity to forested habitats, livestock density, wolf abundance, proximity of livestock to wolf home ranges, presence and abundance of native ungulates, husbandry techniques, the presence of

[35] In 2012, with a minimum known wolf population of 51 wolves, there were six confirmed cattle kills and one confirmed sheep kill. In 2013, with a minimum wolf population of 52 wolves, there was one confirmed cattle depredation. In 2014, with a minimum population of 68 wolves there were two confirmed cattle killed and 28 confirmed sheep killed.

[36] Based on the assumption that confirmed kills represented 12.5% of all kills, the WDFW estimate would suggest that a population of 50 wolves might kill a total of 8-48 cattle and 56-128 sheep per year. If kill rates per wolf are similar in California, a population of 25 wolves might be expected to kill four to 24 cattle and 28-64 sheep per year. In 2010, 9,600 cattle and calves in California were estimated to have been killed by predators, including 5,400 animals killed by coyotes and nearly 3,200 killed by mountain lions or bobcats (USDA-NASS 2011). In 2009, 13,800 sheep were estimated to have been killed by predators (USDA-NASS 2010). Therefore, a population of 25 wolves in California might be expected to increase overall cattle and sheep predation by about 0.5% or less each year.

carrion in or near pastures, and the use of lethal and non-lethal livestock protection techniques.

Seasonal patterns

Though wolf depredation occurs in all months, numerous studies suggest that most wolf depredation occurs from spring through fall (Fritts et al. 1992; Treves et al. 2002; Musiani et al. 2005; Sime et al. 2007; Galle et al. 2009; Morehouse and Boyce 2011). This period generally includes the calving season and the period during which livestock are often grazed in larger pastures or on public land. Livestock that are moved to seasonal ranges are more likely to be within the home ranges of wolves during summer and early fall. Dorrance (1982) found that wolf predation on cattle in Alberta peaked in August and September and noted that the peak coincided with both the maturation of wild ungulate calves and fawns and the increased food demands placed on wolf packs by growing pups. The diet of three Alberta packs shifted seasonally on lands where cattle ranching was the primary land use and the ranges of both species overlapped significantly. From approximately mid-October to April, when most cattle were on private lands, wolves consumed primarily deer and elk. However, during the "grazing season" when most cattle were on public lands, the wolf diet shifted primarily to cattle (Morehouse and Boyce 2011).

Characteristics of pastures and range

Several studies indicate that wolf depredation is more common in relatively remote, wooded or partially wooded locations where livestock are monitored infrequently (Bjorge 1983; Fritts et al. 1992; Morehouse and Boyce 2011). In the western states such locations are often, but not always, found on public lands. However, because fresh carcasses are infrequently located in these environments, depredation is difficult to detect and confirm (Oakleaf et al. 2003). Carcasses are found more readily in open, fenced pastures closer to frequent human activity. In Montana, the great majority of confirmed cattle and sheep depredation from 1987-2006 occurred on private land (Sime et al. 2007).

Comparing the characteristics of neighboring private ranches with and without wolf kills in Idaho and Montana, Bradley and Pletscher (2005) found that pastures where depredation occurred were larger in size, had more cattle, and were farther from residences. These findings were consistent with an earlier Minnesota study (Mech et al. 2000). In another study in the Great Lakes states, depredation was similarly strongly correlated with pasture size and was also more common on farms with lower road density and fewer croplands (Treves et al. 2004). Higher calf densities were correlated with higher calf loss rates in Wyoming (Hebblewhite 2011). In a southwest Alberta study, depredation risk was also lower closer to roads, but in contrast to the findings of Bradley and Pletscher (2005), risk was higher closer to areas with buildings (Muhly et al. 2010b).

In Idaho and Montana cattle pastures, Bradley and Pletscher (2005) found no relationship between depredation and distance of cattle to forest edge, calving location, or whether or not cattle carcasses were removed from pastures. However in Minnesota and Alberta, cattle and sheep depredation was thought to be more common in wooded pastures and pastures adjacent to wooded areas (Bjorge 1983; Fritts et al. 1992). Remote calving locations and the presence of livestock carrion were also thought to influence depredation in Minnesota (Fritts 1982; Fritts et al. 1992).

Presence and abundance of wild ungulates

The effect of wild ungulate presence and density on wolf depredation on livestock remains unclear and may vary depending on circumstance and scale (Linnell et al. 2012). In Idaho and Montana, private pastures where depredations occurred were more likely to have elk present than those without depredations (Bradley and Pletscher 2005). Similarly, in southwest Alberta livestock depredation risk was correlated with elk density (Muhly et al. 2010b) and in the Great Lakes region, wolf depredation on livestock is more common in areas with higher deer densities (Treves et al. 2004). Wolves are likely attracted to areas with larger numbers or higher densities of wild ungulates (particularly elk), and livestock in those areas may be at greater risk of interactions with wolves (and thus possibly being killed). However, it has also been suggested that wolves may kill livestock at greater rates when availability or vulnerability of neonatal wild ungulates is low (Mech et al. 1988).

To evaluate the extent to which cattle depredation is facilitated by the presence and the absence/scarcity of native prey, Nelson et al. (2016) studied cattle depredation in areas occupied by resident and migratory elk in the Greater Yellowstone Ecosytem. Cattle depredations generally occurred in locations where wolves were more likely to encounter livestock. In resident elk areas, cattle depredation sites were associated with elk distribution; wolves tended to kill cattle in areas where cattle commingled with elk. In migratory elk areas, depredation sites were associated with wolf dens, streams, and open habitat, suggesting that in the absence of native prey, spatial patterns of wolf-livestock kills are facilitated by landscape attributes that facilitate wolf-prey encounters.

Wolf abundance and home range location

In the western states, wolf depredation on cattle and sheep has increased as wolves have become more abundant (Galle et al. 2009; USFWS et al. 2013) (Figures 7.5-7.8). However, in some circumstances increase wolf depredation may be partially offset by diminished losses to other predators.[37] For example, in Idaho coyote depredation on sheep declined during the same period that wolf abundance and depredation increased (Galle et al. 2009). Galle et al. (2009) speculated that the coyote depredation declines may have resulted from declines in coyote abundance on sheep summer ranges,

[37] Trends in livestock losses to all predators have been variable in wolf-occupied areas. Data compiled from reports on the USDA websites for Idaho and Wyoming indicates the percentage of sheep and lamb mortality caused by predators has decreased over time in those states (from 1995-2012 in Idaho and from 1999-2013 in Wyoming). From 1984-2012 in Montana, there was no trend in the percentage of sheep mortality caused by predators (USDA NASS statistics available on the NASS Montana website). However, the percentage of cattle and calf losses caused by predators increased from 1995-2010 in the western states (USDA-NASS 2012a).

possibly due to displacement by wolves. The authors also suggested that the use of more intensive livestock protection measures to protect livestock from wolves (e.g., additional livestock guard dogs) might have had the secondary effect of reducing coyote depredation.

Depredation and wolf abundance are also correlated in Michigan (Edge et al. 2011), and wolf range expansion appeared to be the primary factor behind increasing depredation events in Minnesota (Harper et al. 2005). However, in Arizona and New Mexico, there is only a weak correlation between Mexican gray wolf abundance and confirmed cattle depredation (USFWS Mexican Gray Wolf Recovery Program annual reports).

Studies in Idaho and Montana have found that depredation is more likely when livestock occur within or in proximity to wolf home ranges (Oakleaf et al. 2003; Bradley and Pletscher 2005). In Wyoming, wolf-livestock conflicts have generally been less common in areas with high native ungulate densities and relatively few livestock than in areas supporting large numbers of livestock (Wyoming Game and Fish Department et al. 2013).

Wolf pack tendencies

Wolves in many areas encounter livestock regularly but do not attack stock at each encounter (Fritts et al.1992; Chavez and Gese 2006; Sime et al. 2007). Wolf packs vary considerably in their predation on livestock; some packs appear not to depredate or depredate only rarely, while others chronically depredate. One Montana pack was known to have killed livestock only three times over an 18-year period despite the regular occurrence of livestock in its territory and within two miles of a den site (Sime et al. 2007). From 1976-2000 in Wisconsin, two-thirds of packs were never suspected of depredation. However, four packs were each involved in four or more depredation incidents (Treves et al. 2002).

In the NRM DPS, 28% of the 352 packs known to occur at some point during 2012 were involved in at least one confirmed depredation event (USFWS et al. 2013). From 1987-2002 in Idaho, Montana, and Wyoming, an average of 22% of all packs depredated annually; however, not all packs had livestock within their home ranges. Of those packs with livestock in their territories, an average of 30% depredated each year (varying between 10% and 42% annually) (Bradley 2004).

Management tools and livestock protection measures

Livestock producers and wildlife managers have access to a variety of tools and techniques that can potentially reduce wolf depredations (Stone et al. 2008). Most protection methods have specific advantages and drawbacks (see Bangs et al. 2006 for a thorough review), and the use of several techniques (either concurrently or in succession), at a particular location may provide better results than using a single technique (Fritts et al. 1992; Stone et al. 2008). Many of the techniques benefit from maintaining a high level of radio-collared wolves in the population, which allows fine-scale, continuous monitoring of wolf distribution, and can often provide a spatial link between specific packs or pack members to depredation incidents. However, as the wolf population and range grows within an area, intensive wolf trapping, collaring, and monitoring becomes increasingly time-intensive and costly (Kunkel et al. 2005; Bangs et al. 2006).

Non-lethal techniques

Non-lethal techniques for livestock protection include fladry, radio-activated guard boxes, livestock guard dogs, range riders, notification of livestock producers when radio-collared wolves are near their property and livestock, and hazing (such as the use of air horns, spotlights, or cracker shells). Some of these techniques (e.g., fencing) are used to defend specific places, while others (e.g., range riders) are generally used to protect free-ranging animals roaming over large areas.

Fencing (including electric fencing) may provide protection for livestock by excluding wolves (Stone et al. 2008; Linnell et al. 2012). Permanent exclusionary fencing is expensive to install and maintain for large pastures, but may be practical for small areas such as night pens. Temporary electric fencing can be quickly set up to protect small areas. Although few studies on the effectiveness of different fence types have been conducted in North America, mobile electric fences have been used to reduce wolf and bear attacks on sheep in Romania (Mertens et al. 2002). Fencing also has the secondary benefit of confining livestock to areas where they can be better protected.

“Biofences” (the systematic, linear placement of the scat and urine of novel wolves) can be used to manipulate the movements of resident wolves. Ausband et al. (2013) deployed 40 mi (65 km) of biofences in an Idaho study area and found the fences effectively excluded collared wolves from areas the same pack had regularly used the previous summer. However, the collared animals did cross the unmaintained biofence during the second year of the study. Because of the labor and costs involved with establishing biofences and the apparent necessity of regular maintenance and/or fortification, their utility may be limited (Ausband et al. 2013).

Fladry is a technique that involves hanging numerous flags along ropes a short distance above the ground, often along fence lines (Stone et al. 2008). The utility of fladry can be enhanced by using certain flag materials and attachment techniques (Young et al. 2015). Wolves are generally reluctant to cross fladry barriers and research suggests properly-installed and maintained fladry may sometimes prevent wolves from entering livestock pastures for two months or more (Musiani et al. 2003; Davidson-Nelson and Gehring 2010). Musiani et al. (2003) investigated the effectiveness of fladry in Alberta and Idaho. In Alberta, wolves did not enter two fladry-protected 62 ac (25 ha) pastures for 60 days. Wolves approached the fladry barriers on 23 occasions but did not cross them. During the trials, wolves killed livestock on neighboring ranches without fladry. In Idaho, wolves did not enter a 1,000 ac (400 ha) fladry-protected pasture in Idaho for 61 days. On day 61, however, wolves crossed the barrier and killed cattle (Musiani et al. 2003). In Michigan, Davidson-Nelson and Gehring (2010) found that compared to adjacent unprotected areas, wolf visitation was significantly less inside pastures protected by fladry. Wolves crossed the fladry barriers on two occasions during the 75 day trial. However, in both instances the fladry barrier had been compromised - by livestock in one case and human neglect in the other. At nearby control farms without fladry, there was no difference in wolf visitation to the interior and exterior of pastures separated only by livestock fencing (Davidson-Nelson and Gehring 2010). These field results notwithstanding, captive trials suggest that wolves do habituate to fladry and that approaches to fladry increase as food motivation increases (Lance et al. 2010). In trials on five packs of captive wolves, all packs crossed fladry within 24 hours to reach a deer carcass tethered within a fladry-protected 194 ft^2 ($18m^2$) area subsection of their pen (Lance et al. 2010). Furthermore, effective use of fladry requires substantial initial setup costs and regular inspection to ensure that all flags remain in place and hang freely (Davidson-Nelson and Gehring 2010; Lance et al. 2010). It may therefore be more effective on smaller pastures and enclosures, and less effective or impractical on very large or remote pastures.

Electrified fladry (sometimes referred to as “turbo-fladry) is a similar to fladry but also incorporates an aversive stimulus (electric shock) as a secondary repellent. Electrified fladry was substantially more effective than traditional fladry in keeping captive wolves from accessing nearby deer carcasses (mean crossing time for five packs was 10 days rather than one day for traditional fladry) and showed promise in excluding wolves from pastures in field trials (Lance et al. 2010).

Radio-activated guard (RAG) boxes are devices designed to frighten radio-collared wolves. The boxes are stationed within or near livestock pastures and are activated by signals from nearby wolf collars. When activated, they produce visual and/or auditory stimuli that may startle and scare nearby wolves to the extent that they will depart the area without attacking livestock. Field trials suggest that RAG boxes may be effective in protecting livestock in small pastures (<40-62 ac/16-25 ha) (Breck et al. 2002). As wolves can become habituated to the devices, RAG boxes may be most effective when used temporarily (Stone et al. 2008). To reduce the potential for habituation, the boxes can be programmed to produce a variety of different light patterns and/or sounds. Lastly, RAG boxes are only activated by the presence of a collared wolf, and thus will have no impact on uncollared wolves (unless those individuals are in the company of a collared wolf).

Motion-activated guard (MAG) devices also show promise in deterring wolves (Shivik et al. 2003). They produce aversive stimuli similar to those of RAG boxes, but are activated by the movement of large animals. Therefore, it is not necessary for a radio-collared wolf to be present in order for the devices to activate. However, MAGs are only activated when an animal passes within the device’s specific infrared “detection zone” – generally a conical area extending approximately 40-80 feet from one side of the device. Furthermore, as the devices can be triggered by non-target animals (e.g., deer), they may turn on somewhat frequently and thus facilitate the habituation of target animals.

The Foxlight is another commercially-available electronic predator aversion device (Foxlights International PTY LTD, Bexley North, NSW, Australia). Foxlights emit varied light patterns at random intervals during nighttime hours to simulate the presence of a person patrolling pastures or rangelands. The effectiveness of Foxlights at deterring wolves from livestock has not yet been extensively tested, although anecdotes suggest they may reduce depredation by a variety of predators. As is the case with other deterrents that rely on predator aversion to certain stimuli, wolves may become habituated to Foxlights over time, especially if the lights are not periodically moved.

Livestock protection dogs (LPDs) are used across North America to protect livestock from a variety of predators. LPDs are most commonly employed to protect sheep and goats (Bangs et al. 2005; Gehring et al. 2010a). They are rarely used to protect range cattle, as the tendency of the cattle to disperse into small groups makes protection difficult without a large number of dogs (Bangs et al. 2005). The most popular breeds in North America are the Great Pyrenees, Akbash, and Komondor (Andelt 2004). While their use is widespread, experimental research on the effectiveness of LPDs is limited, especially with regard to wolf depredation (Gehring et al. 2010a). Andelt (2004) suggested that LPDs may not be effective against wolves, noting that wolves have killed dogs and dogs have been known to pair-bond with wolves and then assist in livestock depredation. However, an experimental study in Michigan found wolf visitation was significantly lower within fenced 25-100 ac (10-40 ha) cattle pastures protected with Great Pyrenees LPDs than within unprotected control pastures (Gehring et al. 2010b). In the western states, although LPDs have actively protected livestock from wolves, they are also sometimes killed by wolves. At least 18 LPDs (mostly Great Pyrenees) were killed by wolves within the NRM DPS between 1995 and 2004 (Bangs et al. 2005). In most cases the dogs were thought to have been outweighed and outnumbered by attacking wolves (Bangs et al. 2005). Bangs et al. (2005) concluded that while LPDs did not appear effective at protecting highly dispersed livestock, multiple LPDs accompanied by herders appeared to be a viable tool to reduce wolf depredation on confined or closely herded livestock. Bangs et al. (2005) also emphasized that LPDs need to be protected from wolf packs. In an effort to identify LPDs that may be more effective against wolves than Great Pyrenees and other breeds of similar size and temperament, USDA/APHIS (and its research arm the National Wildlife Research Center) began a multi-year study in 2013 to determine the effectiveness of several large European and Asian LPD breeds (USDA/APHIS 2014). These breeds – the Kangal, Karakachan, and Cao de Gado Transmontano - have long been used to protect livestock from wolves and other large carnivores (Gehring et al. 2010b; Urbigkit and Urbigkit 2010).

“Range riders” are cowhands or others (including sheep herders) who patrol ranches and allotments throughout calving and summer grazing seasons, providing a continual (or very frequent) human presence near livestock and the potential for immediate or quick response when wolves interact with livestock. Range riders often travel by horse or vehicle (as conditions dictate) and often have access to a telemetry receiver or other device so they can determine the location of nearby radio-collared wolves. Due to high variability among sites, it is difficult to discern whether range riders actually deter wolf attacks on livestock. Nonetheless, the use of range riders is widespread in the NRM DPS (Becker et al. 2014; Bradley et al. 2014; ODFW 2014a). In Montana, in addition to potentially reducing the risk of livestock depredation, the use of range riders has cultivated trust between ranchers, residents, and agency staff (Bradley et al. 2014). Interviews conducted with ranger rider program participants (coordinators, livestock producers, and range riders themselves) in Montana, Washington, and Oregon suggested that the programs have both livestock management (e.g., depredation mitigation, rapid carcass identification, and increased information on livestock) and social (e.g., influence on public perception, reduced stress, and trust building) benefits (Parks 2015).

Washington and Oregon notify livestock producers or managers when collared wolves are in the vicinity of their property and/or livestock. Such notifications may allow for short-term husbandry modifications or simply increase of human presence and vigilance in the area to prevent depredations. ODFW developed an automated system that notifies potentially affected livestock producers or managers by text message or email when collared wolves are in the vicinity of their livestock. ODFW sent more than 10,000 such messages in 2012 (ODFW 2013) and 83,000 messages in 2013 (ODFW 2014a). Although it is not clear if such notifications actually prevent depredation, ODFW reports that the system has been received favorably by most livestock producers (ODFW 2014a). However, the notification system is limited by GPS collar performance, and these limitations have sometimes led to frustration among livestock producers (ODFW 2014a). For example, collars are sometimes unable to collect or send data, and sometimes fail altogether. Therefore, livestock producers may not always be sent a message when collared wolves are near their livestock. It is also likely that some automated text messages sometimes fail to reach all intended recipients.

In summary, there are many non-lethal techniques that, when properly employed, can reduce the potential for wolf depredation. However, not all techniques are applicable in all settings, and none will eliminate the potential for wolf depredation to occur (Bangs et al. 2006). The protection of livestock utilizing extensive and remote rangelands using existing non-lethal tools and technologies remains a significant challenge.

Lethal techniques

In response to livestock depredation, lethal removal of wolves has been frequently implemented as a means of minimizing the potential for additional depredations (Bradley 2004). The results of wolf removal have seemingly been mixed (Fritts 1982; Tompa 1983 cited by Bjorge and Gunson 1985) and efficacy may be related to both the scale of analysis and the proportion of the wolf population removed. Futhermore, as pointed out by Treves et al. (2016), many studies (including several cited below) assessing the effects of both lethal and non-lethal iinterventions against carnivore predation must be intrepeted with caution due to potentially problematic study designs and implementation.

In an Alberta study area, cattle losses and injuries caused by wolves declined by nearly 60% when more than 90% of the wolves were removed within a two-year period (Bjorge and Gunson 1985). In Minnesota between 1979 and 1998, lethal control in response to depredation events was generally effective at reducing further sheep losses at the scale of individual farms (Harper et al. 2008). Also at the individual farm scale, killing adult male wolves may have reduced subsequent cattle depredation (Harper et al. 2008). However, lethal control did not substantially reduce the following year's depredations at state or local levels (Harper et al. 2008). As Minnesota wolves may learn to exploit livestock, Harper et al. (2005) suggested that it may be necessary to remove all members of packs in order to reduce future depredation.

In an analysis of 1989-2008 data from Idaho, Montana, and Wyoming, Bradley et al. (2015) evaluated the effects of three management responses to wolf depredation on subsequent depredations at the scale of the individual pack or within the same territory: no removal, partial pack removal (averaging 2.2 individuals), and full pack removal. The median time between recurrent depredations was 19 days following no removal, 64 days following partial removal, and 730 days following full removal. Partial pack removal was most effective if conducted within one week of the depredation event. Following partial pack removal, the number of wolves remaining the pack was the best predictor of recurring depredation: each wolf remaining in a pack increased the probability of recurrence within five years by 7% (Bradley et al. 2015)

In an earlier analysis of 1987-2002 data from Idaho, Montana, and Wyoming, Bradley (2004) found that partial or complete pack removal generally resulted in the cessation of local depredation for the remainder of the given grazing season. However, 68% of packs that were partially removed depredated again within one year. Bradley found that removing breeding individuals from packs made them no less likely to depredate again than packs with non-breeders removed. This finding was consistent with earlier results from Minnesota (Fritts et al. 1992). When entire packs were removed in Idaho, Montana, and Wyoming, 60% of those territories were recolonized within one year, and 86% of recolonizing packs eventually depredated (Bradley 2004). This finding suggests that in some cases local factors may have a larger influence on the likelihood of depredation than the specific wolves comprising a pack.

Because of a persistent, strong relationship between livestock depredation and lethal wolf control in southwest Alberta (1982-1996) and Idaho, Montana, and Wyoming (1987-2003), Musiani et al. (2005) suggested culling wolves in response to depredation may primarily be a reactive, rather than preventive, measure and did not find evidence that such removal reduced future depredation at the regional scale. A recent analysis of the effects of lethal wolf control on subsequent wolf-livestock depredation using 1987-2012 data from Idaho, Montana, and Wyoming found that at the regional scale wolf control (as long as it did not exceed 25% of the wolf population) was associated with increased wolf-livestock depredation the following year (Wielgus and Peebles 2014). The authors suggested that a causal mechanism for the increased depredations may have been compensatory increases in breeding pairs and number of wolves after increasing wolf mortality. However, wolf populations were expanding rapidly in those states during the analysis period as wolves colonized previously unoccupied areas (Figures 7.1-7.2), perhaps to the extent that lethal control had little impact on the regional population. As livestock depredation in those states is highly correlated with the number of wolves and the number of breeding pairs present (Figures 7.5-7.8), it is possible that increases in the regional wolf population played a substantial role in the increased depredation observed. Treves et al. (2016) also pointed out that Wielgus and Peebles did not account for the geographic spread in the wolf population as its population increased, which resulted in the exposure of more livestock to potential predation over time. Furthermore, after scrutiny of the Wielgus and Peebles (2014) publication, Poudyal et al. (2016) concluded that Wielgus and Peebles had misspecified models in their analysis thus may have reached inappropriate conclusions. Re-analysis of the same dataset by Poudyal et al. (2016) suggested that more killing of wolves would lead to fewer livestock killings the following year than would be expected by no wolf killing.

In summary, current literature suggests that lethal removal of wolves is primarily effective in reducing subsequent depredation at the local (pack or territory) scale. Lethal control of specific wolves or packs following depredation events may have little effect on future depredation at the regional scale (e.g., northern California and southern Oregon), particularly if the regional wolf population is rapidly expanding.

Human-caused wolf mortality has increased substantially during recent years in Idaho, Montana, and Wyoming (Figure 7.9). Perhaps as a result, wolf populations have declined in some states and may be stabilizing in the overall NRM DPS. This increased mortality has largely resulted from public wolf hunting and trapping (Figure 7.9).[38] Although sport hunting and trapping does not result in the targeted removal of depredating wolves and often may not be focused in areas of greatest livestock use, it can reduce wolf populations and modify pack structure. As wolf abundance in the NRM DPS is correlated with livestock depredation (Figures 7.5 and 7.7), wolf population reduction may reduce the amount of livestock depredation. And at the regional scale, confirmed cattle depredation numbers have declined in recent years (Figures 7.1 and 7.2). And in Idaho and Montana, the two states were human-caused wolf mortality has increased the most, cattle depredation declined significantly from 2009 while the wolf population and number of breeding pairs declined (Idaho) or the wolf population was essentially stable and the number of breeding pairs declined (Montana). On the other hand, despite large increases in the wolf population in both Oregon and Washington since 2009, there is not a clear trend of increasing cattle depredation in those states (USFWS et al. 2016). The number of sheep confirmed as killed by wolves in the NRM

[38] In Idaho, sport wolf hunting began in 2009, discontinued after one year, then resumed with trapping in 2011. In Montana, sport wolf hunting began in 2009, but there was no 2010 season due to legal actions. Trapping began in 2012. In Wyoming, sport hunting of wolves began in 2012 in the northwest part of the state. Trapping is not currently permitted in that area. In the remainder of the state, also in 2012, wolves were classified as predatory animals and can be trapped or shot on sight year-round. In 2014, due to legal action all hunting and trapping has ceased.

DPS varied considerably from year to year from 2009-2015 (Figures 7.3 and 7.4) and does not seem to be clearly linked to wolf population numbers (USFWS 2016). Additional time and research will be necessary to clarify the effect of increasing human-caused wolf mortality on livestock depredation.

2. Indirect Effects

Prey species frequently modify behavior in response to the presence or potential presence of predators (Peacor and Werner 2001; Peckarsky et al. 2008). These behavioral changes are considered the "indirect effects" of predators and typically include heightened vigilance as well as efforts to avoid encounters with and facilitate escapes from predators (Wirsing and Ripple 2011). By their presence and activity, wolves modify the behavior of both wild and domestic ungulates. To the extent that modified livestock behavior (e.g., less foraging due to increased vigilance or selection of poorer-quality foraging areas) adversely affects livestock value or livestock producer operating costs, it represents an additional economic burden to livestock producers operating within occupied wolf range (Ashcroft et al. 2010; Steele at al. 2013).

Interactions between wolves and livestock are frequent in many wolf-occupied areas (Fritts et al. 1992; Chavez and Gese 2006; Sime et al. 2007; Anonymous 2012), and cattle modify behaviors such as vigilance and foraging in response to the presence of predators or depredation events (Kluever et al. 2008; Kluever et al. 2009). Kluever et al. (2009) found that cattle response was stronger to wolf stimuli than mountain lion stimuli, although the authors speculated the stronger response may have been to canids in general (rather than wolf-specific). In Alberta, GPS-collared cows responded to wolf presence by subsequently avoiding areas of high-quality food and selecting areas closer to trails (Muhly et al. 2010a). In another study, individual cattle in Alberta increased path sinuosity and decreased distance to neighbors in response to wolf presence, possibly suggesting that cattle form groups in the presence of wolves. Cattle groups also responded to wolf presence, but their responses were inconsistent and erratic and may indicate that cattle lack consistent and predictable anti-predator behaviors (Laporte et al. 2010). In Oregon and Idaho, wolf-presence on public-land grazing allotments reduced the daily travel distances of cattle (Johnson et al. 2013). The authors suggested the movement reductions may have resulted from increased vigilance or reluctance to leave areas perceived to be safe. Similar indirect effects have been found for elk. Gray wolves affect elk foraging behavior (Creel et al. 2005), nutritional status (Christianson and Creel 2010), habitat use, (Laporte et al. 2010) and for females with calves, increased vigilance (Laundré et al. 2001).[39]

Although few studies have rigorously evaluated the economic impact of indirect effects of wolves upon livestock, several authors have suggested that the behavioral changes

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[39] Studies also suggest the indirect effects of wolves may affect elk pregnancy rates and calf recruitment (Creel et al. 2007, Creel et al. 2011,). However, these findings are not supported by other studies in other locations and remain somewhat controversial (White et al. 2011; Creel et al. 2013; Middleton et al. 2013).

in livestock resulting from wolf presence could adversely impact animal nutrition, weight gain, body condition, reproduction, disease susceptibility, and risk of predation (Howery and DeLiberto 2004; Lehmkuhler et al. 2007). When cattle from Idaho herds that had previously been exposed to wolves and wolf depredation were exposed to simulated wolf encounters, they exhibited increased excitability and fear-related physiological stress responses (Cooke et al. 2013). These behavioral conditions can potentially lead to reductions in weight gain, carcass quality, reproduction, and general health (Cooke 2009). Cattle from wolf-naïve herds did not exhibit such changes in response to the same simulated encounters. A recent study in Montana (Ramler et al. 2014) investigated the effects of various factors, including the presence of wolf packs and confirmed wolf depredations, on the weight of beef (feeder) calves[40]. Non-wolf factors (climate and ranch-specific husbandry variables) explained the great majority of variation in calf weights, and the presence of wolf-pack territories overlapping a ranch and/or its grazing areas did not have statistically significant effects on calf weight. However, when there was at least one confirmed cattle depredation on a given ranch, there was a significant negative effect on the end-of-season weight of the remaining calves on the ranch. The average calf weight was estimated to have been reduced 3.5% (22 pounds). The average number of calves per study ranch was 264, and the per-ranch average estimated loss due to reduced calf weight gain was $6,679 (based on a calf selling price of $1.15 per pound in 2010). A comparison with 2014 sales figures in Montana (http://search.ams.usda.gov/mndms/2014/10/BL_LS75420141006.TXT) would translate to a per-ranch average loss of $14,985.

Additional studies of the indirect effects of gray wolves upon livestock are ongoing. Long term studies examining the presence of wolves on cattle resource-selection, stress, and productivity in Idaho and Oregon continue (see Clark et al. 2009; Clark et al. 2010; Johnson et al. 2013). And in 2014, a cooperative research project began in Washington to investigate the effects of wolf presence on calf weaning weights, pregnancy rates, and cattle space-use (Becker et al. 2014).

B. Effects of Wolves on Dogs

In addition to livestock, wolves sometimes kill domestic dogs. As mentioned previously, livestock protection dogs, particularly those guarding sheep from predators in remote locations, are sometimes killed or injured by wolves. Herding dogs in wolf range face similar risks, though they are often working with a person, who may serve as a deterrent.

[40] Calves stay with the mother cows for about 6 months until they are weaned in the fall and then generally sold as feeder calves (Ramler et al. 2014).

C. Predicting the Potential Effects of Wolves on Livestock and Herding/Guard Dogs in California

Predicting the potential effects of wolves on California livestock and dogs is limited by many uncertainties. It is difficult to predict where wolves will establish in California, how often wolves might interact with livestock, the livestock husbandry practices that may be used in certain areas, the likely ratio of detected vs. non-detected mortalities by area, and the anticipated ongoing improvements in livestock protection measures and other management actions employed by both livestock producers and wildlife managers.

Based on the overlap of wolf habitat suitability models with areas of known grazing in California, Antonelli et al. (2015) suggested that the potential for wolf-livestock conflict is highest in northwestern California, portions of the southern Casdades, and in the northern and central Sierra Nevada. However, the areas of wolf habitat suitability predicted by Antonelli et al. (2015) were generally more spatially constrained than those predicted by CDFW (see Chapter 9 – CDFW predicts a larger portion of the southern Cascades and the Modoc Plateau will be suitable for wolves). If wolves eventually establish throughout much of northern California, CDFW anticipates that wolf/livestockinteractions will be more frequent in the Cascade Range and Modoc Plateau areas than in the Klamath Mountains and much of the Northern Coast Ranges. Compared to the Klamath Mountains area, the southern Cascades and Modoc Plateau are generally characterized by more gentle topography, more extensive shrub-steppe and meadow habitats, and more open forests, which increases their relative suitability for livestock grazing (particularly for beef cattle) at the landscape-level. Several studies suggest the density of predators and/or livestock is one of the strongest predictors of livestock predation (Miller 2015), and county-wide beef cattle and sheep densities are higher in the Cascade Range and Modoc Plateau than the Klamath Mountains (Figures 7.10 and 7.11). Public land grazing allotments are also much more extensive and generally support more livestock in the Cascade Range and Modoc Plateau area (Figures 7.12 and 7.13).

If wolves establish in the Sierra Nevada, livestock conflicts will likely vary depending on pack location. Counties within the Sierra Nevada area with relatively high densities of both beef cows and sheep include Placer, Amador, Calaveras, Madera, Tulare, and Fresno (Figures 7.10 and 7.11). In the central and southern Sierra, Yosemite, Sequoia, and Kings Canyon national parks together comprise more than 1.5 million acres that are free of livestock. However, due to elevation and terrain where snow remains for much of the year, a considerable portion of the land within these parks would be primarily suitable as summer wolf range. Wolves inhabiting the parks would also use adjacent lands, particularly during winter months when many mule deer migrate beyond park boundaries to lower elevation areas (Grinnell and Storer 1924, CDFW unpublished data on the Tuolumne deer herd). Grazing allotments are common on USFS lands north, west, and south of Yosemite National Park (Figures 7.12 and 7.13).

Although livestock losses from wolves in California would be expected to occur on large ranches and public land grazing allotments, some wolf-related losses may occur on smaller parcels in rural-residential areas. Many Californians reside in such areas, which are often located in deer winter range and/or adjacent to large blocks of public land or private timberland that support medium and large carnivores. In addition to cattle and sheep, horses, goats, llamas, and donkeys are common in these settings, and depredation by coyotes, mountain lions, and black bears is not uncommon (CDFW unpublished data).

In addition to livestock, wolves sometimes kill domestic dogs. Livestock protection dogs, particularly those guarding sheep from predators in remote locations, are sometimes killed or injured by wolves. Herding dogs in wolf range face similar risks, though they are often working with a herder, who may serve as a deterrent. Protection dogs are commonly employed in rural or remote landscapes to protect sheep from predators such as mountain lions, coyotes, and bears. Success of livestock protection dogs has varied when employed for protection against wolves, although there is ongoing research to determine if some larger European dog breeds may be more effective than more commonly used breeds in the western United States (USDA/APHIS Wildlife Services 2014).

Based on data from the western states, wolf depredation on dogs is anticipated to occur infrequently in California. Working dogs associated with livestock appear to be more effective and less at risk from wolf interactions when an adequate number of dogs per herd are present with the presence of trained herders. This higher vigilance comes with added costs to livestock producers. Working dogs and trained herders may be more effective for protecting sheep flocks than protecting cattle (ODFW 2005)

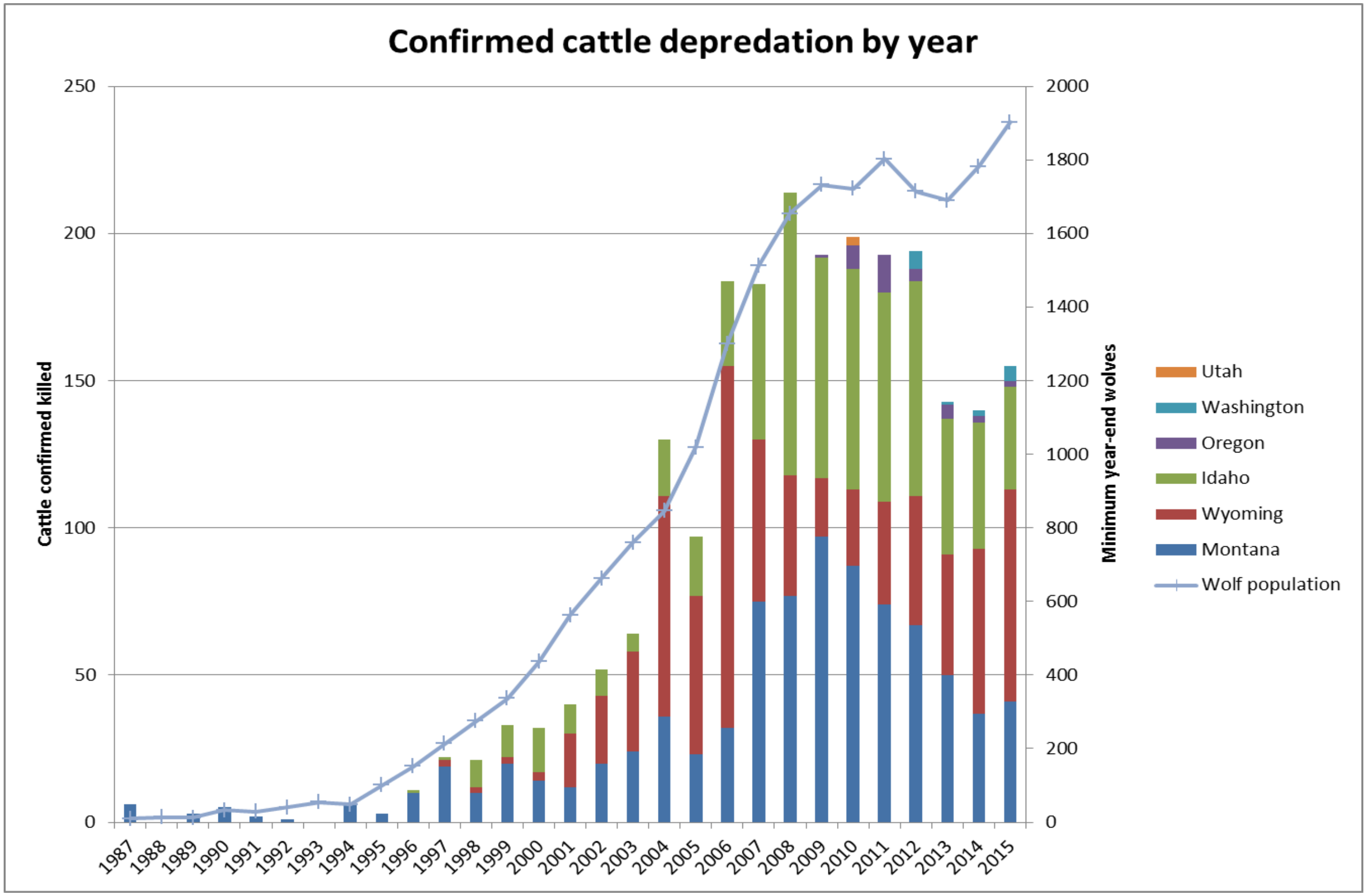


Figure 7.1. Confirmed wolf depredation on cattle and wolf abundance by year in the NRM DPS, 1987-2015. Data from USFWS et al. 2016.

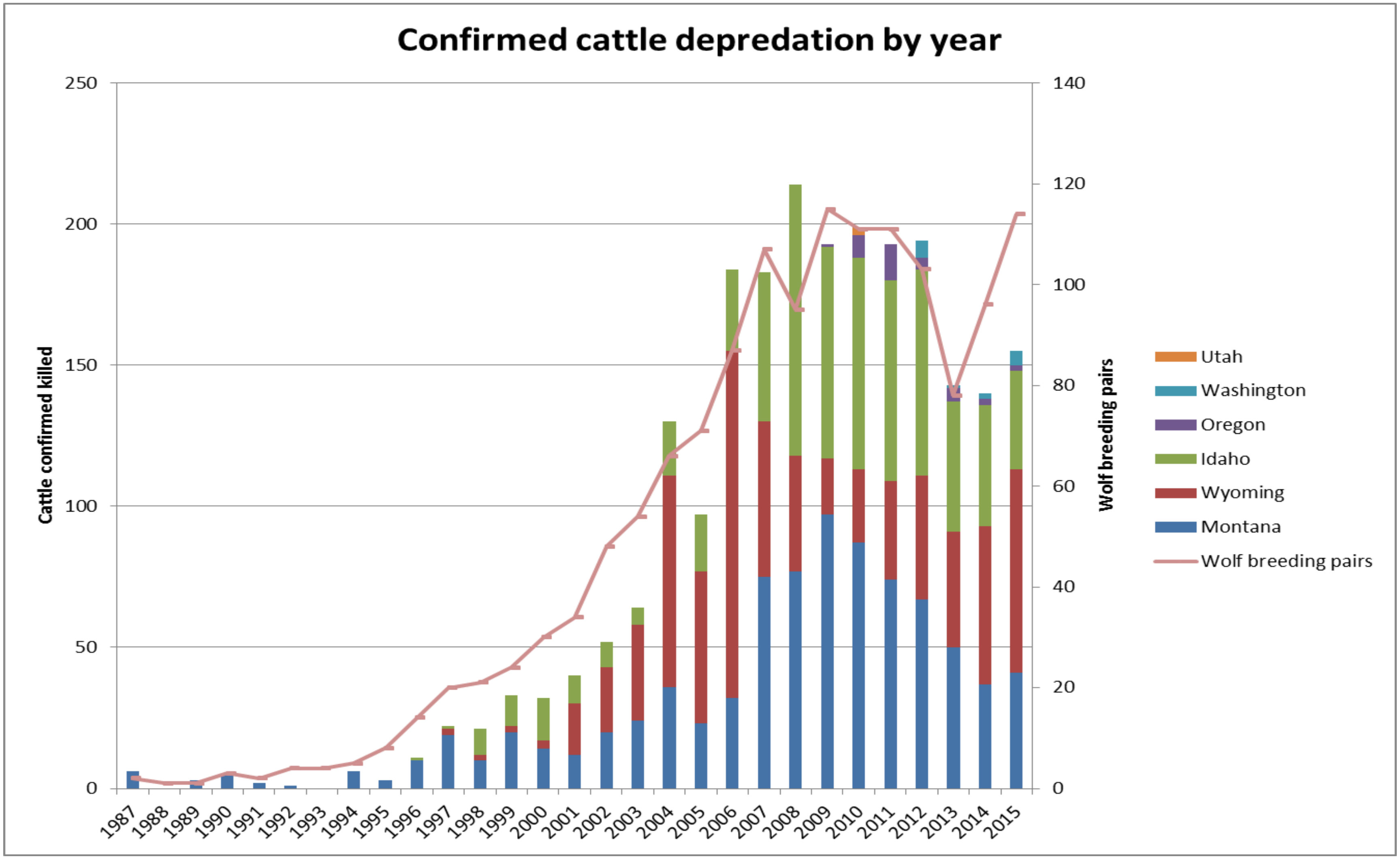


Figure 7.2. Confirmed wolf depredation on cattle and wolf breeding pairs by year in the NRM DPS, 1987-2015. Data from USFWS et al. 2016.

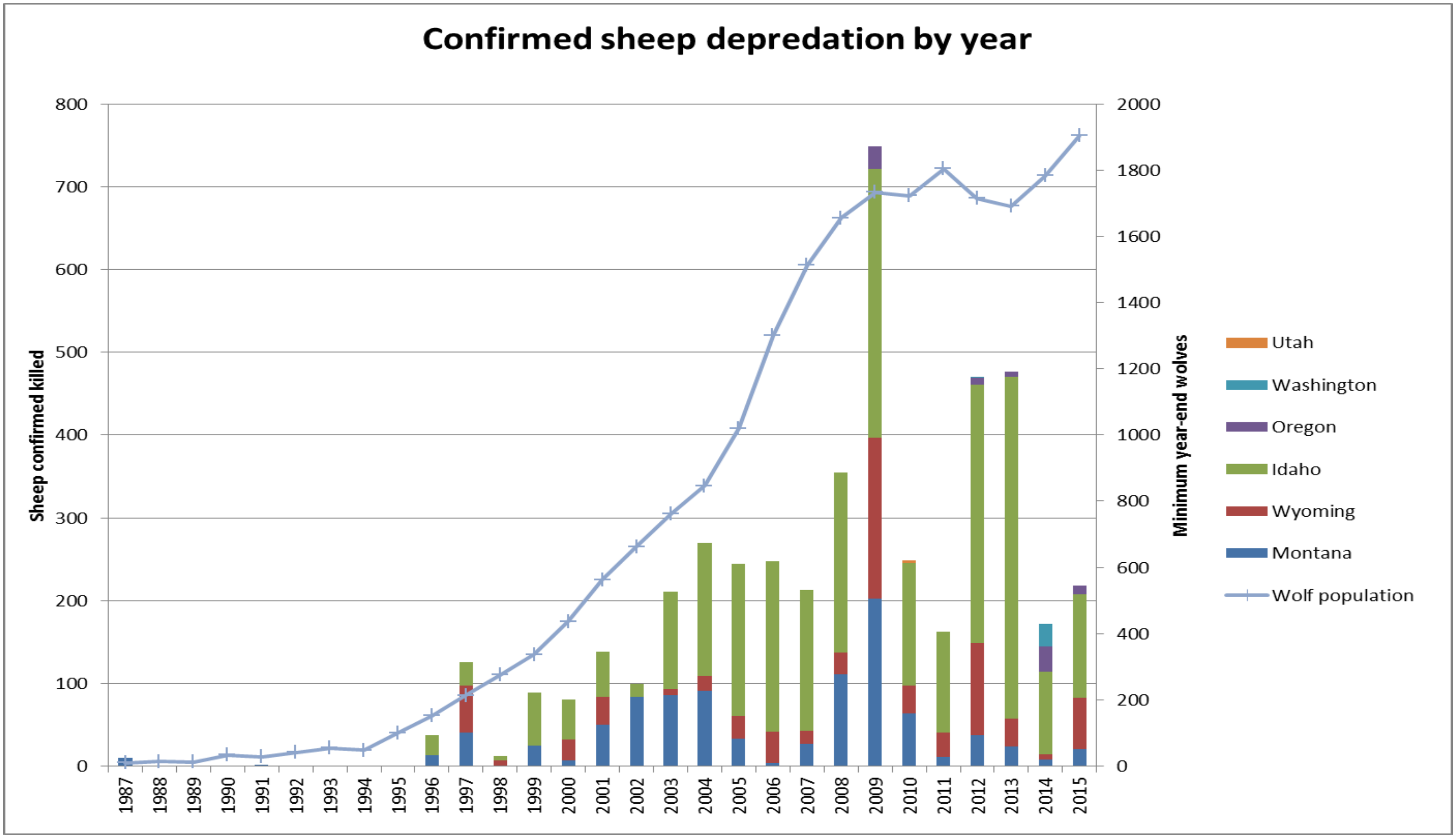


Figure 7.3. Confirmed wolf depredation on sheep and wolf abundance by year in the NRM DPS, 1987-2015. Data from USFWS et al. 2016.

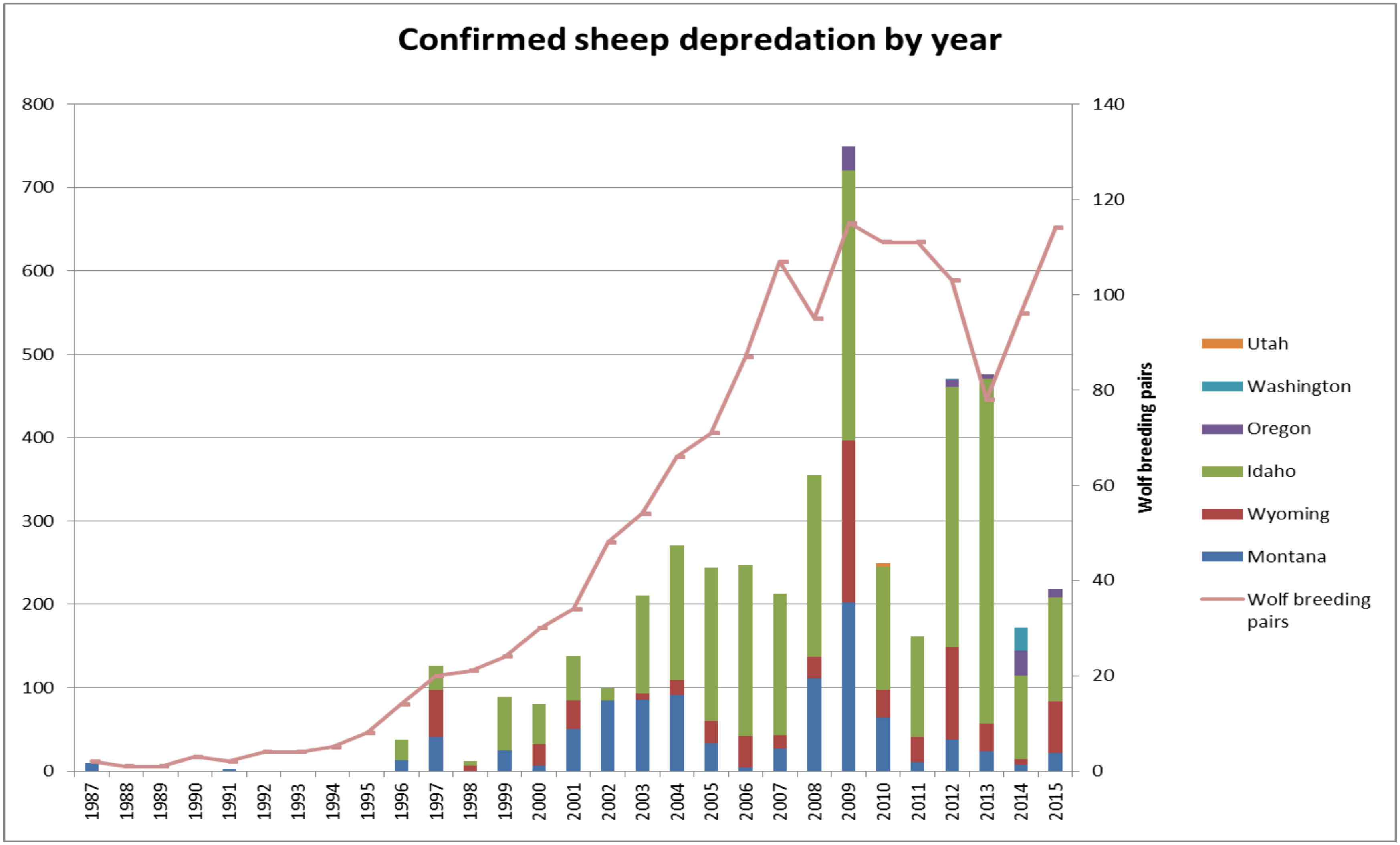


Figure 7.4. Confirmed wolf depredation on sheep and wolf breeding pairs by year in the NRM DPS, 1987-2015. Data from USFWS et al. 2016.

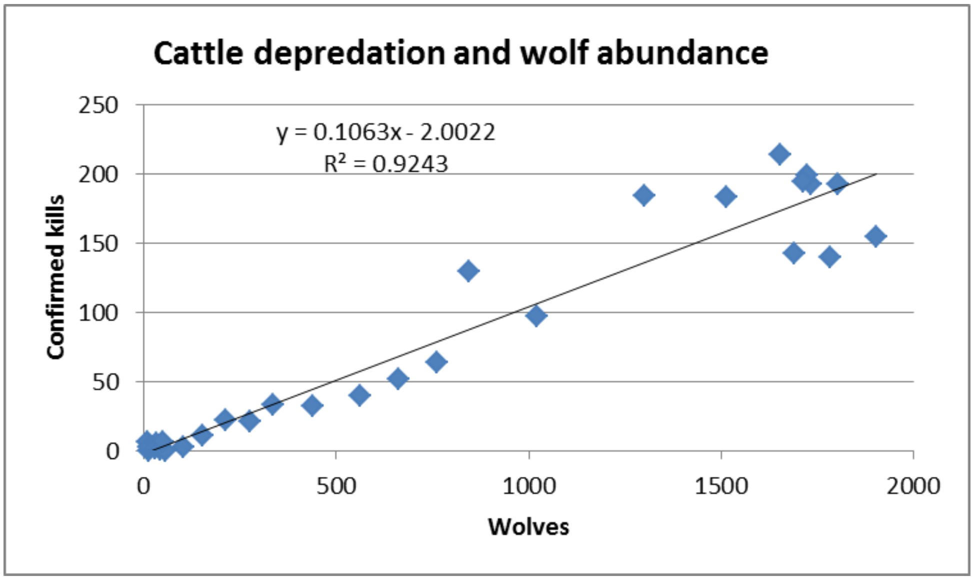


Figure 7.5. The relationship between confirmed cattle depredation and wolf abundance in the NRM DPS, 1987-2015. Data from USFWS et al. 2016.

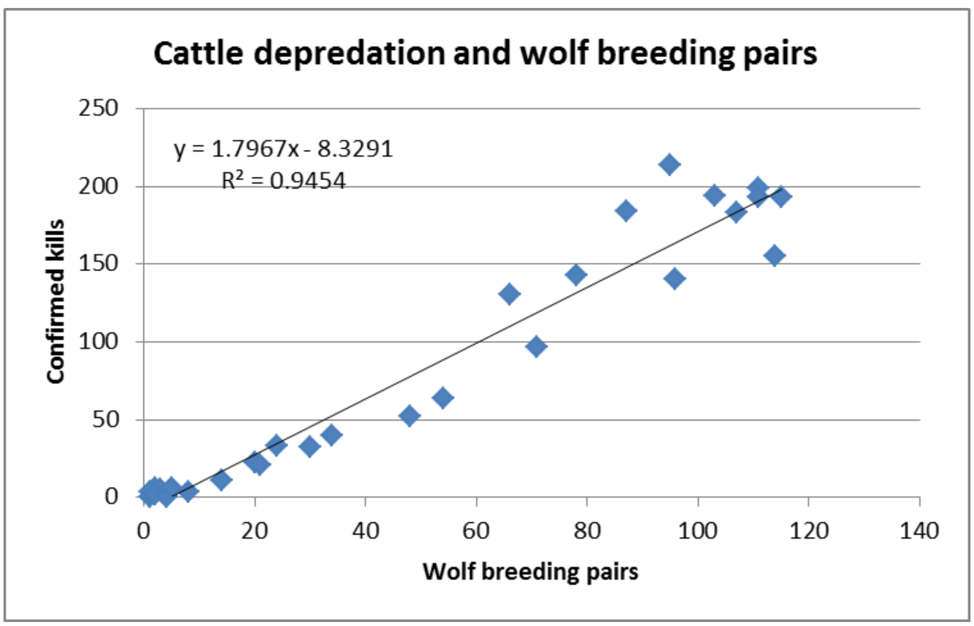


Figure 7.6. The relationship between confirmed cattle depredation and wolf breeding pairs NRM DPS, 1987-2015. Data from USFWS et al. 2016.

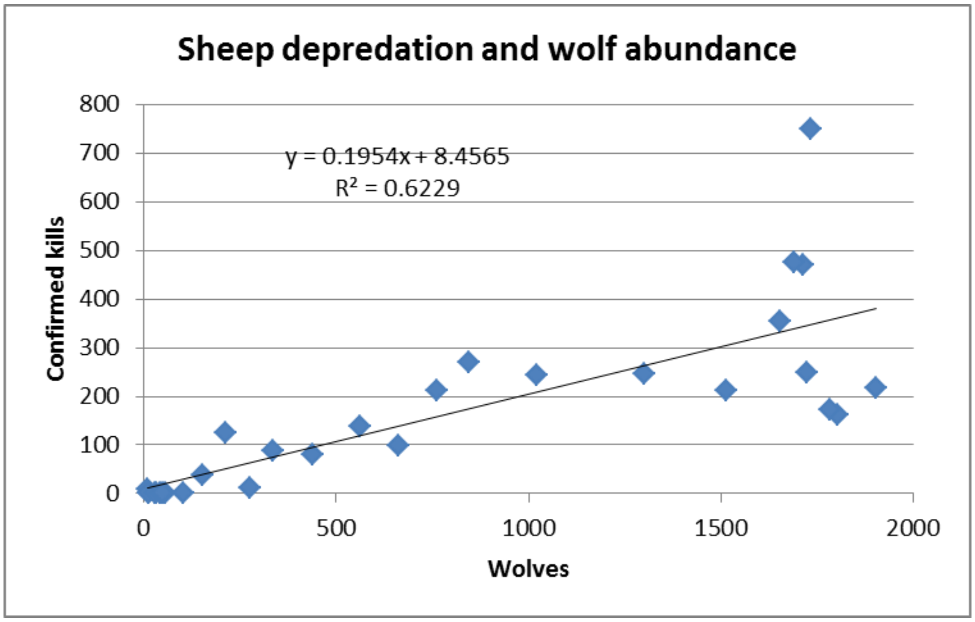


Figure 7.7. The relationship between confirmed sheep depredation and wolf abundance in the NRM DPS, 1987-2015. Data from USFWS et al. 2016.

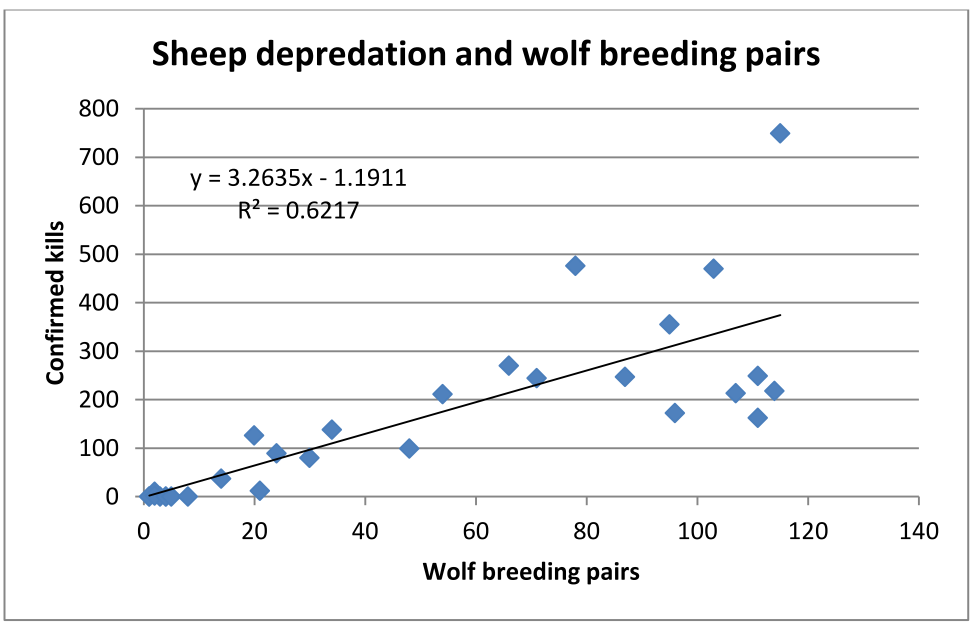


Figure 7.8. The relationship between confirmed sheep depredation and wolf breeding pairs in the NRM DPS, 1987-2015. Data from USFWS et al. 2016.

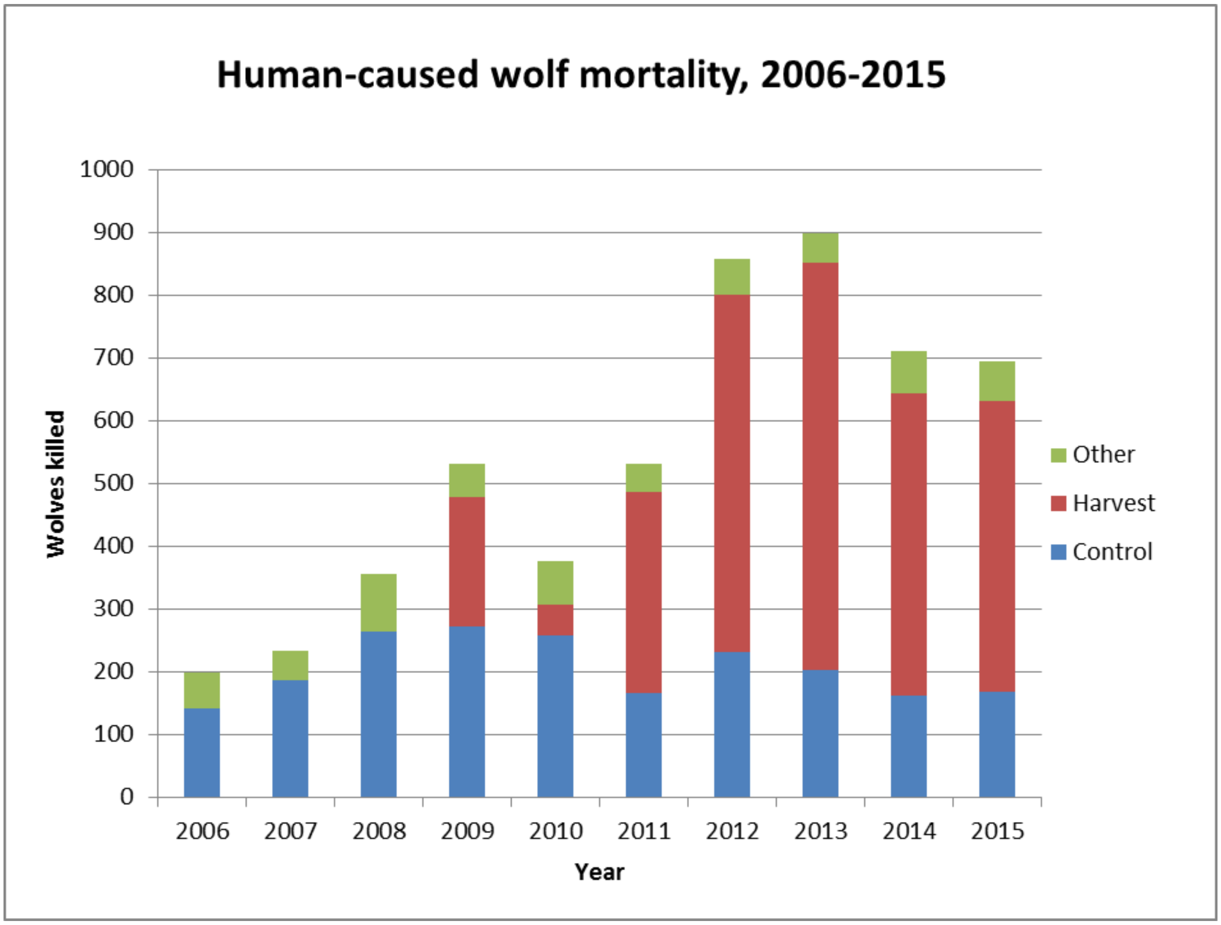


Figure 7.9. Human-caused wolf mortality in the NRM DPS, 2006-2015. Data compiled from USFWS and state annual gray wolf monitoring/management wolf reports, 2006-2015 (available online at http://www.fws.gov/mountain-prairie/species/mammals/wolf/).

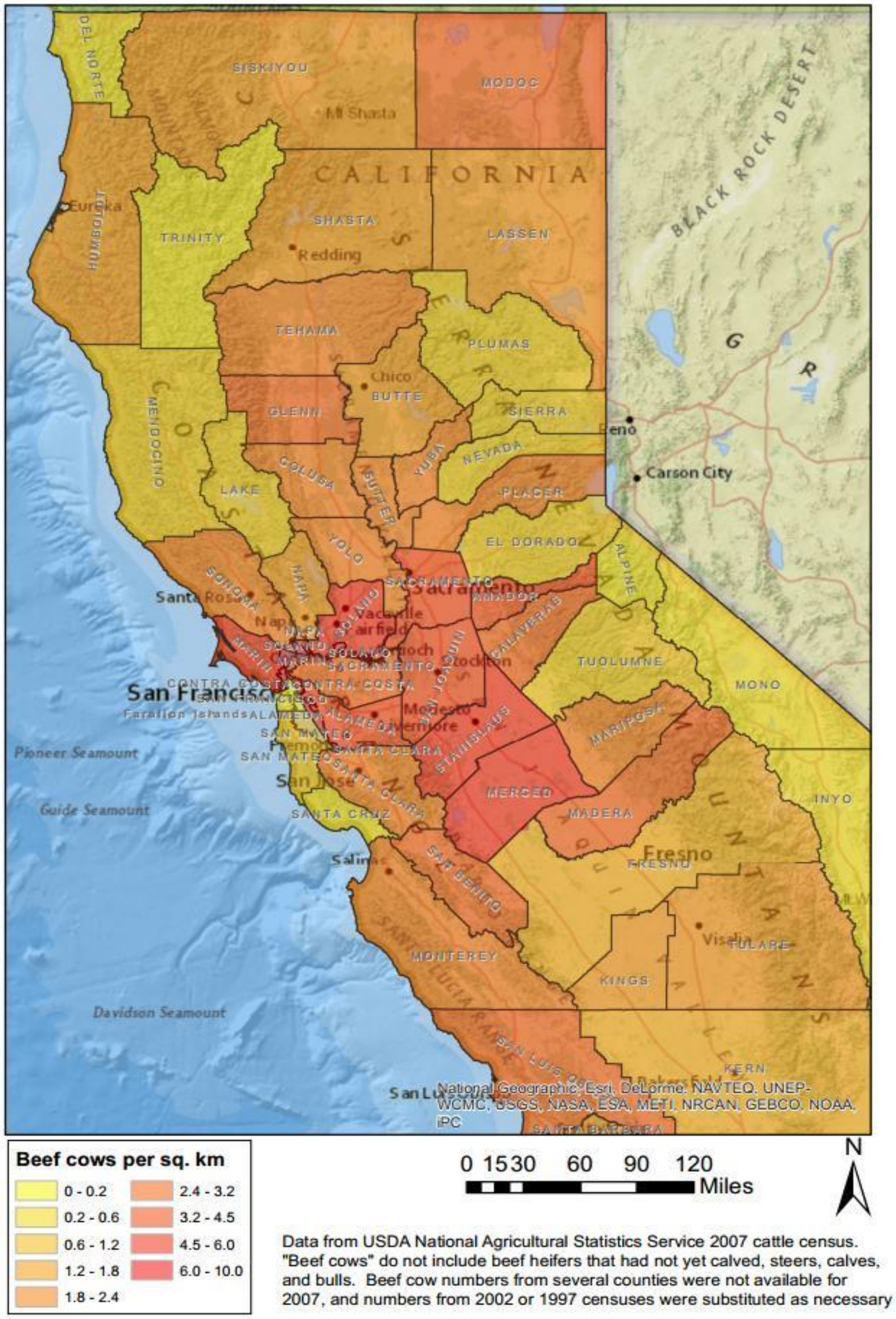


Figure 7.10. Beef cows per square kilometer in each California County.

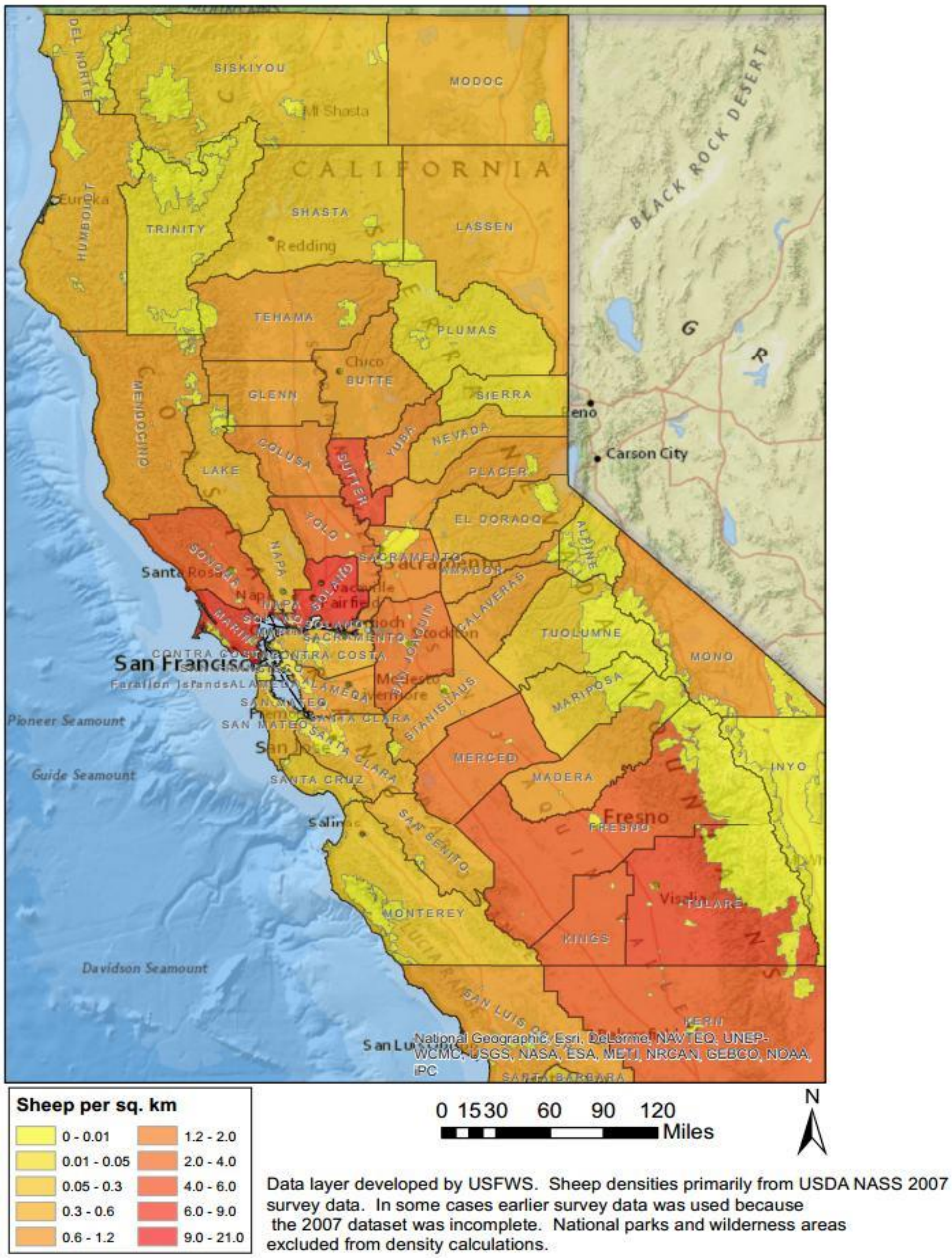
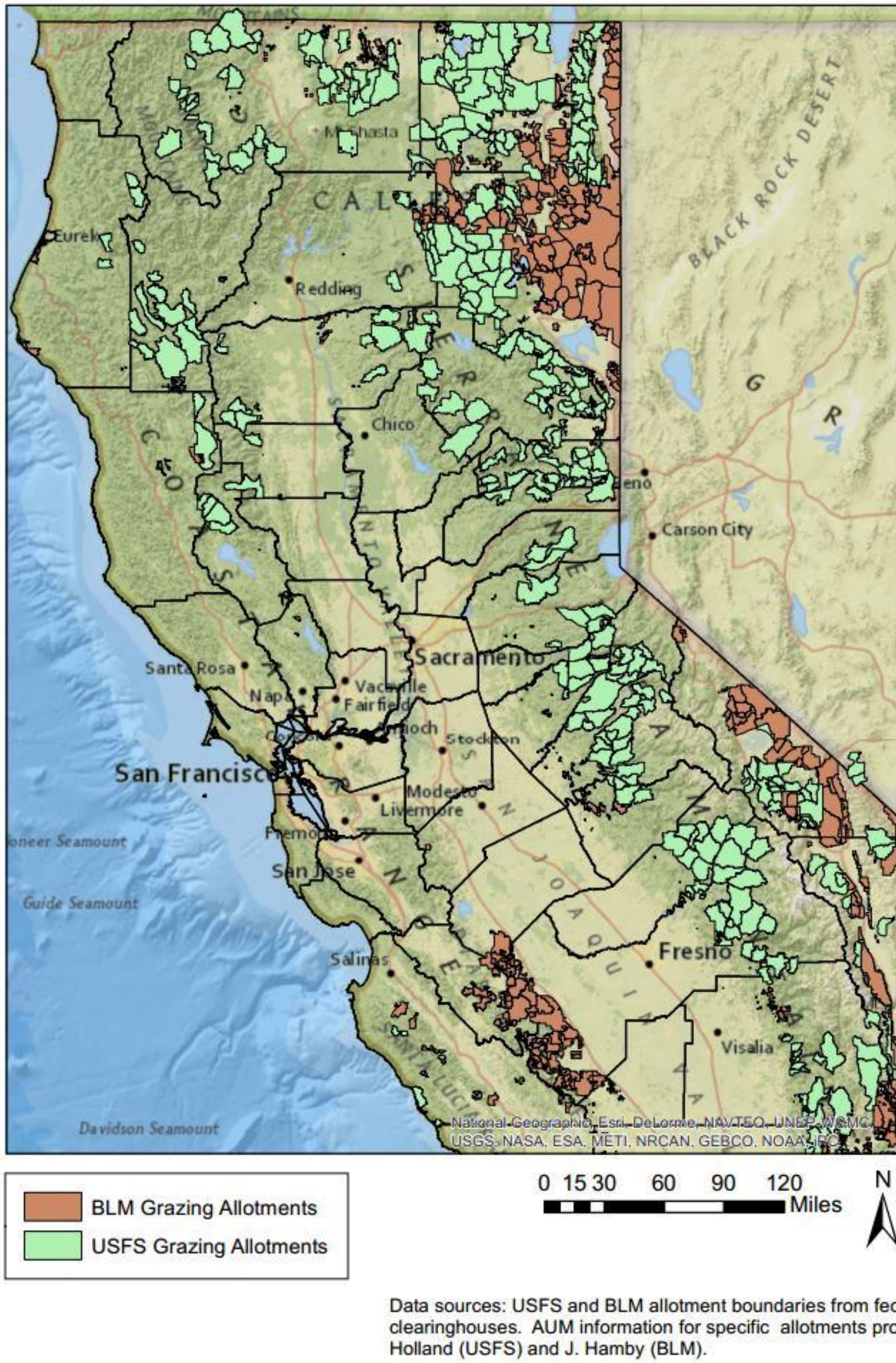


Figure 7.11. Sheep per square kilometer in each California County.



Data sources: USFS and BLM allotment boundaries from federal GIS clearinghouses. AUM information for specific allotments provided by C. Holland (USFS) and J. Hamby (BLM).

Figure 7.12. Active grazing allotments on USFS and BLM lands in California.

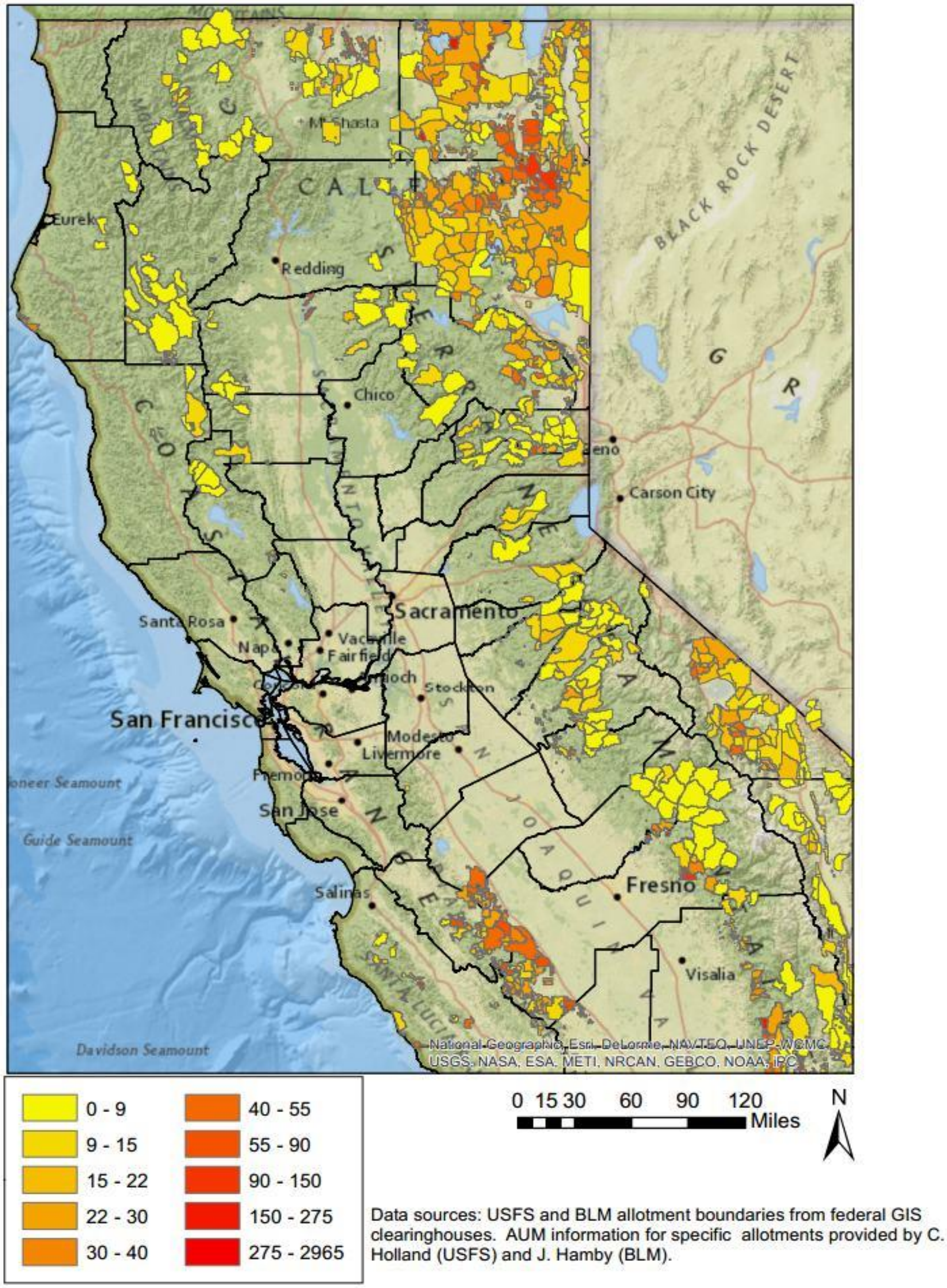


Figure 7.13. Animal unit months (AUMs) per square kilometer on active USFS and BLM livestock allotments in California.

CHAPTER 8 COORDINATION WITH OTHER STATES AND FEDERAL AGENCIES

Regulatory authority and management of wildlife species and their habitats can be complex taking into account whether a species migrates seasonally, crosses state boundaries, can pose risk to private property or the public, has some special status associated with it (state and/or federal), whether it is a hunted species, etc. In addition, the general public participates in processes where input, recommendations, and expectations may be directed to multiple agencies and regulatory bodies for the same species. While the gray wolf is the focus of this planning effort, other species such as waterfowl, other wetland birds including shorebirds, cranes, and waders, interstate deer herds, sage grouse, bats, coyotes, black bears, and mountain lions can be just as challenging for CDFW. This necessitates coordination with those agencies and states to meet requirements for species conservation and management consistent with CDFW goals.

This chapter will cover CDFW's efforts to engage and/or continue to coordinate with other states and federal agencies relative to wolf conservation in California. Specifically:

- As stated in the *Introduction*, the gray wolf is listed as endangered throughout portions of its range, including California, under the ESA. Wolves that enter the State are therefore protected by the ESA, which, in this case is administered and enforced by the USFWS.

- Despite the most innovative, site specific preventative measures to minimize and deter wolf impacts on livestock, it is anticipated that at some point local depredation will occur. CDFW will seek training and assistance with USDA/APHIS WS.

- Information used for the preparation of the California Wolf Plan was gathered from a number of sources including those states with established wolf populations and existing wolf plans including likely sources for wolves to California (i.e. Oregon).

- As previously discussed, the opportunities to address improvements to habitat for ungulates (and hence habitat for wolves) is nowhere more important than through recommendations to the two largest federal public land management agencies with holdings in northern California and the southern Sierras[41]; namely

[41] This is not to dismiss holdings by the National Park Service or other lands in state and federal ownership. Our efforts were to focus on the largest land base by federal ownership in northern California.

the USFS and BLM (Figures 8.1 and 8.2). Adoption of recommendations as priorities for wildlife resources in balance with the needs of other sensitive species and mandates within the respective agencies' Resource Management Plans can insure the restoration and most critically the long-term maintenance of early seral habitats across the landscape.

Cooperation with USFWS Actions

Section 6(c) of the ESA authorizes the USFWS to enter into cooperative agreements with states for the conservation of federally listed species. Signed in 2015, California's agreement with the USFWS acknowledges CDFW's statutory responsibility and authority to conserve such species, and affirms that CDFW has developed an acceptable program for their conservation. The agreement authorizes CDFW to investigate the status of listed species[42], to take necessary conservation actions such as land acquisition, and to involve the public in designating species status. The agreement further provides that CDFW may request funds for the implementation of their conservation program, cooperate in the enforcement of ESA laws[43], and exchange biological data on listed species.

When northern Rocky Mountain states developed wolf plans they were required to exceed federal population goals established by USFWS recovery plans (USFWS 2009; Wydeven et al. 2009) because wolves were federally listed as endangered under ESA in those regions. In Oregon, Washington, and California there are no federal population objectives to consider because the states are not included in the NRM Wolf Recovery Plan (USFWS 1987), although most wolves recolonizing those states originated in the NRM. Having delisted wolves in the NRM in 2011, USFWS proposed in 2013 to delist the gray wolf throughout its range in the U.S., while maintaining protections for the Mexican wolf subspecies. Pending a final ruling by the USFWS, federal restrictions on the take of wolves remain in place in California.

The current Section 6 agreement does not authorize lethal take of endangered species. If wolves are reclassified by USFWS as threatened, CDFW would have more latitude for management. If the wolf is removed from the Federal List of Threatened and Endangered Species management authority will revert entirely to the State.

Coordination with USDA/APHIS Wildlife Services (WS)

WS is the federal agency with nationwide responsibilities for managing wildlife damage problems. Wolves sometimes depredate livestock and/or other domesticated animals and this type of depredation must be investigated. While the CDFW has the lead for

[42] This includes investigating requirements for the survival of the species.
[43] CDFW therefore agrees not to issue permits authorizing take of listed species without prior issuance from the USFWS.

investigating reports of wolf activity, WS is a key partner in wolf management. WS is also experienced in management intervention to prevent or minimize further depredation, as may be warranted in some circumstances. In addition cooperation with WS can consist of valuable opportunities for training and providing support to CDFW in investigating livestock depredation incidents. This type of training has been identified as a priority for CDFW.

Oregon and Other States

As mentioned previously, wolf conservation in California cannot be achieved in isolation from the greater wolf population, particularly those in adjacent states. Indeed California's wolf population will actually be a subpopulation of the larger wolf metapopulation. Ideally, California's wolves will be linked with the greater metapopulation by dispersal of wide-ranging individuals, primarily those in Oregon, and possibly Nevada and Arizona[44] in the future. As a consequence it will be incumbent upon CDFW to seek collaboration with the fish and wildlife agencies in those states in ensuring continued wolf conservation efforts here. This type of regional approach to conservation planning for wolves could be a more appropriate scale at which to establish management objectives for a Pacific states wolf subpopulation.

Within the foreseeable future, wolves will likely enter California from known sources of established gray wolf populations in Oregon and possibly Idaho. As habitat generalists, wolves are very adaptable and can occupy every habitat in the Northern Hemisphere (Fuller et al. 2003). Wolves require only a sufficient year-round prey base and protection from excessive human-caused mortality (Wiles et al. 2011). As such (and discussed elsewhere in the Wolf Plan) wolves can be expected to occupy suitable habitat on both public and private lands. Within northern California, federal land management agencies with holdings likely to encompass suitable wolf habitat include; USFS, BLM, and to a lesser degree based on land coverage, the National Park Service (see footnote 98).

USFS Overview

The mission of the USFS is to "sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations." These lands are managed using a multiple-use approach that sustains healthy terrestrial and aquatic ecosystems and addresses the need for resources, commodities and services.

USFS lands are established and administered for outdoor recreation, range, timber, watershed, and wildlife and fish purposes (Multiple-Use Sustained-Yield Act of 1960).

[44] In November 2014, the USFWS confirmed the presence of a radio-collared gray wolf in northwestern Arizona that had dispersed from Wyoming. This animal was killed in December 2014, having been mistaken for a coyote.

There are 18 national forests in California (see Figure 8.1). Each national forest is governed by a Land and Resource Management Plan (LRMP) developed under the 1982 USFS Planning Rule. Each LRMP is intended to be revised approximately every 15 years subject to review, analysis, public disclosure and participation under the National Environment Policy Act (NEPA).

Currently, national forests are anticipated to undergo amendments and revisions to their respective LRMPs in California under a newly adopted 2012 Planning Rule. Three National Forests in the southern Sierra are currently undergoing that process with seven forests within the Northwest Forest Plan have initiated this process in early 2015. As the state trustee agency for fish and wildlife in California (Title 14 §15386), CDFW is and will be involved in collaborating with the USFS on National Forest Plans (subject to the 2012 planning revision) and providing recommendations to maintain and improve wildlife and aquatic habitats. Activities that maintain, enhance, and restore these habitats and particularly ungulate habitats (meadows, oak woodlands, and early seral and brush habitats) that will indirectly benefit wolves will be recommended to the USFS. However, the USFS will make the final decision on their respective LRMPs, finding balance on their mandate for multiple-use.

Figure 8.1. USFS Ownership in California (Courtesy of Diana Craig, USFS).

BLM Overview

Unlike the USFS which has broad coverage over Northern California, BLM's holdings in the northern part of the state are largely contained within Modoc and Lassen counties (northeastern corner of California) and other much smaller, scattered properties in Shasta, Trinity, Tehama, Siskiyou, and Humboldt counties (Figure 8.2). While predominately high desert environments, these holdings also include northern mixed conifer-hardwood and redwoods forest habitats.

Similar to USFS, the BLM mission is to manage and conserve public lands for use and enjoyment of present and future generations under their mandate for multiple-use and sustained yield. Administration and management is directed by various Field Offices and operate under respective Resource Management Plans (RMP) that establishes the framework for management of those holdings based largely on national priorities. The RMPs have a life span of about 20 years and are developed in consultation with the public and with BLM partners from tribal, state, and location governments and other federal agencies.

When authorizing land use activities (established under the RMPs) such as recreation, livestock grazing, energy development, or forest management, BLM must ensure the needs of wildlife, fish and plants are taken into consideration. BLM manages these resources in cooperation with state and other federal agencies.

Whether preparing RMPs or land use activities under already authorized RMPs, BLM is subject to the environmental review process under NEPA (similar to USFS LRMPs). Because wolves are listed as endangered under federal ESA, the development and implementation of actions on BLM lands supporting gray wolves will involve consultation with the USFWS to insure that proposed actions will not negatively affect this species.

Again, as the state trustee agency for natural resources in California, CDFW is and will be involved in collaborating with the BLM on RMPs and providing recommendations to maintain and improve wildlife and aquatic habitats for native species. Activities that maintain, enhance, and restore these habitats and particularly native ungulate habitats (meadows, grasslands, oak woodlands, and early seral, brush, and sagebrush habitats) that will indirectly benefit wolves will be recommended to BLM. However, the BLM will make the final decision on their respective RMPs, finding balance on their mandate for multiple-use.

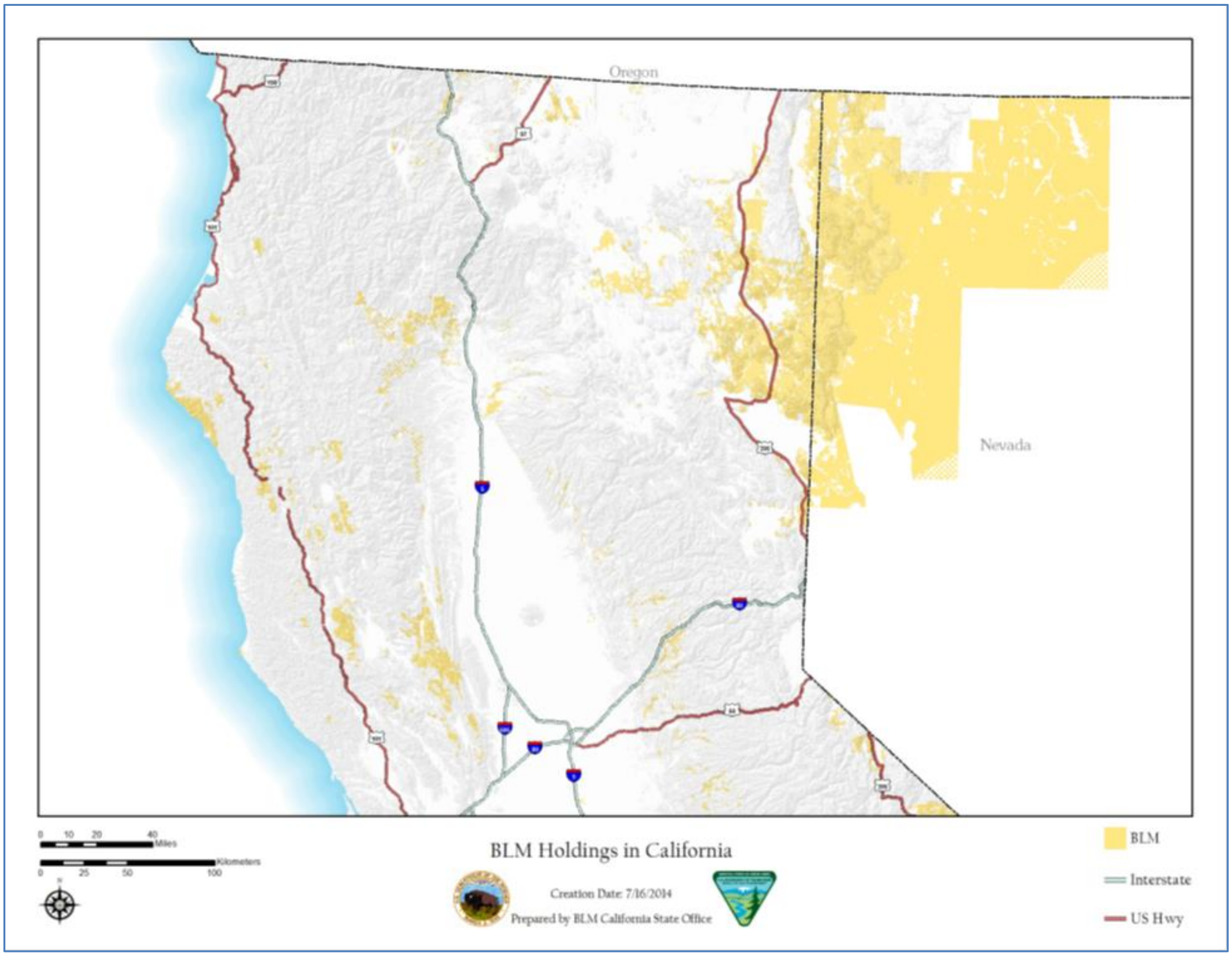


Figure 8.2. BLM Ownership in Northern California. (Courtesy of Amy Fesnock, BLM)

Livestock Grazing Activities on Federal Lands

As both the BLM and USFS manage for livestock grazing as part of their respective mandates, it is important for state and federal entities to coordinate activities as they relate to wolf conservation and provide management recommendations/actions to avoid and minimize wolf-livestock conflicts.

On public lands administered by either BLM or USFS where wolves are present, CDFW (in conjunction with USFWS while federally listed) will work with both federal agencies as well as livestock permittees to provide recommendations to avoid and minimize wolf-livestock conflicts.

CHAPTER 9 WOLF CONSERVATION

A. Introduction

The gray wolf is a controversial and polarizing wildlife species. Highly charismatic, wolves elicit feelings of deep respect and admiration in some people, who may advocate for preservation above all other considerations. On the other hand, wolves have long evoked deeply felt sentiments of fear and hatred, which are fueled by conflicts with humans in several contexts. These negative reactions to and conflicts with wolves have led to historic and current programs ranging from localized lethal control to regional eradication. Such strong interest in the species by humans has led to an enormous body of research by both wildlife and social scientists on wolf behavior, ecology, population dynamics, management, conflict resolution, human behavior and value beliefs, and many other topics (Musiani et al. 2010), which facilitates the science necessary for wolf conservation in California.

Wolves were extirpated in California in 1924 when the last known wolf was taken in Lassen County. They suffered a similar fate throughout the nation, such that by the mid-20th century only a handful of wolves remained in the conterminous United States, primarily in far northern Minnesota (USFWS 1978). As a consequence, in 1967 the species was listed as endangered under the federal Endangered Species Act (ESA) of 1966, and legally protected in 1974 under the ESA of 1973[45]. Reintroductions into the northern Rocky Mountains were initiated in 1995. The population in that region has since grown and expanded into other states, including Oregon and Washington. In 2011 a radio-collared young male from northeastern Oregon temporarily entered California, becoming this state's first known wolf in nearly 90 years. This prompted several environmental organizations to petition the California Fish and Game Commission (Commission) to provide the species with protections under CESA, and in 2014 the Commission elected to list the gray wolf as endangered in California.

In addition to enforcing the prohibition of take of wolves while listed under CESA, CDFW is mandated to conserve wolves under CESA. This chapter provides information on factors that may threaten wolves in California and assessments that may provide the necessary information to ensure wolf conservation.

[45] The International Union for the Conservation of Nature's Red List of Threatened Species has identified the gray wolf global population status as "stable" and of "least concern" (ICUN 2011; See Figure 1.4). Based on respective western state's annual wolf reports for Oregon, Washington, Idaho, Montana, and Wyoming (including YNP) for 2015, the gray wolf population in the conterminous U.S. is estimated at 1,904.

B. Threats to Wolf Conservation

Conservation threats are factors that may extirpate or continually depress a wildlife population (Boitani 2003). In the context of this Plan, threats also include any actions that may preclude, defer, or constrain the establishment of a wolf population in California. Any particular threat may vary in its significance depending on the circumstances under which it occurs. For example, a wolf mortality rate of 35% or greater for one or two years in a large population may cause a short-term population decline (Fuller et al. 2003) with little long-term effect, whereas the same mortality rate in a small population experiencing low reproduction, low recruitment[46], or other factor(s) of conservation concern, could threaten the long-term survival or establishment of a population (Boitani 2003; Chapron et al. 2003). Wolf diseases are not discussed in this chapter as they are covered extensively in Chapter 2: *Wolf Diseases.*

Human-Caused Mortality

As mentioned previously, wolves were extirpated from most of their range in the conterminous United States by the mid-20th century, including California (Young 1944; USFWS 1978; Jurek 1994). The campaign to exterminate wolves was carried to North America by European immigrants who held long-standing prejudices, beliefs, and laws from the Old World where they had already successfully eradicated the species in significant portions of its former range (Young 1944; Lopez 1978; USFWS 1978; Boitani 2003). As Euro-American settlements expanded westward, bounties on predators including wolves helped drive the development of increasingly more effective trapping devices and poisons (Young 1944; Cluff and Murray 1995). By the early 20th Century the U.S. government had established the Division of Predator and Rodent Control within the Biological Survey (later the USFWS), and hunters were paid to kill wolves and other predators such that by mid-century wolves were gone from the U.S. with the exception of northern Minnesota and Alaska (Mech 1970; Van Ballenberghe 1974; Boitani 2003). Endangered species legislation provided protections for wolves beginning in 1974, however legal and illegal killing of wolves continued. In a 22-year study in the NRM, during which time hunting was not permitted, 30% of wolf deaths occurred due to legal control and 24% to illegal killing (Smith et al. 2010).

Sport harvest and predator control are common tools to manage large carnivores (Creel and Rotella 2010). Wolf harvest was banned in the U.S. (except Alaska) under the federal ESA until the NRM DPS was delisted (except Wyoming) in 2011[47]. Subsequently Montana and Idaho implemented wolf harvest as part of their state wolf

[46] Recruitment is generally defined as the number of offspring reaching the adult age class in a given year.

[47] Wolves in Wyoming were delisted in 2012, but this decision was reversed in court in 2014. At the time of this writing the Wyoming wolf population remains listed and is under USFWS management as a nonessential experimental population, and hunting is not permitted, however lethal control methods are used.

management programs. In 2015, legal harvest in these states constituted 25% (MT), and 22% (ID) of their population estimates (USFWS et al. 2016). Traditional methods of hunting and trapping wolves have not been shown to pose a significant conservation threat, as they are difficult and time-consuming undertakings. Modern methods of hunting by snowmobile or aircraft, which makes hunting easier and therefore more effective, may affect populations locally (Boitani 2003), however aerial hunting is not allowed for hunting big game in states with wolf hunting programs. Currently, because of the wolf's listing status as endangered under CESA, wolf hunting is not permitted in California. Lethal control of wolves represented 6.9% and total human-caused mortality represented 28% of the minimum estimated wolf population in the NRM states in 2015 (USFWS et al. 2016).

The response of wolves to different levels and causes of mortality is variable. Wolves are relatively long-lived mammals with a complex social structure in which dominant breeding adults play important roles in pup survival (Brainerd et al. 2008) and learned behaviors[48] (Sand et al. 2006; MacNulty et al. 2011; Cassidy 2013). As a result, the loss of one or both breeding individuals from a pack may have a disproportionate impact on the dynamics of the pack and possibly the population, relative to the loss of individuals with lower reproductive value (Kokko 2001; Hauser et al. 2006; Brainerd et al. 2008; Smith et al. 2010). Brainerd et al. (2008) found that pack persistence after breeder loss was affected by whether one or both breeders were lost. In their study of data collected in Alaska, the NRM, Wisconsin, Greece, and Scandinavia, they found that 25.8% of packs dissolved when one breeder was lost, and 84.6% when both breeders were lost. Most breeding wolves (56.8%) that died in the study were killed by humans. Wolf packs that occur in chronically high risk areas, such as where conflicts over livestock occur, tend to be smaller and possibly at a competitive disadvantage to larger packs, thereby incurring additional risks due to intraspecific strife[49] (Smith et al. 2007; Smith et al. 2010).

Using data from the long-term wolf study in Denali National Park and Preserve, Borg et al. (2014) found that, while breeder loss coincided with most cases of pack dissolution, packs remained intact after breeder loss in approximately two-thirds of overall cases. Sex and pack size were the most important predictors of pack persistence following breeder mortality. Packs were about 15 times more likely to persist after the loss of the breeding male, and only about three times more likely after the loss of the breeding female, compared to the loss of both breeders. The probability of pack persistence was less than 50% if pack size was fewer than 11 members when both breeders were lost, and less than 50% if pack size was fewer than six if only the female breeder died. Season and cause of mortality were also important factors in pack persistence. Packs were more likely to persist if breeders were lost in summer, and if mortality occurred due to natural causes. Seasonality may be important because of its effect on the

[48] For more detailed information on wolf pack social structure, see Chapter 1 *Wolf Life History and Background*.
[49] Intraspecific strife is defined as conflict between members of the same species. In wolves this usually occurs between members of different packs, or between packs and lone dispersers.

reproductive value of individuals. For example the loss of a breeding female during summer when she is not pregnant and the pups are more independent, may have less impact on the family group than the loss of a pregnant female who is nearing parturition[50], when it is unlikely that a replacement breeder can become pregnant. The effect of human-caused mortality on pack dissolution is most likely due to this seasonal effect, in that wolf harvest is concentrated during the winter pre-breeding and spring breeding seasons. Finally, Borg et al. (2014) found that pup recruitment was significantly decreased in packs that experienced the loss of one or both breeders.

Neither breeder loss nor pack dissolution in the Borg et al. (2014) study affected population growth in the year during which the loss occurred, or the year following. The authors concluded that compensatory mechanisms such as the timing of the breeder mortality and availability of replacement breeders may moderate the negative effects of breeder loss in the socially complex wolf. Conversely, in a study of NRM wolves, Gude et al. (2011) found that wolf population growth is significantly impacted by both human-caused mortality and recruitment. Smith et al. (2010) also found impacts to population growth resulting from poor recruitment[51] and high levels of human-related conflict in the northwest Montana (NWMT) recovery area of the NRM. Thus, while significant impacts to wolf packs likely occur as a result of human-caused mortalities, the impact to the population's growth potential remains uncertain, and is probably context-specific.

Habitat Alteration

Historically wolves have inhabited a wide variety of habitats from deserts and prairies to woodlands, swamps, tundra, and "barren lands" from about 20° latitude to the polar ice pack (Young and Goldman 1944; Fuller et al. 2003). Wolf researchers generally contend that vegetation type matters little to wolves, and suitable habitat primarily means habitat that can provide them with adequate food (Fuller et al. 2003). However DNA data from both North American and European wolves showed genetic variation among populations that was best explained by climate, habitat variables (Geffen et al. 2004), and diet composition (Pilot et al. 2006). These authors suggested that prey skills learned by juveniles in particular habitats become imprinted on wolves, who will then seek similar habitats as dispersers, leading to a pattern of genetic structure in the wolf metapopulation[52]. This pattern may provide an explanation for apparent prey selection by wolves (Wayne 2010. As a consequence, many areas of wolf recolonization that are highly altered landscapes may present limits to wolf population growth and dispersal (Haight et al. 1998). Habitat alterations may therefore pose both direct and indirect threats to wolf conservation, and consist of those that lead to the decline of the wolf's

[50] Parturition is the act of giving birth.
[51] In this usage of recruitment, the term refers both to pup survival and immigration of animals into the population.
[52] A metapopulation is a cluster of spatially separate subpopulations of the same species. The subpopulations interact to varying degrees depending upon the extent to which the intervening habitat allows movement of individuals.

prey base (Boitani 2003), to limitations on local population size, and to dis-connectivity with a source population (Haight et al. 1998).

Despite apparent prey "preferences" developed by wolves (Geffen et al. 2004), they can and do consume a wide variety of prey including salmon, rabbits (*Lepus* sp.), beaver, and carrion (Mech 1988; Peterson and Page 1988; Klein 1995; Darimont, et al. 2003); however in North America approximately 72% of the variation in wolf density has been attributed to variations in their main prey, large hoofed mammals (i.e. ungulates) (Keith 1983; Fuller 1989b). Careful management of California's native ungulates and their habitat will therefore be a key factor in achieving wolf population objectives (Boitani 2003).

In California, historical overexploitation of native ungulates dates back to the 19th Century when mining, logging, agriculture, and market hunting all contributed to severe declines in elk, mule deer, bighorn sheep, and pronghorn populations by converting or degrading habitat, and through direct mortality. Today, harvest regulations, reintroduction efforts, and natural expansion have contributed to increases in both the distribution and abundance of tule, Roosevelt, and Rocky Mountain elk (*C. e. nelsoni*) in California. California's mule deer have experienced greater fluctuations in their population than elk, as a result of overexploitation in combination with, at various times increasing or decreasing habitat suitability. Increasing habitat suitability occurs when early seral stage[53] vegetation – preferred by deer and elk – occurs as a result of clearing, logging, and burning in forests (Leopold 1950), and can sometimes offset overharvest if it leads to increased fertility. Habitat suitability decreases through suppression of forest fires and logging activity, and when areas are overgrazed by livestock, leaving less forage for native ungulates (Longhurst et al. 1952). Overall, mule deer numbers have been in decline across the western U.S. since the late 1960s, most likely due to a combination of habitat loss and deterioration, predation, competition with livestock, severe winters, and drought (Stewart et al. 2002; de Vos et al. 2003; Wasley 2004; Monteith et al. 2010; Brown and Conover 2011; Anderson et al. 2012).

A second area of potential concern for wolf conservation with respect to habitat is that of humans and human infrastructure effects on wolves. Prior to increased protections of wolves through legislation, wolves were typically considered to be intolerant of humans and their infrastructure[54], especially near dens and rendezvous sites (Boitani 2003). As a consequence wolves had come to be associated primarily with wilderness (Theberge et al. 1998). In 1985 Thiel found that recolonizing wolves in Wisconsin lived where road density did not exceed 0.6 km per km^2, and these figures were corroborated in Michigan (Jensen et al. 1986) and Minnesota (Mech et al. 1988). These studies contributed to the

[53] A seral stage is a phase in the sequential change in plant communities over time. An early seral stage is one that occurs early after a disturbance, such as fire or logging, which opens canopies and allows for grasses and forbs to grow. Later stages occur when new shrub and tree growth occurs.
[54] Road density (Thiel 1985; Mech et al. 1988; Mladenoff 1995), human population density (Weise et al. 1975; Fuller et al. 1992), and forest cover (Hell 1993; Boitani and Fabbri 1982) have all been implicated in defining wolf distribution.

belief that wolves were denizens of the wilderness, and road density became the standard by which wolf habitat suitability was measured (Mech 1995). However some researchers suspected this to be more a consequence of the history of human persecution, with wolves having been extirpated in all non-wilderness areas (Young 1944; Mech 1995). In the period during which wolves were federally listed under the ESA, and as they recovered in portions of their former range, they showed signs of greater tolerance to human infrastructure and were tracked in areas of greater road density, and more accessible and populated areas (Fuller et al. 1992; Mech 1995). It is unclear what effect federal delisting and the subsequent implementation of state wolf hunting programs[55] will have on the long-term distribution of wolves in the NRM and Western Great Lakes region.

A third habitat-related wolf conservation concern is that of habitat fragmentation. Whether by natural barriers such as mountains or rivers; through human infrastructure such as roads, urban development, or conversion of native habitat to agricultural use; or due to areas of human intolerance, fragmentation and "landscape resistance"[56] can impact wildlife dispersal across landscapes, especially for wide-ranging species such as wolves (Stronen et al. 2012a, b). Mortality risk associated with dispersal is a concern for many species, especially where populations inhabit small, isolated, protected areas (Soule' and Simberloff 1986; van Vuren 1998) surrounded by lower quality areas through which dispersing animals may have to pass (Franklin 1993; Kramer-Schadt et al. 2004). Such risk may lead to altered long-term metapopulation dynamics through genetic isolation of subpopulations (Stronen et al. 2012a, b) and susceptibility to stochastic effects. Importantly, genetically effective dispersal (i.e. dispersal that leads to successful reproduction) is the goal of maintaining connectivity between subpopulations (von Holdt et al. 2010).

Stronen et al. (2012a, b) studied the effects of fragmented habitat on wolves in western Manitoba. Intensive conversion of forests to farmland, and road densities of 1.1 mi per mi^2 (0.7km per km^2) had fragmented the region and isolated Riding Mountain National Park (RMNP) from other forested areas. RMNP wolves have been tracked for several multi-year studies since 1974, with no detection of successful dispersal from the park into other wolf-occupied areas (Carbyn 1980; Paquet 1992; Stronen 2009). Mitochondrial DNA studies detected distinct RMNP haplotypes[57], and microsatellite analysis estimated moderate genetic differentiation in the subpopulation (Stronen et al. 2012a), indicating lack of connectivity to other subpopulations. In another example Smith et al. (2010) found lower survival in the NWMT recovery area population in the NRM. These wolves experienced higher levels of human-caused mortality due to greater private property and agriculture-related conflicts in the region as compared to

[55] Roads provide access to humans into wolf territories. With the implementation of hunting programs, it is conceivable that wolves may again retreat to more isolated areas due to the impact from hunting.
[56] This term refers to dispersal constraints such as human intolerance that are not physical barriers to movement.
[57] A haplotype is a collection of DNA sequences that occur together on a chromosome and are inherited together; a unique haplotype within a group suggests genetic isolation of the group.

the other two NRM recovery areas (Central Idaho and YNP). The authors stressed the importance of improving habitat conditions outside core areas to increase success of natural dispersal into NWMT from the other recovery areas.

A number of examples provide evidence that wolves can travel long distances despite habitat fragmentation and human infrastructure. Wolf OR7 dispersed several hundred miles through Oregon and northern California, crossing highways and rivers, and eventually breeding successfully in southern Oregon. Merrill and Mech (2000) presented evidence of telemetry-monitored wolves in the Great Lakes region travelling from 114–307 miles (183–494 km) on dispersal forays, three of which crossed highways on as many as 215 occasions. The authors concluded that their study supported findings that wolves in the Midwest were adapting to human presence, and few structures should be considered travel barriers.

Population Size

Small, isolated populations are at risk of losing fitness[58] through loss of genetic diversity. This loss of diversity can occur through the founder effect, when a small population is established from a larger population; through a population bottleneck, a sharp reduction in population size due to a random event such as a storm that kills many individuals; or through genetic drift, which is a random loss of genetic diversity due to chance (Avise 2004). The genetic health of such populations is dependent upon the infusion of new genetic variation from immigrating individuals. Without such immigration, any of these events can eventually lead to inbreeding depression[59] (Boitani 2003; Avise 2004; Vucetich and Peterson 2014).

The experimental Mexican wolf population is one such small, isolated population. All Mexican wolves alive today are the descendants of one of three captive lineages (the Certified, Ghost Ranch, and Aragon lineages), developed from a founding population of seven wolves, which were managed independently until 1995 when a fourth lineage (the McBride lineage) was established through the crossing of two of the initial lineages (Hedrick et al. 1997; Fredrickson et al. 2007). By the time of this cross, each of the three original lineages had accumulated substantially decreased levels of heterozygosity[60] as compared to wild gray wolf populations (approximately half; Wayne and Vila 2003). In these wolves, inbreeding did not appear to cause an effect on fitness. However after the lineages were crossed, significant increases in fitness were seen through larger litter sizes (Fredrickson et al. 2007). The previously undetected inbreeding had likely led to reduced sperm quality in the males (Roldan et al. 1998; Gage et al. 2006), and/or to

[58] Fitness refers to ability of individuals in a population to survive and reproduce.
[59] Inbreeding depression is the decrease in growth, survival, or fertility often observed following mating of related individuals, a phenomenon which is more likely to occur in small populations (Avise 2004).
[60] Heterozygosity is a measure of the genetic variation in a population. Low heterozygosity indicates low genetic variability which may lead to inbreeding depression, whereas moderately high heterozygosity indicates strong genetic diversity.

loss of ova or embryos before implantation in the females (Lacy et al. 1996; Nordrum 1994).

Other small wolf populations have exhibited signs of inbreeding depression. The isolated wolf population on Isle Royale, Michigan was founded when one female and one or two males crosses an ice bridge from the mainland in the 1940s (Vucetich and Peterson 2014). The population has fluctuated since, with an average census size of 24 animals (Raikkonen et al. 2009). Mean wolf abundance has been lower in the past three years than in any other three year period since observations began 56 years ago, reaching just nine animals in 2014 (Vucetich and Petersen 2014). A genetic evaluation comparing microsatellites from Isle Royale wolves to those of the mainland suggested that Isle Royale wolves had lost approximately 60% of their genetic diversity (J. Pollinger, unpublished data cited in Raikkonen et al. 2009). Raikkonen et al. (2009) found that 58% of the wolves in this population had congenital abnormalities in the spine, suggesting a form of inbreeding depression. Mainland wolves have periodically immigrated to Isle Royale on ice bridges, and infused the population with new genetic variation. This explains the population's slower-than-expected loss of genetic diversity. However ice bridges have formed less frequently in recent winters, leaving the wolf population on Isle Royale more isolated (Vucetich and Petersen 2014), and therefore potentially susceptible to further declines.

The naturally recolonizing population of wolves in Scandinavia was founded in 1983 by three individuals. Liberg et al. (2006) traced the ancestry of this population and, combined with microsatellite DNA analysis, estimated a mean inbreeding coefficient of 0.21 (0.00–0.41)[61]. The sizes of litters in this population were strongly affected by inbreeding[62], and the investigators were able to discount environmental causes for the effect.

In spite of these and several other very small wolf populations globally (under 200 individuals), few appear to be threatened by a loss of genetic diversity (Fritts and Carbyn 1995); however it is possible that any evidence of this disappeared with the extirpation of local populations (Ballou 1997; Boitani 2003). California's wolf population will likely be connected through migration with the larger wolf metapopulation in the Pacific Northwest, which will provide important infusions of genetic variation toward population health.

Hybridization

The evolutionary relationship of gray wolves to other canids has been reconstructed by analyzing DNA sequences in both mitochondrial and nuclear regions of the species'

[61] The inbreeding coefficient is the probability that individuals in a population carry versions of a gene that stem from the same ancestral copy (i.e. are identical by descent; Avise 2004).
[62] The investigators estimated a reduction of 1.15 pups per litter for each increase of 0.1 in the pups' inbreeding coefficient.

genomes (Wayne et al. 1997; Gotelli et al. 1994; Vila et al. 1999). These studies have shown that the most closely-related wild species to the gray wolf are the coyote, and the Ethiopian wolf (*C. simensis*). Further, the gray wolf is the exclusive ancestor to the domestic dog, the species to which the gray wolf is most closely related (Tsuda et al. 1997; Vila et al. 1997; Vila et al. 1999; Leonard et al. 2002; Savolainen et al. 2002). As a result of their close relatedness, all members of the genus *Canis* in North America (gray wolves, dogs, and coyotes) can hybridize (Vila and Wayne 1999; Wayne and Vila 2003; Wayne 2010) and produce fertile offspring (Gray 1954).

Wildlife conservationists and managers are concerned about the impacts of hybridization on small and/or threatened wolf populations. Hybridization could cause such populations to lose specific adaptations, or even cause extinction as a distinct taxon (Gotelli et al. 1994; Simberloff 1996; Randi 2008; Muñoz-Fuentes et al. 2010; Allendorf et al. 2013). On the other hand introgression[63] may be adaptive (Reyer 2008; Hedrick 2013), in which case hybridization may provide advantages in some circumstances. One such example is the black coat color in gray wolves, believed to be the result of hybridization with dogs (Anderson et al. 2009; Caniglia et al. 2013), which in forested environments may confer better life expectancy because these animals are less conspicuous (Anderson et al. 2009; Hedrick 2009; Coulson et al. 2011). In fact, some canid researchers propose that *Canis* “species” may share genetic material so readily because they are not truly separate species at all, but rather subspecies of each other (Coppinger et al. 2010). Coppinger et al. (2010) contend that wildlife managers inappropriatelyconsider species as if their genomes are fixed entities, without consideration for the possibility that a common species (e.g. coyotes) may be more evolved than a rare species (e.g. red wolves), or that hybridization might be a source of variability needed for the rare species to adapt to a changing environment. Until such time that these questions are more scientifically answered, legal protections and conservation science compel us to address hybridization as a potential threat to wolves and other listed species. Chapter 4: *Wolf and Domestic Dog Interactions* provides information on wolf-dog hybrids.

Wolf-Coyote Hybridization

As with dogs, wolves and coyotes share identical karyotypes, and are able to produce fertile hybrid offspring (Wayne 2010). This is of greatest conservation concern in the Great Lakes Region for eastern (Algonquin) wolves (*C. lycaon*) (Lehman et al. 1991; Wilson et al. 2000), and in the southeast U.S. for red wolves (*C. rufus*) (Jenks and Wayne 1992; Roy et al. 1996; Hedrick et al. 2002; Miller et al. 2003). The taxonomic status of these two species is under ongoing dispute, precisely because of the difficulty in determining whether they are distinct species, subspecies, or hybrids. Algonquin wolves (wolves that possess new world wolf mtDNA haplotypes) hybridize with both gray wolves (wolves that possess old world wolf mtDNA haplotypes) and coyotes

[63] Introgression is the movement of a gene from one species into the genome of another species through hybridization.

(Wayne 2010). In this case, some investigators hypothesize that the coyote's relatively recent range expansion eastward meant contact between two previously unfamiliar species, which increased the likelihood of hybridization (Crispo et al. 2011; Stronen et al. 2012c), whereas in the west coyotes and gray wolves have been sympatric[64] long enough to have evolved reproductive barriers[65]. As a consequence the Algonquin wolf's genetic uniqueness may be affected (Stronen et al. 2012c). Similarly in the case of the red wolf, geneticists believe that hybridization with coyotes has affected the genetic uniqueness of this critically endangered wolf (Jenks and Wayne 1992; Roy et al. 1996; Hedrick et al. 2002; Miller et al. 2003), and remains the species' primary threat (Wayne 2010). However hybridization with coyotes is not expected to present a significant threat to gray wolves in California.

C. Assessing and Monitoring California's Wolf Population

As wolves begin recolonizing California it will be important to estimate where wolves may be most likely to successfully establish, and to collect information in those locations that will help document the potential effects wolves may have on those systems. Of equal importance, it will be necessary to monitor wolves closely to track their conservation status and apply an adaptive approach to managing their population. Research on wolves in other locations has provided valuable information that can be incorporated into an initial wolf plan for California, but California-specific information will be necessary to appropriately respond to wolf conservation needs here.

Modeling potential suitable habitat for wolves will be important to guide such assessment efforts. Important data to collect prior to wolf recolonization will include ungulate population sizes, sex ratios, fertility rates, recruitment, survival, mortality rates and causes, and habitat parameters such as the type and structure of vegetation used by ungulates(see Chapter 6: *Wolf Interactions with Ungulates* for more information). Additionally, estimates of population size, distribution, and diet of other carnivores will help CDFW to measure the effects wolves will have on those other carnivores as well as on the ungulate prey populations. Key parameters to estimate and monitor in wolves as they begin to reestablish in California will be wolf population size, distribution, and change over time; pack size and distribution; home range size; dispersal behavior and corridor mapping; causes and rates of mortality; fertility, recruitment, and survival rates; disease and health status; genetic relationships within and between packs; habitat use and diet; and interactions with non-prey wildlife. Such data will guide the development of future wolf conservation phases and management objectives for wolves. Research will be needed and likely conducted by CDFW, federal agencies, tribes, and universities, singly and under cooperative agreements with each other.

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[64] Species are sympatric when they occur in the same geographic area at the same time.

[65] Experimental insemination of western coyotes with semen from male western gray wolves resulted in successful pregnancy, demonstrating compatibility of the two species' gametes. Behavioral and physical incompatibility between the two species are still in question. (Mech et al. 2014)

Potential Suitable Habitat in California

The historical distribution of wolves in California is unknown due to a lack of verifiable information (Shelton and Weckerly 2007). Published maps and descriptions of the historic range vary, but most indicate wolf presence in the northernmost one-fourth of the state (Grinnell et al. 1937; Young 1944; Nowak 2002), and some include the Sierra Nevada (Hall 1981). The data that do exist are anecdotal rather than systematic. Of the two museum-confirmed specimens of wolves from California, one was killed in 1924 in Lassen County[66] and the other was killed in 1922 in the Providence Mountains in San Bernardino County[67]. It is impossible to know if these animals were relicts of an dwindling wolf population, or drifters from other regions. Much of the habitat once potentially occupied by wolves in California has been converted to agriculture or developed, so is highly fragmented. Statewide road densities have increased substantially, and the human population has grown to over 38 million people; however the northern portion of California does have a lower human density and is therefore potentially suitable for successful wolf recolonization.

Wolves are habitat generalists, occupying most habitats in the northern hemisphere where large ungulates occur, and where conflicts with humans are minimal or moderated. Habitat models are tools that allow researchers to assess the quality, or suitability of a particular habitat for a particular species, based on observations of that species' use of habitat in other locations. Numerous researchers have developed models of wolf habitat in different regions of the United States (Mladenoff et al. 1995, 1999; Carroll et al. 2003, 2006; Larsen and Ripple 2006; Oakleaf et al. 2006) to identify areas most likely to support wolves, and to utilize them in a management framework. Such models should be based on empirical data, possess relatively few variables and thereby make the fewest possible assumptions. Some published wolf habitat models (Larsen and Ripple 2006; Oakleaf et al. 2006) have shown that prey abundance (primarily elk), public land ownership (Figure 9.1), and forest cover increased the probability of occupancy by wolves; and human influences in the form of human presence, road density, and/or domestic sheep presence, decreased the probability of occupancy by wolves due to the potential for conflict in these areas.

[66] Lassen County is in northern California within the northernmost one-fourth of the state; this animal has since been genotyped as a northern gray wolf.
[67] This area is within the Mojave Desert region in southern California, outside the typical wolf range estimate for the state; this animal has since been genotyped as a Mexican gray wolf.

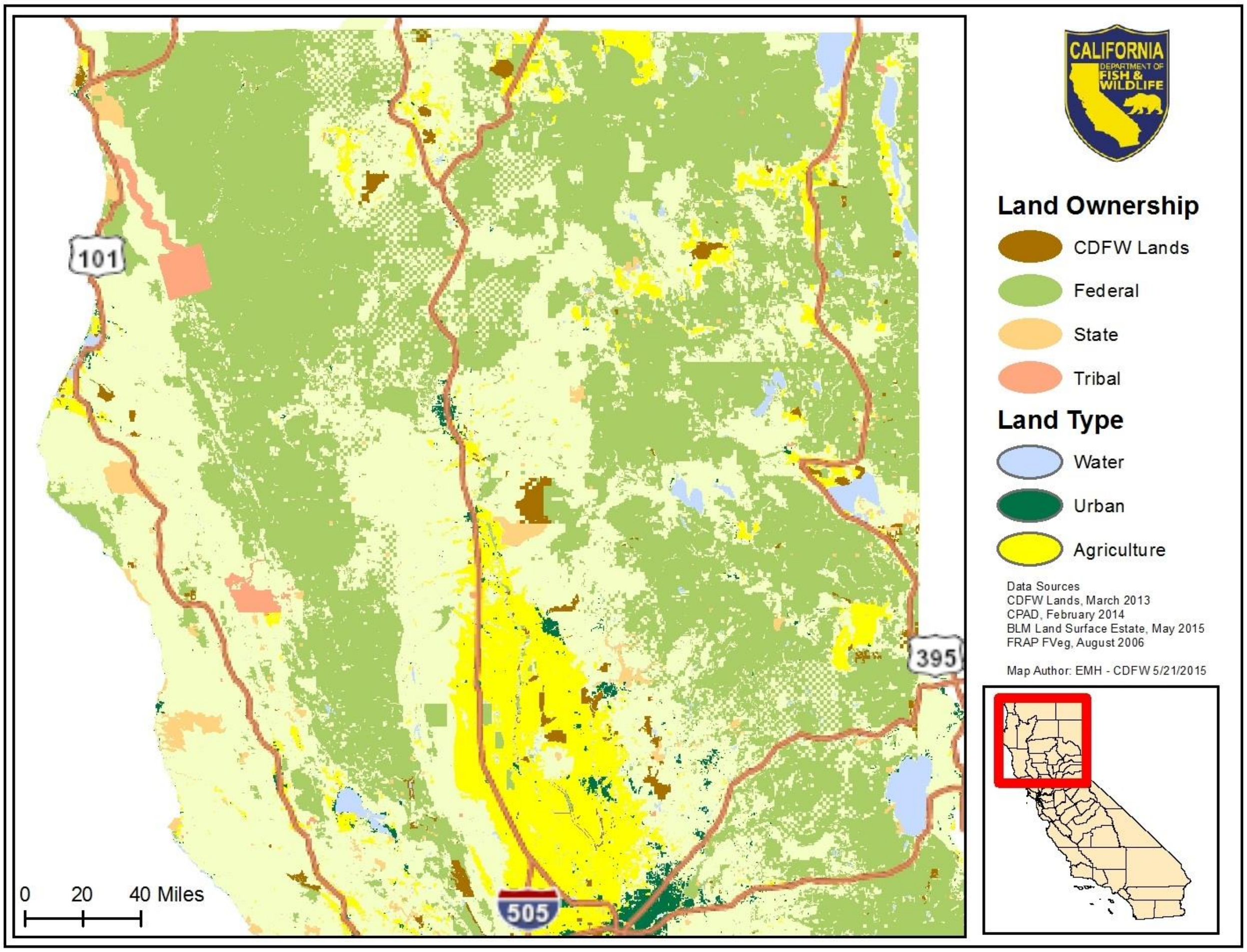

Figure 9.1. Public land ownership in northern California, demonstrating the patchy nature of most areas, and the few areas of core forested habitat. Federal land consists of USFS, BLM, and National Parks.

The wolf habitat suitability model published by Oakleaf et al. (2006) was intended to identify suitable as-yet-unoccupied habitat within the Northern Rocky Mountain region, and was based on empirical data from wolves occupying territories in that region. The model published by Larsen and Ripple (2006) was also based on data from wolves in the Northern Rocky Mountains, was tested in that region, and was applied to the Pacific Northwest (Oregon and Washington). Carroll et al. (2006) used a spatially explicit population model based on currently occupied wolf habitat in the Northern Rocky Mountains to analyze potential wolf habitat in the western contiguous U.S. including California; this model did not incorporate livestock distribution. California's geography, distribution of habitat types, availability and distribution of prey, potential barriers to movement, landscape features that facilitate movement and expansion, and areas of potential human conflict are uniquely different from other states that support wolf packs, so models developed in other regions may be only marginally relevant in California. This level of uncertainty and the fact that wolves only recently have begun to reinhabit

California makes the applicability of currently published habitat maps and models for California highly theoretical.

Despite the above uncertainties, existing wolf habitat models can help identify areas more likely than others to support wolves in California. CDFW staff therefore combined simplified versions of the three models described above[68] (Carroll et al. 2006, Larsen and Ripple 2006, Oakleaf et al. 2006), with data for California, to identify possible areas where wolves may become established (Figure 9.2). As new data become available from monitoring the current reestablishment of wolf populations in Oregon and California, new models can be developed to improve predicting wolf occurrence locally. It is important to reiterate here that the map depicted in Figure 9.2 is based on factors associated with wolf occupancy in the Northern Rocky Mountain region, and will need to be revised based on actual habitat use by wolves in California. Note that the model for potential wolf habitat appears as a subset of public land ownership due to the fact that suitability of habitat reflects land ownership, sufficient populations of wild ungulates, and lower potential for livestock and human conflicts.

Biological Carrying Capacity

Wolf densities vary widely across the species' range. Studies in far northern areas recorded as few as five wolves per 386 mi^2 (1,000 km^2) (Ballard et al. 1997), whereas on Isle Royale, Michigan wolves were recorded as high as 92 per 386 mi^2 (Peterson and Page 1988). Midwinter wolf densities in 32 studies throughout North America averaged approximately 18 per 386 mi^2 (Fuller et al. 2003). These studies were conducted on wolves using a variety of prey species including moose, caribou, elk, bison, deer, mountain goat, and/or wild sheep at varying densities, and occurring in vastly differing habitats from arctic tundra, to coastal rainforest, to the northern Rocky Mountains. Because of the state's lower ungulate densities and species diversity compared with many of those locations, CDFW suspects California's eventual wolf density will likely occur on the low end of this range.

[68] Suitability levels were removed from the Oakleaf et al. (2006) and Larsen and Ripple (2006) models, and lambda (potential long-term viability) levels were removed from the Carroll et al. (2006) model.

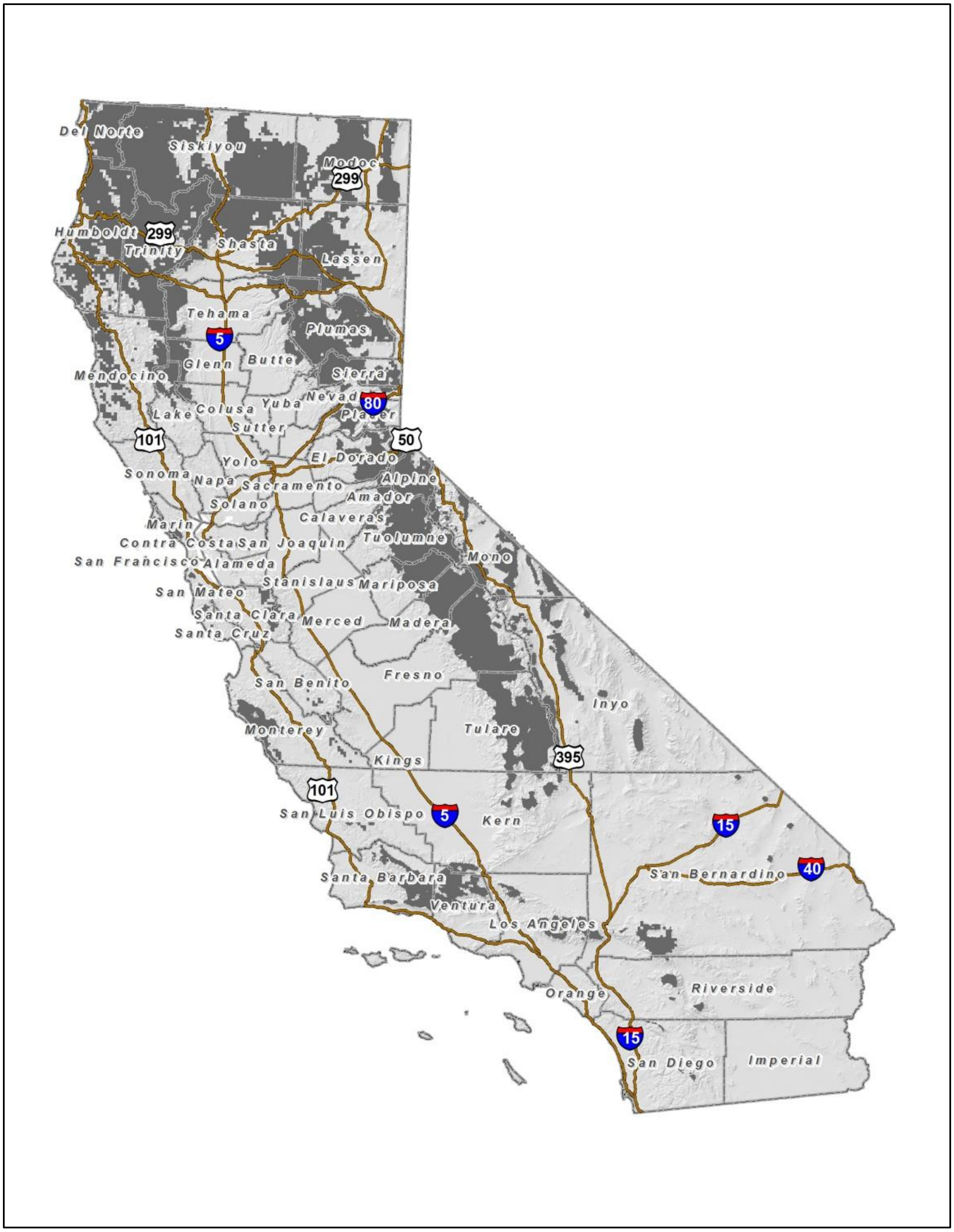

Figure 9.2. Potentially suitable habitat for wolves in California delineated in dark gray. Model is based on habitat used by wolves in the northern Rocky Mountains states. Prey abundance, public land ownership, and forest cover increased the probability of wolf occurrence, whereas human influences and domestic sheep presence decreased the probability of wolf occurrence (Carroll et al. 2006, Larsen and Ripple 2006, Oakleaf et al. 2006).

Two basic approaches may be used to estimate potential biological carrying capacity for locations where wolves have not yet recolonized. One approach is to utilize prey biomass and wolf density data from various other locations (Fuller et al. 2003), and a second approach is to apply spatial and pack size information for wolf territories in areas where wolves are reestablished (Wiles et al. 2011).

It is important to note that estimates obtained for California using these approaches are very general for a number of reasons:

- First is a lack of adequate population estimate figures for ungulates in California, and the patchy distribution and relatively lower densities in which deer and elk occur in the state.
- Second, California's ungulates are subject to predation by a suite of carnivores that likely differ both in species composition and abundance from other areas.
- Third, California's landscape and climate differ from those in which much of the biomass per wolf estimates were made, and these differences affect prey species' vulnerabilities as well as wolf territory sizes.
- Finally, the much greater density of the human population and its related activities and infrastructure are likely to impact California's potential wolf population size differently relative to other regions where wolves have been assessed.

As a result of these and likely other factors, the wolf population estimates for California discussed below provide preliminary characterizations of what may occur, and will probably be substantially adjusted in the future, when actual data from wolves here has been collected and evaluated. Consequently, the actual population of wolves that will eventually occur at a biologically sustainable level in California is unknown at this time.

Prey-Based Approach to Estimating Carrying Capacity for Wolves in California

Early wolf researchers suggested that wolf populations may be regulated intrinsically (i.e. they are density dependent; Pimlott 1967; Mech 1973). This mechanism may operate in some locations, but most recent investigators tend to agree that prey biomass and vulnerability is the greatest influences on wolf population size (Keith 1983; Fuller 1989b; Fuller et al. 2003; McRoberts and Mech 2014). McRoberts and Mech (2014) suggest that all possible factors regulating wolf population density should be investigated. See Chapter 1 *Wolf Life History and Background* for additional discussion on this topic.

Due to the strong correlation found between ungulate biomass and wolf density (see Table 9.1), and using the ungulate biomass indexes[69](BMI) per wolf estimated for other regions, CDFW has estimated to the extent feasible, the potential prey-based carrying capacity for wolves in northern California (Table 9.2) to provide preliminary information for this planning effort.

Table 9.1. Summary of statistical test results for three analyses of the relationship between ungulate biomass and wolf demographics. The first looked at the effect of ungulate biomass per wolf on pack size, the second on the effect of total ungulate biomass on pack size. Neither of these two relationships was statistically significant. The third analysis showed a statistically significant effect of total ungulate biomass on mean wolf density (Fuller et al. 2003).

Test		r^2	**d.f.**	**P**	**Regression**
1	BMI/wolf and mean pack size	.06	24	.23	
2	Total BMI and mean pack size	.004	24	.76	
3	Total BMI and mean wolf density	.64	31	<.001	Y=3.5 + 3.27x

[69] BMI is calculated by multiplying the population estimate for each ungulate species in the system by a factor representing the biomass of individuals of that species relative to the biomass of a deer. For example deer population estimate is multiplied by 1, elk population estimate is multiplied by 3 (because elk are approximately 3 times the mass of a deer) and the two numbers are then summed. This number is then divided by the wolf population estimate, which gives a BMI per wolf value for a given wolf-ungulate system.

Table 9.2. Prey-based estimate of potential wolf population in northern California*. The mean BMI per wolf used in this estimate is an average from seven studies in Minnesota, Wisconsin, and Ontario (Pimlott et al. 1969; Kolenosky 1972; Berg and Kuehn 1980; Fritts and Mech 1981; Fuller 1989b; Wydeven et al. 1995; Gogan et al. 2000) where white-tailed deer represented > 70% of the ungulate BMI (T. Fuller pers. comm.).

	Estimate per 1,000 km^2				**Total Estimate**			
Species	Ungulate Pop. Estimates[70]	Biomass Index	Mean BMI per wolf	Estimated Wolf Pop.	Ungulate Pop. Estimates	Biomass index	Mean BMI per wolf	Estimated Wolf Pop.
Deer	1,971	2,271	306	**7**	133,754	152,054	306	**497**
Elk	100				6,100			

*Available historical information related to distribution, abundance, and ecological role of wolves in California is nonexistent or extremely limited. The information presented here is based on studies from other locations and has uncertain or limited application to current and future conditions in California. This information is included as a. preliminary assessment that will be revised once data specific to California has been gathered and analyzed thereby providing greater predictive value

Spatial Approach to Estimating Carrying Capacity for Wolves in California

The estimated total suitable wolf habitat in California for the northern portion of the state (north of Interstate 80[71] – see Figure 9.2) is 23,200 mi^2 (60,088 km^2); the estimated mean territory size for wolves in Idaho and Washington is 360 square miles (Wiles et al. 2011); and the estimated mean pack size for wolves in Washington, Montana, Idaho, Oregon, and Wyoming is 5.8 (Becker et al. 2014; Bradley et al. 2014; IDFG 2014; ODFW 2014a; WGFD 2014). CDFW used these figures to estimate a northern California wolf population size as shown in Table 9.3.

[70] Ungulate population estimates are for the B1, B2, B3, B6, C2, C3, X1, X2, X4, and X6a deer zones, and the Northeastern, Siskiyou, Marble Mountain, and North Coast elk units. These units were selected for the wolf population estimation because of their overlap with the estimated suitable wolf habitat as displayed in Figure 9.2.

[71] The area of potential suitable wolf habitat in the Sierra Nevada south of Interstate 80 (see Figure 9.2) is not included in this calculation due to the low likelihood that wolves will establish in that region during Phase 1 of wolf planning in California.

Table 9.3. Spatial-based estimate of potential wolf population in northern California*. Estimated mean wolf territory size from Wiles et al. (2011). Mean wolf pack size from 2013 Annual Reports to USFWS from Washington, Oregon, Idaho, Montana, Wyoming wildlife agencies.

Total Area of Estimated Suitable Wolf Habitat in northern California	Estimated Mean Wolf Territory Size	Estimated Number of Wolf Territories in northern California	Mean Wolf Pack Size	Estimated Northern California Wolf Population
23,200 mi^2	360 mi^2	64.4	5.8	**371.2**

*.Available historical information related to distribution, abundance, and ecological role of wolves in California is nonexistent or extremely limited. The information presented here is based on studies from other locations and has uncertain or limited application to current and future conditions in California. This information is included as a preliminary assessment that will be revised once data specific to California has been gathered and analyzed thereby providing greater predictive value.

Connectivity

The strategy for wolf recovery in the NRM region was to support the natural reestablishment of wolves in the NWMT population, and introduce populations in the Greater Yellowstone Area and Central Idaho (USFWS 1987, 1994). The plan called for establishing successfully reproducing packs in core areas of secure habitat where wolf mortality would be minimized because livestock grazing and motorized vehicle use, factors known to contribute to increased wolf mortality, were limited (USFWS 1994; Mitchell et al. 2008). These core areas are surrounded by less suitable habitat dominated by agriculture, so wolf survival there would likely be reduced. However dispersal was expected to be successful enough between the cores to facilitate connectivity, thereby constituting a large metapopulation (USFWS 1987; Pletscher et al. 1997; Boyd and Pletscher 1999; Smith et al. 2010).

In northern California a mix of public- and privately-owned lands leads to a matrix of land use types with few core areas of undisturbed wilderness (Figure 9.2). It will be important to wolf conservation in California to assess the scope and distribution of core areas as well as to determine in the future important dispersal corridors both within California and with other wolf populations outside California.

Estimating Wolf Demographics and Movements

Estimating demographics in carnivores poses challenges for wildlife managers due to their relatively low densities, and typically elusive behavior. In addition large carnivores have large home ranges, usually travelling long distances daily. Wolves in particular tend to occur in areas of steep terrain, often in densely forested habitats (Pollock et al. 2012). As a result it can require substantial logistical effort, manpower, and funding to obtain sufficient amounts of data to estimate demographic parameters of wolves

(Karanth et al. 2010). Visually counting them is usually not possible, and managers may therefore often resort to indirect methods for estimating wolf abundance (Long et al. 2008; Thompson 2004).

Wolf monitoring objectives include documenting wolf presence, estimating wolf numbers, documenting reproduction, and determining rates and causes of mortality. During the early period of wolf reestablishment in California it will be critical to closely monitor reproducing wolves, requiring intensive effort by CDFW. While many survey techniques have been used for wolves worldwide (Reinhardt et al. 2015), there are some limitations (Blanco and Cortés 2012). The most widely-used method to monitor small wolf populations is with telemetry. This is an appropriate and reliable method but is expensive (particularly if using aircraft), labor intensive, and not without risk to wolves that are captured and handled in order to fit with a radio collar. This method may need to be supplemented by or replaced with other methods, especially if wolf populations grow. Less invasive monitoring methods that may be of use in California could include track/scat/hair deposit surveys, howling surveys, and remote camera surveys. Different methods vary in their usefulness in different situations, and it is likely that the CDFW will need to employ multiple methods as a result of California's diverse landscapes and climate conditions (Kunkel et al. 2005).

Observations of wolves from landowners, public agency land management staff, and members of the pubic who may be travelling through, work and/or recreate within outdoor environments where wolves may be present will also be important. It will be incumbent upon CDFW and other agency staff to follow-up on credible information to determine wolf presence.

Population Viability

Population objectives for listed species should be set at numbers and geographic distributions that ensure that biologically sustainable populations can be achieved. For the purposes of this document, a biologically sustainable population is one that can sustain its size, distribution, and genetic variation in the long-term in spite of fluctuations in abundance and recruitment as a result of human caused mortality, variation in food supply, disease, and habitat quality, without requiring human intervention and conservation actions. In California, wolf population sustainability will also depend on connectivity to wolf populations in neighboring states as both a source and a destination for dispersing individuals to maintain genetic diversity of the region's metapopulation (von Holdt et al. 2010).

The minimum size of any wildlife population required to achieve biological sustainability is widely debated. Numerous attempts have been made to estimate the minimum viable population[72] (MVP) size required for sustainability of different species, with widely varying results, and many authors are critical of the value of MVP as a standardized tool for estimating species conservation targets[73]. The formal application of MVP requires extensive, high-quality data drawn from intensive, long-term studies, which is frequently limited for most species of conservation concern (Flather et al. 2011). Flather et al. (2011) cited a lack of general applicability across taxa with widely varying life histories, and experiencing very different localized environmental conditions. These authors used supplementary data from Traill et al. (2007) to demonstrate the high degree of variability in MVPs estimated for a single species. The gray wolf, for example, had four independent estimates of MVP ranging from 248 to 6,332. Flather et al. (2011) attributes this within-species variability to the importance in environmental context in determining population viability, and recommend against using results of these models to set conservation targets unless they are based on data specifically from the focal population.

As with other models, calculation of MVP requires some assumptions to address limitations of the model's application. One of these assumptions is that the studied population is isolated from other populations of the same species. For wolves this is rarely true, and it will not be true for California. A California wolf population most likely will not be ecologically separate from the increasing and recovering population in western North America which comprised more than 1,904 individuals in 2015[74]. Rather, California's wolves will be linked with the greater metapopulation in North America by dispersal of wide-ranging individuals[75], particularly those in Oregon, Washington, and Idaho, which will in turn be linked with wolves in the rest of the U.S. and Canada. Other necessary assumptions in estimating MVP are that habitat quantity and quality remain constant through the period of time included in the estimate. If those assumptions are not realized then the reliability of the MVP estimate is further compromised, commensurate with the magnitude of habitat change. It is predictable that the human population will increase, and that the climate will change (although in what manner is not known) in California. As a consequence the current utility of estimating a wolf MVP for California is highly questionable, and probably not scientifically credible. It is of greater utility to identify and address factors that may limit the growth and persistence of a wolf population in California.

[72] MVP has been defined as the number of individuals required to have a specified probability of persistence over a given period of time (Shaffer 1981; Gilpin and Soulé 1986; Nunney and Campbell 1993). It essentially asks how large a population must be to avoid extinction given the current and projected future set of risks it will face (Brook et al. 2006).
[73] The need for rapid decisions for conservation targets, frequently without adequate data, has led managers and conservationists to seek general guidelines for developing MVPs.
[74] This is the most current population estimate at the time of this writing.
[75] The NRM wolf population is similarly connected to the population in Canada, consisting of over 60,000 animals.

CHAPTER 10 PUBLIC INFORMATION AND OUTREACH

A. Purpose and Need

A well-informed public is essential to gray wolf conservation and some authorities consider outreach efforts to be the highest priority in restoring the species (Fritts et al. 1995, 2003). It is crucial that wolves and wolf management issues be presented in an objective and unbiased manner, and that the public receives accurate information on the species. Conflicts with wolves and the solutions and compromises needed to resolve those conflicts however unpalatable to some publics must be discussed fairly (Fritts et al. 2003).

Extensive public outreach was conducted before and during wolf recovery in Montana, Idaho, and Wyoming, with a broad mix of approaches used (Fritts et al. 1995). These efforts conveyed a factual and balanced view of wolves, and stressed the differences between wolves and other members of the dog family (canids).

To be effective, this public information and outreach program should have both active and passive components, because some people will actively seek information from a wide variety of sources, including some that are neither scientifically factual nor unbiased. Others who are only mildly interested will wait for CDFW (and others) to “feed” them information.

A well-informed populace is also essential to democracy and to ensure that the public is knowledgeable enough to give intelligent, rational comments to their elected representatives on any subject. The subject of wolves – skewed with centuries of superstition, mythology, misinformation, and bias from all viewpoints – requires the dissemination of honest, accurate information on a massive scale more than most subjects, due to the very strong interest of the public.

Because the wolf management strategies throughout the rest of this Plan will have to be adaptive, the information and outreach strategies should also be adaptive. The chosen strategies and communication tools must allow flexibility and be based on available technology, ongoing management activities, and available funding.

It will be the CDFW’s responsibility to inform interested people about wolf behavior and biology, and management of wolves in California. It is essential that CDFW provide thorough, honest, accurate, and timely information to the general public as well as to stakeholders on all sides of the issue. Consistent with CDFW’s previous approach regarding the location of OR7, the Shasta Pack (discovered in 2015), and the Lassen County pair (November 2016), generalized locations will not be publicized immediately.

B. Information and Outreach Goals

CDFW will create and implement a wolf information and outreach program with the following goals:

- Inform all CDFW employees who may interact with the public, so they can provide accurate and consistent information about wolf conservation and management, and CDFW's related activities. This is particularly important for Office of Communications, Education and Outreach (public affairs) staff, law enforcement (wardens), scientists, all Northern and North Central Region staff and management, and the Directorate.
- Inform the public, the Governor and Legislators of the presence of wolves in California, their historic place in and value to the ecosystem, and the likely consequences (both positive and negative) of their return. This is an identified priority for the Department.
- Inform the public regarding wolves' legal status and the appropriate responses to chance encounters with wolves.
- Develop and implement a comprehensive outreach program that prepares citizens in areas where wolves are present or likely to be present.
- Inform livestock producers and outdoor recreationists in particular to prevent or reduce the likelihood of conflicts with wolves.
- Provide wolf monitoring information to livestock producers, outdoor recreationists, and other government agencies, as needed, to keep them informed of wolf activities and movements. Conversely, provide them with a way to inform CDFW of sightings, etc.
- Proactively inform livestock producers in areas where wolves are present about non-lethal wolf management techniques. This is identified as a high priority for the Department.
- Work with livestock producers and their organizations, county extension services, county agricultural commissioners, and people living in areas wolves are believed or likely to be, to develop and deliver a comprehensive outreach program to prevent and minimize wolf depredation. This is identified as a high priority for the Department.
- Establish and maintain an open, collaborative atmosphere in which the public can both receive and provide accurate information about the wolves in California. Coordinate information and education efforts with other agencies and non-government organizations to ensure that accurate information is disseminated to interested parties in cost-effective ways.
- Ensure that the public and media have access to the most current information on wolf management through written materials, website content, social media, news releases, and verbal presentations.

Californians (and others) will want access to information about wolves and wolf management in our state from wildlife managers. Wildlife managers will need information from Californians on sightings, actual wolf behavior, and depredation events to effectively manage wolves. Without a process to create and support two-way communications, implementation of any wolf conservation/management plan will be constrained, and neither wildlife managers nor the general populace will have the information they need to make wise decisions and evaluate the status of plan objectives.

Effective communication will require consideration of all groups of people who may be interested in wolves and wolf management. Each group (or audience) may desire or require a slightly different method of communication. The following are some of the audiences that are likely to have an interest in wolf management issues and the implementation of a wolf conservation and management plan in California:

- CDFW staff
- Owners/managers of livestock in areas where wolves are present as well as the organizations who represent those interests
- People who live and/or work in areas where wolves are present
- Pet owners where wolves are present
- Law Enforcement Agencies
- USDA/APHIS
- Media: News reporters and photographers, wildlife program producers
- USFWS, US Geological Service
- Public land managers – federal, state, regional and local
- County governments
- Legislators
- Native American tribes
- Wildlife agencies in adjoining and other western states
- Wildlife watchers and photographers
- Backcountry recreationists
- Teachers
- Students of all ages
- Hunters who hunt in California and the organizations who represent those interests
- California timberland managers
- Wildlife and wilderness-oriented NGOs, especially wolf advocacy groups

C. Possible Strategies for Implementation

1. Create a Keep Me Wild and/or Living With Wildlife e-brochure about wolves. Because some of the people who need this information may not have Internet access, this should be supplemented with some printed brochures. Notify the public of and distribute brochures in areas where wolves are, and are likely to soon be present.

2. Develop written materials on wolves and the wolf management program for distribution and web dissemination. Create printed materials that can be disseminated by multiple agencies, whenever possible.

3. Create a bulletin board-style monthly notice on the CDFW website that describes the current situation. This could include such facts as the number of wolves confirmed in California, general descriptions of where they are located, date they were first seen in the state, genders and approximate ages (if known), videos, and trail camera photos.

4. Ask collaborating agencies to post a link to the above website on their wolf or other web pages.

5. Add wolves to the wildlife discussed in the Project Wild curricula.

6. Maintain a wolf web page (within the greater CDFW website) that includes pertinent documents such as our wolf conservation and management plan, Frequently Asked Questions, photos and graphics that inform people how to identify wolves or their presence, and a map indicating general areas where wolves are known to be in California. Include statistics as they become available (as on mountain lion pages) and links to wolf information on other government web pages.

7. Hold public information workshops (meetings) in counties most affected by presence of wolves. Local warden(s), scientist(s), a public affairs officer and any needed support staff should provide same information as in number 1 above, customized for local relevance. Use video, computer graphic software and/or whatever media is likely to facilitate respectful conversation. A high-level manager should participate, to answer questions about CDFW’s policies.

8. Develop posters that tell people how and why to report wolf sightings and what to do if they believe a wolf has damaged property (i.e. livestock, pets). Distribute posters to merchants, colleges, public agencies, libraries, and other organizations with public meeting places in areas wolves are believed to be present. Distribute this information to news media in nearby media markets.

9. Issue news releases to the appropriate audience(s) when something newsworthy occurs that the public needs or would want to know regarding wolf management in California.

10. Develop CDFW wolf expertise that would be available to speak and distribute written materials designed to inform the public about wolf biology, history in California, and CDFW's wolf-related activities. Dissemination of this information could include meetings hosted by other organizations (e.g., colleges with wildlife programs, livestock owners' associations, civic organizations, wildlife interest and hunting groups). This is particularly important near areas where wolves are believed to exist. The greatest demand for this is likely to be in the first year after wolf presence is confirmed in California (i.e. beyond dispersing individual wolves).

11. Include information on wolf identification in California Hunting Regulations books, *Outdoor California,* web pages, and other outreach materials for hunters.

12. Create an annual report on the wolf population and management activities for the Governor, Legislature, Commission, and for public dissemination through the website, and other public meetings and outreach events.

13. Produce a five-to-10 minute video of "Gray Wolves in California: An Evaluation of Historical Information, Current Conditions, Potential Natural Re-colonization and Management Implications" for the CDFW YouTube channel. If necessary, make several short videos, each covering one of those subjects.

14. Cooperate with producers of TV programs carried by PBS, The History Channel, Discovery Science, Animal Planet, or others who may seek to create educational shows about the wolves' return to California.

15. If funding permits, periodically survey public attitudes toward wolves.

CHAPTER 11 FUNDING NEEDS AND OPPORTUNITIES

Within the preceding chapters of the Plan, CDFW has discussed and identified strategies to implement conservation and management actions for wolves in California. Successful implementation of the Plan will require adequate funding and staffing to accomplish these actions. CDFW provided greater emphasis on the research needs for ungulates prior to, during, and post-wolf reestablishment. These costs are expected to remain consistent and would increase during initial wolf establishment in California. Should wolf populations increase, it is expected costs will increase concomitantly due to needs for: increased wolf monitoring, CDFW assistance in proactive wolf deterrence actions, livestock depredation investigations, livestock depredation compensation actions (if any become authorized), and increased public outreach needs.

This chapter covers the following:

- Elements of need and implementation
- Existing funding sources
- Prioritization of activities
- Funding opportunities

A. Elements of Need and Implementation

To fully implement the elements and strategies of the Plan, an appropriate “program” would need to be developed within CDFW’s Wildlife function at both the headquarters Branch and Regional levels coincident with staffing and secured funding. Activities can be anticipated to include:

Administrative – Facilitate federal land management agency coordination; federal and state resource agency (USFWS, WDFW, ODFW) coordination; stakeholder/elected representative/Agricultural Commission, Fish and Game Commission, etc. coordination; collaboration and coordination with others regarding monitoring and research needs for wolves and ungulates; develop and coordinate human dimension surveys regarding wolves and ungulates in California; seek funding opportunities to develop and fund future wolf and ungulate research as well as habitat restoration/enhancement on resource lands.

Scientific – Develop monitoring activities, research actions, and disease surveillance for wolves and ungulates including investigations on habitat conditions and utilization, species health, spatial distributions, reproduction, predation, population trends; conduct mortality investigations; develop and coordinate capture actions for ungulates and wolves.

Management – Coordinate with private landowners regarding locational information on wolves; conduct investigations of livestock depredation and public safety; develop land management actions to benefit habitat for ungulates and provide recommendations to public and private land owners; coordinate/conduct proactive non-lethal training conflict deterrence activities with livestock producers including demonstration and deployment of non-lethal equipment (e.g. fladry); conduct effectiveness monitoring of non-lethal deterrence activities; respond and provide outreach to those interested in wolf management activities.

Information/Outreach – Prepare regular updates for CDFW website, press, and other media regarding wolves in California; disseminate wolf/ungulate information as information and outreach materials; conduct public meetings to share wolf/ungulate information statewide; and develop video media to disseminate to media, schools, interested groups, etc. regarding wolves in California and CDFW activities for wolf and ungulate management.

Other – Conduct laboratory analysis for wolf genetics and wolf/ungulate diseases; implement research projects; develop contracts for helicopter and GPS server (collars providing locational information); implement acquisition, conservation easement, habitat restoration/enhancement actions; implement livestock depredation and compensation actions; implement co-existence actions with private landowners. Much controversy regarding wolves in the United States involves lawsuits challenging resource agencies tasked with management of this species. It is reasonable to expect CDFW will be similarly affected. Funding will be necessary to address this activity.

B. Existing Funding Sources

Funding for CDFW's fish and wildlife operations comes from approximately 48 different sources, including 27 dedicated accounts within the Fish and Game Preservation Fund, 19 of which are funded through consumptive user tag fees. About 16% of CDFW's funding comes from tax dollars in the state General Fund and about 20% comes from hunting and fishing license fees. Other sources include endangered-species tax check-off funds, environmental license plate sales, fees, fines or mitigation, voter-approved bond measures, federal grant programs, and donations.

CDFW has limited discretion in how it spends its money, with much of its operating revenues designated for specific programs in the state budget. By law, hunting and fishing revenues must be spent on hunting and sport fishing programs, including fish hatcheries and stocking, habitat restoration, wildlife management and education programs. Other environmental revenues are directed toward conservation planning, environmental review and permitting and water resource management.

Existing funding sources to implement portions of the Plan could include:

1.) <u>State Funding</u>

- **General Fund** – This funding source is from the generation of public tax revenue. How the money in California's General Fund is spent is determined by the Governor and the Legislature through the annual state budget process. The spending choices available to the Governor and the Legislature are limited by the federal and state laws and requirements, court orders, and ballot measures passed by the voters. In fiscal year 2012-13, about 2% of General Fund dollars were spent on Natural Resources.
(See www.sco.ca.gov/state_finances_101_state_spending.html)

- **Fish and Game Preservation Fund** (FGPF) – This funding source is from the generation of revenue from sport licenses, permits, and tags. The Legislative intent reads:

Chapter 855, Statutes of 1978 specifically provided that the cost of hunting and sport fishing programs are to be financed out of hunting and sport fishing revenues. The costs of commercial fishing programs are to be paid solely out of revenues from commercial fishing taxes, license fees, and receipts from other sources for such purposes. This chapter also provided that the Department of Finance shall include in the Governor's Budget sufficient moneys from the General Fund to pay for the cost of the Department of Fish and Wildlife's nongame programs necessary for the protection and enhancement of California's nongame fish and wildlife and their habitat.

- **CDFW's Big Game Management Account[76],** which is deposited in the FGPF, may be used for implementation of the deer and elk management plans that, could also be integrated with implementing portions of the Plan.

2.) <u>Federal Funding</u>

Federal funding for Wildlife Program activities comes from a number of sources principally through the USFWS grant appropriates to the states. These include:

- **Wildlife and Sport Fish Restoration Grants (WSFR)** – WSFR is funded by the generation of excise taxes on firearms, ammunition, and archery equipment (Wildlife Restoration Program) and fishing equipment (Sport Fish Restoration Program). The legislative intent is that the funding is used to promote fish and wildlife conservation and habitat restoration, maintenance and research.

(See http://wsfrprograms.fws.gov/Subpages/AboutUs/ItemsTaxedJuly2014.pdf)

[76] This funding source is generated from the sale of big game tags (elk, deer, wild pig, pronghorn antelope, bighorn sheep, and black bear) and is dedicated to benefit big game and their habitats.

- The Wildlife Restoration Program fund is variable annually and is apportioned to states based on population and hunting license sales. This fund currently provides base funding for CDFW's existing statewide Wildlife Program which includes wildlife and lands management. Expenditures of WSFR require a state match of 25%.

- **State Wildlife Grants** – The source of this funding is an annual congressional budget appropriation and is also variable. Generally this funding is to be used to benefit wildlife and their habitats with emphasis on species of greatest conservation need. It requires a state match of 35%.

- **Section 6 Grants** – The source of this funding is through an annual congressional budget appropriation to assist in federally listed species recovery. This funding source is also variable annually. It requires a 25% state match.

C. Prioritization of Activities

Given limited funding, prioritization of conservation and management actions identified throughout the Plan is necessary. As inferred previously, activities to support wolf capture, monitoring, and research, should be funded from the General Fund, Environmental License Plate Fund, or the Rare, Threatened, and Endangered Species Tax-Checkoff fund. Existing federal funding sources include State Wildlife Grants, Section 6, and WSFR (Wildlife Restoration) Grants. Given the current federal listing of gray wolves as endangered (under ESA) and the requirements for securing any one of these funding sources, the only grant type currently appropriate for wolves would be federal Section 6 funding. The California state allocation is competitive for projects to support federal species recovery for the 93 federally endangered (and 38 federally threatened) listed animal species and 137 federally threatened (and 50 federally threatened) listed plant species that occur throughout the state. The requests for funding annually within CDFW exceed the Section 6 amount apportioned to the state.

Existing state and federal funding sources may limit what activities identified in the Plan may be funded. CDFW has identified high priority activities in implementation of the Plan. These activities include:

- Monitor wolf distribution and abundance – It will be important to gather the most basic information on wolves in California necessary to determine where wolves are present and general population status.
- Expand monitoring of ungulate populations – This will be important prior to, during, and post wolf establishment in California to understand the effects of wolf-ungulate interactions and dynamics.
- Providing training to CDFW staff who will be involved in potential wolf-livestock depredation investigations and/or deployment and efficacy monitoring of proactive deterrents to avoid/reduce wolf-livestock conflicts.

- Providing outreach to livestock producers including assistance with proactive deterrents to reduce livestock conflicts.
- Providing outreach/education to the general public regarding wolves during and post-wolf establishment.

D. Funding Opportunities

The following list identifies some funding opportunities that may or may not be in existence in California presently or that the state is currently eligible (meets the definition of qualifying entity) to apply for. These are identified to highlight funding activities that have been used successfully outside of California and may have some future application.

1.) <u>State Funding</u>

- **California Wildlife Conservation Board** – The Wildlife Conservation Board (WCB) was created by legislation in 1947 to administer a capital outlay program (i.e. acquire, maintain, repair, or upgrade capital assets such as land and facilities) for wildlife conservation and related public recreation. Originally created within the California Department of Natural Resources, and later placed with the CDFW, WCB is a separate and independent Board with authority and funding to carry out an acquisition and development program for wildlife conservation (Fish and Game Code 1300, et seq.). WCB consists of the President of the Fish and Game Commission, the Director of CDFW and the Director of the Department of Finance. Legislation that created WCB also established a Legislative Advisory Committee consisting of three members of the Senate and three members of the Assembly, which meet with WCB, providing legislative oversight.

  The primary responsibilities of WCB are to select, authorize and allocate funds for the purchase of land and waters suitable for recreation purposes and the preservation, protection, and restoration of wildlife habitat. WCB approves and funds projects that set aside lands within the state for such purposes, through acquisition or other means (e.g. conservation easements), to meet these objectives. WCB can also authorize the construction of facilities for recreational purposes on property in which it has a proprietary interest.

  WCB's three main functions are land acquisition, habitat restoration and development of wildlife oriented public access facilities, which are carried out through its programs.

- **Special Interest (Vanity) License Plates –** There are at least 13 different special interest license plates. For example, agriculture (supports Department of Food and Agriculture ag leadership development, etc.), environmental (supports environmental programs), memorial (supports law enforcement to fight terrorism), Lake Tahoe (supports the Lake Tahoe Conservancy to fund projects in the Lake Tahoe area), and Pet Lovers (supports the Veterinary Medical Board for spay and neuter programs).

- **Tax Check Off –** Administered by the California Franchise Tax Board (enacted through legislation) where a voluntary contribution is made by state taxpayers to designate an amount on their annual tax return to a charitable fund. In 2013 there were 17 different Contribution Funds. CDFW receives some funding from two of these sources, the California Sea Otter, and the Rare and Endangered Species Preservation Program.

2.) Federal Funding

- **USFWS – Wolf Livestock Demonstration Project Grants –** Approximately $900,000 is available for eligible states and tribes for demonstration projects intended to reduce and address the impact of wolves on livestock operations. These include prevention grants for proactive measures to reduce risk, and compensation grants that reimburse for livestock losses. These grants require a 50% cost share.

- **Natural Resources Conservation Service – Environmental Quality Incentive Program (EQIP) –** The state itself would not qualify for this federal funding; eligibility is limited to agricultural producers and owners of non-industrial private forestland and tribes to "address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation or improved or created wildlife habitat." EQIP provides both technical and financial assistance and require a cost share similar to other federal grants.

3.) Other Funding

- **Private Funding –** Some western states have worked with non-government conservation organizations, various stakeholders and private partners who have assisted in providing supportive funding and/or equipment that contributed to implementation of wolf management actions. CDFW will continue its working relationships with outside groups and seek to take advantage of these funding opportunities to implement the Plan when possible.

- **Wolf Stamps –** In 2014, the Montana Department of Fish, Wildlife and Parks proposed a "wolf conservation stamp" with proceeds earmarked for wolf management. Following public hearings, the proposal was not adopted, however provides options for California to consider. The revenue generated by this proposal was considered a donation to the agency and contribute to a) a livestock loss reduction program, b) wolf monitoring habitat protection or acquisition within occupied wolf habitat, scientific research of wolves, or public education and outreach activities related to wolves, and c) hiring of additional game wardens within occupied wolf habitat. Legislative action would be required for a similar funding mechanism in California.

CHAPTER 12 PLAN EVALUATION AND REPORTING

It is clear that the public's interest in the future of California wolves is strong and likely to increase once wolf establishment occurs. As such, one measure of the external success of the Plan's implementation will be demonstrated with how well public support continues for wolf conservation through funding, continued engagement, and constructive dialog.

It will be the responsibility of CDFW to continue to gather information within California, gather applicable information outside of California, and apply this information adaptively in the conservation of wolves. This includes dissemination of this information to the public. One proposed action would be the preparation of an annual Wolf Report which would be presented to the Commission, the public and others, providing a summary of the prior's years activities identified within the Plan. Based on the strategies in the Plan, CDFW anticipates conducting a status review of wolves in California when the number of successful breeding pairs reaches six pairs for two consecutive years. It is unknown how long it may take to reach this population level.

Assuming that funding has been available during wolf establishment to conduct research and gather important information, various aspects of the Plan (as well as the status review) can be updated and modified to reflect newer aspects of wolf ecology in California including potential population objectives, important habitat areas, strategies for maintaining/enhancing ungulate populations, minimization of wolf-livestock conflicts, and adaptive management where appropriate for wolf conservation through time. It is unknown how long it will take to gather this information as wolves are only newly present in California, and funding opportunities for wolf-specific research is currently unidentified. CDFW anticipates initiating ungulate research in a portion of northern California (Siskiyou County) in late 2015. Funding for this work will be supported in part through CDFW's Big Game Management Account.

Another consideration would be a change in federal or state status associated with listing as an endangered or threatened species (under ESA/CESA). Should wolves be delisted at the federal level, management strategies in California may or may not change depending on the action and subject to whether or not wolves would still be state listed. Any changes in status would necessitate revision to the Plan.

PERSONAL COMMUNICATIONS

Chapter 1

- Ed Bangs, USFWS NRM Gray Wolf Coordinator October 2010
- Mike Jimenez, USFWS NRM Gray Wolf Coordinator
- Ben Sacks, University of California Davis November 2013

Chapter 2

- Kent Fowler, Animal Health Branch Chief, California Department of Food and Agriculture
- Annette Jones, State Veterinarian, California Department of Food and Agriculture
- Pam Swift, Wildlife Veterinarian (retired), California Department of Fish and Wildlife
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Chapter 3

- Bill Hunt, Resource Conservation Manager, Banff National Park, June 2016
- Rick Stronks, Chief Park Naturalist, Algonquin Provincial Park, Ontario, Canada June 2015
- Todd Windle, Human-Wildlife Conflict Specialist, Pacific Rim National Park Reserve, June 2016

Chapter 4

- Ed Bangs, USFWS NRM Gray Wolf Coordinator October 2010
- Chris Brennan, USDA/APHIS Wildlife Services Mendocino County March 2011
- Mike Jimenez, USFWS NRM Gray Wolf Coordinator 2014

- Russ Morgan, Oregon Department of Fish and Wildlife, Wolf Program Coordinator May 2014

Chapter 5

- Donny Martorello, Washington Department of Fish and Wildlife June 2014

- Doug Smith, Yellowstone National Park August 2014

Chapter 6

- Randy Botta, Senior Environmetal Scientist Specialist, CDFW Region 5, January 2015

- Tom Stephenson, Senior Environmental Scientist Supervisor, CDFW Region 5, January 2015

- Alexandra Few. CDFW Region 6 Environmental Scientist. Bighorn Sheep Program

- Mark Hebblewhite, Ungulate Ecology Lab, College of Forestry and Conservation, University of Montana

Chapter 7

- Todd Grimm, USDA/APHIS Wilflie Services April 2014

Chapter 9

- Todd Fuller, Department of Environmental Conservation, University of Massachusetts Amherst, Massachusetts October 2014

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GLOSSARY OF ACRONYMS, SCIENTIFIC NAMES, AND TERMS

Acronyms

BLM – Bureau of Land Management
BNP – Banff National Park
BP – Breeding pair
BRWRA – Blue Range Wolf Recovery Area
CDFG – California Department of Fish and Game (former name of the Department)
CDFW – California Department of Fish and Wildlife (current name of the Department)
CESA – California Endangered Species Act
DPA – depredation prevention agreement
DPS – distinct population segment
EMU – elk management unit
ESA – federal Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.)
FGC – Fish and Game Code
mtDNA – mitochondrial DNA
GPS – global positioning system
LPD – Livestock protection dog
NRM – Northern Rocky Mountain wolf population
NRM DPS – Northern Rocky Mountain Distinct Population Segment
ODFW – Oregon Department of Fish and Wildlife
OHV – off highway vehicle
PLM – Private Lands Management program
RAG – radio-activated guard box
SHARE – Shared Habitat Alliance for Recreational Enhancement program
SNP – single nucleotide polymorphism
SWG – (California wolf) Stakeholder Working Group
UCANR – University of California Department of Agriculture and Natural Resources
USDA – U.S. Department of Agriculture
USDA APHIS – USDA Animal and Plant Health Inspection Service
USDA NASS – USDA National Agricultural Statistics Service
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
VHF – very high frequency
WDFW – Washington Department of Fish and Wildlife
WS – USDA APHIS Wildlife Services
YNP – Yellowstone National Park

Species' Scientific Names

American badger – *Taxidea taxus*
American marten – *Martes americana*
American white pelican – *Pelecanus erythrorhynchos*

Arctic fox – *Alopex lagopus*
Amargosa vole – *Microtus californicus scirpensis*
bald eagle – *Haliaeetus leucocephalus*
beaver – *Castor canadensis*
big sagebrush – *Artemisia tridentata*
bighorn sheep – *Ovis canadensis*
bison – *Bison bison*
bitterbrush – *Purshia tridentata*
black bear – *Ursus americanus*
black-billed magpie – *Pica hudsonia*
black-tailed hare – *Lepus californicus*
black tern – *Chlidonias niger*
bluebunch wheatgrass – *Pseudoroegneria spicata*
blue oak – *Quercus douglasii*
bobcat – *Lynx rufus*
burro – *Equus asinus*
California black rail – *Latterallus jamaicensis coturniculus*
California condor – *Gymnogyps californicus*
caribou – *Rangifer tarandus*
cheatgrass – *Bromus tectorum*
coho salmon - *Oncorhynchus kisutch*
Columbian black-tailed deer - *Odocoileus hemionus columbianus*
coyote – *Canis latrans*
creosote bush – *Larrea tridentata*
desert bighorn sheep - *Ovis canadensis nelsoni*
desert kit fox – *Vulpes macrotis arsipus*
desert tortoise – *Xerobates agassizii*
dog louse – *Trichodectes canis*
domestic dog – *Canis lupus familiaris*
eastern (Algonquin) wolf – *Canis lycaon* or *Canis lupus lycaon*
elk – *Cervus elaphus*
Ethiopian wolf – *Canis simensis*
feral horse – *Equus ferus caballus*
fescue – *Festuca* spp.
fisher – *Pekania pennanti*
golden eagle – *Aquila chrysaetos*
gray fox – *Urocyon cinereoargenteus*
gray wolf – *Canis lupus*
gray-headed pika – *Ochotona princeps*
greater sage-grouse – *Centrocercus urophasianus*
greater sandhill crane – *Grus Canadensis tabida*
grizzly bear – *Ursus arctos horribilis*
interior live oak – *Quercus wislizenii*
long-tailed weasel – *Mustela frenata*
low sagebrush – *Artemisia arbuscula*
lynx – *Lynx canadensis*
Mexican wolf – *Canis lupus baileyi*
mink – *Mustela vison*

Mohave ground squirrel – *Xerospermophilus mohavensis*
moose – *Alces alces*
mountain lion – *Puma concolor*
mule deer – *Odocoileus hemionus*
northern harrier – *Circus cyaneus*
northern timber wolf – *Canis lupus occidentalis*
Oregon snowshoe hare – *Lepus americanus klamathensis*
Peninsular (population of desert) bighorn sheep – *Ovis canadensis nelsoni*
pig – *Sus scrofa*
plague – *Yersinia pestis*
plains bison – *Bison bison bison*
plains wolf – *Canis lupus nubilis*
ponderosa pine – *Pinus ponderosa*
pronghorn – *Antilocapra americana*
pygmy rabbit – *Brachylagus idahoensis*
rabbit – *Lepus* spp.
rabbitbrush – *Chrysothamnus nauseosus*
raccoon – *Procyon lotor*
raven – *Corax corax*
red fox – *Vulpes vulpes*
red wolf – *Canis rufus*
reindeer – *Rangifer tarandus*
river otter – *Lutra canadensis*
Rocky Mountain elk – *Cervus elaphus nelsoni*
Roosevelt elk – *Cervus elaphus roosevelti*
sage – *Artemisia* spp.
salmon – *Oncorhynchus* spp.
saltbush – *Atriplex* spp.
San Joaquin kit fox – *Vulpes macrotis mutica*
short-eared owl – *Asio flammeus*
short-tailed weasel – *Mustela erminea*
Sierra Nevada bighorn sheep – *Ovis canadensis sierrae*
Sierra Nevada red fox – *Vulpes vulpes necator*
Sierra Nevada snowshoe hare – *Lepus americanus tahoensis*
Sitka spruce – *Picea sitchensis*
snowshoe hare – *Lepus americanus*
spotted skunk – *Spilogale gracilis*
squirrel-tail – *Elymus elymoides*
striped skunk – *Mephitis mephitis*
tule elk – *Cervus elaphus nannodes*
tumbling mustard – *Sisymbrium altissmum*
western hemlock – *Tsuga heterophylla*
western juniper – *Juniperus occidentalis*
white-tailed deer – *Odocoileus virginianus*
white-tailed hare – *Lepus townsendii*
wolf – *Canis lupus*
wolverine – *Gulo gulo*
yellow rail – *Coturnicops noveboracensis*

Terms

Adaptive management – management strategies and practices that may change over time because they incorporate new information gathered through monitoring, evaluation, and other credible sources as it becomes available.

Biologically sustainable – a population is one that can sustain its size, distribution, and genetic variation in the long-term in spite of fluctuations in abundance and recruitment, as a result of, human caused mortality, variation in food supply, disease, and habitat quality, without requiring human intervention and conservation actions. In California, wolf population sustainability will also depend on connectivity to Oregon's population as both a source and a destination for dispersing individuals to maintain genetic diversity of the region's metapopulation.

Breeding pair – see successful breeding pair.

Carrying capacity – the size of a wildlife population that can be sustained in the environment given the existing supply of food, habitat, water, and other essential needs the species may have.

Co-existence – the goal of conserving wolves while minimizing and managing conflicts with humans, other wildlife, and livestock.

Co-existence strategy – strategies intended to reduce conflict between livestock producers and wolves including the development of local wolf advisory groups, and compensation for ongoing use of non-lethal deterrence methods.

Conserve/Conservation – FGC defines conserve, conserving, and conservation to mean the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which these measures are no longer necessary. Such measures include but are not limited to research, census, law enforcement, habitat acquisition, restoration and maintenance, propagation, live trapping, transplantation, and in some cases regulated taking.

Delist – to change to classification of an endangered, threatened, or sensitive species to a classification other than endangered, threatened, or sensitive because of improvements to the species status.

Depredation – death or injury of livestock caused by a predator.

Depredation Prevention Agreement – an official agreement between the Department and a livestock producer that outlines specific measures required of the producer to prevent depredation of his or her livestock by wolves. The Department provides cost share funding for approved plans in counties deemed to be priorities due to the known presence of wolves.

Dispersal – the natural movement of an animal, usually from its area of birth to another location where it establishes a territory.

Distinct Population Segment – (DPS) a discrete subgroup that is the smallest division of a species permitted for protection under the federal ESA.

Endangered – as defined under CESA, endangered means a native species or subspecies of bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all or a significant portion of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease.

Extinct – a wildlife species that no longer occurs anywhere in the wild.

Extirpated – a wildlife species that no longer occurs in the wild in a given location, but occurs elsewhere.

Fish and Game Code – the section of California law that governs the state's fish and wildlife resources. These laws are interpreted by the Fish and Game Commission through Title 14 – Natural Resources of the California Code of Regulations, which are then implemented and enforced by the California Department of Fish and Wildlife.

Fladry – a method of nonlethal deterrent that entails hanging numerous strips of flagging along a fence or other device, and is intended to keep wolves out of an area occupied by livestock.

Habituation – a wild animal's decreased responsiveness to humans due to repeated contact with them; often results from positive reinforcement from food, whether provided deliberately or accidentally.

Human-caused mortality – wolf mortality by humans, including public safety lethal control, poaching, vehicle accidents, accidental death from trapping or hunting, and any authorized lethal take for management.

Information sharing agreement – an agreement between the Department and livestock producers in which the Department provides focused disclosure information on collared wolf locations when in the vicinity of the producers' livestock, and producers agree to not disclose the location information to an unauthorized person.

Injurious harassment – aversive conditioning that causes any object to physically contact a wolf, including firearms discharging nonlethal ammunition (e.g. rubber bullets or bean bags) or using motorized equipment (e.g. an all-terrain vehicle, motorcycle, or four wheel drive vehicle) to follow or pursue a wolf.

Intraspecific strife – conflict between members of the same species. In wolves this usually occurs between members of different packs, or between packs and lone dispersers.

Lethal control – will be implemented when a wolf demonstrates aggressive action that has resulted in physical contact with a human; or a wolf exhibits an immediate threat to public health and safety, given the totality of the circumstances.

Livestock – domesticated animals raised as a commodity. Includes beef and dairy cattle, sheep, goats, pigs, and poultry.

Livestock depredation compensation – monies paid to livestock producers to mitigate for losses of livestock due to verified wolf depredation.

Metapopulation – a cluster of spatially separate subpopulations of the same species. The subpopulations interact to varying degrees depending upon the extent to which the intervening habitat allows movements of individuals.

Mitochondrial DNA – (mtDNA); genetic material found in mitochondria rather than in the nucleus of a cell. These organelles are inherited strictly from the female parent by both male and female offspring. mtDNA sequences can thus be used to trace maternal lineages which provides information about the evolutionary history of a population or species.

Non-injurious harassment – aversive conditioning intended to provide an unpleasant experience for wolves in proximity to humans or livestock, causing them to associate such stimuli with humans or livestock and possibly reduce subsequent conflicts.

Non-lethal livestock depredation assistance – assistance provided by the Department to livestock producers with the goal of preventing depredation of livestock by wolves using non-lethal methods.

NRM DPS – The Northern Rocky Mountain DPS is a DPS of the gray wolf that occurs throughout the states of Idaho, Montana, Wyoming, and the eastern one-third of the states of Washington and Oregon, and a small part of north-central Utah.

Prey vulnerability – the extent to which wolves' prey is vulnerable to capture; this is affected by an animal's age and health status, weather, snow depth, ruggedness of terrain, prey density, vegetation density, and other factors.

Radio Activated Guard box – (RAG); a device designed to frighten radio-collared wolves; the boxes are located near livestock pastures and are activated when a collared wolf approaches, setting off visual or auditory stimuli which may startle the wolves, causing them to leave the area.

Recovery – this term is used in the context of the federal Endangered Species Act to refer to the same goal of conservation as stated in FGC Section 2061, which is to improve the condition of a listed species to a point where the protections provided under ESA are no longer needed.

Recruitment – the number of offspring reaching the adult (and therefore reproductive) age class in a given year.

Seral stage – a phase in the sequential change in plant communities over time. An early seral stage is one that occurs early after a disturbance such as fire or logging, which opens canopies and allows for grasses and forbs to grow; later stages occur when new shrub and tree growth occurs.

Single nucleotide polymorphism – (SNP; pronounced *snip*); a single nucleotide site in a nucleotide sequence of DNA where more than one nucleotide (A, T, G, or C) is present in a population. SNPs are the most common type of genetic variation among individuals, and are inherited by offspring. These genetic markers can be used for multiple purposes including comparing the relationships of different populations of a species, identifying individuals, and estimating an individual's relatedness to other individuals.

Sink population – a subpopulation for which mortality exceeds reproductive success and therefore has difficulty sustaining itself without continued immigration from a source population.

Source population – a subpopulation for which reproductive success exceeds mortality and therefore produces young that emigrate to other subpopulations and unoccupied areas.

Successful breeding pair – a mated male and female wolf pair which have produced pups, at least two of which have survived through December 31st of the year in which they were born.

Sympatric – refers to populations or species occurring in the same place at the same time.

Take – under CESA, take means to hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill.

Ungulate – a hoofed, typically herbivorous, four-legged mammal; for the purposes of this plan and unless otherwise defined, ungulates refer to native elk, deer, pronghorn, and bighorn sheep.

Wolf pack – two or more wolves traveling together and using a definable area.

APPENDIX A

List of California Wolf Plan Stakeholder Working Group Members and Representatives.

Stakeholder Member	Participant Name
California Agriculture Commission and Sealers - Tehama County	Rick Gurrola
California Agriculture Commission and Sealers - Siskiyou County	Patrick Griffin
California Cattlemen's Association	Kirk Wilbur
California Deer Association	Jerry Springer
California Farm Bureau Federation	Noelle Cremers
California Houndsmen for Conservation	Bill Gaines
California Wolf Center	Karin Vardaman
California Wool Growers Association	Lesa Eidman
Center for Biological Diversity	Amaroq Weiss
Defenders of Wildlife	Pamela Flick
Endangered Species Coalition	Mark Rockwell
Environmental Protection Information Center	Kimberly Baker
Modoc County Resource and UCCE Farm Advisor	Sean Curtis
Mule Deer Foundation	Randy Morrison
Mule Deer Foundation	Rich Fletcher
Natural Resources Defense Council	Damon Nagami
Rocky Mountain Elk Foundation	Mike Ford
Sierra Club	Marilyn Jasper
The Wildlife Society Western Section	Linda Leeman
The Wildlife Society Western Section	John McNerney
UC Agriculture and Natural Resources	Robert Timm

APPENDIX B
California Wolf Stakeholder Working Group Operating Principles

For any collaborative process to operate smoothly, it is helpful for those involved to agree at the outset on the purpose for the process and on the procedures by which the group will govern its discussions, deliberations, and decision-making.

Background

With the arrival into the state of a naturally dispersing, radio-collared gray wolf from Oregon in 2011, the California Department of Fish and Wildlife (CDFW) embarked on an effort to provide outreach to the public including information on the history of gray wolves in California, basic wolf biology, legal status, etc., and of particular interest to the public the general whereabouts of the wolf while it remained in the State. CDFW also sought out those stakeholders who would be most closely affected by the potential return of gray wolves to California and began a collaborative effort to receive input on future direction of wolf management in the state.

As a result of these efforts the need to develop a plan to address wolves in California became apparent. In 2013, the CDFW initiated a process to develop a California Wolf Plan (Plan). The scope of the Plan will be constrained by the following **SIDEBOARDS**:

1. As populations of gray wolves continue to expand within the Pacific Northwest, the potential for additional gray wolves to enter California will increase. This planning effort will include a number of alternatives that address gray wolves within the State and because of this potential the option of planning for a future with no wolves in California is not an alternative in this plan.

2. The CDFW will not reintroduce wolves from another State or country into California, or introduce wolves in any way (e.g. from a captively bred California population.)

3. As a result of human influences and the subsequent changes in the California landscape, there is not sufficient habitat for wolves to be restored to their entire historic range. Consequently, the option of planning for a future with wolves distributed throughout the species historic range or abundance in California is not an alternative in this Plan.

I. Purpose of the Wolf Stakeholder Working Group

The Wolf Stakeholder Working Group (SWG) has been assembled to develop recommendations for CDFW to consider toward the first draft of the California Wolf Plan. These recommendations will help CDFW to achieve the following **GOALS**:

1. If and when wolves establish in California, seek to conserve biologically sustainable populations of wolves in the State

2. Manage the distribution of wolves within the State where there is adequate habitat
3. Manage native ungulate populations in the State to provide abundant prey for wolves and other predators, intrinsic enjoyment by the public and harvest opportunities for hunters

4. Manage wolf-livestock conflicts to minimize livestock losses

5. Communicate to the public that natural dispersal of wolves into California is reasonably foreseeable given the expanding populations in the Pacific Northwest. Inform the public with science-based information on gray wolves and the conservation and management needs for wolves in California, as well as the effects of having wolves in the State

The Plan will address the various opportunities and limitations on authority, for CDFW to accomplish the above purposes while accounting for uncertain future listing status under the Federal Endangered Species Act and potential listing under the California Endangered Species Act (CESA).

The Director of CDFW has authorized staff to develop this Stakeholder Working Group (SWG) to guide the CDFW in developing a plan (consistent with the above **GOALS**) for gray wolves, which are expected to make their way to California from growing populations in neighboring states, particularly Oregon. The SWG will develop recommendations for the CDFW to consider as the draft Plan is developed. All SWG products will be conveyed to the CDFW; however, this does not mean that all recommendations will necessarily be incorporated in the draft or final plan. Members of the SWG represent livestock ranching and agriculture, conservation groups, biologists, hunters and other outdoor enthusiasts. The composition of the SWG may change further as this process to develop a California Wolf Plan (Plan) proceeds.

II. Participation

Interests Represented. SWG members represent interests that may be substantially affected by the recovery of wolves in California. The members have a variety of interests, experience with wolf or related natural resource issues, and willingness to work together in a collaborative, consensus process. In order to foster creative problem solving, members are encouraged to voice their individual viewpoints and ideas. In order to broaden and strengthen the chances of successful collaboration for the anticipated final recommendations, members are expected to bring the perspectives of their constituent groups, as well as others with similar interests, to the SWG process.

Meeting Attendance. Members are expected to make a good faith effort to attend all full meetings. It is expected that the group will only meet several times prior to release of a draft Plan. If a member cannot attend, he or she may designate an individual to attend in their place to represent their interests (an alternate) and fully engage on the member's behalf. The alternate should be knowledgeable about wolf issues, current on the SWG and Plan status, and the topics to be discussed at the upcoming meeting. The alternate's primary responsibility is to inform the member about the deliberations and recommendations advanced at the conclusion of the meeting. It is the responsibility of the member to prepare the alternate for the meeting by sharing background information and an overview of the deliberations leading up to the meeting.

The member will strive to provide the name and background of the alternate as soon as possible, and no later than five days, in advance of the meeting. All individuals attending for members are bound by these Operating Principles. The facilitator will work with alternates to assist as needed in making their participation as constructive as possible.

Withdrawal from the SWG. Any member may withdraw from the SWG at any time without prejudice. Communication about the reasons for withdrawing, if related to the SWG process, will be appreciated. Good faith provisions apply to those who withdraw.

The decision to replace a member will depend on factors such as how far along the group is in the process, whether addition of a new member would be disruptive, and whether the loss of the interests represented by the withdrawing member creates a serious deficiency for on the SWG in terms of expertise and/or interests. Authority for decisions about replacing members rests with the CDFW Director. Any replacement member, or alternate, is expected to accept the process "as it stands" at the point in time when they first participate.

III. Organizational Structure

SWG Members. The members are working together to achieve a mutually acceptable outcome that satisfies, to the greatest degree possible, the interests of all participants. In order for the Plan to be acceptable and implementable, those involved in developing the plan agree to work together to produce recommendations that integrate the mandates, concerns, and ideas of all those significantly affected by the plan. All SWG members agree to:

- Attend meetings and follow through on promises and commitments;
- Bring concerns from their interest group or organization up for discussion at the earliest feasible point in the process;
- Share all relevant information that will assist the group in achieving its goals;
- Keep its organization's representatives informed of potential decisions and actions, in order to expedite approval for the final product;
- Support the eventual product if they have concurred in it; and
- Concur in decisions about the Stakeholder SWG process, including overseeing the implementation of the operating principles.

SWG members recognize that final decision-making authority to develop a California Wolf Plan rests with the CDFW. The CDFW is committed to developing a plan that has achieved concurrence and support from the range of stakeholders, to the extent possible.

The SWG will have assistance from CDFW staff who will attend all meetings.. While CDFW staff may sit at the table and participate in the SWG deliberations as needed, they are not SWG members. Karen Kovacs, Northern Region Wildlife Program Manager is the CDFW team leader for this effort. Eric Loft, Wildlife Program Branch Chief; Angela Donlan, Senior Staff Counsel; Mark Stopher, Senior Policy Advisor; and other CDFW staff will support the SWG.

Facilitation. CDFW prefers to use professional facilitators and is exploring the possibility of doing so for the SWG. Until that possibility is resolved, CDFW will utilize trained facilitators when possible from within CDFW. The facilitator will not take positions on the issues before the

SWG. The facilitator will work to ensure that the process runs smoothly. The facilitator's role usually includes developing draft agendas, distributing meeting materials, facilitating meetings, working to resolve any impasse that may arise, preparing meeting summaries, and other tasks as requested.

Sub-Groups. As necessary, the SWG may choose to form sub-groups. The SWG will designate sub-group members as needed for any anticipated tasks and outcomes. At the direction of the SWG, sub-group members may develop draft products and make recommendations to the SWG. Sub-groups will not make decisions on behalf of the SWG. Any SWG member can be a member of a sub-group.

IV. Meetings

Open to the Public. All SWG meetings will be open to the public. However, the CDFW expects that the range of public perspectives will be included in the SWG process primarily through the involvement of the SWG members. As such, there will only be a 15 minute period for public comment at the end of each SWG meeting. Members of the public are encouraged to submit written comments on the work of the SWG which will then be distributed to all members for consideration. Questions may be presented to the facilitator during meeting breaks for discussion at the end of the meeting.

Agendas. Proposed meeting agendas will be drafted by the facilitator in consultation with SWG members, circulated in advance of meetings, and approved or revised at the beginning of each meeting.

Action Item Memos. In order to assist the SWG in documenting its progress and activities, within ten business days of each meeting the Facilitator will prepare and distribute an action items memo. These memos will convey major decisions and ensure that timelines for completing agreed upon actions are clear to all participants. These will be distributed to CDFW staff and all SWG members for review prior to preparing a final memo.

Breaks and Caucuses. Meetings may be suspended at any time at the request of any member to allow consultation among SWG members. Requests should be respectful of all members' time. If the use of caucuses becomes disruptive, the SWG will revisit the process.**V. Decision-Making and Commitments**

Consensus. The SWG will strive to operate by consensus. Consensus is defined as all SWG members can live with the recommendation or decision. All recommendations and materials will be reviewed and discussed by the SWG before being forwarded to the CDFW for their consideration.

Decision Making. Decisions will be made by consensus of those SWG members present at a meeting. If the members present at a meeting reach consensus on a major product, the facilitator will convey the results to those absent from the meeting and assess their ability to agree. Full consensus will not be achieved until all members have confirmed agreement.

Absence of Consensus. If full consensus cannot be reached the SWG may choose to articulate areas of agreement and disagreement and the reasons why differences continue to exist, or communicate separate sets of recommendations (i.e., majority and minority reports).

If the SWG chooses to articulate areas of agreement and disagreement, members representing the different perspectives on specific issues will be asked to prepare language reflecting their views. The language should clearly identify the issues and information needs and uncertainties. In addition, those members that support each perspective will be identified.

If separate sets of recommendations (i.e., majority and minority reports) are conveyed to the CDFW, members representing the minority point of view will be asked to prepare a communication reflecting their views.

VI. Safeguards for the Members

Good Faith. All members agree to act in good faith in all aspects of the collaborative effort. As such, members will consider the input and viewpoint of other participants and conduct themselves in a manner that promotes joint problem solving and collaboration.

Acting in good faith also requires that: specific proposals made in open and frank problem solving conversations not be used against any other member in the future; personal attacks and prejudiced statements are not acceptable; negative generalizations are not productive and have the potential to impede the ability of the SWG to reach consensus; individuals not represent their personal or organization's views as views of the SWG, and members express consistent views and opinions in the SWG and in other forums, including in press contacts.

Should a SWG member be found to be acting in bad faith the facilitator will be asked to talk with the individual(s) about the situation. A variety of approaches will be explored, accordingly, to redress the concerns. The authority to replace and/or remove a member from the SWG rests with the CDFW Director.

Rights in Other Forums. Participation in the SWG process does not limit the rights of any member. Members will make a good faith effort to notify one another in advance, if another action outside the process will be initiated or pursued, which will affect the terms of proposals, recommendations, or agreements being discussed.

Public Communications. All SWG members agree to refrain from making negative comments about or characterizing the views of other SWG members in contacts with the press, or on internet web postings, in newsletters or in email or letter communications to members of respective stakeholder groups. They also agree not to knowingly mischaracterize the positions and views of any other party, nor their own, in public forums.

VII. Process Suggestions/Ground Rules

SWG members agree to consider and apply the following process suggestions and ground rules:

- Seek to learn and understand each other’s perspective.
- Encourage respectful, candid, and constructive discussions.
- Provide balance of speaking time.
- Seek to resolve differences and reach consensus.
- As appropriate, discuss topics together rather than in isolation.
- Make every effort to avoid surprises.
- Limit sidebars.
- Turn off cell phones or put them in the non-ring mode during formal meeting sessions.

VIII. Schedule

In developing its initial recommendations, the SWG will meet approximately every other month, beginning in late February 2013 and ending in July 2014. Exact dates will be determined by CDFW in consultation with SWG members. CDFW staff may also be holding public meetings during preparation of the draft plan. The CDFW is scheduled to complete its initial draft Plan by July 31, 2014. The draft will then be available for 45 days to the SWG for their review, and a panel of peer reviewers. Comments from peer reviewers and consensus comments by the SWG will be addressed by CDFW as appropriate and proposed plan revisions will be shared with the SWG. Upon completion of the draft plan, CDFW will release the plan for a 90-day public review process.

Final approval of a Wolf Plan, by the CDFW, is anticipated by December 30, 2014.

APPENDIX C

Current Elk Conservation and Management Planning

CDFW is in the process of finalizing a statewide elk management plan that will guide conservation and management actions throughout California. Previously, specific management plans were prepared for individual elk herds. California is divided into 18 Elk Management Units (EMUs; Figure 7.3), each of which has established management or population objectives. Population objectives for elk in many EMUs consist of a range of upper and a lower population levels, along with desired bull:cow and calf:cow ratios[77]. CDFW considers numerous factors when setting population objectives that can include current elk population size, distribution, available habitat, existing and potential conflicts with private landowners, and amount of private and public land. These objectives may be adjusted as CDFW obtains new information on elk population levels, composition, distribution, depredation, and other factors. In some EMUs population objectives are not clearly defined and consist of one or more of the following:

- maintain a healthy elk population within the confines of the available habitat;
- alleviate landowner conflict due to elk depredation of private property, often in the form of fence damage and/or consumption of crop intended for cattle feed; and
- increase or maintain hunting and public viewing opportunities.

If a herd exceeds its upper or lower population objectives, CDFW implements one or more of several management options to attempt to adjust the herd's trajectory. These include increasing or decreasing hunter harvest, manipulating timing of hunting seasons, issuing depredation permits, relocating animals, and/or providing recommendations to public and private land managers about enhancing elk habitat. Table C.1 below lists population estimates and objectives for EMUs in those areas anticipated as early wolf occupation range in California[78]. Statewide, most populations are below objectives because many elk herds were recently established (within the last 30 years) and are still expanding (CDFW 2014a).

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[77] Bull:cow and calf:cow ratios are indices of productivity and survival in a population, and are reported as the number of bulls or calves per 100 cows (Eberhardt et al. 1996).

[78] Wolves recolonizing California will originate from Oregon's expanding wolf population. While it remains uncertain exactly where wolves will establish in California, during the early period of recolonization it is likely they will occur in the northernmost counties in areas with adequate ungulate populations to support them. These counties include Modoc, Siskiyou, Del Norte, Humboldt, Trinity, Shasta, and Lassen, and possibly Mendocino, Lake, Tehama, and Plumas counties. See Chapter 9 *Wolf Conservation* for additional information.

Figure C.1. Elk Management Units in California. These are regulatory boundary descriptions and may not have elk equally distributed within each EMU (see Figure 7.2).

Calf recruitment[79] (or calf:cow ratio), bull:cow ratios, overall survival rates, and hunter success rates assist CDFW in estimating population trends and composition, which in turn aid in determining appropriate harvest rates for the following year. Calf recruitment can and does vary by individual herd and year. For example the Grizzly Island herd experiences high calf recruitment up to approximately 75% in some years (CDFW unpublished data). This high calf recruitment has resulted in large population increases in many years. Bull ratios are reviewed to help establish appropriate bull harvest and to maintain adequate adult males for breeding. CDFW provides for a very conservative harvest of elk, and potential harvest impacts are estimated by hunt zone using a predictive population model known as KILLVARY (Smith and Updike 1987) that estimates post-harvest adult elk population levels. Population numbers are modeled using harvest and survey information for each elk hunt zone and are used to support existing or proposed hunting programs and opportunities.

Table C.1. Elk population estimates and objectives for EMUs in northern California where wolves are expected to occur during the early period of wolf recolonization.

EMUs within potential early wolf occupation range			
Elk Management Unit	**Subspecies**	**Population Estimate***	**Objective****
Northeastern	Rocky Mountain	1,000	See elk plan
Siskiyou	Roosevelt	700	See elk plan
Marble Mountains	Roosevelt	2,700	See elk plan
North Coast	Roosevelt	1,700	See elk plan
EMUs adjacent to potential early wolf occupation range			
Elk Management Unit	**Subspecies**	**Population Estimate***	**Objective****
Mendocino	Roosevelt/tule	650	See elk plan
Lake Pillsbury	tule	125	See elk plan
East Park	tule	120	See elk plan
Cache Creek/Bear Valley	tule	200	See elk plan

* Estimates based on best available information
** Objectives are described in the EMU plan for each population and may be adjusted as additional surveys and research are implemented and results obtained

[79] Recruitment is a measure of the number of calves that survive until one year of age per 100 adult females; hence they are "recruited" into the population.

APPENDIX D

Current Deer Conservation and Management Planning

CDFW's Deer Management Program is currently undergoing a comprehensive update of all deer planning documents, and is therefore in a transition period while converting to a new approach to deer management in California. The last comprehensive deer management planning effort was conducted by CDFW in response to the Legislature's adoption of the 1976 "*A Plan for California Deer*". To implement the 1976 plan, CDFW developed 80 individual herd management plans. Although these plans still contain valuable information (e.g., demographics, recommendations for research and habitat work, and recommendations for public use) they no longer accurately portray the stressors impacting deer populations and the habitats upon which they depend. Managing deer in the face of an increasing human population and associated anthropogenic impacts requires an updated approach to management.

A new statewide deer plan is being developed as a replacement to the 1976 *"A Plan for California Deer."* The new plan has been prepared to: 1) describe the current state of deer conservation and management in California; and 2) introduce an updated strategy for maintaining sustainable deer populations. The overarching statewide deer plan goal is conservation of the state's deer populations, and the habitats upon which they depend, by developing and implementing management practices that support a sustainable population for use and enjoyment by the public.

The approach to deer conservation and management described in the new deer plan divides the state into several Deer Conservation Units (DCUs*)* based on natural divisions and ecological criteria (e.g., mountain ranges and habitat types). Under the DCU system, deer and their habitats will be surveyed and assessed at the more general DCU level, and hunting and other public use management decisions can be made at the more specific Deer Management Unit (DMU) level. Currently the state is divided into 44 Deer Management Units (DMUs) equivalent to the 44 general deer hunt zones (Figure D.1.). Populations are estimated by hunt zone using the KILLVARY predictive population model (Smith and Updike 1987) that estimates post-harvest adult deer population levels. Population numbers are modeled using harvest and survey information for each deer hunt zone and are used to support existing or proposed hunting programs and opportunities. Harvest is primarily (98%) bucks, requiring a less rigorous data collection protocol than would be necessary if more female deer were taken.

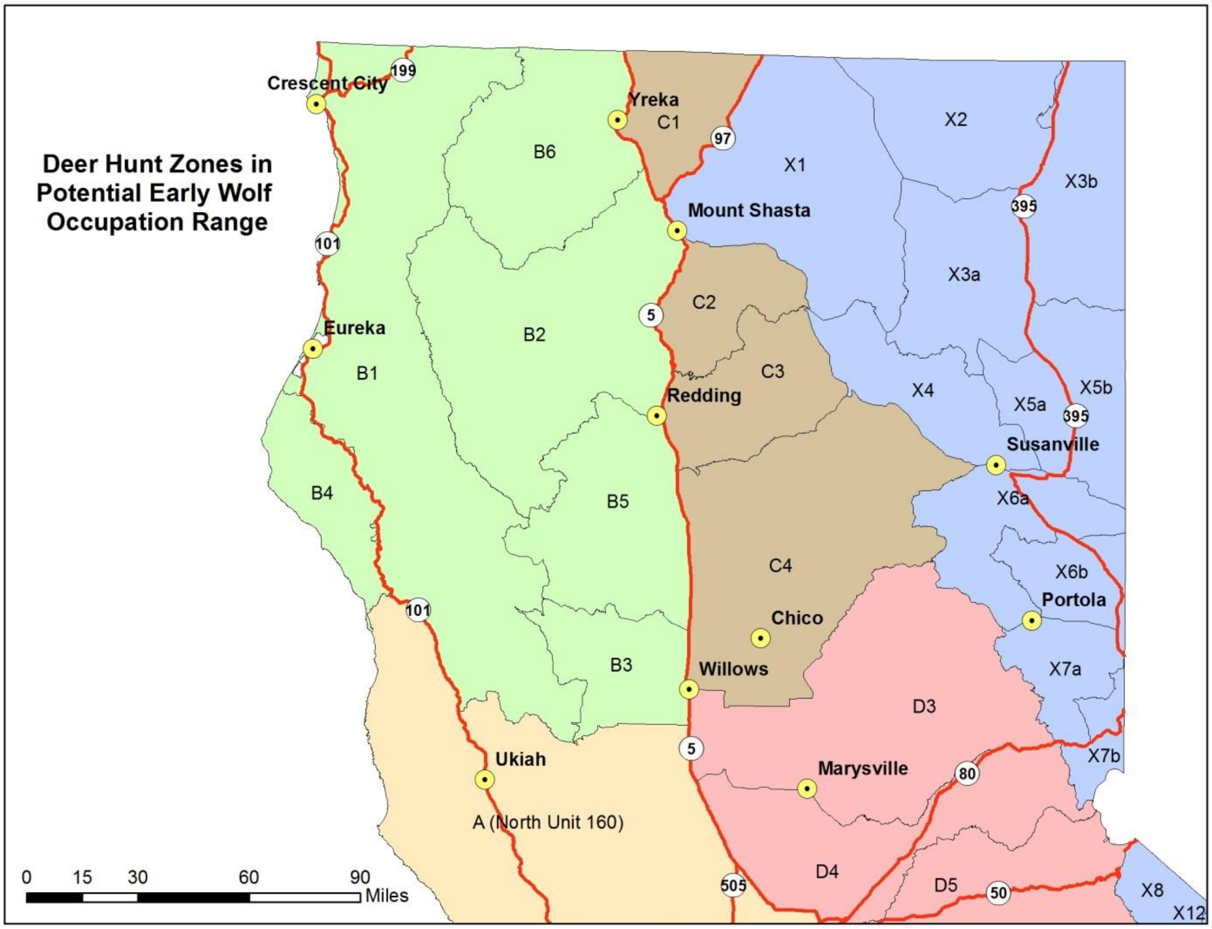

Figure D.1. Deer hunt zones in early potential wolf occupation range. The area of potential early wolf occupation range roughly includes all of the B zones, the C zones, and the X zones north of Lake Tahoe (X1-X7B). Portions of zones A and D3 occur on the southern boundary of the estimated wolf range.

Deer population performance is currently measured using hunter success, buck ratios, and over-winter fawn survival data (where appropriate - mainly in migratory herds in areas that annually receive snow). Buck ratios are measures of the proportion of bucks in the population relative to the number of does (numbers of bucks per 100 does). When considered alone, they are not an indicator of population size. Additional information about harvest or other mortality is needed to estimate the number of deer in a particular population.

Buck ratios are used extensively for harvest management of deer in California because the main hunting strategy in the state is for bucks-only. A buck ratio serves to measure the relative impact of hunting on the male segment of the population. As long as a minimum proportion of bucks remain in the population, bucks-only harvest generally does not affect total numbers of deer because it does not impact potential fawn recruitment (CDFG 2004).

Spring fawn ratios (numbers of fawns per 100 does) are also collected in appropriate areas and used to estimate the number of fawns that survived the winter and will be entering the breeding population the following fall/winter. Fawn ratios are highly variable and must be used with other parameters to determine appropriate harvest rates for the following year. Fawn recruitment (estimated using fawn:doe ratios), buck:doe ratios, overall survival rates, and hunter success rates are used to estimate population trends and composition.

Current population estimates, deer tag quotas, and percent harvest for each of the primary deer zones are listed in Table D.1. The overall harvest is conservative, ranging between 5% and 10% of the population and averaging approximately 7% for the total area.

Table D.1. Population estimates, tag quotas, and harvest for the major deer hunt zones within the potential early wolf occupation range.

<table>
<tr><th colspan="6">Deer Hunt Zones/Deer Management Units (DMUs) Within Potential Early Wolf Occupation Range</th></tr>
<tr><th>Zone/DMU</th><th>Population Estimate (Average 2012-2014)</th><th>General Season Tag Quota (2014)</th><th>Archery Season Tag Quota (2014)</th><th>Estimated Harvest (2013)</th><th>% Harvest</th></tr>
<tr><td>Zone B1/DMU 200</td><td>38,296</td><td colspan="2" rowspan="6">35,000</td><td>3,001</td><td>8%</td></tr>
<tr><td>Zone B2/DMU 240</td><td>29,459</td><td>2,030</td><td>7%</td></tr>
<tr><td>Zone B3/DMU 260</td><td>7,591</td><td>659</td><td>9%</td></tr>
<tr><td>Zone B4/DMU 210</td><td>4,926</td><td>398</td><td>8%</td></tr>
<tr><td>Zone B5/DMU 250</td><td>11,259</td><td>671</td><td>6%</td></tr>
<tr><td>Zone B6/DMU 230</td><td>16,354</td><td>872</td><td>5%</td></tr>
<tr><td>Zone C1/DMU 310</td><td>6,713</td><td colspan="2" rowspan="4">8,150</td><td>564</td><td>8%</td></tr>
<tr><td>Zone C2/DMU 320</td><td>3,395</td><td>282</td><td>8%</td></tr>
<tr><td>Zone C3/DMU 330</td><td>5,486</td><td>387</td><td>7%</td></tr>
<tr><td>Zone C4/DMU 340</td><td>23,097</td><td>1,826</td><td>8%</td></tr>
<tr><td>Zone X1/DMU 610</td><td>6,385</td><td>770</td><td>130</td><td>398</td><td>6%</td></tr>
<tr><td>Zone X2/DMU 620</td><td>1,699</td><td>150</td><td>10</td><td>153</td><td>9%</td></tr>
<tr><td>Zone X3A/DMU 630</td><td>3,809</td><td>275</td><td>30</td><td>208</td><td>5%</td></tr>
<tr><td>Zone X3B/DMU 640</td><td>6,703</td><td>795</td><td>70</td><td>391</td><td>6%</td></tr>
<tr><td>Zone X4/DMU 650</td><td>3,184</td><td>385</td><td>110</td><td>196</td><td>6%</td></tr>
<tr><td>Zone X5A/DMU 660</td><td>770</td><td>65</td><td>10</td><td>63</td><td>8%</td></tr>
<tr><td>Zone X5B/DMU 670</td><td>1,224</td><td>50</td><td>5</td><td>60</td><td>5%</td></tr>
<tr><td>Zone X6A/DMU 680</td><td>3,168</td><td>320</td><td>50</td><td>251</td><td>8%</td></tr>
<tr><td>Zone X6B/DMU 690</td><td>2,649</td><td>305</td><td>90</td><td>193</td><td>7%</td></tr>
<tr><td>Zone X7A/DMU 700</td><td>1,552</td><td>225</td><td>45</td><td>154</td><td>10%</td></tr>
<tr><td>Zone X7B/DMU 710</td><td>1,344</td><td>135</td><td>25</td><td>100</td><td>7%</td></tr>
<tr><td>TOTALS</td><td>179,064</td><td></td><td></td><td>12,857</td><td>Average Harvest = 7%</td></tr>
</table>

APPENDIX E

Predictive Levels of Wolf Predation on Ungulates in California

The rates at which wolves kill and consume prey throughout the year are variable. Both prey size (i.e., body mass) and wolf pack size influence these rates, which are typically expressed as biomass per wolf per day. The range in recorded kill rate is from 0.2 to 11.3 lbs (0.4 to 24.8kg) per wolf per day, with an average of 3.3 lbs (7.2kg) per wolf per day. Studies have shown that in general the kill rate is higher for larger prey species than for smaller prey, but the reasons for this are unexplained (Mech and Peterson 2003). Consumption rate in 18 studies of wild wolves in North America averaged 2.5 lbs (5.5kg) per wolf per day (Peterson and Ciucci 2003). Most of these studies were conducted in winter and early spring when wolf caloric need is highest, and when ungulates are in poorest condition, so these estimates may represent the high end of the range. Conversely, Sand et al. (2008) found kill rate of wolves in Scandinavia was higher in spring and summer due to higher predation of calves and fawns, which could cause an underestimate of annual kill rate if extrapolating solely from data taken in winter. This makes estimating actual numbers of prey killed per wolf per year difficult. However, some attempts have been made. Estimates for white-tailed deer ranged from 15 to 19 deer per wolf per year with the assumption that other prey constituted 20% of the annual diet (Mech 1971; Kolenosky 1972; Fuller 1989b). In YNP, winter kill rates on elk varied from 1.1 elk/wolf/30 days (later period of wolf recolonization) to 1.9 elk/wolf/30 days (early period of wolf recolonization; Stahler et al. 2006). As noted in the Yellowstone study, wolf kill rates are higher for expanding wolf populations than for those that are well-established (Jaffe 2001), presumably because of the vulnerability of naïve prey and its proximity to carrying capacity.

There are many uncertainties about where and how quickly wolves will occupy territory in California, making predictions about their impacts on ungulate populations extremely tentative and speculative. Prey species distribution, abundances, and behavioral and numerical responses, as well as the presence or absence of other large carnivores will all have an effect on wolf distribution and prey selection, and hence their impacts on prey species. As a consequence, the effects of wolf predation on California's ungulate populations will be highly situation-specific (Garrott et al. 2005).

With those caveats in mind, CDFW has developed some general approximations of wolf predation rates based on data from the northern Rocky Mountains. Figures E.1 and E.2 display two predation scenarios that display the approximate numbers of elk and deer that may be killed per year at four different wolf population sizes. The first example represents the possible diet composition of wolves when they initially begin recolonization in California. CDFW suspects that wolves may prey predominantly on elk during that phase of reestablishment. In this example 16 wolves[80] may kill 469 elk and 45 deer annually, assuming a diet of 90% elk and 10% deer. The second example represents the suspected diet of established wolves that may switch to a higher proportion of deer after the elk population has become less abundant. In this example, 32 wolves may kill 261 elk and 494 deer annually, assuming a 25% elk and 55% deer diet, with the

[80] In this example, sixteen wolves is the minimum wolf population size when four pairs breed successfully with at least two young surviving until December of the year in which they are born. This population represents the minimum at which Phase 2 of the Wolf Conservation Strategy would begin.

remaining 20% represented by “other” prey items such as hares and other small mammals, birds, and possibly salmon. These overall levels of predation could result in substantial impacts on elk and deer populations in localized areas, but the broader-scale impacts are uncertain.

Most California elk herds are below carrying capacity and therefore, as discussed previously in this chapter, predation by wolves may be additive. Additive mortality by wolves could limit the elk population’s ability to continue to expand to their historical distribution in California. As noted elsewhere, wolves may also influence deer and elk distribution, which could affect their vulnerability to hunter harvest (Creel and Winnie 2005; Mao et al. 2005; Proffitt et al. 2009). A larger wolf population would be expected to have a greater impact on ungulate populations and therefore possibly hunter opportunity.

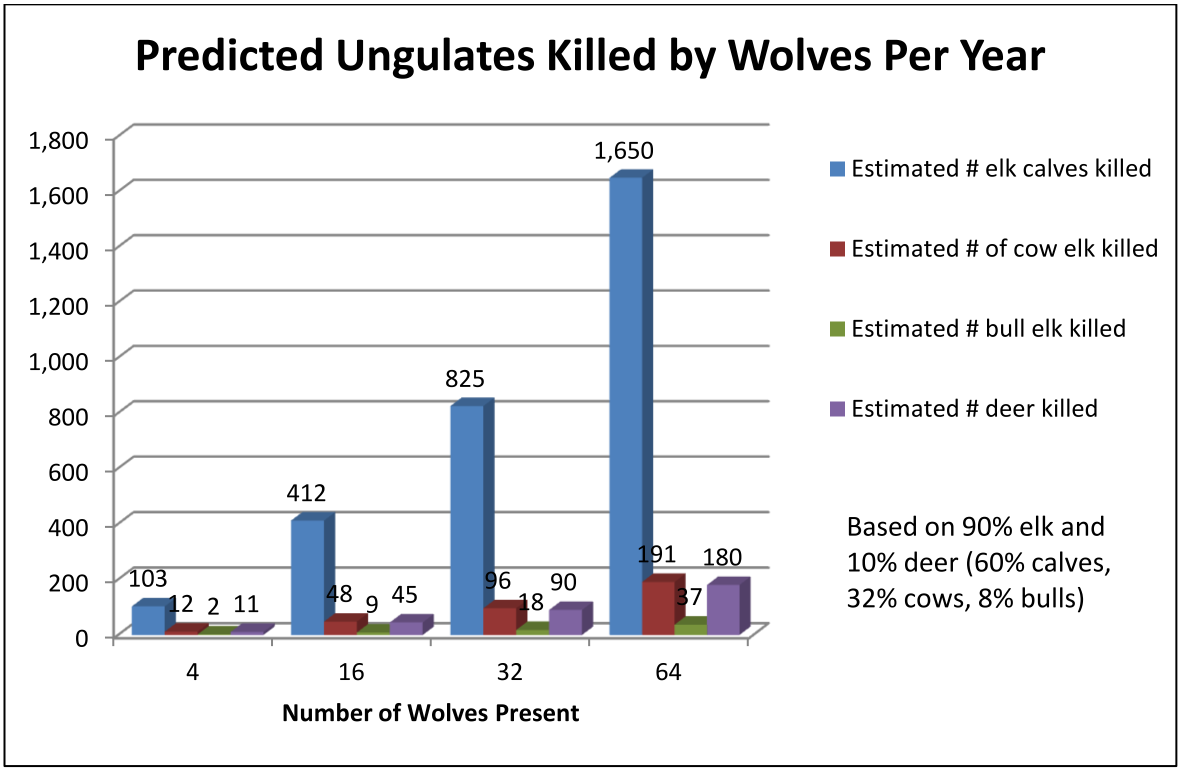

Figure E.1. Predicted ungulate kill rate by wolves per year. Percent elk age class in diet (calf = 60%, cow = 32%, bull = 8%) based on Husseman et al. (2003). Deer age classes not separated. Estimated weights of prey: elk calf = 100 lbs (45.4 kg), cow elk = 460 lbs (208.6 kg), bull elk = 600 lbs (272.1 kg), mule deer = 170 (77.1 kg). Daily wolf biomass requirement estimated to be 8.4 lbs (3.8 kg) per day based on Mech and Peterson (2003). A population of 16 wolves represents the minimum wolf population size with four successful breeding pairs.

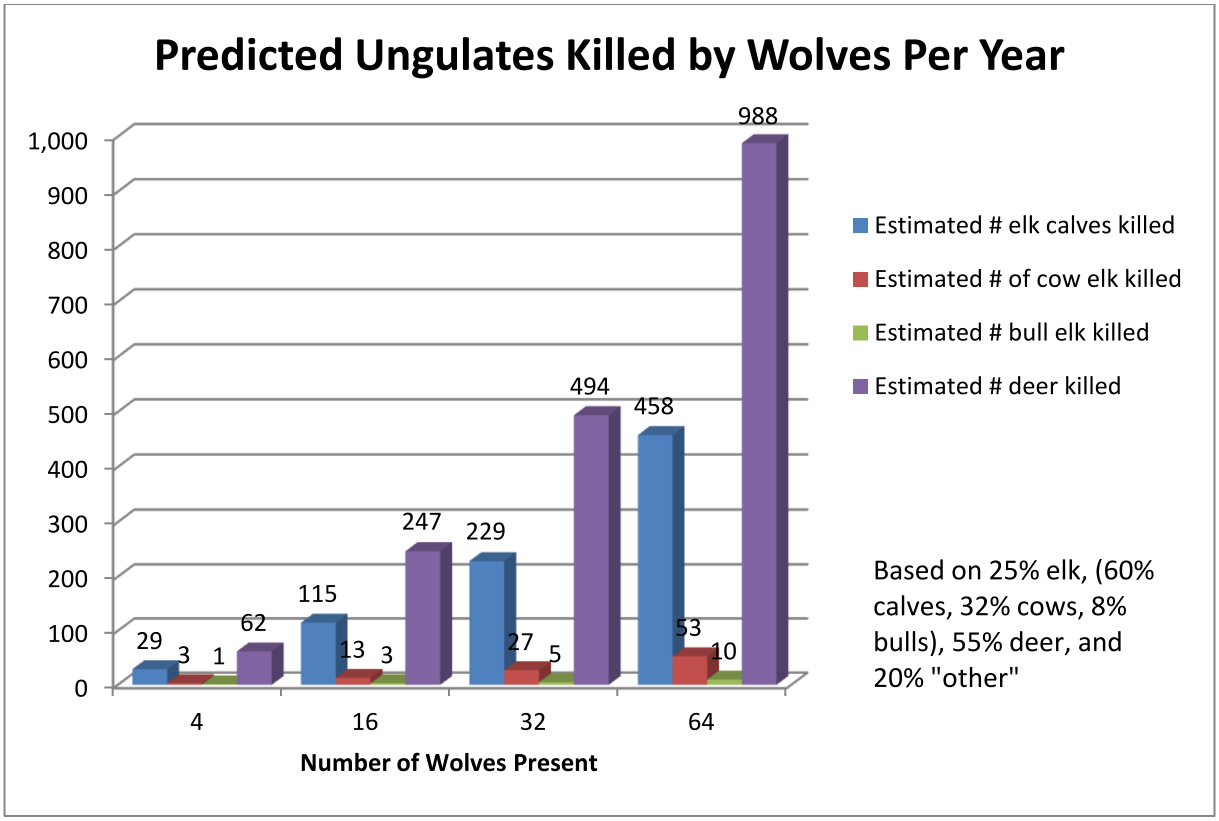

Figure E.2. Predicted ungulate kill rate by wolves per year. Percent elk age class in diet (calf = 60%, cow = 32%, bull = 8%) based on Husseman et al. (2003). Deer age classes not separated. Estimated weights of prey: elk calf = 100 lbs (45.4 kg), cow elk = 460 lbs (208.6 kg), bull elk = 600 lbs (272.1 kg), mule deer = 170 lbs (77.1 kg). Daily wolf biomass requirement estimated to be 3.8 kg per day based on Mech and Peterson (2003). "Other" prey items consist of hares and other small mammals, birds, or other prey opportunistically captured. A population of 16 wolves represents the minimum wolf population size with four successful breeding pairs.

APPENDIX F

Selected California Fish and Game Code Sections

86. "Take" means hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill.

450. It is hereby declared to be the policy of the Legislature to encourage the conservation, restoration, maintenance, and utilization of California's wild deer population. Such Conservation shall be in accordance with the principles of conservation of wildlife resources set forth in Section 1801 and in accordance with the objectives and elements stated in "A Plan for California Deer, 1976."

1801. It is hereby declared to be the policy of the state to encourage the preservation, conservation, and maintenance of wildlife resources under the jurisdiction and influence of the state. This policy shall include the following objectives:

(a) To maintain sufficient populations of all species of wildlife and the habitat necessary to achieve the objectives stated in subdivisions (b), (c), and (d).

(b) To provide for the beneficial use and enjoyment of wildlife by all citizens of the state.

(c) To perpetuate all species of wildlife for their intrinsic and ecological values, as well as for their direct benefits to all persons.

(d) To provide for aesthetic, educational, and nonappropriative uses of the various wildlife species.

(e) To maintain diversified recreational uses of wildlife, including the sport of hunting, as proper uses of certain designated species of wildlife, subject to regulations consistent with the maintenance of healthy, viable wildlife resources, the public safety, and a quality outdoor experience.

(f) To provide for economic contributions to the citizens of the state, through the recognition that wildlife is a renewable resource of the land by which economic return can accrue to the citizens of the state, individually and collectively, through regulated management. Such management shall be consistent with the maintenance of healthy and thriving wildlife resources and the public ownership status of the wildlife resources.

(g) To alleviate economic losses or public health or safety problems caused by wildlife to the people of the state either individually or collectively. Such resolution shall be in a manner designed to bring the problem within tolerable limits consistent with economic and public health considerations and the objectives stated in subdivisions (a), (b) and (c).

(h) It is not intended that this policy shall provide any power to regulate natural resources or commercial or other activities connected therewith, except as specifically provided by the Legislature.

1802. The department has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species. The department, as trustee for fish and wildlife resources, shall consult with lead and responsible agencies and shall provide, as available, the requisite biological expertise to review and comment upon environmental documents and impacts arising from project activities, as those terms are used in the California Environmental Protection Act (Division 13 (commencing with Section 21000) of the Public Resources Code).

2050. This chapter shall be known and may be cited as the California Endangered Species Act.

2051. The Legislature hereby finds and declares all of the following:

(a) Certain species of fish, wildlife, and plants have been rendered extinct as a consequence of man's activities, untempered by adequate concern and conservation.

(b) Other species of fish, wildlife, and plants are in danger of, or threatened with, extinction because their habitats are threatened with destruction, adverse modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors.

(c) These species of fish, wildlife, and plants are of ecological, educational, historical, recreational, esthetic, economic, and scientific value to the people of this state, and the conservation, protection, and enhancement of these species and their habitat is of statewide concern.

2052. The Legislature further finds and declares that it is the policy of the state to conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat and that it is the intent of the Legislature, consistent with conserving the species, to acquire lands for habitat for these species.

2052.1. The Legislature further finds and declares that if any provision of this chapter requires a person to provide mitigation measures or alternatives to address a particular impact on a candidate species, threatened species, or endangered species, the measures or alternatives required shall be roughly proportional in extent to any impact on those species that is caused by that person. Where various measures or alternatives are available to meet this obligation, the measures or alternatives required shall maintain the person's objectives to the greatest extent possible consistent with this section. All required measures or alternatives shall be capable of successful implementation. This section governs the full extent of mitigation measures or alternatives that may be imposed on a person pursuant to this chapter. This section shall not affect the state's obligations set forth in Section 2052.

2053. The Legislature further finds and declares that it is the policy of the state that state agencies should not approve projects as proposed which would jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat essential to the continued existence of those species, if there are reasonable and prudent alternatives available consistent with conserving the species or its habitat which would prevent jeopardy.

Furthermore, it is the policy of this state and the intent of the Legislature that reasonable and prudent alternatives shall be developed by the department, together with the project proponent and the state lead agency, consistent with conserving the species, while at the same time maintaining the project purpose to the greatest extent possible.

2054. The Legislature further finds and declares that, in the event specific economic, social, or other conditions make infeasible such alternatives, individual projects may be approved if appropriate mitigation and enhancement measures are provided.

2055. The Legislature further finds and declares that it is the policy of this state that all state agencies, boards, and commissions shall seek to conserve endangered species and threatened species and shall utilize their authority in furtherance of the purposes of this chapter.

2056. The Legislature further finds and declares that the cooperation of the owners of land which is identified as habitat for endangered species and threatened species is essential for the conservation of those species and that it is the policy of this state to foster and encourage that cooperation in furtherance of the purposes of this chapter. Therefore, a landowner of property on which an endangered, threatened, or candidate species lives shall not be liable for civil damages for injury to employees of, or persons under contract with, the department if the injury occurs while those persons are conducting survey, management, or recovery efforts with respect to those species.

2060. The definitions in this article govern the construction of this chapter.

2061. "Conserve," "conserving," and "conservation" mean to use, and the use of, all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary. These methods and procedures include, but are not limited to, all activities associated with scientific resources management, such as research, census, law enforcement, habitat acquisition, restoration and maintenance, propagation, live trapping, and transplantation, and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking.

2062. "Endangered species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease. Any species determined by the commission as "endangered" on or before January 1, 1985, is an "endangered species."

2077. (a) The department shall review species listed as an endangered species or as a threatened species every five years to determine if the conditions that led to the original listing are still present. The review shall be conducted based on information which is consistent with the information specified in Section 2072.3 and which is the best scientific information available to the department. The review shall include a review of the identification of the habitat that may be essential to the continued existence of the species and the department's recommendations for management activities and other recommendations for recovery of the species. The department shall notify any person who has notified the commission, in writing with their address, of their interest, and the department may notify any other person.

(b) Review of species that are listed by both the commission and the United States Department of Interior will be conducted in conjunction with the five-year review process of the United States Department of Interior.

(c) Initial review of those species listed by the commission before January 1, 1982, that are not listed by the federal government shall be undertaken and completed by July 1, 1987. Initial review of those species listed by the commission after January 1, 1982, that are not listed by the federal government shall be undertaken and completed within five years of the date the species was originally listed by the commission.

(d) Notwithstanding any other provision of this section, the commission or the department may review a species at any time based upon a petition or upon other data available to the department and the commission.

(e) The department shall report in writing to the commission the results of its five-year review for each listed species. The commission shall treat any report of the department under this subdivision which contains a recommendation to add a species to, or remove a species from, the list of endangered species or the list of threatened species as a department recommendation submitted pursuant to Section 2072.7.

2079. The department shall, by January 30 of every third year, beginning January 30, 1986, prepare a report summarizing the status of all state listed endangered, threatened, and candidate species, and shall post the report on the commission's Internet Web site. This report shall include, but not be limited to, a listing of those species designated as endangered, threatened, and candidate species, a discussion of the current status of endangered, threatened, or candidate species, and the timeframes for the review of listed species pursuant to this article.

2080. No person shall import into this state, export out of this state, or take, possess, purchase, or sell within this state, any species, or any part or product thereof, that the commission determines to be an endangered species or a threatened species, or attempt any of those acts, except as otherwise provided in this chapter, the Native Plant Protection Act (Chapter 10 (commencing with Section 1900) of this code), or the California Desert Native Plants Act (Division 23 (commencing with Section 80001) of the Food and Agricultural Code).

2080.1. (a) Notwithstanding any other provision of this chapter, or Chapter 10 (commencing with Section 1900) or Chapter 11 (commencing with Section 1925) of Division 2, but subject to subdivision (c), if any person obtains from the Secretary of the Interior or the Secretary of Commerce an incidental take statement pursuant to Section 1536 of Title 16 of the United States Code or an incidental take permit pursuant to Section 1539 of Title 16 of the United States Code that authorizes the taking of an endangered species or a threatened species that is listed pursuant to Section 1533 of Title 16 of the United States Code and that is an endangered species, threatened species, or a candidate species pursuant to this chapter, no further authorization or approval is necessary under this chapter for that person to take that endangered species, threatened species, or candidate species identified in, and in accordance with, the incidental take statement or incidental take permit, if that person does both of the following:

(1) Notifies the director in writing that the person has received an incidental take statement or an incidental take permit issued pursuant to the federal Endangered Species Act of 1973 (16 U.S.C.A. Sec. 1531 et seq.).

(2) Includes in the notice to the director a copy of the incidental take statement or incidental take permit.

(b) Upon receipt of the notice specified in paragraph (1) of subdivision (a), the director shall immediately have published in the General Public Interest section of the California Regulatory Notice Register the receipt of that notice.

(c) Within 30 days after the director has received the notice described in subdivision (a) that an incidental take statement or an incidental take permit has been issued pursuant to the federal Endangered Species Act of 1973, the director shall determine whether the incidental take statement or incidental take permit is consistent with this chapter. If the director determines within that 30-day period, based upon substantial evidence, that the incidental take statement or incidental take permit is not consistent with this chapter, then the taking of that species may only be authorized pursuant to this chapter.

(d) The director shall immediately publish the determination pursuant to subdivision (c) in the General Public Interest section of the California Regulatory Notice Register.

(e) Unless deleted or extended by a later enacted statute that is chaptered before the date this section is repealed, this section shall remain in effect only until, and is repealed on, the effective date of an amendment to Section 1536 or Section 1539 of Title 16 of the United States Code that alters the requirements for issuing an incidental take statement or an incidental take permit, as applicable.

2081. The department may authorize acts that are otherwise prohibited pursuant to Section 2080, as follows:
(a) Through permits or memorandums of understanding, the department may authorize individuals, public agencies, universities, zoological gardens, and scientific or educational institutions, to import, export, take, or possess any endangered species, threatened species, or candidate species for scientific, educational, or management purposes.
(b) The department may authorize, by permit, the take of endangered species, threatened species, and candidate species if all of the following conditions are met:
(1) The take is incidental to an otherwise lawful activity.
(2) The impacts of the authorized take shall be minimized and fully mitigated. The measures required to meet this obligation shall be roughly proportional in extent to the impact of the authorized taking on the species. Where various measures are available to meet this obligation, the measures required shall maintain the applicant's objectives to the greatest extent possible. All required measures shall be capable of successful implementation. For purposes of this section only, impacts of taking include all impacts on the species that result from any act that would cause the proposed taking.
(3) The permit is consistent with any regulations adopted pursuant to Sections 2112 and 2114.
(4) The applicant shall ensure adequate funding to implement the measures required by paragraph (2), and for monitoring compliance with, and effectiveness of, those measures.
(c) No permit may be issued pursuant to subdivision (b) if issuance of the permit would jeopardize the continued existence of the species. The department shall make this determination based on the best scientific and other information that is reasonably available, and shall include consideration of the species' capability to survive and reproduce, and any adverse impacts of the taking on those abilities in light of (1) known population trends; (2) known threats to the species; and (3) reasonably foreseeable impacts on the species from other related projects and activities.
(d) The department shall adopt regulations to aid in the implementation of subdivision (b) and the requirements of Division 13 (commencing with Section 21000) of the Public Resources Code, with respect to authorization of take. The department may seek certification pursuant to Section 21080.5 of the Public Resources Code to implement subdivision (b).

2800. This chapter shall be known, and may be cited, as the Natural Community Conservation Planning Act.

2801. The Legislature finds and declares all of the following:

(a) The continuing population growth in California will result in increasing demands for dwindling natural resources and result in the continuing decline of the state's wildlife.

(b) There is a need for broad-based planning to provide for effective protection and conservation of the state's wildlife heritage while continuing to allow appropriate development and growth.

(c) Natural community conservation planning is an effective tool in protecting California's natural diversity while reducing conflicts between protection of the state's wildlife heritage and reasonable use of natural resources for economic development.

(d) Natural community conservation planning promotes coordination and cooperation among public agencies, landowners, and other private interests, provides a mechanism by which landowners and development proponents can effectively address cumulative impact concerns, promotes conservation of unfragmented habitat areas, promotes multispecies and multihabitat management and conservation, provides one option for identifying and ensuring appropriate mitigation that is roughly proportional to impacts on fish and wildlife, and promotes the conservation of broad-based natural communities and species diversity.

(e) Natural community conservation planning can provide for efficient use and protection of natural and economic resources while promoting greater sensitivity to important elements of the state's critical natural diversity.

(f) Natural community conservation planning is a voluntary and effective planning process that can facilitate early coordination to protect the interests of the state, the federal government, and local public agencies, landowners, and other private parties.

(g) Natural community conservation planning is a mechanism that can provide an early planning framework for proposed development projects within the planning area in order to avoid, minimize, and compensate for project impacts to wildlife.

(h) Natural community conservation planning is consistent with, and will support, the fish and wildlife management activities of the department in its role as the trustee for fish and wildlife within the state.

(i) The purpose of natural community conservation planning is to sustain and restore those species and their habitat identified by the department that are necessary to maintain the continued viability of those biological communities impacted by human changes to the landscape.

(j) Natural community conservation planning is a cooperative process that often involves local, state, and federal agencies and the public, including landowners within the plan area. The process should encourage the active participation and support of landowners and others in the conservation and stewardship of natural resources in the plan area during plan development using appropriate measures, including incentives.

2802. The Legislature further finds and declares that it is the policy of the state to conserve, protect, restore, and enhance natural communities. It is the intent of the Legislature to acquire a fee or less than fee interest in lands consistent with approved natural community conservation plans and to provide assistance with the implementation of those plans.

2805. The definitions in this section govern the construction of this chapter:

(a) "Adaptive management" means to use the results of new information gathered through the monitoring program of the plan and from other sources to adjust management strategies and practices to assist in providing for the conservation of covered species.

(b) "Candidate species" has the same meaning as defined in Section 2068.

(c) "Changed circumstances" are reasonably foreseeable circumstances that could affect a covered species or geographic area covered by the plan.

(d) "Conserve," "conserving," and "conservation" mean to use, and the use of, methods and procedures within the plan area that are necessary to bring any covered species to the point at which the measures provided pursuant to Chapter 1.5 (commencing with Section 2050) are not necessary, and for covered species that are not listed pursuant to Chapter 1.5 (commencing with Section 2050), to maintain or enhance the condition of a species so that listing pursuant to Chapter 1.5 (commencing with Section 2050) will not become necessary.

(e) "Covered species" means those species, both listed pursuant to Chapter 1.5 (commencing with Section 2050) and nonlisted, conserved and managed under an approved natural community conservation plan and that may be authorized for take. Notwithstanding Sections 3511, 4700, 5050, or 5515, fully protected species may be covered species pursuant to this subdivision, and taking of fully protected species may be authorized pursuant to Section 2835 for any fully protected species conserved and managed as a covered species under an approved natural community conservation plan.

(f) "Department assurance" means the department's commitment pursuant to subdivision (f) of Section 2820.

(g) "Monitoring program" means a program within an approved natural community conservation plan that provides periodic evaluations of monitoring results to assess the adequacy of the mitigation and conservation strategies or activities and to provide information to direct the adaptive management program. The monitoring program shall, to the extent practicable, also be used to meet the monitoring requirements of Section 21081.6 of the Public Resources Code. A monitoring program includes all of the following:

(1) Surveys to determine the status of biological resources addressed by the plan, including covered species.

(2) Periodic accountings and assessment of authorized take.

(3) Progress reports on all of the following matters:

(A) Establishment of habitat reserves or other measures that provide equivalent conservation of covered species and providing funding where applicable.

(B) Compliance with the plan and the implementation agreement by the wildlife agencies, local governments, and landowners who have responsibilities under the plan.

(C) Measurements to determine if mitigation and conservation measures are being implemented roughly proportional in time and extent to the impact on habitat or covered species authorized under the plan.

(D) Evaluation of the effectiveness of the plan in meeting the conservation objectives of the plan.

(E) Maps of land use changes in the plan area that may affect habitat values or covered species.

(4) A schedule for conducting monitoring activities.

(h) "Natural community conservation plan" or "plan" means the plan prepared pursuant to a planning agreement entered into in accordance with Section 2810. The plan shall identify and provide for those measures necessary to conserve and manage natural biological diversity within the plan area while allowing compatible and appropriate economic development, growth, and other human uses.

(i) "Person" has the same meaning as defined in Section 711.2.

(j) (1) "Plan participant," prior to approval of a natural community conservation plan and execution of an implementation agreement, means a signatory to the planning agreement.

(2) Upon approval of a natural community conservation plan and execution of an implementation agreement, "plan participant" means the permittees and any local agency that is a signatory to the implementing agreement.

(k) "Unforeseen circumstances" means changes affecting one or more species, habitat, natural community, or the geographic area covered by a conservation plan that could not reasonably have been anticipated at the time of plan development, and that result in a substantial adverse change in the status of one or more covered species.

(l) "Wildlife" has the same meaning as defined in Section 711.2.

(m) "Wildlife agencies" means the department and one or both of

the following:
(1) United States Fish and Wildlife Service.
(2) National Marine Fisheries Service.

2809. Any person, or any local, state, or federal agency, independently, or in cooperation with other persons, may undertake natural community conservation planning.

2810. (a) The department may enter into an agreement with any person or public entity for the purpose of preparing a natural community conservation plan, in cooperation with a local agency that has land use permit authority over the activities proposed to be addressed in the plan, to provide comprehensive management and conservation of multiple wildlife species, including, but not limited to, those species listed pursuant to Article 2 (commencing with Section 2070) of Chapter 1.5. The agreement shall include a provision specifying the amount of compensation, if any, payable to the department pursuant to Section 2829.

(b) The agreement shall meet all of the following conditions:

(1) The agreement shall be binding upon the department, other participating federal, state, and local agencies, and participating private landowners.

(2) The agreement shall define the geographic scope of the conservation planning area.

(3) The agreement shall identify a preliminary list of those natural communities, and the endangered, threatened, candidate, or other species known, or reasonably expected to be found, in those communities, that are intended to be the initial focus of the plan.

(4) The agreement shall identify preliminary conservation objectives for the planning area.

(5) The agreement shall establish a process for the inclusion of independent scientific input to assist the department and plan participants, and to do all of the following:

(A) Recommend scientifically sound conservation strategies for species and natural communities proposed to be covered by the plan.

(B) Recommend a set of reserve design principles that addresses the needs of species, landscapes, ecosystems, and ecological processes in the planning area proposed to be addressed by the plan.

(C) Recommend management principles and conservation goals that can be used in developing a framework for the monitoring and adaptive management component of the plan.

(D) Identify data gaps and uncertainties so that risk factors can be evaluated.

(6) The agreement shall require coordination with federal wildlife agencies with respect to the federal Endangered Species Act (16

U.S.C. Sec. 1531 et seq.).
(7) The agreement shall encourage concurrent planning for wetlands and waters of the United States.
(8) The agreement shall establish an interim process during plan development for project review wherein discretionary projects within the plan area subject to Division 13 (commencing with Section 21000) of the Public Resources Code that potentially conflict with the preliminary conservation objectives in the planning agreement are reviewed by the department prior to, or as soon as possible after the project application is deemed complete pursuant to Section 65943 of the Government Code and the department recommends mitigation measures or project alternatives that would help achieve the preliminary conservation objectives. As part of this process, information developed pursuant to paragraph (5) of subdivision (b) of Section 2810 shall be taken into consideration by the department and plan participants. Any take of candidate, threatened, or endangered species that occurs during this interim period shall be included in the analysis of take to be authorized under an approved plan. Nothing in this paragraph is intended to authorize take of candidate, protected, or endangered species.
(9) The agreement shall establish a process for public participation throughout the plan development and review pursuant to Section 2815.
(c) The approval of the planning agreement is not a project pursuant to Division 13 (commencing with Section 21000) of the Public Resources Code.
(d) Prior to department approval of the planning agreement, the public shall have 21 calendar days to review and comment on the proposed planning agreement.

2815. The department shall establish, in cooperation with the parties to the planning agreement, a process for public participation throughout plan development and review to ensure that interested persons, including landowners, have an adequate opportunity to provide input to lead agencies, state and federal wildlife agencies, and others involved in preparing the plan. The public participation objectives of this section may be achieved through public working groups or advisory committees, established early in the process. This process shall include all of the following:
(a) A requirement that draft documents associated with a natural community conservation plan that are being considered for adoption by the plan lead agency shall be available for public review and comment for at least 60 days prior to the adoption of that draft document. Preliminary public review documents shall be made available by the plan lead agency at least 10 working days prior to any public hearing addressing these documents. The review period specified in

this subdivision may run concurrently with the review period provided for any document required by the California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) that is associated with the natural community conservation plan. This subdivision shall not be construed to limit the discretion of a public agency to revise any draft documents at a public hearing.

(b) A requirement to make available in a reasonable and timely manner all draft plans, memoranda of understanding, maps, conservation guidelines, species coverage lists, and other planning documents associated with a natural community conservation plan that are subject to public review.

(c) A requirement that all public hearings held during plan preparation or review for approval are complementary to, or integrated with, those hearings otherwise provided by law.

(d) An outreach program to provide access to information for persons interested in the plan, including landowners, with an emphasis on obtaining input from a balanced variety of affected public and private interests, including state and local governments, county agricultural commissioners, agricultural organizations, landowners, conservation organizations, and the general public.

2820. (a) The department shall approve a natural community conservation plan for implementation after making the following findings, based upon substantial evidence in the record:

(1) The plan has been developed consistent with the process identified in the planning agreement entered into pursuant to Section 2810.

(2) The plan integrates adaptive management strategies that are periodically evaluated and modified based on the information from the monitoring program and other sources, which will assist in providing for the conservation of covered species and ecosystems within the plan area.

(3) The plan provides for the protection of habitat, natural communities, and species diversity on a landscape or ecosystem level through the creation and long-term management of habitat reserves or other measures that provide equivalent conservation of covered species appropriate for land, aquatic, and marine habitats within the plan area.

(4) The development of reserve systems and conservation measures in the plan area provides, as needed for the conservation of species, all of the following:

(A) Conserving, restoring, and managing representative natural and seminatural landscapes to maintain the ecological integrity of large habitat blocks, ecosystem function, and biological diversity.

(B) Establishing one or more reserves or other measures that provide equivalent conservation of covered species within the plan area and linkages between them and adjacent habitat areas outside of the plan area.

(C) Protecting and maintaining habitat areas that are large enough to support sustainable populations of covered species.

(D) Incorporating a range of environmental gradients (such as slope, elevation, aspect, and coastal or inland characteristics) and high habitat diversity to provide for shifting species distributions due to changed circumstances.

(E) Sustaining the effective movement and interchange of organisms between habitat areas in a manner that maintains the ecological integrity of the habitat areas within the plan area.

(5) The plan identifies activities, and any restrictions on those activities, allowed within reserve areas that are compatible with the conservation of species, habitats, natural communities, and their associated ecological functions.

(6) The plan contains specific conservation measures that meet the biological needs of covered species and that are based upon the best available scientific information regarding the status of covered species and the impacts of permitted activities on those species.

(7) The plan contains a monitoring program.

(8) The plan contains an adaptive management program.

(9) The plan includes the estimated timeframe and process by which the reserves or other conservation measures are to be implemented, including obligations of landowners and plan signatories and consequences of the failure to acquire lands in a timely manner.

(10) The plan contains provisions that ensure adequate funding to carry out the conservation actions identified in the plan.

(b) A natural community conservation plan approved pursuant to this section shall include an implementation agreement that contains all of the following:

(1) Provisions defining species coverage, including any conditions of coverage.

(2) Provisions for establishing the long-term protection of any habitat reserve or other measures that provide equivalent conservation of covered species.

(3) Specific terms and conditions, which, if violated, would result in the suspension or revocation of the permit, in whole or in part. The department shall include a provision requiring notification to the plan participant of a specified period of time to cure any default prior to suspension or revocation of the permit in whole or in part. These terms and conditions shall address, but are not limited to, provisions specifying the actions the department shall take under all of the following circumstances:

(A) If the plan participant fails to provide adequate funding.

(B) If the plan participant fails to maintain the rough proportionality between impacts on habitat or covered species and

conservation measures.
(C) If the plan participant adopts, amends, or approves any plan or project without the concurrence of the wildlife agencies that is inconsistent with the objectives and requirements of the approved plan.
(D) If the level of take exceeds that authorized by the permit.
(4) Provisions specifying procedures for amendment of the plan and the implementation agreement.
(5) Provisions ensuring implementation of the monitoring program and adaptive management program.
(6) Provisions for oversight of plan implementation for purposes of assessing mitigation performance, funding, and habitat protection measures.
(7) Provisions for periodic reporting to the wildlife agencies and the public for purposes of information and evaluation of plan progress.
(8) Mechanisms to ensure adequate funding to carry out the conservation actions identified in the plan.
(9) Provisions to ensure that implementation of mitigation and conservation measures on a plan basis is roughly proportional in time and extent to the impact on habitat or covered species authorized under the plan. These provisions shall identify the conservation measures, including assembly of reserves where appropriate and implementation of monitoring and management activities, that will be maintained or carried out in rough proportion to the impact on habitat or covered species and the measurements that will be used to determine if this is occurring.
(c) If a plan participant does not maintain the proportionality between take and conservation measures specified in the implementation agreement and does not either cure the default within 45 days or enter into an agreement with the department within 45 days to expeditiously cure the default, the department shall suspend or revoke the permit, in whole or in part.
(d) Any data and reports associated with the monitoring program required by this section shall be available for public review. The entity managing the plan shall also conduct public workshops on an annual basis to provide information and evaluate progress toward attaining the conservation objectives of the plan.
(e) To the extent provided pursuant to Division 13 (commencing with Section 21000) of the Public Resources Code and any guidelines adopted pursuant thereto, if the impacts on one or more covered species and its habitat are analyzed and mitigated pursuant to a program environmental impact report for a plan adopted pursuant to this chapter, a plan participant that is a lead agency or a responsible agency under that division shall incorporate in the review of any subsequent project in the plan area the feasible mitigation measures and alternatives related to the biological

impacts on covered species and their habitat developed in the program environmental impact report.

(f) The department may provide assurances for plan participants commensurate with long-term conservation assurances and associated implementation measures pursuant to the approved plan.

(1) When providing assurances pursuant to this subdivision, the department's determination of the level of assurances and the time limits specified in the implementation agreement for assurances may be based on localized conditions and shall consider all of the following:

(A) The level of knowledge of the status of the covered species and natural communities.

(B) The adequacy of analysis of the impact of take on covered species.

(C) The use of the best available science to make assessments about the impacts of take, the reliability of mitigation strategies, and the appropriateness of monitoring techniques.

(D) The appropriateness of the size and duration of the plan with respect to quality and amount of data.

(E) The sufficiency of mechanisms for long-term funding of all components of the plan and contingencies.

(F) The degree of coordination and accessibility of centralized data for analysis and evaluation of the effectiveness of the plan.

(G) The degree to which a thorough range of foreseeable circumstances are considered and provided for under the adaptive management program.

(H) The size and duration of the plan.

(2) If there are unforeseen circumstances, additional land, water, or financial compensation or additional restrictions on the use of land, water, or other natural resources shall not be required without the consent of plan participants for a period of time specified in the implementation agreement, unless the department determines that the plan is not being implemented consistent with the substantive terms of the implementation agreement.

2821. Concurrent with the approval by the department of a final natural community conservation plan, the department shall do both of the following:

(a) Establish a list of species that are authorized for take pursuant to Section 2835 and the department shall make specific findings to support coverage pursuant to Section 2820. For purposes of determining whether a species should receive coverage under a plan, the department shall use, in addition to the standards required for the adoption of a plan, one or more of the following criteria:

(1) Coverage is warranted based upon regional or landscape level consideration, such as healthy population levels, widespread

distribution throughout the plan area, and life history characteristics that respond to habitat-scale conservation and management actions.

(2) Coverage is warranted based on regional or landscape level considerations with site specific conservation and management requirements that are clearly identified in the plan for species that are generally well-distributed, but that have core habitats that must be conserved.

(3) Coverage is warranted based upon site specific considerations and the identification of specific conservation and management conditions for species within a narrowly defined habitat or limited geographic area within the plan area.

(b) Find that the mitigation measures specified in the plan and imposed by the plan participants are consistent with subdivision (d) of Section 2801.

2822. The department may seek injunctive relief against any plan participant, person, or entity to enforce this chapter.

2823. The department shall suspend or revoke any permit, in whole or in part, issued for the take of a species subject to Section 2835 if the continued take of the species would result in jeopardizing the continued existence of the species.

2825. The department may adopt regulations for the development and implementation of natural community conservation plans consistent with this chapter.

2826. Nothing in this chapter exempts a project proposed in a natural community conservation planning area from Division 13 (commencing with Section 21000) of the Public Resources Code or otherwise alters or affects the applicability of that division.

2827. To the extent practicable, implementation of natural community conservation plans shall use the services of either the California Conservation Corps or local community conservation corps.

2828. Nothing in this chapter prohibits a local government from exercising any power or authority granted to it pursuant to state law to acquire land or water to implement a plan.

2829. (a) The department may be compensated for the actual costs incurred in participating in the preparation and implementation of natural community conservation plans. These costs may include consultation with other parties to agreements authorized by Section 2810, providing and compiling wildlife and wildlife habitat data, reviewing and approving the final plan, monitoring implementation of the plan, and other activities necessary to the preparation and implementation of a plan.

(b) The department may be compensated for those expenses identified in subdivision (a) according to a schedule in the agreement authorized by Section 2810.

2830. Nothing in this chapter prohibits the taking or the incidental take of any identified species if the taking is authorized by the department pursuant to any of the following:

(a) A natural community conservation plan or amended plan approved by the department prior to January 1, 2002. Any permits, plans, implementation agreements, and amendments to those permits, plans, or implementation agreements described in this section are deemed to be in full force and effect as of the date approved or entered into by the parties insofar as they authorize the take of identified species pursuant to an approved natural community conservation plan and shall be governed solely by former Chapter 10 (commencing with Section 2800) as it read on December 31, 2001.

(b) Any natural community conservation plan, or subarea plan, approved, or amended on or after January 1, 2002, for which a planning or enrollment agreement meets any of the following criteria, which shall be solely governed in accordance with former Chapter 10 (commencing with Section 2800) as it read on December 31, 2001:

(1) The natural community conservation plan was entered into between the department and plan participants prior to January 1, 2001, and is carried out pursuant to Rule 4(d) for the California Gnatcatcher (Federal Register Volume 58, December 10, 1993), including the southern subregion of Orange County.

(2) The natural community conservation plan was prepared pursuant to the planning agreement for the San Diego Multiple Species Conservation Plan.

(3) The natural community conservation plan was prepared pursuant to the planning agreement for the San Diego Multiple Habitat Conservation Plan.

(c) Any programmatic natural community conservation plan approved by the department on or before January 1, 2002.

(d) Any natural community conservation plan developed pursuant to a planning or enrollment agreement executed on or before January 1, 2001, and for which the department finds that the plan has been developed using a public participation and scientific analysis process substantially in conformance with the intent of paragraph (5) of subdivision (b) of Section 2810 and Section 2815.

(e) Any natural community conservation plan developed pursuant to a planning agreement executed on or before January 1, 2002, and which the department finds is in substantial compliance with Section 2820.

(f) (1) Any natural community conservation plan or subarea plan initiated on or before January 1, 2000, or amendments thereto, by Sweetwater Authority, Helix Water District, Padre Dam Municipal Water District, Santa Fe Irrigation District, or the San Diego County Water Authority, which the department determines is consistent with the approved San Diego Multiple Habitat Conservation Program or the San Diego Multiple Species Conservation Program, is exempt from Section 2810, and paragraph (1) of subdivision (a) of Section 2820, except as provided in paragraph (2), if the department finds that the plan has been developed and is otherwise in conformance with this chapter.

(2) The public water agencies identified in this subdivision and the department shall include independent scientific input as described in subparagraphs (A) to (D), inclusive, of paragraph (5) of subdivision (b) of Section 2810 into the proposed plans in a manner that focuses on the covered species that are proposed for take authorization and that are not otherwise covered in the San Diego Multiple Species Conservation Program or the San Diego Multiple Habitat Conservation Program.

The scientific input required by this paragraph shall be based on the best and most current scientific data generally available, and shall assure that documentation for coverage of all species is equal or greater than the San Diego Multiple Habitat Conservation Program.

2831. (a) Notwithstanding any other provision of law, lands designated as of January 1, 2013, as open-space lands in a document entitled "Declaration of the Dedication of Land" approved by a resolution of the San Diego City Council in the same manner in which the city council processes approval of dedicated open space, reserving to the city council the authority to grant easements for utility purposes in, under, and across dedicated property, if those easements and facilities to be located thereon do not significantly interfere with the park and recreational use of the property, and filed with the Office of the City Clerk for the City of San Diego, and, if required, at the Office of the County of San Diego Assessor/Recorder/County Clerk, are dedicated land under the City Charter of the City of San Diego.

(b) Upon filing of that document in accordance with subdivision (a), the Office of the City Clerk for the City of San Diego, and, if applicable, the Office of the County of San Diego Assessor/Recorder/County Clerk shall make the document available for inspection by the public upon request.

2835. At the time of plan approval, the department may authorize by permit the taking of any covered species, including species designated as fully protected species pursuant to Sections 3511, 4700, 5050, or 5515, whose conservation and management is provided for in a natural community conservation plan approved by the department.

3953. **Deposit of revenue fromm sale of big game tags into Big Game Management Account; Expenditure; Grants; Review of funded project by advisory committee**

(a) The Big Game Management Account is hereby established within the Fish and Game Preservation Fund.

(b) All revenues from the sale of antelope, elk, deer, wild pig, bear, and sheep tags, including any fundraising tags, shall be deposited in the Big Game Management Account to permit separate accountability for the receipt and expenditure of these funds.

(c) Funds deposited in the Big Game Management Account shall be available for expenditure upon appropriation by the Legislature to the department. These funds shall be expended solely for the purposes set forth in this section and Sections 3951 and 3952, and Chapter 5 (commencing with Section 450) of Division 1, Chapter 7 (commencing with Section 4650), and Chapter 11 (commencing with Section 4900), including acquiring land, completing projects, and implementing programs to benefit antelope, elk, deer, wild pigs, bear, and sheep, and expanding public hunting opportunities and related public outreach. Any land acquired with funds from the Big Game Management Account shall be acquired in fee title or protected with a conservation easement and, to the extent possible, be open or provide access to the public for antelope, elk, deer, wild pig, bear, or sheep hunting. The department may also use funds from the Big Game Management Account to pay for administrative and enforcement costs of the programs and activities described in this section. The amount allocated from the account for administrative costs shall be limited to the reasonable costs associated with administration of the programs and activities described in this section.

(d) The department may make grants to, reimburse, or enter into contracts or other agreements as defined in subdivision (a) of Section 1571 with, nonprofit organizations for the use of the funds from the Big Game Management Account to carry out the purposes of this section, including related habitat conservation projects.

(e) An advisory committee, as determined by the department, that includes interested nonprofit organizations that have goals and objectives directly related to the management and conservation of big game species and primarily represent the interests of persons licensed pursuant to Section 3031 shall review and provide comments to the department on all proposed projects funded from the Big Game Management Account to help ensure that the requirements of this section have been met. The department shall post budget information and a brief description on an Internet Web site for all projects funded from the Big Game Management Account.

(f) Big game projects authorized pursuant to this section are not subject to Part 2 (commencing with Section 10100) of Division 2 of the Public Contract Code or Article 6 (commencing with Section 999) of Chapter 6 of Division 4 of the Military and Veterans Code.

(g) The department shall maintain the internal accountability necessary to ensure compliance with the collection, deposit, and expenditure of funds specified in this section.

APPENDIX G

Phases of Wolf Re-Establishment and Options/Actions

This section presents in table form, the CDFW anticipated phases of gray wolf re-establishment and increase in California, and links those anticipated population levels to possible/desirable conservation and management actions.

Before presenting the proposed phasing for this Plan, CDFW believes it is useful to review the experience of wolf population establishment and growth in the other western states. The following table (Table G.1) presents data which illustrate population parameters for each state when 4 and 8 BPs were documented and the population change estimate for four years after each BP threshold is reached.

Table G.1. Selected Wolf Population Data from Western States.

	Montana		Idaho		Wyoming[81]		Oregon		Washington	
	Year	#	Year	#	Year	#	Year	#	Year	#
First two successive yrs. w/≥ 4 BPs	1992	4	1997	6	1996	4	2012	6	2012	5
	1993	4	1998	10	1997	9	2013	4	2013	5
Minimum wolf population on Dec.31	1992	41	1997	71	1996	40	2012	46	2012	51
	1993	55	1998	114	1997	86	2013	64	2013	53
Annual % population growth rate in subsequent four years	1994	-12.7	1999	6.8	1998	30.2	2014	26.6	2014	30.7
	1995	37.5	2000	19.9	1999	-4.5	2015	35.8	2015	32.3
	1996	6.1	2001	34.8	2000	43.0	2016	TBD	2016	TBD
	1997	-20.0	2002	4.8	2001	23.5	2017	TBD	2017	TBD
First two successive yrs with ≥ 8 BPs	2002	17	1998	10	2000	12	2014	8	2015	8
	2003	10	1999	10	2001	13	2015	11	TBD	
Minimum wolf population on December 31 (coinciding with row above)	2002	183	1998	156	2000	153	2014	81	2015	90
	2003	182	1999	187	2001	189	2015	110	TBD	
Annual % population growth rate in subsequent four years	2004	-19.7	2000	19.9	2002	14.8	TBD		TBD	
	2005	68.4	2001	34.2	2003	7.8				
	2006	23.4	2002	4.8	2004	16.2				
	2007	33.5	2003	31.2	2005	-7.4				
2015 # BPs	32		33		30		11		8	
2015 Minimum Wolf Population	536		786		382		110		90	

[81] Data for Yellowstone National Park is included in Wyoming data.

Several inferences can be drawn from these data, including:

1. The wolf population in the second successive year with ≥ 4 or ≥ 8 BPs is larger (except 2003 in Montana) than the first year.
2. The annual wolf population trend once ≥ 4 BPs are documented is, with a few exceptions, positive.
3. For Oregon, Montana, Idaho, and Wyoming, wolf populations increased substantially in the interval between documenting ≥ 4 BPs and ≥ 8 BPs (i.e. 67% - 331%).
4. Wolf populations and BPs are now substantially higher than they were when ≥ 8 BPs were first documented in Montana, Idaho and Wyoming.
5. To date, wolf population growth in Oregon and Washington appears to be following a pattern which is similar to the experience in Montana, Idaho and Wyoming.
6. The wolf population growth experience, in all five other western states with wolf populations, indicates very little risk that wolf populations will decline after reaching 4 BPs.

Phases 1, 2, and 3 of Wolves in California

CDFW has conceptually thought of wolf re-establishment and population growth in three phases with associated potential actions that would be considered during each phase (Table G.2a, G.2b, G.2c, and G.2d). Phases 1 and 2 include measureable population thresholds to prompt subsequent adaptive management actions. Some actions are common to all phases (Table G.2a).

Phase 1 is now underway and intended to manage an initial wolf population consistent with state policy to conserve species listed as endangered under CESA, and also to recognize that any wolves in California are currently federally listed as endangered. Phase 1 is expected to account for the period of reestablishment of wolves as resident wildlife in California, first as individual dispersing wolves and then through formation of the first packs. CDFW proposes that Phase 1 will conclude when there are 4 BPs for two successive years confirmed in California. At a minimum, this means at least 16 wolves. Based on information from Washington and Oregon, the estimated population at the conclusion of Phase 1 would likely be in the range of 90-110 wolves[82] (Table G.1).

Phase 2 will begin after CDFW confirms 4 BPs for two successive years. This phase will likely correspond to the time when the California wolf population's growth is driven more by natural reproduction than by continued net immigration by Oregon wolves. This phase is envisioned as a period of time when wolves range into and inhabit suitable areas of northern California, and

[82] As to monitoring and/or estimating wolf populations to identify progression through all Phases, it is important to note that wolf populations are dynamic and difficult to monitor with precision. Until recently, other state wildlife agencies' and the USFWS' standard practice has been to comprehensively monitor wolf packs, estimate minimum population sizes as of December 31, and acknowledge that the actual population size is probably larger than that estimate. As wolf populations have grown, the monitoring costs increased and federal funding to support these efforts has declined. Consequently, western states are turning to methods for estimating populations, rather than trying to count every wolf.

perhaps portions of the central Sierra Nevada. CDFW anticipates that additional relevant information will continue to become available, physical and biological conditions in California will continue to change, legal frameworks and authorities may change, and CDFW staff will have gained additional experience with wolves. Such events present an opportunity to adapt the Plan to conditions as they then exist. Initially, the Plan envisions that additional latitude to manage impacts of wolves on livestock[83] or wolf predation on sympatric[84] wild ungulate populations may be warranted in Phase 2.

Phase 3 is proposed to begin when CDFW confirms that there have been 8 BPs for two successive years. This will be a suitable time to conduct a status review of the species to evaluate whether state listing as endangered remains warranted. Any status review will then be provided to the Commission for its consideration of the facts and whether they warrant some discretionary action by the Commission. Phase 3 is envisioned as implementation of long-term management strategies. Necessarily, this phase can only be framed in general terms because forecasting the details of this future is impossible using currently available information. For example, if wolves are then abundant they may be delisted. Deferring development of specifics for long-term management until the middle of Phase 2 is likely to be more productive.

In 2013, Oregon documented 4 BPs, 14 years after the first wolf in modern times was detected. CDFW adapted this population metric (i.e. 4 BPs), when documented for two successive years, as the planned endpoint for Phase 1. In both Oregon and Washington, the wolf population grew in small incremental steps from year to year, and first reached 4 BPs when the minimum statewide populations reached about 50 wolves. In the three consecutive years following that population, in both Oregon and Washington, the number of BPs has remained at or above 4, and the wolf populations in both states have continued to grow. Wolves can now be described as a resident species. Based on these observations, and similar data (see Table 1) from Montana, Idaho, and Wyoming, CDFW has selected 4 BPs, for two consecutive years as the criteria for which to move from Phase 1 to Phase 2. Further, the best available information, which CDFW believes is the data collected on wolf recovery in the five western states with gray wolves (see Table G.1), supports the hypothesis that a wolf population with ≥ 4 BPs is biologically sustainable when that population is protected by state or federal take prohibitions or restrictions.

Several considerations contributed to this strategy, including these assumptions:

- This standard will likely not be met within the next 10 years but may be met soon after.
- Once there are at least 4 BPs for two successive years in California, experience from other western states indicates that the population will continue to grow.
- Federal status as endangered will likely be in effect for at least the first years of Phase 1.
- A population with 4 BPs is likely not sufficient to warrant changing the status of wolves from endangered to either threatened or delisted, under CESA.

[83] Livestock is used here to refer to domesticated animals raised and/or kept for their economic value or other use.
[84] Refers to populations or species occurring in the same place at the same time.

- During Phase 1 additional useful information for wolves in California is likely to become available on:
    - Federal listing status
    - Proximity of breeding wolf packs in southern Oregon
    - Habitat selection
    - Geographic distribution
    - Population size and pack status
    - Mortality factors
    - Conflicts with livestock
    - Prey selection
    - Effectiveness of initial management strategies

The SWG did not reach consensus regarding CDFW's proposed criteria (i.e., number of BPs or the number of successive years that the BP criterion must be met) which should be achieved before advancing to the next phase of the Plan. The environmental caucus recommended that more BPs and years would be more appropriate. Agricultural and conservation caucus members of the SWG did not propose alternative criteria, but felt that the BP threshold should be lower for concluding Phases 1 and 2, and that lethal take should be a Phase 1 management option.

If wolves in California are still federally listed as endangered when 2 BPs are documented for two successive years, CDFW will consider petitioning USFWS to downlist wolves to threatened in California. That process will likely require some time to complete and will set the stage for transitioning management to the state.

Initially, and likely throughout Phase 1, wolf population growth in California will be augmented by net immigration of wolves from Oregon. To plan for necessary changes in management strategies, and to make appropriate adjustments based on knowledge gained as wolves become established, CDFW intends to commence additional planning for Phase 2 when 2 BPs have been confirmed for two successive years. This work will include a review of scientific information which may not have been available previously, and data on wolf establishment in California to determine if it is then possible to estimate potential future distribution of wolves and more accurately predict suitability of California habitats.

Although other western states' wolf plans proposed demographic criteria to trigger the commencement of delisting from state or federal endangered species laws, CDFW is not proposing delisting criteria at this time. Existing information is not yet sufficient to articulate what a "conserved", condition for gray wolves means in California. Sufficient information to support development of delisting criteria may be available near the end of Phase 2, or in Phase 3. At that time, relevant data on the pace of wolf establishment, population growth, distribution, and mortality will be available and useful for determining whether the provisions of CESA remain necessary, or to project the conditions under which they will remain necessary in the future. It is possible that CESA's protections may be necessary for quite a long time to maintain what may be a small future population of wolves in California.

Table G.2a. Summary of planned or potential conservation options/actions that are common to all three time phases of wolf re-establishment in California and were evaluated by the SWG. Each of the options/actions described are contingent upon having the funding, personnel, and legal authority to carry them out effectively.

Planned/Potential Options/Actions	Description of Options/Actions Common to all 3 Phases of Plan
Collection of data on ungulates in northern California in advance of wolf occupation	Data collection to be expanded and modified in northern California with an emphasis on elk and deer herds adjacent to Oregon.
Payments to livestock producers[85] for wolf presence	Implemented in priority counties with sympatric distributions of wolves and livestock. List of priority counties to be updated as needed, but at least annually by CDFW. Applications by livestock producers will be scored based on a formula that accounts for wolf presence, number of livestock exposed to wolves and implementation of non-lethal deterrents by the livestock producer. Annual payments for wolf presence will be reduced by any amounts paid in compensation for confirmed depredation by wolves on livestock.
Non-lethal livestock depredation assistance by CDFW	Establish County Wolf Advisory Groups in Modoc, Siskiyou and Lassen counties initially. Expand to additional counties as resident wolves become established. Provide technical information (e.g. telephone and email assistance, web access to information, local public meetings). On-site evaluations and recommendations if requested by livestock producers. Develop maps of current wolf territories and make them available to the public. Focused disclosure when GPS collared wolves are detected within a geographic area developed for a specific livestock producer. An information sharing agreement between CDFW and the producer must be in place for this to occur. A commitment to not disclose provided information will be required. Short-term loan of equipment (e.g. fladry, RAG box, noisemakers). Individual agreements will set terms of the loan. Technical assistance, funding and approval for Depredation Prevention Agreements (DPA)[11].
Non-lethal depredation reduction practices	Must be implemented before lethal management options are taken. Implementation is necessary to prevent, reduce or eliminate conflicts. Options include but are not limited to: Reducing attractants Human presence Barriers - fladry and fencing Protection dogs and guard animals Alarm and scare devices Livestock management and husbandry techniques Experimental practices

[85] As used in this chapter, the term "livestock producer" refers to all owners and managers of livestock and includes those engaged in commercial and non-commercial livestock production.

Planned/Potential Options/Actions	Description of Options/Actions Common to all 3 Phases of Plan
Depredation Prevention Agreement (DPA) with livestock producers	Implemented in priority counties with overlapping distributions of wolves and livestock. List of priority counties to be updated as needed, but at least annually by CDFW. CDFW may withhold 10% of available funding, on an annual basis, from regular allocation, as an emergency response fund. Cost share (i.e. 50%) funding up to $10,000 annually by state for CDFW approved plans[86]. Plans will initially be valid for a 12-month period beginning at time of approval and may be renewed or amended. CDFW may cap the funds to be allocated by county. On-site evaluation by CDFW will be required. Livestock producer must report on implementation and effectiveness of the actions. An evaluation by CDFW is required prior to amending or renewing a DPA.
State managed livestock depredation compensation program	Livestock producer must notify CDFW within 24 hours, or as soon as possible, of discovery of dead or injured livestock. Protect the carcass(es) and site and provide access to CDFW or its agent to investigate. Any investigator must have been trained and approved by CDFW prior to responding. Any investigation will follow established protocols and provide substantive documentation to support any determination. File a claim within six months of CDFW determination of confirmed or probable wolf depredation. 100% of fair market value for confirmed depredation[87]. 50% for probable depredation. After two confirmed depredation incidents in any 12-month period, future compensation for the affected producer is available only if that producer has applied for a DPA with CDFW and the application is still active or has been approved.
Actions/options outside of CDFW regulatory authority in cooperation with other agencies may be pursued by CDFW to enhance ungulate populations.	Forage and water enhancements, restoring/enhancing upland, meadow, aspen, and riparian habitats, management of forest openings and other early successional habitats, controlling noxious weeds, livestock grazing modification, controlling competition for forage and water with wild (feral) horses and burros, limiting OHV use, managing hunter harvest, and other strategies. Conserve important lands as wildlife habitat through easements, acquisitions, and other appropriate methods. Work with CalTrans and other agencies to reduce other mortality factors such as road kill, fence entanglement, illegal harvest, etc. Petition to list an ungulate species as threatened or endangered. Work through the legislative process to seek a remedy to the impact of wolves on game species of ungulates.

[86] Funding priority will be established by relative scoring of all plans received during the designated application period which exceed a previously established minimum acceptable score.
[87] Process claims in the chronological order received and pay claims on a July 1-June 30 fiscal year basis until annual funds are exhausted.

Planned/Potential Options/Actions	Description of Options/Actions Common to all 3 Phases of Plan
Actions within the authority of the CDFW or Commission (as recommended by CDFW) may be implemented to reduce non-wolf mortality to ungulates or enhance ungulate populations.	Reduce hunter harvest if population and harvest data indicate tag reductions are warranted. Translocate elk within California to enhance elk populations (where potential conflicts with private landowners are minimal). Encourage landowner agreements (such as Private Lands Management[88] (PLM) or SHARE[89] hunting opportunity). List Rocky Mt., Roosevelt, or Tule elk as threatened or endangered within a significant portion of their range. Increase law enforcement presence in select areas to reduce poaching concerns on deer and elk. Consider and encourage increased take of other predators such as bears and coyotes if they have been demonstrated as having an effect on ungulate populations.
Non-injurious harassment methods	Allowed when wolves are within 100 yards of occupied dwelling, agricultural structure (e.g. barns, shops, storage sheds, lambing sheds, corrals, pens, other livestock confinement facilities, cages), commercial facility including waste management sites, campsites or within 0.25 mile of livestock. Harassment is not allowed within 0.25 mile of known den or rendezvous sites. CDFW will advise affected livestock producers of these locations.
Lethal control for human safety	Federal and state law authorize a person to act in self-defense or defense of others if there is an actual and reasonable belief in the need to defend, the belief is objectively reasonable, and the fear is of imminent danger to life or great bodily injury. After federal delisting, if state law allows, CDFW may carry out removal of, or authorize its agents to remove, wolves for public safety purposes..[90]

[88] The PLM program offers landowners incentives to manage their lands for the benefit of wildlife.

[89] SHARE (Shared Habitat Alliance for Recreational Enhancement) is designed to improve public access to private or landlocked public land. Participating landowners will be compensated with monetary payment and liability protection for providing access to or through their land for recreational use and enjoyment of wildlife. SHARE is funded with SHARE Access Permit Application fees.

[90] Lethal take is anticipated to be an extremely rare occurrence and will be implemented when a wolf demonstrates aggressive action that has resulted in physical contact with a human; or a wolf exhibits an immediate threat to public health and safety, given the totality of the circumstances. Immediate threat refers to a wolf that exhibits one or more aggressive behaviors directed toward a person that is not reasonably believed to be due to the presence of responders. Public safety includes situations where a wolf remains a threat despite efforts to allow or encourage it through active means to leave the area.

Table G.2b. Summary of planned or potential conservation options/actions for consideration during Phase 1 of wolf re-establishment in California and were evaluated by the SWG. Each of the options/actions described are contingent upon having the funding, personnel, and legal authority to carry them out effectively.

Planned/Potential Options/Actions	Description of Options/Actions During Phase 1 of Plan (0-4 BPs[91])
Commence development of next phase when:	2 breeding pairs (BPs) for two consecutive years. Consider petition USFWS to downlist wolves under the ESA, in California, to threatened.
Conclude phase when:	4 BPs anywhere in California for two successive years[92].
Conservation Planning	Review scientific information on wolf habitat use in western states and data on wolves as they establish in California to model probable distribution and abundance of wolves over time in California.
Injurious harassment[93]	1. Not allowed while federally listed. 2. Not proposed in Phase 1.
Operational framework for lethal control. Allowed when authorized by CDFW in Phases 2 and 3, if legal to do so, and carried out by CDFW or its agent.	1. Not allowed while federally listed. 2. Not currently allowed under state law.
Lethal control of wolves depredating livestock	1. Not allowed while federally listed. 2. Not proposed in Phase 1.
Lethal control of specific wolves or wolf packs confirmed by CDFW to be significantly reducing or likely to extirpate elk or deer populations in a geographic unit or area (such as a herd unit).	1. Not allowed while federally listed. 2. Not proposed in Phase 1.

91 A BP is a pack which includes ≥ 1 adult male, ≥ 1 adult female and ≥ 2 pups on December 31.

92 4 BPs explicitly means at least 16 living wolves at the end of a calendar year. See Table 1 for data on minimum wolf populations in other western states associated with 4 BPs. In Oregon and Washington the data indicates that 4 BPs are correlated with a range of 45-65 wolves at years end. These numbers are not intended to imply meaning for CESA listing status or the current or future carrying capacity of habitat in California for wolves.

93 Defined as any harassment that causes any object to physically contact a wolf, including firearms discharging non-lethal ammunition (e.g. rubber bullets or bean bags) or using motorized equipment (e.g. an all-terrain vehicle, motorcycle, or four wheel drive vehicle) to follow or pursue a wolf.

Table G.2c. Summary of planned or potential conservation options/actions for consideration during Phase 2 of wolf re-establishment in California and were evaluated by the SWG. Each of the actions described are contingent upon having the funding, personnel, and legal authority to carry them out effectively.

Planned/Potential Options/Actions	Description of Options/Actions During Phase 2 of Plan (5-8 BPs)
Commence development of next phase when:	6 BPs for two consecutive years.
Conclude phase when:	8 BPs anywhere in California, for two successive years.
Conservation Planning	Conduct status review to examine California wolf populations, prospects for the future of wolves in California, evaluate appropriate CESA status and report to the Commission.
Injurious harassment[94]	Allowed when authorized by CDFW, consistent with State law.
Operational framework for lethal control. Allowed when authorized by CDFW in Phases 2 and 3, if legal to do so, and carried out by CDFW or its agent.	1. Not allowed while federally listed 2. Not allowed if fewer than 4 BPs are documented in any year. 3. If allowed under state law, managed consistent with the following criteria: a) Allowed if the most recent annual statewide wolf population estimate increased by at least 5% compared to the preceding calendar year. b) Allowed to the extent that total human caused mortality[95] in any year does not exceed 10% of the estimate of the statewide wolf population at the end of the preceding calendar year. c) Any lethal take shall be designed by CDFW to accomplish the specific intended purpose while avoiding or minimizing the potential population effects on wolves in California. d) Subject to additional requirements of the wolf-livestock conflict management strategy. e) Subject to additional requirements of the wolf-ungulate conflict management strategy.
Lethal control of wolves depredating livestock	1. If allowed under future state and federal law, when carried out by CDFW or its agent, consistent with the following criteria:There have been at least four separate incidents of livestock depredation (i.e. death or injury) confirmed by CDFW in a six month period by the same wolf or pack. 2. Non-lethal deterrent methods recommended by CDFW to the producer after the first depredation incident are being implemented or the producer is working toward prompt implementation. 3. Restricted to wolves in packs confirmed by CDFW to have depredated livestock.

[94] Defined as any harassment that causes any object to physically contact a wolf, including firearms discharging non-lethal ammunition (e.g. rubber bullets or bean bags) or using motorized equipment (e.g. an all-terrain vehicle, motorcycle, or four wheel drive vehicle) to follow or pursue a wolf.
[95] Human caused mortality includes public safety take, poaching, vehicle accidents, accidental death from trapping or hunting and any authorized lethal take for management.

Planned/Potential Options/Actions	Description of Options/Actions During Phase 2 of Plan (5-8 BPs)
Lethal control of specific wolves or wolf packs confirmed by CDFW to be significantly reducing or likely to extirpate elk or deer populations in a geographic unit or area (such as a herd unit).	Potentially Allowable (if federally permissible) when carried out by CDFW or its agent, consistent with the following criteria: 1. Reduction in survival of adult females below 90% and 80% for elk and deer, respectively, or 2. 25% or more population reduction in deer or elk herds in a five year monitoring period, or 3. Elk calf:cow ratios fall below 20 calves:100 cows or deer fawn:doe ratios fall below 30 fawns:100 does over a three year period, or 4. Allocated big game tags have been reduced in areas occupied by wolves.

Table G.2d. Summary of planned or potential conservation options/actions for consideration during Phase 3 of wolf re-establishment in California and were evaluated by the SWG. Each of the actions described are contingent upon having the funding, personnel, and legal authority to carry them out effectively.

Planned/Potential Options/Actions	Description of Options/Actions During Phase 3 of Plan (≥9 BPs)
Commence development of next phase when:	When warranted based on experience implementing the Plan or changes to controlling law.
Conclude phase when:	Indeterminate, based on status review initiated in Phase 2.
Conservation Planning	Same as Phase 2
Injurious harassment[96]	Same as Phase 2
Operational framework for lethal control. Allowed when authorized by CDFW in Phases 2 and 3, if legal to do so, and carried out by CDFW or its agent.	1. Not allowed while federally listed. 2. If allowed under state law, managed consistent with the following criteria: a) Allowed if the most recent annual statewide wolf population estimate decreased by no more than 5% compared to the preceding calendar year. b) Allowed to the extent that total human caused mortality in any year does not exceed 15% of the estimate of the statewide wolf population at the end of the preceding calendar year. c) Any lethal take shall be designed by CDFW to accomplish the specific intended purpose while avoiding or minimizing the potential population effects on wolves in California. d) Subject to additional requirements of the wolf-livestock conflict management strategy. e) Subject to additional requirements of the wolf-ungulate conflict management strategy.
Lethal control of wolves depredating livestock	To be determined in the Phase 3 development process based on wolf population and legal status, best available scientific information and experience gained during Phases 1 and 2.
Lethal control of specific wolves or wolf packs confirmed by CDFW to be significantly reducing or likely to extirpate elk or deer populations in a geographic unit or area (such as a herd unit).	To be determined in the Phase 3 development process based on wolf population, legal status, and best available scientific information and experience gained during Phases 1 and 2.

Additionally, two important topics that CDFW and others would employ during one or more of the phases, that deserve more explanation, are conservation planning and aversive conditioning and lethal take:

[96] Defined as any harassment that causes any object to physically contact a wolf, including firearms discharging non-lethal ammunition (e.g. rubber bullets or bean bags) or using motorized equipment (e.g. an all-terrain vehicle, motorcycle, or four wheel drive vehicle) to follow or pursue a wolf.

Conservation Planning

In most cases, conservation measures for newly listed endangered species have relatively little effect on members of the public. That effect, if any, usually arises from requiring persons to avoid any take of endangered species, or implementing the conditions of an incidental take permit. Other California endangered carnivore species, mostly because their populations are quite small, have little effect on prey species and rarely cause property damage.

As apex predators and obligate carnivores, wolves present a much different set of challenges. In the early stages of recovery in California, wolves will likely have an insignificant effect on populations of prey species and cause property damage (i.e. livestock depredation) in only a few limited locations. This period corresponds with Phase 1 of this Plan. As numbers increase, so will both types of effects. Although CESA, in FGC section 2061, states that the practice of conserving a listed species may include regulated taking in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, existing statutes do not provide clear authority for CDFW to take (i.e., kill) wolves to manage impacts on prey populations or private property (i.e. livestock). Phase 1 provides an opportunity to develop data regarding California-specific experience, which data will be used to train staff, establish any needs for additional resources, enact any needed legal reforms and improve the Plan for long term implementation.

Aversive Conditioning and Lethal Take

In this Plan, “aversive conditioning” refers to the application of noxious stimuli in response to undesirable or unwanted behavior with the intention of modifying or terminating future similar behaviors.

Aversive conditioning includes actions characterized as both non-injurious and injurious harassment. This is a term of convenience in the sense that it is reasonably descriptive of the intended actions but does not necessarily imply an action prohibited either by the ESA or CESA.

The types of non-injurious harassment in the Plan are examples of stimuli intended to provide an unpleasant experience for wolves in proximity to humans or livestock. Repeated exposure may cause wolves to associate such stimuli with humans or livestock and possibly reduce subsequent conflicts. These actions have some probability of causing physical injury from which the animal would be expected to recover. Usually, a form of injurious harassment would be used where non-lethal deterrence and non-injurious harassment have been attempted, but have not successfully alleviated the behaviors and consequences of wolf depredation on livestock or the animal displaying certain behaviors that present a risk to human safety.

For purposes of this Plan, lethal take means to kill wolves when non-lethal methods, including aversive conditioning have not been effective in modifying or terminating certain behaviors which lead to, for example, chronic depredation on livestock, or a human safety risk. Lethal take is included in the Plan as a method for mitigating risks to wild ungulate populations, where substantiated. However, aversive conditioning is not a necessary precursor for this measure to be applied because predation on wild ungulates is a natural behavior for wolves.

In this Plan, CDFW proposes that take not be used as a management method during Phase 1.

Phase 2 will begin after CDFW confirms that there have been at least 4 BPs for at least two successive years. If allowed at that time in law, the Plan includes the possibility of lethal take for specific purposes, within specified parameters, when the impacts of wolves cannot be relieved by other non-lethal means. For example, the Plan specifies the following criteria for lethal take: chronic depredation of livestock is occurring, feasible non-lethal deterrent methods have been employed, CDFW has confirmed the depredations, there are at least four confirmed depredation incidents within a six-month period by the same wolves, the population continues to grow, and lethal take will not exceed established thresholds for all human-caused wolf mortalities in a given year.. If those criteria are met, lethal take will only be used against those depredating wolves, and not indiscriminately. Thus, Phase 2 provides for the possibility of lethal take only when other methods have not been effective, and within sideboards that provide for conservation of the species so that progress is still made for conserving and eventual delisting of the species.

Phase 3 will begin after CDFW has confirmed at least 8 BPs for two consecutive years. This criterion theoretically can be met with 32 wolves but may actually represent three to five times that many animals. CDFW anticipates that once the wolf population reaches the parameters specified in Phase 3, reproduction by California wolf packs will increase the rate of population growth, and the relative contribution of dispersing wolves from Oregon will become less of a factor. Because a larger population should be sufficiently resilient, more lethal take (than would have been allowed in Phase 2) may be allowed in Phase 3. The Plan, however, still establishes limitations on the extent of take, consistent with the intent of FGC section 2061, to ensure that the population would be sustained over time.

APPENDIX H

Summary of Public Comments

The public comment period for the Draft California Gray Wolf Conservation Plan (Plan) was held from December 2, 2015 through February 15, 2016. In addition, CDFW held three public meetings focused on review of the draft Plan. These meetings were held on January 21st in Yreka; on January 26th in Long Beach; and on February 1st in Sacramento.

The objectives of the public meetings were to:

- Provide an overview of the history of wolves in California, including their current status
- Explain the purpose, need, and background of the Plan
- Discuss the avenues available for the public to provide input on the plan and how comments will be used
- Receive public comments for consideration in the final Plan

CDFW received a total of 36,541 comments via the following avenues:

- A web portal established to record public comments (956 comments)
- A CDFW email address (20,344 comments)
- Direct contact with CDFW consultants (15,086 comments)
- Written comments sent to CDFW P.O. Box (43 comments)
- Orally at one of the three public meetings (112 comments)

Comments received during the public meetings are summarized below in Table H1, and those received via the other sources listed above are summarized in Table H2. Comments in both tables are organized by topic. A large number of comments expressed general support for, or general opposition to wolf reestablishment in California. A second large focus of comments pertained to modifying, either by increasing or decreasing, the number of wolf breeding pairs that will trigger CDFW to begin the subsequent management phase.

Several common misconceptions were evident in many of the comments (and were clarified in the Final Plan. These included:

- The phased approach outlined in Part I and Appendix G represents a plan to delist wolves when the population reaches 9 breeding pairs (or 50-75 animals)
- The Plan represents CDFW's reintroduction or release of wolves into California
- The estimated breeding pairs and/or wolf population estimates presented in the Plan represent goals or targets CDFW is aiming for
- The Plan represents formal regulatory action by either CDFW or California Fish and Game Commission

Table H1. Summary of Comments Received at Public Meetings	
Topic/Plan Section(s)	**Comments**
General Comments	I am supportive of wolf reestablishment
	I am concerned about wolf reestablishment because of their impacts to livestock and/or wild game populations, and/or human safety
	There should be no ceiling on wolf numbers
	It is important to gather additional data on wolves, implement tools for reducing conflict, communicate with local ranchers in a timely manner, and/or conduct outreach and education
Wolf breeding pair numbers and management phases	Breeding pair numbers proposed to trigger the next management phase are too high • California's ungulate populations cannot support these numbers • There is no scientific basis for these numbers
	Breeding pair numbers proposed to trigger the next management phase are too low • These numbers do not represent an established population • Phase transitions should be established at a future date when more data has been collected • I worry that CDFW will delist wolves when their numbers are too low • I worry that CDFW will shoot wolves for predator management • Management phases should be extended to allow better understanding of population changes over time
Wolf listing status	Plan should be a recovery plan
	Plan should not discuss delisting of wolves
	Plan should spell out a path with details for achieving delisting • If delisted under federal ESA, their rationale should be presented to California Fish and Game Commission
	Wolves should not be a listed species • They are not at risk • Listing poses limits on the ranching community to manage risks and depredations
	Wolves should be delisted when the targets in the plan are reached
Research and management	Plan should not allow a path for lethal management
	Plan should provide a means for livestock producers to use lethal means to protect their herds and/or themselves
	I support Plan's emphasis on non-lethal methods of depredation control
	Plan should have more emphasis on non-lethal methods and/or should give more specific strategies
	Wolves should be collared and tracked by CDFW
	Wolves should not be collared or tracked
	Wolf location information should be shared with ranchers
	No culling of other predators to take pressure off ungulate herds
Research and management	Identifying prey and wolf habitat including movement corridors should be top priority

Table H1. Summary of Comments Received at Public Meetings	
Topic/Plan Section(s)	**Comments**
(continued)	Hunting is an important management tool
	Improved forest management should be emphasized
	Information on wolf impacts to other predators is needed
Wolf diseases	Plan should better detail the potential for disease spread by wolves
	Diseases from wolves have minimal impacts on humans and livestock
	Diseases chapter should mention that wolves can reduce disease spread in ungulates
Wolf-Livestock conflict	Success of wolves will depend on reducing conflicts and promoting coexistence with producers
	Vigilance in removing livestock carcasses will be important
	Number of confirmed depredations within 6 months should be lowered to 2 or 3
	I am concerned that livestock harassment has to be 100% proven
	Clearly articulate the depredation investigation protocol
	It will be difficult to keep wolves away from livestock with nonlethal tools
	I am concerned about livestock harassment and depredations by wolves
Wolves and ungulates	Predation can help ungulate populations through culling of old and sick individuals
	Ungulates are not the only prey for wolves; other prey includes rodents
	I am concerned about the ungulate and wolf biomass relationships described in the plan
	Plan states mule deer is wolves' preferred prey but it should say elk
	I am concerned about lack of baseline data on ungulate populations
Education and outreach	CDFW should emphasize funding for education and outreach in hunting and livestock communities and public most likely to be affected by wolves
	Outreach section should include compliance with USFWS and ESA rules and state regulations
	Cal-Tip or some other wildlife reporting system should be developed/expanded
Budget and funding	Additional funding not related to hunting is needed • Crowd-funding • Tax check-off • School/student fundraising • USFWS grants
	Plan should be more specific about funding including for non-lethal management

Table H1. Summary of Comments Received at Public Meetings

Topic/Plan Section(s)	Comments
Other economic considerations	Consider how to account for loss of hunting revenues as ungulate herd sizes decrease due to wolf predation
	Plan should account for economic losses to producers due to livestock stress, decreased access to rangeland, and other costs
	Consider economic benefits to producers and communities • Ecotourism • Promotion of predator friendly livestock production
	Important to establish a depredation compensation fund
	Concern about economic impacts on local communities
Plan implementation	CDFW should convene a statewide advisory group • County District Attorneys should be included
	What are the priority counties for receiving funds?
	How will enforcement support the plan? • Rules for “take” should be clarified
Public safety	Concern for public health and safety • Safety of pets • Wolf movement into unexpected regions of state
Wolf Ecology	Plan should consider trophic cascades and information on the impacts of wolves on habitat in Montana, Idaho, and Wisconsin

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal

Topic/Plan Section(s)	Comments
General Comments	Thank you for the opportunity to comment on the plan
	I am opposed to conserving wolves in California • They will have a negative effect on wildlife and livestock • They will have a negative effect on livestock producers • They will have a negative effect on hunting opportunity and therefore funding for wildlife management • Californians already have to hunt out of state for deer and elk; opportunity is too low in California • Other states have developed programs to control predators to help support ungulate populations • California’s existing predators are already having a negative effect on our ungulates o Too many lions and bears already • People and domesticated animals are more important than wolves
	I am in favor of conserving wolves in California • Wolves are part of needed restoration of natural habitat • Predators keep prey populations in control • Wolves help keep prey populations healthy by culling the sick and old • Wolves deserve a chance to exist in California

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
General Comments (continued)	The wolves entering California are not native • Wolves should be killed upon entering the state • CDFW doesn't have the money or manpower to regulate a new non-native species • There is no justification for listing wolves since there is no evidence of their having occurred here
	Do not introduce, reintroduce, or release wolves into California • This is a violation of Common Law
	I am in favor of restoring wolves in California
	CDFW is legally obligated to manage wildlife to benefit all citizens
	I applaud CDFW for their efforts
	Great job! • We appreciate the efforts made by CDFW
	The Shasta Nation will not recognize the plan
	Please create a volunteer group with balanced representation to review the plan
	Wolf recovery is a conservation opportunity
	Please clarify the language that allows killing wolves for scientific study • This could be abused
	Reintroducing wolves could lead to wolf hunting opportunity in the future
	Science must incorporate public values
	Do not put restrictions on private landowners to harvest timber in wolf territory
	Policy must apply precautionary approaches
	Plan has strong goals but could be more specific in how CDFW will achieve those goals
	Protect wolves from being killed at all cost • Any problem wolves should be relocated instead of killed
	Reintroduce wolves into National Parks
	Reduce the number of wolves taken by hunting
	Plan should include an outline for how CDFW will use adaptive management in future plan updates
	I object to a plan that includes sport hunting of wolves
	I am glad the plan does not include sport hunting of wolves
	State Wildlife Action Plan identifies gray wolf as a conservation target
	The occurrence of wolves within the cultures of California's Native people is not anecdotal
	Wildlife don't need managing they need protections • We should not interfere with wildlife populations as they are self-regulating when left alone
	Wolves should be managed on a regional (multi-state) scale • Would reduce CDFW's conservation requirements • California will be a sink for wolves from other states so a metapopulation approach is needed
	The proposed wolf range should be expanded to the central and southern Sierra
	I take issue with the system for submitting comments
	Remove "seek to conserve" from goal #1 as it is not measurable

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
General Comments (continued)	Clarify how the strategies relate to the goals • Specific actions should be provided in the strategies, such as how CDFW will protect wolves from illegal killing • It is not clear that the strategies are sufficient to achieve all goals
	Clearly articulate that the plan is not a reintroduction plan
	CDFW should follow the CEQA process for this plan
	Wildlife should have priority over domestic animals on public land
	Consider a wildlife crossing over I-5 in Siskiyou County so wolves can disperse into the Klamath Mountains
Wolf breeding pair numbers and management phases	Breeding pair numbers proposed to trigger the next management phase are too low. • Removal of protections too early can threaten wolf reestablishment • The numbers are not scientifically based • They don't allow enough time to conduct the science needed to inform us about wolf establishment patterns, coexistence strategies, and large mammal habitat requirements • CDFW's analysis of suitable habitat indicates California can support 371-497 wolves • Loss of breeding age wolves (especially females) by illegal killing should factor into the phases • Diseases could wipe out such a low number • Consider a zoned approach – require some breeding pairs in Klamath region • Begin Phase II with 25 pairs, Phase III with 100 pairs
	Much of the wolf genome in southern Cascades is from same pack in Oregon and inbreeding is of concern • Unrelated animals should be introduced naturally or through human intervention
	We need at least 100 wolves to achieve sustainability
	No action on deer tag quotas until final phase is reached
	Breeding pair numbers proposed to trigger the next management phase are too high • The numbers should be drastically lower and vigorously monitored • There is not enough prey to support this many wolves o Delisting will never be achieved
	I support the plan's lack of a cap on wolf population and lack of limits to where wolves can establish territories
	Place a cap on the wolf population to avoid impacting ungulates
	Plan's goal should be to monitor wolf population growth for 5 years rather than establish specific breeding pair/population goals now

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
Wolf breeding pair numbers and management phases (continued)	The proposed wolf population is too low • Should be at least 200-300 animals • Should be well above minimum viable population • CDFW cannot rely on sufficient genetic flow from northern populations where heavy lethal management is used • Should be well above re-listing levels
	I question the target wolf population level of nine pairs • What data interpretation supports this number? • Nine breeding pairs represents over 100 wolves • This many wolves would negatively affect deer and elk
	Breeding pair requirements should be for 3 years
Wolf listing status	Do not remove federal or state protections for wolves at 50-75 animals • Creates conflict between federal and state law • Maintain protections until wolves are fully recovered • Provide scientifically defensible numbers
	Plan updates should occur based on changes to federal legal status • Management authority will revert to state when federally delisted • A California population is not required for federal recovery of the species ○ USFWS considers the species recovered now • More scientific information will be available for status review and plan update when federally delisted
	It is doubtful that the wolf population will expand in California • California will be probably be a sink population • Lack of evidence for a historical population likely means they weren't here in large numbers
	Explain why wolves are being delisted in Oregon and other states
	Remove all language about delisting – creates expectations • Wait for the plan's redraft
	Provide the strongest possible protections for wolves
	Include guidelines for delisting under CESA
	Wolves should not be listed as endangered • CDFW should be able to manage wolves to protect livestock producers' investments
	Killing a wolf in self-defense should not be illegal
	The large population of wolves in Canada and Alaska proves that wolves are not endangered
	Establish fully protected status for wolves like that for mountain lions
	Do not provide fully protected status for wolves • This disempowers CDFW to manage the species as necessary
	Improve the definition of "take" to distinguish lethal from non-lethal take • Allow for hazing to protect self and livestock
Wolves and other wildlife species	CDFW has not considered the impacts of wolves to sage grouse
	Close coyote shooting/hunting/trapping to protect wolves • Plan does not adequately address this concern

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
Research and management	Do not consider killing other predators to take pressure off ungulate populations
	Consider an ecosystem approach to managing wolves • Required per AB2402
	Do not seek authority to kill wolves as a management tool to conserve elk and deer • Damages pack social structure • Consider birth control to manage wolf populations
	More wolf research needed • Evaluate threats to wolves including poaching and disease • Evaluate wolf population trends, home range, distribution
	Once prey-based carrying capacity for wolves is reached the population should be controlled
	More research on ungulates needed to assess population trends
	Agree with collaborating with universities
	Minnesota DNR has the longest state history of managing wolves and is therefore a valuable resource for CDFW
	Wolves should be fitted with collars and their locations closely monitored • Specifics needed on CDFW collaborating with USFWS or USDA/APHIS on best practices • As many animals as possible; at least one animal per pack o Establish and implement protocols for sharing information with producers
	Illegal take of wolves has been detrimental in the Pacific Northwest • Plan should clearly address how CDFW will protect wolves
	Wolf numbers should be estimated through counts not modeling
	Plan lacks legal management options for addressing wolf-caused ungulate declines
	Drones may help to monitor wolves
Human perceptions of wolves	Where protections for wolves are lifted, human tolerance declines • Human tolerance is the key threat to wolf population viability • Plan should cite additional sources
	Fear of wolf attacks on humans is not based on facts • More hunting-related injury and death than wolf-related
	Wolves decimated elk in the Northern Rockies
	Wolves carry and spread diseases
	Wolves kill for the fun of it
	Plan should cite results of surveys conducted post-wolf restoration
	Establish protocols for citing and prosecuting violators • Zero tolerance for “mistaken identity” (i.e. mistaking a wolf for a coyote)
Wolf diseases	There are wolf diseases that are not mentioned in the plan

<table>
<tr><th colspan="2">Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal</th></tr>
<tr><th>Topic/Plan Section(s)</th><th>Comments</th></tr>
<tr><td rowspan="10">Wolves and livestock</td><td>Plan should fund programs that emphasize non-lethal strategies for managing wolves
• More specific information needed on how to access non-lethal tools
• Depredation compensation needed
• Program should provide information and support for using proactive tools for reducing conflicts
• Plan should include depredation prevention agreements with livestock producers
• Research will be needed on success of non-lethal practices in California and make changes as needed</td></tr>
<tr><td>Promote coexistence between wolves and livestock producers</td></tr>
<tr><td>Depredation compensation is an inappropriate solution
• Would be paying producers to feed wolves
• It is inappropriate for the public to fund a business's costs
• Some producers may cheat and should be held accountable
• Ranchers can/should have insurance to cover losses
• It is not realistic, nor possible to document all depredation
• These funds should be focused instead on research into effective non-lethal control of wolves near livestock</td></tr>
<tr><td>Depredation investigations should be conducted by unbiased specialists providing accurate and sound results</td></tr>
<tr><td>Wolves should be fitted with collars and their locations closely monitored
• Wolf locations should be shared with livestock producers
    o Will help maintain human presence near their herds
• Plan should provide specifics on what recipients of wolf-location information may/may not do with that information
    o Should require confidentiality agreements</td></tr>
<tr><td>Lethal management of wolves leads to increased, not decreased livestock depredations</td></tr>
<tr><td>Clearly articulate the depredation investigation protocol
• Should include the protocol provided on CDFW website
• CDFW should consider collaborating with USDA/APHIS for investigating depredations, training CDFW staff, and finalizing the plan</td></tr>
<tr><td>Consider a stand-alone wolf-livestock program document</td></tr>
<tr><td>Nonlethal measures should be required before any lethal control measures are allowed
• Lethal control of wolves for livestock depredation on public lands should be prohibited
• Fit wolves with shock collars to keep them out of livestock areas</td></tr>
</table>

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
Wolves and livestock (continued)	Plan should include specifics on the following: • Available nonlethal tools • Conflict management strategies • Process for implementing non-lethal program • How CDFW will confirm livestock depredations • How CDFW will assist/train producers with non-lethal deterrent methods (including opportunity to connect with producers using methods successfully)
	What are the priority counties referenced in the plan for "payment for presence" of wolves?
	Impacts to livestock in Klamath Mountains could be higher than other regions due to topography
	Do not reveal the locations of wolf dens to livestock producers or any member of the public
	Livestock experience many effects from the presence of wolves: • Decreased body condition • Decreased weight gain in calves • Decreased reproductive success • Increased disease susceptibility • Compensation should be for presence of wolves not just depredation
	There are too many cattle in California for 50 wolves to have an impact on them
	Livestock loss due to wolf depredation is low compared to other types of losses; the vast majority of losses are due to: • Disease • Weather • Poor nutrition
	Majority of ranches are small family operations • Range riders not economically feasible • Plan underestimates impacts to this type of operation
	Broaden take allowances for producers to protect their animals • Non-injurious harassment • Injurious harassment • CESA should be amended to allow lethal take as a last resort • Producers should have reasonable discretion over where and when an imminent threat is posed by wolves • Use of motorized vehicles should be deemed as non-injurious harassment • Depredation rates are likely to be much greater than those confirmed by CDFW
	Many of the plan's recommended non-lethal strategies are impractical and/or infeasible
	Plan references depredation data that do not match data from USDA APHIS
	Strengthen wolf-dog aggression information
	Plan should include more information on prey-shifting especially when the shift is to livestock

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
Wolves and livestock (continued)	I am grateful that the plan has an emphasis on proactive measures for protecting wolves and livestock
	Livestock Guardian Dogs are deterrents against wolf depredation, not protection as the plan implies • Best when livestock is bunched or fenced • Dogs must be trained to stay with livestock
	Look at successful models of coexistence programs • Wood River Wolf Project • As suggested by Defenders of Wildlife, CA Wolf Center, Endangered Species Coalition • Producers in other states who are successfully using non-lethal tools
	CDFW should collaborate with local municipalities regarding appropriate garbage/carcass disposal to eliminate attractants
	Ranchers must be willing to change how they operate to coexist with predators
	Each situation involving potential conflict is unique and warrants specific recommendations • Specific deterrent plans and prevention agreements needed
	Non-lethal methods require time and training to be successful • Well-trained staff are critical
Coordination with other agencies	California Indian tribes should be consulted
	Grazing allotment permittees should be included in any discussions with BLM and USFS regarding these allotments
	Wolves should be managed on a regional (multi-state) scale • CDFW should work with Oregon and Washington to ensure appropriate source populations for California
	CDFW should take a more long-term, collaborative, and adaptive approach to managing wolves and other wildlife on public lands
Wolves and ungulates	Wolves could help control feral pigs
	There is already an overabundance of lions and bears in California with limited to no ability to control them
	Plan does not reflect wolf/ungulate science from other states and Canada
	CDFW lacks baseline information on ungulate populations • How will CDFW distinguish impact of wolves vs other mortality factors? • More rigor needed to detect change and its sources • It is important to estimate current mortality factors of elk • What are the current population levels of deer and elk in relation to carrying capacity?
	Ungulate population and habitat management are important aspects of wolf conservation
	Wolves have not switched to deer in other locations where deer outnumber elk • Wolves are more likely to switch to livestock than deer

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
Wolves and ungulates (continued)	Prey populations should be increased • Step up elk reintroductions into new areas • Temporarily ban hunting • Find ways to reduce other forms of human-caused mortality • Reduce livestock impacts to rangeland to improve habitat for native ungulates
	Conservation/recovery planning for ungulates should go hand-in-hand with predator conservation • Should include managing for quality ungulate habitat that is resilient to climate change
	Wolf impacts to bighorn sheep and pronghorn are underestimated in the plan • Consider establishing buffers to protect Sierra Nevada bighorn
	Plan does not address changes to rangeland utilization by native ungulates that change foraging patterns in response to wolves
	Teach naïve wolves how to capture deer in an enclosure
	Omit mention of disease transfer between domestic and bighorn sheep – not relevant in a wolf plan
	California wolf population estimates based on areas with much higher ungulate densities
	Plan should mandate high quality ungulate habitat on all state lands
	Plan is an attempt to limit or end hunting in California
	Hunter opportunity should not be considered in wildlife conservation
	Habitat appropriate for ungulates and habitat appropriate for wolves may not be the same
	I commend CDFW for attempting to estimate wolf predation rates
	Wolf impacts on feral species are a good thing
	Wolf predation will definitely be additive mortality • Hunting will be the only controllable mortality factor • How will CDFW reduce non-wolf related mortality of ungulates?
	The elk population “crash” in Yellowstone was actually a restoration to more sustainable numbers
	Reference Appendix G more frequently in the chapter
	Coordinate with National Park Service, BLM, and USFS to improve ungulate habitat • CDFW should promote progressive policies on grazing and fire management to improve habitat • Timber harvest is a benefit to deer and elk • Invasive plants that reduce forage quality should be controlled • Reduce road density on public lands • CDFW should actively seek opportunities to weigh in on federal land management processes
	Wolves kill more than they need to eat
	“Abundant” should be restated as “biologically sustainable” ungulate populations
	Plan should recommend actions to protect ungulate populations without need for CESA listing

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
Wolves and ungulates (continued)	Average age of wolf take is more than double that of hunter take • Hunter take of prime animals bad for population health
	Wolves and elk will adapt to each other and their populations will balance out
Education and outreach	Fund education about wolves • Promote public's understanding of the benefits provided by wolves (e.g. decreasing diseases in ungulates, ecosystem benefits) • Provide opportunities for people to experience and appreciate wolves • Provide education to hunters on identification of wolves vs coyotes • Outreach should include both urban and rural residents • Who will develop and implement an outreach program? • Provide a calendar of educational events for the public • Include information about appropriate human behaviors needed to optimize human safety
	Establish a volunteer program for the public
	Disseminating information to dispel rumors and myths is an important and beneficial section
	Keep the public informed about wolf updates on the CDFW website
	Establish a webcam or some other wolf information site to attract interest (may generate funding)
	Plan should include a specific plan for education • Include information about complying with relevant Fish and Game Codes, ESA, and CESA and related penalties for noncompliance
	Conduct outreach on the threat of wolf-dog hybrids to livestock
	Provide public additional opportunity for input on Plan updates
	Collaborate with State Parks, US Forest Service, Universities, and NGOs to develop educational materials and programs
	Education should include how human population growth/human development leads to depleted habitat for wildlife
Budget and funding	I am concerned that there is no funding to implement the plan • Wolves are endangered so CDFW should develop a compelling case to the governor, legislature, and public for funding
	Hunting partnerships have contributed millions of dollars to improve ungulate habitat
	Do not divert funds from other wildlife management programs to implement the wolf plan • New appropriations or general funding needed
	The various stakeholder groups should work to address funding the plan with the legislature

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
Budget and funding (continued)	Sources of funding for wolf conservation could include: • Wolf postage stamp • CDFW wolf stamp contest with entry fee • Wildlife Art/Photography contest with entry fee • Wolf vanity plates • Voluntary tax check-off • Carnivore protection and management license • State and federally funded grants • Partnerships with NGOs • Tax breaks for livestock producers • Bond measures that appeal to broad audience • Wolf funding donation site • Wildlife Conservation Board
	Plan should include an itemized budget for implementation costs • Should include start-up and annual operating costs • Would incentivize NGOs to lobby for the plan • Especially for monitoring ungulates with the needed precision
	Provide funding or tax deductions to ranchers who use non-lethal methods
	24 million taxpayers contributing 1 cent would give $240,000 every 4 years
	Non-consumptive citizens can/should help fund the plan • Urban users of public resources can/do provide balance to funding sources for wildlife conservation/management
Other economic considerations	Wolf tourism is a fad and will not contribute to your economy
	Plan underestimates the full range of economic impacts to livestock producers and small rural communities
	Wolves could attract visitors who will benefit the local economy • Consumer market for predator-friendly livestock products
	State should be prepared to compensate public and landowners for lost opportunities to recreate and use their lands
	Hunters and hunting groups provide large amounts of money to conserve wildlife and habitats
	Managing for wolves will cause many ranchers to go out of business, leading to human expansion into wolf territory
Plan implementation	Provide more information on the structure/function of local wolf management advisory groups
	Plan should also specify a statewide advisory group
Public safety	Plan underreports wolf attacks on humans • People and pets have been attacked in Wyoming, Michigan, and Alaska
	Protected wolves may lose their wariness of humans

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**
Public safety (continued)	Plan does not appropriately define suitable wolf habitat • If wolves define their own habitat they will become habituated to humans • Other predators such as lions and bears are euthanized when habituated to humans • Buffer zones should be established around cities and towns
	Clarify the definition of "imminent threat" for self-protection
	Lethal take for public safety is explicitly allowed under California law
	Wolves harm the public's ability to recreate freely and rural land owners to safely use their property
	More than 50% of carnivore attacks result from inappropriate human behavior
	The statement "most interactions between wolves and the public will likely consist of memorable observations" (Part I, pg. 17) is biased and unscientific
Wolf biology and ecology	Wolves contribute to healthy ecosystems
	Available information questioning wolf impacts on ecosystems should be added to the plan
	I support plan's inclusion of biological and ecological information • Helps public better understand wolves
	Wolves run out of space long before running out of prey • In Yellowstone the wolf population has stabilized
	Discussion of trophic cascades should be more comprehensive • Should include information from Great Lakes states
Wolf taxonomy	Chambers et al. paper should not be cited as it was not peer-reviewed
Wolf conservation	In Washington barriers to wolf dispersal are more social than geographic • Illegal killings have impacted recolonization into new areas
	CESA hampers CDFW's ability to establish science-based population goals for species
	Use sound science, not politics to protect wolves • The stakeholder process is biased because it considers nonscientific concerns in conserving a listed species • Science should include assessments of management successes and failures in the source population • Plan should include concise dispersal data from other areas and strategies for improving linkages between core wolf areas • Plan should include estimates of minimum viable population but at a regional (multistate) scale • The NRM pattern of territory expansion could help to model expansion into California • Genetic structure of the source population would be important to understand the metapopulation
	Lethal methods targeted at other species can harm wolves, children, livestock, other unintended targets • Ban the use of poisons and traps/snares

Table H2. Summary of Public Comments Received via Mail, Email, and Web Portal	
Topic/Plan Section(s)	**Comments**

Wolf conservation (continued)	Consider expanding the scope of providing safe travel corridors
	• Improve north/south travel as well as east/west
	• Benefits all wildlife
	• Work with CalTrans on roadkill problem
	    o Install wildlife over/underpasses
	    o Track roadkills of all wildlife

	Plan does not address take avoidance for projects in wolf territory such as prescribed fire or timber harvest
	Hybridization with domestic dogs is not a significant threat to wolves
	Hunting ungulates should not be considered a conservation threat to wolves as it is managed under an established regulatory process
	Many of the threats mentioned in the plan do not pertain to wolves • Wolves have expanded despite highways, rivers, cities • Habitat disturbance supports wolf prey so is not a problem for wolves
	Identifying prey and wolf habitat, including movement corridors, should be top priority • Include CDFW-produced habitat connectivity maps in plan
	CDFW should not consider land acquisition for wolf conservation • Too costly • Wolves too mobile • Focus should be on land management not ownership
	Reassess roadway structure and make changes that improve safety to wildlife • CDFW should track roadkill numbers, especially deer