

BEFORE THE SECRETARY OF THE INTERIOR

**PETITION TO LIST THE CALIFORNIA SPOTTED OWL (*STRIX
OCCIDENTALIS OCCIDENTALIS*) AS THREATENED OR
ENDANGERED UNDER THE FEDERAL ENDANGERED SPECIES
ACT**

The California Spotted Owl

(*Strix occidentalis occidentalis*)



Photo by Monica Bond

December 22, 2014

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Sally Jewell, Secretary
U.S. Department of the Interior
1849 C Street, NW
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Dan Ashe, Director
U.S. Fish and Wildlife Service
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RE: PETITION TO LIST THE CALIFORNIA SPOTTED OWL (*STRIX OCCIDENTALIS OCCIDENTALIS*) AS A THREATENED OR ENDANGERED SPECIES AND TO DESIGNATE CRITICAL HABITAT CONCURRENT WITH LISTING

Dear Ms. Jewell and Mr. Ashe:

Pursuant to Section 4(b) of the Endangered Species Act (“ESA”), 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedure Act, 5 U.S.C. § 553(e), and 50 C.F.R. § 424.14(a), Wild Nature Institute and the John Muir Project of the Earth Island Institute hereby petition the Secretary of the Interior, through the United States Fish and Wildlife Service (“FWS”), to list the California spotted owl (*Strix occidentalis occidentalis*) as a threatened or endangered species, and to designate critical habitat to ensure its survival and recovery.

FWS has jurisdiction over this petition because the FWS implements the ESA on a day-to-day basis for terrestrial species. 50 C.F.R. § 402.01(b). When the FWS receives a petition from the public, it has 90 days to determine whether the “petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted.” 16 U.S.C. § 1533(b)(3)(A). “Substantial information” is “the amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted.” 50 C.F.R. § 424.14(b)(1). This finding is commonly referred to as a “90-day finding.” If, at the 90-day finding stage, the FWS determines that the petition presents “substantial information,” the agency must subsequently conduct “a review of the status of the species concerned.” *Id.* at § 424.14(b)(3). After conducting a status review, if the FWS concludes that listing the species “is warranted,” it must publish a proposed listing rule and provide an opportunity for public comment. 16 U.S.C. § 1533(b)(3)(B). Within 12 months of publishing the proposed rule, the FWS must publish a final decision. *Id.* at § 1533(b)(6)(A).

The FWS must make listing determinations based on five factors: (A) the present or threatened destruction, modification, or curtailment of a species’ habitat or range; (B) overutilization of the species for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting the species’ continued existence. 16 U.S.C. § 1533(a)(1). When applying these five statutory factors, the FWS must rely on the best scientific and commercial data available. 16 U.S.C. § 1533(b)(1)(A).

By requiring that a petition present enough information “indicating” that listing “may be warranted,” and directing the FWS to promptly act upon petitions within 90 days, Section 4(b)(3) of the ESA reflects Congress’ intent that the FWS not impose overly restrictive requirements for

listing petitions. The FWS regulations that implement ESA Section 4(b)(3) likewise confirm that petitions need not demonstrate conclusive scientific proof; rather, a petition need only provide “substantial information,” defined as “that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted.” 50 C.F.R. § 424.14(b)(1). As the FWS has acknowledged previously, the agency must not “subject the petition to rigorous critical review,” and must “accept the petitioners’ sources and characterizations of the information . . . unless [the FWS has] specific information to the contrary.” *Western Watersheds Project v. Norton*, 2007 U.S. Dist. LEXIS 71751, *17 (D. Idaho 2007).

Federal courts have reiterated time and again that the reasonable person, “may be warranted” standard is a low bar. In *Center for Biological Diversity v. Kempthorne*, 2008 U.S. Dist. LEXIS 17517, *25 (D. Ariz. 2008), the court affirmed that “[t]he application of an evidentiary standard requiring conclusive data in the context of a 90-day review is arbitrary and capricious.” *See also Center for Biological Diversity v. Morgenweck*, 351 F.Supp.2d 1137, 1141 (D. Colo. 2004) (“it is clear that the ESA does not contemplate that a petition contain conclusive evidence of a high probability of species extinction to warrant further consideration”); *Moden v. United States Fish & Wildlife Serv.*, 281 F.Supp.2d 1193, 1204 (D. Or. 2003) (“the standard for evaluating whether substantial information has been presented . . . is not overly-burdensome, does not require conclusive information, and uses the ‘reasonable person’”).

Courts have further held that the “may be warranted” standard prohibits the FWS from issuing a negative 90-day finding solely due to conflicting evidence. In *Center for Biological Diversity v. Kempthorne*, 2007 U.S. Dist. LEXIS 4816, *11 (N.D. Cal. 2007), the court noted that “a reasonable person could find that an action ‘may be warranted,’ even in the face of evidence cutting multiple ways,” and that “in cases of such contradictory evidence, the [FWS] must defer to information that supports petitioner’s position.”

This petition sets in motion a specific process, placing definite response requirements on FWS. Specifically, FWS must issue an initial finding as to whether the petition “presents substantial scientific or commercial information indicating that the petitioned action may be warranted.” 16 U.S.C. §1533(b)(3)(A). FWS must make this initial finding “[t]o the maximum extent practicable, within 90 days after receiving the petition.” *Id.* While Petitioners believe that the best available science demonstrates that listing the California spotted owl as endangered is in fact warranted, there can be no reasonable dispute that the available information indicates that listing the species as either threatened or endangered may be warranted. As such, FWS must promptly make a positive initial finding on the petition and commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

Petitioners:

The Wild Nature Institute conducts scientific research on at-risk wildlife species and their habitats, advocates for their protection, and educates the public about the need to preserve wild nature. Wild Nature Institute’s scientists have published more peer-reviewed studies on the relationship between spotted owls and fire than any other.

The **John Muir Project of Earth Island Institute**, and their members and supporters, have worked to protect the California spotted owl and its habitat for many years, and are also concerned with the effective implementation of the ESA.



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Executive Summary

Because too many species in the United States had become extinct “as a consequence of economic growth and development untempered by adequate concern and conservation,” 16 U.S.C. § 1531(a)(1), Congress adopted the ESA to “provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, [and] to provide a program for the conservation of such endangered species” *Id.* at § 1531(b).

This petition demonstrates that the California spotted owl clearly warrants listing under the ESA based on the factors specified in the statute. As discussed in this petition, the California spotted owl population is small and isolated, and has experienced substantial contemporary population declines that are likely to continue if the threats to the species are not significantly reduced.

The term “species” is defined broadly under the ESA to include “any subspecies of fish or wildlife or plants and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.” 16 U.S.C. § 1532 (16). As described in this petition, the small and declining spotted owl population in California’s Sierra Nevada and the mountains of southern California is isolated, is genetically distinct at the level of subspecies, and has long been recognized as a distinct subspecies. Therefore, we request that this California population of spotted owls be considered a subspecies eligible for listing under the ESA.

In 2006, the California spotted owl was denied the protections of the ESA in large part due to perceived uncertainties as to the population trajectory of this subspecies and the impacts of logging on its habitat. These issues have now been further addressed in the literature and it is unequivocally necessary to list this bird and provide it the protections of the ESA. For example recent demography studies all find that the owls are in decline on National Forest and private lands. Furthermore, other studies, post-2006, demonstrate that past and ongoing degradation of owl habitat—whether it be from intensive private lands logging, mechanical treatments on public lands, or post-fire logging—is contributing to owl declines.

The California spotted owl also was denied protection in 2006 based on the assertion that fire represented the primary threat to its survival, and that the threat was being addressed by Forest Service actions. Since 2006, however, much new information has come to light demonstrating

considerable variability in the response of spotted owls to fire, and showing fuels treatments to be more harmful to spotted owls than previously known.

Specifically, spotted owls appear to be well adapted to low- and moderate severity fire, which generally constitutes the majority of fire areas, and although high-severity fire¹ can reduce nesting and roosting habitat, spotted owls have been found to continue to occupy territories post-burn and to select high-severity burned forests within their territory for foraging, possibly due to enhanced small mammal prey abundance or accessibility there. This new information, in combination with pre-2006 information that is now better understood in the context of subsequent studies, indicates that Forest Service management in response to fire is the primary threat to the spotted owl's survival.

Finally, new threats have emerged in recent years, including barred owls, climate change, continued urban sprawl, and rodenticide poisoning that add to concerns about the owl's survival. Thus, as explained below, we request that the FWS move quickly to find in favor of this petition and conduct a status review of the California spotted owl. We look forward to the Service's response to this petition and processing of it pursuant to the procedures and timelines established under the ESA.

¹ In this Petition, we use the terms high-severity fire and high-intensity fire (high energy release, with high flame lengths, which results in high-severity fire effects) interchangeably to mean patches wherein fire has killed most or all of the trees.

Introduction and Background

The California spotted owl has been the subject of conservation concern for many years. On April 3, 2000, the Center for Biological Diversity and the Sierra Nevada Forest Protection Campaign, on behalf of themselves and 14 other organizations, submitted a petition to list the California spotted owl (spotted owl) as a threatened or endangered species (Center for Biological Diversity 2000). Along with listing, the petition also requested the concurrent designation of critical habitat, emergency listing, and emergency designation of critical habitat.

On October 12, 2000, the Service published a 90-day finding on that petition in the Federal Register (65 Fed. Reg. 60605). In that notice, the agency found that the petition presented substantial scientific or commercial information to indicate that listing the California spotted owl may be warranted, and initiated a status review of the taxon. On February 14, 2003, the Service published a 12-month finding on the petition in the Federal Register (68 Fed. Reg. 7580). In that notice, the Service stated that they believed petitioned action was not warranted because the overall magnitude of threats to the species did not rise to the level requiring protection under the ESA.

On May 11, 2004, the Center for Biological Diversity and five other groups filed a lawsuit in Federal District Court for the Northern District of California (Center for Biological Diversity, et al. v. Norton et al., No. C-04-1861) claiming that the Service's 12-month finding violated the ESA and the Administrative Procedures Act (5 U.S.C. § 706). On September 1, 2004, the Service received an updated petition, dated September 2004, to list the California spotted owl as a threatened or endangered species and to designate critical habitat concurrent with listing based, in part, on information that was not available at the time of the original 12-month finding (Center for Biological Diversity 2004). The updated petition was submitted by the Center for Biological Diversity and the Sierra Nevada Forest Protection Campaign, acting on behalf of themselves and six other organizations, and included the information required in 50 C.F.R. § 424.14(a).

In view of the second petition, on March 8, 2005, the District Court in *Center for Biological Diversity v. Norton* issued an Order to Show Cause why it should not stay the litigation pending the Service's action on the new petition. In response to that Order, on March 14, 2005, the Service submitted a declaration to the Court stating that: (1) the agency could submit for publication in the Federal Register a 90-day finding on the new petition by June 13, 2005, and (2) if the agency found that the information presented in the petition was substantial, they could submit for publication in the Federal Register a 12-month finding by March 14, 2006. At a hearing on March 17, 2005, the Court stayed the case for 90 days, directed the Service to report to the Court and the parties concerning the status of its review of the petition by June 13, 2005,

and continued the hearing on pending cross-motions for summary judgment to June 23, 2005. On April 4, 2005, the Court concurred with the parties' requests to continue the hearing date until June 30, 2005, and to allow the Plaintiffs and Intervenor-Defendants (American Forest and Paper Association, California Forestry Association, and Sierra Pacific Industries) until June 23, 2005, to file any responses to the Service's June 13, 2005 filing. On June 13, 2005, the Service submitted a 90-day finding to the Federal Register, which published the finding on June 21, 2005 (70 Fed. Reg. 35607). In that finding, the Service found that the petition presented substantial scientific or commercial information to indicate that listing the California spotted owl may be warranted, and initiated a status review of the taxon, and solicited comments and information to be provided in connection with the status review by August 22, 2005. In light of the June 21, 2005, finding, and pursuant to a joint stipulation of dismissal by the parties to the litigation, the Court dismissed the above case on July 25, 2005.

On October 14, 2005, the Service published in the Federal Register a notice reopening the public comment period through October 28, 2005 (70 Fed. Reg. 60051). On February 14, 2006, the agency filed with the Court their intention to deliver the 12-month finding to the Federal Register by May 15, 2006, to enable them to incorporate results from a meta-analysis of California spotted owls delivered on February 21, 2006.

In the Service's 90-day finding of June 21, 2005 (70 Fed. Reg. 35607), they briefly analyzed the concerns as described in the petition. The Service stated that five changes that had taken place since their 2003 finding constituted substantial information that may affect the status and distribution of the California spotted owl or change the understanding of possible declines in California spotted owl populations and thus justified further detailed analysis in a status review and 12-month finding. These changes were: (1) Revisions to the 2001 Sierra Nevada Forest Plan Amendment ("SNFPA"; also called "Framework") (USFS 2001) in the 2004 SNFPA (USFS 2004a); (2) revisions to the California State Forest Practices Code; (3) possible changes to the draft meta-analysis of the population dynamics of the California spotted owl in the final, published meta-analysis (Franklin et al. 2004); (4) impacts of recent fires and anticipated future fires in spotted owl habitat; and (5) further range expansion of the barred owl. On May 24, 2006, (50 Fed. Reg. 29886), the Service issued a 12-month finding whereby they re-analyzed issues raised in the 2000 petition (Center for Biological Diversity 2000) and included an analysis of concerns presented in the 2004 petition (Center for Biological Diversity 2004). In the May 24, 2006 finding, the Service analyzed these five changes, other concerns expressed in the petition, and other pertinent information relative to whether the California spotted owl should be listed, and issued a decision asserting that the petitioned action was not warranted.

Since 2006, published research demonstrates that the owls are in serious decline on National Forest and private lands, which are also the places where substantial logging occurs. Indeed, studies show that intensive logging (e.g., clearcutting), as well as mechanical thinning and post-fire "salvage" logging, are the primary threats to owl survival. It is therefore imperative that the owls be listed under the ESA so that they can be protected from damaging activities.

Taxonomy and Description

The spotted owl was first described as *Syrnium occidentale* by John Xantus in 1859 based on a specimen collected at Fort Tejon, Kern County, California (Xantus 1859). The species was later reassigned to the genus *Strix* (Ridgway 1914). The specific name was altered to conform to the Code of Zoological Nomenclature, yielding the scientific name *Strix occidentalis* (Service 1993). Currently, the American Ornithologists' Union (AOU) recognizes three subspecies of spotted owls: the California spotted owl (*Strix occidentalis occidentalis*), the northern spotted owl (*Strix occidentalis caurina*), and the Mexican spotted owl (*Strix occidentalis lucida*) (AOU 1957).

Spotted owls are medium-sized, brown owls with brown eyes, round heads without ear tufts, white spots on the head, neck, back, and underparts, and white and light brown bars on the wings and tail. The spotted owl is mottled in appearance. The facial disk is pale brown with concentric rings of dark brown, bordered by a ring of dark brown feathers. A conspicuous light-colored “X” is apparent between the eyes above its pale yellowish beak, where “eyebrows” and “whiskers” merge together. Unlike most other owl species, which have yellow eyes, spotted owls have dark brown eyes. Wings and tail are rounded, and all flight feathers are dark brown with light brown cross-bars. Sexes cannot be distinguished by plumage, but can be readily identified by size and vocalization (Verner et al. 1992b). Females are usually larger than males, with males weighing 470 to 685 grams (g) (17 to 24 ounces (oz)), and females 535 to 775 g (19 to 27 oz) (Gutiérrez et al. 1995). First- and second-year adults can be distinguished by the tips of the tail feathers, which are white and taper to a sharp point until replaced by adult plumage at about 26 months of age (Gutiérrez et al. 1995). The spotted owl is the fifth largest species of owl occurring in North America (Verner et al. 1992b); it is 41 to 48 centimeters (cm) (16 to 19 inches (in)) in length, with a wingspan of 107 to 114 cm (42 to 45 in) (Center for Biological Diversity 2000).

The other subspecies of the spotted owl—the northern spotted owl and Mexican spotted owl—are listed by the Service as threatened. The final rule to list the northern spotted owl was published in the Federal Register on June 26, 1990 (55 Fed. Reg. 26114), and the final rule to list the Mexican spotted owl was published in the Federal Register on March 16, 1993 (58 Fed. Reg. 14248).

Genetics

Three genetic markers (i.e., allozymes, mitochondrial DNA and random amplified polymorphic DNA) have been used to examine the genetic structure of spotted owls. Analysis of allozymes (alternate forms of proteins) supports separation of the Mexican spotted owl from the other two

subspecies (Gutiérrez et al. 1995). Barrowclough et al. (1999) compared the sequences of a fragment of mitochondrial DNA (mtDNA) from 73 individual spotted owls, including samples from all three subspecies and from multiple populations within each subspecies. Their data support the separation of the species into the three currently recognized subspecies. Based on their data, the northern spotted owl appears to have diverged first from the other two subspecies, and the California spotted owl later diverged from the Mexican spotted owl. In this study, gene flow appeared relatively high within subspecies and low between subspecies (Barrowclough et al. 1999). The authors concluded that gene flow between northern and California spotted owls is a recent and uncommon phenomenon.

Haig et al. (2001) used random amplified polymorphic DNA (RAPD) to analyze genetic variation between spotted owls at multiple geographic levels, including between subspecies. They found extremely low RAPD variation in spotted owls, with only 11 of 400 primers showing variation. Their data show genetic separation of Mexican spotted owls from California and northern spotted owls, but could not clearly determine a separation between the California and northern subspecies. Subsequent studies analyzing mtDNA sequences (Haig et al. 2004, Barrowclough et al. 2005, Chi 2006) and microsatellites (Henke 2005) confirmed the validity of the current subspecies designations for northern and California spotted owls.

Chi (2006) studied genetic structure of 91 California and northern spotted owls in California. She found the California spotted owl had 10 polymorphic sites, five unique to the subspecies, whereas the northern spotted owl had 24 polymorphic sites, seven restricted to the subspecies. The haplotype diversity was much greater in the northern subspecies than the California subspecies. Further, within each subspecies the connected inland populations had much higher diversity as indicated by a variety of haplotypes, when compared to each isolated counterpart coastal population. Chi (2006) noted that although the northern and Mexican spotted owl subspecies have received protection under the federal Endangered Species Act, listing of the California spotted owl has been denied twice, despite the fact that the California spotted owl population size is an estimated one-fourth the size of the northern spotted owls (Gutiérrez et al. 1995) and has the most limited genetic variability of all three subspecies (Barrowclough et al. 1999, Haig et al. 2004, Barrowclough et al. 2005, Henke 2005). Chi (2006) stated on page 32: “The California spotted owl’s impoverished genetic pool, low population estimates, and more recently the lack of habitat protection by changes made to the Sierra Nevada Framework [2004 changes to the 2001 Framework; see Threats], are all indicators of a subspecies that requires additional recognition and protection by the Federal Government under the Endangered Species Act.”

Life History

Mating System and Reproduction

Spotted owls usually reach reproductive maturity at two years of age, although there are rare accounts of nesting first-year birds (Verner et al. 1992b). Spotted owls are considered monogamous. They usually pair with the same mate from year to year, although “divorces” have been documented.

The breeding season of California spotted owls extends from mid-February to mid-September or early October (Verner et al. 1992b). Considerable variation exists in both the percentage of pairs that nest and the number of pairs that successfully fledge young, both geographically and from year to year (Verner et al. 1992b). Individuals begin breeding earlier in the San Bernardino Mountains than in the Sierra Nevada. Within a geographic area, individuals begin breeding earlier at lower elevations (Verner et al. 1992b).

California spotted owls are mostly non-migratory, remaining within the same home ranges year round. However, in the Sierra Nevada, some individuals migrate out of their breeding-season ranges to winter habitats from early October to mid-December and return to their breeding territories in late February to late March, possibly to establish disjunct winter home ranges below the level of heavy, persistent snow (Verner et al. 1992b, Laymon 1989, Zabel et al. 1992, Bond et al. 2010). These seasonal migrations range from 13 to 58 km (9 to 36 mi) with altitudinal changes from approximately 500 to 1,500 m (1,640 to 4,921 ft) (Verner et al. 1992b, Laymon 1989, Gutiérrez et al. 1995, Bond et al. 2010).

Laymon (1988) observed California spotted owls migrating from summer home ranges in mixed-conifer forests to winter home ranges in lower elevation pine-oak woodlands. He believed that similar migrations may also occur in Southern California. Tibstra (1999) observed that 10 of 22 dispersing juvenile owls having natal sites in coniferous forest habitats above 1,120 meters (m) (3,675 feet (ft)) moved downslope to lower elevation (305 m (1,000 ft) to 732 m (2,402 ft)) pine-oak woodland habitats. Of those ten, data were available through the following spring for only two, both of which overwintered and then moved back to high-elevation sites. The elevational movements of those two owls were significantly correlated with environmental temperature. Tibstra speculated that the pattern of migration to winter range observed in some adults may be established in the first year by dispersing juveniles.

In nesting season, for approximately two weeks before the first egg is laid, pairs roost together and copulate once or twice each evening. For about one week before the first egg is laid, the female spends most of her time near the nest, and the male brings her prey items (Verner et al. 1992b, Gutiérrez et al. 1995).

California spotted owl eggs are elliptical, white to pearl grey, and smooth to slightly granular in texture. Egg-laying peaks in mid-April. When egg-laying begins, the female spends almost all her time in the nest, and the male supplies almost all of her food. The number of eggs in clutches ranges from one to four, with most nests containing two. Successive eggs are laid approximately

three days apart. Pairs continue to copulate throughout, and for up to four days, after the egg-laying period (Verner et al. 1992b, Gutiérrez et al. 1995). Only the female incubates the eggs. During the first two days of incubation, she may leave the nest for up to two hours, but thereafter she will only leave the nest for 10 to 20 minutes at a time to regurgitate pellets, defecate, preen, or accept food from her mate (Verner et al. 1992b).

Eggs hatch after approximately 30 days. Hatchlings are covered with white natal down, with juvenile plumage starting to replace natal down at about 10 to 20 days (Gutiérrez et al. 1995). The female broods the hatchlings almost continuously for eight to ten days. During this period, the male supplies food for the female and young. Two to three weeks after the eggs hatch, the female begins foraging for one to four hours per night. Males continue to bring food to the nest, which the female passes to the chicks (Verner et al. 1992b).

Most chicks fledge 34 to 36 days after hatching. New fledglings are weak fliers and may spend hours or days on the ground. Approximately three days after fledging, most young are able to fly or climb to elevated perches. Within a week, most are able to fly between trees. Both parents continue to feed the fledglings until mid to late September (Verner et al. 1992, Gutiérrez et al. 1995).

Spotted owls produce from one to four fledglings in a given breeding season. Using reproductive data from 127 spotted owl territories in the San Bernardino Study Area from 1987 to 1998, Peery and Gutiérrez (2013) examined whether spotted owl offspring from a larger brood were less likely to survive to adulthood, have delayed recruitment into the territorial population, and experience lower reproductive success than offspring produced in smaller broods. The probability of a non-territorial owl recruiting into the territorial population was independent of parental reproductive output and offspring age until the offspring's fifth year: the observed age of recruitment was similar among owls born as singletons, in pairs, or in triplets. However, survival was greatest for individual offspring that had fledged in pairs, and relatively low for individuals that had fledged as singletons or in triplets. Juvenile survival was 1.44 times greater for offspring that fledged in pairs than for offspring that fledged as singletons. Subadult and adult survival was 1.11 to 1.18 times greater for offspring that fledged in pairs than for those that fledged as singletons and these advantages occurred beyond the first year of life. These results were interesting in that they contrasted with previously held assumptions about the tradeoffs between reproductive effort and offspring survival. For this sample of spotted owls, evidence existed for the presence of high-quality parents, or parents with access to higher-quality resources. Figure 1, below, shows survival probabilities as a function of parental reproductive output.

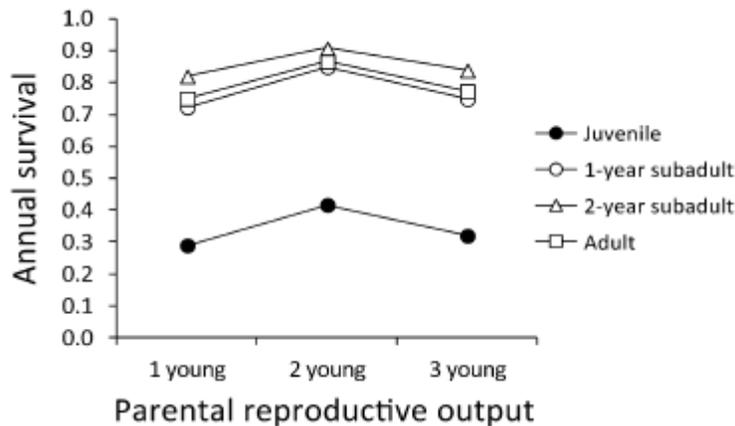


Figure 1. Survival probabilities of California spotted owls in the San Bernardino Mountains from 1987 to 1998, as a function of parental reproductive output. From Peery and Gutiérrez (2013); Figure 3 at page 136.

Further, Peery and Gutiérrez (2013) found that territory quality based on reproductive output was a good predictor of the index of territory quality based on the number of recruits produced.

MacKenzie et al. (2010) investigated the relationship between annual variation in reproduction dynamics and environmental variables at 66 California spotted owl breeding sites from 1997 to 2004 in the Eldorado Study Area in the central Sierra Nevada. The authors found that the patterns of annual variation in probabilities of successful reproduction depended upon whether there was reproduction the previous year: in some years the probability of successful reproduction in a territory is estimated to be higher if there was no reproduction in the previous year, whereas in other years territories that previously had successful reproduction had the higher estimated probability.

Dispersal

Spotted owls primarily disperse as juveniles (natal dispersal), but may also disperse as adults (breeding dispersal) if habitat within their home range has been degraded or if they have separated from a mate (Verner et al. 1992b, Blakesley et al. 2006, Gutiérrez et al. 2011).

Natal Dispersal—Natal dispersal of California spotted owls occurs in September and October. Natal dispersal distances have been estimated using radio telemetry (Verner et al. 1992, Tibstra 1999) and recapturing territorial owls that were banded as juveniles (LaHaye et al. 2001, Blakesley in litt. 2002). Dispersal distances of successfully dispersing owls ranged from 3 km (2 mi) to 76 km (47 mi). Mean natal-dispersal distance of 26 owls in the Sierra National Forest and Sequoia National Park estimated using radio telemetry was 15.9 km (9.9 mi) (Tibstra 1999) and median distance of 42 owls on the Lassen National Forest estimated using recapture data was 25 km (16 mi) for females and 23 km (14 mi) for males (Blakesley in litt. 2002). Mean

natal-dispersal distances of 129 owls in southern California estimated using recapture data were 10.1 km (6.3 mi) for males and 11.7 km (7.3 mi) for females (LaHaye et al. 2001). No significant difference existed in dispersal distance or time to become territorial between sexes (LaHaye et al. 2001). In the southern California study, some dispersing owls did not occupy territories until they were four years old, but over 60 percent occupied territories within one year of fledging. Apparent survival of fledglings (calculated as the percentage of banded fledglings that were later relocated) was 31.8 percent.

LaHaye et al. (2001) concluded that the presence of conspecifics (members of the same species) may play a vital role in the recruitment of dispersing California spotted owls into a territory, because owls that “settled” (established territories) were significantly more likely to do so in territories that were occupied the previous year than would be expected by chance, and all previously vacant territories that were settled were adjacent to occupied territories. The percentage of territories occupied varied from 59 to 95 percent from year to year.

Breeding Dispersal—Breeding dispersal (as opposed to natal or juvenile dispersal) is movement of adults from one breeding territory to another. Four color-banded adults on the Sierra National Forest shifted territories, moving 3.4 km (2.1 mi), 3.5 km (2.2 mi), 3.9 km (2.4 mi), and 7.1 km (4.4 mi) (Verner et al. 1992b). One color-banded female in the Sequoia National Forest moved 2.6 km from the center of her breeding season territory in September and was relocated the following spring in a different territory > 4 km from the previous breeding territory (Bond et al. 2010). In a study of breeding dispersal of California spotted owls in the San Bernardino Mountains (LaHaye and Gutiérrez in litt. 2002), 46 females and 38 males dispersed, which were 22 percent and 17 percent of the total banded females and males, respectively. Among dispersing females, 70 percent were adults and 30 percent subadults; among males, 71 percent were adults and 29 percent were subadults. A significantly higher percentage of subadults dispersed (30 percent) compared to the territorial population as a whole (14 percent). Mean dispersal distances were 4.3 km (2.7 mi) for females and 3.0 km (1.9 mi) for males, which are significantly shorter than natal dispersal distances observed in the same population.

Blakesley et al. (2006) found that in a sample of 54 banded California spotted owls monitored from 1990 to 2001 in the Lassen Study Area of the southern Cascades, the probability of breeding dispersal was greater from less productive sites, and for younger owls, single owls, paired owls that lost their mates, and owls that failed to reproduce the year preceding dispersal. Birds tended to disperse to a more productive site. In a similar study, Gutiérrez et al. (2011) estimated probability of breeding dispersal in a spatially closed population in the San Bernardino Mountains over 12 years (1987 to 1998). Again, probability of breeding dispersal was correlated with previous reproductive performance such that birds with higher mean productivity were less likely to disperse than those with lower productivity. Weak evidence suggested that females were more likely to disperse than males. Further, birds that lost their mates and subsequently dispersed improved their reproductive output, similar to the Lassen Study Area owls.

Interactions with Other Species and Natural Mortality

Spotted owls are mobbed by many species of diurnal birds (Gutiérrez et al. 1995). Red-tailed hawks (*Buteo jamaicensis*) and common ravens (*Corvus corax*) may take away prey items that are captured by spotted owls.

Predators and closest competitors to spotted owls are great horned owls (*Bubo virginianus*) (Forsman et al. 1984) and barred owls (*Strix varia*) (Leskiw and Gutiérrez 1998, Hamer et al. 2001, Kelly et al. 2003). Barred owls have invaded into portions of the range of California spotted owls (Seamans et al. 2004, Gutiérrez et al. 2012, Munton et al. 2012) and are known to displace spotted owls from their territories (Verner et al. 1992b, Gutiérrez et al. 1995), suppress calling behavior (Crozier et al. 2006), and possibly kill spotted owls (Leskiw and Gutiérrez 1998). Northern goshawks (*Accipiter gentilis*), great horned owls, red-tailed hawks and potentially other birds of prey eat spotted owls (Verner et al. 1992, Gutiérrez et al. 1995).

Starvation (Verner et al. 1992b, Gutiérrez et al. 1995, Tibstra 1999) has been documented as a cause of death in California spotted owls. Starvation is more common in juveniles than adults and may result from low prey availability or lack of hunting experience (Verner et al. 1992b). Dispersing juveniles sometimes roost in open habitats during inclement weather, which may result in exposure causing or contributing to their deaths (Gutiérrez et al. 1995).

Feeding and Metabolism

California spotted owls tend to select a few key species among the variety of taxa on which they prey (Verner et al. 1992b). Spotted owls in conifer forests of the Sierra Nevada, especially above mid-elevation mixed-conifer forests from about 4,000 to 5,000 feet (ft) (1,200 to 1,525 meters (m)), often feed on northern flying squirrels (*Glaucomys sabrinus*) which are most common in larger stands of mature forests (Verner et al. 1992b). Spotted owls in the mid to lower elevations of the mixed-conifer zone and the upper elevations of the ponderosa pine (*Pinus ponderosa*)/hardwood belt of the Sierras prey frequently on both flying squirrels and dusky-footed (*Neotoma fuscipes*) or big-eared woodrats (*N. macrotis*) (Thraillkill and Bias 1989, Verner et al. 1992b, Munton et al. 2002). Woodrats are most abundant in shrubby habitats and uncommon in pure conifer forests or forests with little shrub understory (Williams et al. 1992). Pocket gophers (*Thomomys* spp.) were a major prey item of spotted owls in a mid-elevation burned landscape of the Sequoia National Forest (Bond et al. 2013), and spotted owls in southern California feed mostly on woodrats (Smith 1999). Other prey items include mice (*Peromyscus* spp.), diurnal squirrels (*Tamiasciurus douglasii*, *Sciurus griseus*), ground squirrels, (*Spermophilus beecheyi*), and chipmunks (*Eutamias* spp.) and a variety of other rodents, shrews (*Sorex* spp.), moles (*Scapanus* spp.), bats (*Myotis* spp.), birds, frogs, lizards, and insects (Verner et al. 1992b, Gutiérrez et al. 1995, Tibstra 1999). Table 1 (from Bond et al. 2013) shows average percent of prey by biomass in regurgitated spotted owl pellets in four study areas ranging from the central Sierra Nevada to southern California.

Table 1. Average Percent Each Category of Prey Contributed to Total Dietary Biomass in Pooled Samples of Pellets Regurgitated by Spotted Owls in Unburned Areas in the Eldorado, Sierra, and San Bernardino National Forests, California and in an Area Burned by the McNally Fire, Sequoia National Forest.^a From Bond et al. 2013; Table 2 at page 121.

	Eldorado NF ^b <i>n</i> = 139	Sierra NF ^c <i>n</i> = 1269	McNally Fire <i>n</i> = 199	San Bernardino NF ^d <i>n</i> = 8441
<i>Thomomys</i> spp.	7.8	18.4	40.3	10.4
<i>Glaucomys sabrinus</i>	30.7	45.6	25.9	3.0
<i>Neotoma</i> spp.	38.1	11.8	10.9	74.0
Diurnal squirrel	6.6	0.9	8.8	1.3
Bird	12.4	12.9	4.0	3.5
<i>Peromyscus</i> spp.	1.3	5.5	4.5	4.0
<i>Microtus</i> spp.	0.7	1.2	2.6	1.3
<i>Scapanus</i> spp.	2.1	1.5	1.5	0.3
Bat	0.0	0.1	0.8	0.1
Insect	0.3	0.6	0.6	1.2
<i>Sylvilagus</i> spp.	0.0	0.0	0.0	1.0

^aSample size is number of individual prey items. Bold numbers indicate greatest percent biomass by study area.

^bData from Thrailkill and Bias (1989).

^cData from Munton et al. (2002).

^dData from Smith et al. (1999).

Flying squirrels typically use older mature forests because they provide suitable nest sites, including snags, and abundant sources of food including arboreal lichens and truffles, which are associated with an abundance of soil organic matter and decaying logs (Verner et al. 1992b). In second-growth forests in Oregon, northern flying squirrels were found in younger forests if large snags and downed logs remained from earlier stands (Carey and Peeler 1995). Conversely, woodrats are most strongly associated with montane chaparral and young forest (Williams et al. 1992, Ward et al. 1998). A study in the Plumas National Forest found that dusky-footed woodrats were most abundant in pine-cedar and mixed-conifer forests as compared to other forest types (Coppeto et al. 2006).

Spotted owls are “perch and pounce” predators, hunting primarily by selecting an elevated perch, detecting prey by sight or sound, and swooping from the perch to capture the prey with their talons. Spotted owls are not fast fliers, but they are very agile and maneuverable. The flight pattern is a series of quick wing beats interspersed with gliding flight. Spotted owls use gliding flight when approaching prey. When gaining altitude in the forest canopy, they make a series of short climbing flights rather than one continuous flight. Flight is labored when attempting to fly to a higher perch or a nest sight. Flight above the forest canopy is probably rare, except during dispersal (Gutiérrez et al. 1995). If a potential prey item is inaccessible or at a considerable distance from an owl’s perch, the owl may move closer before pouncing (Verner et al. 1992b).

Spotted owls will forage at several sites within a single night (Gutiérrez et al. 1995). They also hunt by capturing in mid-air flying prey such as insects, bats, and birds (Verner et al. 1992b, Gutiérrez et al. 1995). California spotted owls forage primarily at night, but have been observed

hunting during the day, especially while raising young (Laymon 1991, Verner et al. 1992). They may cache prey items on limbs, stumps, or the ground for later consumption (Gutiérrez et al. 1995).

California spotted owls have low metabolic rates relative to other birds. Analysis of metabolic rates and the energy content of prey items indicates that an individual California spotted owl would need to eat one flying squirrel every 1.8 days or one woodrat every 3.7 days (Weathers et al. 2001). Spotted owls have a high water need relative to their metabolic rate (Weathers et al. 2001), and have been observed drinking surface water from seeps and creeks (Gutiérrez et al. 1995). California spotted owls have a narrow thermal neutral zone (the ambient temperature range through which a bird or mammal can maintain its normal body temperature without expending energy to do so) relative to birds in general and are therefore especially subject to heat stress (Gutiérrez et al. 1995, Weathers et al. 2001). They roost higher in the forest canopy during winter and lower during the summer. They will also move during the day in response to changes in ambient temperature and sun exposure. The variety of microclimates available in mature and old-growth forests is a possible explanation for the spotted owl's use of such habitats (Gutiérrez et al. 1995).

Distribution and Range

Grinnell and Miller (1944) described the range of the California spotted owl as “in general, coastal slope of southern California from southern San Diego County northwest to Santa Barbara, Ventura, and western Kern Counties, and west flank of Sierra Nevada north from Tulare County to Tehama County.” They noted that the southern California range was apparently separated from the Sierra portion of the range.

The mapped range of the California subspecies in Grinnell and Miller (1944) indicated a gap in the distribution of spotted owls in Shasta County, separating the California and northern spotted owl subspecies. The Service established the “Pit River area” as the boundary between the northern spotted owl and the California spotted owl (55 Fed. Reg. 26114), which was further confirmed by Gutiérrez and Barrowclough (2005:185). However, recent data (Barrowclough et al. 2011) has rejected the Pit River itself as a barrier, because the hybrid zone between northern and California spotted owls was determined to be 24 km south of the river. Birds north of the Pit River are likely northern spotted owls, birds south and east of Lassen Peak are likely California spotted owls, and birds in between are likely intergrades. Historically, much of the hybrid zone area southeast of Mount Shasta, even prior to logging, was likely low suitability for spotted owls compared to the Sierra Nevada and Coast Ranges because it was dominated by either open mid-elevation ponderosa pine forest or high-elevation fir forest. More recently, the authors note, the area has been affected by logging and large fires which were subsequently salvage-logged and

replaced with tree plantations. Thus, the density of spotted owls, particularly in the immediate vicinity of the Pit River, is low (Barrowclough et al. 2005).

Today the California spotted owl occurs on the west side of the Sierra Nevada from Shasta County south to the Tehachapi Pass, and all major mountains of southern California, including the San Bernardino, San Gabriel, Tehachapi, north and south Santa Lucia, Santa Ana, Liebre/Sawmill, San Diego, San Jacinto, and Los Padres ranges (Beck and Gould 1992). In addition, California spotted owl sites occur on the eastern side of the Sierra Nevada and in the central Coast Ranges at least as far north as Monterey County.

As of 2003, the elevation of known nest sites of California spotted owls ranged from about 305 to 2,348 m (1,000 to 7,700 ft), with approximately 86 percent of sites occurring between 915 and 2,135 m (3,000 and 7,000 ft) (USFS 2001a). In conifer forests, the mean elevation of nest sites was 1,160 m (5,300 ft) in the northern Sierra Nevada and 1,830 m (6,000 ft) in southern California (Gutiérrez et al. 1992).

Number of Territories

No historical data are available regarding pre-European settlement population numbers of the California spotted owl. The number of California spotted owl territories has been used as an index to illustrate the range of the species and jurisdictions in which it occurs. This number is actually a cumulative total of all sites known to be historically or currently occupied by at least one spotted owl. This total increases over time as spotted owls move to new territories and as researchers survey new areas, even though many territories with sufficient suitable habitat may not be occupied in years following their initial discovery and some territories may no longer have sufficient suitable habitat to support spotted owls due to logging, development, or other disturbances. For example, in the Sequoia and Kings Canyon National Parks study area, only 34 of 44 territories (77 percent) with a history of spotted owl occupancy were occupied by either spotted owl pairs ($n = 32$) or resident singles ($n = 2$) in 2004 (Munton in litt. 2005). And in the Eldorado study area, only 26 of 49 territories (53 percent) were occupied by spotted owl pairs ($n = 25$) or a single spotted owl ($n = 1$) in 2004 (Seamans in litt. 2005a). Thus, the number of territories should not itself be viewed as a population estimate for the taxon.

The California Department of Fish and Wildlife (CDFW) maintains a database of the number and location of California spotted owl territories identified on federal, state, or private property and submitted to CDFW since the early 1970s. Other than for research purposes, spotted owls are rarely surveyed for in areas outside of timber harvest boundaries or other project boundaries where the species may be affected.

California spotted owl territories have been located on Forest Service (USFS), National Park Service (NPS), Bureau of Land Management (BLM), California Department of Parks and

Recreation (State parks), California Department of Forestry and Fire Protection (CDF), California State Lands Commission (CSLC), Native American, and private lands, and in Mexico.

Sierra Nevada

In the Sierra Nevada, the California spotted owl is mostly continuously and uniformly distributed, with several breaks in distribution where habitat appears limited due to natural or human-caused factors (Beck and Gould 1992). These are known as “Areas of Concern”.

In Sierra Nevada national forests, 99 percent of owl sites occur on the Lassen, Plumas, Tahoe, Eldorado, Stanislaus, Sierra, and Sequoia National Forests. As of 2003, the number of territories per national forest was as follows: Modoc 3, Lassen 138, Toiyabe 2, Inyo 5, Tahoe 173, Lake Tahoe Basin Management Unit 14, Plumas 254, Eldorado 202, Stanislaus 234, Sierra 226, and Sequoia 148. This results in a sub-total for Forest Service Sierra Nevada lands of 1,399 sites. The number of territories per national park was as follows: Lassen 6, Kings Canyon 19, Sequoia 50, and Yosemite 54. Fourteen territories were recorded on BLM land in the Sierra Nevada. Three territories were on State parks, 1 was on CDF land, and 4 are on CSLC land. One territory was on Native American land, and 314 were on private lands. Thus, as of 2003, the total number of California spotted owl sites known in the Sierra Nevada was 1,865 (Service 2002). Again, however, as discussed above, only a portion of these territories are occupied in any given year. The Forest Service has not updated these figures since 2003. However, as discussed below in the “Declining Populations” section, current data indicate that on two of the study areas on Sierra Nevada national forests, populations have declined by approximately 10 percent since 2003 (Conner et al. 2013), and on the other study area on Sierra Nevada national forest lands the decline has been approximately twice this level since 2003 (Tempel and Gutiérrez 2013, Tempel 2014). Based on these declines, the number of territories periodically occupied may be as low or lower than approximately 1,600 in the Sierra Nevada.

Because of the size of the owls’ home ranges, a given home range may occur across different ownerships. For instance, the Forest Service reported that over 15 percent of 135 Forest Service spotted owl sites analyzed had greater than 15 percent of their likely home range on private lands (USFS 2001).

In the Sierra Nevada, at least 6 timber companies (W.M. Beaty and Associates, Inc.; Collins Pine Company; Fruit Growers Supply Co.; Roseburg Resources Co.; Sierra Pacific Industries (SPI); Soper-Wheeler Co.), as well as Southern California Edison, own or manage the vast majority of California spotted owl habitat on private lands. SPI has reported more than 200 California spotted owl territories on their lands (Steve Self, SPI, in litt. 2005). There are 36 records of nest sites within 4.8 km (3 mi) of W.M. Beaty-managed lands, and three nest sites either on or immediately adjacent to W.M. Beaty managed lands (Bob Carey, W.M. Beaty, in litt. 2005). There were no known spotted owl territory-centers or nests on lands owned by Fruit Growers as of 2006 (John Eaker, Fruit Growers, in litt. 2006) (Spotted owl territory-centers are typically the

locations of nest trees, but if that information is unavailable, they are sometimes recorded as the locations where fledgling owls were found, locations where a pair was detected, or locations where a single owl was detected). There were 40 spotted owl territory-centers situated either on or within 1.6 km (1 mi) of the land owned by Soper-Wheeler as of 2006 (Paul Violett, Soper-Wheeler, in litt. 2006). There were no known California spotted owl territory-centers or nests on lands owned by Collins Pine, and there are fewer than 10 territory-centers or nests immediately adjacent to their lands on national forest land, as of 2006 (Jay Francis, Collins Pine, in litt. 2006). There are no known California spotted owl territory-centers or nests on Roseburg Resources lands as of 2006, but there were four territory-centers or nests within 0.8 km (0.5 mi) of their boundaries (Rich Klug, Roseburg, in litt. 2006). Southern California Edison manages approximately 20,000 acres that is within the range of the CSO in the southern Sierra Nevada near Shaver Lake.

Coast Ranges and Southern California

Estimates for total number of spotted owl territories in southern California include 440 (Service 2002), 547 (Verner et al. 1994a), and 578 (Beck and Gould 1992). In southern California, spotted owls occupy “islands” of high-elevation forests separated by lowlands of chaparral, desert scrub, and, increasingly, human development (Noon and McKelvey 1992, LaHaye et al. 1994). The islands comprise 15–20 populations with 3–270 individuals per population. Islands are separated from each other by 10–72 kilometers (km) (6 to 45 miles (mi)) (Verner et al. 1992a, Gutiérrez 1994, LaHaye et al. 1994). These populations appear to be isolated from one another; no inter-mountain movements were documented for any of the 478 juvenile California spotted owls banded in the San Bernardino Mountains (LaHaye et al. 2001). Using the most recent estimate of 440 total territories for southern California, the known territories on national forests were as follows: 109 on the Los Padres, 64 on the Angeles, 138 on the San Bernardino, and 18 on the Cleveland (Service 2002). As of 2011, the number of territories on the San Bernardino was 168 (Lee et al. 2013) (again, as discussed above, this does not represent an increase in occupied territories within a given year but, rather, a cumulative increase in the number of areas that have been occupied in at least one year since surveys began). In 2002, there were 2 territories known on BLM land, 8 on State park lands, 6 on Native American lands, and 95 on private lands. In addition, there is one known territory in Mexico (Service 2002; see below). These 441 territories in southern California and Mexico comprise 19 percent of the total or approximately 2,300 to 2,400 California spotted owl territories. These figures have not been updated by the Forest Service since 2003. However, as discussed below in the “Declining Populations” section, current data indicate a population decline of approximately 20 percent since 2003 (site occupancy of 0.62 declining to 0.50). Therefore, the current number of sites in southern California and Mexico may be under 400.

Within the California coastal and inland mountain ranges where California spotted owls occur (San Bernardino, San Gabriel, San Jacinto, Castaic, Santa Ana, and Santa Lucia mountains and

San Diego/Peninsular, and Los Padres Ranges), an area of just over 2,428,068 hectares (ha)—or approximately 6 million acres (ac)—was assessed for all habitats by the Forest Service (Stephenson and Calcarone 1999). Land ownership in the assessment area is National Forest (57 percent), private (33 percent), BLM (4 percent), Native American (3 percent), State (2 percent), military (1 percent) and local (1 percent). Not all of the analysis area was suitable spotted owl habitat (mixed-conifer and mixed-conifer/hardwood), thus the portion of the total owl population or sites known on federal lands as determined in Verner et al. (1992a) and Gutiérrez (1994), was higher (75 percent) than their relative ownership in the assessment area (62 percent).

The range of California spotted owls in southern California is disjunct from that in the Sierra Nevada range as a result of natural topographic and manmade factors (Stephenson and Calcarone 1999). Within this southern range, habitat and spotted owls are distributed discontinuously across the landscape reflecting natural vegetation breaks, topographic conditions, and human-induced habitat disturbance and fragmentation (Noon and McKelvey 1992). The spotted owls in the southern portion of the range may function as a meta-population, with separate subpopulations connected by infrequent but persistent interchange of individual owls (Noon and McKelvey 1992, LaHaye et al. 1994).

Mexico

In 1887, A.W. Anthony reported seeing a spotted owl in the Sierra San Pedro Martir mountains of northern Baja California, Mexico (Bryant 1889), and, a few years later, may have had a second sighting in the same area (Anthony 1893). Wilbur (1987) stated that the only other records of spotted owls in Baja California were from the La Grulla area, also in northern Baja California, in 1925 and 1972.

Overall

As of the Service's 2006 finding, a total of 2,306 California spotted owl territories had been documented, 1,865 (81 percent) of which were in the Sierras (Service 2006). Because, as discussed above, approximately 53–77 percent of potential territories are actually occupied at any point in time, an approximate population estimate for the subspecies is 1,222 to 1,776 pairs or resident individuals as of several years ago. However, populations have declined further since then (generally 10–15 percent), as discussed above and below. Therefore, the current population is likely to be 10–15 percent lower than the 1,222 to 1,776 pairs or resident individuals noted above.

Population Trends and Demographic Analyses

Declining Populations

In the FWS' 2006 determination on the California spotted owl listing petition, the FWS relied substantially upon the finding that "spotted owls in the Sierra Nevada have shown increased survival during the past 16 years, and with the exception of one study area which showed a decline that was not statistically significant, spotted owl populations in the Sierras are not declining." 71 Fed. Reg. 29900-01 (2006). Substantial scientific data have accumulated since 2006 which make clear that California spotted owl populations are indeed declining, as discussed in detail below.

As one of the most intensively studied birds in the United States, the spotted owl has been the focus of research for well over three decades. Many sophisticated statistical techniques for estimating population trends have been developed and used to provide information for the California subspecies, including local population trends. Across the range of the California spotted owl, five long-term demography study areas (Lassen, Eldorado, Sierra, Sequoia-Kings Canyon, and San Bernardino), totaling about 2,200 square miles (1,408,000 acres), were established in the late 1980s and early 1990s to examine the subspecies' population status. This research serves as a valuable resource for evaluating whether or not listing under the ESA is warranted as it reflects how the ongoing threats to the species are affecting the population in five large study areas that span the species' range. This section offers a synopsis and evaluation of the most current research on California spotted owl population trends. Because analytical techniques for assessing population status are complex, it is necessary to discuss the techniques, the studies, and their conclusions in some detail.

Several analytical methods have been applied to the analysis of population trend in spotted owls, and each method carries certain strengths and weaknesses. Thus, to best understand population trends, it is important to concurrently assess the results of all methods instead of relying on a single analytical approach. One of the simpler methods uses raw empirical abundance data, where banded owls are counted and numbers are compared over time. Population trends can then be crudely assessed by evaluating abundance data from one year against similar data from a later year, or multiple years of data can be used in a regression analysis to determine the population trend from the slope of a regression line.

While count data may appear straightforward, they are often subject to important sources of unquantifiable bias if the ability to detect owls changes from year to year. This can occur if survey effort changes over the course of the study or if the study area changes in size during the study period. Also, variation in detectability can be caused by environmental or behavioral factors. Numerous sources of possible bias can be present during the collection of abundance data in the field, especially over the long periods of time required to evaluate population trends

in long-lived species such as spotted owls. However, basic abundance data can provide a reference point for comparison with the results of more sophisticated statistical methods, especially when possible error is reduced by careful data collection and accounting for sources of variation during analysis. Abundance data are available for each of the California spotted owl study areas, and were included in past evaluations by the Service.

Because of the problems that accompany abundance data, scientists have developed more sophisticated methods for estimating population trends that can be described in statistical terms, and which allow various statistical tests of the estimated population trend. These methods derive estimates of the annual rate of population change, otherwise known as lambda (λ_t), which is the fundamental measure for retrospective estimation of population trend. Varying analytical methods derive λ from data on vital rates (i.e., birth and death rates). Reproductive output is measured from direct observation of the number of young leaving the nest, and estimates of survival are obtained using mark-recapture techniques. Capture-recapture theory (Lebreton et al. 1992) provides the foundation for deriving a statistical estimate of survival and population trend. In brief, this is done by capturing and uniquely marking individuals, and then recapturing (or resighting) those same individuals in subsequent years (Lebreton et al. 1992). Some of the potential bias factors remain, such as variation in survey effort, but the recapture history for each marked individual serves as the basis for calculating vital rates for each age and gender class. After both fecundity (i.e., birth rate: number of female young fledged per female) and survival are statistically estimated from field sampled data, those estimates are used to compute the finite rate of population change, or λ .

Lambda provides an estimate of two useful measures: the direction in population trend and the magnitude of population change (Franklin et al. 1996). A λ value equal to 1.0 indicates a stationary population; less than 1.0 indicates a declining population; and greater than 1.0 indicates a growing population. The amount by which λ differs from 1.0 indicates the magnitude of the trend (i.e., if $\lambda = 1.10$, the population has increased by an average of about 10 percent each year [$1.10 - 1.0 = 0.10$]). However, λ is a point estimate, and this estimate has a measure of precision. Therefore, researchers often test whether λ is significantly greater or less than 1.0, or equal to 1.0. For example, a $\lambda = 0.97$ may not be statistically different from 1.0 at some predetermined significance level if the confidence interval (CI) includes 1.0 (Lande 1988), based upon the older statistical approach under which an effect (e.g., a trend) is not deemed to occur unless it is ≥ 95 percent certain to be the result of factors other than random chance. This means, however, that true declines (that are, perhaps, as much as 80 percent or 90 percent certain to be occurring) are often not treated as actual trends, even as a rare and imperiled species may decline toward extinction. As noted in Conner et al. (2013), with this methodology, the influence and probability of a Type II error (inability to detect a decline or change) cannot be eliminated from the interpretation of no decline.

Spotted owl population growth rates are more sensitive to some demographic parameters than others: λ is most sensitive to survival of owls > 1 year old (Φ), Φ shows low temporal variability relative to reproductive rate, and reproductive rate is more strongly influenced by stochastic variability than Φ (Lande 1988, Noon and Biles 1990, Franklin et al. 2000, Seamans and Gutiérrez 2007b).

It is possible to use annual estimates of λ_t to find the realized change in population (Δ_t) over a given time period. The realized change represents the proportion of the initial population size remaining each subsequent year (Franklin et al. 2004). This metric is a re-expression of the estimates of the annual change in numbers of owls on each study area (λ_t), as the proportional change in the number of owls without having to rely on estimation of population abundance (Franklin et al. 2004).

It should be noted that the estimates of λ and $\Delta \lambda$ apply only to the period during which the data are collected. For this reason, and the fact that spotted owls are relatively long-lived species with low fecundity, long-term studies are necessary to avoid misinterpretation of apparent trends. For instance, if a population demonstrates cycles that are completed over multiple decades, ten years of data may only capture a down cycle or up cycle, depending on the timing of the study. Fortunately, data are available for more than ten years for all five of the California spotted owl demography study areas.

Four different statistical methods have been used to estimate population trends of California spotted owls within the demography study areas (although every method was not necessarily used on every study area). Below we describe each method:

(1) Projection Matrix—The earliest methods derived survival and fecundity estimates for females using a projection matrix to solve for λ (see Franklin et al. 1996). Several issues potentially affect the validity of the projection matrix approach to calculating λ . First, all study areas with the exception of the San Bernardino were considered open populations. Individuals, particularly juveniles, may emigrate to areas outside the study area boundaries, and even though they could still be alive, these individuals would have been considered mortalities because they disappear from the study area, resulting in a survival rate that may be biased low in the projection matrix method (Raphael 1996). To better understand the possible error in juvenile mortality rates, researchers compared the observed mortality rate with calculated theoretical rates that would be necessary for a stable population, and examined the difference. Although useful in some respects, this exercise does not alter the estimate of λ for the subject owl population. The issue of juvenile emigration was addressed in the 1999 meta-analysis for the northern spotted owl, as well as for some of the individual northern spotted owl study areas, and overall trend estimates were adjusted for juvenile emigration (Franklin et al. 1999).

Another potential problem regarding the projection matrix method is that the calculation includes only territorial birds (which are relatively easy to locate), ignoring non-territorial “floaters” that may be present but undetected; these birds may be available to fill vacancies left by the eventual mortality of breeding birds (Franklin 1992). Trends in the non-territorial segment of the population cannot be evaluated with the projection matrix method, although it is likely that over the long term, trends in the territorial and non-territorial segments will follow similar trajectories, since they both depend on similar environmental conditions.

(2) Pradel Method—As projection matrices might potentially bias results of spotted owl population trends because they do not account for movement of spotted owls in and out of the population, in 2002 the data from the five study areas were reanalyzed for each study area and in a meta-analysis framework using another statistical method (see Franklin et al. 2004). To eliminate a possible bias in projection matrix estimates of λ due to possibly inaccurate rates of survival (resulting from unknown emigration rates), a new technique was used to calculate λ , called the “temporal symmetry capture-recapture model” (Pradel 1996). Pradel’s method calculates the rate of change in population size between two successive years using mark-recapture histories for each owl, and since this technique calculates annual estimates, λ can change each year. In contrast, the projection matrix method calculates an average λ estimate for the period of study using a population’s average birth and death rates. Pradel’s measure applies to subadult and adult territorial owls, and incorporates birth, death, emigration, and immigration rates. Estimates of juvenile survival are unnecessary because movement of spotted owls into and out of the study area is considered in changes of owl numbers over time. The meta-analysis of adult survival was based on female and male adult capture histories for the five study areas, but fecundity was estimated for each study area separately because differences existed in field sampling protocols (Franklin et al. 2004).

If a population is stable, it is important to know if the stability is a result of immigration or new recruits from births in order to understand the health of the local population (Franklin et al. 2004). Thus, it is important that trends in survival and fecundity rates be examined concurrently with assessments of λ . Pradel’s λ provides information as to whether owls are being replaced from within or outside the study area, and not solely whether they are replacing themselves, which is the goal of the projection matrix approach. Because the Pradel method provides an estimate of one λ for each year, the annual λ estimates can themselves be assessed for trends, and a mean estimate can be calculated for the period of study.

Franklin et al. (2004) applied the Pradel method to each of the five individual study areas, and conducted a combined meta-analysis of the results from the five study areas (Lassen, Eldorado, Sierra, Sequoia / Kings Canyon, and San Bernardino). Since survey areas

changed throughout the course of some studies, only those areas (within larger study areas) that received surveys from start to finish were included in the new analysis, and only years that received consistent survey effort were used in the analysis (Lassen study area [490 mi²]: 1992 to 2000; Eldorado study area [137 mi²]: 1990 to 2000; Sierra study area [137 mi²]: 1990 to 2000 Sequoia and Kings Canyon study area [132 mi²]: 1991 to 2000; San Bernardino study area [730 mi²]: 1991 to 1998).

An additional meta-analysis incorporated data collected from 1990 to 2005 in four study areas in the Sierras (Blakesley et al. 2010). The San Bernardino study area was not included in this analysis because there was a gap in survey data after 1998. This new meta-analysis used methods similar to those used in Franklin et al. (2004), but incorporated many improvements. Further, at the request of the Service, the 2010 analysis also included population viability analyses (PVA).

Recent studies have also used Pradel's temporal symmetry model to estimate the annual rates of population change and realized population changes using data from 2006 onwards on the southern Cascades and three Sierra Nevada study areas (Lassen, Sierra, Sequoia and Kings Canyon: Munton et al. 2012, Conner et al. 2013; Eldorado: Gutiérrez et al. 2012, Tempel and Gutiérrez 2013).

(3) Markov Chain Monte Carlo—Using Bayesian Markov chain Monte Carlo (MCMC) methods, a posterior distribution of realized population change (Δ_t) can be used to estimate any probability of population decline. The posterior distribution of Δ_t provides a robust method for detecting and describing retrospective population trajectories, similar to how PVA and, more generally, projection models are used to evaluate potential prospective population trajectories (Conner et al. 2013).

The inclusion of sampling variation in estimates of the annual rate of population change (λ_t) can negatively bias estimates of Δ_t , similar to how it can negatively bias estimates of persistence in PVA models. Bayesian MCMC methods can be used to separate process variation from sampling variation during the estimation of Δ_t . In addition to Bayesian MCMC methods, a random effects estimator, also called a shrinkage or empirical Bayes estimator, is an analytical approach to separate sampling variation from the overall process variance (Burnham and White 2002). Depending on computing tools available, both approaches can be used for estimating λ_t and Δ_t . Conner et al. (2013) utilized these methods to estimate population trends from 1990–2011 for the Lassen, Sierra, and Sequoia and Kings Canyon study areas.

(4) Occupancy Modeling—Statistical methods have been developed for using presence-absence survey data to estimate site occupancy and local rates of local extinction and colonization while accounting for imperfect detectability (MacKenzie et al. 2003, 2006, Kendall et al. 2009). MacKenzie et al. (2003, 2006) describe the use of a computer

program called Presence (Hines 2006) to fit models and estimate survey-specific detection probabilities, initial occupancy, and annual probabilities of colonization and local extinction.

Tempel and Gutiérrez (2013) tested the efficacy of using occupancy data as opposed to mark-recapture data to infer population status. They compared long-term trends (1993–2010) in the finite annual rate of population change (λ_t) and the realized change in population (Δ_t) estimated from both occupancy and mark-recapture data, from California spotted owls in the Eldorado Study Area. They considered each owl territory a site, so the sampling population was similar for both types of data (i.e., all territorial adults on the study area vs. all owl territories). They found similar population trajectories using both methods, indicating that presence-absence data can provide reliable information about population trends. Lee et al. (2012, 2013) also used occupancy data to estimate local rates of extinction and colonization (i.e., by site) in burned and unburned California spotted owl sites in the Sierra Nevada and southern California. These data could be used to examine population trends over the studied time period.

Previous analyses on the five demographic study areas estimated fecundity, apparent survival, and population rate of change, and were discussed in the Service's 2003 and 2006 findings. Franklin et al. (2004) conducted the first meta-analysis of California spotted owl demography studies that examined reproductive output, apparent survival, and population rate of change on five study areas, using data from 1990 through 2000. A second meta-analysis (Blakesley et al. 2010) reported demographic results through 2005 for the four study areas in the southern Cascades and Sierra Nevada, California. Franklin et al. (2004) and a 2006 draft version of Blakesley et al. (2010) were also discussed in the Service's findings.

Since the time of the Service's previous findings on the population trends of California spotted owls (2003 and 2006), new studies have used mark-recapture data collected from 2006 to 2010 or 2011 to update estimates of individual study area demographic rates on the Lassen, Eldorado, Sierra, and Sequoia-Kings Canyon demography study areas (Munton et al. 2012, Conner et al. 2013, Gutiérrez et al. 2012, Tempel and Gutiérrez 2013, Tempel et al. 2014a). Additionally, one study has estimated occupancy rates in the San Bernardino demography study area in southern California using presence-absence surveys conducted from 2003 to 2011 (Lee et al. 2013). These recent studies strongly indicate population declines on four of the five study areas: the Lassen, Eldorado, Sierra, and San Bernardino study areas. Only the population in the Sequoia and Kings Canyon study area (in the national park, which is protected from logging) appears to be stable or increasing. The following discussion details the results from the various methods of estimating population trends: the Projection Matrix analyses, the Pradel Method, the Markov Chain Monte Carlo method, and Occupancy Modeling. First, we briefly repeat the earlier results from individual study areas as they were presented in the Service's 2003 and 2006 findings, after which we describe the recent results from the latest scientific reports and

publications. We also repeat the results from the two meta-analyses of the combined Sierra Nevada study areas as they were presented in the Service's 2003 and 2006 findings, with additional information available in Blakesley et al. (2010).

Lassen Study Area

The Lassen study area (LAS) encompasses approximately 2,200 km² (850 mi²) in northeastern California, the majority of which is located in the Lassen National Forest. The study area is in the southern Cascades, but was included in the Sierra Nevada province by the U.S. Forest Service for management purposes (USFS 2004). Small segments of the study area include the Plumas National Forest, private timber lands, Lassen Volcanic National Park, and Bureau of Land Management land. Population trends on the LAS study area were evaluated as part of meta-analyses conducted in 2001, 2010, and 2013, all three of which showed population declines (Blakesley et al. 2001, Blakesley et al. 2010, and Conner et al. 2013).

Blakesley et al. (2001) covered 10 years of field sampling (1990 to 1999), during which the annual rate of population change was estimated to be 0.910 using the projection matrix method. This estimate was significantly less than that of a stationary population ($\lambda = 1.0$), and suggested that the territorial female owl population (those females that occupy and defend a habitat area) declined 9 percent annually from 1990 to 1999. Blakesley et al. (2001) inferred that if the conditions present during their study remained constant into the future, and if the true rate of change were as low as 4 percent instead of the estimated 9 percent, that the population would decline by one-half within 20 years.

Blakesley et al. (2001) suggested that while incorrect juvenile emigration rates may have resulted in a survival estimate biased low, the magnitude of the bias was probably small. For the Lassen population to demonstrate a stationary trend during the study period (given that all other vital rates were accurate, including an adult survival probability of 0.827), the juvenile survival rate would have to more than double (from the estimated 0.333) to 0.790, which is unlikely.

Blakesley et al. (2010) expanded the analysis to include 15 years of surveys (1990 to 2005) and a somewhat larger area encompassing 1,471 km². In this updated analysis, the mean λ estimate was 0.973 with a 95 percent CI of 0.946 to 1.001, strongly suggesting a declining population (Blakesley et al. 2010; Table 16 at page 24).

Using an additional six years of spotted owl data from the LAS, Conner et al. (2013) found further support for a declining population. Utilizing the same statistical methodology (Pradel's temporal symmetry models) and study area as the two previous meta-analyses, Conner et al. (2013) used individual encounter histories of 323 banded owls from the LAS to estimate the annual rate of population change (λ_t) and realized population change (Δ_t) with data from 1990 to 2011. The authors estimated the mean rate of population change ($\bar{\lambda}$) using a fixed-effects model.

Using the same model, they also used a mixed-model approach to estimate mean rate of population change ($\bar{\lambda}$) and its temporal process variation ($\hat{\sigma}_{temporal}^2$) and to generate random effects estimates of λ_t . Parameters for apparent survival and resight probability were considered fixed effects, and rate of change was a random effect. The authors also used Markov Chain Monte Carlo sampling to estimate posterior distributions of λ_t ($\lambda_{t\text{MCMC}}$) and determine the probability of decline during the period of study.

For all three estimates (Fixed Effects = FE, Random Effects from a Mixed Effects model = RE, and Bayesian Markov Chain Monte Carlo = MCMC), estimated mean lambda was <1.0 for the LAS, which suggests a declining population. The estimate of mean annual rate of population change ($\bar{\lambda}$) was 0.985 (95% CI = 0.950 to 1.022) with the FE model; 0.987 (95% CI = 0.967 to 1.008) with the RE model, and 0.986 (95% CI = 0.880 to 1.072) with the MCMC model. As shown in Figure 2 below, the annual pattern of λ_t was the same between the fixed effects, random effects, and MCMC estimates. The MCMC estimates of median $\lambda_{t\text{MCMC}}$ had smaller and more consistent credible intervals than fixed effects confidence intervals (Fig. 2).

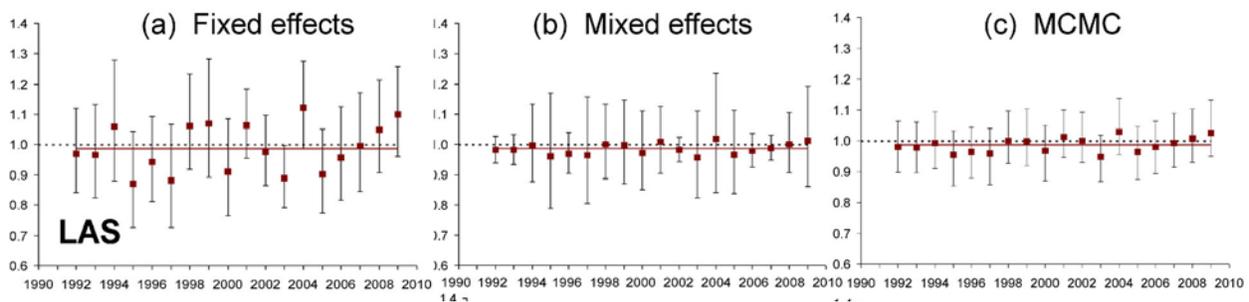


Figure 2. Estimates of annual rate of population change (λ_t) and 95% confidence intervals based on (a) fixed effects estimates, (b) random effects estimates from a mixed effects model, and (c) a Bayesian Markov Chain Monte Carlo (MCMC) approach for California spotted owls on the Lassen study area [LAS] in the southern Cascades, California, 1992–2010. Solid lines indicate best estimates of mean λ from a mixed effects model for each study area. Authors used the root means squared error for 95% confidence intervals for random effects estimates, and show the median and 2.5 and 97.5 percentiles for MCMC methods. From Conner et al. 2013; Figure 2 on page 5.

Credible intervals of estimates of median $\Delta_{t\text{MCMC}}$ started out smaller than CIs of $\hat{\Delta}_t$ (Fig. 3 below), but grew to be approximately the same size by the end of the monitoring period. All of the estimates of realized population change Δ_t suggest that the population of spotted owls in the LAS declined over the study period. Conner et al. (2013) stated on page 5 that “*over the 18-year study period, the different estimators of Δ_t indicated population declines of 21–22% for the Lassen Study Area*” (emphasis added).

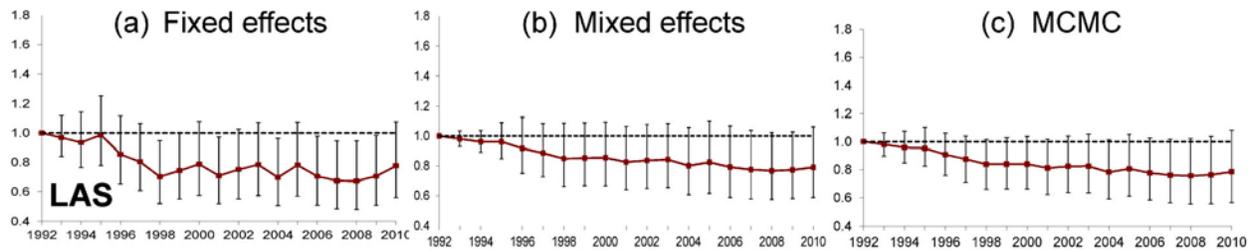


Figure 3. Estimates of realized population change (Δ_t) and 95% confidence intervals based on (a) fixed effects estimates, (b) random effects estimates from a mixed effects model, and (c) a Bayesian Markov Chain Monte Carlo (MCMC) approach. Data are from California spotted owls on the Lassen study area [LAS] in the southern Cascades and Sierra Nevada, California, 1992–2010. Authors used the root means squared error for 95% confidence intervals for random effects estimates, and show the median and 2.5 and 97.5 percentiles for MCMC methods. Realized population change is the proportion of the initial population size remaining each year. From Conner et al. 2013; Figure 3 at page 6.

Additionally, based on the posterior distributions of $\Delta_{t, \text{MCMC}}$, the authors calculated a 0.69 probability that the Lassen owl population declined by more than 15 percent over the past 18 years. Further, the probability that this population declined by > 30 percent was 0.24, with only a 0.07 probability that the population was stationary or increasing. Figure 4 below depicts the population trajectories of populations on three of the demography study areas.

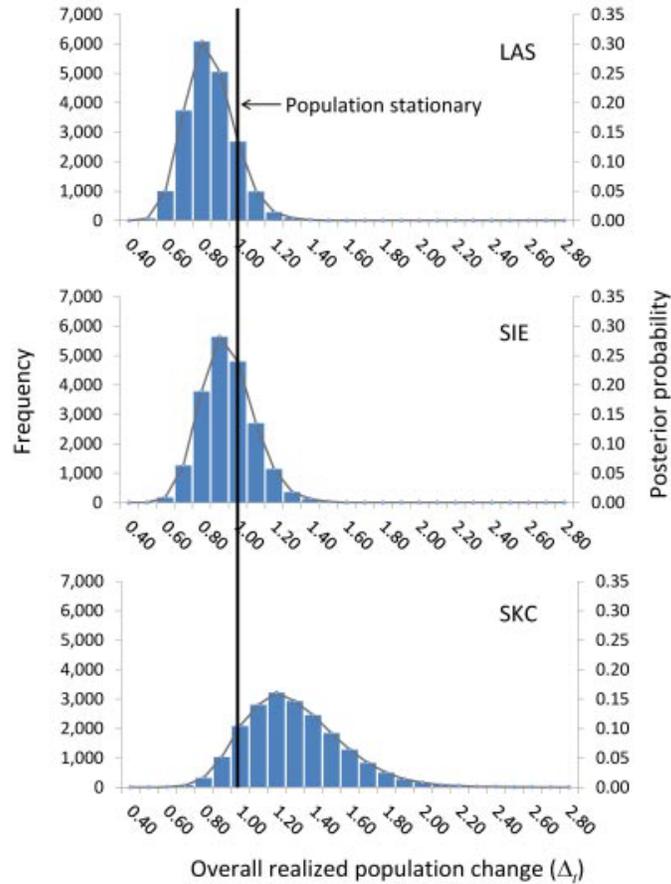


Figure 4. Estimated posterior distributions of overall realized population change (Δ_t) based on posterior distributions of λ_t from 20,000 Markov Chain Monte Carlo (MCMC) simulations. Data are from California spotted owls on 3 study areas (Lassen [LAS], Sierra [SIE], and Sequoia Kings Canyon [SKC]) in the southern Cascades and Sierra Nevada, California, 1992–2010. Authors excluded the first 2 and last estimates because of confounding or potential bias. Overall realized population change is the proportion of the initial population size remaining at the end of the monitoring time period. From Conner et al. 2013; Figure 4 at page 7.

No analysis of population trends conducted in the Lassen Study Area has ever resulted in a positive estimate of lambda for this population of California spotted owls. These estimates using the most up-to-date survey data available in the Lassen Study Area provide the strongest evidence yet that there have been declines in the number of California spotted owls holding territories within the study area over the past two decades.

Eldorado Study Area

The Eldorado study area (ELD) consisted of two segments: a 355-km² (137-mi²) density study area, and a 570-km² (220- mi²) regional study area: the EDSA and RSA together encompass an area of approximately 925 km². The study area is located primarily within the Eldorado National

Forest, the Tahoe National Forest, and the Tahoe Basin Management Area, although 37 percent of the ESDA consists of private land.

Seamans et al. (2001a) covered 10 years of field sampling (1990 to 1999). Surveys took place from 1986 in the density study area, and surveys in the regional study area were initiated in 1997. Only data from 1990 to 1999 were used because survey effort and sample sizes increased dramatically after 1989 due to increased funding (Seamans et al. 2001a). Researchers lacked sufficient data to calculate the juvenile survival rate on the Eldorado study area, so they used the survival rate from the nearby Lassen study area (0.333) as a surrogate. This estimate was thought to be optimistic, as estimates of northern spotted owl juvenile survival from 11 study areas averaged 0.258 (Forsman 1996), and in the Eldorado study area, 11 of 147 individuals banded as juveniles were recaptured as territory holders, which would translate to a survival probability of 0.074 (Gutiérrez et al. 2001). However, the estimated juvenile survival of 0.258 for northern spotted owls might also be underestimated, as it was not corrected for juvenile emigration. A later report (Franklin et al. 1999) adjusted juvenile survival estimates in three northern spotted owl study areas to reflect juvenile emigration rates calculated from radio-telemetry data. The adjusted juvenile survival rates were 0.598, 0.632, and 0.366. These estimates represented increases of 137.2 percent, 41.8 percent, and 87.9 percent in juvenile survival estimates for each respective study area.

Using the projection matrix approach, the annual rate of population change was estimated to be 0.948, which was significantly less than that of a stationary population. This λ value suggested that the territorial female owl population declined 5.2 percent annually from 1990 to 1999. In contrast, female abundance at the start (1990) and finish (1999) of the study was 26 and 28 individuals, respectively. This difference between the estimated λ and the rate calculated from actual numbers could be attributed to immigration of individuals into the study area. If true, this would indicate that individuals were not replacing themselves, but were being replaced by recruits from outside the study population. Earlier estimates of λ from this study area calculated similar trends ($\lambda = 0.947$) using only six years of data (Noon et al. 1992). This six-year estimate was not statistically less than 1.0 (using 95% CI), but the power (ability to detect differences) of this test was low, so the trend of the population was uncertain at the time (Verner et al. 1992). Results from the 2001 study (Seamans et al. 2001a) expanded the sample size and study period, and increased the statistical power of their test so that their estimate of lambda (0.948) was then found to be statistically less than 1.0.

In a subsequent report (Seamans et al. 2001b), the projection matrix estimate of λ was compared to a growth rate calculated from actual numbers of adult females present during the study. The growth estimate from actual numbers was 0.951, and was significantly less than zero. This estimate was calculated using data from 1993 (37 adult females) to 2000 (24 adult females), while the value derived from the projection matrix approach (0.948) was calculated using data from 1990 to 1999. Another study using data from 15 years of surveys (1990 to 2004) of 246

banded spotted owls, including 125 adult females on the Eldorado Study Area (Seamans and Gutiérrez 2007b), found that survival of juvenile owls and owls ≥ 1 year old (Φ) showed far less temporal variability than reproductive output. Survival of older owls most strongly affected population growth rates, while juvenile survival and reproductive output had less effect, but reproductive output had a large influence on the temporal variation in population growth rate.

Seamans and Gutiérrez (2007b) revealed that survival of non-juvenile owls (Φ) and reproductive output were both related to environmental conditions. The Southern Oscillation Index (a measure of El Niño or La Niña) just prior to winter reduced survival of non-juvenile owls, such that owls experienced high survival when conditions were neutral: neither El Niño nor La Niña. Reproductive output was negatively correlated to the SOI in the winter just prior to nesting. Reproductive output also declined with decreasing temperature and increasing mean daily precipitation during incubation. Reproductive output was greatest when conditions during incubation were mild (low precipitation and minimum energy requirement) and also, oddly, when conditions were severe (high precipitation and maximum energy requirement) although the increases under severe conditions were very slight compared with the increases under mild conditions. The top model indicated a negative trend in λ_t which varied with the quadratic form of the SOI just prior to winter, suggesting population growth rate was greatest when conditions were neutral: neither El Niño nor La Niña (see Fig. 5 below). Further, this study demonstrated that juvenile survival and especially reproductive output contributed more than previously estimated to annual variation in λ . Habitat quality can moderate or mitigate the effect of weather to varying degrees and affect the average productivity of a site. Therefore, management should increase reproductive output while not reducing survival of non-juvenile owls. In sum, Seamans and Gutiérrez (2007b) concluded that weather patterns that affected both survival of owls ≥ 1 year old (the SOI) and R (conditions during the incubation period) influenced variability in λ .

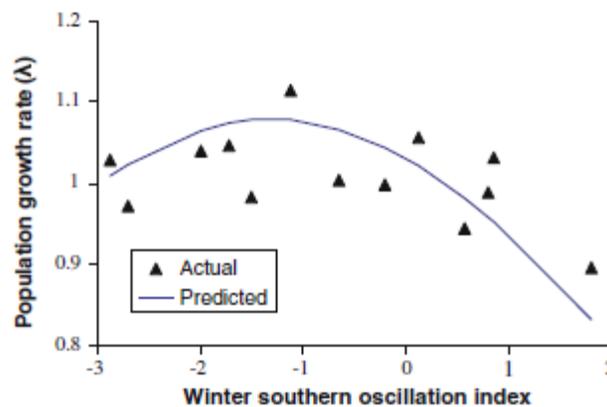


Figure 5. Actual (filled triangles) and predicted (solid lines) annual population growth rate for spotted owls > 1 year old based on capture-recapture data from the Eldorado Study Area, 1990–2004. Actual values are mean estimates for each year from a random effects means model.

Predicted values are from a weather model containing the quadratic form of the SOI for winter. From Seamans and Gutiérrez (2007b); Figure 3 at page 65.

The first meta-analysis for this study area (Franklin et al. 2004) included 11 years of sampling (1990 to 2000) and encompassed the EDSA. The mean λ estimate for this study area was greater than 1.0 (1.042), and was not statistically different from that of a stationary population ($\lambda = 1.0$), but nevertheless showed the steepest decline of all the study areas over the studied time period (raising a concern that the 95% CI approach may have been incapable, in this instance, of detecting a steep population decline). Examination of annual λ estimates showed a significant decline (see Fig. 6 below), and similar to the Lassen study area, adult apparent survival showed no substantive variation or trends through time. No linear trend in fecundity could be identified.

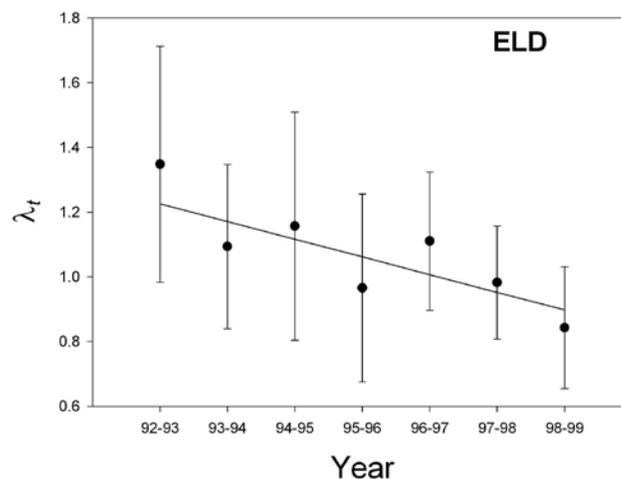


Figure 6. Trends in λ_t for California spotted owls on the Eldorado Study Area in California. Trend lines are from random effects models selected by minimum QAIC_c. Dots, with 95% confidence intervals, are annual estimates of λ_t from the model used to develop the random effects model. From Franklin et al. 2004; Figure 3 at page 25.

The second meta-analysis for the Eldorado Study Area (Blakesley et al. 2010) reported lower point estimates of λ for ELD than that reported in Franklin et al. (2004); lambda showed decreases through the 1999 time period, and then subsequent increases, but it did not increase to the earlier higher estimate (Blakesley et al. 2010). In the PVA, spotted owl populations at ELD were less likely to show declines in populations than were LAS and SIE, but there was still some evidence that a decline might occur; the estimated probabilities of observing a population decline > 10 percent in 7 years was 0.23 (95% CI = 0.00–0.87). Male adult apparent survival was higher than for females, and a troubling result was a decrease in subadult survival over the study period (see Fig. 7 below).

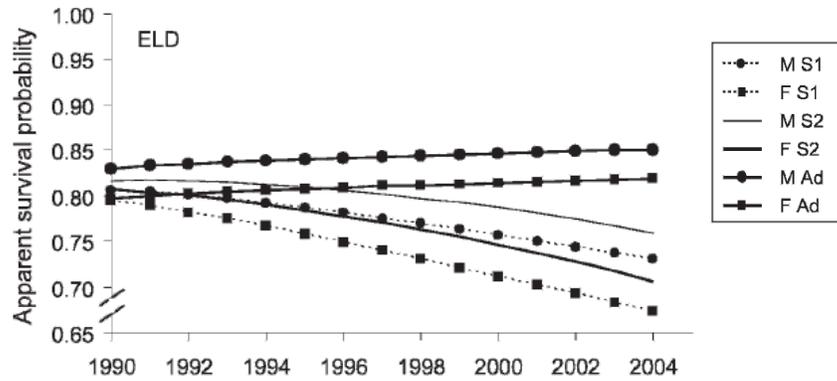


Figure 7. Apparent survival of California spotted owls by age and sex on the Eldorado Study Area in the Sierra Nevada, California, USA, 1990–2004 based on model-averaged estimates from an a priori set of models. S1 = owls that were 1 year old; S2 = owls that were 2 years old; Ad = owls that were > 3 years old. From Blakesley et al. 2010; Figure 2 at page 12.

The ELD also had a negative temporal trend in reproductive output from 1991 to 2005, which was worrisome given that this study population also had the highest reproductive output of the four areas (see Fig. 8).

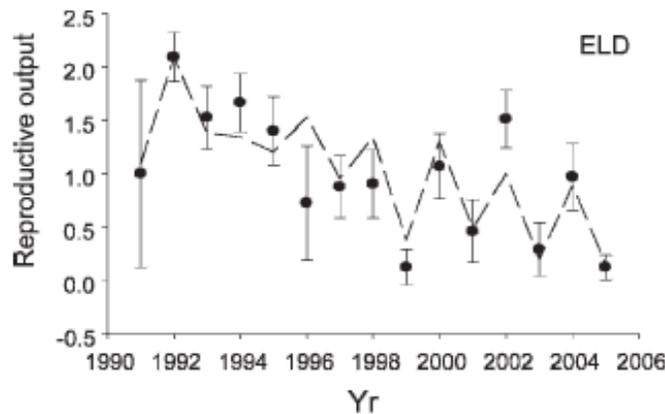


Figure 8. Annual reproductive output (no. of young fledged/female) of California spotted owls on the Eldorado Study Area in the Sierra Nevada, California, USA, 1991–2005 (point estimates and 95% CIs). Dashed lines indicated the best approximating models from mixed-models analyses. From Blakesley et al. (2010); Figure 6 at page 17.

Since the publication of the Service’s 2006 notice, which relied upon the results of Franklin et al. (2004) and a draft version of Blakesley et al. (2010), an additional six years of spotted owl data from the Eldorado Study Area are available and have been analyzed (Gutiérrez et al. 2012) and recently published (Tempel and Gutiérrez 2013). Gutiérrez et al. (2012) is an updated report on

California spotted owl demography in the Eldorado National Forest using the same statistical methodology as Blakesley et al. (2010).

To estimate variation in fecundity, Gutierrez et al. (2012) assessed reproductive status on 539 occasions at 71 territories from 1991–2011. The top-ranked model indicated that fecundity dramatically declined in a log-linear trend over the study period (see Fig. 9 below), varied from year-to-year in an alternating manner, and was negatively related to the proportion of subadults in the female population. To estimate variation in productivity, the authors used 258 occasions when young were successfully fledged at 68 territories from 1991–2011. The top-ranked model indicated that productivity declined in a log-linear fashion over the study period and varied from year-to-year in an alternating manner.

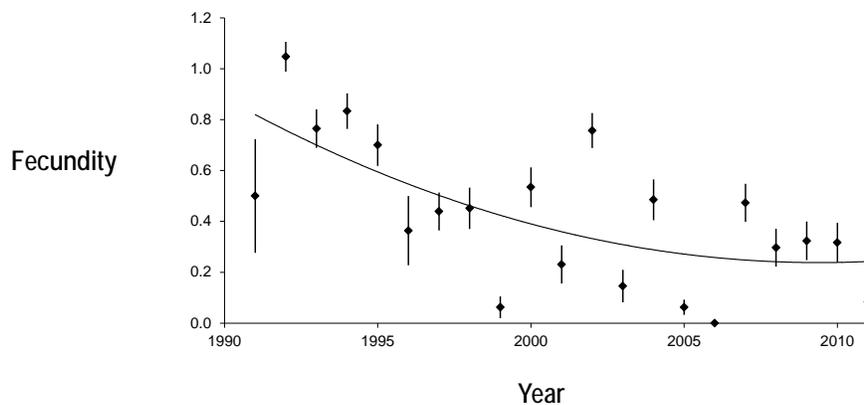


Figure 9. Annual fecundity (# female young per territorial female) of California spotted owls on the Eldorado Density and Regional Study Areas, 1990–2011, in the central Sierra Nevada, California. Error bars represent ± 1 standard error. The solid line indicates the best-fit quadratic time trend. From Gutiérrez et al. 2012; Figure 3 at page 33.

Examination of parameter estimates from all of the models showed that adults always had a higher survival rate than first-year subadults with some models suggesting that adults survived better than both first- and second-year subadults, and males had a higher survival rate than females. These results are similar to those from Blakesley et al. (2010).

Gutiérrez et al. (2012) also examined the percent of surveyed territories that were occupied by spotted owls from 1990 to 2011. The percent of occupied territories declined dramatically (see Fig. 10 below).

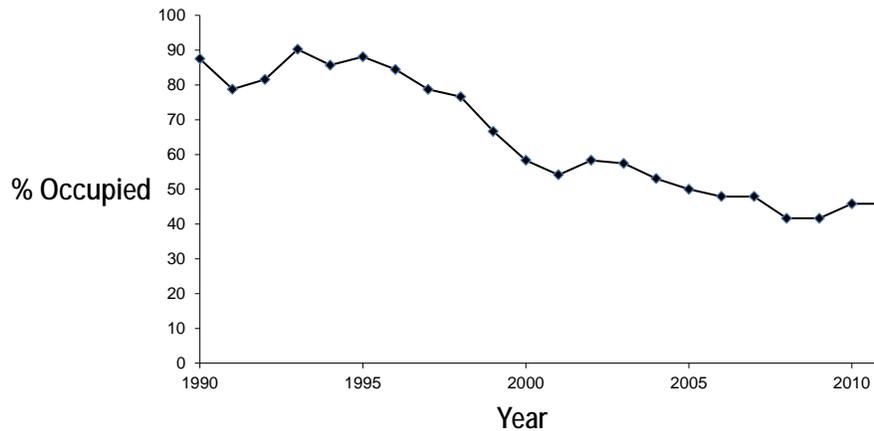


Figure 10. Percent of surveyed territories that were occupied by California spotted owls on the Eldorado Density Study Area, 1990–2011, in the central Sierra Nevada, California. From Gutiérrez et al. 2012; Figure 1 at page 31.

Using capture histories of 232 individuals partitioned by sex to model the population rate of change, Gutiérrez et al. (2012) reported that the top-ranked random-effects quadratic trend model suggested that λ_t was generally lower during the middle years of the study. This result corroborates the results from the earlier meta-analyses where an early negative trend was captured in the Franklin et al. (2004) meta-analysis by a linear model, whereas the increasing trend was captured in the Blakesley et al. (2010) meta-analysis by a quadratic model incorporating five years of additional data. An additional six years of data revealed that λ then exhibited another downward trend (Fig. 11 below). The random-effects means model suggested that the average λ over the study period was < 1.0 , the value for a stable population ($\lambda_t = 0.984$, 95% CI = 0.955 to 1.013). Annual population rate of change exhibited relatively low temporal variability ($\hat{\sigma}_{temporal}^2 = 0.002$, 95% CI = 0.000 to 0.018).

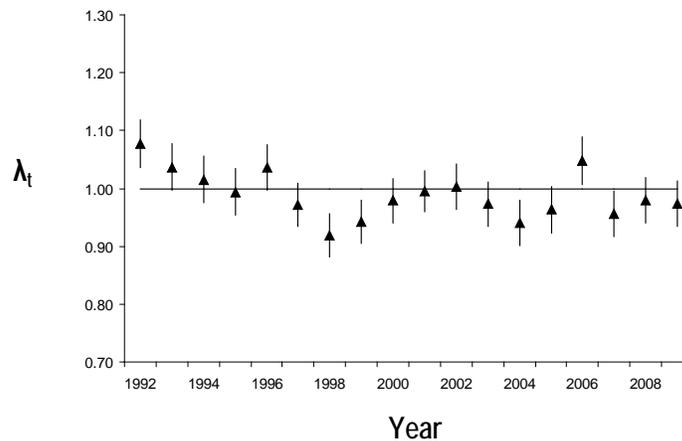


Figure 11. Annual estimates of California spotted owl population rate of change (λ_t) using a modified data set on the Eldorado Density Study Area in the central Sierra Nevada, 1992–2010, using the random-effects means model. Error bars represent ± 1 standard error. Population rate of change for a hypothetical stable population ($\lambda = 1.00$) is indicated by the horizontal line. From Gutiérrez et al. 2012; Figure 5 at page 35.

The estimates of realized population change (which show the proportion of the initial population size remaining each subsequent year) also suggested a decline in owl abundance ($\Delta = 0.81$, 95% CI = 0.54 to 1.22; see Fig. 12 below), similar to the decline in the number of occupied territories (see Fig. 10 above).

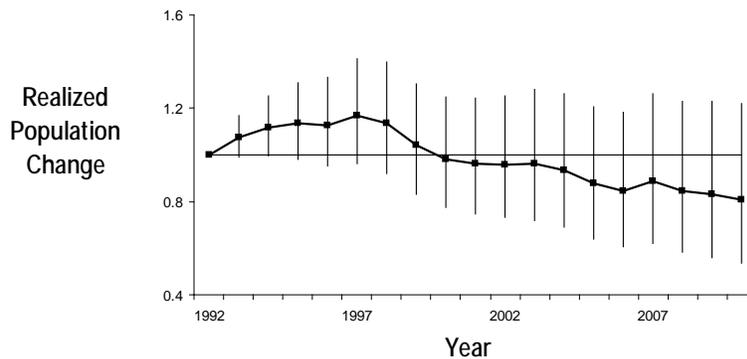


Figure 12. Trend in California spotted owl population size, expressed as realized change, using a modified data set on the Eldorado Density Study Area in the central Sierra Nevada, 1992–2010, using the random-effects means model. Realized change is the proportion of the initial population size remaining each year. Error bars represent the 95% confidence intervals. Population rate of change for a hypothetical stable population ($\lambda = 1.00$) is indicated by the horizontal line. From Gutiérrez et al. 2012; Figure 6 at page 36.

This latest annual report using the most up-to-date statistical methodology and the largest dataset yet of owl capture histories clearly shows that the spotted owl population in the Eldorado Study Area is in trouble. This study area is subjected to relatively intensive logging on the 37 percent of the study area that consists of private lands, as well as extensive mechanical thinning and post-fire logging on national forest lands. The authors stated on page 15 of their report:

Although the 95% C.I. overlapped 1.0 for both the average annual λ and the realized population change, there has been a clear decline in abundance over the last 15 years In 13 of the past 15 years, the annual λ estimate has been ≤ 1.0 . The concurrent decline in the number of occupied territories on the EDSA over the last 15 years provides further evidence of a negative trend in our population

Tempel and Gutiérrez (2013) tested the efficacy of using occupancy data as opposed to mark-recapture data to infer population status using spotted owl data from the Eldorado Study Area. The authors compared long-term trends (1993–2010) in the finite annual rate of population change (λ_t) and the realized change in population (Δ_t) estimated from both

occupancy and mark-recapture data. They considered each owl territory a site, so the sampling population was similar for both types of data (i.e., all territorial adults on the study area vs. all owl territories). They found similar population trajectories using both methods, indicating that presence-absence data can provide reliable information about population trends.

Tempel and Gutiérrez (2013) located 45 owl territories on ELD from 1993–2010, and owls had been detected at least once at all sites by 1997; the vast majority of territories had been productive at least once, indicating these were biologically relevant sites. The authors found that territory extinction increased over time, while territory colonization decreased over time. Thus, territory occupancy declined during the study. The model-averaged estimates of occupancy corresponded with the naïve estimates. Figure 13 below shows annual estimates of territory extinction, colonization, and occupancy in the Eldorado Study Area.

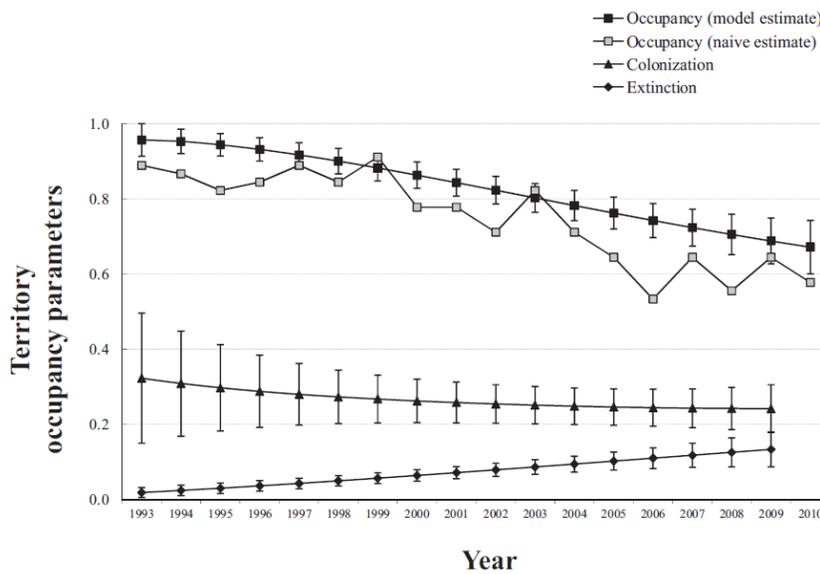


Figure 13. Annual estimates (SE) of territory extinction, colonization, and occupancy at California spotted owl territories in the central Sierra Nevada, 1993–2010. From Tempel and Gutiérrez 2013; Figure 1 at page 1092.

The mark-recapture data indicated that while survival was nearly constant over time, recruitment decreased slightly and as a result, the rate of population change declined over the course of the study $\hat{\lambda}_{1993} = 1.011$ [SE 0.035]; $\hat{\lambda}_{2009} = 0.975$ [SE 0.024]) as shown in Figure 14 below.

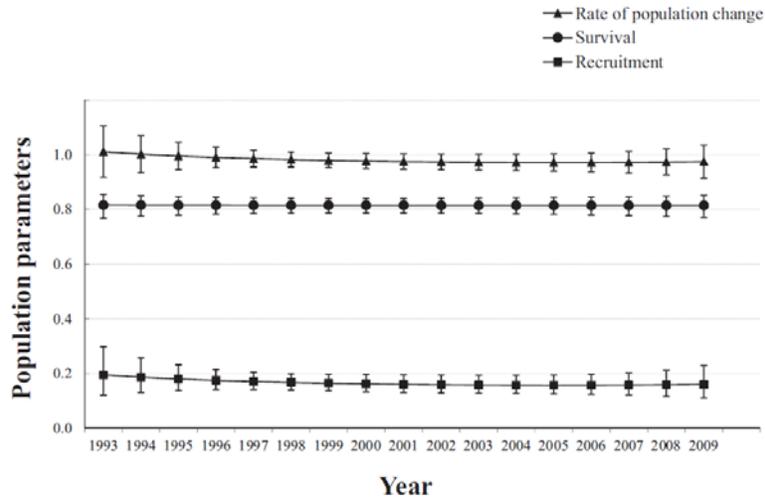


Figure 14. Annual estimates (SE) of survival, recruitment, and finite rate of population change for a California spotted owl population in the central Sierra Nevada 1993–2009. From Tempel and Gutiérrez 2013; Figure 2 at page 1093.

The authors noted that the realized change in occupancy ($\Delta_t = 0.702$; 95% CI 0.552–0.852) and the geometric mean of annual change in occupancy ($\hat{\lambda} = 0.979$; 95% CI 0.967–0.992) also both suggested that territory occupancy declined from 1993 to 2010.

In addition to occupancy, the realized change in population size ($\Delta_t = 0.725$, 95% CI 0.445–1.004) and the geometric mean of the finite rate of population change ($\hat{\lambda} = 0.981$; 95% CI 0.959–1.004) suggest that population size declined from 1993 to 2010, but the estimates were less precise than the realized change in territory occupancy and as a result the 95% confidence intervals overlapped 1.0. See Figure 15 below showing realized population change with occupancy and mark-recapture data for the Eldorado Study Area over the study period.

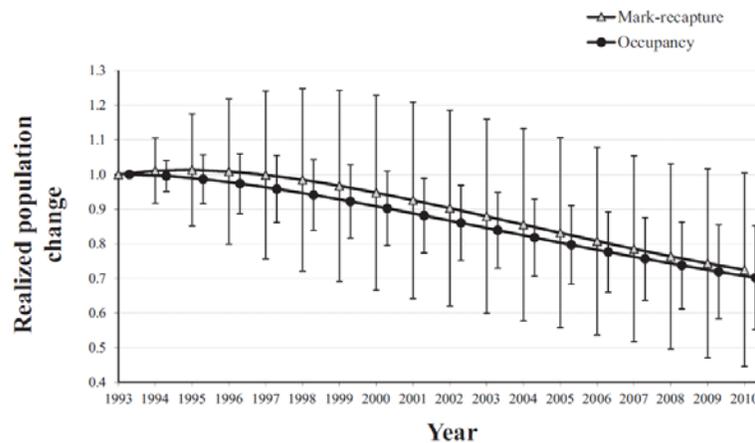


Figure 15. Realized population change (95% CI) with both occupancy and mark-recapture data for a California spotted owl population in the central Sierra Nevada 1993–2010. From Tempel and Gutiérrez 2013; Figure 3 at page 1093.

Tempel and Gutiérrez (2013 at page 1094) concluded:

For the occupancy modeling, territory extinction increased over time, and colonization rates were insufficient to maintain occupancy at its initial level. Annual territory extinction was low during our study, but its effects were significant because most territories were occupied at the study's onset and colonization rates were also low. Territories may not have been colonized because habitat alteration during the study (e.g., logging²) may have affected the quality of vacant owl territories (Seamans and Gutiérrez 2007). In addition, the mark-recapture modeling showed a declining trend in individual recruitment, so the population may have produced an insufficient number of owls to colonize vacant territories and maintain occupancy at its initial level.

Point estimates of the annual finite rate of population change for the Eldorado Study Area have occasionally exceeded 1.0, but twice as often have been below a stationary population. The annual rate of population change declined in the earliest years, showed an increasing trend in the middle years, and then continued to decline again. The most recent data using mark-recapture and occupancy data strongly indicate that overall the population has declined since the early 1990s. Lee et al. (2012) documented no adverse effect of fire on site occupancy of spotted owls in the Sierra Nevada (average of 32 percent high-intensity fire, and most territories with > 50 percent high-intensity fire remained occupied, if they were not post-fire logged); their sample of owls included some in the Eldorado Study Area. Indeed, very few owl sites in this study area were affected by wildfire during the study period (with the exception of the 2001 Star Fire, which impacted 9 territories) but many territories were influenced by past and ongoing logging, which was therefore the likely driver of territory abandonment (Seamans and Gutiérrez 2007a). These studies of the influence of habitat alteration on site occupancy are discussed further in the Habitat Use section below.

Most recently, Tempel (2014) used an Integrated Population Model (IPM), incorporating count, reproductive, and mark-recapture data, to determine population change 1990–2012, and found a significant population decline in this study area ($\hat{\lambda}_t = 0.969$, 95% CI = 0.957–0.980). Overall, Tempel (2014, page 51) found that “the population declined by 50 percent from 1990–2012” (95% CI = 0.384–0.642 for proportional population decline since 1990), and noting (on page 51) that the population has “clearly declined” since 1990 (see Fig. 16 below from the published version, Tempel et al. 2014a).

² The vast majority of sites were affected by logging rather than wildfire.

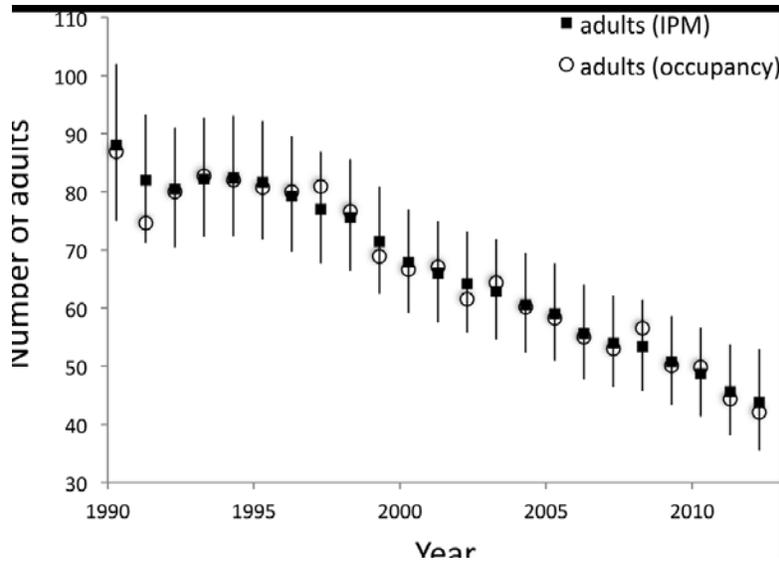


Figure 16. Population change, based upon an Integrated Population Model, for a California spotted owl population in the central Sierra Nevada 1990–2012. From Tempel et al. 2014a, Figure 2.

Tempel (2014, page 55) concluded that his results indicate “that the U.S. Fish and Wildlife Service (2006) may need to reevaluate their recent decision not to list the California spotted owl under the Endangered Species Act.”

Sierra Study Area

The Pacific Southwest Research Station, Fresno, initiated California spotted owl demographic studies in the Sierra National Forest and in Sequoia and Kings Canyon national parks in 1990 to estimate owl reproduction, apparent survival, and population rate of change on the two study areas (Munton et al. 2012). The Sierra study area (SIE) is located primarily (92 percent) within the Sierra National Forest, and encompassed the watersheds of the San Joaquin River and the North Fork of the Kings River (Franklin et al. 2002). The study area includes approximately 693 km² (263 mi²), and the boundaries were delineated based on National Forest boundaries and major topographic features such as ridges and drainages. Spotted owl telemetry studies and intensive surveys began in 1987 and 1990, respectively, on a 160 mi² portion of this study area (old Sierra study area). In 1994, surveys were expanded to include an additional 103 mi² (new Sierra study area; Steger et al. 1999). Juvenile survival rate was not calculated using data from this study area. Instead, the juvenile survival rate from the San Bernardino study area (0.328) was used to approximate the Sierra study area’s juvenile survival rate.

Using survey data from 1990 to 2000 and the projection matrix method, the annual rate of population change was estimated for the old Sierra study area (1987 to 2000) and both old and new Sierra study areas combined (1987 to 2000). Annual rates of population change for the old Sierra and combined Sierra study areas were 0.897 and 0.901, respectively. These estimates were significantly less than that of a stationary population, and suggested that the territorial

female owl population declined about 10 percent annually from 1987 to 2000. For an 11-year period (1990 to 2000), this translates to a population decline of around 60 percent. For the old Sierra study area during 1991 to 2000 (1990 was not examined as survey guidelines were not yet established on the study area), actual owl numbers seemed to corroborate a decline, albeit the drop in numbers was less severe than 60 percent. Owl abundance in 1991 and 2000 were 69 and 55, respectively. These numbers represent a 20 percent decrease, although the accuracy of the count numbers is unknown. The new Sierra study area also showed a decline: actual owl numbers dropped from 37 in 1994 to 29 in 2000.

The first meta-analysis for this study area (Franklin et al. 2004) included 11 years of sampling (1990 to 2000) and encompassed 137 mi². The mean λ estimate for this study area was less than 1.0 (0.961), although the 95% confidence interval encompassed 1.0. Annual λ estimates showed a weak (non-significant, using 95% CI) decline, and adult apparent survival showed no substantive variation or trends through time. The Sierra study showed a negative trend in fecundity. Although the mean λ was statistically stationary using Pradel's methodology and a 95% CI, actual numbers of owls declined; the projection matrix approach showed a decline; there was a negative trend in fecundity; and there was a weak, non-significant (at 95% CI) decline in annual λ estimates (using Pradel's method). The second meta-analysis (Blakesley et al. 2010; Table 16 at page 24) using a longer dataset (1992 to 2004) estimated the mean rate of population change was 0.992 (95% CI = 0.966 to 1.108).

Since the publication of the Service's 2006 notice, which relied upon the results of Franklin et al. (2004) and a draft version of Blakesley et al. (2010), an additional six years of spotted owl data from the Sierra Study Area are available and have been analyzed (Munton et al. 2012) and recently published (Conner et al. 2013). Munton et al. (2012) is an updated report on California spotted owl demography in the Sierra National Forest and Sequoia and Kings Canyon National Parks using the same statistical methodology as Blakesley et al. (2010), with two changes: only owls in conifer forest sites were used and only resident banded owls (paired or observed in the same site on ≥ 2 occasions at least 1 week apart) were used.

Munton et al. (2012) reported that the number of pairs detected between 2006 and 2011 in SIE peaked at 41 in 2007 only to drop to the lowest number of pairs detected (32) for that period in 2008. In 2011, only 34 pairs were detected. In 2009, a large proportion of owl pairs fledged young, resulting in the second highest reproductive output of the study. More than 20 percent of all owls were first-year subadults in 2010 and second-year subadults in 2011, reflecting the high recruitment of fledglings from 2009. The even-odd year effect and proportion of subadults effect received less support in this new dataset than in data analyzed by Blakesley et al. (2010). From 2006 to 2011, reproductive output was near or below study average except in 2009 when it was more than twice the average. Blakesley et al. (2010) reported model-averaged estimates for SIE adult apparent survival for the median year of the study period (1997) ($\hat{S} = 0.848$ SE = 0.015 for males and females); Munton et al. (2012) found little difference in estimates with six additional

years of data from 325 encounter histories ($\hat{S} = 0.851$ SE = 0.012 and = 0.850 SE = 0.012 for males and females, respectively). Munton et al. (2012) found that data supported a trend in apparent survival of second-year subadults only, in contrast to Blakesley et al. (2010).

Using 317 encounter histories, the top model (a random-effects means model) reported an estimated mean λ_t from 1992 to 2010 of 0.989 (95% CI = 0.971 to 1.007). The confidence interval included 1, but once again the point estimate was below 1.0 as was every previous estimate of population rate of change for this population. Further, the last four estimates of Δ_t were among the lowest of the study period (see Fig. 17 below) and indicate the population of territory-holding owls decreased over the period of study. In addition, the 2010 realized population size estimate was 85 percent of the 1992 population ($\Delta_t = 0.85$).

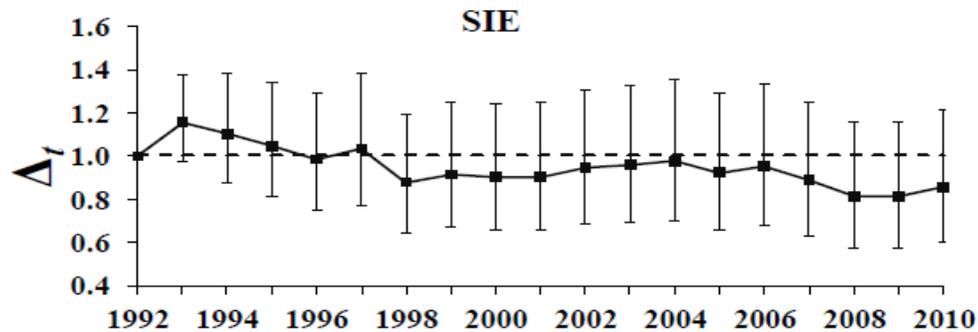


Figure 17. Realized population change (Δ_t) and 95% CIs of California spotted owls in the Sierra National Forest study area (SIE) from 1992 to 2010. From Munton et al. 2012; Figure 5 at page 17.

Conner et al. (2013) is a peer-reviewed publication utilizing the same statistical methodology (Pradel's temporal symmetry models) and core area as Munton et al. (2012) and the two previous meta-analyses. Conner et al. (2013) used individual encounter histories of the 317 banded owls from the SIE to estimate the annual rate of population change (λ_t) and realized population change (Δ_t) with data from 1990 to 2011. As described in the Lassen Study Area section, the authors also used a Markov Chain Monte Carlo sampling approach to estimate posterior distributions of λ_t ($\lambda_{t, \text{MCMC}}$) and determine the probability of decline during the period of study.

For all three estimates (Fixed Effects = FE, Random Effects from a Mixed Effects model = RE, and Bayesian Markov Chain Monte Carlo = MCMC), estimated mean lambda was < 1.0 for the SIE, which suggests a declining population. The estimate of mean annual rate of population change ($\bar{\lambda}$) was 0.993 (95% CI = 0.959 to 1.027) with the FE model; 0.990 (95% CI = 0.973 to 1.008) with the RE model, and 0.993 (95% CI = 0.925 to 1.058) with the MCMC model. As shown in the figure below, the annual pattern of λ_t was the same between the fixed effects, random effects, and MCMC estimates. The MCMC estimates of median $\lambda_{t, \text{MCMC}}$ had smaller and more consistent credible intervals than fixed effects confidence intervals (see Fig. 18 below).

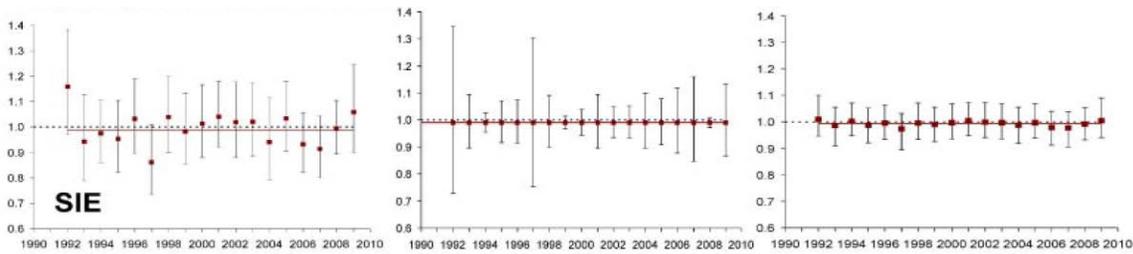


Fig. 18. Estimates of annual rate of population change (λ_t) and 95% confidence intervals based on (a) fixed effects estimates, (b) random effects estimates from a mixed effects model, and (c) a Bayesian Markov Chain Monte Carlo (MCMC) approach for California spotted owls on the Sierra study area [SIE] in the Sierra Nevada, California, 1992–2010. Solid lines indicate best estimates of mean λ from a mixed effects model for each study area. Authors used the root means squared error for 95% confidence intervals for random effects estimates, and show the median and 2.5 and 97.5 percentiles for MCMC methods. From Conner et al. 2013; Figure 2 at page 5.

Credible intervals of estimates of median $\Delta_{t, \text{MCMC}}$ started out smaller than CIs of $\hat{\Delta}_t$ (Fig. 19 below), but grew to be approximately the same size by the end of the monitoring period. All of the estimates of realized population change Δ_t suggest that the population of spotted owls in the SIE declined over the study period. Conner et al. (2013) stated on page 5 that “over the 18-year study period, the different estimators of Δ_t indicated population declines of 11–16% for the Sierra Study Area . . .”

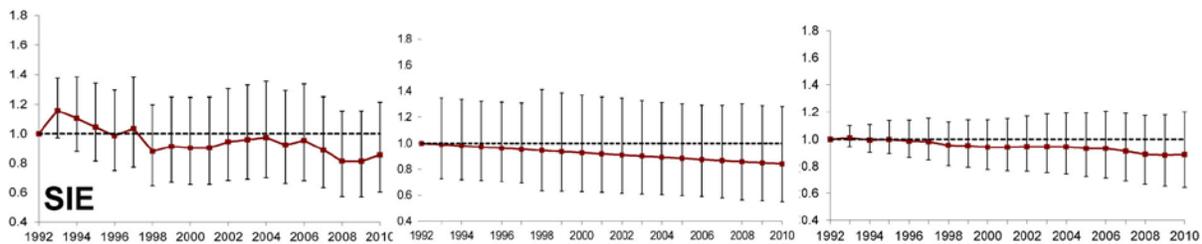


Fig. 19. Estimates of realized population change (Δ_t) and 95% confidence intervals based on (a) fixed effects estimates, (b) random effects estimates from a mixed effects model, and (c) a Bayesian Markov Chain Monte Carlo (MCMC) approach. Data are from California spotted owls on the Sierra study area [SIE] in the Sierra Nevada, California, 1992–2010. Authors used the root means squared error for 95% confidence intervals for random effects estimates, and show the median and 2.5 and 97.5 percentiles for MCMC methods. Realized population change is the proportion of the initial population size remaining each year. From Conner et al. 2013; Figure 3 at page 6.

Additionally, based on the posterior distributions of $\Delta_{t, \text{MCMC}}$ the authors calculated a 0.40 probability that the Sierra owl population declined by more than 15 percent over the past 18

years, and an only 0.22 probability of being stationary or increasing. Figure 20 below depicts the population trajectories of populations on three of the demography study areas.

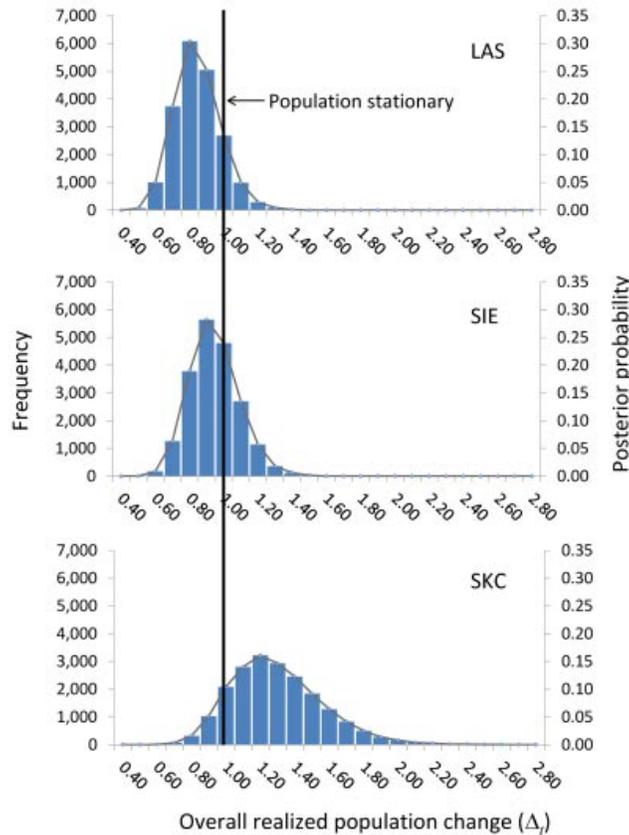


Figure 20. Estimated posterior distributions of overall realized population change (Δ_t) based on posterior distributions of λ_t from 20,000 Markov Chain Monte Carlo (MCMC) simulations. Data are from California spotted owls on 3 study areas (Lassen [LAS], Sierra [SIE], and Sequoia Kings Canyon [SKC]) in the southern Cascades and Sierra Nevada, California, 1992–2010. Authors excluded the first 2 and last estimates because of confounding or potential bias. Overall realized population change is the proportion of the initial population size remaining at the end of the monitoring time period. From Conner et al. 2013; Figure 4 at page 7.

Similar to the Lassen Study Area, no analysis of population trends has ever resulted in a positive mean estimate of lambda for the Sierra Study Area. As with the LAS and ELD, the latest available data strongly indicates declines of this population, again corroborating earlier results.

Sequoia and Kings Canyon Study Area

The original Sequoia and Kings Canyon study area (SKC) encompassed approximately 343 km² (132 mi²) of land in Fresno and Tulare counties. The majority of the area was located in the Sequoia and Kings Canyon National Parks. Small segments of the study area include the Kings River watershed, but most of the study area was in the Kaweah River watershed (Franklin et al. 2002). Surveys in this study area cover 11 years of field sampling (1990 to 2000), but useful

data exist from a previous demographic study that began in 1988 (Steger et al. 2000). Demographic surveys were conducted on 343 km² of land in this area, and methods for calculating λ were identical to those used for the Sierra study area. The annual rate of population growth using the projection matrix method was estimated to be 0.973, suggesting a decline of 2.7 percent per year. Statistical testing found that λ was not significantly less than 1.0 (using a 95% CI). Actual owl counts during the study period seemed to indicate that the population might be growing, but again, the accuracy of such numbers was uncertain. Owl abundance in 1990 and 2000 were 54 and 64, respectively.

The meta-analysis for the SKC covered 132 mi² during 1991 to 2000 (Franklin et al. 2004). The resulting mean λ estimate was 0.984, but was not statistically different from that of a stationary population. A significant quadratic trend (decline, then increase) was detected for annual λ estimates, but adult apparent survival showed no substantive variation or trends through time. A linear trend could not be identified in fecundity estimates, as fecundity was highly variable through time. Apparent survival for SKC was significantly higher (0.877) than that of the other study areas combined (0.819).

Blakesley et al. (2010) described the 283 km² (109 mi²) core study area consisting of sites that were consistently surveyed from 1991 through 2004; results from this core area were used to estimate population rates of change, apparent survival, and reproductive output in the second meta-analysis. Blakesley et al. (2010) reported a mean λ estimate of 1.006 but not statistically different from a stationary population. In addition, apparent adult survival rate was once again higher than the other study areas. The authors suggested (on page 24) that the higher survival rate of adults in the national park as compared to the other study areas subjected to intensive logging may have been related to “differences in habitat quality resulting from differences in forest management both before and during the study period, presence of giant sequoia groves on SKC, differences in the proportion of oak woodland, lower rates of breeding dispersal from SKC, or the interaction between ≥ 2 of these factors.”

In 2005, California spotted owl surveys of SKC were not conducted because funding was unavailable. Surveys were reinstated in 2006 in a reduced study area (SKC Conifer) and continued through 2011. Munton et al. (2012) and Conner et al. (2013) report updated demographic results from surveys conducted through 2011 in the SKC Conifer study area. Munton et al. (2012) noted that between 2006 and 2011, in the SKC the highest number of pairs (30) was detected in 2007; the lowest number of pairs (25) was detected in 2010. In 2011, 26 pairs were detected. Similar to the SIE, 2009 was a boom year for reproductive output in SKC, but did not result in high recruitment of subadults into the population in subsequent years as was seen in SIE.

As with the SIE, the even-odd year effect and proportion of subadults effect received less support in this new dataset than in data analyzed by Blakesley et al. (2010). From 2006 to 2011,

reproductive output was near or below study average except in 2009 when it was more than twice the average. SKC apparent survival estimated from 168 encounter histories showed little difference between sexes ($\hat{S} = 0.8889$ SE = 0.014 for males and 0.882 SE = 0.014 for females). Reproductive output was slightly lower than that estimated by Blakesley et al. (2010) and was higher than SIE but not significantly.

Using 168 encounter histories, the top model (a random-effects means model) reported an estimated mean λ_t from 1993 to 2010 of 1.010 (95% CI = 0.982 to 1.038). The estimated Δ_t from 1993 to 2010 was also above 1.0 ($\Delta_t = 1.24$) and indicate the population of territory holding owls increased over the period of study (Fig. 21 below). However, the 95% confidence intervals for both λ_t and Δ_t included 1.0.

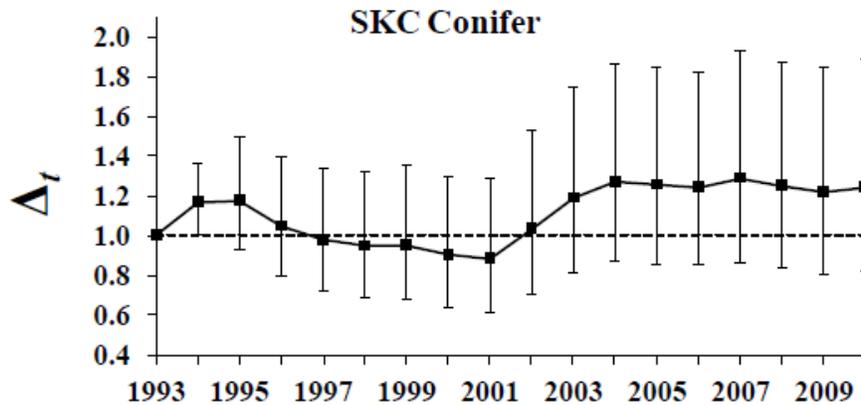


Figure 21. Realized population change (Δ_t) and 95% CIs of California spotted owls in the Sequoia and Kings Canyon conifer forest study area (SKC Conifer) from 1993 to 2010. From Munton et al. 2012; Figure 5 at page 17. From Munton et al. 2012; Figure 5 at page 17.

Conner et al. (2013) is a peer-reviewed publication utilizing the same statistical methodology (Pradel's temporal symmetry models) and core area as Munton et al. (2012) and the two previous meta-analyses. Conner et al. (2013) used individual encounter histories of 165 banded owls from the SKC to estimate the annual rate of population change (λ_t) and realized population change (Δ_t) with survey data from 1990 to 2011. As described in the Lassen and Sierra study area sections, the authors also used a Markov Chain Monte Carlo sampling approach to estimate posterior distributions of λ_t ($\lambda_{t\text{MCMC}}$) and determine the probability of decline during the period of study.

For all three estimates (Fixed Effects = FE, Random Effects from a Mixed Effects model = RE, and Bayesian Markov Chain Monte Carlo = MCMC), estimated mean lambda was > 1.0 for the SKC, which suggests an increasing population. The estimate of mean annual rate of population change ($\bar{\lambda}$) was 1.016 (95% CI = 0.976 to 1.057) with the FE model; 1.010 (95% CI = 0.982 to 1.038) with the RE model, and 1.014 (95% CI = 0.907 to 1.170) with the MCMC model. As

shown in Figure 22 below, the MCMC estimates of median $\lambda_{t\text{MCMC}}$ had smaller and more consistent credible intervals than fixed effects confidence intervals.

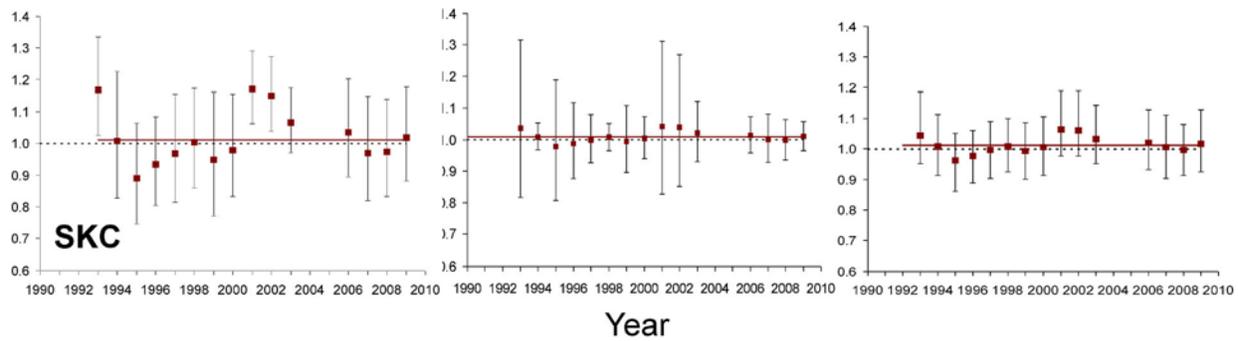


Fig. 22. Estimates of annual rate of population change (λ_t) and 95% confidence intervals based on (a) fixed effects estimates, (b) random effects estimates from a mixed effects model, and (c) a Bayesian Markov Chain Monte Carlo (MCMC) approach for California spotted owls on the Sequoia and Kings Canyon study area [SKC] in the Sierra Nevada, California, 1992-2010. Solid lines indicate best estimates of mean λ from a mixed effects model for each study area. Authors used the root means squared error for 95% confidence intervals for random effects estimates, and show the median and 2.5 and 97.5 percentiles for MCMC methods. From Conner et al. 2013; Figure 2 at page 5.

Credible intervals of estimates of median $\Delta_{t\text{MCMC}}$ started out smaller than CIs of $\hat{\Delta}_t$ (Fig. 23 below), but grew to be approximately the same size by the end of the monitoring period. All of the estimates of realized population change Δ_t suggest that the population of spotted owls in the SKC increased over the study period. Conner et al. (2013) noted on page 5 that over the 17-year study period, the different estimators of Δ_t indicated an increase of 16–27 percent for the SKC Study Area.

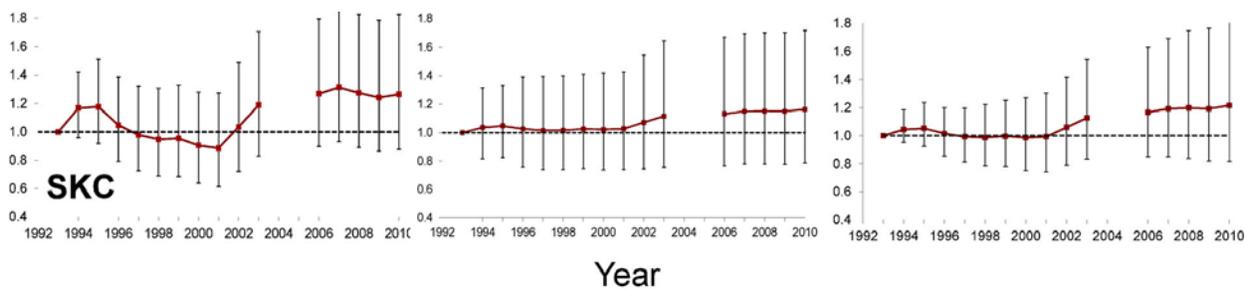


Fig. 23. Estimates of realized population change (Δ_t) and 95% confidence intervals based on (a) fixed effects estimates, (b) random effects estimates from a mixed effects model, and (c) a Bayesian Markov Chain Monte Carlo (MCMC) approach. Data are from California spotted owls on the Sequoia and Kings Canyon study area [SKC] in the Sierra Nevada, California, 1992–2010. Authors used the root means squared error for 95% confidence intervals for random effects estimates, and show the median and 2.5 and 97.5 percentiles for MCMC methods. Realized

population change is the proportion of the initial population size remaining each year. From Conner et al. 2013; Figure 3 at page 6.

Additionally, based on the posterior distributions of Δ_t MCMC the authors calculated low probabilities of population declines and high probabilities of population increases over the past 17 years. Figure 24 below depicts the population trajectories of populations on three of the demography study areas.

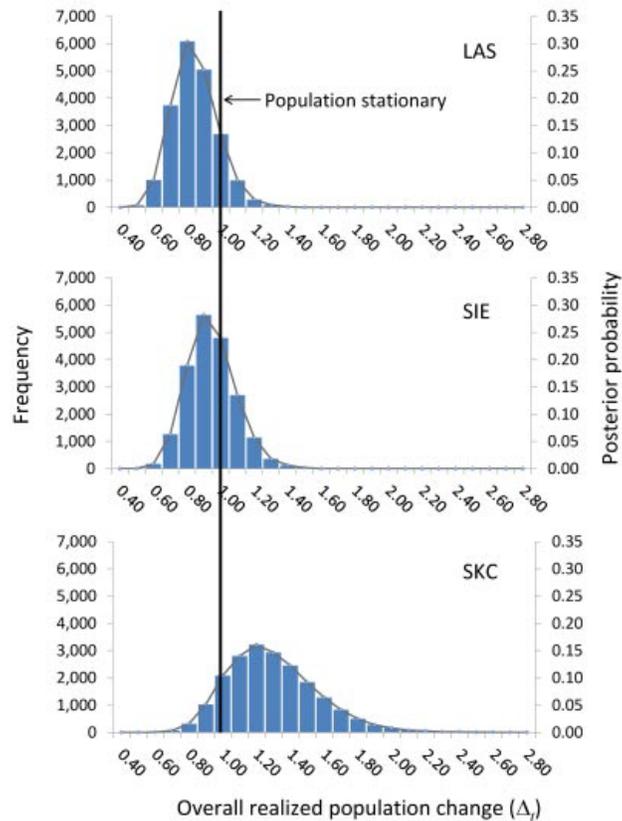


Figure 24. Estimated posterior distributions of overall realized population change (Δ_t) based on posterior distributions of λ_t from 20,000 Markov Chain Monte Carlo (MCMC) simulations. Data are from California spotted owls on 3 study areas (Lassen [LAS], Sierra [SIE], and Sequoia Kings Canyon [SKC]) in the southern Cascades and Sierra Nevada, California, 1992–2010. Authors excluded the first 2 and last estimates because of confounding or potential bias. Overall realized population change is the proportion of the initial population size remaining at the end of the monitoring time period. From Conner et al. 2013; Figure 4 at page 7.

In sum, lambda estimates using the projection matrix approach and Pradel’s method suggest stationary population trends, and actual owl numbers do not show declines. Trend in annual λ estimates also does not show a decline, and apparent survival in this study area was higher than all other study areas examined in this finding. Estimates of the probability of population declines were low whereas estimates of probabilities of population increases were high. These data

provide compelling evidence that past and current protection of spotted owl habitat from logging within the boundaries has played a significant role in stabilizing and conserving owl populations.

San Bernardino Study Area

In southern California overall, approximately 71 percent of past or current territories of spotted owls are located on public lands, virtually all of which are within four national forests (Los Padres, Angeles, San Bernardino, and Cleveland). Other than a few project-specific surveys, there have been no surveys for spotted owls in the Los Padres National Forest since 1991 (Cooper in litt. 2005) or in the Cleveland National Forest since 1995 (Winter in litt. 2005), and results from surveys in the Angeles National Forest since 1994 have not been compiled (Ann Berkley and Leslie Welch, USFS, in litt. 2005).

Most of the data on habitat use and demography for the southern California spotted owl population comes from the San Bernardino Study Area, which is the largest population in southern California. The San Bernardino Study Area is located entirely within the San Bernardino National Forest, and comprised all suitable habitat for spotted owls within the mountains. Surveys covering approximately 200 mi² (Big Bear study area) began in 1987, but were expanded in 1989 to cover the entire San Bernardino Mountain range (approximately 2,140 km², or 730 mi²; San Bernardino Mountains study area; Gutiérrez et al 1999). Additional surveys were conducted in suitable habitat within the San Bernardino National Forest in the San Jacinto Mountains (Gutiérrez and Pritchard 1990). This study area was unique in that it exists in southern California as two relatively isolated populations (Gutiérrez and Pritchard 1990, LaHaye et al. 1994). Higher elevations in the study area contained forested habitat suitable for spotted owls, while lowland areas of unsuitable desert scrub and chaparral habitats surrounded and isolated the higher peaks (Noon and McKelvey 1992). Although all forested habitat within the San Bernardino study area (including unoccupied habitat) was surveyed (Gutiérrez 2001), survey effort increased during the study period. In 1989, 532 total surveys were conducted, whereas in 1998, 1,185 total surveys were conducted (LaHaye et al. 1999).

Early projection matrix studies using four, five, and six years of data estimated significant annual declines between 1987 and 1993 ($\lambda = 0.769, 0.827$ and 0.860 , respectively; LaHaye et al. 1992, Noon et al. 1992, LaHaye et al. 1994). Figure 25 below shows dramatic declines in territory occupancy in the San Bernardino Mountains from 1987 to 1993. The annual rate of population change for the period 1988 to 1998 was estimated to be 0.91 (LaHaye et al. 1999). Using 12 years of demographic data from the San Bernardino California spotted owl population, LaHaye et al. (2004) modeled the relationship between weather and reproduction and survival. They found fecundity of both adult and subadult females was higher when a wet year preceded a dry spring. The authors detected no time trends in survival. Using the weighted mean estimate of fecundity for adults and subadults and model-averaged estimates of apparent survival in a Leslie matrix to estimate finite rate of population change, LaHaye et al. (2004) re-confirmed that the

San Bernardino spotted owl population declined from 1987 to 1998. Lambda was estimated as 0.906, SE = 0.018, and 95% CI = 0.871 to 0.942.

This estimate was significantly less than that of a stationary population, and suggested that the territorial female owl population declined nine percent annually from 1988 to 1998. Over the 11-year study period, this rate of decline would translate to a loss of over 60 percent of the population.

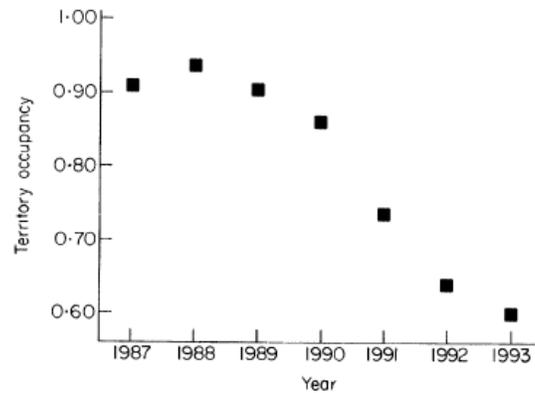


Fig. 3. Territory occupancy in the San Bernardino Mountains population.

Figure 25. From LaHaye et al. 1997.

The 2004 meta-analysis for this study area included eight years of sampling (1991 to 1998) and encompassed 730 mi². The mean λ estimate for this study area was less than 1.0 (0.978), although the 95% CI encompassed 1.0. Examination of annual λ estimates showed a weak (non-significant, with 95% CI) decline, and as with all other study areas, adult apparent survival showed no time trend. No linear trend in fecundity could be identified.

Since the 2004 meta-analysis, additional data are available indicating continued declines in the southern California owl population. The U.S. Forest Service resumed surveys throughout the San Bernardino and San Jacinto mountains in 2003. Each year from 2003 through 2011, biologists attempted occupancy and reproductive surveys at as many known owl sites as possible given budget constraints, but did not capture and band owls (Lee et al. 2013). Tempel and Gutiérrez (2013) demonstrated that presence-absence data can provide reliable information about population trends. Lee (unpublished data) analyzed occupancy data from 168 known spotted owl sites from 2003 to 2011, and detected a continuing downward trend in occupancy probability over the time period, from approximately 0.62 to 0.50, where site occupancy probability accounts for detection probability.

Population Trends Summary

Gutiérrez (2008) noted that studies of spotted owl populations are the most intensive ever to be conducted on an endangered species. Robust new approaches to analyzing owl populations have

been developed over the past 20 years that benefit wildlife science as a whole. As a result of the spotted owl's association with older forests, and ensuing controversies over conservation versus timber harvest, extensive long-term research over large areas involving dozens of territories and thousands of banded birds are available to inform managers of the status of populations. And the latest results from about two decades of these intensive surveys provides strong evidence that populations on four of the five demographic study areas have declined, despite at least some regulatory measures in place to conserve the species. The one population that is not declining is in the national parks where forest management is minimal.

The five demographic study areas are representative of the range of the California spotted owl, from the south Cascades in the north, to the Sequoia and Kings Canyon in the southern Sierra Nevada, to the San Bernardino Mountains in southern California. The Lassen Study Area in the south Cascades (most northerly studied population) apparently experienced the most precipitous declines of all the populations (Blakesley et al. 2010, Conner et al. 2013). Over the past 18 years, the Lassen population declined by an estimated 21–22 percent, with a 0.80 probability of a more than 10 percent decline and 0.69 probability of a > 15 percent decline (Conner et al. 2013). Blakesley et al. (2010 at page 27) speculated as to the reasons why the Lassen population was worse than in the other areas: “The population decline in the LAS study area may have occurred because it is located near the edge of the California spotted owl's range with many territories in suboptimal, drier, and higher elevation forest types compared to the other study areas, including areas east of the Cascade-Sierra Nevada crest. A second possible explanation is that there may have been more timber harvest in LAS; this possibility remains speculative because, unfortunately, timber harvest data are not readily available for all study areas. A third possible explanation is that timber harvest has had a greater negative effect on LAS relative to the other study areas...[T]imber harvest in higher elevation forests may reduce flying squirrel numbers without a concomitant increase in more open-habitat prey. Flying squirrels are a major component of the diet of spotted owls on LAS (0.61 percent of biomass; Verner et al. 1992). Thus, differences in study-area location and effects of management across study areas, operating separately or interactively, might be a plausible hypothesis for differences we observed between LAS and the other 3 study areas.”

The Eldorado Study Area population in the central Sierra Nevada declined during the early years of study, began to increase, and then declined again, and the experts on this population stated unequivocally in their 2012 annual report (Gutiérrez et al. 2012) that “there has been a clear decline in abundance over the past 15 years” Further, both the naïve and modeled estimates of territory occupancy show clearly that extinction is outpacing colonization, resulting in fewer occupied territories at the end of the study period compared with the beginning. The experts noted in their 2013 publication (Tempel and Gutiérrez 2013) that territories may not have been colonized because of habitat alteration. Petitioners note that logging has occurred on both public and private lands in this study area while severe fire was rare, suggesting that logging was the strongest habitat-based driver of declines. Tempel (2014) concluded that the spotted owl

population has declined by 50 percent in this study area since 1990, and continues to decline. Based upon this result, and the results of the other study areas, Tempel (2014) concluded that “the U.S. Fish and Wildlife Service (2006) may need to reevaluate their recent decision not to list the California spotted owl under the Endangered Species Act” since population declines have become “apparent.”

The population of spotted owls on the Sierra Study Area in the southern Sierra Nevada also clearly declined over the past two decades. Over the past 18 years, populations declined by 11–16 percent, with a high probability of declines > 5percent and a 0.54 probability of declines > 10 percent (Conner et al. 2013). The last four estimates of the realized population change were the lowest of the study period and show the population of territorial owls decreased. The 2010 population size was only 85 percent of the 1992 population size (Munton et al. 2012). This population also experienced logging – but little severe fire – over the period of study, suggesting logging may be responsible for the observed decline.

While mark-recapture data were lacking in the San Bernardino Study Area since the late 1990s, occupancy survey data from 2003 through 2011 show that the population trend continued a downward trajectory that had been reported during the 1990s. This region experienced significant logging on private lands after a bark beetle epidemic affected much of the San Bernardino National Forest, which likely adversely modified habitat for the owls. In addition, many more of the spotted owl sites experienced wildfire than in the Sierra Nevada, although there was no statistically significant evidence that fire adversely affected site occupancy compared to unburned sites (Lee et al. 2013, although in core areas high-severity forest fire above a threshold reduced occupancy). It is possible that a drying climate has affected prey populations.

The only study area with a stable or increasing population during the period of intensive study was the Sequoia and Kings Canyon Study Area. The main notable difference between this study area and the others is a lack of forest management (i.e., logging) in the parks as compared to the other study areas. Blakesley et al. (2010) stated on page 24 that: “Seamans and Gutiérrez (2007b) estimated that probability of breeding dispersal on ELD increased when habitat at a site was altered. Thus, because SKC is a National Park, it may have experienced less habitat alteration and lower rates of breeding dispersal, which may have resulted in higher estimates of apparent survival for adults relative to other study areas. The SKC was within 2 National Parks and was managed differently than the other study areas; that is, SKC experienced less timber harvest than other study areas both during the study and during the century before the demographic studies. Territorial owl survival on ELD was correlated with the amount of mature coniferous forest at individual owl sites (Seamans 2005). The protected conservation status of SKC resulted in larger tracts of mature coniferous forest, which may have been correlated with differences in survival relative to managed forests”

Although the vast majority of point estimates of λ from the early 1990s on forests subjected to logging were below 1.0, the 95% confidence intervals for the estimates of rate of population change overlapped 1.0. This suggests that population declines occurred but the sample sizes were too low or there was high variance in the data. In earlier findings, the Service used the slight statistical uncertainty inherent in these studies to reject listing the subspecies, despite the fact that the majority of the estimates of λ were less than 1.0 on managed lands. The 2003 finding even stated that “[l]ow levels of declines may be occurring in some study areas, but if so, they are not clearly evident using existing analytical techniques.” Conner et al. (2013) recently concluded that, statistically, only large population declines are easily detected using the null hypothesis approach with 95% CI, which poses problems for small populations in particular, like the California spotted owl, because lesser declines are typically not detected using a 95% CI, but are still adversely affecting abundance. The authors stated on page 8: “[s]maller populations can drop, undetected by a null hypothesis [95% CI] approach, to low levels where the probability of extinction increases to unacceptably high levels due to demographic variability and stochastic environmental events (White 2000, Lande 2001, Morris and Doak 2002). The undetected decline is a problem faced by ecologists studying sensitive populations.” Therefore, the authors explained, using a Bayesian approach is a powerful and precise tool for estimating the risks or probability of population declines during retrospective analyses. The authors concluded that, for the California spotted owl and other small/rare wildlife populations, this statistical approach provides “more insightful information” than the older 95% CI approach, and “can better inform conservation assessments and strategies.” And their Bayesian analysis revealed clear declines in the Lassen and Sierra demography study areas over a nearly two-decade period, while there was little evidence for a decline in the most protected population in the Sequoia and Kings Canyon national parks. Meanwhile, Tempel and Gutiérrez (2013) and Tempel et al. (2014a) also report a significant decline in California spotted owl territory occupancy in the Eldorado Study Area, and conclude unequivocally that populations are, and have been, declining on this study area (see also Gutiérrez et al. 2012, concluding that there is a “clear decline” in spotted owl population in this study area, based upon the most updated data).

Even though, in the past, numerous studies suggested population declines of California spotted owls, and the Mexican and northern subspecies were listed due to many of the same factors, the Service relied upon small uncertainties in the data, and chose not to offer ESA protections to this subspecies. At this time, it is indisputable that the “low levels of declines” that were taking place have compounded over the years, resulting in concrete evidence that populations are now diminished. Mark-recapture and occupancy data from nearly 20 years of research on five large study areas provide highly compelling evidence that populations declined despite regulatory mechanisms in place to provide some limited habitat protection surrounding owl nests during most of that time period.

Habitat Use

The predominant forest types used by California spotted owls in the Sierra Nevada are mixed-conifer forest [sugar pine (*Pinus lambertiana*), ponderosa pine, white fir (*Abies concolor*), Douglas-fir (*Pseudotsuga menziesii*), giant sequoia (*Sequoiadendron giganteum*), incense-cedar (*Calocedrus decurrens*), black oak (*Quercus kelloggii*)], and red fir forest [red (*Abies magnifica*) and white fir, lodgepole pine (*Pinus contorta*), and quaking aspen (*Populus tremuloides*)]. As of 2003, about 80 percent of known sites were found in mixed-conifer forest, 10 percent in red fir forest, seven percent in ponderosa pine/hardwood forest type [ponderosa pine, interior live oak (*Q. wislizenii*), canyon live oak (*Q. chrysolepis*), black oak, incense-cedar, white fir, tanoak (*Lithocarpus densiflorus*), and Pacific madrone (*Arbutus menziesii*)], and the remaining three percent in foothill riparian/hardwood forest [cottonwood (*Populus* spp.), California sycamore (*Platanus racemosa*), interior live oak, Oregon ash (*Fraxinus latifolia*), and California buckeye (*Aesculus californica*)] and east-side pine [ponderosa and Jeffrey pine (*P. jeffreyi*)] (Verner et al. 1992a, USFS 2001).

In the coast range, California spotted owls occupy redwood/California-laurel forests which consist of a mix of coast redwood (*Sequoia sempervirens*), California laurel (*Umbellularia californica*), tanoak, Pacific madrone, red alder (*Alnus rubra*), and white alder (*Alnus rhombifolia*), coast live oak, Santa Lucia fir (*Abies bracteata*), and big-leaf maple (*Acer macrophyllum*) (Verner et al. 1992a). Spotted owls are found at elevations below 305 m (1,000 ft) along the Monterey coast to approximately 8,500 ft (2,591 m) in the inland mountains (Stephenson and Calcarone 1999).

In the mountains of southern California, spotted owls use mixed-conifer forests (Verner et al. 1992a), live oak/big-cone Douglas-fir forests (coast and canyon live oak, bigcone Douglas-fir (*Pseudotsuga macrocarpa*), and riparian hardwood/hardwood forests [coast and canyon live oak, cottonwood, California sycamore, white alder, and California laurel]).

Spatial positions and vegetation types were compared between plots surrounding 144 California spotted owl territory centers and 144 random plots in the San Bernardino Mountains of southern California (Smith et al. 1999, Humboldt State University, in litt. 2002). California spotted owl territories in this study were found in three vegetation types: canyon live oak/big-cone Douglas-fir (39 percent of territories); mixed conifer/hardwood (which includes canyon live oak, big cone Douglas-fir, sugar pine, white fir, Coulter pine, incense cedar, and black oak) (28 percent of territories); and mixed conifer (which contains white fir, Jeffrey pine, and incense cedar (33 percent of territories). Owl territory centers were significantly closer to one another than random sites, showing a clumped distribution. Owl territory centers contained more area of closed canopy forest, larger mean patch sizes of closed canopy forest, and lower habitat diversity than random sites. Owls on Mount San Jacinto used conifer and riparian hardwood forests

significantly more than would be expected based on their availability and owls on Palomar Mountain primarily used conifer or mixed forests of conifers and hardwoods.

Stephenson and Calcarone (1999) estimated that there were approximately 473,473 ha (1,170,000 ac) of forest habitat types in which spotted owls were known to reproduce (low-elevation oak/bigcone Douglas-fir, mid-elevation conifer/hardwood, and higher elevation mixed conifer) within the range of the subspecies in southern California and the central Coast Ranges. The total amount of available suitable habitat in the analysis area is likely lower, because not all habitat is necessarily in a condition suitable for reproduction, roosting, or foraging.

At a finer spatial scale, California spotted owls use a broader range of habitat types than the northern spotted owl (Call et al. 1992, Gutiérrez et al. 1992, Anderson and Mahato 1995, Moen and Gutiérrez 1997, North et al. 2000), in part due to the relatively more complex landscapes available to the California subspecies (Zabel et al. 1992b, Franklin and Fites-Kaufmann 1996, Helms and Tappeiner 1996, Beardsley et al. 1999). In the Sierra Nevada, this complexity reflects: (1) the variety of environmental conditions due to elevation, latitude, geology, precipitation, and temperature; (2) rich flora; and (3) influence of natural disturbance, especially fire (Andersen and Mahato 1995). The heterogeneity of forests occupied by California spotted owls make quantifying its habitat sensitive to scale. Several studies have found that analysis of habitat at a coarse scale (e.g., using timber type polygons developed for timber management) masks fine grained attributes used or selected by owls (Bias and Gutiérrez 1992, Zabel et al. 1992a, Moen and Gutiérrez 1997, North and Manley PSW-GTR-237, Chapter 6).

Despite the complexity of California spotted owl habitat, several authors have concluded that, like the northern and Mexican spotted owl, the subspecies is a habitat specialist (Andersen and Mahato 1995, Moen and Gutiérrez 1997, LaHaye et al. 1997), selecting habitat at several spatial scales. Studies spanning the range of the California spotted owl have examined habitat use at three scales: landscape; home range; and nest, roost, or foraging stand. These studies have demonstrated that California spotted owls used or selected conifer and mixed conifer-hardwood forested habitats for nesting and roosting that have structural components of old forests, including: large trees (typically greater than 61 cm (24 in) in diameter at breast height (dbh)—breast height has been standardized at 137 cm, or 4.5 ft, above the ground)(Call 1990, Call et al. 1992, Gutiérrez et al. 1992, Zabel et al. 1992a, Moen and Gutiérrez 1997, USFS 2001a, Bond et al. 2004, Blakesley et al. 2005, Seamans 2005); decadent trees (trees with cavities, broken tops, etc.); high density of trees (Laymon 1988, Call 1990, Bias and Gutiérrez 1992, Gutiérrez et al. 1992, LaHaye et al. 1997, Moen and Gutiérrez 1997, Bond et al. 2004, Blakesley et al. 2005, Seamans 2005); multi-layered canopy/complex structure (Call 1990, Gutiérrez et al. 1992, LaHaye et al. 1997, Moen and Gutiérrez 1997); high canopy cover (greater than 40 percent and mostly greater than 70 percent; Laymon 1988, Bias and Gutiérrez 1992, LaHaye et al. 1992, Gutiérrez et al. 1992, Zabel et al. 1992a, Moen and Gutiérrez 1997, North et al. 2000, Bond et al. 2004, Blakesley et al. 2005, Seamans 2005); abundant snags (Laymon 1988, Call 1990, Bias and

Gutiérrez 1992, Gutiérrez et al. 1992, LaHaye et al.1997, Bond et al. 2004); and downed logs (Call 1990).

Several recent studies have confirmed the spotted owl's affinity for nesting and roosting in dense/mature and old-growth forests as well as locating their home ranges in areas with more dense/mature and older forests than generally available, and have linked the presence of dense/mature and old-growth forest to higher occupancy rates, survival, and nesting success. Blakesley et al. (2005) conducted long-term research on 67 spotted owl territories in the Lassen Study Area, and found that the amount of a 200-ha (494 acres) nest core area dominated by ≥ 61 cm (24 in) dbh trees and ≥ 70 percent canopy cover was positively associated with occupancy rates, and that occupancy, apparent survival, and nesting success all increased with increasing amounts of old-forest characteristics within the nest core area. The authors also found that adult survival was positively correlated with the amount of suitable owl habitat in the larger 2,010-acre home range core area. In the Eldorado Study Area, Seamans (2005) investigated the correlations between habitat characteristics and adult survival, reproductive output, and population growth rate. He found that forests with medium (12–24 in) to large (> 24 in) trees and > 70 percent canopy cover at the 400-ha (988-ac) scale were positively associated with survival and probability of site occupancy by adult (> 1 year old) California spotted owls, and amount of hardwood forest, brush-sapling, or pole coniferous forest was negatively associated with these parameters, with such characteristics primarily created through logging.

Habitat modeling of northern spotted owls in California (Franklin et al. 2000) and Oregon (Olson et al. 2004) showed that survival was maximized when northern spotted owl territories included large blocks of mid- and late-seral forests with some edge, but that fecundity was maximized with small blocks of dense, mature/old forest and large amounts of edge between dense, mature forest and other habitats. This difference was due, presumably, to the presence of woodrat prey in more complex early seral habitat (Franklin et al. 2000, Olson et al. 2004). As a result, stable or increasing populations (λ values of 1.0 or higher) only resulted in territories with a substantial mix of dense, old forest and other vegetation types. Franklin et al. (2000, on page 580) emphasized that the type of structurally simplified environment resulting from intensive logging would not be likely to create the conditions that would benefit spotted owls for foraging:

Current logging practices probably do not generate the type of mosaic that we observed in high-fitness territories; clear-cut logging leaves large, regularly shaped patches with clean edges. Fire disturbance, on the other hand, tends to leave smaller, irregularly shaped patches having convoluted edges (see Agee 1991). In addition, fire disturbance leaves a variety of seral stages based on the frequency of low, moderate, and severe burns over time.

Population analysis of California spotted owls in the central Sierra Nevada with habitat covariates at the territory scale indicated there was no relationship between fecundity and early seral conditions which, in that area, resulted almost entirely from intensive logging, as described

above (Seamans 2005). Survival rate and territory occupancy in that study were positively related to the amount of mid- and late-seral forests (Seamans 2005). Further, it was estimated that reproductive output was influenced by weather, and it was hypothesized that reproductive output by California spotted owls at an individual territory was conditional on the territory being occupied during years when weather conditions were conducive to successful reproduction (Seamans 2005, Seamans and Gutiérrez 2007b). Reproduction of spotted owls in the southern Sierra Nevada increased with canopy closure in 430-ha territory centers, as more pairs successfully nested (Lee and Irwin 2005).

Seamans and Gutiérrez (2007a) examined the effects of habitat alteration, which was due to logging, on territory colonization, extinction, and breeding-dispersal of color-banded spotted owls in the Eldorado Study Area from 1990 to 2004. This study evaluated whether: (1) alteration of mature conifer forest (conifer forest with > 70 percent canopy cover and dominated by medium [30.4–60.9 cm dbh] and large [> 60.9 cm dbh] trees) was correlated with immediate, short-term territory colonization probability (probability of an unoccupied territory becoming occupied), extinction probability (probability of an occupied territory becoming unoccupied), or breeding dispersal probability; (2) alteration of mature conifer forest was correlated with long-term territory colonization or extinction probability; and (3) territory colonization or extinction probability, or breeding dispersal, was related to variation in the amount of mature conifer forest among territories. Thirty-eight territories (58 percent) experienced some habitat alteration during the study. Habitat alteration in all but two of these 38 territories was the result of logging in unburned forest (Seamans and Gutiérrez 2007a), while the other two were affected by high-severity wildfire (Seamans and Gutiérrez 2007a), which had been salvage-logged on both private and national forest lands (C. Hanson personal observation). The probability of territory colonization decreased significantly with as little as 20 ha of logging, and territory occupancy was significantly decreased with as little as 20 ha of logging. Further, the probability of breeding dispersal away from a territory was related to the area of mature conifer forest in a territory and increased when ≥ 20 ha of this habitat was altered (see Figure 26 below).

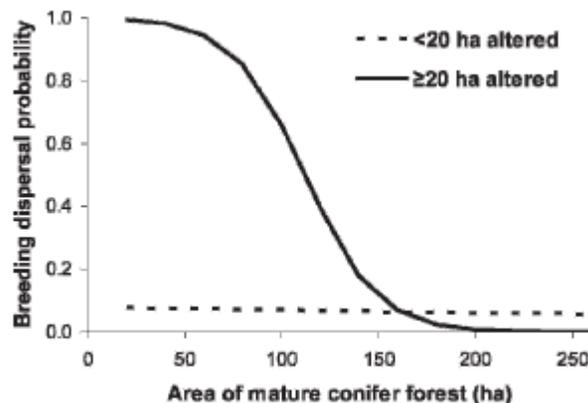


Figure 26. The relationship between paired female Spotted Owl breeding dispersal probability and the amount of mature conifer forest altered by logging in a territory in the Eldorado Study Area, from 1990 to 2004. Dispersal probability increased rapidly at territories with < 150 ha of mature conifer forest when ≥ 20 ha of this habitat type was altered by logging. The x-axis represents the amount of mature conifer forest prior to actual or potential dispersal. The dashed and solid lines represent predicted dispersal probability when < 20 ha or ≥ 20 ha of mature conifer forest were altered, respectively. From Seamans and Gutiérrez 2007a; Figure 2 at page 573.

Nesting and Roosting Habitat

Based on comparisons of time spent by owls in various habitat types to amounts of habitat available, studies of owls showed that the owls preferentially used areas for nesting or roosting with at least 70 percent canopy cover, used habitats with 40 to 69 percent canopy cover in proportion to their availability, and spent less time in areas with less than 40 percent canopy cover (where lower canopy cover was often due to logging effects) than might be expected if habitat were selected randomly (Verner et al. 1992). In these forests, owls preferred stands with significantly greater canopy cover, total live-tree basal area, basal area of hardwoods and conifers, and snag basal area for nesting and roosting. Stands suitable for nesting and roosting had: (1) two or more canopy layers; (2) dominant and co-dominant trees in the canopy averaging at least 61 cm (24 in) in dbh; (3) at least 70 percent total canopy cover (including the hardwood component); (4) higher than average levels of very large, old trees; (5) higher-than-average levels of snags and downed woody material; and (6) at least ~42 square meters per ha (at least 185 square feet per acre) of live tree basal area (Gutiérrez et al. 1992, USFS 2001 [Vol. 3, Chpt. 3, Part 4.4, p. 73]).

High amounts of canopy closure and structural diversity (multi-layered canopy) are typical of nesting and roosting stands used by spotted owls in the Sierras and in southern California (e.g., Laymon 1988, Call et al. 1992, LaHaye et al. 1992; 1997, Zabel et al. 1992a, Moen and Gutiérrez 1997, North et al. 2000, Bond et al. 2004, Seamans 2005). Nesting and roosting stands often have mean canopy closures of greater than 75 percent (Bias and Gutiérrez 1992; Gutiérrez et al. 1992). Verner et al. (1992b:60; emphasis in text) summarized: “Habitats used for nesting typically have greater than 70 percent total canopy cover (all canopy above 7 feet [2.1 m]), except at very high elevations where canopy cover as low as 30–40 percent may occur (as in some red fir stands of the Sierra Nevada). Nest stands typically exhibit a mixture of tree sizes and usually at least two canopy layers, with some very large, old trees usually present. Stands used for roosting are similar to those used for nesting, with relatively high canopy cover, dominated by older trees with large diameters, and with at least two canopy layers.”

California spotted owl nest trees over a wide range of elevations in the Eldorado Study Area were not located closer to forest edges than random locations, and in fact were located farther from high-contrast edges (typically from even-aged logging in this study area) than random

points (Philips et al. 2010). While owls will forage in or near habitat edges, the risk of predation may outweigh energetic savings gained by selecting nests close to logged edges. The authors noted that increased forest fragmentation at nest stands would not benefit spotted owls.

Moen and Gutiérrez (1997) analyzed California spotted owl habitat at the landscape, habitat patch, and microsite levels on a 355 square kilometer (137 square mile) study area on the Eldorado National Forest. They used remote sensing to analyze vegetation in 457 ha (1,129 ac) circular plots surrounding spotted owl activity centers, and compared those plots with randomly selected plots of equal size. Owl plots were significantly more homogeneous than random sites, indicating that owls select against habitat fragmentation (again, as discussed above, in this study area fragmentation is almost entirely from logging on both public and private lands); owl sites contained significantly more area with canopy closure exceeding 70 percent than random plots; and California spotted owl roosts were significantly more likely to be located in mixed-conifer habitat containing trees greater than 30 cm (12 in) dbh than would be expected by chance. In addition, of 82 roost sites examined, 56 (68 percent) were in habitat with greater than 40 percent canopy closure and trees greater than 30 cm (12 in) dbh, and 97 percent of roost sites had trees over 100 cm (39 in) dbh. Microsite comparison between sixteen 0.04 ha (0.10 ac) vegetation plots surrounding nest sites and random plots of equal area showed that nest plots had significantly higher structural diversity, more total trees, larger trees, and more trees over 100 cm (39 in) dbh.

Bond et al. (2004) assessed the utility of six habitat metrics that are easily derived from Forest Inventory Data (FIA) for estimating California spotted owl nesting habitat. Vegetation was sampled at 22 nest plots, and a random subsample of plots in M3N, M3G, M4N and M4G strata (generally, mature/old forest with 40–70 percent [“N”] or > 70 percent [“G”] canopy cover). Plots were 100 m long and 20 m wide oriented in random directions. The top-ranked model of nesting habitat using the six metrics suggested that the number of large (> 76.2 cm) trees and high canopy cover were the best predictors of nesting-habitat selection by California spotted owls in M3 and M4 habitat. Average number of large trees at nest plots was more than twice as high as random forest plots, and canopy cover averaged 77.41 percent at nest plots compared with 55.04 percent at random plots.

Bias and Gutiérrez (1992) attributed low use of private timberlands by roosting and nesting California spotted owls to sanitation (removal of damaged or diseased trees or species of low commercial value) and high-grade logging (harvest of large trees of high commercial value) that removed potential nest trees. Habitat use by California spotted owls has been studied on a private timber production area in the Sierra Nevada, 48 kilometers (km) (30 mi) east of Chico, California (Irwin et al., National Council for Air and Stream Improvement, Incorporated, in litt. 2002). Seven pairs of California spotted owls were repeatedly located using radio-telemetry. Habitat use was similar to that observed in other studies on federal lands. Owls were located in areas with canopy closure averaging 70 percent, numerically dominated by trees 30 to 36 cm (12 to 14 in) in dbh, but also containing numerous larger (over 66 cm (26 in) dbh) trees, and with

tree densities ranging from 930 to 1,360 trees/ha (372 to 544 trees/ac). In a later publication from the same study area incorporating radio-telemetry data from 17 owls over a period of six years, Irwin et al. (2007) documented that roosting locations were close to nests and near streams, and were in stands with greater tree densities, more basal area, more overstory canopy cover, more large trees, and less basal area of ponderosa pine. Such locations also were further from roads, which had been placed higher on slopes or on ridges. Table 2 below shows variables measured at roosting, foraging, and random locations of these owls.

Table 2. Average and standard error for habitat and environmental conditions at roosting, foraging, and random locations, based upon 4,316 telemetry points and 18,815 random landscape locations within California spotted owl home ranges, California, USA, from 1999 to 2004.

Variable	Roosting		Foraging		Random	
	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE
Basal area m ² /ha	49.6	1.0	43.5	1.0	40.1	0.5
Douglas-fir BA	16.6	0.6	13.5	0.4	9.9	0.2
White fir BA	10.4	0.5	10.1	0.2	12.0	0.1
Lodgepole pine BA	6.4	0.5	7.8	0.2	7.1	0.2
Hardwood BA _{SMALL}	2.2	0.2	2.4	0.2	2.4	0.2
Hardwood BA _{LARGE}	8.4	0.2	8.1	0.5	7.8	0.3
Canopy Cover (%)	75.0	1.0	69.0	1.0	67.0	2.0
No. trees/ha	1,345	72	1,160	48	1,205	27
No. green trees >66 cm dbh/ha	20.0	1.0	17.3	0.5	13.8	0.3
Large snag density (no./ha)	3.0	0.3	3.8	0.3	3.5	1.2
Small tree density (no./ha)	275	11	261	10	270	5
QMD (cm)	39.6	0.3	36.0	0.2	33.2	0.2
Aspect (°)	207	3	205	2	203	1
Distance to nearest road (m)	126	3	117	1	114	1
Elevation (m)	1,004	6	1,020	3	1,050	3
Distance to nest (m)	1,154	67	1,286	26	2,340	16
Distance to streams (m)	130	5	137	3	175	2
Slope (°)	5.0	0.8	5.0	0.1	5.0	0.1

California spotted owl nest sites in the San Bernardino Mountains of southern California were more likely to be located in areas with steeper slopes and in the lower third of canyons, and owl nest and roost sites in this area were more likely to be located in areas with higher canopy closure and higher basal area (the area of all trees at breast height) than random sites. Spotted owl nests at 103 sites were in areas with higher canopy closure (mean = 79 percent) than were 296 random sites (mean = 52 percent), and they were in areas with more conifers at least 75 cm (29 in) dbh, more hardwoods at least 45 cm (18 in) dbh, more broken-topped trees, and more snags than were random sites (LaHaye et al. 1997).

Bond et al. (2009) studied California spotted owl nesting, roosting, and foraging habitat selection in recently burned forests that were not subjected to extensive post-fire logging. The study included a total of four nest sites, and three of these were in burned forests—one in a stand burned at low-severity and two in stands burned at moderate severity. The study found that owls

selected low-severity burn areas, but avoided moderate- and high-severity burn areas for roosting. The low-severity burned stands selected for roosting had high canopy cover and an abundance of large trees similar to unburned forests documented in many studies to be preferred by nesting and roosting spotted owls.

Nest Tree Characteristics

California spotted owls nest in a variety of tree species (in both live trees and snags) in pre-existing structures such as cavities, broken top trees, and platforms such as mistletoe brooms, debris platforms and old raptor or squirrel nests (Gutiérrez et al. 1992, 1995). Nest trees are often large, over 89 cm (35 in) average dbh (Gutiérrez et al. 1992, Steger et al. 1997, LaHaye et al. 1997), and larger than other trees in the same stand (Gutiérrez et al. 1992). Nest trees are also often greater than 200 years old (Gutiérrez et al. 1992, North et al. 2000). However, approximately 25 percent of nest trees out of a sample of over 250 were less than 76 cm (30 in) dbh (Gutiérrez et al. 1992). Although old, large trees are important to California spotted owls, intermediate-sized (28 to 61 cm (11 to 24 in)) trees were also selected by nesting (LaHaye et al. 1997; and trees 51 to 76 cm (20 to 30 in) dbh), roosting (Moen and Gutiérrez 1997), and foraging (Laymon 1988) owls.

Basal areas of nesting and roosting sites have been shown to be greater than those in random sites in the Sierras and in southern California (Bias 1989 in Gutiérrez et al. 1992, Laymon 1988 in Gutiérrez et al. 1992, LaHaye et al. 1997). Spotted owls nest in a variety of species of live trees and snags in preexisting structures including cavities, broken top trees, and platforms such as mistletoe brooms, debris platforms and old raptor or squirrel nests; therefore nesting habitat includes more large live, decadent, and dead trees than do forests not used for nesting (Laymon 1988, Call 1990, Bias and Gutiérrez 1992, Gutiérrez et al. 1992; 1995, LaHaye et al. 1997).

Prey and Foraging Habitat

California spotted owls are considered prey specialists (Verner et al. 1992b) because they select a few key species (Verner et al. 1992b) among the variety of taxa on which they prey. In mid-elevation forests of the Sierra Nevada (about 1,200 to 1,525 m (4,000 to 5,000 ft)), a frequent prey species is the northern flying squirrel, which is most common in larger stands of mature forests (Verner et al. 1992b). In lower elevations of the Sierra Nevada and in southern California, the primary prey is the woodrat (Thraillkill and Bias 1989), which is most abundant in shrubby habitats and uncommon in pure conifer forests or forests with little shrub understory (Williams et al. 1992). Pocket gophers were common in the diets of owls in a burned landscape in the southern Sierra Nevada (Bond et al. 2013).

Most of the research conducted on the habitat of California spotted owls has been focused in forests that had not recently experienced fire. Since the Service's 2003 and 2006 findings, new studies have revealed substantial usage of burned forests as foraging habitat. Therefore, below

we describe separately the results from studies in long-unburned forests and burned forests because habitats differ between the two types.

In unburned forests (i.e. forests that had not experienced significant areas of moderate or severe fire within the past several decades), California spotted owls foraged most commonly in intermediate- to late-successional forests with greater than 40 percent canopy cover and a mixture of tree sizes, some larger than 61 cm (24 in) in dbh (Call et al. 1992, Zabel et al. 1992b). The birds consistently selected stands with significantly greater canopy cover, total live tree basal area, basal area of hardwoods and conifers, snag basal area, and dead and downed wood than are found at random locations within the forest. Studies on the Tahoe and Eldorado National Forests found that owls foraged in stands with large diameter trees (defined as trees greater than 61 cm (24 in) in dbh in one study, and trees 51 to 89 cm (20 to 35 in) in dbh in the other), significantly more than expected based on availability. Owls also foraged in stands with trees between 30 and 61 cm (12 and 24 in) dbh and greater than 70 percent canopy cover significantly more than expected, based on the proportion of that forest type (USFS 2001a).

Studies documented that stands suitable for owl foraging have: (1) at least two canopy layers; (2) dominant and co-dominant trees in the canopy averaging at least 28 cm (11 in) in dbh; (3) at least 40 percent canopy cover in overstory trees (30 percent canopy cover in red fir dominated forests); and (4) higher than average numbers of snags and downed woody material. Radio tracking data from the Sierra National Forest showed that owls tended to forage more in sites with greater than 50 percent canopy cover than predicted from their availability, while stands with 40 to 50 percent canopy cover were used about in proportion to their availability (USFS 2001a). California spotted owls avoided open areas for foraging (0–30 percent canopy cover), where the openness was generally the result of past logging (Call et al. 1992, Gutiérrez et al. 1992, Zabel et al. 1992b). Overall, foraging habitat was enhanced by the presence of hardwoods (Verner et al. 1992b).

Irwin et al. (2007) radio-tracked 17 California spotted owls for six years in mixed-conifer forests on private timberlands in the northern Sierra Nevada. Compared to random locations, nocturnal telemetry locations were closer to nests and small streams at lower elevations in stands that contained more total basal area, more basal area in Douglas-fir trees, and more large-diameter trees. Abiotic environmental factors, primarily distance to nest, distance to water, and elevation, were strongly associated with spotted owl foraging habitat selection on private timberlands. The number of nocturnal telemetry locations declined rapidly and nonlinearly with increasing distance from nests and streams, although the relations were nearly linear over the range of distance values in the study area. Forest habitats near first- and second-order streams were more likely to be used for foraging by spotted owls than those near larger streams, but foraging habitat selection was not strongly associated with roads, slope, and aspect. The combined basal areas of Douglas-fir, white fir, and red fir and basal area of hardwoods ≥ 20 cm diameter at breast height were positively and unimodally correlated to foraging habitat selection by owls, whereas the

relative probability of selection decreased with increasing basal area of ponderosa pine. Average tree density at foraging locations was 1,160/ha (470/acre). Overall, the probability of a California spotted owl selecting a stand for nocturnal foraging was most strongly associated with dense fir-dominated forest stands relatively close to nest sites, usually in lower slope positions adjacent to small streams. Those associations probably occurred because densities of the owls' prey likely were more abundant in the riparian zones or moist forests.

Current management guidelines for the Sierra Nevada involve implementation of landscape-scale fuels treatments such as Defensible Fuel Profile Zones (DFPZs), and Strategically Placed Area Treatments (SPLATS), as approaches to modify fire behavior and facilitate fire suppression. The general prescription of fuels treatments is reducing forest canopy cover to 40 percent, removing trees up to 30-inches diameter, and reducing tree density and 'ladder' fuels (USFS 2004). Gallagher (2010) examined foraging-site selection of 10 radio-marked California spotted owls in the Meadow Valley Project area on the Plumas National Forest. Six owls were tracked for two years; two owls were tracked for one year but then were found dead, and two additional owls were captured and tracked for the second year. The project was governed by the Herger-Feinstein Quincy Library Group Forest Recovery Act of 1998. Treatments included 1) DFPZs, landscape-scale forest thins designed to function as fire breaks by a reduction in canopy cover, tree density, and ladder fuels; 2) understory thin, prescribed as removal of shrubs and trees < 10-inches diameter; 3) understory thin followed by underburn; and 4) group selection, a removal of all trees < 30-inches diameter in < 0.8-ha patches. Gallagher (2010) found that across all birds and both study years, only 8 percent of owl foraging locations were located within fuels treatments, and nearly half of those locations were accounted for by a single owl. Owl foraging sites were primarily located in mixed-conifer forest dominated by trees 12–24 inches diameter with an additional large proportion of trees > 30-inches diameter and with a multi-layered understory with numerous small trees. The mean proportion of owl locations in DFPZs was lower than expected by chance, thus the owls avoided foraging in this treatment type.

Meiman et al. (2003) radio-marked a northern spotted owl in the Coast Range of Oregon, prior to commercial thinning (see original study for description of thinning). The authors documented substantially lower use of the thinned area after harvest by this owl.

Williams et al. (2011) used a random selection of 13 radio-marked owls to describe foraging habitat selection in the Eldorado Study Area. Foraging habitat selection was most correlated with vegetation class, patch size, and their interaction. The effect of increasing patch size varied among vegetation classes; the relative probability that hardwood forests and pole-sized conifer forests were used increased as patch size increased, whereas the probability of use of areas with low canopy cover, medium-sized conifer forests with either medium or high canopy cover, and mature forests with either medium or high canopy cover, decreased as patch size increased. These results seem counter-intuitive, however the decrease in relative probability of using mature forests with medium and high canopy cover is very likely due to the scarcity of larger

patches of those vegetation classes. This study suggests that vegetation type, patch size, and their interaction were correlated with foraging habitat selection, but there was a high amount of variation in selection among owls. In general, foraging sites comprised of mature forests with medium (40–70 percent) canopy cover (vegetation class 6) had a high relative probability of selection when patch size was small (< 1 ha). However, the limited availability of patches of this vegetation class that were > 30 ha and the low mapping accuracy suggests that this probability of selection was inconclusive. Mature forests with high (> 70 percent) canopy cover did not have high relative probability of selection at this scale, and owls using this type of forest on average used areas 30.5 m closer to edges than random areas. Thus, owls may be foraging along the edges between older forests and other vegetation classes. The owls apparently also selected pole-sized stands at large patch sizes. With regard to this result, it was possible that small patches of mature forests were embedded within the larger patches of pole-sized stands that the owls used for foraging, or that residual large trees were present, which attracted the owls to the area, but the methodology and mapping in this study were too imprecise to distinguish these elements.

Bond et al. (2009) quantified habitat selection in forests that recently experienced significant amounts of moderate- and high-severity fire. Habitat selection estimates how much owls used forest that burned at a particular severity compared with the availability of that burn severity. The authors radio-tracked seven California spotted owls occupying the McNally Fire in the Sequoia National Forest throughout the breeding season four years after fire. Males and females forage independently (Zimmerman et al. 2001, Irwin et al. 2007, Williams et al. 2011), and analyses compared each bird's foraging locations with random locations within their own foraging ranges. Very little (< 3 percent) of the combined foraging ranges of these owls was post-fire logged, so there were essentially no confounding effects of logging with high-intensity fire. Furthermore, all owls had unburned, low, moderate, and highly burned patches of forest in their foraging ranges from which to choose, so the authors could quantify whether owls selected or avoided any of these burn intensities. This was the first study to specifically examine foraging habitat selection by spotted owls in burned forests that were not subjected to substantial post-fire logging. Spotted owls used all burn severities for foraging, but the probability of an owl using a site for foraging was strongest in severely burned forests, after accounting for distance from nest (see Figure 27 below). Selection for a particular burn class occurred within 1.5 km from the nest, but not beyond. Spotted owls used unburned mature/old forest for foraging 46 percent less than would be expected based upon availability, where post-fire habitat was available for foraging.

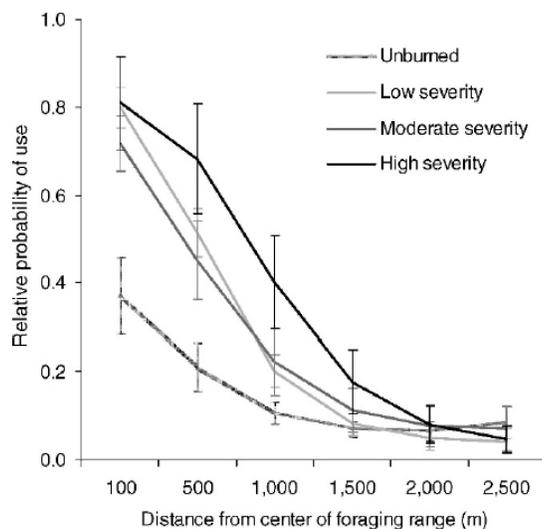


Figure 27. Relative probability of use of a site for 7 California spotted owls foraging at different distances from the center of the breeding range in forest burned at different intensities in the McNally Fire, Sequoia National Forest, 2006. From Bond et al. 2009; Figure 1 on page 1,121.

Bond et al. (2009) also measured vegetation within owl foraging ranges and found that high-intensity burned sites had the greatest herb and shrub cover and basal area of snags. This result suggests that snags, herb, and shrub cover are important components of a post-fire forest that supports foraging habitat for spotted owls.

Bond et al. (2009) documents that when it is available to them, foraging owls appear to select high-severity burned forests not subjected to significant post-fire logging (Bond et al. 2009). Possible explanations for the selection of intensely burned forests for foraging may be increased accessibility or abundance of prey with fire-caused growth in shrubs and forbs. Spotted owls are perch-and-pounce predators, and thus must have an adequate supply of trees (such as snags) upon which to perch and wait for prey. Because intensely burned, non-salvage-logged forests can offer suitable habitat for foraging spotted owls, Bond et al. (2009) recommended “that burned forests within 1.5 km of nests or roosts of California spotted owls not be salvage-logged until long-term effects of fire on spotted owls and their prey are understood more fully.”

Also using radio-telemetry, Clark (2007) found similar selection by northern spotted owls for mature/old forest areas that burned at high-severity fire and were not subsequently salvage logged(see, e.g., Figure 6.2 of Clark 2007). An unpublished thesis, Eyes (2014), reported results that differed from Bond et al. (2009) and Clark (2007), but this study had significant methodological problems, and a closer examination of the data indicates use of high-severity fire areas exceeding availability (**Appendix A**).

Winter Habitat

Winter habitats of owls that undertake altitudinal migrations have similar canopy closures, but lower basal areas of both green trees and snags, and higher shrub densities than higher-elevation summer habitats (Gutiérrez et al. 1995). Bond et al. (2010) found that three of five radio-marked California spotted owls occupying burned landscapes of the southern Sierra Nevada roosted within the fire's perimeter during the winter.

General Description of Suitable Habitat

In 2003, the FWS described nesting habitat for California spotted owls as stands with an average dominant and co-dominant tree diameter of greater than 24 inches and canopy cover of greater than 70 percent.

The U.S. Forest Service considers suitable California spotted owl habitat as forest stands represented by CWHR classes 4M, 4D, 5M, 5D, and 6 (Mayer and Laudenslayer 1988) in mixed-conifer, red fir, ponderosa pine/ hardwood, foothill riparian/hardwood, and east-side pine forests.

The last time the Forest Service formally adopted a definition of suitable habitat for spotted owls was in 2004, as part of the 2004 SNFPA (USDA 2004a). The SNFPA defines suitable habitat as mature/old forest with moderate to high canopy cover (> 50 percent), and high levels of large snags and downed logs.³

Because the Forest Service relies on the 2004 SNFPA for its management direction, the agency has never recognized the foraging habitat suitability of high-severity burned (and not salvage logged) forest stands for spotted owls (Clark 2007, Bond et al. 2009) and, in fact, regularly re-draws Protected Activity Centers (PACs), or even removes them from the PAC system, after severe fire to exclude these areas. The 2004 SNFPA facilitates this due to two key factors 1) its definition of suitable habitat and 2) because it explicitly states: "PACs are maintained regardless of California spotted owl occupancy status. However, after a stand-replacing event, evaluate habitat conditions within a 1.5-mile radius around the activity center to identify opportunities for re-mapping the PAC. If there is insufficient suitable habitat for designating a PAC within the 1.5-mile radius, the PAC may be removed from the network." The result is a lack of protection for suitable burned foraging habitat close to nests/roosts, which in turn allows this suitable

³ "The best available habitat is selected for California spotted owl PACs to include: (1) two or more tree canopy layers; (2) trees in the dominant and co-dominant crown classes averaging 24 inches dbh or greater; (3) at least 70 percent tree canopy cover (including hardwoods); and (4) in descending order of priority, CWHR classes 6, 5D, 5M, 4D, and 4M and other stands with at least 50 percent canopy cover (including hardwoods). HRCAs consist of large habitat blocks that have: (1) at least two tree canopy layers; (2) at least 24 inches dbh in dominant and co-dominant trees; (3) a number of very large (greater than 45 inches dbh) old trees; (4) at least 50 to 70 percent canopy cover; and (5) higher than average levels of snags and down woody material."

foraging habitat to be open to post-fire salvage logging, which evidence indicates adversely affects occupancy (see Threats). This is a major issue, given that a disproportionately large amount of foraging occurs within a 1,000-meter radius of nest trees (Bond et al. 2009, Fig. 1).

Home Range

Spotted owl pairs have large home ranges that may overlap those of conspecifics (Verner et al. 1992b). A portion of the home range is defended as a territory, especially against unknown intruders (Gutiérrez et al. 1995). However, territorial disputes between neighbors are rare. Members of the same sex are more likely to display aggression toward each other than members of the opposite sex (Verner et al. 1992b). Spotted owls may roost near conspecifics other than their mates (Gutiérrez et al. 1995). Verner et al. (1992b) suggested that the spotted owl territorial system functions such that an individual or pair are dominant within a territory and prevent conspecifics from breeding there, but that feeding or roosting by those birds may be tolerated.

Carey et al. (1992) studied the relationship between the amount of habitat used by northern spotted owls and prey abundance within those habitats. They found that owls had smaller home ranges (indicating higher territory fitness) in habitats where the estimated biomass of medium sized prey, primarily flying squirrels and woodrats, was higher. Zabel et al. (1995) found that prey species predicted the size of the northern spotted owl's home range in California better than the proportion of older forest in the home range. In both studies, owls with a greater percent biomass of larger prey in their diet had home ranges smaller than those of owls that consumed more of the smaller prey species (again, with smaller home ranges associated with higher habitat quality and territory fitness). Ward et al. (1998) documented that northern spotted owls in California selected foraging sites according to the distribution of larger prey (e.g., woodrats), which provided an energetic benefit to the owls. The largest home ranges of California spotted owls occurred where flying squirrels comprise the majority of the owl's diet and the smallest (best) occur where woodrats dominate (Verner et al. 1992b, Zabel et al. 1992a).

Woodrat populations are denser than flying squirrel populations, often by at least tenfold, and woodrats weigh nearly twice as much as flying squirrels. Thus, home ranges of owls in areas where the primary prey is northern flying squirrels are consistently larger than those where the primary prey is dusky-footed woodrats, presumably because woodrats occur in greater densities and weigh more than flying squirrels (Zabel et al. 1992a). Variation in prey availability likely affects the percentage of California spotted owl pairs that nest and successfully fledge young. Weather may also affect these parameters, either by directly affecting the owls or by affecting their prey base (Verner et al. 1992b). Verner et al. (1992b) reported that approximately 25 percent of known owl sites in the Sierra Nevada occur where woodrats are the primary prey species and 75 percent of sites occur where flying squirrels are the primary prey species.

Home-Range Size—Estimates of California spotted owl home-range size are extremely variable. Available data indicate that they are smallest in habitats at relatively lower elevations with abundant hardwoods, intermediate in size in conifer forests in the central Sierra Nevada, and largest in the true fir forests in the northern Sierra Nevada (Zabel et al. 1992a, USFS 2001a). Based on an analysis of data from telemetry studies of California spotted owls, mean breeding season pair home-range sizes have been estimated as 3,642 ha (9,000 ac) in true fir forests on the Lassen National Forest; 1,902 ha (4,700 ac) in mixed conifer forests on the Tahoe and Eldorado National Forests; and 1,012 ha (2,500 ac) in mixed conifer forests on the Sierra National Forest. Zimmerman et al. (2001) used radio-telemetry data to estimate the breeding season home range of two pairs of California spotted owls in the San Bernardino Mountains of southern California. The average home range (571 ha (1,410 ac)) was smaller than those reported for the Sierra Nevada and varied widely between the two pairs (325 to 816 ha (803 to 2,016 ac)).

More recently, Williams et al. (2011) used a random selection of 13 radio-marked owls (one with two datasets) in the Eldorado Study Area from June to October to estimate home-range size, describe habitat characteristics associated with differences in home-range size, and estimate home-range habitat selection. This study was in forests that had not burned during at least the past several decades. Mean home-range sizes varied from 508 ha to 946 ha (male average = 578.7 ha, female average = 622.0 ha [excluding one outlier female]).

In the only study examining home-range size of California spotted owls in burned forests, Bond et al. (2013) compared home ranges in a burned landscape of the southern Sierra Nevada (2002 McNally Fire, Sequoia National Forest) with home ranges in three of the unburned demography study areas (Eldorado Study Area, Sierra Study Area, San Bernardino Study Area). The size of the home range of a spotted owl in the McNally Fire area averaged 402.5 ha (SE = 88.7, range 129.8–718.0 ha). Home-range sizes in long-unburned forests (calculated using the same methodology and time period) averaged 487.0 ha (SE = 63.9 ha) in the Tahoe National Forest, 529.0 ha (SE = 72.9 ha) in the Sierra National Forest, and 370.4 ha (SE = 58.7 ha) in the San Bernardino National Forest; Table 4. Thus, the mean home-range size of spotted owls in burned areas is similar to unburned areas, as evidenced by overlapping standard errors. The mean home range in the burned area was 24 percent smaller than the nearest unburned area of similar elevation (Sierra). Owls in the Sierra National Forest foraged mainly on flying squirrels, and on flying squirrels and woodrats in the Eldorado National Forest, while owls in the burned forests of the McNally Fire foraged heavily on pocket gophers (Bond et al. 2013, Table 2 on page 121). The authors noted that spotted owls occupying burned forests do not need to range more widely than owls in unburned landscapes in order to obtain their food.

Table 3. Characteristics of Home Ranges Estimated by the Fixed-Kernel Method of California Spotted Owls Four Years after the 2002 McNally Fire, Sequoia National Forest, and in Three Unburned Areas. From Bond et al. (2013) Table 3 at page 123.

	Study area			
	Tahoe NF ^a	Sierra NF ^b	Sequoia NF McNally Fire	San Bernardino NF ^c
Latitude (degrees N)	40	37	36	34
Elevation (m)	670–1585	1,220–2,925	1,500–2,500	2,000–2,500
Mean home range (ha) ^d	487.0	529.0	402.5	370.4
SE of home range	63.9	72.9	88.7	58.7
Range of home range ^d	284.8–682.3	253.3–718.5	129.8–718.0	242.0–526.5

^aFrom D. Call, unpublished data.

^bFrom T. Munton, unpublished data.

^cFrom G. Zimmerman, unpublished data.

^dEstimated from locations of night-time foraging recorded 22 May–15 August 2006.

Habitat in Home Range— Gutiérrez et al. (1992) analyzed the sizes of stands containing nest trees (i.e., nest stands) and the cumulative sizes of each nest stand plus all adjoining stands that were in vegetation strata preferentially used by owls for nesting. The mean size of nest stands was about 40 ha (100 ac); the mean size of the nest stand plus adjacent suitable stands was about 120 ha (300 ac). In radio-tracking studies, the central area incorporating half of the locations of owls at each site was found to vary from an average of 128 ha (317 ac) on the Sierra National Forest to an average of 319 ha (788 ac) on the Lassen National Forest (Gutiérrez et al. 1992). Bingham and Noon (1997) used radio-telemetry data to calculate core areas within the home ranges of four California spotted owls on the Lassen National Forest. Owls used the core areas more than would be expected if the entire home range were used at random. Core areas contained an average of 66 percent of points at which owls were located within an average of 21 percent of the home range.

In conifer forests of the Sierra Nevada, the proportion of forest in home ranges with canopy cover greater than 40 percent was 68 percent and 81 percent for the two conifer sites studied (Zabel et al. 1992a). Gallagher (2010) found that home-range area of California spotted owls in the Meadow Valley Project area of the Plumas National Forest increased as the total area of fuels treatments within the home range increased, particularly of DFPZ and group selection treatments.

In managed forests of the Eldorado Study Area, Williams et al. (2011) investigated home range characteristics of 14 California spotted owls. The Eldorado study documented the proportions of vegetation classes within home ranges (e.g., used home-range habitat) varied widely among owls, but on average consisted of: hardwood forest = 3.5 percent, areas with low canopy cover = 11.8 percent, pole-sized conifer forest (medium to high canopy cover) = 6.3 percent, medium-sized conifer forest with medium canopy cover = 19.0 percent, medium-sized conifer forest with high canopy cover = 47.1 percent, mature conifer forest with medium canopy cover = 1.6 percent, mature conifer forest with high canopy cover = 10.7 percent, and water = 0.0 percent. Mature forests with medium canopy cover and mature forest with high canopy cover were selected in home ranges most often relative to their availability (i.e., had the highest selection ratios; selection ratios = 2.98 and 3.68, respectively). This sample of owls selected home ranges with high proportions of mature forests, similar to other studies from this area. For example, Chatfield (2005) found that, at the territory scale, selection was strongest for mid- to late-seral mixed-conifer forests having high canopy cover (≥ 70 percent), while other habitat metrics (edge, patch size, patch density) were not related to spotted owl site-occupancy.

Bond et al. (2009, 2013) found that in the McNally fire of the southern Sierra Nevada, high natural habitat heterogeneity from mixed-severity fire that was not post-fire logged (including patches of montane chaparral [shrubs] and high densities of snags intermixed with, or adjacent to, dense, mature/old conifer forest) was associated with home-range sizes that were comparable to or smaller than those in unburned mature/old forest, indicating habitat suitability in the burned forest areas as similar to that in unburned forest areas. This result contrasts with the results of Gallagher (2010) who showed home-range sizes increased with increasing amounts of fuels treatments and that owls avoided foraging in DFPZs. Thus, fuels treatments are documented to have adverse effects on habitat quality while fire was not, undermining the assumption that fire is a greater threat to spotted owl habitat than timber harvesting (see Threats).

Habitat Condition

Historical Habitat Loss

Timber harvest has been the most significant historical factor impacting California spotted owl habitat (Gutiérrez 1994, Verner et al. 1992a). Selective harvest of merchantable trees in the Sierras—often old-growth trees—was the norm during the late 1800s through the 1970s, resulting in the loss of much suitable habitat and the production of forests with younger average tree ages. McKelvey and Johnston (1992) used historical documents to describe the status of Sierran forests at the beginning of the 20th century, and detailed the harvest history from the late 19th century to 1990. In the Sierra Nevada, timber harvest steadily intensified from the railroad building and mining eras of the 1800s until the 1950s, then remained at relatively high levels through the 1980s (intermittent declines occurred during poor economic conditions of the 1930s

and early 1980s) (McKelvey and Johnston 1992). From the 1970s onward, clearcut harvests became increasingly more common (McKelvey and Johnston 1992). Since the late 1980s, the volume of timber harvested in the Sierra Nevada has declined, but cutting became increasingly based on salvage logging (McKelvey and Johnston 1992). And, while the timber volume removed annually on national forests of the Sierra Nevada is less now than it was two decades ago or more, much of the logging that occurs presently is mechanical thinning, which removes fewer board feet per acre than past clearcuts, but nonetheless degrades habitat over large areas, including not only through reduction of canopy cover and removal of mature trees (and further impeding snag recruitment through stand density reduction), as well as loss of understory, but also through creation and maintenance of logging roads to access and maintain thinned areas (USDA 2004a). Moreover, as discussed in the section below, Forest Service management direction, as laid out in the 2004 SNFPA (which is regularly cited to and tiered to in Forest Service logging proposals), promotes landscape-level mechanical thinning as well as salvage logging in California spotted owl habitat. Further, a “Leadership Intent” document for the Forest Service, Region 5 (California), states that the Forest Service plans “to significantly increase the pace and scale” of its actions which means that the Forest Service intends to increase mechanical thinning and salvage logging.⁴

Verner et al. (1992a) discussed five major factors of concern for California spotted owl habitat that have resulted from historical timber-harvest strategies: (1) Decline in the abundance of very large, old trees; (2) decline in snag density; (3) decline in large-diameter logs; (4) disturbance or removal of duff and topsoil layers; and (5) change in the composition of tree species. Thus, extensive commercial logging directly affected key structural components of California spotted owl habitat. It will take many decades for these forests to regain these late-successional components, such that there are long-lasting effects of past logging that persist many decades beyond the point when logging levels began to decline somewhat.

Late-successional/old-growth forests provide habitat attributes selected by California spotted owls, including large trees, high canopy closure, multi-layered canopies, snags, and logs (University of California 1996). The current extent of old forests in the Sierra Nevada is believed to be substantially less than in pre-historic times. Estimates of the current extent have been made by several authors. The University of California (1996) (Sierra Nevada Ecosystem Project Report) reported that in national parks in the Sierra Nevada, which contain the best representation of pre-settlement conditions because almost none of the area has been logged, 55 percent of forests are in late-successional/old-growth forest conditions, but on all Federal lands in the Sierra Nevada, such conditions are now found on only 19 percent of forest lands. The Forest Service (USFS 2001a) reported that old forest conditions have declined from 50 to 90 percent in various vegetation types compared to the range of historical conditions. Beardsley et al. (1999) estimated that approximately 15 percent of coniferous forests in the Sierra Nevada remain in high quality late-successional/old-growth stages; most of these stands are at high

⁴ http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5351674.pdf

elevations and in national parks (Franklin and Fites-Kaufmann 1996). Most of the remaining high quality late-successional/old-growth habitat in the Sierra Nevada is in public ownership; less than two percent of 1,214,000 ha (3 million ac) of private land was classified as high quality late-successional/old-growth habitat (Franklin and Fites- Kaufmann 1996).

By all accounts, the majority of mixed-conifer and ponderosa pine forests in the Sierra Nevada at the turn of the previous century were characterized by very large trees and a high degree of structural complexity (Sudworth 1900, Leiberg 1902, McKelvey and Johnston 1992, Franklin and Fites-Kaufmann 1996 on p. 652). Franklin and Fites-Kaufmann (1996), for example, stated:

The collective inference from all lines of evidence is that stands with moderate to high levels of [late successional / old-growth]-related structural complexity occupied the majority of the commercial forestlands in the Sierra Nevada in presettlement times.

Primarily because of logging, present-day Sierran forests are drastically different from those in pre-settlement times. Franklin and Fites-Kaufmann (1996 on pp. 648–649) concluded:

A logical inference from both the rankings and the tabulated characterizations of the patches developed in the mapping exercise is that large-diameter decadent trees and their derivatives—large snags and logs—are generally absent or at greatly reduced levels in accessible, unreserved forest areas throughout the Sierra Nevada. This reflects the selective removal of the large trees in past timber harvest programs as well as the removal of snags and logs to reduce forest fuels due to wildfire concerns.

Overall declines in old forests have been substantial. Based on a comparison of 2,455 ground plots measured in 1991–1993 with data from a 1940s-era mapping project, Beardsley et al. (1999) estimated that old-growth forests in the mixed conifer, true fir, and pine types declined from 45 percent to 11 percent of the landscape between 1945 and 1993. This is a startling finding, given that the majority of the old forest had already been logged before 1945 (Leiberg 1902). Remaining old forest now occurs primarily on federal lands, reflecting the substantial degradation of private lands. The authors stated that by 1993 “[o]f the 4.8 million acres of mixed-conifer forests in the Sierra Nevada, 371 thousand acres (8%) were old-growth Less than 2% of the 3 million acres of privately owned coniferous forests was old-growth.”

Zielinski et al. (2005) examined changes in old forest cover in the Sierra Nevada over the previous century, as part of a study on changes in the distribution of forest carnivores. Alterations in mature/old-forest cover were represented by the difference between the historical Weislander Vegetation Type Map Survey (1929 and 1934; published in 1946) and contemporary vegetation data from the Sierra Nevada Ecosystem Project (1996). In 1945, old-growth (where > 50 percent of cover was from large, mature trees) comprised 50 percent of the forested area in the Sierra Nevada, and young growth/old-growth (where 20–50 percent of cover was from large, mature trees) comprised an additional 26 percent of the area. The remaining 24 percent was

young growth (immature forest), poorly-stocked forest, and non-commercial areas incapable of producing mature forest. By 1996, only 3 percent of the forested area in the Sierra Nevada was highest-ranking old forest, with 38 percent of the Sierra Nevada being low to high-quality old forest—equating to the loss of approximately half of the old forest between the 1940s and the 1990s (Figure 28). These changes were most evident in the portion of the Sierra Nevada north of Yosemite National Park, where the loss of old forest conditions has been greatest (again, these losses do not include the losses that occurred prior to the 1940s).

Overall, synthesizing all of the available lines of scientific evidence, as a result of past logging, old forest has declined from 50–90 percent of the landscape historically to only about 11 percent currently (USDA 2001 [FEIS, Vol. 2, Chpt. 3, part 3.2, pp. 141, 149]). In other words, historically there was several times more old-growth forest than there is today.

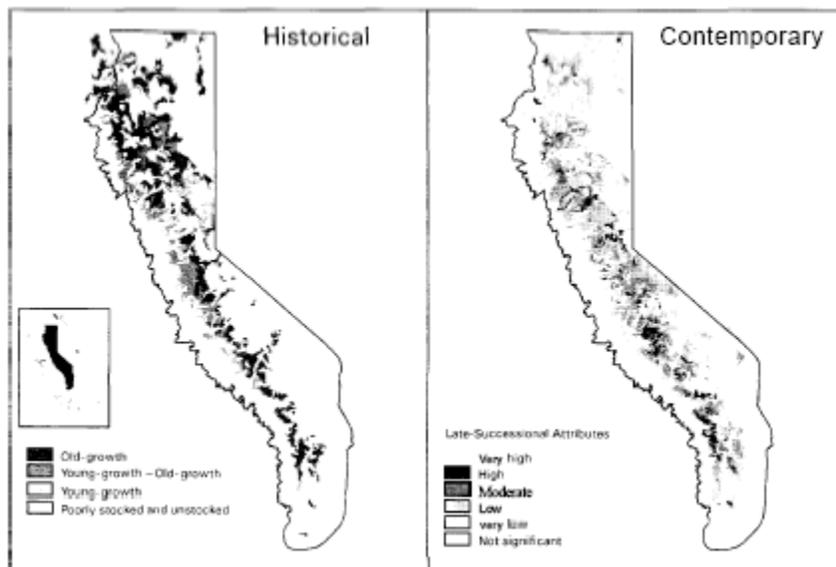


Figure 28. Maps of historical (Weislander Vegetation Type Survey, 1929 and 1934) and contemporary (Sierra Nevada Ecosystem Project, 1996) old forest cover in the Sierra Nevada (from Zielinski et al. 2005).

Present Habitat in the Sierra Nevada

Based on our GIS analysis of the most currently available data, the total current acres of CWHR forest types Ponderosa Pine, Sierran Mixed-Conifer, Klamath Mixed-Conifer, Douglas-fir, and White fir on national forest lands in the Sierra Nevada management region (the 2004 Sierra Nevada Forest Plan Amendment boundaries) is 3,294,209 acres. Of that, the total current acres in each of the following CWHR size/canopy classes, generally consistent with nesting/roosting habitat (i.e., stands dominated by medium and large trees and high canopy cover), are as follows:

4D: 896,568 ac
5D: 751,488 ac
6: 21,312 ac

National forests in the Sierra Nevada include approximately 560,000 ha (1.4 million ac) of private land within their administrative boundaries. Private land inholdings are much greater in extent in the northern national forests (especially the Lassen, Plumas, and Tahoe) than in the southern Sierra Nevada forests. Much of the private land within the boundary of the Lassen and Plumas national forests is in contiguous blocks, leaving national forest lands also fairly contiguous. Most private land on the Tahoe National Forest is in checkerboard ownership, and the Eldorado National Forest has a combination of checkerboard ownership and large contiguous blocks of inholdings.

The total current acres of CWHR forest types on private lands in the Sierra Nevada management region is 879,241 acres. Of that, the total current acres in each of the following CWHR size/canopy classes are as follows:

4D: 198,149 ac
5D: 164,610 ac
6: 3,295 ac

Thus, a small portion of private lands in the Sierra provide high quality habitat for the owl.

With regard to suitable foraging habitat created by high-intensity fire patches (this habitat is preferred owl foraging habitat when it occurs within 1.5 km of occupied owl sites [Bond et al. 2009], and is potential foraging habitat when it is not within an occupied territory), since 1984 high-intensity fire has created less than 300,000 acres (120,000 ha) of such habitat (Miller et al. 2012b, Hanson and Odion 2014), and a portion of this has been removed each year through post-fire logging, shrub eradication, and artificial tree plantation establishment (DellaSala et al. 2014; see also 2013 and 2014 salvage logging projects). If high-intensity fire areas in low- and mid-montane conifer forest in the 2012 and 2013 fires (Chips, Aspen, American, and Rim fires) are included, there have been approximately 360,000 acres of this suitable foraging habitat created by fire since 1984 (www.mtbs.gov)—again, however, this is before much of this habitat was removed by post-fire logging and artificial conifer plantation establishment (USDA 2013a, USDA 2014b, USDA 2014c, USDA 2014d). The 360,000 acres of high-intensity fire since 1984 represents < 9 percent of all CWHR forest types in the Sierra Nevada management region.

Present Habitat in Southern California

As of 2006, it was reported that there were approximately 473,473 ha (1,170,000 ac) of generally suitable California spotted owl habitat in southern California and the central Coast Ranges (Stephenson and Calcarone 1999). However, the total amount of suitable habitat in southern California is likely lower than that amount because habitat types are a broad generalization of

what California spotted owls actually require for habitat to be suitable (for example, a minimum canopy cover is a requisite for suitable habitat, but is not captured in characterization of habitat types).

Fire and Owl Habitat

Historical mixed-conifer forests of the Sierra Nevada and southern California, the major habitat type used by spotted owls, had a mixed-severity fire regime, which included both small and large high-severity fire patches, and these forests were highly variable in density and composition, ranging from open pine forests to dense fir/cedar and pine forests (Leiberg 1902, Beaty and Taylor 2001, Bekker and Taylor 2001, Lydersen et al. 2013, Baker 2014, Hanson and Odion in press).

Most of the research on fire effects to spotted owl habitat (using empirical data with spotted owls) has been conducted on the California subspecies, with seven studies published in the peer-reviewed scientific literature (Bond et al. 2002; 2009; 2010; 2013, Roberts et al. 2011, Lee et al. 2012; 2013). Three published studies are available on fire effects to northern spotted owls (Bond et al. 2002, Clark et al. 2011; 2013); but two additional studies are available in the ‘gray’ literature as conference proceedings (Gaines et al. 1997 and King et al. 1998), and two have been published on the Mexican spotted owl (Bond et al. 2002, Jenness et al. 2004).

Early studies on spotted owl habitat relations and correlations to reproductive success were conducted in unburned areas where the ‘non-suitable’ owl habitat was typically a result of logging (Call et al. 1992, Gutiérrez et al. 1992, Moen and Gutiérrez 1997, Bond et al. 2004, Blakesley et al. 2005, Seamans 2005, Seamans and Gutiérrez 2007a). As spotted owls are usually associated with older, dense forests, it was assumed that the effects of higher-severity wildfires were similar to logged clearcuts, resulting in a total loss of owl habitat (Verner et al. 1992, Weatherspoon et al. 1992). Fire, however, is a different type of disturbance than logging. While high-intensity fire likely reduces habitat suitability for nesting and roosting because it lowers canopy cover, two studies have found that spotted owls utilize and show a preference for intensely burned forests for foraging when the burned stands occurred close to the nest and core roost sites (Clark 2007 [Figure 6.2], Bond et al. 2009).

Many spotted owl sites have continued to be occupied and reproductively successful after fires burned portions of their home ranges, including portions of the core area, at least over a moderate time scale (1 year post-fire [Bond et al. 2002], from 5 to 7 years after fire [Lee et al. 2012], and up to 16 years post-fire [Robert 2008, Roberts et al. 2011]). Other research indicates that the structural legacies created by high-intensity fire provide benefits to spotted owls for much longer periods of time post-fire. For example, North et al. (1999) noted in a study of foraging habitat selection by northern spotted owls, “In our study area, stands with high use by owls typically included many “legacies” (large trees and snags) that survived a fire or windstorm that destroyed much of the previous stand. The survival of just a few dominant and co-dominant

trees from the original old-growth stand increased structural heterogeneity and produced more height class diversity in the regenerating stands.” The authors went on to note: “Large snags were created when tree tops were snapped in early-century windstorms or rot-resistant tree species were killed by fire. The carry-over of these large structures into the regenerating stands may have produced sufficient foraging habitat for the owl even though other attributes of the stand were typical of younger forests.”

Franklin et al. (2000) found that the “effects of landscape habitat characteristics on apparent survival and fecundity (and, hence, habitat fitness potential) can be illustrated by examining territories with relatively high, medium, and low habitat fitness potentials.” High habitat fitness depends upon a mix of dense, old forest and other vegetation types, with a trade-off between enough core spotted owl habitat and ecotones between other vegetation types to promote survival, and convoluted edge with less interior habitat to promote reproduction. The authors noted that these other vegetation types, which promote stable or increasing populations, can be created by fire, but not by clearcut logging. Note, for example, the first territory in the second row of Figure 29 below, showing a slow increase (1 percent increase per year) in a mix of about three-quarters other vegetation and about one-quarter dense, old forest. Conversely, the middle territory in the last row of Figure 29 below shows a steep decline where over 90 percent of the territory is comprised of dense, old forest, and there is too little other vegetation. Similar results were found by Olson et al. (2004).

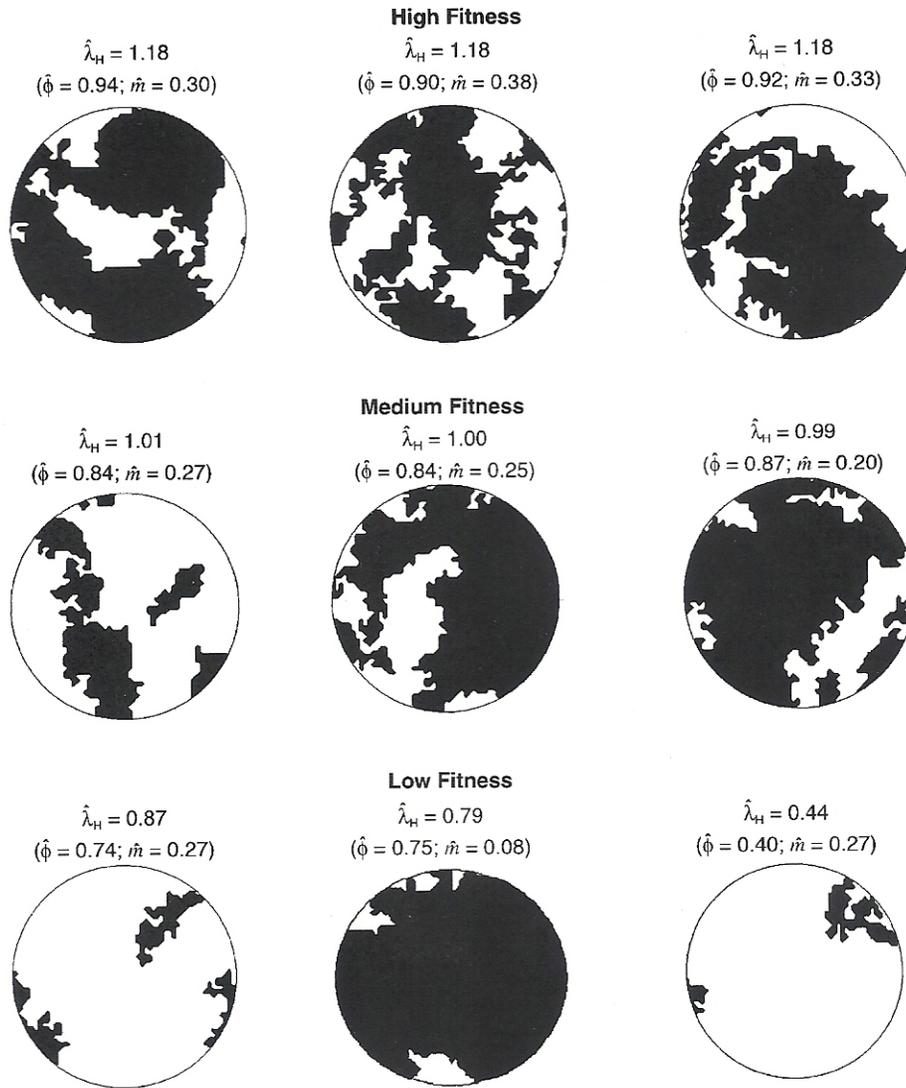


Figure 29. Habitat characteristics needed to maintain high habitat fitness, with dense, mature/old forest shown in black, and other vegetation shown in white. From Franklin et al. (2000, Figure 10).

In a study of California spotted owls in Yosemite National Park, Roberts et al. (2011) found similar detection and occupancy rates of California spotted owls at a total of 32 randomly selected burned (16) and unburned sites (16), with burned sites occupied by owls predominantly affected by low to moderate severity fire (14 percent high-severity fire overall). Because this study was conducted in a national park, no post-fire or recent pre-fire logging had occurred, indicating that mixed-severity fire, dominated by low to moderate severity effects, in the absence of logging does not impact spotted owl occupancy. Further, Roberts (2008) found that spotted owls had 60 percent higher reproduction in the mixed-severity fire areas in this study area, compared to the unburned mature forest.

The existing data also indicate that structural complexity, including high snag density, is important for spotted owl foraging habitat in burned forests. Bond et al. (2009), for example, found that high snag basal area and high shrub cover were the strongest defining variables of high-severity fire areas, and that spotted owls preferentially selected these areas for foraging above any other fire severity condition or long-unburned forests. Similarly, the radio-telemetry results from Clark (2007, M.S. thesis) indicate that northern spotted owls used dense, old forest (nesting/roosting/foraging habitat) that burned at moderate- and high-severity (i.e., areas which necessarily have very high snag densities) more than expected based upon availability, while the owls used young forest (early seral) that burned less than expected based upon availability, and used postfire-logged areas (i.e., where most snags had been removed) less than expected based upon availability (see Fig. 6.2 of Clark 2007). Clark (2007) also reported that, in the instances of foraging detected within salvage-logging units, they strongly tended to be in unlogged areas within these units (e.g., stream buffers and other logging-exclusion zones within logging unit boundaries).

In a large-scale occupancy study in managed forests throughout the Sierra Nevada, Lee et al. (2012) examined 11 years of U.S. Forest Service breeding-season survey data from 41 California spotted owl sites burned in six forest fires and 145 sites in long-unburned areas. The authors found no significant effects of fire on probabilities of local extinction and colonization at burned versus unburned sites over the period of study (2001–2007), after accounting for annual and site-specific variation in detectability. Mean occupancy was slightly higher at burned sites (80 percent) than in unburned forest (76 percent), but the difference was not statistically significant. Post-fire logging occurred on eight of the 41 burned sites; seven of the eight sites were occupied immediately after the fire but none were occupied after post-fire logging, suggesting salvage logging adversely impacted occupancy rates of the burned sites.

Fire has affected proportionately more spotted owl sites in the San Bernardino National Forest of southern California than any other national forest in the range of the subspecies. Like the Lassen Study Area, this region is at the edge of the subspecies' range. Using occupancy survey data from 2003 to 2011 for all-detections and pairs-only data, Lee et al. (2013) estimated annual extinction and colonization probabilities at 71 burned and 97 long-unburned breeding-season sites before and after fire, while controlling for confounding effects of non-fire-related temporal variation and among-site differences in habitat characteristics. The authors found no statistically significant effects of fire or salvage logging on occupancy dynamics in this population, but they found some evidence that fire and logging effects could have biologically meaningful impacts. For pairs, the model-averaged mean of fire-related effects on colonization and extinction probabilities resulted in a 0.062 lesser site-occupancy probability in burned sites 1-year post-fire relative to unburned sites. Post-fire logging reduced occupancy an additional 0.046 relative to sites that only burned (see Fig. 30 below).

For the San Bernardino study, the mean annual site occupancy probability of all detections (single or pairs) from 2004 to 2011 for unburned sites was 0.477, for sites burned in 2003 mean occupancy was 0.306, and logged sites was 0.255. For spotted owl pairs during the same time period, the mean annual site occupancy probability of unburned sites was 0.346, of burned sites was 0.239, and logged sites was 0.185 (See Fig. 31 below). For both all-detections and pairs data, there was no difference in occupancy between burned and unburned sites until the amount of forest in a 200-ha core area that burned at high intensity exceeded 50 percent (average forested within the 200-ha core = 106 ha, thus no difference until > 50 ha were burned), which pertained to 25 percent of the territories. Post-fire logging reduced burned site occupancy probability an additional 0.051 for all-detections, and an additional 0.054 for pairs (Fig. 31).

Lee et al. (2013) specifically noted (pp. 9, 11) that the spotted owl territories that lost occupancy following high-intensity fire in the San Bernardino National Forest of southern California tended to be low-elevation territories in relatively isolated patches of Bigcone Douglas-fir/canyon live oak forest surrounded by foothill chaparral vegetation; thus there was little or no potential for the owls to shift/adjust the location of their nest/roost sites after fire. Lee et al. (2013) determined (on page 11) that territories in the San Bernardino National Forest had far less pre-fire forest in the core area (106 ha) than did the Sierra Nevada territories that experienced fire (180 ha; studied in Lee et al. 2012); the proportion of high-severity fire in core areas was similar between the two regions, but the Sierra Nevada territories had 70 percent more pre-fire forest in their core areas compared to the San Bernardino territories.

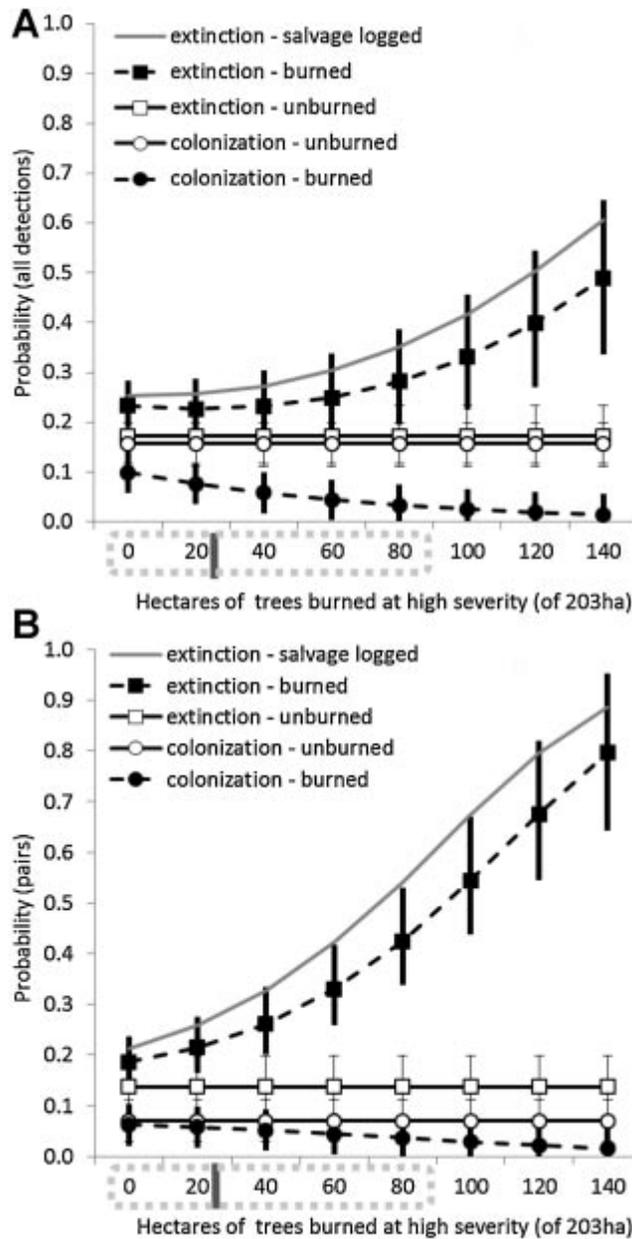


Figure 30. Model-averaged relationship between site colonization and extinction probability and the hectares of owl habitat that burned at high severity within a 203-ha circle around the nest or roost centroid of 71 California spotted owl sites in the San Bernardino and San Jacinto mountains from 2003 to 2011 from all-detection (A) and pairs-only (B) data as calculated from model-averaged beta parameters. Filled symbols and dashed lines are burned owl sites (\pm SE), open symbols and solid lines are unburned sites (\pm SE), and solid gray lines represent burned and salvage-logged site extinction probabilities. Vertical gray line in x-axis indicates the mean amount of owl habitat that burned at high severity in all burned sites. Dotted gray rectangle in x-axis indicates 95% confidence interval of amount of owl habitat that burned at high severity in all burned sites. We set individual (site-specific) covariate values to the mean for each covariate. From Lee et al. (2013); Figure 2 at page 11.

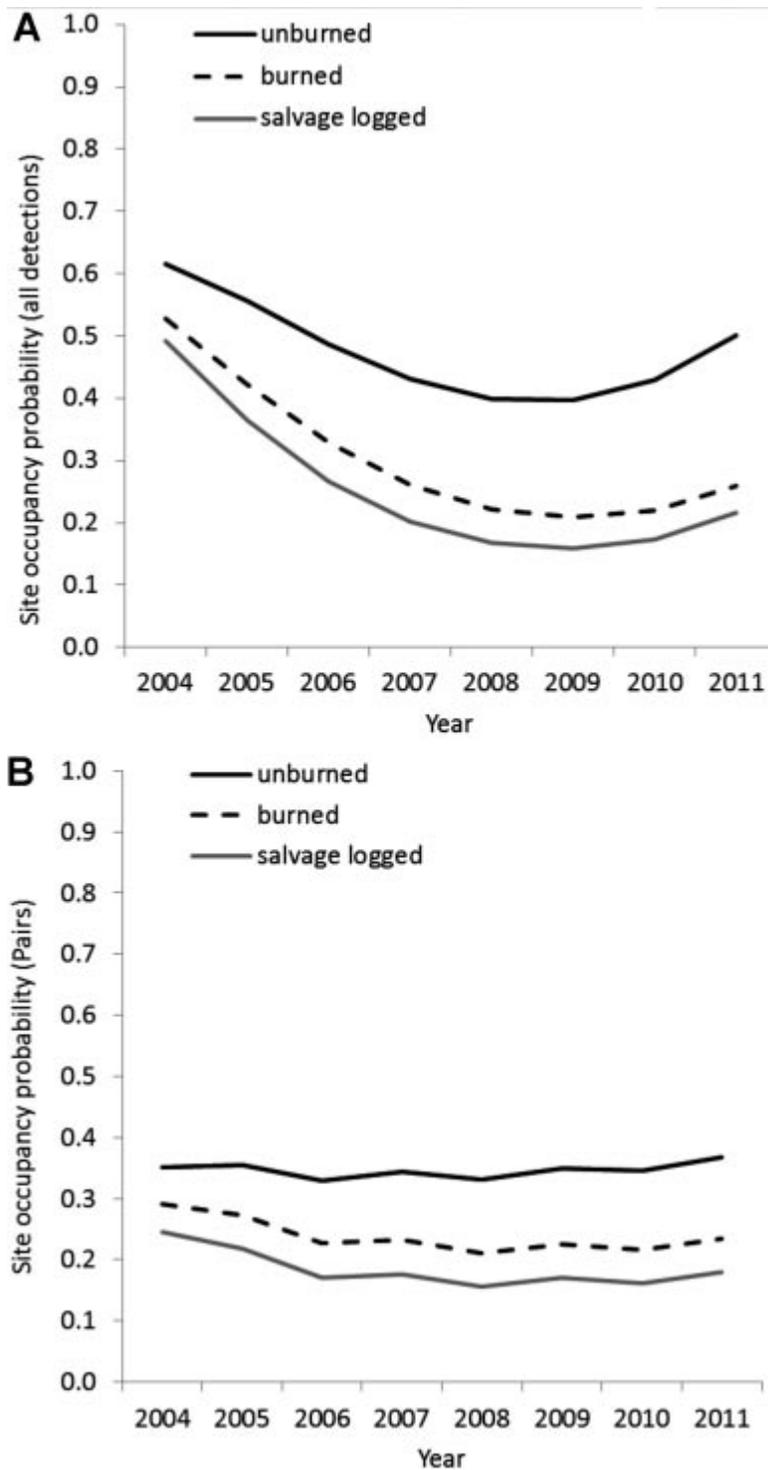


Figure 31. Annual estimates of southern California spotted owl site occupancy probability in unburned sites, sites that burned, and sites that were burned and salvage logged in San Bernardino and San Jacinto mountains. We computed estimates from estimates of initial occupancy, and annual colonization and extinction probabilities from the model-averaged parameters for all-detection (A) and pairs-only (B) data. We calculated burned sites as having burned in 2003. We set individual (site-specific) covariate values to the mean for each covariate. From Lee et al. (2013); Figure 3 at page 11.

In mostly mixed-conifer forests of the western Sierra Nevada, Lee and Bond (in review) found high California spotted owl occupancy at one year post-fire (before post-fire logging) in the 257,314-acre Rim fire of 2013 on the Stanislaus National Forest. One-year post-fire occupancy probability of historical territories (territories occupied in one or more years over the past two decades or so) was 92 percent. Lee and Bond (in review) also found that, in these post-fire territories of the Rim fire, which had not yet been subjected to post-fire logging, pair occupancy was not lower in territories with mostly high-intensity fire effects (occupancy in such territories was still over 90 percent).

Similar results have been documented in other subspecies of spotted owl. Jenness et al. (2004) published a peer-reviewed paper examining pre- and post-fire occupancy and reproduction of a sample of 64 Mexican spotted owl sites in mixed-conifer, pine, and pine-oak forests in four national forests in New Mexico and Arizona. The authors selected owl sites in fires that burned from 1993–1996, and compared levels of occupancy [single, pair, failed reproduction, successful reproduction] in 33 burned and 31 unburned sites, including 29 paired burned and unburned sites within 12 km of each other, in 1997. Post-fire occupancy rates were not significantly different between burned and unburned sites, and did not statistically differ with time since fire. The percent of high-intensity fire in a burned territory had no significant influence on whether the site was occupied ($P = 0.26$, $n = 33$ burned sites). Post-fire logging was relatively minor in most of the fires, largely due to an injunction on logging in the range of the Mexican spotted owl that was instigated in August 1995 (Coronado and Gila national forests, personal communication with M. Bond).

Clark et al. (2013) examined how fire and subsequent post-fire logging affected occupancy dynamics of northern spotted owls in three fires and an unburned area in southwestern Oregon. They found colonization probabilities declined over time at both burned and unburned sites, but extinction probabilities were greater after post-fire logging. Clark et al. (2013), on pages 11–12, concluded the following:

The Timbered Rock study area had an approximately 64% reduction in site occupancy following wildfire, whereas the South Cascades study area had a roughly 25% reduction in site occupancy during the same time period... Our results contrast with those of previous studies that compared occupancy rates of spotted owls in burned and unburned landscapes. Jenness et al. (2004) found that territory occupancy of Mexican spotted owls in burned areas was similar to unburned areas. Roberts et al. (2011) found that site occupancy of California spotted owls in randomly selected burned and unburned areas were similar. Neither of these studies was affected by the high degree of salvage logging we observed following the Timbered Rock burn, which may explain the difference between our results and those of previous studies.

Clark et al. (2013), on page 15, further concluded the following:

Our results also indicated a negative impact of salvage logging on site occupancy by spotted owls. We recommend restricting salvage logging after fires on public lands within 2.2 km of spotted owl territories (the median home range size in this portion of the spotted owl’s range) to limit the negative impacts of salvage logging.

Only one study has examined the effects of fire on survival rates of marked spotted owls in the absence of post-fire logging (Bond et al. 2002). The authors found no effect of fire on short-term (1 year) survival. They examined short-term post-fire survival of 21 banded spotted owls in four demography study areas encompassing all three subspecies (including the San Bernardino Study Area for the California spotted owl). The authors re-sighted bands and determined reproductive status of owls before and after fire in mixed-conifer and mixed-evergreen forests of northwestern California, the San Bernardino Mountains of southern California, the Tularosa Mountains of New Mexico, and in pine-oak forests on the Coconino Plateau in Arizona. All nest and roost areas were burned, and no post-fire logging had occurred before owls were surveyed the year after fire. Fire-intensity maps were available for only eight of the 11 territories: four of eight territories where fire intensities were mapped burned at low to moderate severity, and the other 4 burned 36–88 percent at high severity. The authors found that 18 of 21 (86 percent) individual owls were re-sighted after fire (i.e., survived) and 16 of the 18 (89 percent) were in the same territories after fire. These rates are the same as those for individuals in unburned territories (see Bond et al. 2002, and Table 4 below). All pairs were faithful to their pre-fire territory and mate.

Table 4. Estimates (95% CI) of minimum post-fire survival, site fidelity, and average number of fledglings per pair for 21 spotted owls that experienced fire in their territories in northwestern California, southern California, Arizona, and New Mexico, compared with overall averages for the four populations. From Bond et al. 2002, Table 1 on page 1,026.

Parameter	Post-fire Estimates	Estimates			
		NSO	CSO	MSO	
		NWC	SC	NM	AZ
Survival	0.86 (0.71-1.0) n = 21	0.876 (0.84-0.91)	0.79 (0.76-0.81)	0.832 (0.78-0.89)	0.814 (0.72-0.91)
Site Fidelity	0.89 (0.74-1.0) n = 18	0.88 (0.85-0.92)	0.91 (0.88-0.94)	0.90 (0.85-0.95)	0.92 (0.85-0.99)
Average no. fledglings/pr	1.0 (0.62-1.38) n = 7 pr	0.62 (0.56-0.68)	0.643 (0.59-0.69)	0.77 (0.70-0.84)	0.93 (0.86-1.0)

High annual variability in reproductive rates is typical of spotted owls and has been associated primarily with weather and habitat structure (Franklin et al. 2000, Seamans 2005, Seamans and Gutiérrez 2007b). While weather is a key factor, productivity also differs by site, thus any impacts of fire on reproduction should account for pre-fire reproductive rates of the site and, ideally, reproductive rates of individual banded owls and in comparison with unburned areas. Jenness et al. (2004) found that numbers of successfully reproducing Mexican spotted owl territories did not statistically differ between burned and unburned forests (see Fig. 32, below). Jenness et al. (2004) observed Mexican spotted owls successfully reproducing at 3 sites with 8, 31, and 32 percent high-intensity fire within a 1-km circle of their nest. Moreover, reproductively successful sites had a significantly higher percentage of burned area than occupied sites (including single owls and non-reproducing pairs) that were not reproductively successful.

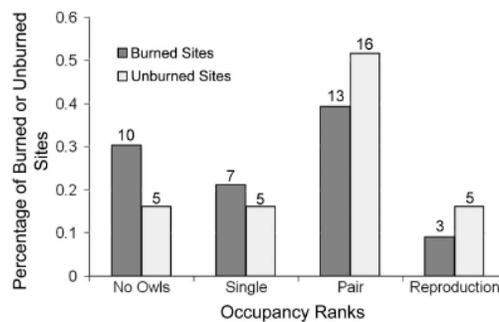


Figure 32. Relative proportions of burned and unburned Mexican spotted owl sites that had no owls, a single bird, a pair, or confirmed reproduction. From Jenness et al. 2004; Figure 2 on page 768.

Bond et al. (2002) also found that productivity of burned California spotted owl territories was higher than overall annual rates of reproduction for unburned territories.

In sum, the literature now demonstrates a complex and nuanced relationship between owls and fire. Low- and moderate-severity fire likely has little negative impact on spotted owl habitat. High-intensity fire can reduce roosting and nesting habitat, but can also provide important foraging habitat. Salvage logging following fire negatively affects spotted owl habitat.

THREATS

Section 4 of the ESA (16 U.S.C. 1533) and its implementing regulations (50 C.F.R. part 424) set forth the procedures for adding species to the federal lists of endangered and threatened species. A species can warrant listing as an endangered or threatened species due to one or more of the five factors described in section 4(a)(1) of the Act: (A) Present or threatened destruction, modification, or curtailment of habitat or range; (B) overutilization for commercial, recreational,

scientific, or educational purposes; (C) disease or predation; (D) inadequacy of existing regulatory mechanisms; or (E) other natural or manmade factors affecting its continued existence. We address each of those factors below.

Factor A. Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

Logging

Private Lands Logging

On private lands in California, logging practices harmful to spotted owls include clear-cutting, commercial thinning, sanitation “salvage,” group selection, selection, and post-fire logging. These practices eliminate or reduce canopy cover, large trees, canopy layers, understory, snags, and downed wood. In short, they eliminate the forest complexity that spotted owls are documented to rely on (see Habitat Use section above).

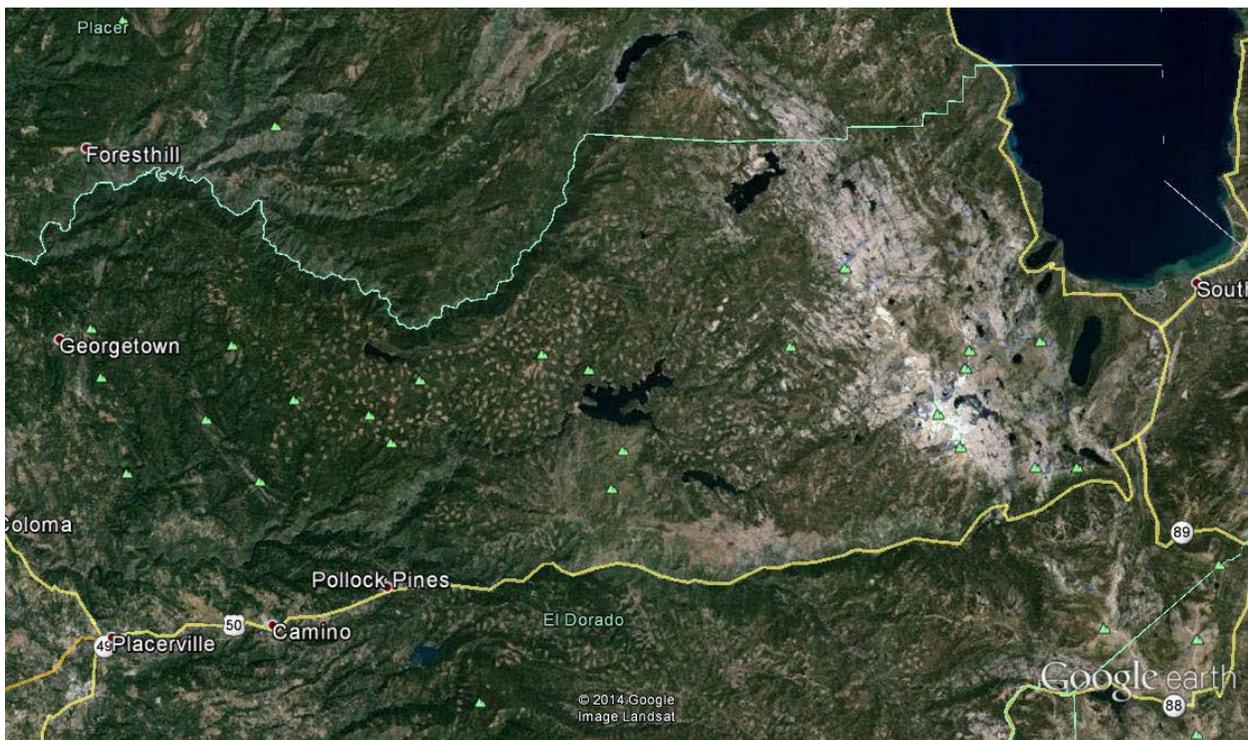
Moreover, the FWS’s 2006 finding on the California spotted owl noted: “When SPI [Sierra Pacific Industries] lays-out a Timber Harvest Plan (THP), it typically delineates a 6.5– 11 ha (16–28 ac) no-cut unit around each territory-center.” As discussed in detail above in the Home Range subsection, the core areas of California spotted owls are vastly larger than this. Further, as Seamans and Gutiérrez (2007a) found, as little as 20 ha of logging within the 400-ha core of California spotted owl home ranges causes a significant reduction in occupancy (and the loss of occupancy is higher with additional logging occurring in the 400-ha core of the home range). The SPI practice described here allows at least 389 ha of the 400-ha home range core to be logged. Thus, this practice serves to illustrate the extreme harm to spotted owls that can occur on private timberlands, and is occurring pursuant to the practices of the largest private timberland owner in California.

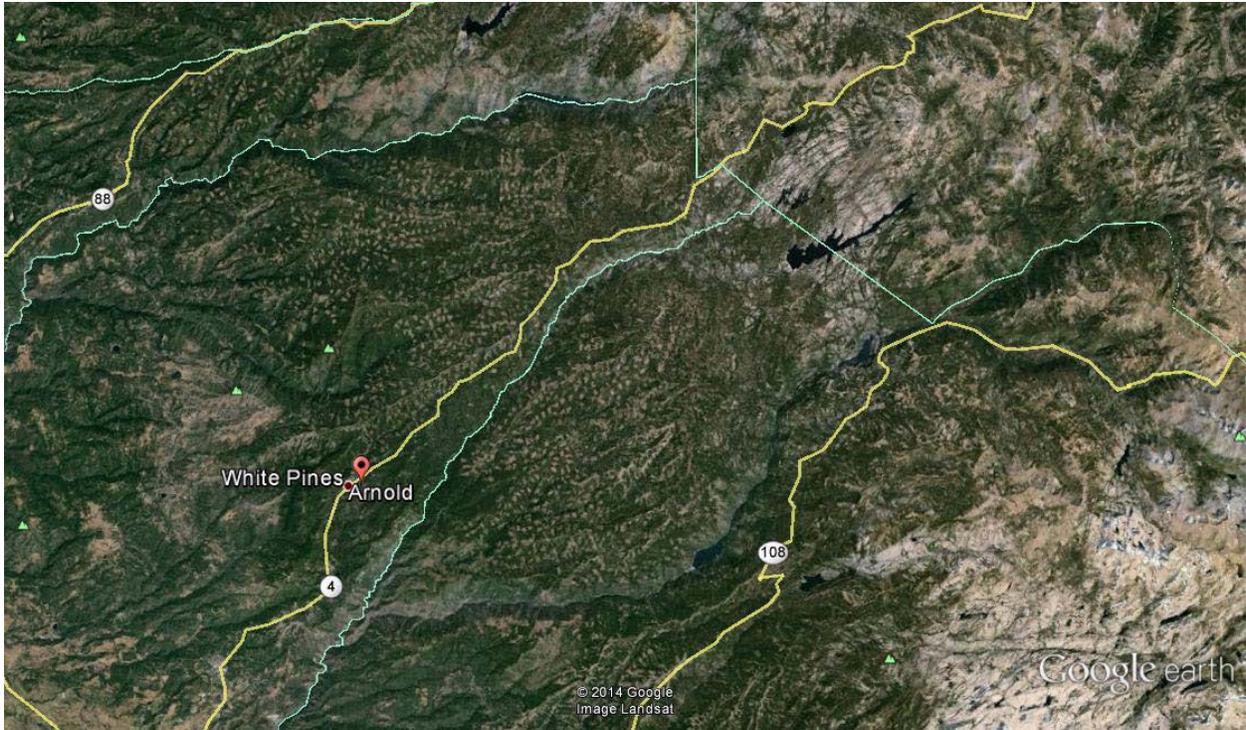
A 2014 SPI Timber Harvest Plan (4-14-026)⁵ further reveals how private lands logging is inhospitable to spotted owls: “Unoccupied nest sites of non-listed species will generally not receive additional special consideration during THP preparation”; if “an occupied nest of a non-listed raptor is discovered prior to, or during, timber operations, the timber operator will suspend all vegetation disturbing activities within 1/4 mile of the occupied nest until an SPI forester (or designee) with the advice of a biologist has designated the nest tree, perch trees(s), screening tree(s), and replacement trees(s), which shall be left standing and unharmed.” In other words, even the grossly inadequate “6.5– 11 ha (16–28 ac) no-cut unit” described above is no longer in effect, and at best, only occupied trees are necessarily left standing. Thus, on SPI lands, there is virtually no owl habitat protection at all. In light of the best available science, which demonstrates loss of occupancy from SPI’s practices (see, e.g., Seamans and Gutiérrez 2007a), it

⁵ ftp://thp.fire.ca.gov/THPLibrary/Sierra_Southern_Region/THPs2014/

is plain that private lands logging is a severe threat to both occupied and unoccupied owl habitat and prevents private land from recovering to a condition in which it can serve as suitable owl habitat.

Private lands logging has been and continues to be extensive. Attached (**Appendix B**) are the acreages by county for private lands logging Plans from 2010 to 2013, showing for example, in 2013, over 2,500 acres of proposed logging in Calaveras County, over 3,400 acres in Eldorado County, over 4,000 acres in Fresno County, over 14,000 acres in Lassen County, over 2,000 acres in Nevada County, over 5,000 acres in Placer County, over 14,000 acres in Plumas County, over 3,000 acres in Sierra County, and over 700 acres in Tuolumne County (see also **Appendix B** at 8, 19, 30, and 41, showing SPI's extensive even-aged management in counties in the Sierra Nevada). Google Earth images of private lands logging are also telling:





Moreover, the data in Appendix B do not include the acreage for the extensive post-fire logging that occurs on private lands pursuant to exceptions/exemptions (see discussion below of State Regulations under Factor D), such as the 2014 post-fire logging that occurred on SPI's land within the Rim Fire area.

Mechanical Thinning, Including Fuels Treatments

In the FWS's 2006 determination on the California spotted owl listing petition, the FWS accepted the view of the U.S. Forest Service that "the greatest continuing threat to spotted owls is loss of habitat and subsequent population losses of spotted owls due to stand-replacing fire in unnaturally dense forest stands." 71 Fed. Reg. 29894 (2006). The FWS further concluded that forest management under the 2004 Sierra Nevada Forest Plan Amendment would not threaten California spotted owls and may benefit them, noting that "the best-available data indicate that Forest Service management documents include adequate safeguards to protect spotted owls and their habitat, and fuels-reduction activities are anticipated to decrease the threat of stand-replacing wildfires. Therefore, we are not anticipating declines in spotted owl numbers due to these activities." 71 Fed. Reg. 29897. Based upon this, FWS concluded that "fuels-reduction activities can have short-term adverse effects, but they can also reduce the greater risk of catastrophic wildfire in the long term which effectively ameliorates the short-term effects." 71 Fed. Reg. 29900.

As discussed above, much has changed since 2006 as to our understanding of spotted owls and burned forest. It is now known that: (a) California spotted owls preferentially select high-severity fire areas that were not salvage logged as suitable foraging habitat (Bond et al. 2009), and within burned forest they select the areas with highest overall density/complexity in terms of total snag basal area, indicating that high levels of standing snags in higher-severity areas is important to California spotted owls (Clark 2007, Bond et al. 2009); (b) California spotted owl reproduction can be higher in mixed-severity fire areas that were not salvage logged than in long-unburned mature forest (Bond et al. 2002, Roberts 2008); (c) high-severity fire can reduce nesting and roosting habitat in a given territory, but can provide a beneficial effect on foraging habitat (Bond et al. 2009) and does not predictably result in loss of occupancy in mixed-severity fire areas, with studies finding comparable occupancy rates and home-range sizes in burned compared to long-unburned forests (Lee et al. 2012, Bond et al. 2013, Lee et al. 2013, Lee and Bond in review); (d) occupancy has been consistently lost and/or reduced in areas where post-fire logging has removed burned habitat created by high-severity fire (Lee et al. 2012, Clark et al. 2013, Lee et al. 2013); and (e) the only area in the Sierra Nevada in which California spotted owl populations are known to be stable or slightly increasing is an area with an active mixed-severity fire regime and no mechanical thinning or post-fire logging (Sequoia/Kings-Canyon National Park), while all study areas on national forests and private lands (characterized by aggressive reduction of fire due to fire suppression, landscape-level mechanical thinning, and common post-fire logging) have declining populations (Conner et al. 2013, Tempel and Gutiérrez 2013, Tempel 2014, Tempel et al. 2014a). These findings indicate that mixed-severity fire (which includes a high-severity fire component) is, on its own, not a significant threat to California spotted owls. Instead, management activities that follow mixed-severity fire (post-fire “salvage” logging), or are conducted ostensibly to “save” owls from higher-severity fire (mechanical thinning), are primary threats to the owl.

As explained in the following bullet points, mechanical thinning, including fuels treatments, is harming spotted owls, and spotted owls are declining as a result of such logging, based upon new scientific evidence that has arisen since 2006:

- As discussed in much greater detail above, California spotted owl populations are indeed declining (Conner et al. 2013, Tempel and Gutiérrez 2013, Tempel 2014, Tempel et al. 2014a), and the only area not experiencing declines is Sequoia Kings-Canyon National Park, which has an active mixed-severity fire regime and no mechanical thinning fuels treatment or post-fire logging programs (Conner et al. 2013).
- Seamans and Gutiérrez (2007a) examined the effects of habitat alteration, which was caused by logging, on territory colonization, extinction, and breeding-dispersal of color-banded spotted owls in the Eldorado Study Area from 1990 to 2004. This study evaluated whether: (1) alteration of mature conifer forest (conifer forest with > 70 percent canopy cover and dominated by medium [30.4-60.9 cm dbh] and large [> 60.9 cm dbh]

trees) was correlated with immediate, short-term territory colonization probability (probability of an unoccupied territory becoming occupied), extinction probability (probability of an occupied territory becoming unoccupied), or breeding dispersal probability; (2) alteration of mature conifer forest was correlated with long-term territory colonization or extinction probability; and (3) territory colonization or extinction probability, or breeding dispersal, was related to variation in the amount of mature conifer forest among territories. Thirty-eight territories (58 percent) experienced some habitat alteration during the study. Habitat alteration in all but two of these 38 territories was the result of logging (Seamans and Gutiérrez 2007a), while the other two were affected by high-severity wildfire (Seamans and Gutiérrez 2007a), which has been salvage logged on both private and national forest lands (C. Hanson personal observation). The probability of territory colonization decreased significantly with as little as 20 ha of logging, and territory occupancy was significantly decreased with as little as 20 ha of logging. Further, the probability of breeding dispersal away from a territory was related to the area of mature conifer forest in a territory and increased when ≥ 20 ha of this habitat was altered (see Fig. 26, above).

- Current management guidelines for the Sierra Nevada involve implementation of landscape-scale fuels treatments such as Defensible Fuel Profile Zones (DFPZs) and Strategically Placed Area Treatments (SPLATS) (both types of mechanical thinning) as approaches to modify fire behavior and facilitate fire suppression. The general prescription of fuels treatments is reducing forest canopy cover to 40 percent, removing many/most trees up to 30 inches diameter, and reducing tree density and ‘ladder’ fuels (USFS 2004a). Gallagher (2010) examined foraging-site selection of 10 radio-marked California spotted owls in the Meadow Valley Project area on the Plumas National Forest. The project was governed by the Herger-Feinstein Quincy Library Group Forest Recovery Act of 1998. Treatments included 1) DFPZs, landscape-scale forest thins designed to function as fire breaks by a reduction in canopy cover, tree density, and ladder fuels; 2) understory thin, prescribed as removal of shrubs and trees < 10 inches diameter; 3) understory thin followed by underburn; and 4) group selection, a removal of all trees < 30 inches diameter in < 0.8-ha patches. Gallagher (2010) found that across all birds and both study years, only 8 percent of owl foraging locations were located within fuels treatments, and nearly half of those locations were accounted for by a single owl. Owl foraging sites were primarily located in mixed-conifer forest dominated by trees 12–24 inches diameter with an additional large proportion of trees > 30 inches diameter and with a multi-layered understory with numerous small trees. The mean proportion of owl locations in DFPZs was lower than expected by chance, thus the owls avoided foraging in this treatment type.

- Gallagher (2010) found that home-range size of California spotted owls in the Meadow Valley Project area of the Plumas National Forest increased as the total area of fuels treatments within the home range increased, particularly of DFPZ (mechanical thinning) and group selection treatments under the 2004 Sierra Nevada Forest Plan Amendment, indicating lower territory fitness in such areas (i.e., owls were having to travel farther, cover more ground, and struggle harder to feed).
- Keane et al. (2012) reported that the Meadow Valley fuels treatment project on the Plumas National Forest, under the 2004 Sierra Nevada Forest Plan Amendment, began in 2006 (Keane et al. 2012, Fig. 10) and was completed in 2007–2008 (Keane et al. 2012, p. 88). After the logging, from 2007 to 2011, the total number of territorial sites of California spotted owls in the Meadow Valley project area declined from 9 to only 4—in just four years (Keane et al. 2012, Table 7).
- Current U.S. Forest Service management direction relies largely on the 2004 Framework which promotes landscape level mechanical thinning in spotted owl habitat, even allowing such action in PACs and HRCAs (USDA 2004a Record of Decision, pages 50–51, 60). The 2004 Framework (page 52) also promotes post-fire salvage logging in PACs and HRCAs and does so by assuming that burned forest is not owl habitat when in fact it is, as discussed in the Habitat section above. The Forest Service Leadership Intent document⁶ seeks to increase the “pace and scale” of implementation of the 2004 Framework which is resulting in increased mechanical thinning as well increased salvage logging (see Schedules of Proposed Actions [SOPAs] for national forests of the Sierra Nevada region; see also Big Hope Project EA, Aspen Project EA, and Rim Fire EIS, as discussed below). Moreover, despite Forest Service rhetoric suggesting otherwise, the vast majority of fuels treatments thus far have been and continue to be implemented via medium-intensity timber harvest, and there is no evidence that prescribed fire programs will be significantly increased in the coming years because the Forest Service has thus far failed to create the infrastructure and support to conduct more prescribed fire.
- The FWS’s 2011 Revised Recovery Plan for the northern spotted owl identified barred owls as a major threat to spotted owls, as discussed in more detail below. A recent study found that logging compounded the impacts of barred owls. Dugger et al. (2011) documented the negative effect of barred owls on northern spotted owl occupancy reported in previous studies, and quantified increased extinction rates of spotted owls in response to decreased amounts of dense, old forests at the territory core and higher colonization rates of spotted owls when dense, old forest habitat was less fragmented. Further, barred owl presence significantly reduced spotted owl territory colonization rates, and significantly increased spotted owl territory extinction rates (Dugger et al.

⁶ R5-MR-048 (March 2011) (http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5351674.pdf).

2011). Most alarmingly, while degradation of dense, old forest by logging increased territory extinction of spotted owls, this effect was compounded twofold to threefold when barred owls were present, indicating a strong interaction between logging and barred owls displacing spotted owls, such that logging had the overall effect of advantaging barred owls and disadvantaging spotted owls (Dugger et al. 2011). Dugger et al. (2011) found “greatly decreased [spotted owl] annual site occupancy rates when barred owls were detected.” Dugger et al. (2011) stated “increased habitat protection for spotted owls may be necessary to provide for sustainable populations in the presence of barred owls, and it is obvious from our results that these two additive stressors on spotted owl populations cannot be decoupled in any conservation efforts.”

- Tempel et al. (2014b) found that mechanical thinning is significantly harming California spotted owls. The authors found that the amount of mature forest with high canopy cover (70–100 percent) was a critical variable for California spotted owl viability (survival, territory extinction rates, and territory colonization rates), and determined that “medium-intensity” logging—mechanical thinning under the 2004 Amendment, and earlier prescriptions generally consistent with the 2004 Amendment— significantly adversely affects California spotted owls at all spatial scales by targeting dense, mature forests with high canopy cover, degrading the quality of such habitat by reducing it to moderate canopy cover. This is adversely affecting California spotted owl reproduction (Tempel et al. 2014b). The authors (on page 2,103) noted specifically that the adverse effects of mechanical thinning on California spotted owls is likely even larger than their results indicated: “Understory removal is generally an important component of fuel-reduction strategies, but we caution that medium-intensity harvesting with understory treatments occurred on only 5.2% of the total area within owl territories, which could have limited our power to detect effects . . . ” In other words, the adverse effects of mechanical thinning were apparent even with a relatively small portion of the study area affected by such logging. The authors further noted the following (on page 2103): “In addition, only 42.8% of medium-intensity harvests occurred in high-canopy forests; thus, over half of these harvests occurred in habitats that might be less important to spotted owls (Fig. 5c). When medium-intensity harvests *were* implemented within high-canopy forests, they reduced the canopy sufficiently for mapped polygons to be reclassified into a lower-canopy vegetation class in 90.1% of these treated areas (Fig. 5d). As described above, such changes were associated with reductions in survival and territory colonization rates, as well as increases in territory extinction rates. As a result, we believe the most appropriate inference about the influence of medium-intensity harvesting practices is that they appear to reduce reproductive potential, and when implemented in high-canopy forests, likely reduce survival and territory occupancy as well.” The results of Tempel et al. (2014b) indicated that some high-intensity logging on a very small percentage of the landscape, where dense brush had been allowed to grow after logging (possibly

facilitating habitat growth for some small mammal species), was associated with lower levels of territory extinction, but the authors strongly cautioned that such logging should not be conducted in spotted owl habitat, as it would reduce/remove high-quality owl habitat and would degrade habitat for other key prey. Owl survival was positively associated with the juxtaposition of mature forest and brushy shrub/sapling habitat areas (not necessarily associated with past logging) (Tempel et al. 2014b, pages 2103–2104). Finally, Tempel et al. (2014b) found no effect of wildland fire on spotted owl reproduction, survival, occupancy, or territory extinction. They did report an adverse effect of fire on territory colonization, but the fire covariate was “unestimable” due to very small sample size (page 2,099), meaning that the model could not be fitted and therefore the beta estimate for fire was not valid. The authors noted that territory colonization was low in fire-affected areas for two reasons: (1) in the largest fire that accounted for most of the fire-affected territories, 5 of the 9 territories remained occupied in every single year after the fire (pages 2,100–2,101), thus “colonization could not occur by definition”(page 2,104); and (2) the authors noted that the main reason that the “effect of wildfire on territory colonization was strongly negative” was “due to a high-severity fire that occurred on our study area in 2001 and completely burned two territories, which were subsequently never colonized by owls” (page 2,097), and two other territories had very low post-fire occupancy and colonization. The modeling result of the study, in addition to reporting a fire effect not supported by the statistical results, did not account for the fact that the permanent loss of occupancy (and no colonization) in the two “completely burned” territories, and the two other territories with very low post-fire occupancy/colonization, was associated with intensive logging after the fire (see, e.g., *Sierra Club v. Eubanks*, 335 F.Supp.2d 1070, 1075 (E.D. Cal. 2004) [noting that all of the heavily burned forest in the Star fire of 2001 had been subjected to post-fire logging on public and private lands outside of the Duncan Canyon Inventoried Roadless Area, which is the portion of the Star fire that is outside of the Tempel et al. 2014b study area]). Google Earth imagery also clearly shows heavy post-fire logging within 1.5 kilometers (and much closer) of the two territories that completely lost occupancy (PLA055 and PLA075) and the two with near-complete loss of occupancy and colonization post-fire (PLA016 and PLA099) (see **Appendix C**). Moreover, the study does not address other empirical research—Lee et al. (2012)—which found that mixed-severity fire (dominated by moderate- and high-severity fire effects) did not reduce California spotted owl occupancy in the Sierra Nevada, while observational data suggested that post-fire logging did reduce occupancy. Unlike in Tempel et al. (2014b), the fire covariate in Lee et al. (2012) was estimable because the sample size was much larger. The same was also true in Roberts et al. (2011) which found that detection and occupancy rates were similar between burned and unburned sites (Roberts focused on low and moderate severity burned areas). Thus, the statistically valid studies of fire effects on California spotted

owls in the Sierra Nevada found that mixed-severity fire—in areas without post-fire logging—does not reduce occupancy.

- Approximately 50 percent of all California spotted owl territories are within or adjacent to wildland-urban interface (WUI) areas in the Sierra Nevada (Blakesley et al. 2010), which exacerbates the threat to owl populations. This is because, aside from a minor 7.3-ha area around the nest tree, the 2004 Sierra Nevada Forest Plan Amendment explicitly allows mechanical thinning fuels treatments under the “forest-wide standards and guidelines for mechanical thinning” within California spotted owl Protected Activity Centers (PACs) and HRCAs in the WUI, which includes the “Defense Zone” and the “Threat Zone” (USDA 2004a, p. 60). As discussed above, Seamans and Gutiérrez (2007a) found that as little as 20 ha of logging in the 400-ha core area of California spotted owl home ranges significantly reduces occupancy (with increasing loss of occupancy occurring with higher proportions of logging); the 2004 Sierra Nevada Forest Plan Amendment allows up to 393 ha of the 400-ha cores of owl home ranges to be logged in the WUI. The Defense Zone extends ¼-mile from homes, cabins, commercial buildings, or “administrative sites with facilities”, and the Threat Zone extends 1.5 miles beyond the Defense Zone, and both can be expanded to cover even larger areas (USDA 2004a, p. 40). This extremely broad definition of the WUI is the reason that half of spotted owl territories in the Sierra Nevada are within WUI boundaries. Within the Threat Zone, up to 60 percent of the forest basal area can be removed, as can live conifers up to 30 inches in diameter, and canopy cover can be reduced to below 40 percent (USDA 2004a, page 50). In the Defense Zone, no basal area, canopy cover, or tree size retention requirements exist (USDA 2004a, page 50).
- A recent analysis by Stephens et al. (2014) found a 43 percent loss of California spotted owl occupancy within a few years following mechanical thinning and group selection logging in a study area in the northern Sierra Nevada. Specifically, the authors found the following: “In the Meadow Valley study area, the number of territorial owl sites declined after treatment. Prior to and throughout the implementation of the treatment, the number of owl sites ranged from seven to nine. Between the final year of the DFPZ and group-selection installations (2008) and two years after treatment (2009–2010), the number of owl sites declined by one (six territorial sites), and by 3–4 years after treatment (2011–2012), the number of sites had declined to four—a decline of 43% from the pretreatment numbers”. The authors noted that, while spotted owl populations have been declining in the northern Sierra Nevada as a whole, the steep rate of decline in this fuels treatment study area were of “a greater magnitude” than elsewhere on the landscape.

Post-fire Logging

Post-fire logging is harming spotted owls, and spotted owls are declining as a result of such logging based upon new scientific evidence that has arisen since 2006:

- Lee et al. (2012) studied six representative fires, covering 11 years of breeding season data, and spanning the southern Sierra Nevada to the northern Sierra Nevada (and representing all available data for fires in spotted owl habitat where pre-fire and post-fire occupancy data had been gathered). They reported that mixed-severity fire, averaging 32 percent high-severity fire effects in a 400-ha core area around nests or roost sites, did not reduce occupancy of California spotted owls in the Sierra Nevada and, in fact, occupancy in mixed-severity fire areas was slightly higher than in unburned mature forest, and even most territories with > 50 percent high-severity fire remained occupied (at levels of occupancy comparable to unburned forests). This, however, was not the case in post-fire logged sites, as every site that was salvage logged lost occupancy, even though they were occupied after the fire but before the salvage logging (Lee et al. 2012). Specifically, post-fire logging occurred on at least 8 of the 41 burned sites; 7 of the 8 sites were occupied immediately after the fire but none were occupied after post-fire logging.
- In the Moonlight fire of 2007 on the Plumas National Forest, while a larger number of spotted owl PACs remained in the system due to historical occupancy, at the time of the Moonlight fire there were only 9 California spotted owl sites occupied by pairs (much of the area had been logged in previous years/decades), based upon occupancy data provided by the Plumas National Forest. All 9 sites lost occupancy by the pairs following extensive post-fire logging on adjacent private timberlands (and, later, on national forest lands), which began in the summer of 2007, just days and weeks after the fire occurred, indicating that post-fire logging, not fire, was the cause of lost occupancy (DellaSala et al. 2010). **Appendix D** shows nearly all Moonlight fire PACs immediately adjacent to private industrial timberlands, which were clearcut in 2007 and 2008. Indeed, the only PAC that was occupied by a pair at 1 year post-fire (after the salvage logging on private lands immediately adjacent to the other PACs had already occurred) was PL107 (in the southern/central portion of the fire area), which is the only one of them that was not adjacent to post-fire clearcutting on private industrial timberlands (see **Appendix D**; see also Keane et al. 2012, Fig. 16) (this PAC also had predominantly high-severity fire effects—see Keane et al. 2012, Fig. 12a). This also demonstrates that PACs alone are not sufficient to sustain spotted owls (which have home ranges many times larger than mere ~120 ha PACs, as discussed above in the Home Range subsection), contrary to the implication in the 2006 FWS determination on the California spotted owl listing petition (i.e., the implication that retaining the PAC, or some small portion of the PAC surrounding nest trees, in an unlogged condition is sufficient to conserve owl populations and prevent a loss of occupancy). 71 Fed. Reg. 29894-29898, 29900-29903 (2006). This

is broadly consistent with the findings of Clark et al. (2013), who found that post-fire salvage logging in high-severity fire areas significantly increased territory extinction of northern spotted owls in southwestern Oregon. The available scientific data indicate that post-fire logging on both public and private lands is a major threat to California spotted owl occupancy and populations.

- As discussed above, the 4 California spotted owl territories in Tempel et al. (2014b) that had little or no occupancy and colonization after the Star fire of 2001 were heavily logged following the Star fire (**Appendix C**). The logging on private lands began in 2001, soon after the Star fire was out (C. Hanson and M. Bond, personal observation). The most severe, and extensive, post-fire logging occurred on the two owl territories that completely lost occupancy (PLA055 and PLA075), and were never again colonized subsequent to the post-fire logging (**Appendix C**).
- Bond et al. (2009) quantified habitat selection, which is how much owls used forest that burned at a particular severity compared with the availability of that burn severity. The authors banded and radio-marked 7 California spotted owls occupying the McNally Fire in the Sequoia National Forest 4 years after fire, and radio tracked them throughout the breeding season. Very little (< 3 percent) of the foraging ranges of these owls was salvage logged, so there were essentially no confounding effects of logging with high-intensity fire. Furthermore, all owls had unburned, low, moderate and highly burned patches of forest in their home ranges from which to choose, so the authors could quantify whether owls selected or avoided any of these burn intensities. This is the first study to examine foraging habitat selection by spotted owls in burned forests that were not subjected to substantial post-fire logging. The probability of an owl using a site for foraging was significantly greater in burned—especially severely burned—forests than unburned forest, after accounting for distance from nest (see Fig. 27 above). Selection for a particular burn class occurred within 1.5 km from the nest. Bond et al. (2009) also measured vegetation and found that high-intensity burned sites had the greatest herb and shrub cover and basal area of snags. This result suggests that snags, herb, and shrub cover are important components of a post-fire forest that supports foraging habitat for spotted owls, as these features provide excellent habitat for the owl’s small mammal prey base.
- The 2004 Sierra Nevada Forest Plan Amendment allows the Forest Service to eliminate protections for spotted owl PACs, or eliminate protections for portions of PACs, even when the PACs remain occupied by owls (USDA 2004, pages 37, 52). This policy leads to Forest Service reports and environmental impact statements or environmental assessments claiming numerous California spotted owl PACs as being “lost” or rendered unsuitable simply by virtue of having experienced a significant proportion of moderate-

or high-severity fire effects, regardless of whether the PACs are occupied by owls post-fire. As discussed in detail below, this policy under the 2004 Sierra Nevada Forest Plan Amendment results in significant amounts of post-fire salvage logging in California spotted owl Protected Activity Centers (PACs) and Home Range Core Areas (HRCAs) (approximately 700-acre zones surrounding PACs), while allowing the Forest Service to claim otherwise. This policy is resulting in a loss of spotted owl occupancy in post-fire areas that otherwise could remain occupied but for post-fire logging.

- Spotted owl scientist Monica Bond analyzed numerous fires on Sierra Nevada national forests, and post-fire logging under the 2004 Sierra Nevada Forest Plan Amendment, on California spotted owl occupancy, using data obtained from the U.S. Forest Service. Bond (2011, pages 22–23) found that many historically occupied owl territories, with no recent pre-fire occupancy, were occupied after the fires, and nearly all of the territories that were occupied post-fire (but before post-fire logging) subsequently lost occupancy after post-fire logging (where surveys were conducted after logging), despite the 300-acre PACs (as redrawn by USFS after fire, in order to include only lightly burned forest) being avoided by post-fire logging. This again indicates that PACs alone are not sufficient to sustain spotted owls (Bond 2011, pages 11–12, 22–23). In the Power Fire area and the Freds Fire area, the 2004 Sierra Nevada Forest Plan Amendment allowed the Forest Service to treat the higher-severity fire areas within the pre-fire PAC boundaries as being lost/unsuitable, which not only opened the PACs to post-fire logging, but also allowed the Forest Service to misleadingly claim that “0” acres of “suitable habitat” within the PACs would be salvage logged (Bond 2011).
- In the 2012 Chips Fire area, the Forest Service “re-mapped” 11 California spotted owl PACs and 16 HRCAs to exclude from protection areas with over 50 percent basal area mortality, regardless of post-fire occupancy (which had not even been determined at the time of the re-mapping of PACs and HRCAs in April of 2013), thus allowing salvage logging of these areas (USDA 2013a, pages 46–49). This, despite confirmed post-fire (and pre-salvage-logging) occupancy of all of the California spotted owl PACs that were surveyed by the Forest Service after the Chips Fire (see Appendix C [raw 2013 occupancy data, and 2014 report and maps from U.S. Forest Service]). Occupancy was lost in owl territories with the highest proportions of high-intensity fire effects within several hundred meters of the nest/roost site, where significant amounts of post-fire logging occurred (e.g., Clear Creek territory), while occupancy was retained where little or no post-fire logging occurred within several hundred meters of the territory centers (e.g., Crablouse Ravine and North French territories) (see **Appendix E** [2014 report and maps from U.S. Forest Service]).

- Using the Forest Service’s California spotted owl survey data during the first breeding season post-fire (surveys occurring in 2014, prior to implementation of the Rim post-fire logging project) for the 257,314-acre Rim fire area, Lee and Bond (in review) found 92 percent estimated occupancy of historical spotted owl territories (territories previously occupied in one or more years) (see also **Appendix F** [August 21, 2014 letter from Monica Bond et al. to the U.S. Forest Service, conveying findings]). Lee and Bond (in review) also found that 87 percent of historical territories were occupied by pairs, and that pair occupancy was not reduced in the territories comprised mostly of high-intensity fire effects (see **Appendix F**). Further, in the Forest Service’s chosen post-fire logging decision in the Rim fire area, every single occupied territory would be subjected to post-fire logging (within 1.5 kilometers of the nest/roost site; Bond et al. 2009), and many occupied territories would have most of their area salvage logged. Much of this post-fire logging would occur in the nest core, within areas formerly protected as PACs, but opened to large-scale post-fire clearcutting (over 95 percent tree removal, generally) under the 2004 Sierra Nevada Forest Plan Amendment’s provisions, allowing “redrawing” of PACs, and post-fire logging, after fires (USFS 2014a, b). Nowhere in the Final Environmental Impact Statement for the Rim fire logging project did the Forest Service ever disclose the high level of post-fire occupancy of spotted owls, or divulge the amount of post-fire logging planned within these occupied territories (within 1.5-km of nest/roost sites), or the adverse impacts of post-fire logging on occupancy. Logging began under this decision—heavily targeting occupied spotted owl territories—in September of 2014, and is ongoing. Although environmental plaintiffs filed suit, a judge denied a preliminary injunction, despite the Forest Service’s failure to disclose adverse impacts to spotted owls to the public.
- In the 2013 American Fire on the Tahoe National Forest, by mid-April of 2014—before post-fire California spotted owl surveys had been conducted (and before the results of any post-fire occupancy surveys)—the Forest Service had again used the 2004 Sierra Nevada Forest Plan Amendment to declare all areas with over 50 percent basal area mortality as “unsuitable” to spotted owls, contrary to the scientific evidence (as discussed in detail in the Habitat Use section above), allowing them to delete 2 spotted owl PACs and HRCAs from the spotted owl territory network, and “re-map” an additional 7 PACs and 8 HRCAs, which opened to salvage logging thousands of acres in these areas. The Forest Service simultaneously claimed that “suitable” spotted owl habitat would be minimally impacted by salvage logging (i.e., by erroneously defining areas of > 50 percent basal area mortality as unsuitable, and PACs with > 50 percent high-severity fire as lost to fire) (USDA 2014c, pages 90–92). Furthermore, the Tahoe National Forest decided to categorize an additional 1,487 acres with less than 50 percent basal area mortality as “unsuitable” for spotted owls, opening up even more acres to intensive post-fire logging (USDA 2014c, p. 90). Though environmental plaintiffs filed suit to protect

spotted owls from post-fire logging, a judge (the same judge as in the Rim fire case, discussed above) denied the plaintiffs' request for a preliminary injunction.

- In the 2013 Aspen Fire in the Sierra National Forest, by mid-April of 2014—before post-fire California spotted owl surveys had been conducted (and before the results of any post-fire occupancy surveys)—the Forest Service had again used the 2004 Sierra Nevada Forest Plan Amendment to propose post-fire logging in 1,580 acres of moderate/high-severity fire areas occurring within mature/old forest, and an additional 1,847 acres of post-fire logging in areas within the “Low/Very Low Mortality Category” (i.e., areas that remain suitable spotted owl nesting or roosting habitat after the fire) (USDA 2014d, pages 169–170). One-third of the acreage of the California spotted owl PACs and HRCAs in the Aspen Fire would be subjected to post-fire logging under the Proposed Action, and the Forest Service has proposed to “reconfigure” 4 PACs, facilitating post-fire logging (USDA 2014d, pp. 170–171). Though environmental plaintiffs filed suit to protect spotted owls from post-fire logging, the judge followed the course of the judge in the American fire case, described above, and denied plaintiffs' request for a preliminary injunction.
- Gaines et al. (1997) and Keane et al. (2010) found reduced spotted owl occupancy in areas that had been subjected to post-fire logging. For example, the high-intensity fire areas in northern spotted owl habitat at issue in Gaines et al. (1997) (the 1994 Hatchery Complex fire) were heavily post-fire logged by the U.S. Forest Service (<http://community.seattletimes.nwsourc.com/archive/?date=19950125&slug=2101246>). Keane et al. (2010) pertained to the Moonlight fire of 2007 where, as described above, California spotted owl sites lost occupancy when extensive post-fire logging occurred (though this is not mentioned in Keane et al. 2010: see DellaSala et al. 2010).

Summary

In summary, the best available science now indicates that: (a) private lands logging often eliminates, or, at best, severely degrades, spotted owl habitat; (b) mechanical thinning and mechanical thinning fuels treatments under the 2004 Sierra Nevada Forest Plan Amendment reduce California spotted owl occupancy; (c) post-fire logging reduces California spotted owl occupancy—often extirpating spotted owls completely from fire areas; and (d) California spotted owls are now clearly declining, except in Sequoia/Kings-Canyon National Park, which is protected from mechanical thinning fuels treatments and post-fire logging. Thus, logging is likely the primary driver of spotted owl declines and is a significant threat to the subspecies' existence.

Urbanization and Other Development

Residential development, both through growth of communities and construction of dispersed residences, poses a threat to California spotted owls by removing and fragmenting suitable habitat for the spotted owl, and can remove habitat for prey species, especially woodrats. Residential developments also introduce urban-adapted predators (cats, dogs, skunks, raccoons, ravens, crows) into spotted owl habitat; these predators may kill fledgling spotted owls in the nest or on the ground before they are capable fliers.

Development that is most likely to result in the loss of spotted owl habitat is occurring on private land in the lower elevation foothill areas of the Sierra Nevada and in southern California (Hickey 2005, Verner et al. 1992a). The amount of private versus public lands in the Sierra Nevada and southern California portions of the range varies widely by county. The Sierra Nevada Ecosystem Project (1996) core analysis area encompassed almost 8.5 million ha (21 million ac) in the Sierra Nevada, of which 61 percent is Federal and 38 percent is nonfederal lands. Estimates from the Sierra Business Council (1997) indicate that for the nine Sierra Nevada counties in the range of the spotted owl they analyzed, an average of 46 percent is private land.

Direct and indirect loss and degradation of habitat of California spotted owls and their prey is expected to continue in mid and lower elevation zones of the Sierra Nevada and southern California ranges through residential development, harvest of hardwoods for firewood production, human disturbance, and other consequences of development. Suitable habitat scattered among houses and housing developments was not found to be occupied by California spotted owls in southern California, although areas adjacent to these developments contained dense and productive populations of the subspecies (Gutiérrez 1994). As a result, development has the potential to further impair effective dispersal among isolated populations (Ruth and Standiford 1994). Urbanization has similar negative implications for Sierra Nevada spotted owls that migrate to lower elevations in the winter (Laymon 1988, Verner et al. 1992b).

In the Sierra Nevada, approximately 50 percent of California spotted owl territories are already in the Wildland-Urban Interface (WUI) (Blakesley et al. 2010), where protections are minimal at best (USDA 2004a), and increasing urban, suburban, and ex-urban development will result in even higher proportions of owl territories in the WUI in future years and decades, exacerbating threats.

In southern California, the mountain ranges occupied by California spotted owls probably act as habitat islands with limited dispersal between them. Under natural conditions, if the spotted owl population of one island were reduced or eliminated, that population could be sustained or reestablished through immigration from another island. As a result, a concern is that individual populations of California spotted owls, for example, those in southern California, could become isolated from other parts of the subspecies' range, for example the Sierra Nevada. As urbanization between mountain ranges continues, habitats there may be made unsuitable to

support occasional between-island dispersing California spotted owls, eliminating immigration and potentially leading to extirpation of one or more subpopulations (Verner et al. 1992).

Southern California's human population has grown substantially in recent decades to over 20 million people and is anticipated to grow by another 35 percent by about 2020 (USFS 2005a). A substantial amount of private forest land has been, and may continue to be, developed in the mountains of southern California (USFS 2005a). Verner et al. (1992a) expressed concern that development in southern California could prevent dispersal between spotted owl populations in southern California, as mountain ranges occupied by spotted owls probably act as habitat islands with limited dispersal between them. The best available data indicate that the spotted owl populations in the mountains of southern California are isolated from one another (Verner et al. 1992a, Gutiérrez 1994, LaHaye et al. 1994); further, it is probable that this isolation could increase in the future.

Factor C. Disease or Predation

Avian Trichomonosis

Avian trichomonosis was identified as the cause of death for two California spotted owls in 2012 (Rogers 2014). Avian trichomonosis is a disease caused by the protozoan parasite, *Trichomonas gallinae*. Pathogenicity varies among bird species, ranging from asymptomatic to epidemic. Once infected, this disease can cause lesions to form in the mouth and upper digestive tract, severe organ necrosis, and death. When lesions in the mouth become severe, the host may no longer be capable of swallowing food, leading to weight loss and starvation.

Columbrids, and the raptors that feed on them, are most often associated with avian trichomonosis. In 2012, 10,000 band-tailed pigeons (*Patagioenas fasciata monilis*) were estimated to have died during the winter in California. The range of the spotted owl and band-tailed pigeon largely overlap in California. Although spotted owls feed primarily on small mammals, it is hypothesized the owls became infected when opportunistically feeding on moribund pigeons (Rogers 2014). Reports of trichomonosis mortality events have been increasing in frequency over the past decade and recent research suggests that these mortality events are more likely to occur during dry winters. Although the extent of the effects to the California spotted owl from this disease are largely unknown at this time, due to the rugged nature and relative isolation of spotted owl habitat, their ability to fly and small body size, the probability of locating the remains of infected individuals are low. Despite the odds of finding infected individuals, two California spotted owls were located in 2012, suggesting the effects may have been extensive and widespread.

Factor D. Inadequacy of Existing Regulatory Mechanisms

Federal Regulations

In its 2006 determination on the California spotted owl listing petition, FWS concluded the following: “[N]o available data indicate that the removal of trees and the reduction in canopy cover as prescribed by the SNFPA and described herein would affect California spotted owl reproduction or occupancy such that the California spotted owl is in danger of extinction now or within the foreseeable future.” 71 Fed. Reg. 29901 (2006). Since then, the scientific data have established that California spotted owls are now clearly declining (Conner et al. 2013, Tempel and Gutiérrez 2013, Tempel 2014), as discussed in detail above. The following is a brief summary of the recent history, and current trajectory, of federal regulations relevant to California spotted owls.

In the early 1990s, concerns about the conservation status of the California spotted owl and the inadequacy of existing regulatory mechanisms to protect the owl instigated a technical review of the owl’s status and recommendations for management (Verner et al. 1992). This report suggested interim guidelines for conservation of spotted owls in the Sierra Nevada, conditioned upon additional research to refine and improve protective measures. In 1993, the Forest Service issued a decision which amended the forest plans in the Sierra Nevada to incorporate the interim guidelines, and circulated a draft EIS for an updated California spotted owl management plan. In 1996, the Sierra Nevada Ecosystem Project (“SNEP Report:” Centers for Water and Wildland Resources 1996) was submitted to Congress, which contained a wealth of information about historical and current forest conditions and threats to the natural resources of the Sierra Nevada ecosystem. A federal advisory committee was convened to review the draft EIS for spotted owl management that also took into account the SNEP report. This advisory committee determined that the draft EIS was inadequate, and recommended that the scope of the EIS be expanded to include management guidelines for a host of other issues beyond the spotted owl, including riparian ecosystems and old-growth forests. In 1998, the Forest Service initiated a process that culminated in the 2001 Sierra Nevada Forest Plan Amendment (SNFPA) Record of Decision (signed in January of 2001) and FEIS, also known as the “2001 Framework” (USDA 2001 [Appendix A, Standards & Guidelines]), which was to govern national forest lands in the Sierra Nevada and southern Cascades from the Sequoia National Forest north to the California/Oregon boundary.

The 2001 Framework was designed to “significantly improve the conservation strategy for California spotted owls and all forest resources.” The multi-year process included dozens of public meetings and involved many scientists both inside and outside the Forest Service. Some of the provisions of the Framework (USDA 2001 [see Record of Decision]) designed to protect and manage old forests and associated wildlife species included:

- (1) the designation of 4.25 million acres of Old Forest Emphasis Areas (OFEAs) and the promotion of old-forest conditions in OFEAs by restricting harvest of trees above 30.5 cm and prohibiting reduction of forest canopy by more than 10 percent;
- (2) the complete protection for California spotted owl Protected Activity Centers (PACs), and requirement that spotted owl Home Range Core Areas (HRCAs) be managed as OFEAs;
- (3) the protection of all old-forest stands 1 acre or larger by managing them as OFEAs;
- (4) the implementation of standards and guidelines prohibiting removal of medium and large trees (>51 cm) outside of OFEAs, and prohibiting reduction of canopy cover by more than 20 percent outside of OFEAs; and the prohibition of post-fire salvage logging (removal of snags over 38.1 cm dbh) in any OFEAs except in rare circumstances in which removal of one or more large snags was established to be necessary by the Forest Service to benefit old-forest structure and function.

The 2001 Framework provided some minimum protection for California spotted owls not only by protecting PACs and HRCAs and greatly restricting post-fire logging of suitable foraging habitat (old forest that experiences high-intensity fire), but also by retaining medium and large diameter trees in OFEAs and smaller old-forest stands and by maintaining canopy cover at a minimum of 50 percent and limiting reductions in canopy cover to 10–20 percent. However, almost immediately following the adoption of the 2001 Framework Record of Decision, the newly installed Bush Administration pushed to weaken its conservation measures to allow more logging, under the guise of “increasing flexibility and efficiency in fuels management as well as providing more economically feasible approaches of implementing the fuels reduction provisions of the decision” (Sierra Nevada Plan Amendment Review Team Meeting with Owl Scientists, June 27–28, 2002). At the direction of the Chief of the Forest Service, the Regional Forester and the Sierra Nevada Forest Plan Amendment Review Team circulated a revised Supplemental EIS (SEIS) that significantly increased logging throughout the Sierra Nevada. The revised Sierra Nevada Forest Plan Amendment Record of Decision (2004 SNFPA) was signed in January of 2004 (USDA 2004a).

The 2004 SNFPA (see USDA 2004a [Appendix A, Standards and Guidelines]) opened up PACs and HRCAs to intensive mechanical thinning (including removal of mature trees), allowed elimination of PACs and HRCAs after fire to facilitate post-fire logging even when the PACs/HRCAs remained occupied by spotted owls, eliminated most canopy cover retention requirements, eliminated the previous requirement to retain large snags (over 38.1 cm dbh) in OFEAs, eliminated the requirement to retain portions of unlogged burned forests, and also eliminated or greatly weakened retention standards for structural elements such as large trees in all land allocations throughout the Sierra Nevada. With respect to large trees, the 2001 Framework included a logging upper diameter limit of 30.5 cm within OFEAs and 51 cm in general forest and threat zones. The 2004 SNFPA replaced these standards with a size of 76.2 cm applicable in all land allocations. More recently, the U.S. Forest Service has taken the

position that there are no enforceable diameter limits in the 2004 SNFPA, if the agency characterizes logging projects as “restoration” (e.g., ostensibly for aspen regeneration), such as in the Environmental Assessment for the Bald Mountain project on the Sierra National Forest (USDA 2013a). Moreover, the 2004 SNFPA also allows canopy cover to be reduced by as much as 30 percent, to a minimum of 40 percent, in CWHR 5M, 5D, and 6 areas (areas dominated by large trees > 60.1 cm dbh, and with 40–60 percent, or > 60 percent, canopy cover), and requires no canopy cover retention in CWHR 4M and 4D areas (areas dominated by mature, medium-sized trees 28–60 cm dbh, and with 40–60 percent, or > 60 percent, canopy cover, respectively).

The 2004 SNFPA eliminated meaningful protection of OFEAs and smaller old-growth stands by allowing harvest of large trees up to 76.2 cm dbh and managing them similar to general forest.

The degradation and loss of suitable California spotted owl habitat allowed and encouraged by the 2004 SNFPA not only directly impacts or eliminates suitable habitat, but also indirectly impacts spotted owls by reducing habitat suitability for their small mammal prey species (Meyer et al. 2005).

Recently, the Forest Service has further signaled its future management direction in California spotted owl habitat with the release of the new forest plan for the Lake Tahoe Basin Management Unit (LTBMU) national forest (USDA 2013b). The new plan currently (it is in the objection process): (a) allows clearcuts 10 acres in size in spotted owl habitat [Standard&Guideline #31]; (b) eliminates the 30-inch diameter limit on removal of live trees, allowing removal in just about any circumstance, e.g., where the Forest Service decides that large trees are at “risk” of inhabitation by native bark beetles, where the Forest Service decides that there are too many large trees, where the Forest Service decides that removal of large firs and cedars could benefit pine growth, where the Forest Service supports removal of large trees ostensibly for aspen regeneration, etc.) [Standard&Guideline #33]; and (c) eliminates protections for spotted owl PACs and HRCAs, allowing mechanical thinning or other forms of commercial logging to reduce canopy cover down to any level (no minimum retention requirement) wherever the Forest Service claims that canopy cover “exceeds desired conditions” [Standard&Guideline #88] (USDA 2013b).

To justify this severe weakening of protections for California spotted owl habitat, the LTBMU claimed that, prior to 2004, 18 California spotted owl PACs “could be considered ‘lost’” due to fire, citing the 2004 Sierra Nevada Forest Plan Amendment (USDA 2013b, page 3-490). However, this claim in the 2004 SNFPA was never substantiated by any empirical data, and it was later found that it was based upon U.S. Forest Service administrative decisions to declare spotted owl PACs “lost” to fire, despite continued occupancy post-fire in the spotted owl territories that were not salvage logged (see **Appendix G** [Associated Press investigative stories]). The LTBMU similarly claimed that, based upon an unpublished 2008 “GIS exercise” by a Forest Service biologist, 33 California spotted owl PACs were “rendered unusable by spotted owl[s]” ostensibly because they “had more than 75% of their area burned at either high

or moderate severity” in “8 major wildfires on NFS lands” in the Sierra Nevada (USDA 2013b, p. 3-490). However, this claim was not based upon loss of spotted owl occupancy from fire but, rather, the scientifically inaccurate *assumption* that any areas of moderate- and high-severity fire represent a loss of suitable spotted owl habitat, and the assumption that any PAC with a combined moderate/high-severity acreage covering > 75 percent of the PAC would be “unusable by spotted owls.” However, as discussed above in the “Post-fire Logging” subsection, the Forest Service declares spotted owl PACs as “lost” to fire without regard to post-fire owl occupancy, and the current scientific data show that mixed-severity fire alone does not reduce California spotted owl occupancy, while post-fire logging *does* reduce or eliminate occupancy. Lee et al. (2012), for example, found that mixed-severity fire does not reduce California spotted owl occupancy, and occupancy is not significantly different in fire areas than in unburned forest, but territories known to have been salvage logged all lost occupancy. Even in territories where high-severity fire alone (i.e., not including moderate severity) comprised > 50 percent of fire effects, 63 percent of such California spotted owl territories were occupied (Lee et al. 2012), which is comparable to, or higher than, current occupancy in long-unburned forest (see, e.g., Fig. 17 in the “Declining Populations” section above, from Gutiérrez et al. 2012, showing just under 50 percent current occupancy in unburned forests).

In sum, the current trajectory of protection of owl habitat on Forest Service lands shows that regulatory mechanisms are only projected to get worse than the already inadequate 2004 Sierra Nevada Forest Plan Standards and Guidelines. Indeed, the Forest Plan Revision scoping document⁷ for the three early adopter Forests (Sierra, Sequoia, and Inyo National Forests) bears this out, as it does not contain any serious protections for owl habitat (see pages 29–32). Post-fire logging of owl home ranges is not addressed, protection of home ranges in general is not addressed (instead, the mere 300-acre PAC is continued as the unit of protection, despite abundant scientific evidence that it is woefully insufficient), burned forest habitat is ignored, and mechanical thinning is promoted (USDA 2014e).

State Regulations

The primary body of regulation affecting management of California spotted owl habitat on private lands is the California Forest Practices Rules (hereafter referred to as “the Rules”). The Rules are administered by the California Department of Forestry and Fire Protection (CDFFP), and are the regulations implementing the Z’berg Nejedley Forest Practices Act of 1973 (Cal. Pub. Res. Code Ch. 8). The Rules provide for timber harvest and site preparation practices to be utilized. The Rules require timber operators to produce a Timber Harvest Plan (THP) that is intended to serve as a substitute for the planning and environmental protection requirements of the California Environmental Quality Act of 1970 (Pub. Res. Code §§ 21000-21177). THPs are

⁷ Titled “Detailed Proposed Action in Support of the Need to Change Items in the Notice of Intent in Support of the Need to Change Items in the Notice of Intent for Forest Plan Revision for the Inyo, Sequoia and Sierra National Forests”

comprised of a lengthy checklist and supporting documentation, or in the case of the majority of the plans exempted from the THP process, by 1–2 page applications. The Rules allow complete removal of unburned and post-fire habitat and do not provide protection of elements essential to the species, such as large trees, snags and downed wood, and high canopy closure. The lack of direction to protect these habitat elements has resulted and continues to result in degradation and destruction of late-successional habitat. Indeed, private land owners such as SPI regularly report in their THPs that there does not exist any late-successional forest in the particular plan area.

Lack of forests with late-successional characteristics on private lands is not surprising given that the applicable rules allow utilization of intensive logging methods and provide almost no protections for spotted owls. Specific methods allowed in the Rules include clearcutting, in which all or most of the stand is removed at once; seed tree regeneration, in which most of the stand is removed, and then the few remaining seed trees are removed in a second step; and shelterwood regeneration, in which a stand is removed in three steps. These methods entail complete removal of forest canopy and large trees, and as is clear by their definitions, would result in elimination of California spotted owl habitat. In addition, these methods result in significant reductions in canopy closure. Moreover, the various logging methods, and lack of rules otherwise, are likely to result in removal of almost all snags as well as trees appropriate for the future recruitment of large snags.

The Rules also allow uneven-age regeneration prescriptions, including transition, selection, and group selection logging (14 CCR § 913.1, 913.2). The uneven age methods involve removal of individual trees or groups of trees. Though occurring over several entries, these methods on private lands also result in removal of habitat characteristics required by the owl—high densities of trees, and large trees and snags.

The Rules also define several “intermediate treatments.” (14 CCR § 913.3) These treatments include both commercial thinning and sanitation-salvage logging. Under the Rules, commercial thinning is defined as follows:

Commercial thinning is the removal of trees in a young-growth stand to maintain or increase average stand diameter of the residual crop trees, promote timber growth, and improve forest health. The residual stand shall consist primarily of healthy and vigorous dominant and codominant trees from the preharvest stand.

This treatment is designed to remove most trees, leaving a relatively small number of widely spaced trees. Such stands lack most or all of the stand components required by spotted owls, as described in the sections above.

Further, the Rules governing forest management on private lands in California allow immediate removal of 100 percent of suitable post-fire spotted owl foraging habitat. Post-fire salvage logging, or the “emergency management” of timber, is exempted from the requirements of the THP process. This exemption applies to stands that have been substantially affected by fire or

other natural causes. Cal. Pub. Res. Code § 4592; 14 CCR §§ 895.1 (definitions), 1052, 1052.1, 1052.2. In addition, the sanitation/salvage method is a commonly utilized prescription under the timber planning process and is defined in the Rules as removal of trees that are “insect attacked or diseased trees...[or, for sanitation logging] trees...that are dead, dying, or deteriorating” because of damage from a variety of causes (14 CCR § 913.3 (b)). The Rules provide little criteria for defining what constitutes a “dying or diseased” tree.

While the Forest Practice Rules provide no explicit protection for the California spotted owl and its habitat, the Rules do require that where significant impacts to non-listed species may result, the forester “shall incorporate feasible practices to reduce impacts” (14 CCR §§ 919.4, 939.4, 959.4). However, the Rules do not mandate surveys be conducted for spotted owls, do not require identification of suitable habitat, and provide no information concerning possible thresholds over which impacts to spotted owl habitat or the species might be “significant.” Thus, this provision does not result in meaningful protections. Further, the Rules fail to identify what constitutes a significant impact, and reduction of impacts is generally treated as optional, rather than required.

Although snags clearly are a critical component of spotted owl habitat, as discussed in the sections above, the Rules list numerous conditions under which snags may be removed and fail to require that a minimum number of snags be retained. Further, the Rules encourage removal of snags. In practice, few timber harvest documents appear to require actual retention of snags.

The “emergency management” of burned forests is exempted from THP requirements. The outcome is that essentially all intensely burned forests on private lands can be immediately salvage-logged with no protections or even surveys for spotted owls.

The net result is that the Rules do not regulate logging on private lands in a manner that is adequate to maintain California spotted owl habitat or populations on private land within California. Few or none of the logging prescriptions described in the Rules would result in retention of habitat features critical to the maintenance of California spotted owl populations on private land.

Factor E. Other Natural or Manmade Factors Affecting Its Continued Existence

Inherent Vulnerability of Small Populations

As discussed above, with 2,306 potential California spotted owl territories as of several years ago, and 53–77 percent occupancy by pairs or resident singles in any year, there were an estimated 1,222–1,776 pairs or resident singles as of several years ago, though populations have declined since then. The mid-point of the range of annual occupancy is 65 percent, which equates to 1,499 pairs or individuals. If we optimistically assume that two-thirds of the occupied territories have pairs, rather than individuals, this equates to approximately 2,500 individual California spotted owls as of several years ago. Again, however, the population has been

declining, so the current number is likely even lower than this. Traill et al. (2007), in a meta-analysis of numerous studies on multiple taxa, found that bird populations less than about 3,700 individuals are at a significant risk of extinction in the near future, and the degree of risk increases as populations, which are declining, fall farther below this threshold. LaHaye et al. (2001) concluded that the presence of conspecifics (members of the same species) may play a vital role in the recruitment of dispersing California spotted owls into a territory, because owls that “settled” (established territories) were significantly more likely to do so in territories that were occupied the previous year than would be expected by chance and all previously vacant territories that were settled were adjacent to occupied territories. The percentage of territories occupied varied from 59 to 95 percent from year to year, and that percentage is declining, as discussed in the subsection above, raising concerns about the lack of effective gene flow due to small population size.

The genetics study by Chi (2006) (on p. 32) found the following: *“The California spotted owl’s impoverished genetic pool, low population estimates, and more recently the lack of habitat protection by changes made to the Sierra Nevada Framework [2004 changes to the 2004 Framework; see Threats], are all indicators of a subspecies that requires additional recognition and protection by the Federal Government under the Endangered Species Act.”*

Climate and Climate Change

Climate may influence vital rates (survival, fecundity, and recruitment) of spotted owls directly, or through indirect means such as effect on prey populations (LaHaye et al. 1994, Verner 1999, Franklin et al. 2000, North et al. 2000). In southern California, drought was postulated to affect spotted owl population dynamics through its effects on prey (LaHaye et al. 1994), and statistical modeling showed that drought is associated with reduced fecundity (LaHaye et al., in litt. 2002). North et al. (2000) found synchronous low reproductive success of owls in the Sierra National Forest and Sequoia and Kings Canyon National Parks correlated to high spring precipitation and lower spring temperatures, presumably due to effects of weather on prey species. Statistical modeling indicated lower fecundity in years with higher spring precipitation in spotted owls in southern California (LaHaye et al., in litt. 2002).

Increasing weather extremes due to anthropogenic climate change may have greater impacts on spotted owls when working in concert with habitat degradation. Research by North et al. (2000) for California spotted owls indicate the important role habitat may play in buffering against the negative effects of climate. North et al. (2002) found that the characteristics of nest-site structures can modify microclimate conditions. Despite synchronous low reproduction, certain nests consistently exhibited higher reproductive success. In oak woodlands, these nests were on shrubby, north-aspect slopes in trees or snags surrounded by a well-developed canopy and in conifer forests they were overtopped by a canopy with a high foliage volume (high canopy cover). The authors concluded that reproduction is influenced by both regional weather conditions and nestsite canopy structure, which protects fledglings from detrimental weather.

Thus, if habitat features that buffer the effects of weather are removed, climate may have greater negative effects on spotted owls.

The last century has included some of the most variable climate reversals, at both the annual (extremes and high frequency of El Niño and La Niña events) and near decadal scales (periods of five to eight year drought and wet periods) documented (USFS 2001b). These events may have negative effects on California spotted owls. Modeling of population response to climate in northern spotted owls by Franklin et al. (2000), suggests that cold high-precipitation springs, as would be expected in California during El Niño years, lead to higher mortality. Alternately, low precipitation (as expected during La Niña years) may have negative effects on prey populations (Verner et al. 1992a). Changes in climate that occur faster than the ability of endangered species to adapt could cause local extinctions (United States Environmental Protection Agency (USEPA) 1989).

Climate modeling indicates that the overall effects of global warming on California will include higher average temperatures in all seasons, and potentially higher or lower total annual precipitation (Krawchuk et al. 2009, Westerling et al. 2011, Krawchuk and Moritz 2011). California spotted owls are susceptible to heat stress (Weathers et al. 2001) and are therefore likely to suffer from increased temperatures. Higher precipitation during the breeding season may increase mortality of spotted owls (Franklin et al. 2000). Decreased runoff from snowpacks may cause decreases in the extent or quality of riparian habitats, which are important for California spotted owls and their prey species, especially in southern California (Verner et al. 1992a). In contrast, Peery et al. (2011) used stochastic, stage-based matrix models parameterized with vital rates linked to annual variation in temperature and precipitation to project southern California owl populations forward in time under three IPCC emissions scenarios relative to contemporary climate. Fecundity was expected to increase in southern California under climate change, although survival rates were not affected by predicted changes in temperature or precipitation, suggesting that southern populations of owls may be more robust to climate change than in other regions within the range of the species.

High-severity Fire in Nesting and Roosting Habitat

In its 2006 denial of endangered species protection for the California spotted owl, the Fish and Wildlife Service identified “stand-replacing” fire as the primary threat and argued that Forest Service management would reduce this threat (71 Fed. Reg. 29895). As discussed above, studies published since 2006 show both that fire poses less risk to owls than previously believed and that Forest Service treatments to reduce fire risk have a greater adverse impact on owls than was known in 2006. Specifically, studies show that low- and moderate-severity fire do not pose a threat to owl nesting, roosting or foraging habitat, that high-severity fire has benefits for foraging owls, that owls can and often do persist following fires that result in portions of the home range burning, including at high severity, and that fuel treatments being conducted by the Forest

Service substantially reduce owl occupancy (Lee et al. 2012; 2013, Stephens et al. 2014, Tempel et al. 2014b) and adversely affect owl foraging probability (Gallagher 2010).

Nevertheless, in the small percentage of cases in which most of a particular core nesting area or PAC experiences high-severity fire (see e.g., Lee and Bond in review regarding sites with single owls in the Rim Fire), where pre-fire habitat is scarce and isolated, such as in portions of the San Bernardino National Forest (Lee et al. 2013), high-severity fire can temporarily result in loss of occupancy of owl territories; thus, in these circumstances, high-severity fire can present an additional risk to owl territories.

Occurrence of high-severity fire will be influenced by climate change, which may result in more or less high-severity fire. Projections of future fire, due to climate change, vary widely, depending upon the modeling assumptions chosen. Some, such as Lenihan et al. (2008) and Westerling et al. (2011), project that average annual acres of fire will increase by about 20–50 percent in California’s forests (with some localized decreases), including those of the Sierra Nevada, by the end of the 21st century, based upon the assumption of generally hotter and drier conditions. Others, such as McKenzie et al. (2004), Krawchuk et al. (2009), and Gonzalez et al. (2010), project increases in desert regions, but mostly decreases (and some localized increases) in conifer forests later in the 21st century, based upon the assumption of warmer and wetter conditions, and some research predicts that summer precipitation in particular will be a more influential variable than temperature over time (Krawchuk and Moritz 2011).

There are studies that have found that high-severity has already increased in the Sierra Nevada. Miller et al. (2009), Miller and Safford (2012), and Mallek et al. (2013) reported an increase in the extent of high-severity fire and patch size in the Sierra Nevada between 1984–2010, using Forest Service mapping of fire perimeters and satellite data. Hanson and Odion (2014), in contrast, examined satellite data that included a more extensive area of the Sierra Nevada and did not find any trend in the proportion, area, or patch size of high-severity fire, and found a statistically significant bias toward reporting increasing severity in the previous studies’ methods. Also, Odion and Hanson (2006, 2008) and vag Wagtendonk et al. (2012) found that, contrary to common assumptions about fuel accumulation, the most long-unburned forests had mostly low- and moderate-intensity fire, and did not have significantly higher proportions of high-intensity fire than more recently burned forests.

Mallek et al. (2013) compared fire area and severity in seven forest types of eastern California between the pre-settlement period (~1500–1850) and the modern period (1984–2009) and found that “modern rates of burning” are far below pre-settlement levels for all forest types. Mallek et al. (2013, Table 3) also reported that there is currently far less high-severity fire (average annual area of high-severity fire) now than there was historically in all forest types, except for yellow pine (ponderosa and Jeffrey pine forests), which based on model assumptions is roughly equivalent to the proportion of high-severity fire in the pre-settlement period. However, several other studies found higher historical proportions of high-severity fire in yellow pine, ranging

from 8–39 percent (Leiberg 1902, Show and Kotok 1924, Minnich et al. 2000, Hanson and Odion in press, Baker 2014), suggesting that high severity fire has declined in yellow pine. Based on a comparison of fires on Forest Service lands and fires in Yosemite National Park, Miller et al. (2012b) postulated that the patch size of high-severity fires may be larger than historically, under the assumption that contemporary fire management in the National Park mimics pre-settlement conditions. Hanson and Odion (in press) found that large high-severity fire patches occurred historically in mixed-conifer and ponderosa pine forests, including in the Stanislaus/Yosemite region.

Barred Owl Invasion

Historically, the barred owl was native to eastern North America and absent from the range of the California spotted owl. Barred owls have expanded their range into western North America, moving into the range of the California spotted owl from the north.

The barred owl invasion of western North America probably has been facilitated by alteration of habitats by humans. The barred owl is a forest species, but does not rely on late-successional forests as do spotted owls. The establishment of riparian forests and the planting of trees that occurred simultaneously with human settlement of the northern Great Plains may have created habitat used by dispersing barred owls as they moved west across the mid-western United States and southern Canada. Barred owls readily use disturbed habitats, and logging in the Rocky Mountains, Cascades, and Sierra Nevada may have facilitated their colonization of forests there.

In its most recent 2011 Revised Recovery Plan for the northern spotted owl, the U.S Fish and Wildlife Service recognized that competition with barred owls is one of the three largest threats facing recovery of the northern spotted owl. Management of the threat posed by barred owls was one of the five main tenets of the 2011 Plan.

Appendix B-10 of the Revised Recovery Plan described the severity of the adverse effects of barred owls on populations of spotted owls as follows:

Forsman et al. (2011) and Anthony et al. (2006) have documented increasing barred owl numbers across Washington, Oregon, and California from 1990–2008. While barred owls have expanded into California more recently (Kelly et al. 2003), Forsman et al. (2011) provides strong evidence of increasing barred owl populations in this region. Occupancy of territories by spotted owls in study areas in Washington and Oregon was significantly lower after barred owls were detected within 0.5 miles of the territory center but was “only marginally lower” if barred owls were located more than 0.5 miles from the spotted owl territory center (Kelly et al. 2003:51). In the Gifford Pinchot National Forest, there were significantly more barred owl site-centers in unoccupied spotted owl circles than in occupied spotted owl circles with radii of 0.5 miles, 1 mile, and 1.8 miles centered on spotted owl sites (Pearson and Livezey 2003). In the eastern Washington Cascades, barred owls had a significant negative effect on site

occupancy by any spotted owl (both single and pair spotted owl detections combined); however, barred owls did not have a negative effect on site occupancy by spotted owl pairs (Kroll et al. 2010). Spotted owl simple extinction probabilities (probability that a site center changed from occupied to unoccupied) were significantly higher in the eastern Washington Cascades when barred owls were detected in a site center during the year (Kroll et al. 2010). In Olympic National Park, spotted owl pair occupancy declined significantly at sites where barred owls had been detected, whereas pair occupancy remained stable at spotted owl sites without barred owls (Gremel 2005). Annual probability that a spotted owl territory would be occupied by a pair of spotted owls after barred owls were detected at the site declined by five percent in the HJ Andrews study area, 12 percent in the Coast Range study area, and 15 percent in the Tyee study area (Olson et al. 2005).

Barred owls evidently are appropriating spotted owl sites in flatter, lower-elevation forests in some areas (Pearson and Livezey 2003, Gremel 2005, Hamer et al. 2007). Apparently in response to barred owls, some marked spotted owl site centers have moved higher up slopes (Gremel 2005). According to one study, “the trade-off for living in high elevation forests could be reduced survival or fecundity in years with severe winters (Hamer et al. 2007:764).” It is unknown whether this slope/elevation tendency found in Washington is prevalent throughout the range of the spotted owl, how long spotted owls can persist where they are relegated to only steep, higher-elevation areas, and whether barred owls will continue to move upslope and eventually supplant the remaining spotted owls in these areas. Reproduction of spotted owls in the Roseburg study area, Oregon, was negatively affected by the presence of barred owls (Olson et al. 2004). Apparent survival of spotted owls was negatively affected by barred owls in two (Olympic and Wenatchee) of 14 study areas throughout the range of the spotted owl (Anthony et al. 2006). The researchers attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate. It is likely that this study underestimated the effects of barred owls on the reproduction of spotted owls because spotted owls often cannot be relocated after they are displaced by barred owls (E. Forsman personal communication 2006).

Only 47 spotted owl/barred owl hybrids were detected in an analysis of more than 9,000 banded spotted owls throughout their range (Kelly and Forsman 2004). Consequently, hybridization with the barred owl is considered to be “an interesting biological phenomenon that is probably inconsequential, compared with the real threat—direct competition between the two species for food and space” (Kelly and Forsman 2004:808).

The preponderance of evidence suggests barred owls are contributing to the population decline of spotted owls, especially in Washington, portions of Oregon, and the northern coast of California (Gutiérrez et al. 2004, Olson et al. 2005) which may explain the sharper decline in the spotted owl population trend in the northern portion of the spotted owl’s range compared to those in the southern portion of the range.

Barred owls apparently have displaced many northern spotted owls from their territories (Kelly et al. 2003, Pearson and Livezey 2003, Gremel 2005), and have expanded their range into that of the California spotted owl (Dark et al. 1998) as far south as the southern Sierra Nevada. Barred owls physically attack (Pearson and Livezey 2003) and kill (Leskiw and Gutiérrez 1998) northern spotted owls as well as negatively affect northern spotted owl site occupancy (Kelly et al. 2003, Pearson and Livezey 2003), reproduction (Olson et al. 2004, Livezey 2005), and survival (Anthony et al. 2004). Studies of northern spotted owls and barred owls in the Pacific Northwest (Pearson and Livezey 2003, Hamer et al. 2007, Singleton et al. 2010) show that barred owls do use mature and old-growth forest. Barred owl diets are more diverse and general than those of spotted owls (Forsman et al. 2004) and include more species associated with riparian and other moist habitats, along with more terrestrial and diurnal species (Hamer et al. 2001) and soft-bodied prey (Livezey et al. 2008). The 2011 Revised Recovery Plan for the northern spotted owl noted (at Appendix B-10) that “[t]he more-diverse food habits of barred owls appears to be the reason that barred owls have much smaller home-ranges than spotted owls do (Hamer et al. 2007).”

As of the 2006 finding, the known range of barred owls has expanded 200 miles southward in the Sierra Nevada. By that time, two hybrid spotted/barred owls were documented in the Eldorado National Forest (Seamans et al. 2005; Seamans in litt. 2005) and a male barred owl was documented in Kings Canyon National Park (Steger et al. in review).

One female barred owl was detected in SKC (Sequoia-Kings Canyon Study Area) on 15 September 2011. The first documented barred owl detection in SIE (Sierra Study Area, Sierra National Forest) or SKC was a male and occurred in SKC in 2004 (Steger et al. 2006). The 2011 detection occurred at night, and a resident male spotted owl was observed within approximately 20 meters of the barred owl (Munton et al. 2012).

A recent study (Dugger et al. 2011) corroborated the negative effect of barred owls on northern spotted owl occupancy found in previous studies, and quantified increased extinction rates of spotted owls in response to decreased amounts of dense, old forests at the territory core and higher colonization rates of spotted owls when dense, old forest habitat was less fragmented. Further, barred owl presence significantly reduced spotted owl territory colonization rates, and significantly increased spotted owl territory extinction rates (Dugger et al. 2011). Most alarmingly, while degradation of dense, old forest by logging increased territory extinction of spotted owls, this effect was compounded twofold to threefold when barred owls were present, indicating a strong interaction between logging and barred owls displacing spotted owls, such that logging had the overall effect of advantaging barred owls and disadvantaging spotted owls (Dugger et al. 2011). Dugger et al. (2011) found “greatly decreased [spotted owl] annual site occupancy rates when barred owls were detected.” Dugger et al. (2011) stated “increased habitat protection for spotted owls may be necessary to provide for sustainable populations in the presence of barred owls, and it is obvious from our results that these two additive stressors on spotted owl populations cannot be decoupled in any conservation efforts.” Similarly, Wiens

(2012) found that higher levels of dense, old forest was a “potential limiting factor in the competitive relationship” between spotted owls and barred owls (i.e., ample dense, old forest can mitigate the overall disadvantage that spotted owls often have when barred owls are present).

Thus, there is substantial scientific information to conclude that barred owls constitute a potential major threat to site occupancy, reproduction, and survival of California spotted owls if the population of barred owls increases. Since the FWS’s 2006 finding on the California spotted owl listing petition, the threat from barred owls to spotted owls has grown.

Rodenticide Poisoning

Secondary exposure to anticoagulant rodenticides (AR) and other pesticides have been well documented affecting wildlife for over 40 years (Thompson et al. 2013), including owls (Mendenhall and Pank 1980). Determining the extent of exposure can prove to be problematic, especially in remote and isolated areas as it requires the recovery of liver tissue from an intact non-scavenged carcass (Thompson et al. 2013). However, 70 percent of animals sampled by the California Department of Fish and Wildlife tested positive for AR exposure (Hosea 2000).

It is often assumed chance of exposure decrease as one moves away from agriculture and urban-interface areas where use is relatively high, however, recent studies have shown that AR compounds are affecting populations of the rare and imperiled Pacific fisher (*Pekania pennanti*), a mink-like carnivore that often co-occurs with California spotted owls in dense, mature/old low/mid-elevation conifer forests in portions of the western Sierra Nevada. Specifically, 33 of 40 fishers in the southern Sierra Nevada tested positive for exposure to AR compounds attributed to illegal marijuana growing on public lands (Gabriel et al. 2012). In addition, the study found no spatial clustering of AR detections, suggesting that AR contamination is widespread within the fisher’s, and subsequently the spotted owl’s range in the southern Sierra Nevada.

Since 2000, hundreds of illegal marijuana cultivation sites have been found and eradicated within the Sierra National Forest alone, and law enforcement agents report finding large quantities of rodenticides and other pesticides at these sites (Thompson et al. 2013). Cultivation sites are often located far from developments and roads, and in remote parts of the forests where detection is unlikely (Gabriel et al. 2013). While each cultivation site would be best described as a point-source for AR or pesticide contamination, the large number of sites identified makes it a landscape-level problem (Thompson et al. 2013). Beyond finding ARs, remediation frequently identifies restricted and banned pesticides including organo-phosphates, organochlorines, and carbamates as well as thousands of pounds of nitrogen-rich fertilizers (Gabriel et al. 2013). Many of the discovered pesticides have been banned for use in the U.S., Canada, and the European Union, specifically certain carbamates, which gained notoriety worldwide after an explosion of public awareness about their use to kill African wildlife.

The ARs used by illegal marijuana growers are now a significant source of Pacific fisher illness and mortality, due to toxicity exposure, as fishers eat poisoned small mammal prey (Gabriel et al. 2012). Because California spotted owls feed on many of the same small mammal prey species that Pacific fishers prey upon (see Zielinski et al. 1999 and Bond et al. 2013) and their range encompasses most of the fisher's range, spotted owls are also likely being adversely affected by ARs. Although data have not been published on the effects of ARs to California spotted owls, a northern spotted owl died as a result of exposure to ARs associated with home use in Marin County in 2012. Using barred owls as a surrogate for spotted owls due to similar diets, distribution, and habitat overlap, preliminary results from an ongoing study by M. Gabriel (personal communication 2014) indicate a 40 percent exposure rate of barred owls to ARs on Forest Service-managed lands in northwestern California. The Forest Service is not legally authorized to use several of the specific chemicals being detected in the barred owls, specifically brodifacoum, suggesting that illegal marijuana cultivation is the source.

Although direct mortality is an obvious concern, ARs may also have indirect effects such as behavior changes that reduce survival and reproduction. Modeling efforts support the concept that toxicant-related reductions in survival and reproduction may be sufficient to drive a population into negative growth (Roelofs et al. 2005). Thompson et al. (2013) found that likelihood of female fisher survival was associated with the number of grow sites within its home range. The extent of the effects of ARs to California spotted owls is unknown at this time, due to the rugged nature and relative isolation of spotted owl habitat, their ability to fly and small body size, the likelihood of locating the remains of affected individuals is relatively low. However, it is highly probable that ARs are affecting the species due to their preference for small mammals targeted by ARs, documented susceptibility to ARs, and the existence of large number of marijuana cultivation sites within their range. The loss of even a few individual adults a year or small reductions in reproduction to a species with high adult survival and low fecundity would be significant and exacerbate the observed population declines.

Conclusion

With nearly a decade's worth scientific data, we now know that California spotted owl populations are clearly declining throughout the range of the subspecies, and that those declines are associated with areas characterized by past and ongoing extensive mechanical thinning and post-fire logging. Current regulatory mechanisms on both public and private lands have permitted the forest management practices and associated population declines and are thus inadequate to stabilize or reverse the declines. Due to the Forest Service's continued focus on logging, management practices that have resulted in the observed spotted owl population declines are unlikely to change, absent protections under the ESA. We also know that habitat degradation from logging greatly exacerbates the growing threat to California spotted owls from both barred owls and anthropogenic climate change, and post-fire logging in high-intensity fire

patches tends to reduce occupancy. Further, these threats are exacerbated by rodenticides. The data therefore clearly indicate that the California spotted owl is at serious risk of extinction throughout most of its range, and listing the owl as threatened or endangered under the federal ESA is warranted.

Acknowledgements

We thank the staff of the Center for Biological Diversity and Sierra Forest Legacy for many helpful suggestions as we wrote this petition.

References

- Barrowclough, GF, RJ Gutiérrez, JG Groth, JE Lai, and DF Rock. 2011. The hybrid zone between northern and California spotted owls in the Cascade—Sierran Suture Zone. *The Condor* 113:581-589.
- Baker, W.L. 2012. Implications of spatially extensive historical data from surveys for restoring dry forests of Oregon's eastern Cascades. *Ecosphere* 3: Article 23.
- Baker, W.L. 2014. Historical forest structure and fire in Sierran mixed-conifer forests reconstructed from General Land Office survey data. *Ecosphere* 5: Article 79.
- Beaty, R.M., and A.H. Taylor. 2001. Spatial and temporal variation of fire regimes in a mixed conifer forest landscape, Southern Cascades, USA. *Journal of Biogeography* 28: 955–966.
- Bekker, M. F., and A.H. Taylor. 2001. Gradient analysis of fire regimes in montane forests of the southern Cascade Range, Thousand Lakes Wilderness, California, USA. *Plant Ecology* 155: 15-28.
- Bekker, M. F., and A.H. Taylor. 2010. Fire disturbance, forest structure, and stand dynamics in montane forest of the southern Cascades, Thousand Lakes Wilderness, California, USA. *Ecoscience* 17: 59-72.
- Bias, MA, and RJ Gutiérrez. 1992. Habitat associations of California spotted owls in the central Sierra Nevada. *Journal of Wildlife Management* 56:584-595.
- Blakesley, JA, BR Noon, and DR Anderson. 2005. Site occupancy, apparent survival, and reproduction of California spotted owls in relation to forest stand characteristics. *Journal of Wildlife Management* 69:1554-1564.

- Blakesley, JA, DR Anderson, and BR Noon. 2006. Breeding dispersal in the California spotted owl. *The Condor* 108:71-81.
- Blakesley, JA, ME Seamans, MM Conner, AB Franklin, GC White, RJ Gutiérrez, JE Hines, JD Nichols, TE Munton, DWH Shaw, JJ Keane, GN Steger, and TL McDonald. 2010. Population dynamics of spotted owls in the Sierra Nevada, California. *Wildlife Monographs* 174:1-36.
- Bond, ML. 2011. A review of impacts of the 2004 Freds fire and 2005 Freds Fire Restoration Project, Eldorado National Forest, California, USA. April 6, 2011.
- Bond, ML, RJ Gutiérrez, AB Franklin, WS LaHaye, CA May, and ME Seamans. 2002. Short-term effects of wildfires on spotted owl survival, site fidelity, mate fidelity, and reproductive success. *Wildlife Society Bulletin* 30:1022-1028.
- Bond, ML, ME Seamans, and RJ Gutiérrez. 2004. Modeling nesting habitat selection of California spotted owls (*Strix occidentalis occidentalis*) in the Central Sierra Nevada using standard forest inventory metrics. *Forest Science* 50:773-780.
- Bond ML, DE Lee, RB Siegel, and JP Ward. 2009. Habitat use and selection by California spotted owls in a postfire landscape. *Journal of Wildlife Management* 73:1116-1124.
- Bond ML, DE Lee, and RB Siegel. 2010. Winter movements by California spotted owls in a burned landscape. *Western Birds* 41:174-180.
- Bond, M.L., and D.E. Lee. 2014. Occupancy of California spotted owl sites after a large fire in the Sierra Nevada, California. *The Condor* (in review).
- Bond, ML, DE Lee, RB Siegel, and MW Tingley. 2013. Diet and home-range size of California spotted owls in a burned forest. *Western Birds* 44:114-126.
- Buchalski, M.R., J.B. Fontaine, P.A. Heady III, J.P. Hayes, and W.F. Frick. 2013. Bat response to differing fire severity in mixed-conifer forest, California, USA. *PLOS ONE* 8: e57884.
- Burnham, KP, and GC White. 2002. Evaluation of some random effects methodology applicable to bird ringing data. *Journal of Applied Statistics* 29:245-264.
- Call, DR, RJ Gutiérrez, and J. Verner. 1992. Foraging habitat and home-range characteristics of California spotted owls in the Sierra Nevada. *The Condor* 94:880-888.
- Chatfield, AH. 2005. Habitat selection by a California spotted owl population: A landscape scale analysis using resource selection functions. MS Thesis University of Minnesota.
- Chi, T.Y. 2006. Genetic characterization of four populations in two subspecies of spotted owl. Master's Thesis, San Jose State University. San Jose, California.

- Clark, D.A. 2007. Demography and habitat selection of northern spotted owls in post-fire landscapes of southwestern Oregon. Master's Thesis, Oregon State University. Corvallis, Oregon.
- Clark, DA, RG Anthony, and LS Andrews. 2011. Survival rates of northern spotted owls in post-fire landscapes of southwest Oregon. *Journal of Raptor Research* 45:38-47.
- Clark, DA, RG Anthony, and LS Andrews. 2013. Relationship between wildfire, salvage logging, and occupancy of nesting territories by northern spotted owls. *Journal of Wildlife Management* 77:672-688.
- Cohen, J.D. 2000. Preventing disaster: home ignitability in the Wildland-Urban Interface. *Journal of Forestry* 98: 15-21.
- Cohen, J.D., and R.D. Stratton. 2008. Home destruction examination: Grass Valley Fire. U.S. Forest Service Technical Paper R5-TP-026b. U.S. Forest Service, Region 5, Vallejo, CA.
- Conner MM, JJ Keane, CV Gallagher, G Jehle, TE Munton, PA Shaklee, RA Gerrard. 2013. Realized population change for long-term monitoring: California spotted owls case study. *Journal of Wildlife Management*.
- Coppeto, SA, DA Kelt, DH Van Vuren, JA Wilson, and S Bigelow. 2006. Habitat associations of small mammals at two spatial scales in the northern Sierra Nevada. *Journal of Mammalogy* 87:402-413.
- Crozier, ML, ME Seamans, RJ Gutiérrez, PJ Loschl, RB Horn, SG Sovern, and ED Forsman. 2006. Does the presence of barred owls suppress the calling behavior of spotted owls? *The Condor* 108:760-769.
- DellaSala D., M. Bond, W. Baker, D. Odion, and C. Hanson. 2010. A reply to North et al. *Wildlife Professional*, Summer 2010.
- DellaSala, D.A., M.L. Bond, C.T. Hanson, R.L. Hutto, and D.C. Odion. 2014. Complex early seral forests of the Sierra Nevada: what are they and how can they be managed for ecological integrity? *Natural Areas Journal* (in press).
- Dugger, KM, RG Anthony, and LS Andrews. 2011. Transient dynamics of invasive competition: Barred owls, spotted owls, habitat, and the demons of competition present. Preprint, Ecological Society of America.
- Eyes, S.A. 2014. The effects of fire severity on California spotted owl habitat use patterns. Master's Thesis, Humboldt State University, Arcata, California.
- Franklin, A.B., D.R. Anderson, R.J. Gutiérrez, and K.P. Burnham. 2000. Climate, habitat quality, and fitness in northern spotted owl populations in northwestern California. *Ecological Monographs* 70: 539-590.

Franklin AB, RJ Gutiérrez, JD Nichols, ME Seamans, GC White, GS Zimmerman, JE Hines, TE Munton, WS LaHaye, JA Blakesley, GN Steger, BR Noon, DWH Shaw, JJ Keane, TL McDonald, and S Britting. 2004. Population dynamics of the California spotted owls (*Strix occidentalis occidentalis*): A meta-analysis. Ornithological Monographs No. 54.

Gabriel, M.W., G.M. Wengert, J.M. Higley, S. Krogan, W. Sargent, and D.L. Clifford. 2013. SilentForests?: rodenticides on illegal marijuana crops harm wildlife. Wildlife Professional 7:46-50.

Gabriel, M.W., L.W. Wood, and R. Poppenga, R.A. Sweitzer, C. Thompson, S.M. Matthews, J.M. Higley, S.M. Keller, K. Purcell, R.H. Barrett, G.M. Wengert, B.N. Sacks, D.L. Clifford. 2012. Anticoagulant rodenticides on our public and community lands: spatial distribution of exposure and poisoning of a rare forest carnivore. PLoS ONE 7: e40163.

Gaines, WL, RA Strand, and SD Piper. 1997. Effects of the Hatchery complex fires on Northern spotted owls in the Eastern Washington Cascades. Pages 123-129 in J. N. Greenlee, editor. Proceedings of the Fire Effects on Rare and Endangered Species and Habitats Conference, International Association of Wildfire and Forestry, Coeur D'Alene, Idaho, USA.

Gallagher, C.V. 2010. Spotted owl home range and foraging patterns following fuels-reduction treatments in the northern Sierra Nevada, California. MS Thesis, University of California Davis.

Gibbons, P. et al. 2012. Land management practices associated with house loss in wildfires. PLoS ONE 7: e29212.

Gonzalez, P., R.P. Neilson, J.M. Lenihan, and R.J. Drapek. 2010. Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. Global Change and Biogeography 19:755-768.

Gremel, SA. 2005. Factors controlling distribution and demography of northern spotted owls in a reserved landscape. M.S. University of Washington.

Gutiérrez, RJ and J. Pritchard. 1990. Distribution, density and age structure of spotted owls on two southern California habitat islands. The Condor 92:491-495.

Gutiérrez RJ., J Verner, KS McKelvey, BR Noon, GN Steger, DR Call, WS LaHaye, BB Bingham, and JS Senser. 1992. Habitat relations of the California Spotted Owl. Pages 79-98 in J Verner, KS McKelvey, BR Noon, RJ Gutiérrez, GI Gould, Jr., and TW Beck, eds. The California Spotted Owl: a technical assessment of its current status. U. S. Forest Service General Technical Report PSW-GTR-133, Albany, California.

Gutiérrez, RJ, WS LaHaye, and GS Zimmerman. 2011. Breeding dispersal in an isolated population of spotted owls *Strix occidentalis*: evidence for improved reproductive output.

- Gutiérrez, RJ, MZ Peery, DJ Tempel, and WJ Berigan. 2012. Population ecology of the California spotted owl in the central Sierra Nevada: Annual Results 2011. Annual Progress Report: Region 5, USDA Forest Service, May 24, 2012.
- Hamer, TE, ED Forsman, and EM Glenn. 2007. Home range attributes and habitat selection of barred owls and spotted owls in an area of sympatry. *The Condor* 109:750-768.
- Hanson, C.T. 2007. Post-fire management of snag forest habitat in the Sierra Nevada. Ph.D. dissertation, University of California at Davis. Davis, CA.
- Hanson, C.T., and M.P. North. 2009. Post-fire survival and flushing in three Sierra Nevada conifers with high initial crown scorch. *International Journal of Wildland Fire* 18: 857-864.
- Hanson, C.T. , D.C. Odion, D.A. DellaSala, and W.L. Baker. 2009. Overestimation of fire risk in the Northern Spotted Owl Recovery Plan. *Conservation Biology* 23: 1314–1319.
- Hanson, C.T., D.C. Odion, D.A. DellaSala, and W.L. Baker. 2010. More-comprehensive recovery actions for Northern Spotted Owls in dry forests: Reply to Spies et al. *Conservation Biology* 24: 334-337.
- Hanson, C.T., and D.C. Odion. 2014. Is fire severity increasing in the Sierra Nevada mountains, California, USA? *International Journal of Wildland Fire* 23: 1-8.
- Hanson, C.T., and D.C. Odion. Historical forest conditions within the range of the Pacific Fisher and Spotted Owl in the central and southern Sierra Nevada, California, USA. *Natural Areas Journal* (in press).
- Hickey, E. (Editor). 2005. Planning for the future—a Sierra Nevada land use index. Sierra Nevada Alliance, South Lake Tahoe, CA.
- Hines, JE. 2006. PRESENCE 2—software to estimate patch occupancy and related parameters. Patuxent Wildlife Research Center, Laurel, MD.
<<http://137.227.242.23/software/doc/presence/presence.html>> (9 September 2011).
- Irwin LL, LA Clark, DC Rock, and SL Rock. 2007. Modeling foraging habitat of California spotted owls. *Journal of Wildlife Management* 71:1183-1191.
- Jenness, JJ, P Beier, and JL Ganey. 2004. Associations between forest fire and Mexican spotted owls. *Forest Science* 50:765-772.
- Keane, J.J., C.V. Gallagher, R.A. Gerrard, G. Jehle, and P.A. Shaklee. 2010. California spotted owl module: 2010 annual report. Davis (CA): Pacific Southwest Research Station, U.S. Forest Service.

Keane, J., M. Conner, C.V. Gallagher, R.A. Gerrard, G. Jehle, and P.A. Shaklee. 2012. Plumas Lassen Administrative Study, 2011 Annual Report: Spotted Owl Module. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

Kelly, EG, ED Forsman, and RG Anthony. 2003. Are barred owls displacing spotted owls? *The Condor* 105:45-53.

Kendall , WL, SJ Converse, PF Doherty Jr., MB Naughton, A Anders, JE Hines, and E Flint. 2009. Sampling design considerations for demographic studies: a case of colonial seabirds. *Ecological Applications* 19:55-68.

King, GM, KR Bevis, MA Rowe, and EE Hanson. 1998. Spotted owls use of habitat impacts by the 1994 fires on the Yakama Indian Reservation: three years postfire. *Proceedings of the Second Fire Effects on Rare and Endangered Species Conference, March 29-April 1, International Association of Wildlife Fire, Coeur D'Alene, ID.*

Krawchuk, M.A., and M.A. Moritz. 2011. Constraints on global fire activity vary across a resource gradient. *Ecology* 92:121-132.

Krawchuk, M.A., M.A. Moritz, M. Parisien, J. Van Dorn, and K. Hayhoe. 2009. Global pyrogeography: the current and future distribution of wildfire. *PloS ONE* 4: e5102.

LaHaye, WS, RJ Gutiérrez, and H Reşit Akçakaya. 1994. Spotted owl metapopulation dynamics in Southern California. *Journal of Animal Ecology* 63:775-785.

LaHaye, WS, RJ Gutiérrez, and DR Call. 1997. Nest-site selection and reproductive success of California spotted owls. *Wilson Bulletin* 109:42-51.

LaHaye, W WS, RJ Gutiérrez, and JR Dunk. 2001. Natal dispersal of the spotted owl in southern California: Dispersal profile of an insular population. *The Condor* 103:691-700.

LaHaye, WS, GS Zimmerman, and RJ Gutiérrez. 2004. Temporal variation in the vital rates of an insular population of spotted owls (*Strix occidentalis occidentalis*): Contrasting effects of weather. *The Auk* 121:1056-1069.

Lee D.E. and Bond, M.L. In review. Occupancy of California spotted owl sites after a large fire in the Sierra Nevada, California.

Lee DE, ML Bond, and RB Siegel. 2012. Dynamics of breeding-season site occupancy of the California spotted owl in burned forests. *The Condor* 114:792-802.

Lee DE, ML Bond, MI Borchert, and R Tanner. 2013. Influence of fire and salvage logging on site occupancy of spotted owls in the San Bernardino and San Jacinto mountains of southern California. *Journal of Wildlife Management*. DOI: 10.1002/jwmg.581

Leiberg, J. B. 1902. Forest conditions in the northern Sierra Nevada, California. USDI Geological Survey, Professional Paper No. 8. U.S. Government Printing Office, Washington, D.C.

Lenihan, J.M., D. Bachelet, R.P. Neilson, and R. Drapek. 2008. Response of vegetation distribution, ecosystem productivity, and fire to climate change scenarios for California. *Climatic Change* 87:S215-S230.

Livezey KB, MF Elderkin, PA Cott, J Hobbs, and JP Hudson. 2008. Barred owls eating worms and slugs: the advantage in not being picky eaters. *Northwestern Naturalist* 89:185-190.

Lydersen, J.M., M.P. North, E.E. Knapp, and B.M. Collins. 2013. Quantifying spatial patterns of tree groups and gaps in mixed-conifer forests: Reference conditions and long-term changes following fire suppression and logging. *Forest Ecology and Management* 304: 370-382.

MacKenzie, DI, JD Nichols, JE Hines, MG Knutson, and AD Franklin. 2003. Estimating site occupancy, colonization and local extinction when a species is detected imperfectly. *Ecology* 84:2200-2207.

MacKenzie, DI, JD Nichols, JA Royle, KH Pollock, LL Bailey, and JE Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier, Oxford, United Kingdom.

MacKenzie KI, ME Seamans, RJ Gutiérrez, and JD Nichols. 2010. Investigating the population dynamics of California spotted owls without marked individuals. *Journal of Ornithology* DOI 10.1007/s10336-010-0544-6

Mallek, C., H. Safford, J. Viers, and J. Miller. 2013. Modern departures in fire severity and area vary by forest type, Sierra Nevada and southern Cascades, USA. *Ecosphere* 4: Article 153.

Martinson, E.J., and P.N. Omi. 2003. Performance of fuel treatments subjected to wildfires. USDA Forest Service Proceedings RMRS-P-29.

Mendenhall, V.M., and L.F. Pank. 1980. Secondary poisoning of owls by anticoagulant rodenticides. *Wildlife Society Bulletin* 8:311-315.

Meiman, S, R Anthony, E. Glenn, T Bayless, A Ellingson, MC Hansen, and C Smith. 2003. Effects of commercial thinning on home-range and habitat-use patterns of a male northern spotted owl: a case study. *Wildlife Society Bulletin* 31:1254-1262.

Miller JD, Safford HD, Crimmins M, Thode AE. 2009. Quantitative evidence for increasing forest fire severity in the Sierra Nevada and southern Cascade Mountains, California and Nevada, USA. *Ecosystems* 12: 16-32.

Miller JD, Safford HD. 2012a. Trends in wildfire severity: 1984 to 2010 in the Sierra Nevada, Modoc Plateau, and southern Cascades, California, USA. *Fire Ecology* 8: 41-57.

- Miller, J.D., B.M. Collins, J.A. Lutz, S.L. Stephens, J.W. van Wagendonk, and D.A. Yasuda. 2012b. Differences in wildfires among ecoregions and land management agencies in the Sierra Nevada region, California, USA. *Ecosphere* 3: Article 80.
- Moen, CA and RJ Gutiérrez. 1997. California spotted owl habitat selection in the central Sierra Nevada. *Journal of Wildlife Management* 61:1281-1287.
- Munton, TE, Johnson, KD, Steger, GN, and Eberlein, GP. 2002. Diets of California Spotted Owls in the Sierra National Forest, in Proceedings of a symposium on the Kings River Sustainable Forest Ecosystems Project: Progress and current status (J Verner, KS McKelvey, BR Noon, RJ Gutiérrez, GI Gould, Jr., and TW Beck, tech. coords.), pp. 99-105 U.S. Forest Serv. Gen. Tech. Rep. PSW-183.
- Munton, RE, JJ Keane, and SK Sutton-Mazzocco. 2012. California spotted owl demography in Sierra National Forest and Sequoia and Kings Canyon National Parks. Annual Report, USDA Forest Service, February 13, 2012.
- Noon BR, and CM Biles. 1990. Mathematical demography of spotted owls in the Pacific Northwest. *Journal of Wildlife Management* 54:18-27.
- Noon BR, KS McKelvey, DL Lutz, WS LaHaye, RJ Gutiérrez, and CA Moen. 1992. Estimates of demographic parameters and rates of population change. Pages 175-186 in J Verner, KS McKelvey, BR Noon, RJ Gutiérrez, GI Gould, Jr., and TW Beck, editors. *The California Spotted Owl: a technical assessment of its current status*. U. S. Forest Service General Technical Report PSW-GTR-133, Albany, California.
- McKenzie, D., Z. Gedalof, D.L. Peterson, and P. Mote. 2004. Climatic change, wildfire, and conservation. *Conservation Biology* 18: 890-902.
- North, M.P., ed. 2012. *Managing Sierra Nevada forests*. General Technical Report PSW-GTR-237, Chapter 15. U.S. Forest Service, Pacific Southwest Research Station, Albany, California. Pp. 165-172.
- North, M. P., J. F. Franklin, A. B. Carey, E. D. Forsman, and T. Hamer. 1999. Forest stand structure of the northern spotted owl's foraging habitat. *Forest Science* 45: 520-527.
- North, M., P. Stine, K. O'Hara, W. Zielinski, and S. Stephens. 2009. An ecosystem management strategy for Sierran mixed-conifer forests. U.S.D.A. Forest Service General Technical Report PSW-GTR-220. Pacific Southwest Research Station, Albany, CA.
- Odion, D.C., and C.T. Hanson. 2006. Fire severity in conifer forests of the Sierra Nevada, California. *Ecosystems* 9: 1177-1189.
- Odion, D.C., and C.T. Hanson. 2008. Fire severity in the Sierra Nevada revisited: conclusions robust to further analysis. *Ecosystems* 11: 12-15.

Odion, D.C., and Hanson, C.T. 2013. Projecting impacts of fire management on a biodiversity indicator in the Sierra Nevada and Cascades, USA: the Black-backed Woodpecker. *The Open Forest Science Journal* 6: 14-23.

Odion, D.C., C.T. Hanson, A. Arsenault, W.L. Baker, D.A. DellaSala, R.L. Hutto, W. Klenner, M.A. Moritz, R.L. Sherriff, T.T. Veblen, and M.A. Williams. 2014. Examining historical and current mixed-severity fire regimes in ponderosa pine and mixed-conifer forests of western North America. *PLoS ONE* 9: e87852.

Olson, GS, EM Glenn, RG Anthony, ED Forsman, JA Reid, PJ Loschl, and WJ Ripple. 2004. Modeling demographic performance of northern spotted owls relative to forest habitat in Oregon. *Journal of Wildlife Management* 68:1039-1053.

Omi, P.N., and E.J. Martinson. 2002. Effects of fuels treatment on wildfire severity. Final report. Joint Fire Science Program Governing Board, Western Forest Fire Research Center, Colorado State University, Fort Collins, CO. Available from <http://www.cnr.colostate.edu/frws/research/westfire/finalreport.pdf>.

Pearson, RR, and KB Livezey. 2003. Distribution, numbers, and site characteristics of spotted owls and barred owls in the Cascade Mountains of Washington. *Journal of Raptor Research* 37:265-276.

Peery, MZ, and RJ Gutiérrez. 2013. Life-history tradeoffs in spotted owls (*Strix occidentalis*): implications for assessment of territory quality. *The Auk* 130:132-140.

Peery, MZ, RJ Gutiérrez, R. Kirby, OE Ledee, and WS LaHaye. 2011. Climate change and spotted owls: potentially contrasting responses in the Southwestern United States. *Global Change Biology* doi: 10.1111/j.1365-2486.2011.02564.x.

Phillips CE, DJ Tempel, and RJ Gutiérrez. 2010. Do California spotted owls select nest trees close to forest edges? *Journal of Raptor Research* 44:311-314.

Roberts, SL. 2008. The effects of fire on California spotted owls and their mammalian prey in the central Sierra Nevada, California. Chapter 1, PhD Dissertation, UC Davis, Davis, CA.

Roberts SL, JW Van Wagtendonk, AK Miles, and DA Kelt. 2011. Effects of fire on spotted owl site occupancy in a late-successional forest. *Biological Conservation* 144:610-619.

Roelofs, W., D.R. Crocker, R.F. Shore, D.R.J. Moore, G.C. Smith, H.R. Akcakaya, R.S. Bennett, P.F. Chapman, M. Clook, M. Crane, I.C. Dewhurst, P.J. Edwards, A. Faibrother, S. Ferson, D. Fischer, A.D.M. Hart, M. Holmes, M.J. Hooper, M. Lavine, A. Leopold, R. Luttik, P. Mineau, S.R. Mortenson, D.G. Noble, R.J. O'Connor, R.M. Sibley, M. Spendiff, T.A. Springer, H.M. Thompson, and C. Topping. 2005. Case study part 2: probabilistic modeling of long-term effects of pesticides on individuals breeding success in birds and mammals. *Ecotoxicology* 14: 895-923.

- Rogers, K. 2014. Avian trichomonosis in great gray owls and California spotted owls. *The Wildlife Professional*, Spring 2014.
- Seamans ME. 2005. Population biology of the California spotted owl in the central Sierra Nevada. PhD Dissertation University of Minnesota.
- Seamans ME and RJ Gutiérrez. 2007a. Habitat selection in a changing environment: the relationship between habitat alteration and spotted owl territory occupancy and breeding dispersal. *The Condor* 109:566-576.
- Seamans ME and RJ Gutiérrez. 2007b. Sources of variability in spotted owl population growth rate: testing predictions using long-term mark-recapture data. *Oecologia* 152:57-70.
- Seamans, ME, J Corcoran, and A Rex. 2004. Southernmost record of a Spotted Owl x Barred Owl hybrid in the Sierra Nevada. *Western Birds* 35: 173-174.
- Singleton, PH, JF Lehmkuhl, WL Gaines, and SA Graham. 2010. Barred owl space use and habitat selection in the Eastern Cascades, Washington. *Journal of Wildlife Management* 74:285-294.
- Smith, RB, MZ Peery, RJ Gutiérrez, and WS LaHaye. 1999. The relationship between spotted owl diet and reproductive success in the San Bernardino Mountains, California. *Wilson Bulletin*, 111:22-29.
- Stephens, S.L., S.W. Bigelow, R.D. Burnett, B.M. Collins, C.V. Gallagher, J. Keane, D.A. Kelt, M.P. North, L.J. Roberts, P.A. Stine, and D.H. Van Vuren. 2014. California Spotted Owl, songbird, and small mammal responses to landscape fuel treatments. *BioScience* (in press).
- Strom, B.A., and P.Z. Fule. 2007. Pre-wildfire fuel treatments affect long-term ponderosa pine forest dynamics. *International Journal of Wildland Fire* 16: 128-138.
- Tempel, DJ. 2014. California spotted owl population dynamics in the central Sierra Nevada: an assessment using multiple types of data. PhD Dissertation, University of Minnesota, St. Paul, MN.
- Tempel, D.J., and R.J. Gutiérrez. 2013. Relation between occupancy and abundance for a territorial species, the California spotted owl. *Conservation Biology* 27:1087-1095.
- Tempel, D.J., M.Z. Peery, and R.J. Gutiérrez. 2014a. Using integrated population models to improve conservation monitoring: California spotted owls as a case study. *Ecological Modelling* 289: 86-95.
- Tempel, D.J., R.J. Gutiérrez, S.A. Whitmore, M.J. Reetz, R.E. Stoelting, W.J. Berigan, M.E. Seamans, and M.Z. Peery. 2014b. Effects of forest management on California spotted owls:

implications for reducing wildfire risk in fire-prone forests. *Ecological Applications* 24:2089-2106.

Thompson, C., R. Sweitzer, M. Gabriel, K. Purcell, R. Barrett, and R. Poppenda. 2013. Impacts of rodenticide and insecticide toxicants from marijuana cultivation sites on fisher survival rates in the Sierra National Forest, California. *Conservation Letters* 7: 91-102.

USDA. 2001. Sierra Nevada Forest Plan Amendment, Final Environmental Impact Statement and Record of Decision. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

USDA. 2004a. Sierra Nevada Forest Plan Amendment, Final Environmental Impact Statement and Record of Decision. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

USDA. 2013a. Chip-Munk Recovery and Restoration Project, Wildlife Biological Assessment/Evaluation. U.S. Forest Service, Plumas National Forest, Quincy, CA.

USDA. 2013b. Lake Tahoe Basin Management Unit, Revised Land and Resource Management Plan, Final Environmental Impact Statement. U.S. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe, CA.

USDA. 2014a. Rim Fire Hazard Trees Project, Environmental Assessment. U.S. Forest Service, Stanislaus National Forest, Sonora, CA.

USDA. 2014b. Rim Fire Recovery Project, Final Environmental Impact Statement and Record of Decision. U.S. Forest Service, Stanislaus National Forest, Sonora, CA.

USDA. 2014c. Big Hope Fire Salvage and Restoration Project, Preliminary Environmental Assessment. U.S. Forest Service, Tahoe National Forest, Nevada City, CA.

USDA. 2014d. Aspen Recovery and Reforestation Project, Environmental Assessment. U.S. Forest Service, Sierra National Forest, Clovis, CA.

USDA. 2014e. Detailed Proposed Action in Support of the Need to Change Items in the Notice of Intent for Forest Plan Revision for the Inyo, Sequoia and Sierra National Forests. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

van Wagtenonk, J.W., and J.A. Lutz. 2007. Fire regime attributes of wildland fires in Yosemite National Park, USA. *Fire Ecology* 3: 34-52.

van Wagtenonk, J.W., K.A. van Wagtenonk, and A.E. Thode. 2012. Factors associated with the severity of intersecting fires in Yosemite National Park, California, USA. *Fire Ecology* 8: 11-32.

Wiens, J.D. 2012. Competitive Interactions and Resource Partitioning Between Northern Spotted Owls and Barred Owls in Western Oregon. Ph.D. Dissertation, Oregon State University, Corvallis, Oregon.

Westerling, A.L., B.P. Bryant, H.K. Preisler, T.P. Holmes, H.G. Hidalgo, T. Das., and S.R. Shrestha. 2011. Climate change and growth scenarios for California wildfire. *Climatic Change* 109 (Suppl 1): S445-S463.

Williams PJ, RJ Gutiérrez, and SA Whitmore. 2011. Home range and habitat selection of spotted owls in the central Sierra Nevada. *Journal of Wildlife Management* 75:333-343.

Zabel, CJ, KS McKelvey, and JD Johnston. 1992a. Patterns of habitat use by California spotted owls in logged forests of the northern Sierra Nevada. Pages 165–174 in J Verner, KS McKelvey, BR Noon, RJ Gutiérrez, GI Gould, Jr., and TW Beck, technical coordinators. *The California spotted owl: a technical assessment of its current status*. General Technical Report PSW-GTR-133. Albany, CA: Pacific Southwest Research Station, Forest Service, USDA. 285 p.

Zabel, CJ, GN Steger, KS McKelvey, GP Elberlein, BR Noon, and J Verner. 1992b. Home-range size and habitat-use patterns of California spotted owls in the Sierra Nevada. Pages 149–163 in J Verner, KS McKelvey, BR Noon, RJ Gutiérrez, GI Gould, Jr., and TW Beck, technical coordinators. *The California spotted owl: a technical assessment of its current status*. General Technical Report PSW-GTR-133. Albany, CA: Pacific Southwest Research Station, Forest Service, USDA. 285 p.

Zabel, CJ, K McKelvey and JP Ward, Jr. 1995. Influence of primary prey on home range size and habitat-use patterns of northern spotted owls (*Strix occidentalis caurina*). *Canadian Journal of Zoology* 73:433-439.

Zimmerman, GS, WS LaHaye, and RJ Gutiérrez. 2001. Breeding-season home ranges of spotted owls in the San Bernardino Mountains, California. *Western Birds* 32:83-87.