25. NORTHERN SPOTTED OWL

Today's Item **Information** ☐ **Action** ☒

Consider whether to add the northern spotted owl (NSO) to the list of endangered species and, if FGC determines that listing may be warranted, authorize staff to publish notice of its intent to amend Section 670.5, Title 14, CCR.

Summary of Previous/Future Actions

• Received petition	Sept 7, 2012
• FGC transmits petition to DFW	Sept 10, 2012
• Published notice of receipt of petition	Oct 5, 2012
• Approved DFW request for 30-day extension	Dec 12, 2012; San Diego
• Received DFW's evaluation and recommendation	Mar 6, 2013; Mount Shasta
• Postponed whether petitioned action may be warranted	Apr 17, 2013; Santa Rosa
• Accepted petition for candidacy	Aug 7, 2013; San Luis Obispo
• Approved DFW request for six month extension	Dec 3, 2014; Van Nuys
• Received DFW status review report	Feb 10-11, 2016; Sacramento
• **Today take action to determine if listing is warranted**	**April 13-14, 2016; Santa Rosa**

Background

At the Aug 5, 2015 meeting, FGC received the Environmental Protection Information Center's (EPIC) Independent Report of the northern spotted owl (NSO) petition, pursuant to Subsection 670.1(h), which allows interested parties to submit a detailed written scientific report to FGC on the petitioned action (Exhibit 1).

FGC received DFW's status review report at the Feb 2016 meeting (Exhibit 2). DFW provided one paper copy of the status review report at that meeting. The document is available for public review at http://www.fgc.ca.gov/regulations/2012/index.aspx#nso.

The status review report represents DFW's final written review of the status of NSO and is based upon the best scientific information available to DFW. The status review report contains DFW's recommendation that listing of the NSO as threatened is warranted.

Significant Public Comments

1. EPIC independent report, dated May 7, 2015 (Exhibit 3)
2. EPIC peer review comments on independent report, dated Jul 3, 2015 (Exhibit 4)
3. Over 3,000 comments in support of listing NSO received since Feb 11, 2016 (Exhibit 5)
4. Keith A. Hamm, representing Green Diamond Resource Company, commented that Green Diamond believes habitat conditions for NSO are improving through several measures. Encourages DFW and FGC to utilize existing regulatory framework and process for protecting NSO while finding opportunities to encourage landowner participation in feasible regional efforts to control threats from barred owls. This will

provide additional information on NSO in response to these efforts and immediate conservation benefits to the species (Exhibit 6).

5. Copy of DFW letter to Director Mike Miles, Humboldt Redwood Company, LLC, transmitting a copy of DFW's California Endangered Species Act Consistency Determination No. 2080-2014-001-01 (Exhibit 7), with the following attachments:
   a. Humboldt Redwood NSO Annual Report 2015, dated Feb 1, 2016.
   b. Letter from Sal Chinnici, HRC, received via email on Mar 30, 2016. Mr. Chinnici requests that FGC postpone any listing decision, and requests that DFW reevaluate their conclusion in light of NSO population numbers on managed forestlands within the range of the NSO.
6. Stuart L. Farber, W.M. Beaty & Associates, Inc., recommends that FGC consider delaying a final decision on the status of the NSO until all public comments are considered (Exhibit 8).
7. David A Bischel, Calforest, commented that for decades, forest owners have willingly engaged in additional, effective voluntary science, monitoring and enhancement programs to further the knowledge about protecting NSO. The net result is that NSO within its California range, and with a robust barred owl control program, is well-protected, well-distributed across the landscape, and is dynamic yet stable with quality nesting, roosting, and foraging habitat that moves across the landscape over time (Exhibit 9), with the following attachments:
   a. Research Article "Demographic Response of Northern Spotted Owls to Barred Owl Removal"
   b. Sierra Pacific Industries "NSO near Weaverville and Trinity Lake, Trinity County Within the Landscape Survey Strategy Area (An Interim Report)" January 2016
10. Edward C. Murphy, representing Sierra Pacific Industries (SPI), urges FGC to list NSO. SPI asks FGC to work with agencies, private landowners, and the general public to address the largest threats to the species (Exhibit 10), with the following attachments (Exhibit 11):
   a. Northern spotted owls near Weaverville and Trinity Lake in Trinity County within the Landscape Survey Strategy Area (An interim report)
   b. NAIP imagery (2014) (30 Pages) at each reproductive Activity Center that is discussed in NSOs near Weaverville and Trinity Lake in Trinity County within the Landscape Survey Strategy Area (An interim report)
11. Rob DiPerna, representing Environmental Protection Information Center, concludes that the listing of the NSO as an “endangered” rather than a “threatened” species “is warranted,” and that FGC should act promptly and accordingly (Exhibit 12).

Recommendation

FGC staff: Supports DFW's recommendation to list NSO as threatened

DFW: Recommends listing as threatened

Exhibits

1. Petition

2. DFW's status review report (see: http://www.fgc.ca.gov/regulations/2012/index.aspx#nso)
3. Environmental Protection and Information Center's independent report, dated May 7, 2015
4. Environmental Protection and Information Center's peer review comments, dated Jul 3, 2015
5. Support letter (sample email)
6. Letter from Keith A. Hamm, Green Diamond Resource Company, received Mar 30, 2016
7. DFW letter to Director Mike Miles, Humboldt Redwood Company, received Mar 30, 2016
8. Letter from Stuart L. Farber, W.M. Beaty & Associates, Inc., received Mar 30, 2016
9. Letter from David A Bischel, Calforest, received Mar 30, 2016
10. Letter from Edward C. Murphy, Sierra Pacific Industries, received Mar 30, 2016
11. Attachments for letter from Edward C. Murphy in Exhibit 10
12. Letter from Rob DiPerna, Environmental Protection Information Center, received Mar 30, 2016

Motion/Direction

1a. Moved by _____ and seconded by _____ that the Commission, pursuant to Section 2075.5 of the Fish and Game Code, finds the information contained in the petition to list the northern spotted owl (*Strix occidentalis caurina),* and the other information in the record before the Commission warrants listing the northern spotted owl as a threatened species under the California Endangered Species Act. (Note: Findings will be adopted at a future meeting.)

AND

1b. Moved by _____ and seconded by _____ that the Commission, authorizes publication of its intent to amend Section 670.5, Title 14, CCR, to add the northern spotted owl to the list of animals of California declared to be threatened.

OR

2. Moved by _____ and seconded by _____ that the Commission, pursuant to Section 2075.5 of the Fish and Game Code, finds that the information contained in the petition and other information before the Commission does not warrant listing the northern spotted owl as an endangered or threatened species under the California Endangered Species Act. (Note: Findings will be adopted at a future meeting.)

BEFORE THE STATE OF CALIFORNIA
FISH AND GAME COMMISSION

PETITION TO LIST THE NORTHERN SPOTTED OWL AS "THREATENED" OR "ENDANGERED" UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

ENVIRONMENTAL PROTECTION INFORMATION CENTER

September 4, 2012

Notice of Petition

California Fish and Game Commission
1416 Ninth Street, Suite 1320
Sacramento, CA 95814

The Environmental Protection Information Center (EPIC) hereby formally petitions the California Fish and Game Commission to list the northern spotted owl (*Strix occidentalis caurina*) as "threatened" or "endangered" pursuant to the California Endangered Species Act (CESA). California Fish and Game Code §§ 2050 *et seq*. This petition is filed under Sections 2072 and 2073 of the California Fish and Game Code and pursuant to Section 670.1, Title 14 of the California Code of Regulations which grants interested parties the right to petition for issue of a rule. This petition demonstrates that the northern spotted owl clearly warrants listing under CESA based on the factors specified in the statute.

This petition sets in motion a specific process placing definite response requirements on the California Fish and Game Commission and the California Department of Fish and Game and specific time constraints upon those responses. Petitioner certifies that all statements made in this petition are true and complete.

Petitioner:

Andrew J. Orahoske, Conservation Director
Environmental Protection Information Center
145 G Street, Suite A
Arcata, CA 95521

The Environmental Protection Information Center (EPIC) is a nonprofit organization that works to protect and restore ancient forests, watersheds, coastal estuaries, and native species in Northern California. EPIC's members have a direct interest in the conservation of the forests that support Northern Spotted Owls on both public and private lands which contribute to the continued existence of this species. Consequently, EPIC seeks to promote sustainable, restoration-based forestry through education, outreach, litigation, advocacy, and collaboration.

www.wildcalifornia.org

Executive Summary

The Northern Spotted Owl (*Strix occidentalis caurina*) has been listed under the federal Endangered Species Act (ESA) as "threatened" since 1990. By definition, a threatened species is ". . . likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. §1531. Despite more than 20 years of protections, the northern spotted owl is now closer to extinction than ever. Recently, spotted owl biologists have published a comprehensive analysis that determined the species has been declining on seven of eleven active demographic study areas at about 3% annually range-wide from 1985-2008, and that the decline is accelerating in recent years (Forsman et al. 2011). The rate of decline is steepest in northern Oregon and Washington, where spotted owl populations would decline by more than half in the next 20 years. On the remaining federal lands, population decline is accelerating and vital rates are deteriorating (Forsman et al. 2011). On non-federal lands, including areas that once provided some of the highest quality habitat for spotted owls, declines are significantly greater than on federal lands, with vast areas no longer supporting any spotted owls at all. (Forsman et al. 2011, Anthony et al. 2006). The outlook for the northern spotted owl is dire based on the population trends, continued habitat loss, competition by the aggressive, invading barred owl, and the inadequacy of regulatory mechanisms, especially the lack of recovery efforts on state and private lands. This petition requests the U.S. Fish and Wildlife Service (USFWS) to acknowledge the best available science, and to act accordingly by changing the status of the northern spotted owl from "threatened" to "endangered" under the ESA.

The State of California has never acted to protect the northern spotted owl under the California Endangered Species Act (CESA). California Fish and Game Code §§ 2050 *et seq*. This is despite clear declines throughout the species range in California, as well as the remainder of the range. After listing the owl under the ESA, the USFWS and federal land managers developed a strategy, the "Northwest Forest Plan," to recover the spotted owl by heavily relying on a selection of federal lands to shoulder the burden of conservation. The plan's centerpiece was a network of habitat islands for spotted owls, termed "late-successional reserves" (LSRs). Unfortunately, the reliance on the Northwest Forest Plan meant that the conservation needs for spotted owls outside of the LSRs were largely ignored. This was especially true on state and private lands where spotted owls have been largely extirpated, with the remaining individuals in dire need of protections. The heavy reliance on fragmented reserves on federal lands without a comprehensive approach to spotted owl conservation on non-federal lands has proven to be a critical error, and one of the primary reasons why recovery has failed. Coupled with continued habitat loss is the very significant threat posed by the barred owl, which displaces spotted owls and thrives in the highly fragmented and simplified industrial forest landscapes.

It is now time for the State of California Fish and Game Commission to recognize its duties under CESA, and based on the overwhelming evidence, act swiftly to protect the northern spotted owl. Without a more holistic view of species recovery and landscape-scale conservation, the spotted owl is likely to go extinct in the foreseeable future.

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I. Introduction

The northern spotted owl (*Strix occidentalis caurina*) is a subspecies of spotted owls that was listed as "threatened' under the federal Endangered Species Act (ESA) in 1990, due to widespread loss of suitable habitat and the inadequacy of existing regulatory mechanisms. (USFWS 1990). The State of California has never acted to protect the northern spotted owl under the California Endangered Species Act (CESA). California Fish and Game Code §§ 2050 *et seq*. This subspecies has a low reproductive rate, restrictive habitat requirements and specializes on a limited number of prey species. In this petition we summarize the evidence of population declines and ongoing threats that are well documented in recently published literature making the subspecies vulnerable to extinction (Forsman et al 2011, Courtney et al. 2004, 2008, Davis et al. 2011, Anthony et al. 2006, Noon and Blakesley 2006).

This petition, combined with recent extensive studies of spotted owls, and the extensive documentation provided to the Fish and Game Commission herein, leads to the conclusion that northern spotted owls should be listed as "threatened' or "endangered" under the CESA. The best available science clearly shows that threats faced by the northern spotted owl have increased since listing the subspecies as "threatened" in 1990, and that the owl has been extirpated or nearly extirpated in many portions of its range. In light of this overwhelming evidence, the northern spotted owl is presently in danger of extinction, as defined by the CESA.

II. The Listing Process under the California Endangered Species Act

The State of California enacted the California Endangered Species Act (CESA) in order to address and prevent the extinction of native biological diversity. The purpose of CESA is to "conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat...." Fish & Game Code § 2052. The first step under CESA is to identify and list species as "threatened" and "endangered." A "threatened species" refers to a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of special protection and management efforts. Fish & G. Code § 2067. An "endangered species" refers to a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease. Fish & G. Code § 2062.

The California Fish and Game Commission (Commission) is the administrative body that makes all final decisions regarding the listing of species under CESA. The California Department of Fish and Game (DFG) is the expert agency that makes recommendations to the Commission regarding species listings. The listing process may be set in motion in two ways: "any person" may petition the Commission to list a species, or the Department may on its own initiative put

forward a species for consideration. “Petitions shall include information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant.” Fish & G. Code § 2072.3. In the case of a citizen proposal, CESA sets forth a process for listing that contains several discrete steps.

Upon receipt of a petition to list a species, a 90-day review period ensues during which the Commission refers the petition to the Department, as the relevant expert agency, to prepare a detailed report. The Department’s report must determine whether the petition, along with other relevant information possessed or received by the Department, contains sufficient information indicating that listing may be warranted. Fish & G. Code § 2073.5.

During this period interested persons are notified of the petition and public comments are accepted by the Commission. Fish & G. Code § 2073.3. After receipt of the Department’s report, the Commission considers the petition at a public hearing. Fish & G. Code § 2074. At this time the Commission is charged with its first substantive decision: determining whether the Petition, together with the Department’s written report, and comments and testimony received, present sufficient information to indicate that listing of the species “may be warranted.” Fish & G. Code § 2074.2. This standard has been interpreted as the amount of information sufficient to "lead a reasonable person to conclude there is a substantial possibility the requested listing could occur." Natural Resources Defense Council v. California Fish and Game Comm. 28 Cal.App.4th at 1125, 1129.

If the petition, together with the Department’s report and comments received, indicates that listing “may be warranted,” then the Commission must accept the petition and designate the species as a “candidate species.” Fish & G. Code § 2074.2. “Candidate species” means a “native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that the commission has formally noticed as being under review by the department for addition to either the list of endangered species or the list of threatened species, or a species for which the commission has published a notice of proposed regulation to add the species to either list.” Fish & G. Code § 2068.

Once the petition is accepted by the Commission, then a more exacting level of review commences. The Department has twelve months from the date of the petition’s acceptance to complete a full status review of the species and recommend whether such listing “is warranted.” Following receipt of the Departments status review, the Commission holds an additional public hearing and determines whether listing of the species “is warranted.” If the Commission finds that the species is faced with extinction throughout all or a significant portion of its range, it must list the species as endangered. Fish & G. Code § 2062. If the Commission finds that the species is likely to become an endangered species in the foreseeable future, it must list the species as threatened. Fish & G. Code § 2067.

Notwithstanding these listing procedures, the Commission may adopt a regulation that adds a species to the list of threatened or endangered species at any time if the Commission finds that there is any emergency posing a significant threat to the continued existence of the species. Fish & G. Code § 2076.5.

Despite the fact that the northern spotted owl has been threatened with extinction since the 1980's, and listed under the federal Endangered Species Act since 1990, the Commission has not protected the northern spotted owl under the California Endangered Species Act (CESA).

III. Biology and Ecology of the Northern Spotted Owl

A. Physical Description and Taxonomy

The northern spotted owl is a medium-sized owl and the largest of the three subspecies of spotted owls currently recognized by the American Ornithologists' Union (Gutierrez et al.1995). It is dark brown with a barred tail and white spots on the head and breast, and has dark brown eyes that are surrounded by prominent facial disks. The taxonomic separation of these three subspecies is supported by numerous factors (Courtney et al. 2004), including genetic (Barrowclough and Gutierrez 1990, Barrowclough et al. 1999, Haig et al. 2004, Barrowclough et al. 2005) morphological (Gutierrez et al. 1995), behavioral (Van Gelder 2003), and biogeographical characteristics (Barrowclough et al. 1999).

B. Range

Historically, the northern spotted owl was found from British Columbia through western Washington, western Oregon, and northwestern California from Siskiyou County south to Marin County (American Ornithological Union 1957, Forsman 1976, Forsman et al. 1984, Gutiérrez et al. 1995). The ranges of the northern and California subspecies of spotted owls meet at the southern end of the Cascade Range, near the Pit River area in northern California (Thomas et al. 1990, USFWS 1992, Barrowclough et al. 1999, Haig et al. 2001).

Currently, the northern spotted owl is extirpated or nearly extirpated from a portion of its historic range. Populations in British Columbia are nearly extinct (COSEWIC 2008), and those in Washington have been extirpated or nearly extirpated in many areas, including most notably southwestern Washington and much of the Olympic Peninsula and Puget Sound where the owl has suffered particularly precipitous declines. Significant populations remain in southern Oregon, but in northwestern Oregon and much of the Oregon Coast Range the owl is nearly extirpated. And, in California, populations are declining in two of three long-term monitoring sites, while numerous historic territories have been lost from interior forests in California. The Revised Recovery Plan for the northern spotted owl states: "Many historical spotted owl site-centers are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or fires" (USFWS 2011). The California Department of Fish and Game maintains records of

spotted owl territories in the California Natural Diversity Database (CNDDB). Detailed distribution maps of northern spotted owls are provided below.

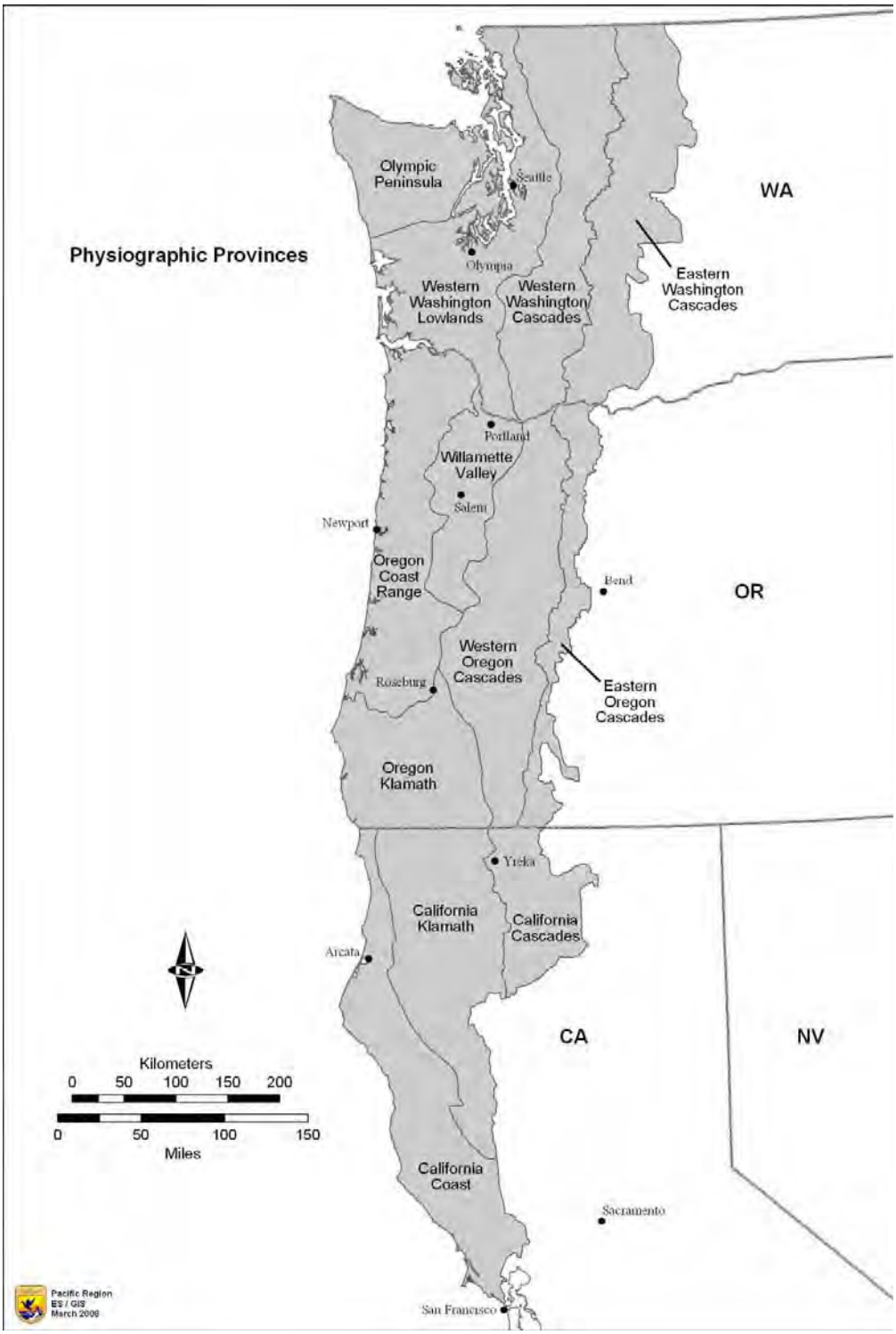


Figure 1: Overall range of the Northern Spotted Owl

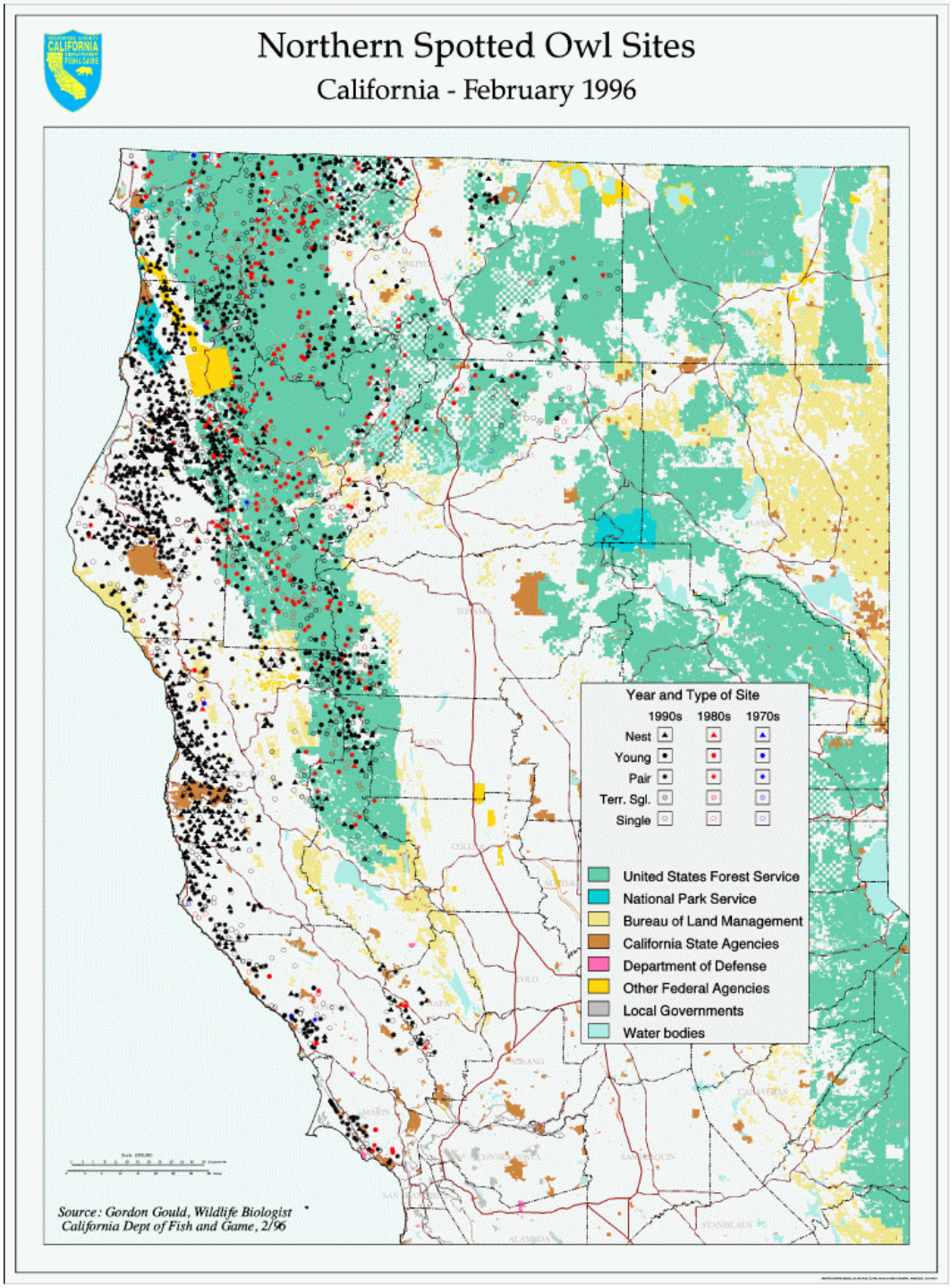


Figure 2: Northern Spotted Owl distribution in California (see legend for details).

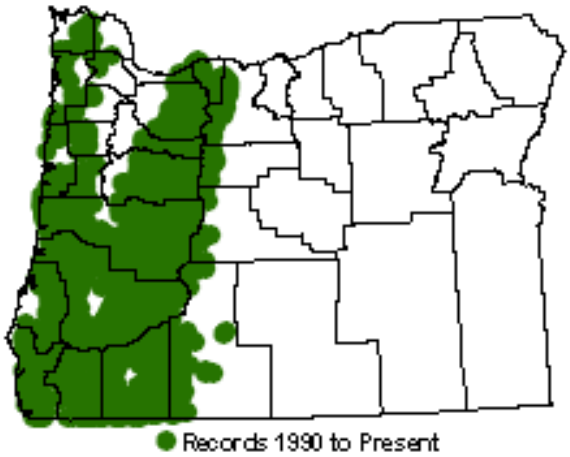


Figure 3: Northern spotted owl distribution in Oregon (green shaded area).

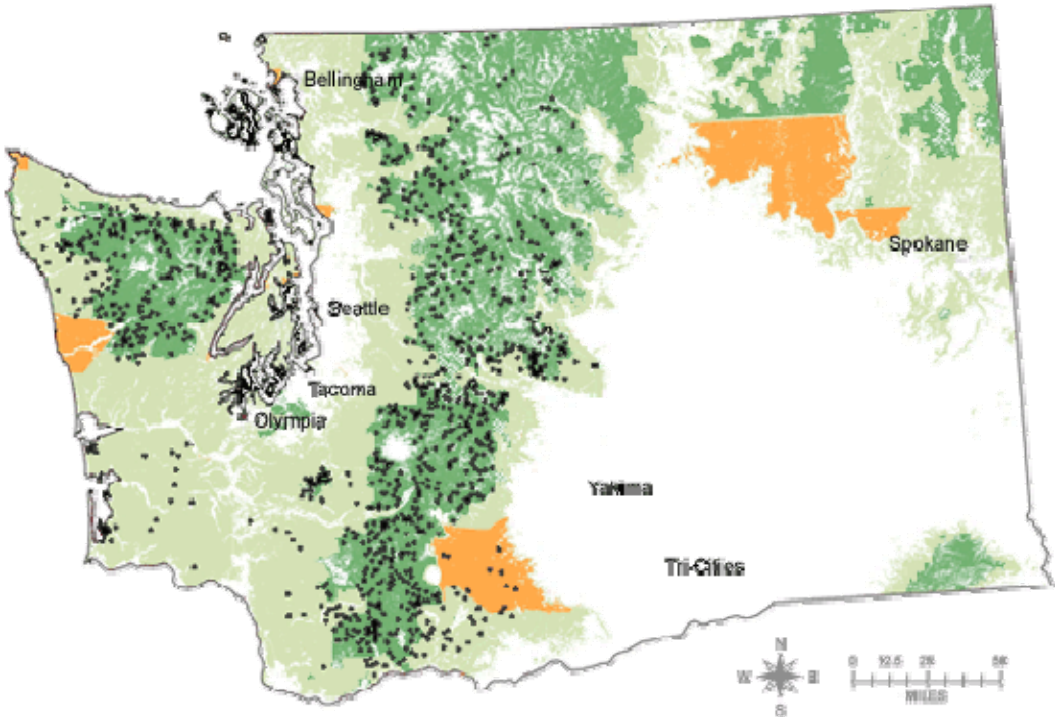


Figure 4: Northern Spotted Owl distribution in Washington (black dots).

C. Prey

Prey distribution and abundance plays a central role in the ecology of the northern spotted owl (Carey et al. 1992, Carey and Peeler 1995, Courtney et al. 2008). There is significant variation in the prey of the northern spotted owl across its range (Forsman et al. 2004, Courtney et al. 2008) and even within prey species, life history, and ecology vary geographically (Carey 2000, Lehmkuhl et al. 2006, Courtney et al. 2008). The northern portions of the owls' range lack several key prey species. For example, the red tree vole (*Aborimus longicaudus*) and dusky-footed wooded rat (*Neotoma fuscipes*) are not found north of the Columbia River (Carey et al.

1992, Carey 1999). However, southern Oregon provides some of the best remaining northern spotted owl habitat. In the margins of river valleys such as those along the Umpqua River, both the number of prey species and their abundance reaches a peak. In these areas, prey biomass may be the highest in the owl's entire range (Carey et al. 1992, Carey 1999). Ecotones between areas of older hemlock and mixed conifer forests may have three abundant prey species—red tree vole, bushy-tailed wood rat (*Neotoma cinerea*), and northern flying squirrel (*Glaucomys sabrinus*). Valley margins in southern Oregon often have these three prey species plus dusky-footed wood rat in abundance.

Carey et al. (1992) estimated the effect of the number of available prey species on the area needed to support a pair of northern spotted owls. In Douglas-fir (*Pseudotsuga menziesii*) / western hemlock (*Tsuga heterophylla*) forests in the southern Oregon Coast Range, when flying squirrels and bushy-tailed woodrats were available, 1,000 ha of old growth within a 2,000-ha area was sufficient to provide a high expectation of a pair surviving for one year. In more diverse nearby mixed conifer forests, with flying squirrels, bushy-tailed wood rats, dusky-footed wood rats, and red tree voles, owls needed less than half the area reported elsewhere. Cary et al. (1992) estimated that 500 ha of old forest within a 2,000-ha range could support a pair of northern spotted owls with a high probability of surviving for one year. In northern California, dusky-footed wood rat provides a major part of the northern spotted owl's diet (Courtney et al. 2008). The red tree vole is found in northwestern most California and is replaced by the Sonoma vole (*Arborimus pomo*) farther south.

While Courtney et al. (2004, 2008) provide a more extensive review of the diet of the northern spotted owl, little is known about the abundance and variability of prey populations. Owl demographic rates and population size may be influenced by prey abundance (Korpimäki 1992, Rohner 1996, Hakkarainen et al. 1997). Much of the high variation in northern spotted owl demographic rates may be explained, at least partially, by variations in prey abundance (Courtney et al. 2004).

D. Habitat Requirements

The best available science shows that relatively large areas of structurally complex, older forests provide the habitat necessary to support viable populations of northern spotted owls (Forsman et al. 2011). Spotted owls generally rely on older forested habitats because such forests contain the structures and characteristics required for nesting, roosting, and foraging, and dispersal. Forest characteristics associated with spotted owls usually develop with increasing forest age, but their occurrence may vary by location, past forest practices, and stand type, history, and condition. Although spotted owl habitat is variable over its range, some general attributes are common to the owl's life-history requirements throughout its range. To support northern spotted owl reproduction, a home range requires appropriate amounts of nesting, roosting, and foraging habitat arrayed so that nesting pairs can survive, obtain resources, and breed successfully. In northern parts of the range where nesting, roosting, and foraging habitat have similar attributes, nesting is generally associated with increasing old forest in the core area (Swindle et al. 1999). In some southern portions of the range, northern spotted owl survival is positively associated with

the area of old forest habitat in the core, but reproductive output is positively associated with amount of edge between older forest and other habitat types in the home range (Franklin et al. 2000). This pattern suggests that where dusky-footed woodrats (*Neotoma fuscipes*) are the primary prey species, core areas that have nesting habitat stands interspersed with varied types of foraging habitat may be optimal for northern spotted owl survival and reproduction. Both the amount and spatial distribution of nesting, roosting, foraging, and dispersal habitat influence reproductive success and long-term population viability of northern spotted owls. Population growth can occur only if there is adequate habitat in an appropriate configuration to allow for the dispersal of owls across the landscape. This includes support of dispersing juveniles, as well as nonresident subadults and adults that have not yet recruited into the breeding population. The survivorship of northern spotted owls is likely greatest when dispersal habitat most closely resembles nesting, roosting, and foraging habitat, but owls may use other types of habitat for dispersal on a short term basis. Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities.

Large areas of older, structurally complex forests provide the habitat necessary to support viable populations of northern spotted owls. Extensive studies have supported the strong association of northern spotted owls and older forests. Northern spotted owls select older forests for nesting (Hershey et al. 1998, Swindle et al. 1999) and roosting and foraging (Forsman et al. 1984, Bart and Forsman 1992, Thomas et al. 1990, Herter et al. 2002, Glenn et al. 2004, Forsman et al. 2005). Nest site occupancy also is related to the presence of mature and old-growth forests throughout the owls' range although the nature of this relationship varies (Carroll and Johnson 2008). On private lands in northwestern California, northern spotted owls usually occur in the oldest forests available (Diller and Thome 1999). Understory structure characteristic of late-successional habitat is also important for northern spotted owls and their prey (Carey et al. 1992, Rosenberg and Anthony 1992, Buchanan et al. 1995, LaHaye and Gutiérrez 1999, Lehmkuhl et al. 2006).

Recruitment is positively related to the proportion of older forest habitat in owl territories, and higher levels of recruitment have been observed on federal lands with high proportions of old forest habitat (Forsman et al. 2011). Other studies have documented lower reproduction in areas with less old forest habitat. For example, pairs produced fewer fledglings in areas with less than 20 percent old forest habitat (average = 0.33 fledglings/pair) than in areas with greater than 60 percent old forest habitat (average = 0.93 fledglings/pair) (Bart and Forsman 1992).
Survival and fecundity are positively associated with the proportion of old forest surrounding nesting territories (Franklin et al. 2000, Dugger et al. 2005, Olson et al. 2004). In southern Oregon reproduction increased as the proportion of old forest within 730 m of activity centers increased (Dugger et al. 2005). Habitat may partially mitigate the effects of the invasive barred owl. The effects of barred owls increase with a decrease in old forest habitat (Dugger et al. 2011).

IV. Population Status

Forsman et al. (2011) determined that northern spotted owl populations declined on 7 of 11 study areas range-wide from 1985-2008. Overall population declines were documented throughout the range of the northern spotted owl at 2.9% annually, with estimates of population declines ranging from 5 to 15% in the Tyee, Klamath, Southern Cascades, and Hoopa study areas, and 40 to 60% in the Olympic, Cle Elum, Rainier, and Oregon Coast Range study areas (Forsman et al. 2011). See Table 1.

TABLE 1: Summary of trends in demographic parameters for northern spotted owls, from 11 study areas 1985-2008, adapted from Forsman et al. (2011).

Study Area	**Fecundity**	**Apparent survival**	**Population trend**
Washington			
Cle Elum	Declining	Declining	Declining
Rainier	Increasing	Declining	Declining
Olympic	Stable	Declining	Declining
Oregon			
Coast Range	Increasing	Declining since 1998	Declining
H.J. Andrews	Increasing	Declining since 1997	Declining
Tyee	Stable	Declining since 2000	Stationary
Klamath	Declining	Stable	Stationary
Southern Cascades	Declining	Declining since 2000	Stationary
California			
Northwestern California	Declining	Declining	Declining
Hoopa	Stable	Declining since 2004	Stationary
Green Diamond	Declining	Declining	Declining

Areas of primarily non-federal land support few or no owls and Forsman et al. (2011) state that too few northern spotted owls exist in these regions (i.e., southwestern Washington, the Coast Range of northwest Oregon, the California Cascades, and much of Washington's Olympic Peninsula) even to conduct a demographic study with their methods. It is likely that these declines will continue on both federal and especially on non-federal lands.

The effectiveness monitoring program of the NWFP confirms the dire trajectories reported in the studies discussed above. Analysis of data from government monitoring of owl populations on eight sites on federal lands (including sites in Washington, Oregon, and California) show a 2.8% decline per year. A 3.1% decline per year was calculated for the other three study areas (Davis et al. 2011). While these declines are dramatic, rates of decline are even more precipitous on non-federal lands (Anthony et al. 2006, Davis et al. 2011).

Funk et al. (2010) provide additional independent evidence that northern spotted owls continue to decline and document that the subspecies is experiencing a reduced effective population size. The loss of genetic variation in the spotted owl is an emerging threat not considered during the original listing. The evidence for recent genetic bottlenecks in northern spotted owls is based on a large genetic dataset. This study observes that the genetic bottleneck, in addition to field

evidence for demographic decline, highlights the increasing vulnerability of the northern spotted owl to extinction.

Demographic data from studies initiated as early as 1985 have been analyzed every 5 years to estimate northern spotted owl demographic rates and population trends (Franklin et al. 1999, Anthony et al. 2006, Davis et al. 2011, Forsman et al. 2011). The most current evaluation of population status and trends is based on data through 2008 (Forsman et al. 2011). Based on this analysis, populations on 7 of 11 study areas (Cle Elum, Rainier, Olympic Peninsula, Oregon Coast Ranges, H.J. Andrews, Northwest California, and Green Diamond) were declining (Forsman et al. 2011). Estimates of realized population change (cumulative population change across all study years) indicated that, in the more rapidly declining populations (Cle Elum, Rainier, and Olympic Peninsula), the 2006 populations were 40 to 60 percent of the population sizes observed in 1994 or 1995 (Forsman et al. 2011). Populations at the remaining areas (Tyee, Klamath, Southern Oregon Cascades, and Hoopa) showed declining population growth rates as well, although the estimated rates were not significantly different from stable populations (Forsman et al. 2011). A meta-analysis combining data from all 11 study areas indicates that rangewide the population declined at a rate of about 2.9 percent per year for the period from 1985 to 2006. Northern spotted owl populations on Federal lands had better demographic rates than elsewhere, but still declined at a mean annual rate of about 2.8 percent per year for 1985–2006 (Forsman et al. 2011). In addition to declines in population growth rates, declines in annual survival were reported for 10 of the 11 study areas (Forsman et al. 2011). Number of young produced each year showed declines at 5 areas (Cle Elum, Klamath, Southern Oregon Cascades, Northwest California, and Green Diamond), was relatively stable at 3 areas (Olympic Peninsula, Tyee, Hoopa), and was increasing at 2 areas (Oregon Coast Ranges, H. J. Andrews) (Forsman et al. 2011). The barred owl has emerged as a greater threat to the northern spotted owl than was previously recognized. The range of the barred owl has expanded in recent years and now completely overlaps that of the northern spotted owl (Crozier et al. 2006). The presence of barred owls has significant negative effects on northern spotted owl reproduction (Olson et al. 2004), survival (Anthony et al 2006), and number of territories occupied (Kelly et al. 2003; Olson et al. 2005). The determination of population trends for the northern spotted owl has become complicated by the finding that northern spotted owls are less likely to call when barred owls are also present; therefore, they are more likely to be undetected by standard survey methods (Olson et al. 2005, Crozier et al. 2006). As a result, it is difficult to determine whether northern spotted owls no longer occupy a site, or whether they may still be present but are not detected. The 2011 Revised Recovery Plan for the Northern Spotted Owl concludes that ‘‘barred owls are contributing to the population decline of spotted owls, especially in Washington, portions of Oregon, and the northern coast of California.’’ (USFWS 2011). British Columbia has a small population of northern spotted owls. This population has declined at least 49 percent since 1992 (Courtney et al. 2004), and by as much as 90 percent since European settlement (Chutter et al. 2004) to a 2004 breeding population estimated at about 23 birds on 15 sites (Chutter et al. 2004). Chutter et al. (2004) suggested immediate action was required to improve the likelihood of recovering the spotted owl population in British Columbia. In 2007, the Spotted Owl Population Enhancement Team recommended to remove spotted owls from the wild in British Columbia. Personnel in British Columbia captured and brought into captivity the remaining 16 known wild

spotted owls. Prior to initiating the captive-breeding program, the population of spotted owls in Canada was declining by as much as 35 percent per year (Chutter et al. 2004).

V. Nature, Degree and Immediacy of the Threat to Northern Spotted Owls in California

The following sections provide an overall summary of the threats to northern spotted owls throughout their range, including California. Taking all of the information together, it is clear that the species should be protected under CESA.

A. Present or threatened destruction, curtailment, or modification of habitat or range

The destruction of old-growth forests in the Pacific Northwest and northern California is the original reason why spotted owls are imperiled. The warning signs of extinction were first document in the 1970s, due to the heavy logging throughout the owl's range, especially on many federal lands that had escaped logging up until that point. Lower elevation forests throughout Washington, Oregon and California were clearcut and substantial amounts of spotted owl habitat was high-graded by logging the biggest trees first (USFWS 1990). Many of these areas have never recovered to a point that they support spotted owls, particularly in southwestern Washington and the coast ranges of Oregon. The patchily distributed federal lands present in these regions are insufficient to provide sufficient habitat to recover spotted owls. Therefore, the spotted owl has been extirpated from large portion of its historic range and it is unlikely that the habitat on these predominantly private lands will be recovered in the foreseeable future. Management of federal lands, while improved from before ESA-listing, continues to allow the removal and degradation of spotted owl habitat, even areas deemed critical to their conservation. The Revised Recovery Plan even contemplates continued habitat losses with Recovery Action 32 (USFWS 2011). This action provides protections for "high quality" habitat but not for suitable owl habitat – as a result, ongoing losses are anticipated for nesting, roosting, foraging, and dispersal habitat that is not determined to be "high quality" by the action agencies or through consultation with USFWS.

According to the USFWS, spotted owl habitat losses have continued across ownerships despite the "threatened" listing (Moeur et al. 2005, Raphael 2006, Courtney et al. 2004). See Table 2.

TABLE 2. Spotted owl habitat losses across ownerships, 1994 to 2004.

Area (acres)	Time	Ownership	Cause	Description	Citation
16,900	1994 to 2003	Federal	Logging	older forest	Moeur et al. 2005
141,300	1994 to 2004	Federal and non-	Stand-replacing fire	owl habitat	Raphael 2006

		Federal			
155,999	1994 to 2003	Federal	Logging	owl habitat	Courtney et al. 2004
583,500	1994 to 2004	Non-Federal	Logging	owl habitat	Courtney et al. 2004

According to Campbell et al. 2010, over 50% of the state's old-growth forests have been lost. From 1994 to 2003 in Oregon and Washington fragmentation of forests increased substantially, in some regions as high as five-fold (Davis and Lint 2005). Even if owl habitat has not been completely lost by clearcut logging, most other types of commercial logging remove important components of functional owl habitat. This simplification of forest ecosystems contributes the overall decline in habitat quality and the ability of owls to survive over the long-term. Within native forests with older-forest habitat, important components for owls and their prey such as standing dead trees, large down wood, multi-layered canopies, and other features have been lost throughout much of the owls' range and are in short supply particularly on nonfederal lands mainly because of lax forest practices. In many places, it will take centuries for forests to recover their former productivity even with the Northwest Forest Plan, and other measures in place due to the extensive ecological debt in late-seral habitat (Strittholt et al. 2006).

1. Ongoing and Threatened Habitat Loss in California

Within California alone, EPIC has identified numerous logging proposals on both private and public lands that will destroy or degrade spotted owl habitat. For example, on private lands owned by Sierra Pacific Industries, EPIC has identified over 27 timber harvest plans (THPs) that are currently ongoing or proposed that will destroy over 7,000 acres of spotted owl habitat. See Table 3. We provide the supporting information for the identified Sierra Pacific THPs, including the owl and habitat survey data with this petition to the USFWS.

TABLE 3: Sierra Pacific Industries' timber harvest plans (THPs) destroying northern spotted owl habitat in violation of the ESA Section 9 "Take" prohibition

THP number	**THP Name**	**Spotted Owl Habitat Destroyed (acres)**
1-09-054HUM	Roweisner	157
1-09-061HUM	Rerun	399
1-09-085HUM	Acer	371
1-10-025HUM	Green Mule	130
1-10-048HUM	Kragness	112
1-10-085HUM	Marvel	34
1-12-042HUM	Hiker's Parade	724
2-09-010TRI	Hogs	83
2-09-038TRI	Wilcox	727
2-09-041TRI	Halls	227
2-09-042SHA	Derby	68

2-09-078LAS	Big Widow	123
2-09-085TRI	Bowman	91
2-09-091TRI	Lowball	64
2-10-011TRI	Dyno	403
2-10-019TRI	Ebert	321
2-10-074TRI	Ranger	189
2-10-075TRI	Hinkey	22
2-11-004TRI	Llium	54
2-11-014TRI	3B's	138
2-11-035TRI	Bowtie	2
2-11-061TRI	Pappy	895
2-11-064TRI	Southern Star	271
2-11-070TRI	Thurman	426
2-11-076SHA	Tea Kettle	167
2-11-078SHA	Uncle	717
2-11-080TRI	Hay	173
		7088 acres destroyed in total

Notably, the ongoing destruction of northern spotted owl habitat by Sierra Pacific Industries is taking place without an incidental take permit as required under the ESA. Therefore, EPIC has formally notified Sierra Pacific Industries with letter of intent to sue over violations of the ESA (EPIC 2012). The Secretary and USFWS have been aware of this ongoing "take" since at least February 2012, but the federal authorities have failed to act. The overall habitat destruction on Sierra Pacific Industries and other private lands in northern California has resulted in the abandonment of dozens of historic spotted owl territories (USFWS 2009). Those that remain are mostly all severely deficient in suitable habitat, particularly nesting and roosting habitat made up of older forests.

2. Habitat Loss and the Decline of Preferred Prey Species

Northern Flying Squirrel

The northern flying squirrel northern flying squirrel (*Glaucomys sabrinus*) is an essential prey species for spotted owls, particularly in the Oregon and Washington. Carey (2003) determined that logging in forests of the Pacific Northwest and northern California has produced imbalanced mammal communities, with some species that were once common in natural forests (Carey, 1995; Carey and Johnson, 1995) no being low in abundance. In particular, northern flying squirrels are very rare in the industrial timber stands due to dense homogeneous tree plantations with simplified understory while also promoting excessively high and uniform chipmunk abundance (Carey 2003). Manning et al. (2011) determined that large-scale commercial thinning of Douglas-fir forests is detrimental northern flying squirrels, and brings into question many of the proposed thinning treatments in spotted owl habitat. A recent meta-analysis of effects of silvicultural practices on northern flying squirrels found that previous studies asserting a benefit or no effect of harvesting on squirrel populations lacked statistical power and support for those

assertions (Holloway and Smith 2011). The implication of Holloway and Smith's meta-analysis is that forest management practices that are currently widespread in the Pacific Northwest (thinning and clearcutting) have negative short-term and long-term impacts on northern flying squirrels (Manning et al 2011).

Tree Voles

Tree voles are small, mouse-sized rodents that live in conifer forests and spend almost all of their time in the tree canopy. Tree voles rarely come to the ground, and do so only to move briefly between trees. They are one of the few animals to persist on a diet of conifer needles, which is their principal food. Spotted owls in Oregon and California rely on heavily on tree voles as a main source of prey. Tree voles are endemic to the humid, coniferous forests of western Oregon and northwestern California. Recently, the USFWS has proposed listing the northwestern Oregon distinct population segment of red tree vole under the ESA. See 76 Fed. Reg. 198 (October 13, 2011). The status review found that despite federal protections afforded by the Northwest Forest Plan, that the red tree vole was threatened due to ongoing clearcutting and habitat destruction on private, state and federal lands. Id. The clear declines for red tree voles throughout the range of the spotted owl are another indication that the owl faces significant threats warranting an endangered listing.

B. Disease or Predation

West Nile Virus is a potential threat to the northern spotted owl (Blakesley et al. 2004). Large numbers of wild birds have been killed by West Nile Virus since its introduction in 1999 and subsequent spread across North America (McLean et al. 2001, Caffrey 2003, Marra et al. 2004, Blakesley et al. 2004). Owls are known to be susceptible to West Nile Virus (Fitzgerald et al. 2003) and a captive spotted owl has died of the virus (Gancz et al. 2004). In addition, recent examination of the rates of infection by blood parasites indicates that northern spotted owls have a high rate of infection by *Leucocytozoon* and other parasites (Ishak et al. 2008). In addition, a *Plasmodium* parasite was documented for the first time in a northern spotted owl. The observed discrepancy between prevalence of blood parasites in barred and spotted owls could be explained by a better host immune response to the parasites. This differential in blood parasite infection rates led Ishak et al. (2008) to speculate that barred owls on the West coast may have a competitive advantage over the potentially immune compromised spotted owls.

C. Predation

Northern spotted owls are subject to predation by great horned owls (*Bubo virginianus*), goshawks (*Accipiter gentilis*), and red tailed hawks (*Buteo jamaicensis*) (Forsman et al. 1984, Courtney et al. 2004). This natural predation has been severely exacerbated by the destruction and fragmentation of suitable habitat. Industrial forestry models across millions of acres of private lands that create dense tree plantations, coupled with ongoing habitat degradation on public lands has resulted in more open habitat suitable for predators of spotted owls (Courtney et

al 2004). Additionally, barred owls (*Strix varia*) physically attack (Livezey and Fleming 2007) and may prey upon spotted owls (Leskiw and Gutiérrez 1998). With the expansion of the barred owl's range (Livezey 2009) this source of predation is increasing.

D. Inadequacy of Existing Regulatory Mechanisms

The inadequacy of existing regulatory mechanisms has been repeatedly cited as a primary threat to northern spotted owls for more than 20 years (USFWS 1990, Franklin and Courtney 2004, USFWS 2004, USFWS 2011). The primary inadequacies are the lack of protections for spotted owls on non federal lands, especially large swaths of industrial forestry lands controlled by a few large corporations. The regulatory inadequacies on non-federal lands were reviewed by DellaSala (2011) and categorized as follows: variable and often inadequate protection given to owls and owl habitat; lack of landscape-scale planning, especially on non-federal lands; use of survey protocols and other standards that fail to incorporate current relevant science; prevalence of discretionary guidelines and/or unclear or unsuitable direction; failure to consistently require involvement of personnel with biological expertise in evaluating/assessing ecological information. On federal lands and despite the protections afforded by the Northwest Forest Plan, insufficient protections and a lack of recovery planning outside of late-successional reserves continues to plague the agencies involved in forest management. This petition and supporting documentation clearly show that existing regulatory mechanisms have not prevented the continued decline of northern spotted owls since the 1990 ESA listing.

1. Non-federal Lands

Private and state lands managed for intensive timber production, employing clearcutting and short rotation, mono-culture and herbicide use have been largely overlooked by state regulators. Even though such practices were the primary reason for the original ESA-listing, this major cause of the spotted owl's decline and continued imperilment is simply not adequately addressed by existing laws and regulations. Most attention has focused on federal forest management, primarily because federal authorities have refused to prosecute ESA violations. Because the USFWS has abandoned its clear duties to prosecute "take" under the ESA, the lack of adequate regulations non-federal lands continues to pose a threat to northern spotted owls. Rather than issue protective regulations or prosecute violations of the ESA, the USFWS has allowed individual state agencies with conflicting missions to issue inadequate regulations in an attempt to create a façade of conservation. The following sections describe the regulatory approach and inadequacies for California, Oregon and Washington.

a) California

The California Forest Practices Rules ("CA FPRs") are the primary state regulations affecting the management of the spotted owl on private lands in California. These regulations implement the Z'berg Nejedley Forest Practices Act of 1973 (4 Pub. Res. Code Ch. 8). Unbelievably, the State of California has never listed the spotted owl under the state's own California Endangered

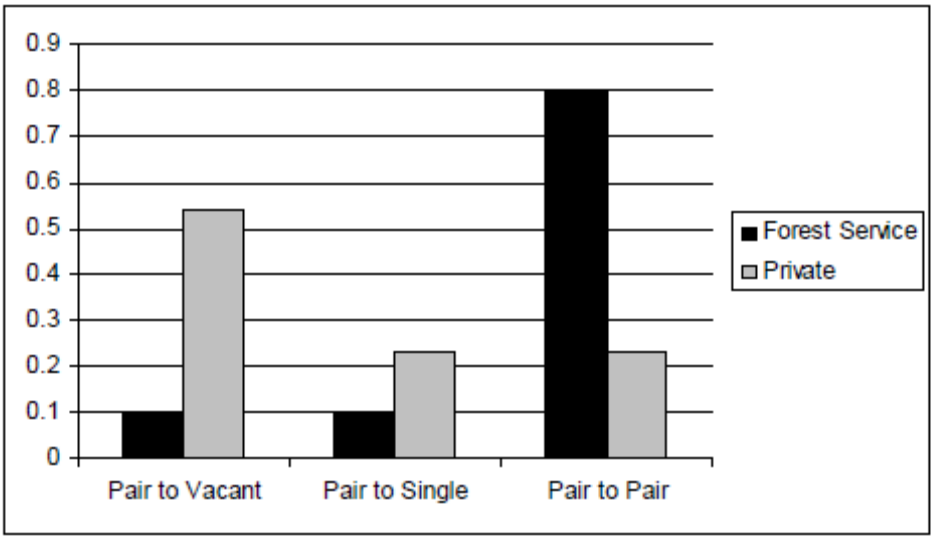
Species Act (CESA). Lacking any listing under CESA, the California Department of Fish and Game (CA DFG), the state agency charged with defending the public wildlife trust, is completely absent from conservation efforts. Therefore, the CA FPRs, as administered by the California Department of Forestry and Fire Protection (CalFire), are the state's only attempt at conserving spotted owls, and they are woefully inadequate. The CA FPRs require timber operators to prepare and submit 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 sections 21000-21177). The CA FPRs allow for the removal of spotted owl habitat below threshold guidelines for the avoidance of "take" set by the U.S. Fish and Wildlife Service (CA FPRs 2012, USFWS 2009).

The Yreka Field Office of the U.S. Fish and Wildlife Service completed an extensive analysis of the status of historical spotted owl activity centers on federal and private lands in interior northern California (USFWS 2009). The Service found that extensive losses of owl pairs occurred on private lands, which sharply contrasted with the persistence of owl pairs on federal lands. Yreka USFWS concluded:

> To quantify the pattern of territory loss identified during the technical assistance process, we compared results of protocol surveys conducted at verified NSO territories supporting at least one year of occupancy by paired owls on Forest Service lands (N=196) with similar data from private timberlands (N=75) in Shasta and Trinity counties. The data set consisted of activity center status records in the California Department of Fish and Game's Spotted Owl Database (CDFG-NSO database), supplemented with territory locations and recent survey records received during technical assistance. We first evaluated the validity of activity center records in the CDFG-NSO database, and eliminated 18 sites on private lands due to lack of verification of status. The remaining 57 private-land activity centers had verified NSO status in at least one year between 1989 and 2007; 44 of these sites had supported pairs during at least one year. Of these verified pair sites, 54% declined from pair status to no response, and an additional 23% declined from pair status to a territorial single owl during subsequent protocol surveys (Figure I.B.1). On Forest Service-administered lands, 80% of pair sites did not change status during the same time periods. While we recognize that annual variation in survey effort and results at this relatively coarse scale of resolution may influence this type of analysis, the strong differences in trends observed on private versus federal lands supports the contention that management on private timberlands is creating habitat conditions that do not support sustained occupancy by NSO.

(USFWS 2009: 11-12). The Service also created the figure below to illustrate the results of their analysis. Clearly, the California Forest Practice Rules are completely inadequate to protect spotted owls on private lands.

Figure I.B.1. Status of valid historical northern spotted owl activity centers (pair sites only) when resurveyed after 5-10 years. Data are from U.S. Fish and Wildlife Service technical assistance records and USFS monitoring records



The application of the limited protections contained in the CA FPRs depends upon prior identification of areas as "activity centers." If an activity center has not been identified, then no habitat protections nor surveys are required. In addition, the current database of activity centers is generally acknowledged to be out of date, poorly maintained, not well updated, and not reliable. Further, the definition of an "active nest site" or "pair activity center" in §919.9(g)(1-2) & 939.9(g)(1-2) (known as "Option G") is not inclusive enough to apply to all the sites entitled to protection under the Endangered Species Act. For known activity centers, the CA FPRs "Option G" only requires that a minimum amount of general spotted owl habitat be maintained, and makes no distinction as to whether the habitat must be nesting, roosting or foraging habitat. This critical deficiency means that logging operations may result in the complete removal of nesting and roosting habitat from an activity center, and still comply with the rules so long as enough foraging habitat remains. This on-the-ground reality is why the USFWS has found most activity centers on private lands have been abandoned since the early 1990s.

b) Oregon

Only a nest site and 70 acres of adjacent habitat is protected in Oregon, and the Oregon Department of Forestry does not consider foraging habitat to be a specific resource site, and therefore it is not protected under the Oregon forest practice rules (Oregon Administrative Rules (OAR) 665, Oregon Forest Practice Act Rulebook 2010). Nothing contained within the state rules reflects the best available science regarding the habitat needs for spotted owls. Even though the species is listed under the Oregon Endangered Species Act, the state has not developed a regulatory mechanism adequate to protect, much less recover, northern spotted owl habitat and populations.

c) Washington

Although the northern spotted owl has been listed as "endangered" under the Washington State Endangered Species Act since 1988, the subspecies has declined most precipitously in this state. There is no state recovery plan for spotted owls. Under the Washington State Forest Practice Rules, significantly different protections apply to northern spotted owls and their habitat depending on their location within or outside of designated Spotted Owl Special Emphasis Areas (SOSEAs). Conservation measures for northern spotted owls on private lands outside SOSEAs are "substantially less" than within SOSEAs (Ward 2006, Sweeden 2006). Even within SOSEAs, the designation does not prohibit detrimental forest practices so long as some environmental review takes place. The State of Washington and Weyerhaeuser Corporation were prosecuted for illegal "take" of northern spotted owls, resulting in a legal settlement that created a working group to recommend changes to Washington's Forest Practice Act. *See* Seattle Audubon Society v. Sutherland, 2:06−cv−01608−MJP, W.D. Washington. The federal court issued a preliminary injunction against further logging due to ongoing and threatened harm to spotted owls outside of SOSEAs. Id. The subsequent working group produced recommendations for changes to private lands logging in Washington to the state's forest practice board (Berg et al. 2009). The State of Washington's forest practice board has failed to act on those recommendations to the present day, and therefore spotted owls are still lacking adequate protections.

2. Federal Lands

While protections and conservation strategies are much better than on private and state lands, federal land management still poses many problems for spotted owls. All federal lands within the range of the northern spotted owl are currently managed under the provisions of the Northwest Forest Plan ("NWFP"). The NWFP was adopted in 1994, and it amended land management planning documents for nineteen National Forests and seven Bureau of Land Management districts throughout Washington, Oregon and California. The NWFP established a late-successional reserve (LSR) network and specified management standards and guidelines to further the recovery of northern spotted owls.

The 15-year report on the NWFP performance for spotted owls was recently released and it plainly shows that the plan is simply not enough to recover the species (Davis et al. 2011). The NWFP was based on overly optimistic assessments of spotted owl demographic performance (Franklin et al. 1999, Anthony et al. 2006). Demographic studies (Franklin et al. 1999, Anthony et al. 2006, Forsman et al. 2011, Davis et al. 2011) have demonstrated that the population declines are much greater rate than was anticipated across their range and particularly in Washington. In light of this decline, the Forsman et al. (2011) stressed the importance of retaining high quality owl habitat: "[i]n view of the continued decline of Spotted Owls in most study areas, it would be wise to preserve as much high quality habitat (i.e., late-successional forests) for Spotted Owls as possible, distributed over as large an area as possible."

The NWFP protected some of the remaining high quality owl habitat, but not the entirety of remaining high quality owl habitat was protected. In addition, recent estimates have shown that

only about 36% of late-successional reserves actually include late-successional forests, with the majority of the designated reserves expected to acquire such conditions over decades (Strittholt et al. 2006). Similarly, recent scientific literature suggests that the limited, bare minimum approach taken by the NWFP is inadequate to stabilize populations. Of particular note is the omission of all remaining nesting, roosting, and foraging habitat from reserves. While qualifying as late-seral the remaining nesting, roosting, and foraging habitat may not meet the standards of high quality habitat implicit in the Revised Recovery Plan (USFWS 2011). Thus, important owl habitat on federal lands will remain vulnerable to ongoing logging at a time when owl populations are declining more rapidly than anticipated, and risks are increasing from presumed competitive pressures from barred owls.

The NWFP noted that "certain thinning and salvage activities would be allowed in the reserves," however, thinning or other silvicultural treatments inside reserves theoretically are authorized "only if those treatments are beneficial to the creation of late-successional forest conditions" (USDA Forest Service and USDI BLM 1994). Some studies have indicated that spotted owls are somewhat resilient to low to mid-severity fire effects (Clark 2007, Bond et al. 2009). However, post-fire logging is often employed after fires, and a bigger threat to owls (Clark 2007, Bond et al. 2009, Hanson et al. 2010). Northern spotted owls remain vulnerable to post-fire logging even within late-successional reserves, as the NWFP is inadequate to protect owls from this threat. During the decades since original adoption of the NWFP, post-fire logging has become a more significant source of timber from federal lands, including late-successional reserves, and fire associated management (including thinning, suppression, and post-fire logging) has become a substantial emphasis of both the Forest Service and the Bureau of Land Management. As a result, supposedly protected owl habitat is at risk of fire-associated management (Hansen et al. 2009). This is particularly relevant on BLM lands in western Oregon, where the Secretary of Interior recently proposed a pilot process following active management guidelines in Johnson and Franklin (2009) that could extend thinning limits within reserves in dry forested regions from current 80-year limits to 120-years. Thus, active forest management designed to open forest canopies is increasing and could result in degrading additional owl habitat (Hanson et al. 2009, 2010).

E. Other natural or manmade factors affecting the continued existence of the species

1. Barred Owl

The barred owl (*Strix varia*), closely related species to spotted owls, has expanded its range from its original home in eastern North America into the Pacific Northwest, much to the detriment of spotted owls. (USFWS 2011, Campbell 1973, Hamer et al. 1994, 2001, Dark et al. 1998, Herter and Hicks 2000, Pearson and Livezey 2003, Livezey 2009a and 2009b). Recent studies report that barred owls have "increased dramatically" on the demographic study areas over the last two decades (Forsman et al. 2011).During the second half of the 20thcentury, barred owls expanded their range from eastern to western North America, and the range of the barred owl now completely overlaps that of the northern spotted owl (Gutierrez et al. 1995, Crozier et al. 2006).

Barred owls compete with northern spotted owls for habitat and resources for breeding, feeding, and sheltering, and the presence of barred owls has significant negative effects on northern spotted owl reproduction, survivorship, and successful occupation of territories. The loss of habitat has the potential to intensify competition with barred owls by reducing the total amount of resources available to the northern spotted owl and by increasing the likelihood and frequency of competitive interactions. Barred owls select very similar habitat to spotted owls for breeding, feeding, and sheltering, and loss of habitat has the potential to intensify competition between species. While conserving habitat will not alleviate the barred owl threat, Dugger et al. (2011) found that spotted owl occupancy and colonization rates decreased as both barred owl presence increased and available habitat decreased. These authors concluded that, similar to another case in which increased suitable habitat was required to support two potentially competing raptors, increased habitat protection for spotted owls may be necessary to provide for sustainable populations in the presence of barred owls (Dugger et al. 2011).

Maintaining high-quality habitat has been important since the northern spotted owl was initially listed as threatened in 1990, and this competitive pressure from barred owls has intensified the need to conserve and restore large areas of contiguous, high quality habitat across the range of the northern spotted owl (Dugger et al. 2011, Forsman et al. 2011, USFWS 2011). The Revised Recovery Plan states:

> Barred owls reportedly have reduced spotted owl site occupancy, reproduction, and survival. Limited experimental evidence, correlational studies, and copious anecdotal information all strongly suggest barred owls compete with spotted owls for nesting sites, roosting sites, and food, and possibly predate spotted owls. . . Because the abundance of barred owls continues to increase, the effectiveness in addressing this threat depends on action as soon as possible

(USFWS 2011, p. III-62). Barred owls initially proliferated in Washington and Oregon much more rapidly, but barred owls are becoming increasingly common in northern California (USFWS 2012, Dark et al. 1998, Kelly 2001, Kelly et al. 2003, Forsman et al. 2011).

The USFWS has recently embarked on a barred owl removal experiment, releasing a draft environmental impact statement in March 2012 that includes an exhaustive list of research and documentation outlining the threat posed by barred owls (USFWS 2012). While it encouraging that the USFWS will finally begin addressing the threat of barred owls, many researchers have questioned the utility of barred owl removal. Furthermore, given the landscape scale changes to Pacific Coast forests, and the rapid saturation of barred owls into these landscapes, a distinct question arises about USFWS' plans for addressing overall habitat changes in the range of the spotted owl. Regardless of whether the USFWS will address habitat loss and barred owls together, because it has taken 20 years for the USFWS to even begin addressing barred owls, whatever outcome may be too little too late for spotted owls across much of their historic range. Barred owls will likely always be present in the spotted owl's range, despite control efforts described by USFWS (2012).

Studies have clearly shown a negative impact on spotted owls due to direct displacement and occupancy of nesting sites and territories (Kelly et al. 2003, Olson et al. 2005). A negative impact on spotted owl fecundity (Olson et al. 2004). Forsman et al. (2011) found that the presence of barred owls has a negative effect on spotted owl recruitment, in turn affecting their survival and population trends. Of all the factors contributing to declines in the demographic rates of northern spotted owls, the presence of barred owls is the strongest and most consistent across study areas (Forsman et al. 2011, p. 75). Kelly et al. (2003) concluded that the presence of barred owls at historical northern spotted owl sites reduced spotted owl occupancy. Gremel (2005) determined that the presence of barred owls appeared to be reducing northern spotted owl occupancy at their historical sites and increasing the detection distance between spotted owls and their original site centers.

Crozier et al. (2006) showed that northern spotted owls have a reduced response rate in the presence of barred owls. While not the focus of the study, this provides evidence that barred owls may disrupt certain behaviors important to spotted owls. Vocalizations are an important part of the spotted owl's territorial behavior.

Barred owls will choose old or mature forests for nesting and compete for nest cavities with spotted owls (USFWS 2012, McGarigal and Fraser 1984, Mazur and James 1998, Carroll and Johnson 2008, Mazur et al. 1997, Buchanan et al. 2004). Barred owls prey upon the same species of small mammals that are the primary prey species of Spotted Owls (Forsman et al. 2001, Hamer et al. 2001). In addition, barred owls also prey upon a wider variety of prey not taken by spotted owls (Elderkin 1987, Bosakowski and Smith 1992, Hamer et al. 2001, Livezey et al. 2008). Further, annual home ranges of sympatric northern spotted owls were 3–4 times larger than those of barred owls in the western Cascade Mountains of Washington (Hamer 1988, Singleton et al. 2005), probably due to the more-varied prey base of barred owls (Hamer et al. 2001, Livezey 2007, Livezey et al. 2008). Barred owls also breed more regularly and have consistently larger broods than do spotted owls (Livezey and Fleming 2007).

Finally, barred owls are capable of exploiting younger forest stands, and semi-forested urban and suburban landscapes in the range of the northern spotted owl that are seldom used by spotted owls (Livezey and Fleming 2007) and use forests in the Pacific Northwest outside of the range of the spotted owl (Buchanan 2005). As a result, barred owls have large source populations that, with their greater dispersal capability (Gutiérrez et al. 2004, Livezey and Fleming 2007), can supplement numbers of barred owls within the range of the spotted owl. As expected, the overlap between barred and spotted owls in habitat and prey coupled with the larger size and more aggressive nature of the barred owl has resulted in significant concern for the long-term sustainability of the northern spotted owl. Livezey and Fleming (2007) concluded that barred owls have a competitive advantage over spotted owls.

VI. Recommended Management and Recovery Actions

- List the northern spotted owl as an endangered species within California under the California Endangered Species Act.

- Initiate a long-term planning process to create a northern spotted owl recovery plan based on the best available science. Such a plan should include the development of clear conservation goals for the recovery of northern spotted owls.

VII. Conclusion

Northern spotted owls are now facing extinction throughout a significant portion of their range. Continued habitat loss range-wide, the failure on non-federal lands to protect and restore spotted owl habitat, the invasion of the barred owl and additional threats listed above require that the California Fish and Game Commission immediately begin the process of listing the species as "threatened" or "endangered" under the CESA. Many populations of spotted owls have already been extirpated, and the remaining populations are reduced and declining. The best available scientific evidence is clear that the northern spotted owl is in danger of extinction throughout all or a significant portion of its range.

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The Northern Spotted Owl in California: Current Status and Threats

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Photograph courtesy of Peter Carlson.

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Introduction

This Independent Status Report was prepared pursuant to the California Endangered Species Act's (CESA) implementing regulations, specifically Cal. Code Regs., tit. 14, § 670.1 (h), which allows "interested parties . . . to submit a detailed written scientific report to the commission on the petitioned action." This same regulation explains that parties "may seek independent and competent peer review of this report prior to submission", and the author did so (see acknowledgements section at end of each chapter). Furthermore, to comply with the Fish and Game Code, section 2074.6, this report must be "based upon the best scientific information available."

This report was prepared by Wildlife Ecologist, Dan L. Hansen. His CV is attached, and a brief description of his qualifications is included herein (see *Project Author and Funding*).

This Independent Status Report was commissioned by the Environmental Protection Information Center (EPIC). However, its contents, conclusions, and management recommendations were exclusively developed by the author.

Executive Summary

This synthesis is organized into two parts. Part I consists of a single chapter: Status and Trends in California (Ch. 1). Part II covers four primary potential threats to northern spotted owls (*Strix occidentalis caurina*; NSOs) in California: Timber Harvesting (Ch. 2), Wildfires (Ch. 3), Barred Owls (Ch. 4), and Outdoor Marijuana Cultivation (Ch. 5). Following these chapters, a brief list of management recommendations is provided based on the information reviewed herein.

Chapter 1 is a review of the current status and trends of NSOs in California. Multiple types of information are available for evaluating the subspecies' status and trends in the state, including potential changes in its range, distribution, population densities, occupancy rates, demographic rates, metapopulation dynamics, and genetics. However, the most compelling information comes from long-term demographic studies in northwestern California (Forsman et al. 2011, Higley and Mendia 2013, Franklin et al. 2014, Green Diamond Resource Company 2014). These studies indicate that NSOs are declining in that portion of the state and that the rate of decline is accelerating. Competitive pressure from the congeneric barred owl (*S. varia*) appears to be the primary cause of increasing rates of population decline in the three demographic study areas. Occupancy data further support conclusions that NSOs in California's three demographic study areas are declining at an increasing rate and that the decline is largely driven by negative effects of barred owls (Franklin et al. 2014, Green Diamond Resource Company 2014). Less rigorous information is available for describing the NSO's current status and trends in California outside the state's demographic study areas. Only one published paper described occupancy in the eastern portion of the NSO's range in California (eastern Klamath and southern Cascades) (Farber and Kroll 2012). That paper described a substantial decline in occupancy by NSOs, which was likely associated with intensive timber harvesting and possibly, wildfires. Recent reports from demographic studies in southern Oregon further suggest that NSOs may be declining in relatively nearby and ecologically similar areas in California (eastern Klamath and southern Cascades) (Davis et al. 2013b, Dugger et al. 2014). Most of the other information for describing the subspecies' status and trends in California comes from monitoring reports by National Parks and industrial timber companies. NSOs appear to have been mostly displaced by barred owls in the Redwood National and State Parks (Schmidt 2013). In contrast, few barred owls have invaded National Park land in Marin County and occupancy by NSOs appears to be relatively stable in the area (Ellis et al. 2013). Industrial timber companies in California have uniformly concluded that NSO populations are stable on their lands (Calforests 2014). However, the available information for those ownerships does not support strong conclusions about the NSO's status or trends and some of the information actually appears to indicate at least gradual declines in occupancy.

Chapter 2 is a review of timber harvesting as a potential threat to NSOs in California. Habitat loss to timber harvesting was a primary impetus for listing the NSO under the federal Endangered Species Act (USFWS 1990). An estimated 60-88% of old forest was harvested within the NSO's range during the 19th and 20th centuries (USFWS 1990, Strittholt et al. 2006). Following federal listing of the NSO and adoption of the Northwest Forest Plan in the early 1990s, timber harvesting was dramatically curtailed on federal lands (Healey et al. 2008, Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012). However, there is currently considerable interest among some ecologists, land managers, and agencies in use of widespread

forest thinning to reduce the risk of large severe wildfires on public lands (USFS and BLM 1994, USFWS 2008, 2011, 2012a, Franklin and Johnson 2012). The term thinning can encompass a wide array of silvicultural practices and prescriptions but the limited available evidence suggests that NSOs and their primary prey in California generally respond negatively to thinning and partial harvesting (see Ch. 2). Timber harvesting is still responsible for most habitat loss and degradation for NSOs on private lands (Davis and Dugger 2011). Habitat loss and degradation on private lands does not appear to be offset by habitat recruitment; even in California, which has more stringent habitat protection measures on private lands than do Oregon and Washington (Davis and Dugger 2011, Moeur et al. 2011). Although timber harvesting is generally accepted to have been the primary cause of the NSO's initial decline and federal listing, its effects on the subspecies are poorly known. Several rigorous studies in the southern part of the NSO's range, including in northwestern California, have found that the NSO's fitness (a function of survival and reproduction) is typically highest in landscapes with both a core concentration of mature and old forest and some degree of habitat heterogeneity (e.g., a moderate amount of habitat edge due to convoluted shapes of older forest patches) (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005, Schilling et al. 2013). Timber harvesting that substantially reduces either of these habitat attributes could negatively affect NSOs (USFWS 2009). The U.S. Fish and Wildlife Service (2009) concluded that current habitat retention guidelines for NSOs on industrial timberlands in interior California (CAL FIRE 2014) are inadequate and are not based on a current understanding of the subspecies' ecology.

Chapter 3 is a review of wildfire as a potential threat to NSOs in California. Several studies have investigated responses of NSOs to wildfires but their inferences are limited due to small sample sizes, short time frames, confounding effects of post-fire salvage logging, or pooling of data from all three subspecies. This information is supplemented in Chapter 3 with reviews of studies of effects of fire on California spotted owls (*S. o. occidentalis*) and Mexican spotted owls (*S. o. lucida*). Inferences from those studies are similarly limited by small sample sizes, short time frames, confounding effects of post-fire salvage logging, or pooling of different kinds of fire (prescribed fires, wildfires, and wildfires allowed to burn under specified conditions). Currently available information indicates that spotted owls respond in variable and complex ways to fire. The species appears to be generally resilient to low-, moderate-, and mixed-severity or patchy fires (Ch. 3: Table 3.1). It is possible that fires such as these sometimes benefit spotted owls by temporarily increasing access to prey that respond positively to fire (Ream 1981, Zwolak and Foresman 2007, Zwolak 2009, Bond et al. 2013). In contrast, spotted owls appear to generally respond negatively to extensive severe wildfires (Ch. 3: Table 3.1). While some spotted owls may preferentially forage in or near severely burned areas, they rarely nest and roost in such areas and may generally avoid foraging deep within them (Ch. 3: Table 3.1). The limited available information suggests that post-fire salvage logging negatively affects spotted owls (Clark 2007 and Clark et al. 2013, Lee et al. 2012, 2013). Salvage logging could reduce prey availability after fires by removing important structures, such as snags, logs, and shrubs. Habitat suitability modeling projected that wildfires caused substantial loss, degradation, and fragmentation of nesting and roosting habitat for NSOs on federal lands during the first 15 years of the Northwest Forest Plan (Davis and Dugger 2011). Most of these habitat changes were caused by a small number of extensive severe fires in southern Oregon and northern California. There is scientific debate regarding recent versus historical frequencies of high severity fire in southern Oregon and northern California (e.g., Hanson et al. 2009, 2010 vs. Spies et al. 2010).

Nonetheless, it is clear that large wildfires are now relatively common within the NSO's range in California (CAL FIRE 2008, Davis et al. 2011), and that some recent wildfires have severely burned very large areas (e.g., 2002 Biscuit Fire). Climate change research generally projects that large wildfires will become more common in California (Westerling et al. 2006, Lenihan et al. 2008, Westerling and Bryant 2008, Littell et al. 2009, Moritz et al. 2012, Stavros et al. 2014). It is reasonable to assume that some of these large wildfires will include extensive areas of high-severity fire and will therefore continue to be a source of habitat loss for NSOs.

Chapter 4 contains an evaluation of the barred owl as a potential threat to NSOs in California. The available information suggests that barred owls are currently the primary threat to NSOs throughout their range, including in California. Information from long-term demographic studies indicates that barred owls have contributed to the NSO's population declines in multiple study areas (Forsman et al. 2011) and that the barred owl's presence and negative impacts on NSOs are continuing to increase (Davis et al. 2013b, Higley and Mendia 2013, Franklin et al. 2014, Dugger et al. 2014). A large body of research conducted across much of the NSO's range has also shown that barred owls are associated with declines in occupancy rates by NSOs (Kelly 2001, Kelly et al. 2003, Pearson and Livezey 2003, Gremel 2005, Olson et al. 2005, Kroll et al. 2010, Dugger et al. 2011, Higley and Mendia 2013, Franklin et al. 2014, Green Diamond Resource Company 2014). Barred owls negatively affect NSOs by competing for space, habitat, and food (Gutiérrez et al. 2004, 2007, USFWS 2013, Wiens et al. 2014). The barred owl appears to be a superior competitor to the NSO due to its larger size, more aggressive behavior, higher reproductive potential, higher population densities, and broader ecological niche (e.g., USFWS 2013, Wiens et al. 2014). The available information suggests that lethal control of barred owls is a viable management option for some areas, although there is ethical and emotional resistance to this within some segments of society (Diller et al. 2013, Higley 2014). The negative effects of habitat loss and fragmentation on NSOs can be exacerbated by the presence of barred owls (Dugger et al. 2011). Thus, the barred owl threat magnifies the importance of habitat conservation for NSOs, rather than reducing it.

Chapter 5 is a review of outdoor marijuana cultivation as an emerging potential threat to NSOs in California. Marijuana is one of California's largest cash crops (Gettman 2006) but little is known about the environmental effects of its cultivation. Recent research in northwestern California has shown that both fishers (*Pekania pennanti*) and barred owls are regularly exposed to anti-coagulant rodenticides used to protect marijuana plants from rodents (Gabriel et al. 2012, 2014). Multiple fishers are known to have died due to poisoning from anti-coagulant rodenticides (Gabriel et al. 2012, 2013). Fishers and barred owls have overlapping distributions, habitat associations, and diets with NSOs so it is likely that many NSOs in California are likewise exposed to these toxicants. This was supported by recovery of a dead NSO in Mendocino County, which tested positive for exposure to anti-coagulant rodenticides (Calforests 2014). Marijuana cultivation could also negatively affect NSOs through habitat changes caused by illegal and poorly planned logging, road construction, pollution, and water diversion (Gabriel et al. 2013, Bauer et al. 2015). Marijuana cultivation can particularly impact riparian areas. These impacts could indirectly affect NSOs, which often show a preference for nesting, roosting, and foraging in riparian areas (e.g., Hamer et al. 2007, Irwin et al. 2012). Safety concerns about encounters with armed marijuana growers are resulting in reduced conservation research and

monitoring effort and efficiency for NSOs and other sensitive wildlife species in California (Keane et al. 2011, Gabriel et al. 2013, D. Hansen pers. obs.).

Overall, this synthesis supports conclusions that NSOs in California are declining at an increasing rate (Ch. 1) and that they face an array of threats to their persistence (Chs. 2-5). Barred owls appear to pose the greatest current threat to NSOs (Ch. 4). If conservation of NSOs is to remain a priority then widespread barred owl removal programs may be necessary. Habitat protection also remains an important aspect of NSO conservation. Listing under the California Endangered Species Act, substantial changes to the California Forest Practice Rules habitat retention guidelines, and greater involvement by knowledgeable spotted owl biologists in the Timber Harvest Plan review process may be necessary to adequately protect habitat for NSOs on private lands in the state. The available information suggests that large severe wildfires pose a threat to NSOs on federal lands in California (Ch. 3). Some ecologists and land management agencies have proposed widespread use of forest thinning and prescribed fire to reduce this risk. However, the available information also suggests that spotted owls often respond negatively to thinning (Ch. 2). It is important for land managers to consider potential tradeoffs in costs and benefits of thinning in landscapes occupied by NSOs. Thinning could potentially be focused in areas that generally receive the least use by spotted owls and that have the highest fire risk, such as upper and southwesterly slopes (see Ch. 3). The limited information currently available suggests that post-fire salvage logging negatively affects NSOs and their prey (Ch. 2). Further research of this topic is needed but this practice does not appear to be generally concordant with conservation of NSOs in California. Marijuana cultivation appears to pose a substantial emerging threat to NSOs in California; particularly trespass operations on federal lands (Ch. 5). Increased research, law enforcement, and site cleanup and restoration efforts are likely needed to protect NSOs from negative effects of outdoor marijuana cultivation in California.

Methods

The northern spotted owl (*Strix occidentalis caurina*; NSO) has been a focus of conservation concern and research for more than three decades (see reviews in Courtney et al. 2004 and USFWS 2011a). Although substantial habitat protection measures exist for NSOs on federal lands, the subspecies has continued to decline across much of its range (Forsman et al. 2011). Indeed, the U.S. Fish and Wildlife Service (2015) recently concluded that uplisting the NSO from 'threatened' to 'endangered' under the federal Endangered Species Act may be warranted. The California Fish and Game Commission will soon decide whether or not to list the NSO under the California Endangered Species Act. The large body of research and monitoring information concerning the NSO can be challenging for natural resource agencies and policymakers to evaluate. In order to inform the California Endangered Species Act listing decision and other policy and management actions, I have endeavored to synthesize much of the available scientific information concerning the NSO's current status, trends, and threats in the state.

While writing this synthesis, I reviewed information from a variety of sources but generally gave greater weight to peer-reviewed publications, particularly those based on more rigorous field and analytical methods. For example, in Chapter 1, I attempted to carefully consider all available information about the NSO's current status and trends in California but gave greatest weight to results of long-term demographic studies. Some topics related to the NSO's ecology and conservation are scientifically and politically contentious; for example, whether wildfire constitutes a threat to the subspecies and, if so, whether or not it should be addressed through active management approaches, such as forest thinning (see Ch. 3). In these situations, or when published information was limited (e.g., regarding effects of forest thinning on NSOs: see Ch. 2), I treated research results as 'case studies' and described each study's methods and findings in more detail than is common in these kinds of reviews. Although this approach could have underweighted peer-reviewed publications, it allowed me to thoroughly search for patterns among numerous studies, draw tentative conclusions based on those patterns, and highlight gaps in available information about the topic. I also felt that it was important to carefully consider all available sources of information, rather than peer-reviewed publications alone, due to the tremendous variation in ecology and management history that exists within the NSO's range in California. For instance, I felt that it was especially important to evaluate timber industry and National Park monitoring data for portions of California outside the area that includes the state's three demographic studies (see Ch. 1: Figure 1.22 or USFWS 2011a Appendix C for California ecoregional boundaries). In all cases, I was transparent about my approach and the strengths and weaknesses of the available information.

Project Author and Funding

Dan Hansen is a freelance wildlife ecologist (see attached CV). He has an M.S. in animal behavior (conservation biology track) from the University of California at Davis and a B.A. in biology (ecology, evolution, and behavior emphasis) from the University of California at Santa Cruz. He has worked as a contractor for the U.S. Fish and Wildlife Service (USFWS) and U.S. Forest Service (USFS) through the Humboldt State University Sponsored Programs Foundation for most of the last decade. During this period, he primarily coordinated, wrote, and edited scientific syntheses aimed at informing public policy and land management decisions. Documents that Dan contributed to include the USFWS revised recovery plan for the northern spotted owl (critical habitat modeling and effects of forest thinning), the USFS conservation assessment for the northern goshawk in California (a peer-reviewed book to be published in 2015), a USFWS peer-reviewed white paper supporting changes to the California Forest Practice Rules habitat retention guidelines for northern spotted owls in interior northern California, and a USFWS 12-month finding on a petition to list two salamander species under the Endangered Species Act. In addition to working as a technical coordinator, writer, and editor, Dan has worked in the field researching or monitoring spotted owls, golden eagles, bald eagles, peregrine falcons, northern goshawks, carnivores, small mammals, marine mammals, and other wildlife. Prior to working at Humboldt State University, Dan co-managed a large study of California spotted owls in the northern Sierra Nevada.

This document was funded by the Environmental Protection Information Center (EPIC), a non-profit organization focused on environmental issues in northwestern California. EPIC filed a petition with the California Fish and Game Commission in September 2012 to list the northern spotted owl as 'threatened' or 'endangered' pursuant to the California Endangered Species Act. Although EPIC funded the following synthesis, they provided minimal feedback during its writing and were supportive of Dan's goal of producing an unbiased, peer-reviewed synthesis concerning the northern spotted owl's current status and threats in California. All conclusions and management recommendations in this synthesis are the author's alone and do not necessarily reflect those of EPIC or any of the document's reviewers.

Part I, Ch. 1: Status and Trends in California

Introduction

Several lines of evidence are available for evaluating the northern spotted owl's (*Strix occidentalis caurina*; NSO) status and trends in California. These include changes in the subspecies' geographic range and distribution, density and abundance, occupancy and demographic rates, meta-population dynamics, and genetics. The most reliable information available for examining the NSO's status and trends is provided by long-term demographic studies. Data from these studies are periodically analyzed together in meta-analyses for describing larger demographic patterns within ecoregions and rangewide. A new demographic meta-analysis is expected to be released later this year. This document will provide the best available information for determining the NSO's current status and trends. However, only a small portion of the NSO's range in California occurs within demographic study areas and those study areas all occur in relatively productive forests in the northwestern part of the state. It is therefore important to consider other sources of information, such as data collected for monitoring NSOs in National Parks and on industrial timber company lands and results of demographic studies in areas that ecologically resemble portions of interior northern California. The NSO's status and trends likely vary among regions, forest types, and ownerships and could be influenced by a host of factors, such as differences in forest ecology, management history, and stressors such as competition with invasive barred owls (*Strix varia*). It is also important to remember that available sources of information for evaluating the NSO's status and trends in California vary substantially in terms of their purpose and scientific rigor.

Range

The current range of the NSO includes southwestern British Columbia and the Cascade Mountains, coastal ranges, and intervening forests of Washington, Oregon, and California (USFWS 2011a). In California, the NSO's range extends from the Oregon border through the Northern Coast Ranges to Marin County, across the Klamath Mountains, and down the southern Cascades to the vicinity of the Pit River, where it contacts the range of the California spotted owl (*S. o. occidentalis*) (Figure 1.1).

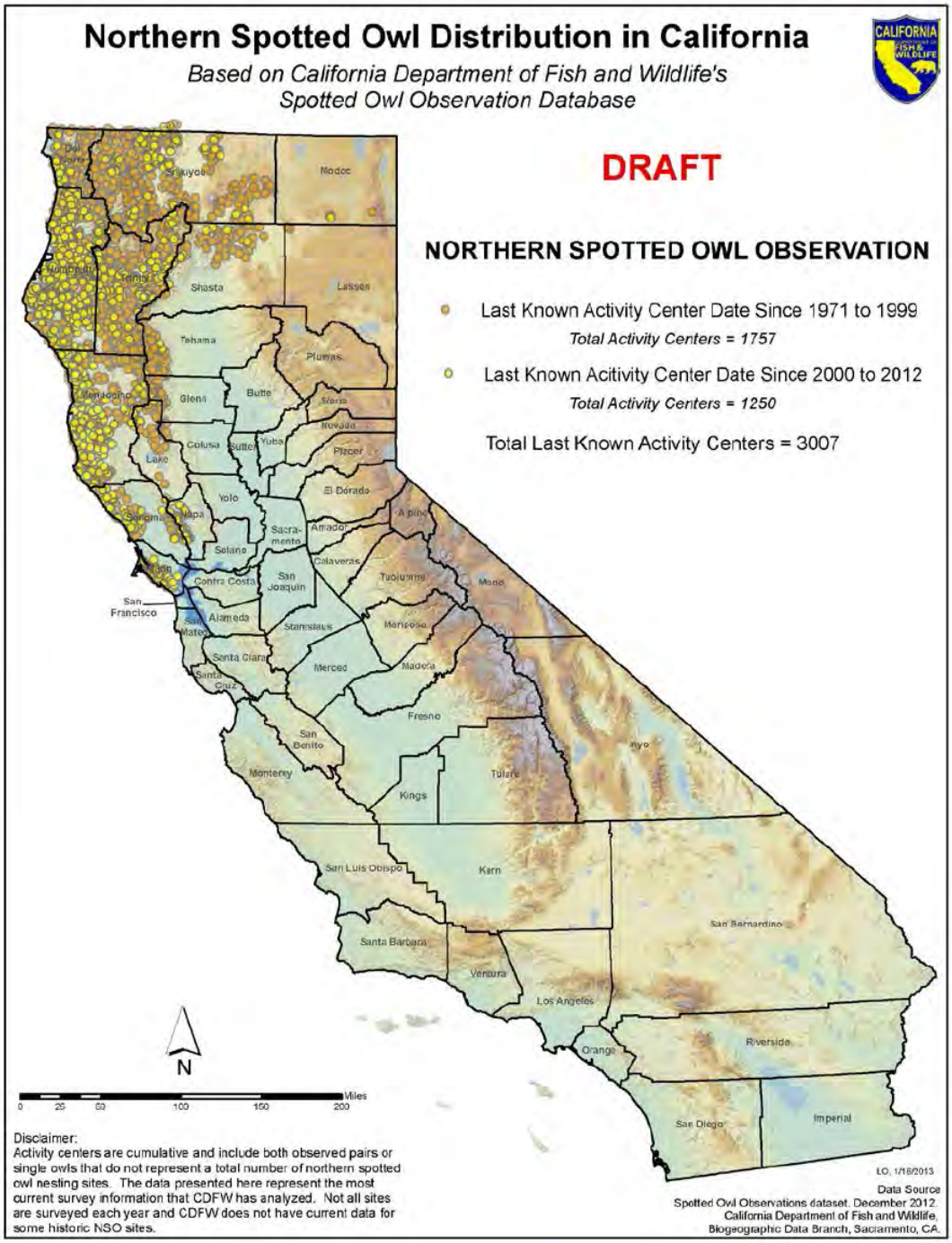
The precise historical range of the NSO is unknown. Thus, despite substantial loss, degradation, and fragmentation of NSO habitat (see Ch. 2 and 3), there is no evidence that the subspecies' range has contracted since Euro-American settlement (Thomas et al. 1990). However, British Columbia's NSO population has declined to very low numbers and is highly vulnerable to extirpation (Chutter et al. 2004). NSO populations in the Cascades and Olympic Peninsula of Washington and the Northern Coast Range of Oregon are also rapidly declining and may become vulnerable to extirpation (Forsman et al. 2011; see *Demography*, below). Loss of NSO populations could cause substantial contraction of the subspecies' range. For example, extirpation of NSOs from British Columbia alone would reduce the subspecies' range by approximately 8% (Cooper 2006).

Distribution

NSOs are thought to have been well distributed throughout most coniferous forests in the Pacific Northwest and northwestern California prior to Euro-American settlement (USFWS 2011a). The abundance and distribution of NSOs have likely declined due to removal of most (ca. 60-88%) old forest within its range (USFWS 1990; see Ch. 2). For example, the Puget Trough in Washington and the Willamette Valley in Oregon no longer support NSOs due to land conversion and timber harvesting and very few NSOs remain in British Columbia (Thomas et al. 1990, Courtney et al. 2004). The NSO's distribution has decreased in other areas of Washington and Oregon as well, due primarily to negative effects of timber harvesting, wildfires, and competition with barred owls (*Strix varia*) (Thomas et al. 1990, USFWS 2011a; see Ch. 2-4).

It is unknown if the NSO's distribution has changed in California. A difference is evident in the distribution of known historically (1971-1999) and recently (2000-2012) occupied activity centers (ACs) in the Eastern Klamath, Interior Northern Coast Ranges, and Southern Cascades regions of the state (Figure 1.1; see Figure 1.22 [left side] and USFWS 2011a Appendix C for ecoregional boundaries generally followed in this synthesis). It is unclear from these data, however, whether the distribution of NSOs has in fact decreased in these areas or if the apparent decline in distribution is due to some other factor such as decreased survey effort or reporting of detections. It is also possible that this difference is due to the greater number of years included in the historical period than in the recent period (29 vs. 13 yrs). However, the two periods are similar in length relative to federal listing of the NSO (10 vs. 13 yrs) when survey effort presumably became more intensive and widespread. Some portions of the Klamath, Interior Northern Coast Ranges, and Southern Cascades have experienced widespread intensive timber harvesting or large wildfires, which could have reduced the NSO's distribution (see Ch. 2 and 3). These forms of disturbance, along with competition with invasive barred owls, have likely contributed to declining occupancy by NSOs in some areas of California (see *Occupancy*, below). Nonetheless, the Klamath and Interior Northern Coast Ranges (but not the Southern Cascades) still appear to contain relatively large amounts of well connected suitable habitat and may function as crucial population sources for NSOs (Schumaker et al. 2014; see *Source-Sink Dynamics*, below). It is also possible that the distribution of NSOs has expanded at local or sub-regional levels in some portions of California due to increased distribution or density of suitable forest habitat in the absence of fire (Skinner 1995, Spies et al. 2006).

Figure 1.1: Distribution of northern spotted owl activity centers in the California Department of Fish and Wildlife's Spotted Owl Observation Database (from California Department of Fish and Wildlife 2013).



Density and Abundance

Species are rarely uniformly distributed across their range. Knowledge of variation in the density and abundance of NSOs is of potential conservation value because it can help identify areas where limited conservation resources should be focused. For example, while declines in low-abundance areas may be more likely to cause contraction of a species' range or distribution (see *Range* and *Distribution*, above), declines in high-abundance areas may disproportionately impact the species' probability of long-term persistence; particularly when high-abundance areas function as population sources (Pulliam 1988, Rodríguez 2002, Schumaker et al. 2014; see *Source-Sink Dynamics*, below).

Several studies have estimated either crude densities (owls or occupied territories per unit area) or ecological densities (owls per unit area of specified habitat class[es]) of NSOs in California (Blakesley et al. 2004; Table 1.1). These estimates are interesting in that they appear to reflect geographic variation in the ecology of NSOs (see below). However, they have limited utility for evaluating the NSO's status or trends in California. Available density estimates for the state are largely restricted to relatively mesic areas of northwestern California, which differ ecologically from drier interior forests (e.g., in terms of climate, forest productivity, and prey communities). Inferences from most density estimates are also limited because they are based on empirical counts of unmarked NSOs, which can bias estimates (Franklin et al. 1990, Diller and Thome 1999). Many of the currently available density and occupancy estimates for NSOs in California were provided by timber companies (Tables 1.1 and 1.2). While potentially useful for evaluating effects of management activities on timber company lands, these estimates do not describe population trends. Rigorous evaluation of NSO population trends require long-term statistically valid sampling designs from which estimates of abundance, or population growth rate with confidence intervals, can be repeatedly obtained within the same study area. In contrast, timber companies generally shift their NSO survey areas over time as timber harvest projects are completed in some areas and begun in others.

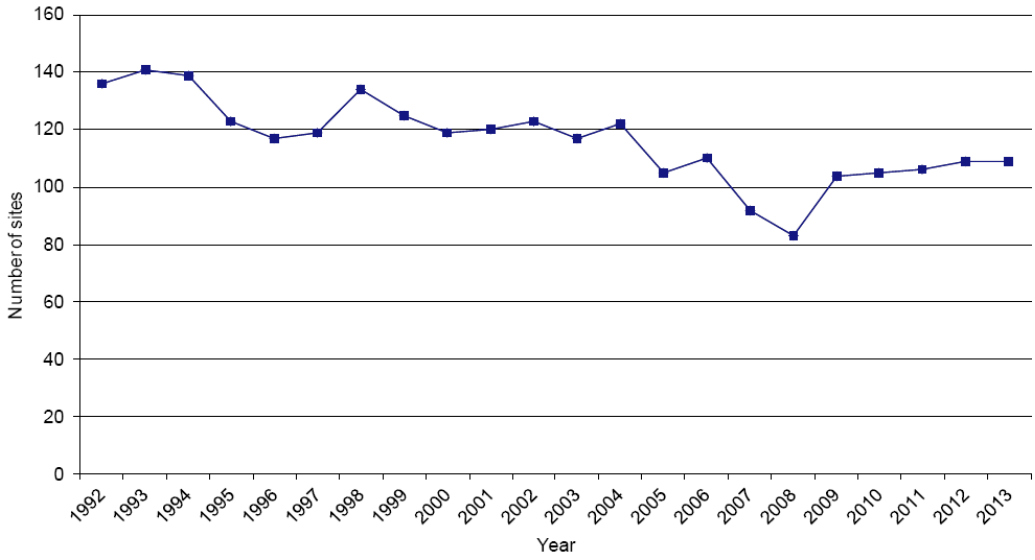
Based on limited information, both crude and ecological densities of NSOs appear to be substantially higher in northwestern California than in the Oregon Coast Ranges (Blakesley et al. 2004; Table 1.1). Lower densities in the Oregon Coast Ranges could be partially related to widespread intensive timber harvesting, which apparently contributed to a major decline in densities during the early 1990s (Thrailkill et al. 1998). Some areas of northwestern California have also experienced widespread intensive timber harvesting (see Ch. 2) but its effect on NSOs might have differed from that in the Oregon Coast Ranges. In general, NSOs in California primarily subsist on dusky-footed woodrats (*Neotoma fuscipes*) (in terms of biomass contribution to diets). NSOs that primarily subsist on dusky-footed woodrat often have smaller home ranges, and apparently occur at higher densities, than those that primarily rely on smaller-bodied prey (Carey et al. 1992, Zabel et al. 1995). Furthermore, in contrast with other primary prey species, such as northern flying squirrels (*Glaucomys sabrinus*) and tree voles (*Arborimus* spp.), dusky-footed woodrats seem to respond positively, albeit temporarily, to some forms of intensive timber harvesting (see Ch. 2).

Densities of NSOs are also thought to be higher in northwestern California than in the state's interior (Calforests 2014). However, there are apparently only two density estimates currently

available for interior northern California and both of these were for crude densities of occupied territories, rather than for individual owls as estimated by most studies in northwestern California (Table 1.1). These crude territory densities are substantially lower than those found on two timber companies' lands in the Redwood Region (Table 1.1). NSO densities may be relatively low in the Southern Cascades of California due to the prevalence of drier, less productive forests, a history of widespread intensive harvesting, and effects of recent large wildfires (see Ch. 2 and 3). Additional density estimates are needed for the Eastern Klamath of California. It is uncertain whether Sierra Pacific Industries' (2013) estimates are representative of densities across the region as a whole. Most ACs included in Sierra Pacific's density estimates were located near the margins of the company's lands or on adjacent ownerships, rather than within the interiors of the company's holdings (see Maps 2-5 in Sierra Pacific Industries 2013, which are copyrighted and cannot be reproduced without permission). This pattern suggests that densities could be higher on neighboring lands, such as the Shasta-Trinity National Forest, which have generally experienced less intensive management.

The California Forestry Association cited annual density estimates in timber company monitoring reports as evidence of stable or increasing NSO populations on private timberlands in the state (Calforests 2014). Reported crude densities on Humboldt Redwood Company, Mendocino Redwood Company, and The Conservation Fund lands in the Redwood Region were indeed relatively similar among years (Calforests 2014). However, it is unclear how changing survey methods and survey areas, as well as changing detectability of NSOs, influenced these companies' estimates over time (see Franklin et al. 1990). For example, recent adoption of survey protocols requiring more survey passes and use of electronic callers likely increased detection rates, and thus density estimates, on some of these lands. Estimates of crude densities of NSOs and numbers of ACs on Green Diamond Resource Company lands in the Redwood Region suggest that NSO densities have declined on that ownership (Figure 1.2; Table 1.1). The number of NSO ACs on Green Diamond lands briefly increased in 1998, apparently due to the company's acquisition of 70,000 acres of timberland that year (Green Diamond Resource Company 2014). Following a substantial decline during 2004-2008, the number of ACs began to gradually increase in 2009 (Figure 1.2). This increase appears to have been due to the company's adoption of a more rigorous survey protocol and implementation of a barred owl removal experiment during that same year (Green Diamond Resource Company 2014; see Ch. 4). Sierra Pacific Industries' (2013) density trends for its ownerships in the Eastern Klamath are difficult to evaluate and are therefore not included here. Sierra Pacific Industries' (2013) estimates are empirical, potentially influenced by changing survey effort and areas, mostly descriptive of ACs at the margin of or outside the company's ownership, and were compared among blocks of years, rather than annually.

Figure 1.2: Number of NSO activity centers ("sites") on Green Diamond Resource Co. lands during 1992-2013 (from Green Diamond Resource Co. 2014).



Rigorous ecological density estimates can be used to estimate population sizes for ecologically similar areas (Franklin et al. 1990). However, there are currently insufficient data for producing such an estimate for California or any of its regions. The California Forestry Association estimated that as many as 6,000 NSO territories currently exist in the state (Calforests 2014). This figure was based on an estimated statewide crude density of 0.28 territories per mile^2. This density estimate was, in turn, based on the cumulative number of known NSO ACs in California (see *Distribution*, above) and the proportion of "potential" habitat in the state that has been surveyed. The number of ACs known to have been recently occupied is substantially lower than the cumulative number that have been identified since the early 1970s (USFWS 2011a; see *Distribution*, above). This could be due to multiple factors, including declining occupancy rates (see *Occupancy*, below) and NSOs' use of different ACs over time. Thus, the timber industry's estimate provides little or no insight into the current number of NSOs or occupied ACs in the state. Furthermore, while reasonable projections of suitable habitat exist for NSOs in California (Davis and Dugger 2011, USFWS 2011a Appendix C, Schumaker et al. 2014), the California Forestry Association did not cite these data and it is unclear how it estimated the total and surveyed areas of suitable habitat in the state.

Table 1.1: Density estimates for NSOs in California and Oregon.

Study	Region	Owner	Method	Crude Density (owls/ mi²)*	Crude Density (occupied territories/ mi²)*	Ecological Density (owls/ mi²)**†
Diller and Thome 1999	N Redwood	Green Diamond	Mark-Recapture	0.54 (0.24-0.91)		0.97-2.72
Green Diamond Resource Co. 2014	N Redwood	Green Diamond	Empirical (marked)	0.34 (0.12-0.53)		
Tanner and Gutierrez 1995 cited in Diller and Thome 1999	N Redwood	Redwood National Park	Empirical	0.57		
Humboldt Redwood Co. 2013	N Redwood	Humboldt Redwood	Empirical	0.53-1.01	0.36-0.50	
Mendocino Redwood Co. 2014	N Redwood	Mendocino Redwood	Empirical	0.47-.077		
The Conservation Fund unpubl. data in Calforests 2014	N Redwood	The Conservation Fund	Empirical		0.29-.036	
Chow 2001	S Redwood	Public (Various)	Empirical	0.97		2.09
Franklin et al. 1990	W Klamath	Six Rivers National Forest, Other	Mark-Recapture	0.61		1.41-1.71
Sierra Pacific Industries 2013	E Klamath	Sierra Pacific Industries	Empirical		0.17-0.18	
Woodbridge and Cheyne 1995	So Cascades	Klamath National Forest	Empirical		0.05-0.20	
Thrailkill et al. 1998	OR Coast Ranges	Bureau of Land Management	Empirical	0.07-0.25		0.57-0.90
Anthony et al. 2000 cited in Blakesley et al. 2004	OR Coast Ranges	Oregon Dept. of Forestry	Empirical	0.13-0.27		

*Ranges = low-high survey areas (Woodbridge and Cheyn 1995, Thraillkill et al. 1998, Diller and Thome 1999, Anthony et al. 2000, Green Diamond Resource Co. 2014), low-high survey years (Humboldt Redwood Co. 2013, Mendocino Redwood Co. 2014). **Habitat definitions used to calculate ecological densities: Franklin et al. 1990: all conifer cover classes weighted by NSO use (based on telemetry), but mostly ≥20.6 in DBH; Diller and Thome 1999: all forest classes weighted by NSO use (based on nest locations) but mostly >40 yrs; Chow 2001: all forested area; Thrailkill et al. 1998: old, mature, old over young, mature over young. †Ranges of ecological densities: Franklin et al. 1990: with two different habitat definitions; Diller and Thome 1999: low-high survey areas.

Occupancy

NSO population trends are most directly evaluated with demographic data (see *Demography*, below). However, occupancy data are often more logistically and economically feasible to collect than demographic data and, with proper accounting of detection probability, can provide a useful index of spotted owl population rates (MacKenzie 2005, Olson et al. 2005, Mackenzie et al. 2012, Tempel 2014). Occupancy data that inadequately incorporate detection probabilities for spotted owls must be interpreted carefully since they can be strongly influenced by survey effort, habitat attributes, social and reproductive status of NSOs, presence of barred owls, and other factors (Mackenzie 2005, Olson et al. 2005). Recent research in NSO demographic study

areas suggests that competition with barred owls is driving NSOs to move large distances (several miles) between different territories within the same season (Davis et al. 2013, Higley and Mendia 2013). Higley and Mendia (2013) warned that occupancy estimates for unmarked populations may therefore be inflated (i.e., the same individual could appear to occupy multiple territories within the same season) and suggested using the presence of pairs, rather than individuals, to determine occupancy.

There is limited information available for describing occupancy trends for NSOs in California. Much of the available information is from annual monitoring reports provided by industrial timber companies (Table 1.2). These data show trends in annual proportions of known, surveyed, or previous year's ACs found to be occupied (see Table 1.2 footnote). It is important to acknowledge that much of the data presented in Table 1.2 provide only crude indices of occupancy in California and that most of them cannot be compared among ownerships due to differences in monitoring and analytical methods. Future efforts to evaluate the status of NSOs in California would benefit from greater consistency in occupancy monitoring and from reporting of modeled occupancy rates, which account for detectability of NSOs and other factors that can obscure occupancy trends (e.g., Figure 1.5).

Recent occupancy estimates are unavailable for the Redwood National and State Parks in the northern portion of the Redwood Region. The National Park Service has discontinued surveying most historical territories in these parks due to apparent widespread displacement of NSOs by barred owls (Schmidt 2013; see Ch. 4). In contrast with an apparently strong decline in occupancy in the Redwood National and State Parks, NSO occupancy rates on National Park Service lands in the southern portion of the Redwood Region have fluctuated annually but suggest a stable trend over time (Ellis et al. 2013; Table 1.2; Figure 1.3). Perhaps due to the area's geographic isolation, barred owls are still relatively uncommon the southern Redwood Region (Ellis et al. 2013; see Ch. 4). Occupancy by NSOs appears to be gradually declining on industrial timberlands in the northern Redwood Region (Table 1.2; Figures 1.2, 1.4, 1.5, and 1.7). Given the substantial and increasing presence of barred owls in NSO territories on these lands (see Ch. 4), it is surprising that more dramatic declines in NSO occupancy are not evident (e.g., see Table 1.2 for occupancy rates in Washington and Oregon). It is possible that NSOs respond differently to barred owls on these lands than elsewhere within their range. It is also possible that a more rapid decline is currently occurring than is indicated by the crude data presented in these companies' reports. Yet another possibility is that a more rapid decline will occur on these lands after a post-colonization lag period has elapsed or a critical threshold level of barred owl presence is reached (USFWS 2013).

NSO occupancy in the Northwestern California demographic study in the Western Klamath Region has declined dramatically in recent years (Franklin et al. 2013, 2014; Table 1.2). This decline has coincided with increasing barred owl presence in the study area, suggesting that NSOs are being displaced by barred owls (see Ch. 4). The recently increased rate of declining occupancy by NSOs in this study area appears to support the hypothesis that barred owls can have lag or threshold effects on NSO populations. Recent declines in occupancy in the Northwestern California study area may also be related to effects of multiple consecutive years of poor weather conditions on demographic rates (see *Demography*, below). Recent annual reports from the Hoopa demographic study did not include analyses of occupancy data for NSOs

(Higley and Mendia 2012, 2013). However, unmodeled occupancy rates in 2012 and 2013 were low (0.40 and 0.35, respectively). Low occupancy rates on the Hoopa Reservation may be related to substantial declines in numbers of NSOs, likely due to decreasing demographic rates (see *Demography*, below) and increasing numbers of NSO territories with barred owl detections (see Ch. 4). Greater declines in numbers of NSOs and increases in NSO territories with barred owl detections beginning in 2005 provide additional support for the hypothesis that barred owls have lag or threshold effects on NSOs.

There is currently no clear pattern in occupancy data available for the Eastern Klamath and Southern Cascades of California. Timber companies in those regions have reported evidence of stable occupancy rates (Sierra Pacific Industries 2013, Michigan-California Timber Company 2014; Figure 1.6; note: Sierra Pacific's estimates are not provided in Table 1.2 for reasons discussed in *Density and Abundance*, above). However, more rigorous, published research conducted primarily on industrial timberlands in the Eastern Klamath and Southern Cascades found substantial declines in both simple (total) and pair occupancy (Farber and Kroll 2012; Figure 1.7). The barred owl invasion appears to still be in the early colonization phase in the Eastern Klamath, where this study was primarily conducted (Farber and Kroll 2012; see Ch. 4). Thus, declining occupancy during the study was likely caused by some other factor, such as timber harvesting on the industrial timberlands that comprised much of the study area or wildfires on neighboring public lands (see Ch. 2 and 3). Research in other areas of the NSO's range indicates that occupancy can be negatively affected by habitat loss and fragmentation (Dugger et al. 2011, Sovern et al. 2014).

Table 1.2: Estimates and indices of occupancy by northern spotted owls in California, Oregon, and Washington.

Study	Region	Owner	Years	Number of Sites	Proportion Occupied (Total)	Proportion Occupied (Pairs)	Modeled Occupancy (Total)	Modeled Occupancy (Pairs)	Apparent Trend
Mendocino Redwood Company 2013	N Redwood	Private	2001-2013 (proportion); 2001-2008 (modeled)		0.75 - 0.69*		0.88 - 0.78*†		Declining (weak)
Humboldt Redwood Company 2014	N Redwood	Private	2003-2013		0.81 - 0.63*†				Declining (weak)
Green Diamond Resource Company 2014	N Redwood	Private	1999-2013 (no. sites); 2009-2013 (occupancy)	135 - 108*†	0.88 - 0.83*‡				Declining (weak)
Ellis et al. 2013	S Redwood	NPS	1999-2012		0.86 - 0.94*	0.72 - 0.87*			Stable
Franklin et al. 2002, 2003, 2010-2014	W Klamath	USFS, BLM, Private	2001-2013		0.67 - 0.37*	0.59 - 0.28*			Declining (strong)
Farber and Kroll 2012	E Klamath, S Cascades	Private, USFS	1995-2009				0.81 - 0.50*	0.75 - 0.46*	Declining (strong)
Michigan-California Timber Company 2014	E Klamath, S Cascades	Private	2000-2013		0.35 - 0.52 (2001-2013: 0.66 - 0.52)*†				Stable
Davis et al. 2013a	OR Klamath	BLM, State, Private	2001-2013		0.86 - 0.49*	0.62 - 0.30*			Declining (strong)
Dugger et al. 2011	OR S Cascades	USFS	1991/1992-2006				w/o barred owls: 0.86 - 0.71*†; w/ barred owls: 0.87 - 0.11*†		Declining (strong)
Kroll et al. 2010	WA E Cascades	NPS, USFS, Private	1990/1-2003				w/o barred owls: 0.83 - 0.64*†; w/ barred owls: 0.73 - 0.30*†	w/o barred owls: 074 - 0.36*†	Declining (strong)

*Start and end values. †Estimated from graph. ‡Occupancy of previous year's sites.

Figure 1.3: Occupancy status at monitored northern spotted activity centers on National Park Service lands in Marin County, California during 1999-2012 (from Ellis et al. 2013).

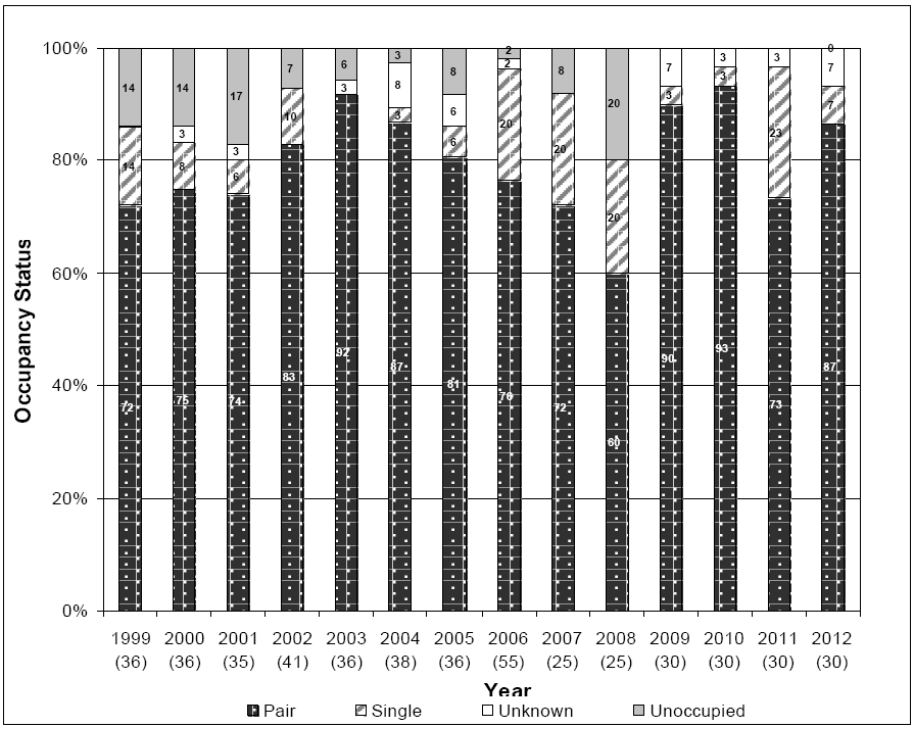


Figure 1.4: Annual numbers of known and occupied northern spotted owl activity sites (activity centers) on Humboldt Redwood Company lands during 2003-2013 (from Humboldt Redwood Company 2014).

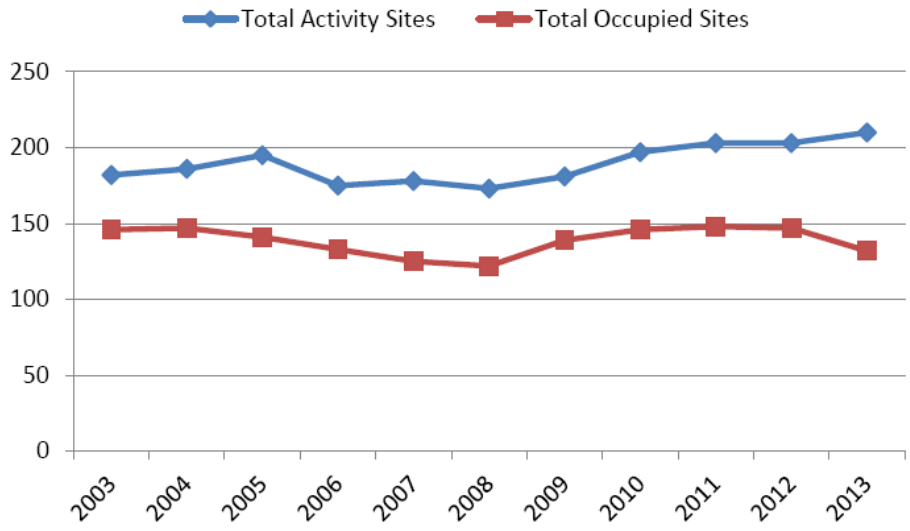


Figure 1.5: Annual proportion of northern spotted owl activity centers occupied (blue line) and modeled occupancy probability (red line) on Mendocino Redwood Company lands (from Mendocino Redwood Company 2013). Note the apparent decline in modeled occupancy compared with the lack of a clear trend in unmodeled occupancy.

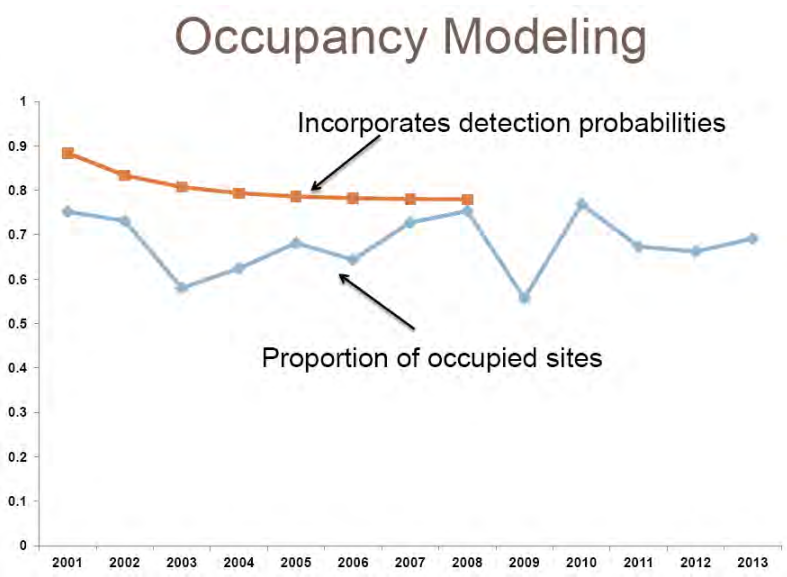


Figure 1.6: Percent of surveyed northern spotted owl sites occupied on Michigan-California Timber Company lands during 2000-2013 (from Michigan-California Timber Company 2014).

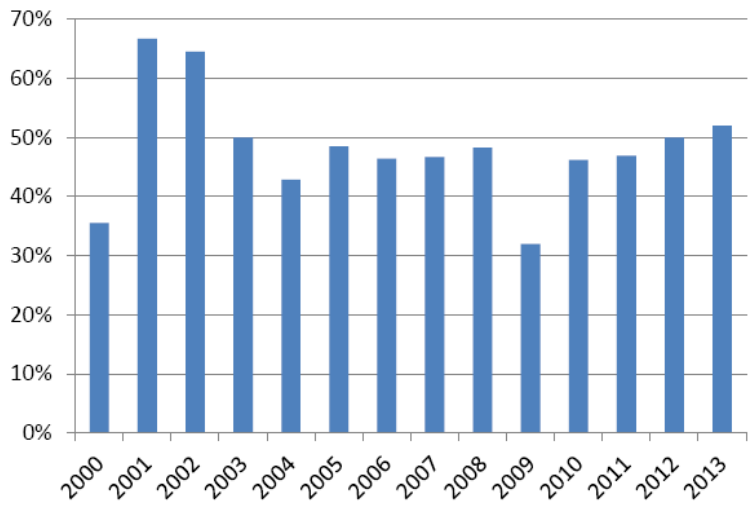
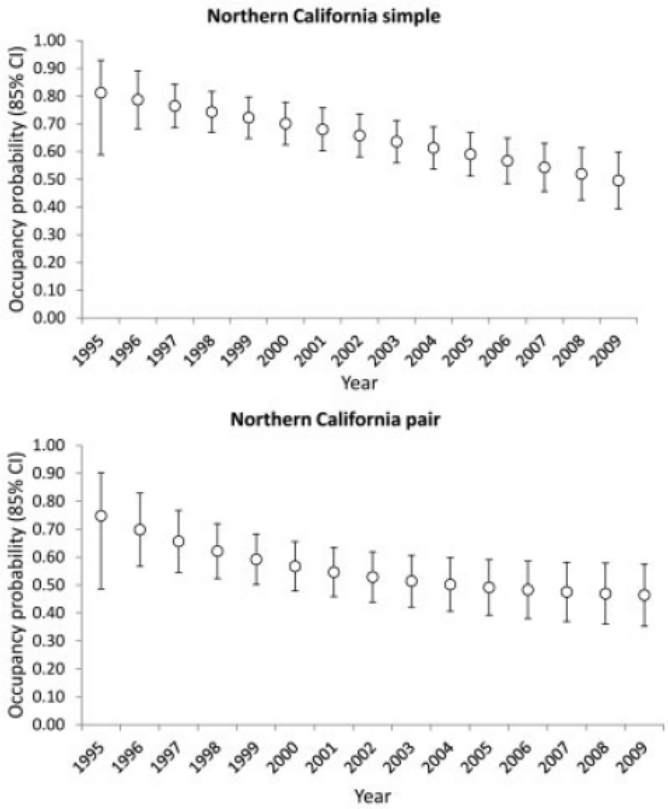


Figure 1.7: Estimated annual simple (total) and pair occupancy probabilities (with 85% confidence intervals) for northern spotted owls in the Eastern Klamath Region of California during 1995-2009 (from Farber and Kroll 2012).



Demography

Reproduction

Reproductive data are commonly collected as part of monitoring efforts for NSOs (e.g., Calforests 2014). They are easier and more cost-effective to obtain than those required for estimating survival or population trends. NSOs exhibit considerable annual fluctuations in reproduction (Forsman et al. 2011, Calforests 2014). Given often large annual fluctuations in reproduction, evaluation of trends in reproduction could require longer-term datasets than are available for many monitoring areas.

The 2011 demographic meta-analysis reported that fecundity of NSOs (number of female fledglings per female) significantly declined during 1985-2008 in four of 11 density study areas, may have declined in three other areas, and was stable in four areas (Forsman et al. 2011). Two of the four study areas with significant declines in fecundity were located in California (Northwestern California in the Western Klamath Region and Green Diamond in the Redwood Region). Two others were located in portions of southwestern Oregon (Klamath and South Cascades) that are nearby and ecologically similar to the Eastern Klamath and Southern Cascades of California (see USFWS 2011a Appendix C, USFWS 2012a, and Figure 1.22 [left side] for regions). Also, the one area in California with stable fecundity (Hoopa) had low fecundity estimates compared to other areas. Together these data, which represent the most

reliable evidence currently available, indicate that NSO reproduction could be declining across much of California and southwestern Oregon.

Annual fluctuations in fecundity were evident in all three demographic studies in California and were remarkably synchronous (Forsman et al. 2011; Figure 1.8). Forsman et al. (2011) found that variation in fecundity was associated with a variety of variables, including the age of breeding females, whether the year was even or odd, weather or climate (e.g., early nesting season temperature or precipitation), percent cover of suitable habitat, and the presence of barred owls. Franklin et al. (2013) noted a pattern of "good" and "bad" reproductive years in the Northwestern California demographic study area, which is likely associated with annual variation in weather during the early nesting season (also see Franklin et al. 2000). Franklin et al. (2013) also observed that particularly poor reproductive years have occurred in their study area at four-year intervals, suggesting that "some other extrinsic factor may be operating, such as seed production governing small mammal populations." Forsman et al. (2011) reported that barred owl presence was in the top models explaining fecundity in the Green Diamond study area, suggesting that competition with barred owls contributed to declining reproduction on that ownership. Reports from the Klamath and South Cascades demographic studies in southern Oregon noted negative associations between reproduction and rainfall during the early nesting season (Davis et al. 2013b, Dugger et al. 2014). Declining reproduction in these study areas also appears to be related to increasing presence of barred owls.

Following publication of the 2011 meta-analysis, California's demographic studies reported three consecutive years (2011-2013) of very low reproduction (Franklin et al. 2013, Higley and Mendia 2013, Green Diamond Resource Company 2014). This dip in reproduction might have been partially driven by high rainfall during the early nesting season during 2010-2012 (see below). Those three consecutive years of low reproduction exacerbated the negative long-term trend that was already occurring on Green Diamond lands (Green Diamond Resource Company 2014; Figure 1.9). Negative trends in reproduction also occurred in the Klamath and South Cascades demographic study areas subsequent to the end of the 2011 meta-analysis study period (Davis et al. 2013b, Dugger et al. 2014; Figures 1.10 and 1.11). Davis et al. (2013b) concluded that particularly poor reproduction during recent years "…may indicate potentially serious problems with maintaining a stable population. This is even more alarming since these results are following a long term downward trend."

Figure 1.8: Mean annual fecundity in California's three northern spotted owl demographic studies during 1985-2008 (from Forsman et al. 2011).

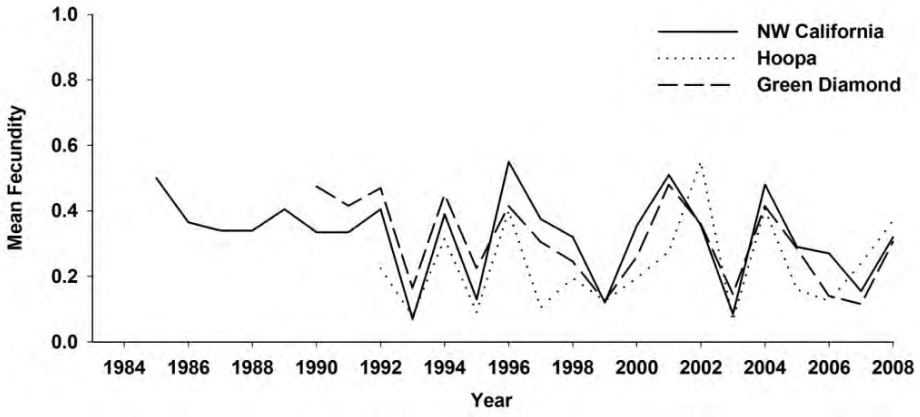


Figure 1.9: Number of fledglings produced per monitored pair of northern spotted owls on Green Diamond Resource Company lands during 1992-2013 (from Green Diamond Resource Company 2014).

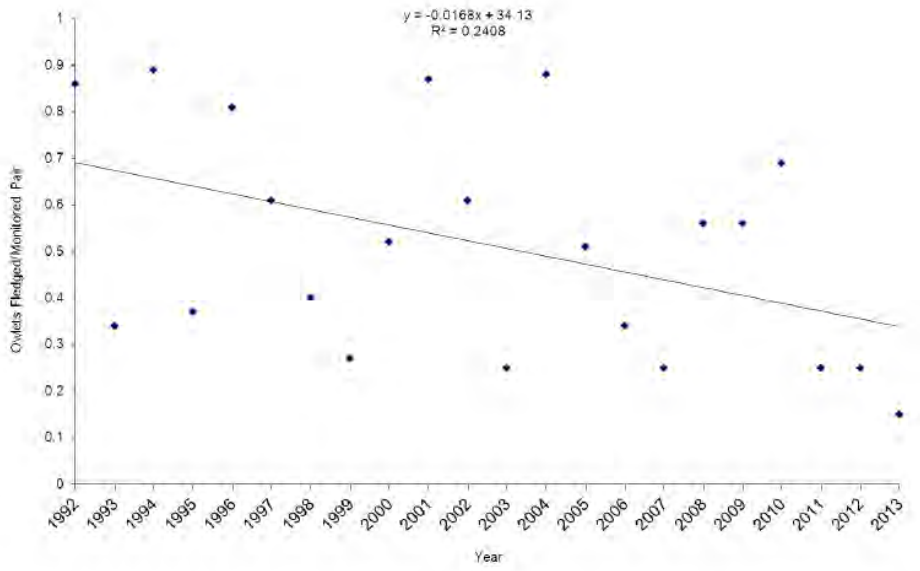


Figure 1.10: Fecundity of northern spotted owls ("STOC") in the Klamath demographic study area during 1990-2013 (from Davis et al. 2013a). Dashed line is a polynomial trend line ($r^2 = 0.419$). Vertical line represents the first year in which barred owls ("STVA") were detected in more than 10% of spotted owl territories.

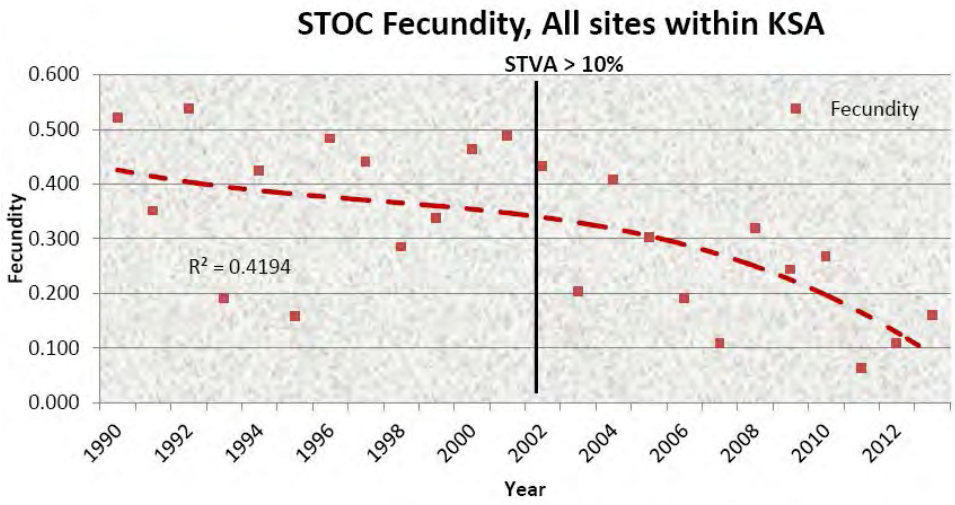
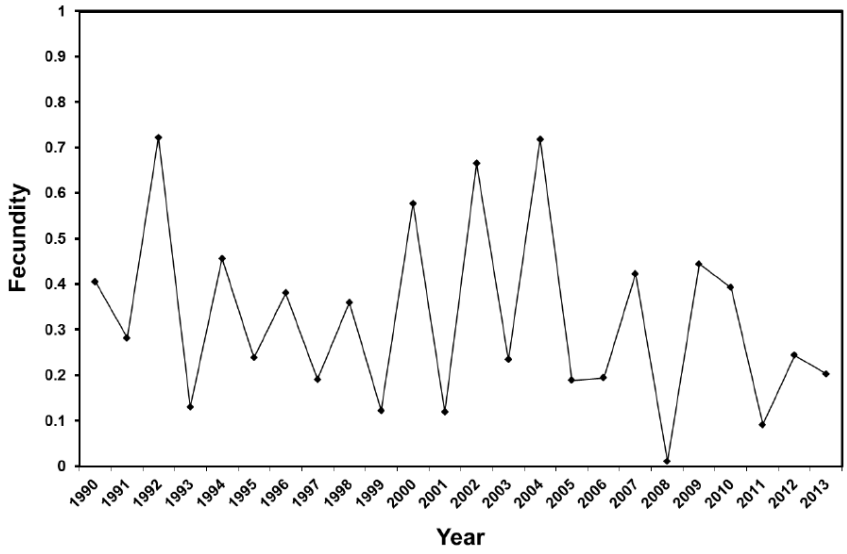


Figure 1.11: Fecundity of northern spotted owls in the South Cascades demographic study area during 1990-2013 (from Dugger et al. 2014).



Information is also available for describing recent trends in NSO reproduction in portions of California outside of demographic study areas. Ellis et al. (2013) found below average fecundity during 2007 and 2010-2012 on National Park Service lands in the southern Redwood Region (Figure 1.12). Humboldt Redwood Company (2013) and Mendocino Redwood Company (2014) likewise reported low reproduction during those years (Figures 1.13 and 1.14). These observations, along with those from demographic studies in California and southern Oregon described above, suggest that low reproduction during recent years was primarily driven by a factor that acted at a very large spatial scale, rather than at the scale of individual ownerships or ecological regions. As noted above, high rainfall during the early

nesting season was likely a primary cause of low reproduction during recent years. This apparent relationship is illustrated by the negative association between NSO reproductive success and early season rainfall observed on Mendocino Redwood Company lands (Figure 1.13).

Monitoring results suggest a stable long-term trend in reproduction on National Park Service lands in the southern Redwood Region (Figure 1.12). In the northern Redwood Region, Humboldt Redwood Company (2013) data likewise suggest little or no trend, although the period covered could be too short to capture long-term trends in reproduction (Figure 1.14). Mendocino Redwood Company (2014) provided a longer-term data set that suggests that a shallow decline in reproduction has occurred on their lands, primarily due to below average reproduction during seven of eight years during 2006-2013 (Figure 1.13). Data provided by the Fruit Grower's Supply Company (2014) suggests that a decline in reproduction occurred on their lands in the Eastern Klamath and Southern Cascades regions of California during 1990-2005 (Figure 1.15). It is important to note, however, that these are only descriptions of apparent trends based on patterns in relatively crude data. A more rigorous analysis of the data is needed to support strong conclusions about reproductive trends on industrial timberlands in California.

Figure 1.12: Fecundity of northern spotted owls on National Park Service lands in Marin County during 1999-2005 and 2007-2012 (from Ellis et al. 2013). The solid line indicates mean fecundity during these periods combined, the dashed lines are one standard deviation from the mean, error bars indicate ±1 standard error, and n is the total number of spotted owl territories.

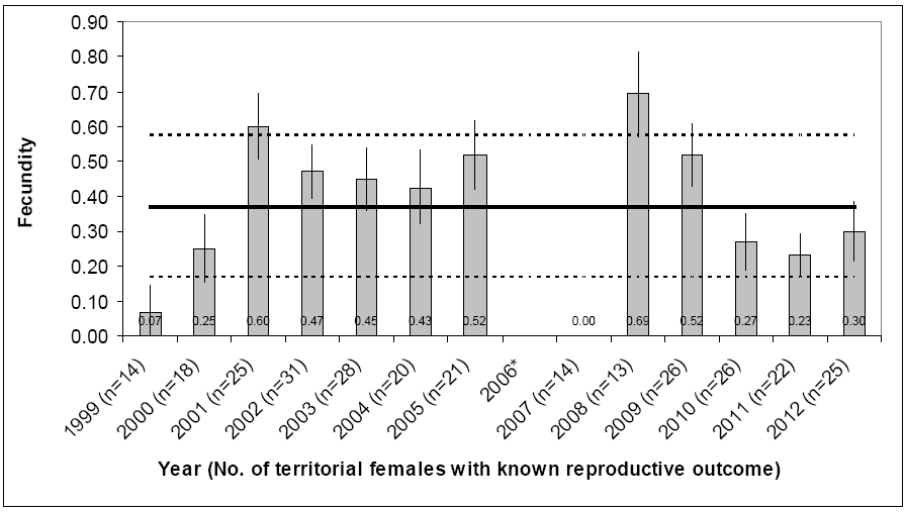


Figure 1.13: Reproductive success (average number of fledglings/pair) of northern spotted owls and amounts of rainfall during the early nesting season on Mendocino Redwood Company lands during 1989-2013 (from Mendocino Redwood Company 2014).

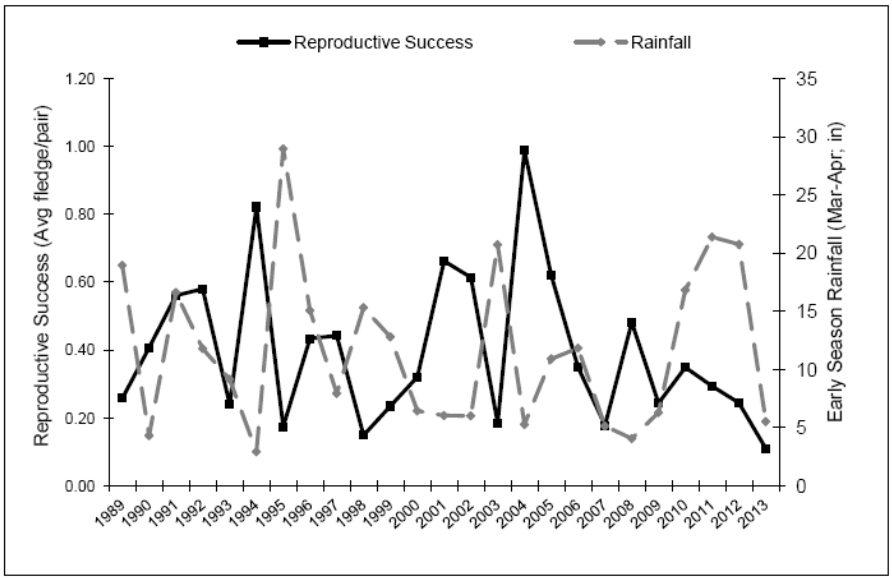


Figure 1.14: Reproductive rate and numbers of nesting pairs and juveniles on Humboldt Redwood Company lands during 2003-2012 (from Humboldt Redwood Company 2013).

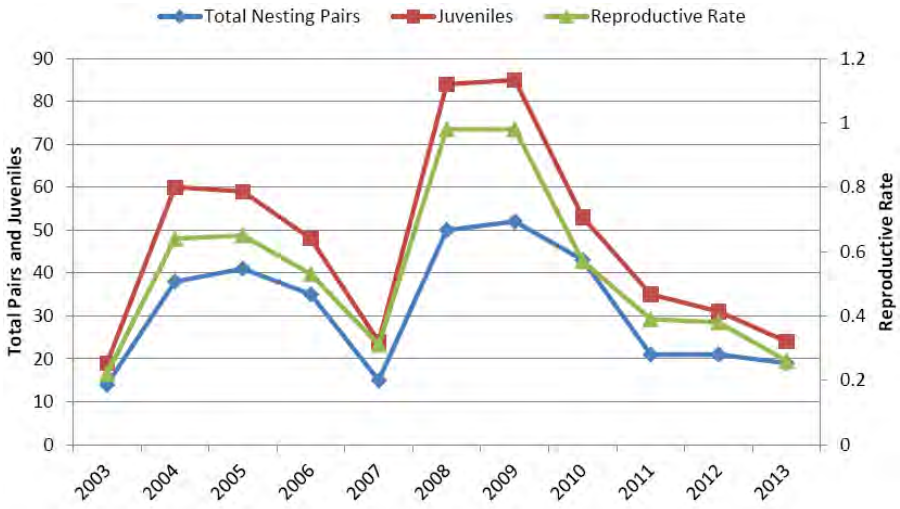
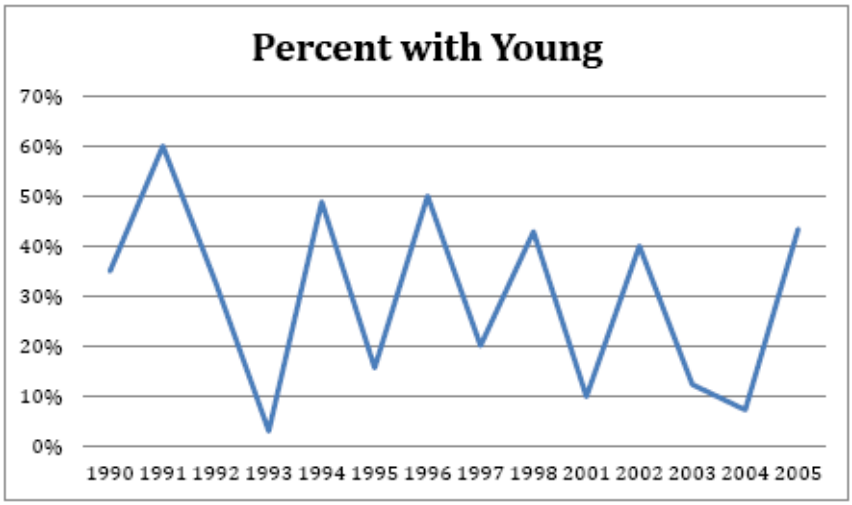


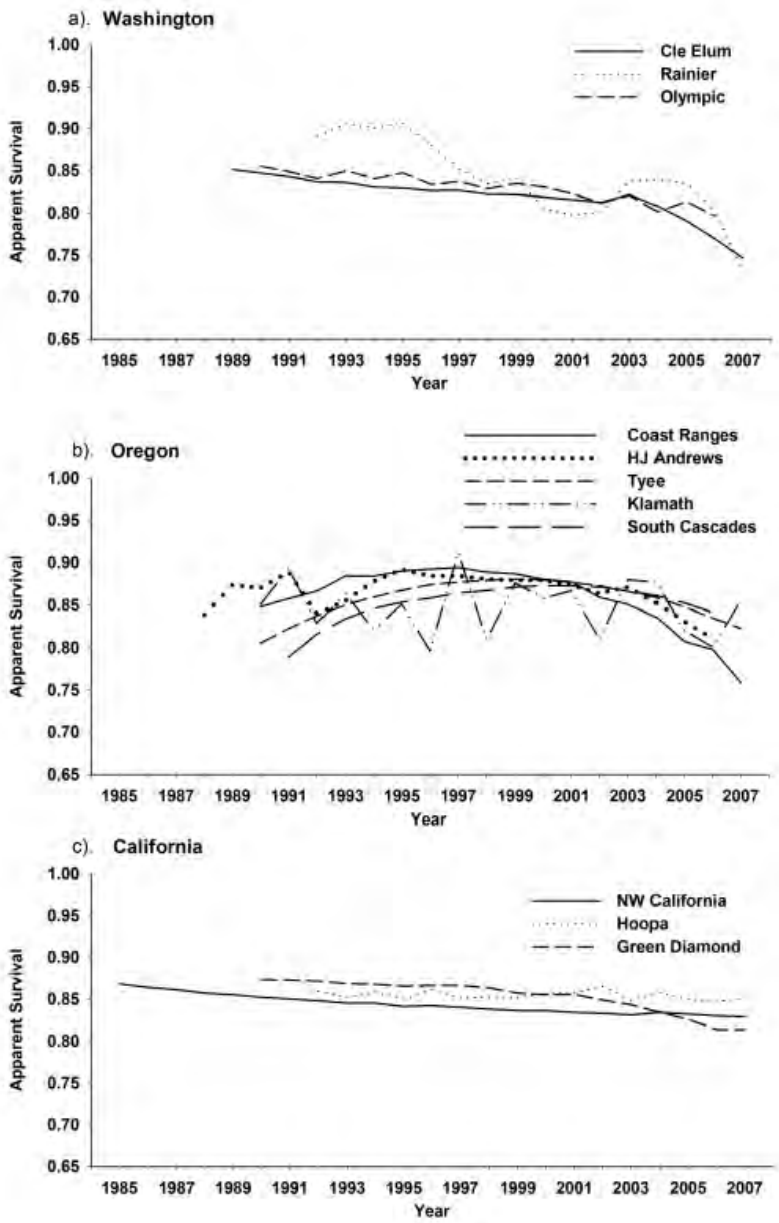
Figure 1.15: Fecundity of northern spotted owls on Fruit Growers Supply Company land during 1990-2005 (from Fruit Growers Supply Company 2014).



Survival

Available information concerning recent survival rates of NSOs is mostly limited to that provided in the 2011 demographic meta-analysis (Forsman et al. 2011). Survival data are not collected by timber companies other than Green Diamond Resource Company, which submits its data for analysis and reporting in the demographic meta-analyses. Forsman et al. (2011) reported statistically significant declines in apparent survival for 10 of 11 NSO demographic study areas, including all three study areas in California (Figure 1.16). Declines in many study areas were most precipitous during the last five years of the study period (i.e., 2003-2007 for survival; Figure 1.16). The Klamath in southern Oregon was the only study area that did not have a significantly declining survival rate through 2007. Forsman et al. (2011) stated that "collectively, the declines in apparent survival of Northern Spotted Owls across much of the subspecies' range are cause for concern because Spotted Owl populations are most sensitive to changes in adult survival rates (Noon and Biles 1990, Lande 1991)."

Figure 1.16: Model averaged estimates of apparent survival of adult female northern spotted owls three study areas in Washington (a), five study areas in Oregon (b), and three study areas in California (c) during 1985-2007 (from Forsman et al. 2011).



NSO demographic studies have largely deferred reporting of more recent survival data to the forthcoming meta-analysis, which is expected to be released in 2015. The limited information available prior to release of that meta-analysis suggests that survival has continued to decline since the 2011 meta-analysis study period. Davis et al. (2013b) reported that subsequent "…data regarding occupancy (in the Klamath study area) has shown a rapid decline, which suggests the stability of the survival rate may no longer be valid." Franklin et al. (2013) reported an alarming drop in apparent survival in 2011 on the Northwestern California demographic study area (Figure 1.17). Their subsequent annual report deferred reporting of 2012-2013 survival data to the forthcoming meta-analysis (Franklin et al. 2014). Higley and Mendia (2013) reported a statistically non-significant decline in survival of NSOs on the Hoopa Valley Indian Reservation in the Western Klamath (Figure 1.18). Their best model explaining survival of NSOs suggested that the decline was at least partially related to increasing numbers of barred owls in the study area.

Figure 1.17: Annual estimates (solid dots with 95% confidence intervals) of, and trend in (solid line), apparent survival for subadult and adult northern spotted owls in northwestern California during 1985-2012 (from Franklin et al. 2013).

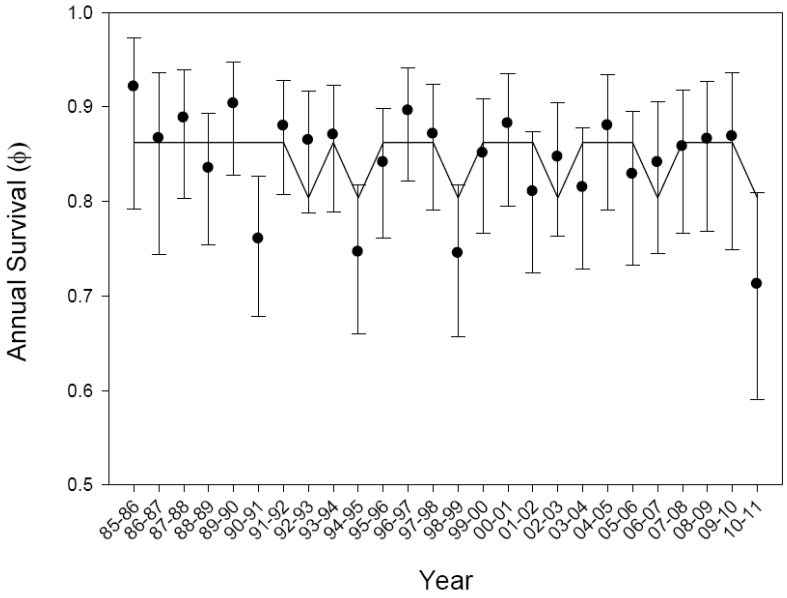
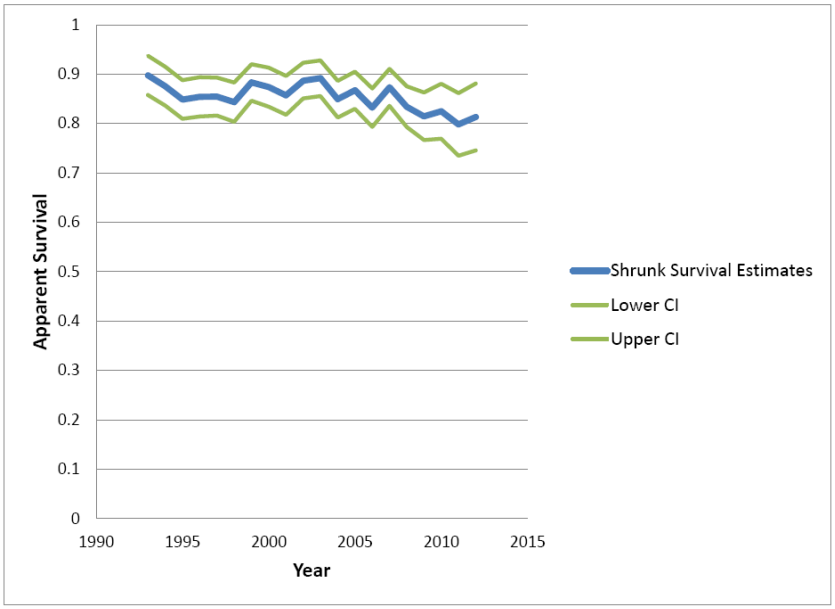


Figure 1.18: Estimates and 95% confidence intervals for NSO apparent survival on the Hoopa Valley Indian Reservation, Humboldt County, California during 1994-2012 (from Higley and Mendia 2013).



Forsman et al. (2011) reported that the presence of barred owls was included in the best model structures for several study areas, including the Green Diamond and Klamath, and was in a competitive model for Northwestern California (Forsman et al. 2011). Given evidence that barred owl presence continued to increase after the study period covered by Forsman et al. (2011) (see Ch. 4), it is likely that the forthcoming meta-analysis will report continued declines in apparent survival for many, if not all, demographic study areas. Franklin et al. (2013) noted that apparent survival in the Northwestern California study area, like reproduction, is influenced by annual variation in weather during the early spring. Thus, recent consecutive years with poor weather during the early spring further suggest that survival has likely continued to decline since the period analyzed by Forsman et al. (2011).

Population Change

A new demographic meta-analysis is expected to be released in 2015. Until then, the 2011 meta-analysis (Forsman et al. 2011) provides the most current available estimates of population change for NSOs across their range. Except for the Green Diamond Resource Company, which submits its data for analysis and reporting in periodic meta-analyses, timber companies do not estimate population change for NSOs. Forsman et al. (2011) stated that their results likely "…reflected conditions on federal lands and areas of mixed federal and private lands within the range of the Northern Spotted Owl because the study areas were (1) large, covering ≈ 9% of the range of the subspecies, (2) distributed across a broad geographic region and within most of the geographic provinces occupied by the owl, and (3) the percent cover of owl habitat was similar between our study areas and the surrounding landscapes." Only one of the study areas included in the meta-analysis was entirely located on private lands (Green Diamond). Thus, it is unclear whether results from the 2011 meta-analysis reflect demographic trends on private lands across the range of the NSO. Given weaker habitat conservation measures for NSOs on many private ownerships compared with federal lands, Forsman et al. (2011) stated that, "if anything, our results depict an optimistic view of the overall population status of the Northern Spotted Owl."

Forsman et al. (2011) reported estimates of the annual finite rate of population change (λ) for 11 study areas located across the NSO's range. Estimates of λ ranged from 0.929 to 0.996 (i.e., declines of 0.4 to 7.1% per year) for these study areas during the period of 1990-2006. There was strong evidence of population declines on seven of the study areas, including the Northwestern California (-1.7% per year) and Green Diamond (-2.8% per year) study areas in California. Negative population trends were also found on the Hoopa study area in California (-1.1% per year) and on the Klamath and South Cascades in southern Oregon (-1.0% and -1.8% per year, respectively) but they were not statistically significant. The weighted mean estimate of λ for all study areas combined was 0.971, indicating an average population decline of 2.9% per year during the study. Variables included in the best model in the meta-analysis of λ indicated effects of ecoregion (geographic location and major forest type) and the proportion of NSO territories with barred owl detections.

In addition to estimates of annual rate of population change, Forsman et al. (2011) provided estimates of realized population change, which describes population change over the study period (Figure 1.19). NSO populations in Washington and northern Oregon declined by approximately 40-60% during 1990-2006. Populations on the Northwestern California and Green Diamond study areas declined by 20-30% during the study period, although the 95% confidence intervals for these estimates slightly overlapped zero (Figure 1.19). Declines of 5-15% were evident on the Hoopa, Klamath and South Cascades study areas but these trends were not statistically significant (Figure 1.19).

Figure 1.19: Estimates of realized population change with 95% confidence intervals for northern spotted owls in California and southern Oregon (from Forsman et al. 2011).

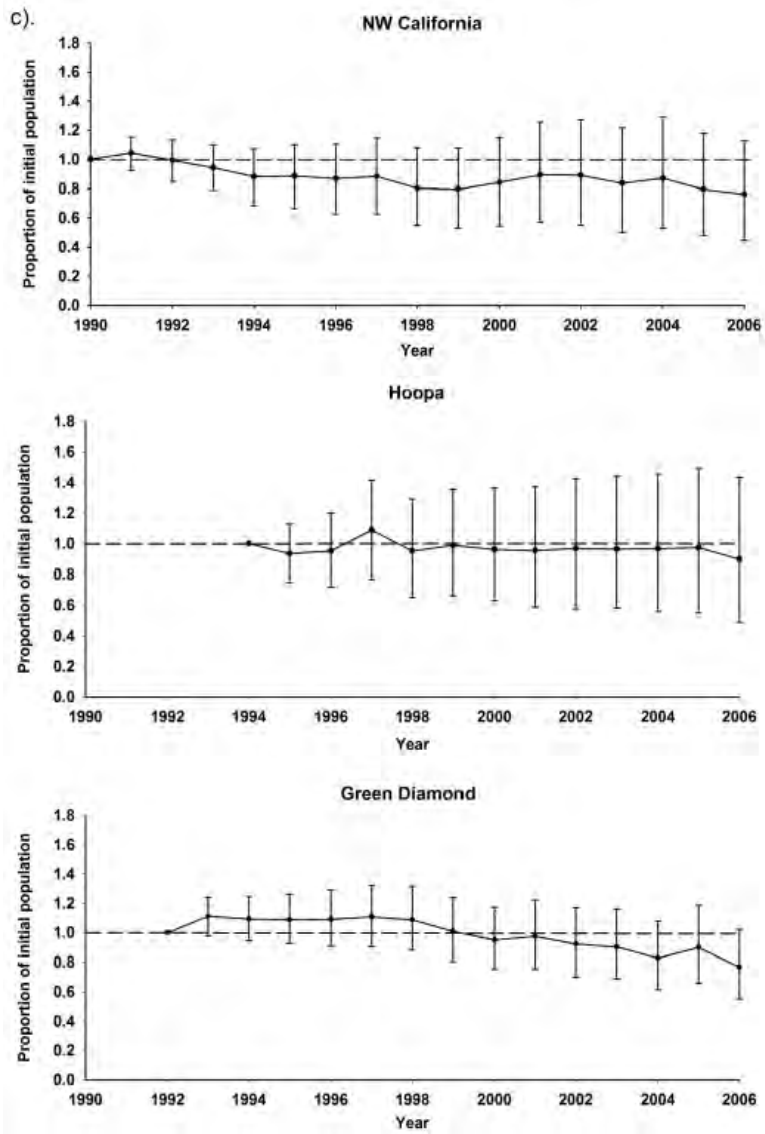
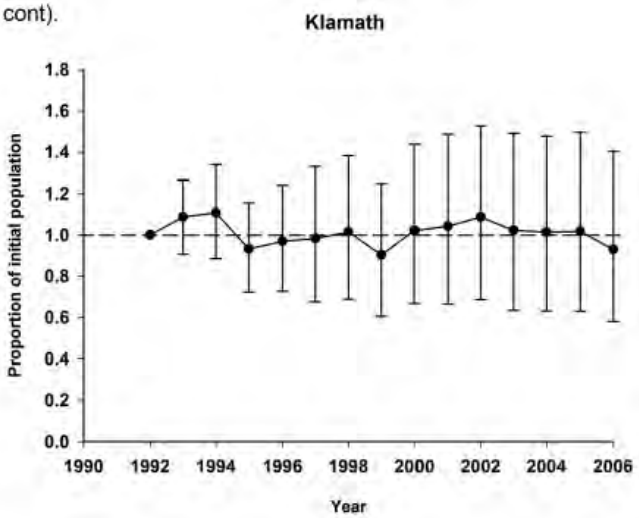
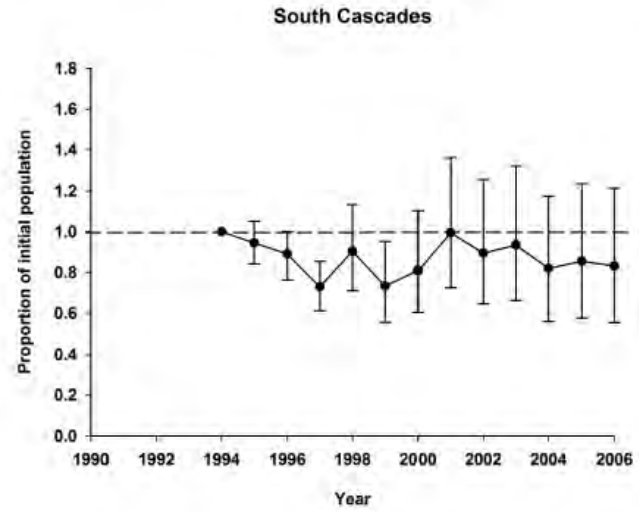


Figure 1.19 (cont.).

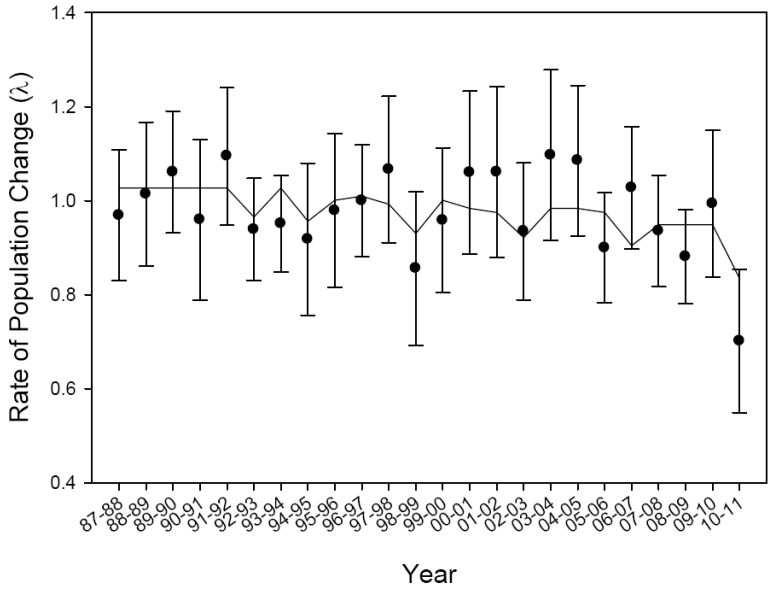
b cont).





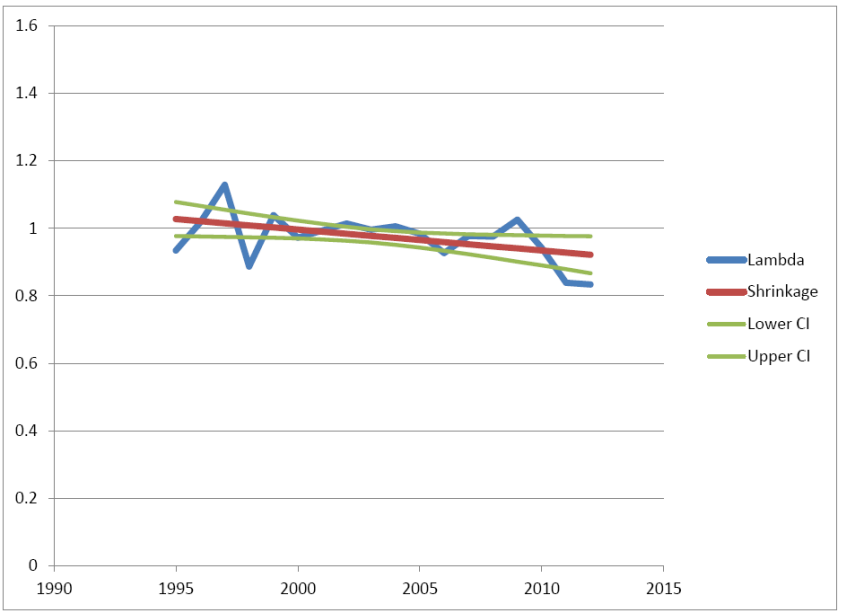
Following the 2011 meta-analysis study period (i.e., >2007), NSOs in the Northwestern California study area experienced a further decline in λ (mean = 0.978 or -2.2% per year) (Figure 1.20). The last year included in this analysis (2011) had the lowest annual estimate of λ found during the 24-year analysis period (Figure 1.20). The forthcoming meta-analysis should reveal whether the substantial drops in apparent survival and λ in the Northwestern California study area in 2011 were anomalous or indicative of an increased rate of population decline in the study area. Franklin et al. (2013) found that fecundity, apparent survival, and λ in the study area fluctuated during "good" and "bad" years, which was likely at least partially related to weather (see above). Annual rate of population change was also apparently negatively affected by increasing presence of barred owls. Given continued increases in barred owls (see Ch. 4), poor weather during the early spring during 2010-2012, and poor reproduction by NSOs during 2011-2013 (see above), it is likely that λ continued to decline on this study area and probably others in California and southern Oregon.

Figure 1.20: Annual estimates of (dots with 95% confidence intervals) and trend in (solid line) rate of population change in the Northwestern California study area (from Franklin et al. 2013).



Higley and Mendia (2013) reported that the estimate of λRJS (Jolly-Seber Capture-Recapture model) for the Hoopa demographic study during 1995-2012 was 0.977, indicating a mean annual population decline of 2.3%. The decline was statistically significant in 2011 and 2012 (point estimates of λRJS not included in the 95% CI; Figure 1.20). Higley and Mendia (2013) noted that "the recent decline in survival, the point estimate of λRJS and the actual number of birds detected this past season all point to a population that is in fact, declining. This apparent decline in spotted owls corresponds with an increase in total annual barred owl detections and proportion of spotted owl territories with barred owl detections." They further noted that the forthcoming meta-analysis will show that it is "...very clear that northern spotted owls are in decline across all 11 study areas and that in many cases the decline is accelerating."

Figure 1.21: Trend in rate of population change on the Hoopa Valley Indian Reservation, Humboldt County, California during 1994-2012 (from Higley and Mendia 2013).



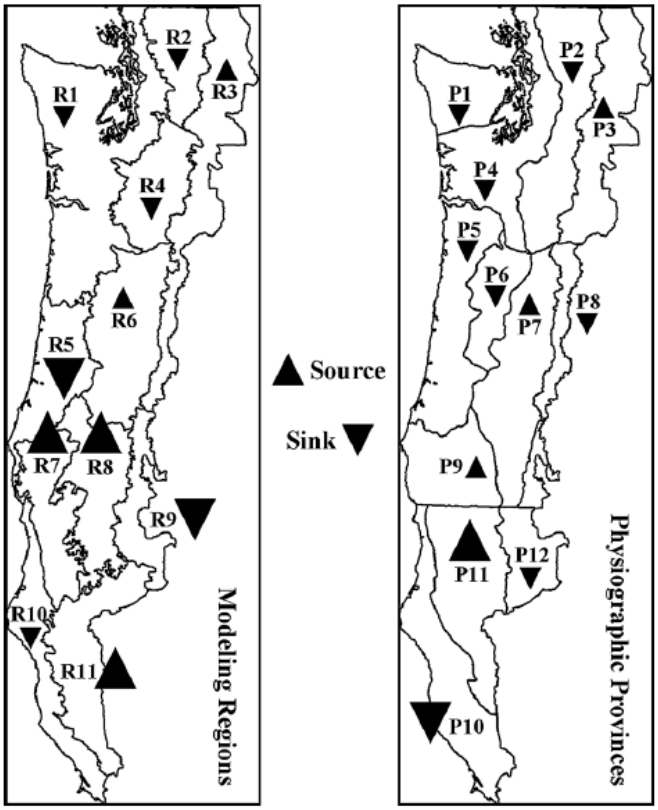
Source-Sink Dynamics

As described by Gutiérrez and Harrison (1996), source-sink dynamics exist for species "…that occupy both high-quality habitats (sources) where populations grow and produce emigrants, and low-quality habitats (sinks) where populations cannot sustain themselves in the absence of immigration." Population sinks potentially function as reservoirs for repopulation of sources that go extinct but may also reduce population growth rates (Pulliam 1988, Gutiérrez and Harrison 1996). Identifying source and sink areas is therefore, an important component of conservation research and planning. For example, identification of population sinks might be useful for determining where to focus habitat restoration or barred owl removal efforts. Empirical studies of relationships between NSO fitness and habitat attributes (Habitat Fitness Potential *sensu* Franklin et al. 2000) provide a rigorous measure of sources and sinks but only at the territory scale and within a given study area, rather than at population or regional levels (see Ch. 2 and 3 for further discussion of Habitat Fitness Potential). In the absence of direct empirical measures of large-scale source-sink dynamics, it may be useful to evaluate the results of source-sink simulation modeling based on empirical data.

Schumaker et al. (2014) recently published a rangewide study of source-sink dynamics for NSOs at the spatial scales of ecological regions and physiographic provinces. Their source-sink simulation modeling incorporated an array of regional data for NSO movement distances and rates, life history attributes, habitat suitability and connectivity, encounter rates with barred owls, and environmental stochasticity. Source-sink dynamics in this study emerged from simulated interactions between individual NSOs and landscapes, rather than being predefined based on habitat suitability as was done in previous studies. The simulation models by Schumaker et al. (2014) predicted that most ecological regions and physiographic provinces currently function as population sinks for NSOs (Figures 1.22 and 1.23). The study's results projected that the Klamath Provinces of California and Oregon and the Interior Northern Coast Ranges of California are the subspecies' strongest population sources (Figure 1.23). The Klamath

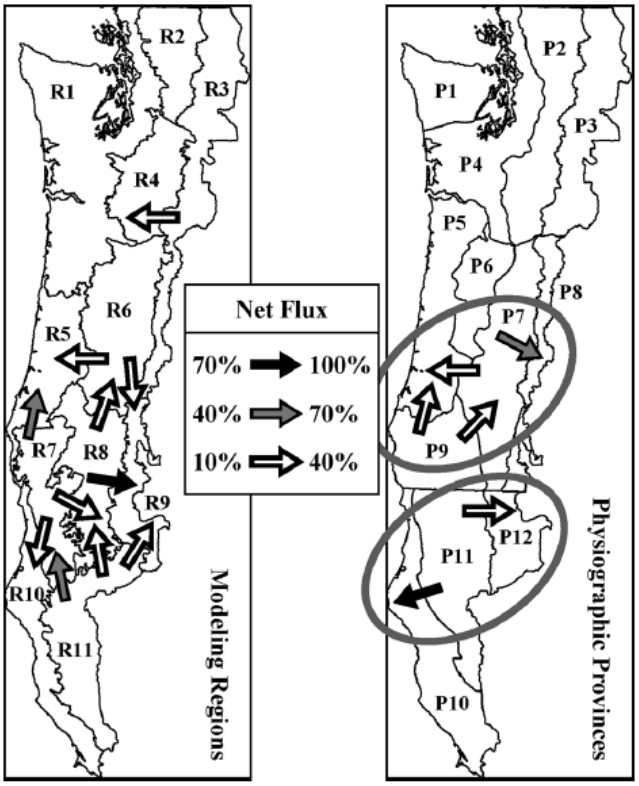
Provinces may be particularly important for maintaining NSO population stability due not only to being net population sources but to their high levels of population connectivity with multiple surrounding regions (Schumaker et al. 2014; Figure 1.23). The Redwood and Southern Cascades regions in California were both classified as moderate population sinks. Schumaker et al. (2014) identified the Klamath Provinces and California Cascades as areas in which it could be particularly important to focus habitat protection and restoration efforts, respectively.

Figure 1.22: Relative source and sink values in northern spotted owl modeling regions and physiographic provinces (from Schumaker et al. 2014). The sizes of symbols denote major versus minor or moderate sources and sinks.



R7: Klamath West, R8: Klamath East, R9: Eastern Cascades South, R10: Redwood Coast, R11: Inner California Coast Ranges, P10: California Coast Range, P11: California Klamath, P12: California Cascades. See Schumaker et al. (2014) for other modeling regions and physiographic provinces.

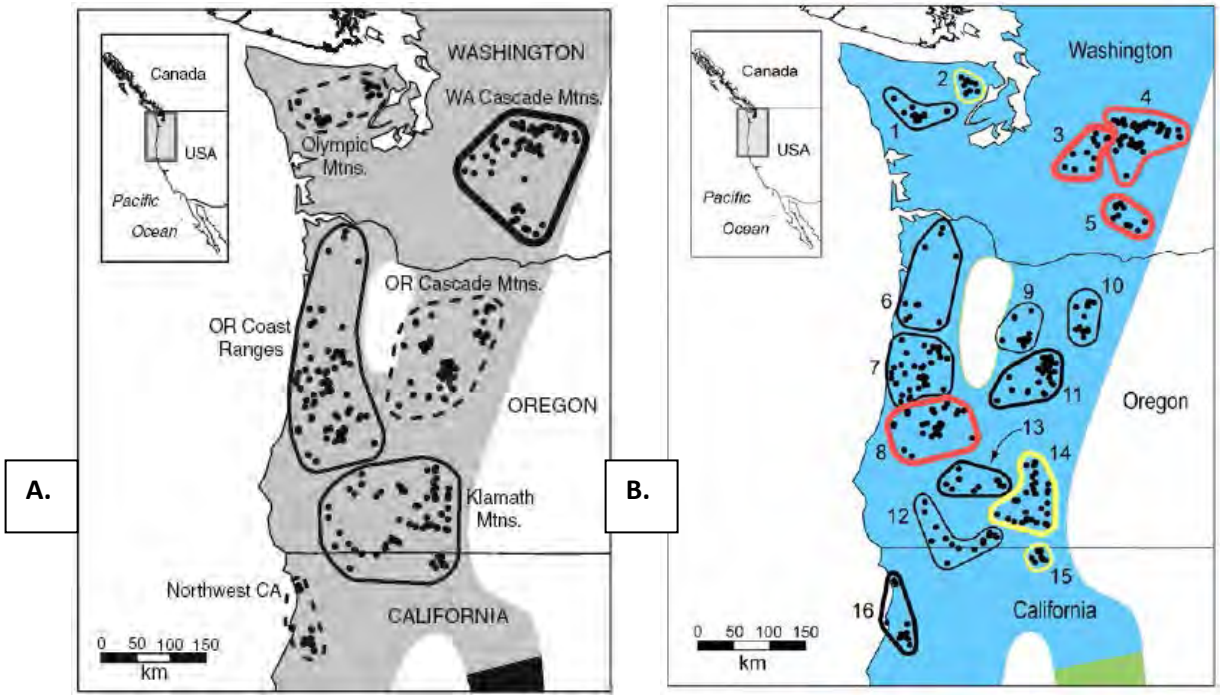
Figure 1.23: Graphical representation of net movement ("Net Flux") of individual (simulated) northern spotted owls from one modeling region or physiographic province to another (from Schumaker et al. 2014). The largest Net Flux values are shown in black, intermediate values in gray, and smallest values in white. Gray ovals highlight two areas with strong patterns of Net Flux.



Genetics

Funk et al. (2010) found statistically significant evidence that NSOs have experienced genetic bottlenecks during recent decades in the Washington Cascades, Oregon Coast Ranges, and "Klamath Mountains" of Oregon and California (Figure 1.24). An earlier report on this study indicates that evidence of a bottleneck in the Klamath Mountains analysis area was primarily driven by data from the southern Cascades of Oregon and California, rather than from the Klamath Provinces (Funk et al. 2008; Figure 1.24). Evidence of recent genetic bottlenecks in the Washington Cascades, Oregon Coast Ranges, and southern Cascades are concordant with recent demographic declines in these regions (Forsman et al. 2011; see *Demography*, above). Surprisingly, Funk et al. (2010) did not find evidence of a genetic bottleneck in the Olympic Mountains of Washington, where NSOs have recently experienced dramatic population declines (Forsman et al. 2011). However, they noted that their small sample size for this region limited their power to detect a genetic bottleneck if one occurred. Funk et al. (2010) did not find statistically significant evidence of a recent genetic bottleneck in northwestern California (Western Klamath and Redwood regions). They suggested that this could likewise have been due to low statistical power or to the relatively gradual population declines reported for that area at the time (see *Demography*, above). The analyses of Funk et al. (2010) did not address whether genetic bottlenecks were solely a result of population declines or were also contributing to them. Genetic declines can contribute to reduced demographic rates through effects of inbreeding depression and loss of adaptive genetic variation (reviewed in Funk et al. 2010).

Figure 1.24: Recent population bottlenecks in NSOs. Points represent 352 individual owls included in the analysis which are grouped into six (A) and 16 (B) regions. Statistically significant bottlenecks are represented by solid lines (A) or yellow (p = 0.05) and red (p = 0.01) lines (B). (A) represents significant bottlenecks under 5, 10, and 15% multi-step mutation models as solid bold lines and under 10 and 15% multi-step mutation models as finer solid lines (see Funk et al. 2010). (B) indicates greater magnitude bottlenecks with bolder lines. From Funk et al. 2010 (A) and 2008 (B).



Summary of Current Status and Trends

Rigorous long-term research has indicated that NSO populations are dramatically declining in Washington and northern Oregon and more gradually declining in southern Oregon and California (Forsman et al. 2011). Yet, while less precipitous than those in the northern portion of the NSO's range, the rapidity of population declines in southern Oregon and California are cause for grave concern regarding the subspecies' status and trends. A new demographic meta-analysis, which is due for public release during 2015, will replace the 2011 meta-analysis and provide the most reliable information for evaluating the NSO's current status and trends. Based on information available in annual research reports, it is clear that the forthcoming meta-analysis will show that populations in southern Oregon and California are declining more rapidly than was evident in the 2011 meta-analysis (Davis et al. 2013a, Franklin et al. 2013, Higley and Mendia 2013, Dugger et al. 2014, Green Diamond Resource Company 2014).

The NSO's status and trends are less clear in portions of California outside the state's three demographic study areas. Much of the information for these areas is provided by industrial timber companies, which have uniformly concluded that NSO populations on their lands are stable (Calforests 2014). However, the data provided by these companies are insufficient for drawing strong conclusions about the NSO's status and trends, and may in fact indicate declines in occupancy and reproduction on some ownerships (see *Occupancy* and *Demography*, above). Forsman et al. (2011) suggested that, due to weaker habitat

protection, NSO demographic trends could generally be worse on non-federal lands than on the federal and mixed federal/non-federal lands on which most demographic studies are conducted. This appears to be true in California, where NSOs experienced greater declines on Green Diamond Resource Company lands than on nearby tribal and Forest Service lands (Forsman et al. 2011; see *Occupancy* and *Demography*, above). However, the degree to which these differences were due to variation in land management, effects of competition with barred owls, or other factors is unclear.

It is likewise unclear if demographic trends in California's three demographic study areas accurately represent those in drier, less productive forests in the state's interior. An occupancy study in California's Eastern Klamath and Southern Cascades (Farber and Kroll 2012) and demographic studies in ecologically similar areas of southern Oregon (Davis et al. 2013a, Dugger et al. 2014) could provide the most reliable information currently available for evaluating NSO's status and trends in interior California (see *Occupancy* and *Demography*, above). These studies indicate that NSOs are currently declining in at least some portions of the Eastern Klamath and Southern Cascades regions (note: these regions cover portions of both California and southern Oregon as they are ecologically rather than politically defined; see USFWS 2011a Appendix C and Figure 1.22 [left side]). Evidence of population declines in the Klamath regions (Forsman et al. 2011, Farber and Kroll 2012, Davis et al. 2013a, and Franklin et al. 2013) are particularly concerning in light of the critical contributions these areas may provide to the NSO's long-term persistence (Schumaker et al. 2014; see *Source-Sink Dynamics*, above).

Although the Redwood Region is projected to currently function as a population sink, it still retains high densities and abundances of NSOs and is therefore important to the subspecies' conservation (Schumaker et al. 2014; see *Density and Abundance* and *Source-Sink Dynamics*, above). There is limited information available for evaluating the NSO's status and trends in portions of the Redwood Region outside of Green Diamond's lands. Monitoring on National Park Service lands and adjacent ownerships suggest that the population in Marin County is stable while NSOs in the Redwood National and State Parks have substantially declined. These differences appear to be largely due to negative effects of high barred owl densities in the Redwood National and State Parks and the relatively slow rate of the barred owl invasion in Marin County (see *Occupancy*, above). In contrast with the Green Diamond Resource Company, other timber companies in the northern portion of the Redwood Region have concluded that their NSO populations are stable (Calforests 2014). It is possible that NSOs have indeed fared better on these ownerships than on Green Diamond lands; for example, due to less intensive timber harvesting or more recent colonization by barred owls. However, the data provided by these companies are insufficient for drawing firm conclusions about the NSO's status and trends on these lands, and actually appear to indicate at least gradual declines in some areas. More consistent and rigorous monitoring (e.g., consistent survey areas and protocols; reporting of modeled occupancy rates) would assist future evaluations of the NSO's status and trends on industrial timberlands in California.

Acknowledgements

I am extremely grateful to Lowell Diller for his helpful review of this chapter and to Jeff Dunk for his comments on the *Source-Sink Dynamics* section.

Part II: Threats to Northern Spotted Owls in California

Forsman et al. (2011) concluded that habitat loss was partly responsible for declines in NSO fecundity, apparent survival, and/or populations observed in most demographic study areas. Due to a lack of a suitable habitat map at the time, they did not include a habitat variable in models for California. However, a substantial body of research has shown that stand- and landscape-level habitat attributes influence habitat selection, densities, occupancy, reproduction, survival, and metapopulation dynamics of NSOs in California and southern Oregon (e.g., Carey et al. 1992, Gutiérrez et al. 1998, Hershey et al. 1998, Thome et al. 1999, Franklin et al. 2000, Zabel et al. 2003, Carroll and Johnson 2008, Schumaker et al. 2014). Loss of approximately 60-88% of all old forest within the NSOs range during the 19th and 20th centuries was a primary reason for the subspecies' federal listing (USFWS 1990, Strittholt et al. 2006). Despite greater habitat protection following federal listing and implementation of the Northwest Forest Plan, intensive timber harvesting and large wildfires have continued to cause a downward trend in suitable habitat for NSOs and thus, continue to threaten the subspecies (Davis and Dugger 2011, USFW 2011). Yet, NSOs in California and southern Oregon may have complex relationships with these disturbances. For example, low-to-moderate or mixed severity wildfires could sometimes benefit NSOs in these areas by contributing to prey diversity and abundance, provided they do not excessively remove nesting and roosting habitat. In-depth reviews of these topics are provided in Chapters 2 and 3 of this volume.

Demographic analyses indicate that worsening NSO population declines in California and southern Oregon have been driven to a large degree by increasing competitive pressure from invasive barred owls (Forsman et al. 2011, Davis et al. 2013a, Franklin et al. 2013, Higley and Mendia 2013, Dugger et al. 2014, Green Diamond Resource Company 2014). A large body of quantitative and anecdotal information indicates that barred owls negatively affect NSOs in a variety of ways and that they currently pose one of the primary threats to the NSO's long-term persistence (USFWS 2013). These topics, with particular emphasis on information from California, are reviewed in Chapter 4.

Outdoor marijuana cultivation has dramatically increased in recent years and has emerged as a serious potential threat to NSOs in California (Gabriel et al. 2013, Calforests 2014). There is little quantitative information concerning impacts of outdoor marijuana cultivation on NSOs. However, published research of fishers (*Pekania pennanti*), which have overlapping home ranges, habitat associations, and diets with NSOs, suggests that anti-coagulant rodenticides and other pesticides used in outdoor marijuana cultivation currently pose a widespread risk to NSOs in California (Gabriel et al. 2012, 2013, Thompson et al. 2014). In addition to potential behavioral and demographic effects of pesticides on NSOs, outdoor marijuana cultivation could impact the subspecies through suppression of prey populations; ecological changes due to water diversion, clearcutting, and pollution; or habitat loss to wildfires ignited by growers (Gabriel et al. 2013, Bauer et al. 2015). Marijuana cultivation could also impact conservation of NSOs by reducing the ability of biologists to safely and efficiently conduct conservation research and monitoring (Gabriel et al. 2013). These topics are further discussed in Chapter 5.

The apparent effects of weather and climate variables on NSO demographic rates suggest that anthropogenic climate change could pose a major threat to the subspecies (Glenn et al. 2010). This hypothesis is further supported by projections of increased numbers of large wildfires in California under plausible climate change scenarios (see Ch. 3). Climate change could also impact NSOs in California through other climate or weather effects (e.g., increased frequency of droughts), outbreaks of insects and pathogens, large-scale redistribution of major vegetation types, and unpredictable effects on

prey communities (reviewed in USFWS 2012b). Due to limited time and funding, and the complex and ever-increasing body of science covering these topics, a synthesis of this information is not included in this document. State and federal agencies should thoroughly evaluate climate change as a potential threat to NSOs and other species prior to determining their conservation status.

Although not reviewed herein, the stressors described above and in the remainder of this document could have cumulative and interactive impacts on NSOs. For example, Dugger et al. (2011) found that barred owls and habitat fragmentation had an additive negative effect on NSO occupancy rates in southern Oregon. This finding suggests that habitat loss and fragmentation due to timber harvesting or severe wildfires can increase competitive pressure from barred owls. Decreasing population sizes, apparently due primarily to habitat loss and competition with barred owls, can increase risks posed to NSOs by other factors. For example, small NSO populations may become vulnerable to extinction due to chance events such as epidemics or extreme weather or climate events (Franklin et al. 2000). Decreasing population sizes may also have negative genetic effects on NSOs. For example, genetic bottlenecks could further reduce demographic rates through inbreeding depression and loss of adaptive variation (Funk et al. 2010). Also, hybridization between NSOs and barred owls could become more frequent in the future as NSOs become less able to find conspecific mates (Gutiérrez et al. 2007). Policymakers and land managers should acknowledge that, despite limited research of the topic, multiple past and current stressors for NSOs could have important cumulative and interactive impacts on the subspecies.

Ch. 2: Timber Harvesting

Introduction

Timber harvesting was a primary impetus for federal listing of the NSO and is still regarded as one of the major threats to the subspecies (Thomas et al. 1990, USFWS 1990, Courtney et al. 2004, USFWS 2011a). Timber harvesting can directly impact NSO populations by removing, degrading, or fragmenting habitat for them or their prey (reviewed below). Harvesting might also indirectly affect NSOs by increasing effects of other stressors, such as competitive pressure from barred owls (*Strix varia*) (Forsman et al. 2011, USFWS 2011a; see Ch. 4). However, timber harvesting likely has complex effects on NSOs in the southern part of their range due to divergent effects of habitat conditions on survival versus reproduction (Franklin et al. 2000, Olson et al. 2004, Diller et al. 2010). The information reviewed herein suggests that some forms and amounts of harvesting may be sustainable in northern California but that large-scale removal or fragmentation of habitat around activity centers can have strong negative impacts on NSOs (reviewed below and in USFWS 2009).

The kinds of habitat concentrations associated with high survival and fitness of NSOs may be limited in some parts of the subspecies' range due to removal of the majority of old forest during the 19th and 20th centuries (USFWS 1990, Strittholt et al. 2006). Harvesting has been substantially curtailed on federal lands since implementation of the Northwest Forest Plan (Healey et al. 2008, Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012). However, removal of suitable NSO habitat continues on federal lands and is occurring at higher rates on non-federal lands (Davis and Dugger 2011). On non-federal lands, habitat loss to logging is only partially offset by recruitment of new habitat (Davis and Dugger 2011, Moeur et al. 2011; reviewed below). This is cause for concern since non-federal lands contain a considerable portion of remaining suitable breeding habitat for the subspecies (e.g., >30% of older forest in the Pacific Northwest and northwestern California currently exists on non-federal lands: Moeur et al. 2011) and because recovery of the NSO could partially depend on voluntary conservation efforts on these lands (USFWS 2011a). The timber industry has cited relatively strict harvest regulations in California as evidence that listing of the NSO under the California Endangered Species Act is unnecessary (Calforests 2014). Yet, contemporary harvesting has still resulted in a net loss of suitable breeding habitat for NSOs on non-federal lands in California (reviewed below). Furthermore, the U.S. Fish and Wildlife Service (2009) recently concluded that California's regulations for avoiding "take" of NSOs inadequately protect the subspecies and do not reflect the best available science. Inconsistent or poor implementation of existing regulations could further weaken protections for NSOs on private timberlands in California (reviewed below).

Responses of NSOs to Timber Harvesting

<u>Interior of Northern California and Southern Oregon</u>

NSOs in interior northern California show a strong general preference for relatively old, structurally complex forest. This is illustrated by studies describing both small-scale plots around NSO locations (Solis and Gutiérrez 1990, Rissler 1995, White 1996, Hershey et al. 1998; but see Irwin et al. 2013) and landscape-scale analysis areas around activity centers (Chávez-León 1989, Solis and Gutiérrez 1990, Hunter et al. 1995, Gutiérrez et al. 1998). This body of research can be used to inform conservation measures for NSOs in interior northern California (e.g., for evaluating appropriate habitat definitions in take-avoidance guidelines: USFWS 2009). However, the following review is focused on studies of associations between landscape-scale habitat attributes and NSO demography in interior forests

(Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005, Schilling et al. 2013). These studies are based on rigorous demographic data and provide the best available insight into potential effects of timber harvesting on NSO populations (USFWS 2009). This review is supplemented with information from studies of associations between landscape-level habitat characteristics in southern interior forests and NSO home range sizes and probability of occurrence (Carey et al. 1992, Carey and Peeler 1995, Zabel et al. 2003, Carroll and Johnson 2008, Schilling et al. 2013).

In the California Klamath, Franklin et al. (2000) found that NSO survival was highest when estimated breeding core areas (390 ac) contained large amounts of both interior (>326 ft from edge) older forest (conifer or mixed forest with conifer QMD ≥21 in and canopy cover ≥70%) and edge with other vegetation classes. In contrast, reproduction was typically highest with lower amounts of interior older forest and greater amounts of edge. Estimated breeding core areas supporting high fitness for NSOs (a function of both survival and reproduction) contained both a large concentration of interior older forest and considerable habitat edge provided by a mosaic of other vegetation patches with convoluted shapes. Franklin et al. (2000) emphasized the difference between total area of older forest versus area of interior older forest. For example, they noted that large amounts of older forest edge cannot occur with low total amounts of older forest. This study did not directly address effects of timber harvesting on NSOs. Vegetation other than older forest was combined into a single class and edges occurred wherever that class and older forest met. Franklin et al. (2000) noted, however, that the dominant silvicultural system in their study area at that time was large-scale clearcutting, which they concluded was unlikely to contribute to the kinds of habitat mosaics found in territories supporting high fitness.

In an unpublished report, Matthews et al. (2008) evaluated the demography of NSOs on the Hoopa Valley Indian Reservation in the California Klamath. Their best performing model explaining NSO survival indicated that survival increased with greater amounts of interior mature or old forest (>80 yrs with "heavy" canopy cover, ≥328 ft from edge) up to about half of a 200-acre analysis area around activity centers and then slightly declined with higher proportions. Survival also increased with increasing amounts of brushy pole-timber forest (conifer stands 10-20 yrs with a "heavy brush component", meant to represent dusky-footed woodrat [*Neotoma fuscipes*] habitat) within estimated territories (917 ac) up to about 16% of the area and then leveled off. Survival was negatively associated with pre-commercial thinning (prescription not described) of brushy pole-timber forest, which Matthews et al. (2008) attributed to a negative long-term effect of thinning on dusky-footed woodrat populations. The best performing model explaining patterns of NSO reproduction indicated that the influence of woodrat habitat on reproduction depended on whether it was a high or low reproduction year and on amounts of mature and old forest. During years with high reproduction, productivity was highest at sites with moderate amounts (19%) of woodrat habitat in a larger core analysis area around activity centers (517 ac), whereas woodrat habitat had little influence on NSO reproduction during low reproduction years. Furthermore, high amounts of mature and old forest apparently offset negative effects of low amounts of woodrat habitat on reproduction; possibly by providing access to alternative prey (e.g., northern flying squirrels) or greater protection from predators or inclement weather (Matthews et al. 2008).

In the interior of the Oregon Coast Range, Olson et al. (2004) found that NSO survival was positively associated with greater amounts of both "mid-seral" (9.5-31.5 in DBH) and "late-seral" (>31.5 in DBH) forest in landscapes around activity centers (≤4,921 ft) and lower amounts of early-seral forest and non-forest (<9.5 in DBH). Reproduction, in contrast, was negatively associated with area of mid- and late-seral forest and positively associated with edge between early-seral and non-forest and other vegetation classes. Olson et al. (2004) encountered technical difficulties with the habitat fitness potential portion of

their modeling but noted that territories supporting high fitness must contain attributes associated with both high survival and high reproduction. This was supported by diagrams made from aerial photos of landscapes around activity centers, which showed remarkably similar habitat mosaics to those presented by Franklin et al. (2000).

Dugger et al. (2005) found a positive association between NSO survival in the Oregon Klamath Province and greater amounts of mature and old forest (≥100 yrs) within estimated breeding core areas (413 ac) and a moderate amount of non-habitat (non-forest, early-seral vegetation, and older forest with harvest entries ≥40% basal area) in the landscape beyond the core area (3,430-ac ring). The specific contribution of timber harvesting (and of different harvest types and intensities) to the non-habitat class and thus, its effects on NSO fitness, were not reported. This study's findings differed from others in that reproduction was positively, rather than negatively, associated with greater amounts of older forest within estimated core areas. These findings suggest that widespread harvesting of older forest within NSO core areas would negatively affect both survival and reproduction in this area but that some level of harvesting might be sustainable in the broader landscape (to the degree that it contributes to "optimal" amounts of non-habitat in the 3,430-ac ring surrounding estimated core areas).

Schilling et al. (2013) found additional evidence of a positive influence of both older forest and habitat heterogeneity on NSO survival in the Oregon Klamath. Their best performing model indicated that monthly survival probabilities for NSOs were highest when home ranges (based on radio-telemetry) contained more patches of mature and old forest (≥20 in DBH and ≥40% canopy cover). The second best performing model indicated a positive association between survival and clustering of (i.e., close distances between) older forest patches. Unlike other studies, they did not find an association between survival and total amount of older forest. They noted that this could have occurred due to their small sample size or because most NSO home ranges in their study had amounts of mature and old forest (mean = 72%) that exceeded threshold amounts required for survival. A third competitive model suggested that survival was also positively associated with a moderate amount of edge between forest (mean DBH ≥5 in) and other cover classes; thus providing additional support for the value of habitat heterogeneity for NSOs in southern interior forests.

Zabel et al. (2003) modeled probability of NSO occurrence (i.e., habitat suitability) across interior northern California based on habitat conditions at an estimated core area scale (500 ac). The best performing model in their study indicated that the probability of NSOs occurring in a given location was highest with large amounts of suitable nesting-roosting habitat (generally ≥17 in DBH and canopy cover ≥60%) and intermediate amounts of foraging habitat (≥10 in DBH and canopy cover ≥40%) at the core area scale. The second and third best performing models at the core area scale included habitat edge. The results of this modeling study provide further support for conclusions that a combination of both a large concentration of suitable habitat and some form of habitat heterogeneity is important to NSOs in interior northern California.

Carroll and Johnson (2008) also modeled probability of NSO occurrence in interior northern California. Based on their best model, predicted abundance of NSOs in the area was highest when most of the landscape (5,930-ac areas) consisted of mature and old forest (>50 yrs). However, predicted abundance slightly declined when area of mature and old forest increased beyond about 80% of the landscape. This study therefore, provides evidence of at least a slight positive effect of other vegetation classes on probability of NSOs occurring in a given area. These results contrasted with the study's findings for more northern parts of the NSO's range, where the probability of occurrence continued to increase (albeit diminishingly) with greater amounts of older forest.

Studies of home range sizes provide another line of evidence concerning habitat and harvesting influences on NSOs in interior southern forests. Home range studies in the Oregon Klamath found that home range size increased with habitat fragmentation (Carey et al. 1992, Schilling et al. 2013). NSOs in the area are known to use regenerating harvest units for foraging, particularly when closer to the activity center or outside the breeding season (Carey and Peeler 1995, Irwin et al. 2013). However, Carey and Peeler (1995) concluded that the energetic benefit of increased access to dusky-footed woodrats in heavily fragmented forest is often outweighed by the energetic cost of increased travel.

In summary, studies in interior northern California have found that NSOs in the region benefit from both large amounts of older forest concentrated around activity centers and some form of habitat heterogeneity (Franklin et al. 2000, Zabel et al. 2003, Carroll and Johnson 2008, Matthews et al. 2008). Similar results have been found in the Klamath (Dugger et al. 2005, Schilling et al. 2013) and interior Coast Range of Oregon (Olson et al. 2004). These findings suggest that NSO populations in southern interior forests can tolerate some level of timber harvesting provided suitable breeding habitat is retained in sufficiently large concentrations around activity centers (USFWS 2009). However, whether and how timber harvesting contributes to beneficial habitat heterogeneity in interior southern forests is unclear. Available studies differed in their findings of types, amounts, and locations of beneficial heterogeneity and did not directly evaluate whether timber harvesting contributed to it. In contrast, it is clear from research of associations between landscape-level habitat attributes and the demography, presence, and home range sizes of NSOs that harvesting within core concentrations of suitable habitat has the potential to negatively affect populations in southern interior forests (USFWS 2009).

Redwood Province

Most of the literature concerning NSOs in the Redwood Province pertains to research on intensively harvested lands owned by the Green Diamond Resource Company. Studies on these lands found a preference among NSOs for landscapes with greater amounts of intermediate-age or older forest than expected based on general availability of those forest classes (Thome et al. 1999, Folliard et al. 2000, Keithley and Motroni 2000, Gonzales 2005, Diller et al. 2010). However, site fidelity and reproduction on these lands were positively associated with presence of younger forest classes and measures of habitat heterogeneity (e.g., edge) (Thome et al. 1999, 2000, Diller et al. 2010). Studies of the habitat associations of dusky-footed woodrats on these lands appear to provide additional support for the value of younger forest and habitat heterogeneity to NSOs in the area (Hamm et al. 2007, Hamm and Diller 2009). Unpublished but relatively rigorous modeling of associations between landscape-level habitat attributes and NSO fitness and population growth rate has confirmed that NSOs on Green Diamond lands have complex relationships with timber harvesting (Diller et al. 2010). NSOs on Green Diamond lands indeed appear to benefit from some level of habitat heterogeneity, which is currently maintained through “small-patch” ($\leq$20 ac) clearcutting (Diller et al. 2010). Yet, habitat quality on these lands (measured as habitat fitness potential, *sensu* Franklin et al. 2000) is positively associated with protection of suitable breeding habitat, and both habitat quality and population growth rate are negatively associated with harvesting of suitable habitat (Diller et al. 2010). Thus, appropriate management of NSOs on Green Diamond lands appears to include avoiding take, setting aside suitable habitat from harvesting, and focusing economically-driven harvest requirements in relatively homogeneous blocks of unsuitable forest created by past large-block clearcutting. Diller et al. (2010) did not describe habitat conditions associated with habitat fitness potential $\geq$1 (i.e., conditions associated with NSOs replacing themselves or contributing to a population surplus). Peer reviewed reporting of these conditions could

be used to refine current take-avoidance guidelines for the Redwood Province (see USFWS 2011b, CAL FIRE 2014).

There does not appear to be any published information concerning the ecology and appropriate management of NSOs on other ownerships within the Redwood Province. Habitat conditions available to and selected by NSOs appear to differ among public and private ownerships (Keithley and Motroni 2000), industrial timber company ownerships (Appendix 2.1), and industrial versus non-industrial timberland ownerships (K. Hoffman, pers. comm.). This variability could reflect differences among forest types (e.g., redwood vs. mixed-evergreen), management regimes (e.g., intensive even-age, intensive uneven-age, and low-intensity uneven-age), and natural disturbance regimes (e.g., pre-settlement fire return intervals in northern vs. southern forests) (see Stuart and Stephens 2006, Sawyer 2007).

The USFWS (2011a, 2012a) recently conducted habitat suitability modeling based on attributes of landscapes (494 ac) surrounding 392 activity centers distributed across much of the Redwood Province. The model selected for the region included a suite of habitat variables and performed well in terms of its ability to discriminate between areas around NSO activity centers and random sites. The resulting map of relative habitat suitability was incorporated into the USFWS (2012a) process for designating critical habitat for NSOs but has limited utility for characterizing habitat selection by the subspecies. However, "deconstruction" of the habitat suitability modeling outputs (cf. Dunk and Hawley 2009, Woodbridge et al. 2012, Zielinski et al. 2012) allows evaluation of associations between habitat suitability and the full range of candidate variables, including ones not included in the best performing model. Deconstruction of the habitat modeling output for the Redwood Province shows that the probability of NSOs occurring in a given area in the region increases with larger amounts of forest with relatively dense canopy cover and large diameter trees (Appendix 2.2). Compared with those in the lowest suitability class, landscapes in the highest suitability class contained an average of 1.8 times more nesting-roosting habitat; 2.4 times higher basal area of conifers $\geq$20 inches DBH; 2.3 times higher basal area of live trees $\geq$30 inches DBH; and 2.0, 1.8 and 1.9 times higher densities of conifers $\geq$20, 30, and 39 inches DBH, respectively. There was a high degree of variability (standard deviation) in terms of structural attributes within habitat suitability classes, particularly for rare habitat elements such as very large diameter trees. As noted above, this variability likely reflects the high diversity of forest types, management histories, and natural disturbance regimes in the region (see Stuart and Stephens 2006, Sawyer 2007). Nonetheless, consistent patterns of association between habitat suitability and mean amounts of these variables are evident. In addition, variability in amounts of many of these habitat attributes (coefficient of variation) declined with increasing habitat suitability, further indicating that they are often important to NSOs in the province. These results suggest that timber harvesting that reduces availability of these structural attributes would generally reduce the probability of NSOs occurring in a given area within the Redwood Province. Changes in availability of these structural attributes can occur with a variety of silvicultural approaches and are not solely caused by even-age harvesting.

Effects of Uneven-Age Harvesting and Thinning

Some private landowners in northern California currently emphasize uneven-age regeneration or management, which typically cause less visually dramatic changes to forests than does even-age harvesting. These forms of harvesting, particularly intensive uneven-age regeneration, nonetheless have the potential to cause substantial changes to forest structure or composition. For example, intensive selective logging of Douglas-fir (*Pseudotsuga menziesii*) has resulted in extensive conversion of mixed-evergreen forest to hardwood-dominated forest in parts of the Redwood Province (Sawyer 2006).

Relatively little harvesting has occurred on federal lands within the NSO's range since adoption of the Northwest Forest Plan (Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012; see below). However, federal agencies have expressed support for widespread thinning to reduce wildfire risk, restore wildlife habitat, and meet economic objectives in the Plan area (USFS and BLM 1994, USFWS 2011a, 2012a).

Effects of contemporary uneven-age harvesting and thinning on NSOs are difficult to evaluate due to the paucity of rigorous research on the topic. Most of the available information about NSO responses to these silvicultural systems is based on the behavior of very small numbers of telemetered owls and was gathered in an opportunistic fashion during studies of other topics (reviewed in Hansen and Mazurek 2010, USFWS 2011a; see below). Evaluation of this topic is further complicated by poor descriptions of harvest methods, locations and intensities and, perhaps more importantly, post-harvest habitat conditions. The terms uneven-age harvesting and thinning encompass a tremendous variety of harvest types, objectives, and effects (e.g., Graham et al. 1999). Harvesting described in relation to NSO telemetry consisted of a variety of commercial thinning or partial harvesting (leaving residual trees) prescriptions, including understory thinning of various intensities, removal of most trees up to a relatively large diameter class, and shelterwood harvests prior to or without removal of residual trees (see Hansen and Mazurek 2010). The effects of thinning and uneven-age harvesting on NSOs may also be influenced by the condition of the landscape surrounding the harvest unit (e.g., amount, contiguity, and location of suitable NSO habitat), which could be affected by climate, soils, natural disturbance regimes, and past harvesting.

In a synthesis prepared for the 2011 revised recovery plan for the NSO (USFWS 2011a), Hansen and Mazurek (2010) provided detailed summaries of data concerning responses of both NSOs and California spotted owls (*S. o. occidentalis*; CSOs) to uneven-age harvesting, partial harvesting, and thinning. This information was gleaned from both peer-reviewed and gray literature and was based on small sample sizes. The authors therefore, opted to review each data source as a "case study" so that relatively detailed descriptions of harvesting and post-harvest conditions could be provided and so that the methodological strengths and weaknesses of studies could be evaluated. Their review is summarized below, with the addition of thee citations: Matthews et al. 2008, Gallagher 2010, and Tempel et al. *in press*.

All of the reviewed studies that described habitat use patterns by NSOs or CSOs documented at least some use of areas harvested with uneven-age harvesting, partial harvesting, or thinning. At least four of the studies found owls nesting in harvest areas (Forsman et al. 1984, Zabel et al. 1992, King 1993, and Buchanan et al. 1995) and at least five recorded roosting in them (Solis 1983, Sisco 1990, King 1993, Hicks et al. 1999, and Meiman et al. 2003). It is important to note, however, that older-forest structural attributes had been retained or regenerated in most of the harvest areas used for nesting or roosting. Three of the four studies that documented nesting in harvest areas described the nest stands as mature or old forest or an equivalent classification (USFS Region 5 "suitable habitat"; "understory reinitiation phase…of stand development"). The other study did not describe the harvest area used for nesting (King 1993). Harvest areas used for roosting in three studies likewise were either classified as mature or old forest (Solis 1983) or contained some older-forest structural characteristics, such as relatively high basal area or dense canopy cover (King 1993, Meiman et al. 2003). Two studies observed roosting in harvested stands that appeared to differ from this pattern; but one of the authors thought that the deaths of three spotted owls that roosted in them were due to higher predation risk in the more open stands (Sisco 1990, Hicks et al. 1999).

Most of the reviewed studies found that spotted owls foraged to some degree in uneven-age harvested, partially harvested, or thinned areas. Irwin et al. (2005, 2008) stated that some NSOs in their study areas selectively used certain harvest units but not others. However, they did not provide quantitative comparisons of prescriptions, post-harvest conditions, or proximities of harvest units to activity centers. Two other studies found that spotted owls generally avoided foraging in areas that recently experienced moderate to intensive partial harvesting or thinning, whereas use of lightly harvested areas varied among individuals (Anthony and Wagner 1999, Gallagher 2010). Anthony and Wagner (1999) found that NSOs (n = 15) in southern Oregon foraged in heavy and moderate partial-cuts less than expected (old stands with ≥30-40% of the original basal area removed and ≥"moderate" canopy cover reduction [not described]). Light partial-cuts (old forest with ≤20% of the original basal area removed and "small" reductions of "crown cover" [not described]) were used more than expected by two owls, as often as expected by five, and less than expected by eight. In the northern Sierra Nevada, Gallagher (2010) found that CSOs (n = 9) used heavily thinned "defensible fuel profile zones" (canopy cover reduced to 40%, removal of trees <30 in DBH, reduction of tree density and ladder and surface fuels) less than expected based on availability. She also reported a near-significant tendency ($p = 0.08$, n = 5) for avoidance of areas recently treated with understory thinning. Use and availability of harvest areas varied among individuals. Most individuals exhibited avoidance of defensible fuel profile zones and areas treated with understory thinning but one male showed strong selection for thinned areas (primarily understory thinning). It is possible that understory thinning improved prey availability or otherwise benefited this male. However, Gallagher (2010) noted that thinning treatments were located unusually close to this male's activity center, which potentially increased his likelihood of using them due to central place foraging. She also noted that an unusually large proportion of understory thinning units in the male's home range were also treated with prescribed fire, which could have temporarily increased abundances of deer mice (*Peromyscus* spp.) or other prey that tend to respond positively to fire (see Ch. 3).

The limited available information suggests that thinning and uneven-age harvesting causes some spotted owls to increase their home range sizes, which could impose energetic costs on individuals (Meiman et al. 2003, Gallagher 2010). Meiman et al. (2003) reported that a male NSO's breeding season home range in the Oregon Coast Range was slightly larger before commercial thinning than afterward but that its nonbreeding season home range was 2.3 times larger afterward. The individual also appeared to shift its breeding season core area to include less of the thinned area. In the northern Sierra Nevada, Gallagher (2010) found that the home range sizes of CSOs (n = 9) significantly increased with greater total area of fuels treatments (defensible fuel profile zones and understory thinning). She also reported near-significant trends of increasing home range size with greater area of defensible fuel profile zone ($p = 0.08$) and group selection harvesting ($p = 0.06$).

Four studies reported that thinning or partial harvesting near nests or roosts displaced spotted owls from those areas (Forsman et al. 1984, King 1993, Hicks et al. 1999, Meiman et al. 2003; also J. Reid, pers. comm.). The only study to describe this effect for more than two NSOs suggested that pairs' responses to harvesting near their nests depended on the intensity of the harvest, whether or not habitat in the nest area was excluded from harvesting, and whether or not suitable alternative habitat was available within the home range (Forsman et al. 1984).

At least two studies have evaluated potential relationships between spotted owl demographic rates and forest thinning. On the Hoopa Indian Reservation in the Western Klamath region of California, Matthews et al. (2008) found a negative association between survival of NSOs and pre-commercial thinning (prescription not described) of brushy-poletimber forest (conifer forest 10-20 yrs with a dense

brush layer). The researchers attributed this finding to a long-term negative effect of thinning on dusky-footed woodrat populations in the area (see below regarding timber harvest effects on spotted owl prey). Tempel et al. (*in press*) examined associations between CSO demographic rates at 70 territories in the central Sierra Nevada and area of "medium-intensity" harvesting (generally, retention of trees ≥30 in DBH and 40% mean DBH, reduction of fuels). Their best performing model explaining reproduction included a negative effect of medium-intensity harvesting, although evidence for this was statistically weak (95% CI of the beta coefficient broadly overlapped zero).

A recent study modeled recruitment of habitat for NSOs under a particular wildfire and forest thinning scenario in the Klamath and "dry Cascades" regions and concluded that negative effects of thinning on NSOs will outweigh potential benefits to the subspecies due to reduced risk of severe wildfire (Odion et al. 2014). Some of this study's assumptions do not appear to reflect the current scientific understanding of spotted owl-habitat relationships and wildfire and thinning effects on the species. For example, recruitment of NSO habitat was broadly defined in the study (recruitment of forest with basal area ≥120 ft^2/ac) and does not reflect the subspecies' relationships with other structural attributes, such as canopy cover, canopy layering, and large diameter trees. This study was also based on an assumption that commercially thinned and severely burned areas are always unsuitable for NSOs. NSOs are known to nest, roost, and forage in thinned areas (see above) and patchy severe fire appears to benefit NSOs in some areas, provided it does not result in extensive loss or degradation of nesting and roosting habitat (see above and Ch. 3). This study was further based on an assumption that federal agencies will blindly apply thinning to landscapes, including substantial areas of NSO habitat, rather than strategically locating treatments in areas more likely to burn at high severity and less likely to be used by NSOs (e.g., upper slopes, southwesterly aspects, densely-canopied young forest: Skinner and Taylor 2006, Skinner et al. 2006, Irwin et al. 2012). Modeling simulations have suggested that thinning can be strategically applied to relatively small portions of landscapes to reduce fire risk while minimizing negative short-term effects on spotted owls (Ager et al. 2007, Lehmkuhl et al. 2007, Prather et al. 2008).

Federal agencies have expressed support for widespread thinning to reduce the risk of severe wildfire in dry forests within the NSO's range (USFS and BLM 1994, USFWS 2011a, 2012a). The review provided in Chapter 3 suggests that spotted owls are often resilient to wildfire, and may benefit from some amount of low-to-moderate severity, mixed severity, or patchy fire in interior forests in southern Oregon and California, but that extensive severe fire can negatively affect the species by reducing amounts and contiguity of nesting and roosting habitat. This conclusion might appear to support widespread thinning to reduce the risk of large severe fires in NSO home ranges. However, preliminary findings of negative effects of thinning on spotted owls and the overall lack of reliable information on the topic suggest that rigorous research is needed to determine how best to balance tradeoffs for habitat conservation and fuels reduction objectives. If thinning is applied prior to conducting rigorous research of its effects on NSOs, research of the subspecies' habitat and prey relationships suggests that it should generally be located well away from activity centers and focused in young, closed-canopy stands with poorly developed brush layers. Thinning in these stands has the potential to increase habitat heterogeneity and accelerate development of complex, older-forest structure for NSOs and their prey (Carey 2006; but see below regarding effects of thinning on primary prey species). Planning of treatments should also integrate regional or local information about relationships between wildfires and topography (see Ch. 3), the composition of NSO diets or prey communities, and other ecological factors that could influence how thinning affects wildfires and NSOs.

Timber Harvest Effects on Prey

The primary prey for NSOs in California are dusky-footed woodrats, northern flying squirrels (*Glaucomys sabrinus*), and tree voles (*Arborimus* spp.) (Zabel et al. 1995, White 1996, Ward et al. 1998, Farber and Whitaker 2005, Diller et al. 2010, Klamath National Forest, unpubl. data). Other important prey in the state (either in terms of frequency or biomass contributions to diets) include other voles (*Myodes californicus*, *Phenacomys* spp., and *Microtus* spp.), deer mice (*Peromyscus* spp.), pocket gophers (*Thomomys* spp.), broad-footed moles (*Scapanus latimanus*), and juvenile brush rabbits (*Sylvilagus bachmani*) and snowshoe hares (*Lepus americanus*). These species have a broad array of habitat associations and thus, likely respond quite differently to timber harvesting and other forest disturbances. The review below focuses solely on timber harvest effects on the three primary prey species for NSOs in California. It is important to acknowledge, however, that NSOs typically have broad diets (see diet studies cited above) and that other prey species may also influence spotted owl demographic rates (Ward and Block 1995, Rosenberg et al. 2003).

Dusky-footed woodrats can occur in relatively high abundances in old forest, particularly in riparian areas and other locations with a well developed understory or brush layer (Carey et al. 1992, 1999). However, they generally reach their highest abundances in stands of brushy poletimber that develop following severe disturbances (Carey et al. 1992, 1999, Sakai and Noon 1993, Anthony et al. 2003, Hamm et al. 2007). Thus, intensive harvesting of intermediate-age stands could potentially result in temporary increases in abundance of dusky-footed woodrats. There is little information regarding effects of less intensive harvesting on dusky-footed woodrats. Hamm and Diller (2009) rarely found dusky-footed woodrats in thinned stands on Green Diamond Resource Company lands in the Redwood Region. They suggested that thinning without prescribed burning was insufficient for promoting growth of the disturbance-adapted shrubs locally favored by the species (see Ch. 3 regarding short-term effects of fire on prey). Matthews et al. (2008) did not directly evaluate effects of thinning on dusky-footed woodrats in the California Klamath. However, they suggested that the negative association between NSO survival and pre-commercial thinning of brushy-poletimber forest in their study was likely due to long-term declines in woodrats following thinning.

Densities and demographic rates of northern flying squirrels are positively associated with habitat elements found in forests (e.g., arboreal lichens, truffles, and snags: Rosenberg and Anthony 1992, Carey 1995, Waters and Zabel 1995, Gomez et al. 2005, Meyer et al. 2005, Lehmkuhl et al. 2006). Thus, they are likely to respond negatively to intensive forms of timber harvesting (e.g., Waters and Zabel 1995). Northern flying squirrels are also generally sensitive to habitat fragmentation caused by intensive harvesting (Smith 2007). For example, Rosenberg and Raphael (1986) found that densities of northern flying squirrels in the California Klamath Province were substantially lower in the smallest and most insular habitat patches (due to surrounding clearcut harvesting) than in the largest and best connected patches.

Research concerning the effects of thinning and other lower-intensity forms of harvesting on northern flying squirrels has generated inconsistent results (e.g., Carey 2000, Ransome and Sullivan 2002, Ransome et al. 2004, Gomez et al. 2005, Manning et al. 2012). Some of the inconsistency appears to be due to whether treated young stands are compared with structurally simple young stands (e.g., Gomez et al. 2005), structurally complex young stands (e.g., Carey 2000), or stands that have not recently experienced harvesting (Holloway and Smith 2011). The available research suggests that treated stands are more likely to contain relatively low abundances of northern flying squirrels when compared with structurally complex or mature and old stands, whereas they may exhibit similar or even higher

abundances when compared with structurally simple young stands. Harvest intensity and levels of retention appear to be another major determinant of thinning effects on northern flying squirrels, with higher intensity thinning (lower retention levels) having stronger negative effects (Meyer et al. 2007, Holloway and Smith 2011, Manning et al. 2012; but see Ransome et al. 2004). Whether thinning is patchy or uniform (in terms of location and intensity) might also be important. For example, thinning can reduce the availability of truffles, the northern flying squirrel's primary food, for more than 10-20 years; but variable-density thinning appears to be less harmful than commercial thinning (Waters et al. 1994, Colgan et al. 1999, Luoma et al. 2003, Meyer et al. 2005).

Tree voles generally occur at higher densities in old forests than in young forests (reviewed in Sztukowski and Courtney 2004, USFWS 2011c) and selectively use forests containing higher concentrations of habitat elements typically found in older stands (e.g., older stand age, larger diameter downed wood, greater basal area: Dunk and Hawley 2009). Tree voles are thought to be highly vulnerable to logging and other disturbances that reduce the extent and contiguity of old forests (Carey 1991, Huff et al. 1992, Hayes 1996, Adam and Hayes 1998, USFWS 2011c). Some tree vole populations occur in intensively managed landscapes with little or no old forest (e.g., Thompson and Diller 2002). However, the U.S. Fish and Wildlife Service (2011b) noted that "the limited evidence available suggests that tree vole occupation of younger forest stands may be relatively short-lived (Diller 2010, pers. comm.) or intermittent (Hopkins 2010, pers. comm.)." Based on the natural histories of these species, reducing or fragmenting older forest could negatively affect them; but retention of older Douglas-fir (*Pseudotsuga menziesii*) trees and patches of well-connected canopy might ameliorate those impacts (Hayes 1996, Adam and Hayes 1998, USFWS 20011b). Clear-cutting and other severe disturbances should have the strongest effects on tree voles, due to the species' diet, nesting habitat associations, arboreal mode of travel, and apparently poor mobility (USFWS 2011c). However, for these same reasons, thinning could also negatively affect tree voles (Wilson and Forsman 2013).

Habitat Lost to Past Timber Harvesting (1800s to 1994)

Rigorous research has shown that the fitness of NSOs in the southern part of their range is highest in landscapes with large concentrations of suitable breeding habitat (reviewed above). The following review shows that the current availability of suitable breeding habitat was strongly affected by past timber harvesting, which removed or modified the majority of old forest that existed historically.

There do not appear to be any existing estimates of the amount of suitable NSO habitat that existed at the time of Euro-American settlement (early to mid-1800s). Nesting-roosting habitat for NSOs generally occurs in relatively old, structurally complex conifer forest (Blakesley 2004). It is therefore, reasonable to evaluate historical trends in old conifer forest as a rough proxy for changes in amounts of suitable NSO habitat (USFWS 1990). Estimates reviewed for the NSO's federal listing determination indicated that approximately 18-24 million acres of old forest existed in western Oregon and Washington and northwestern California during the early to mid-1800s (USFWS 1990). These estimates did not include all regions or potentially suitable forest types within the subspecies' range. After including all regions and conifer forests, Strittholt et al. (2006) estimated that about 40 million acres of old conifer forest (>150 yrs) existed at the time of Euro-American settlement (Table 2.1). This is a crude approximation, as it is based on incomplete historical information and an assumption that nearly all pre-settlement conifer forest was old (i.e., had not experienced severe disturbance within the previous 150 years). However, Strittholt et al. (2006) noted that their regional estimates closely matched previous estimates for similar regions and forest types, suggesting that they provide a reasonable baseline for comparison with contemporary forest conditions.

Using satellite imagery, Strittholt et al. (2006) estimated that 11.5 million acres of old conifer forest existed in 2000 (Table 2.1). Thus, an estimated 72% of old conifer forest was lost in the Pacific Northwest during the 19th and 20th centuries (Table 2.1). This estimated post-settlement loss of old conifer forest is similar to earlier estimates of 60-88% reviewed in the NSO's federal listing determination (USFWS 1990). Strittholt et al. (2006) did not provide estimates of old forest declines for California alone. Old conifer forests declined by 62% in the Klamath provinces ("Klamath-Siskiyou Forests") and 79% in the eastern Cascades provinces ("Eastern Cascades Forests"), both of which substantially overlap with the NSO's range in northern California. Other than in two small regions surrounding major population centers in Washington and Oregon, declines in old conifer forest were primarily caused by widespread intensive logging (Strittholt et al. 2006). Mountainous terrain in the Klamath and eastern Cascades limited timber harvesting compared with more accessible areas but major losses of old conifer forest nonetheless occurred in those areas (Strittholt et al. 2006). Strittholt et al. (2006) did not evaluate trends in amounts of old forest for the Redwood Province but other sources estimated that 85-96% of old redwood forest was lost to intensive timber harvesting during the post-settlement period (USFWS 1992).

Table 2.1: Area (ha) of Pacific Northwest ecoregions and estimated historical (early to mid-1800s) and contemporary (2000) extents of old (>150 yrs) and mature (50-150 yrs) conifer forest within them (from Strittholt et al. 2006).

	Cascade Mountain Leeward Forests	*North Cascades Forests*	*Puget Lowland Forests*	*Central Pacific Coastal Forests*	*Central & Southern Cascades Forests*	*Eastern Cascades Forests*	*Klamath-Siskiyou Forests*	*Willamette Valley Forests*
Ecoregion area	1,600,444	1,278,056	1,719,726	4,267,988	4,481,279	5,398,139	5,033,181	1,487,769
Historical old conifer area	960,279	766,844	1,289,794	3,627,790	3,361,005	3,238,883	2,516,625	371,942
Percentage of ecoregion	60	60	75	85	75	60	50	25
Current old conifer area	420,394	511,396	67,353	668,281	1,328,796	687,836	946,394	34,993
Percentage of historical old conifer	44	67	5	18	39	18	38	9
Percent change	−56	−33	−95	−82	−61	−79	−62	−91
Mature conifer area	285,441	203,994	229,634	683,098	899,266	947,215	1,239,586	270,362
Percentage of historical old conifer	30	27	18	19	27	25	49	73
Combined area	705,835	715,391	296,987	1,351,379	2,228,063	1,635,051	2,185,980	305,355
Percentage of historical old conifer	74	93	23	37	66	43	87	82

Strittholt et al. (2006) reported that the majority of old (78%) and mature (50%) conifer forest in 2000 existed on public lands. Nearly all of the remaining old redwood forest likewise occurs on public lands, such as California state parks. Much of the current difference among ownerships in amounts of older forest and suitable breeding habitat is due to past timber harvest rates. For example, loss of forest to harvesting during the 1970s through early 1990s occurred at substantially higher rates on private timberlands than on federal lands (e.g., >2 times faster in western Oregon) (Cohen et al. 2002, Staus et al. 2002, Healey et al. 2008). Nonetheless, an estimated 32% of suitable breeding habitat for NSOs occurred on non-federal lands at the time of the Northwest Forest Plan's implementation (1994), so conservation efforts for NSOs on non-federal lands remain important.

Although timber harvesting was substantially curtailed on federal lands following implementation of the Northwest Forest Plan (Healey et al. 2008, Kennedy et al. 2012; reviewed below), biologists noted the possibility that NSOs would continue to decline for many years due to lag effects of past harvesting (Courtney et al. 2004). The NSO has a relatively low reproductive rate and might therefore be unable to

immediately recover following removal or reduction of threats (Noon and Biles 1990). Furthermore, substantial recruitment of old forest and suitable nesting-roosting habitat could take multiple decades in areas that formerly experienced widespread intensive harvesting (Moeur et al. 2011; see below). Past harvesting could therefore be among the causes of continuing poor demographic performance of some NSO populations (Courtney et al. 2004). Forsman et al. (2011) noted, however, that some populations are declining on lands not previously subjected to widespread intensive timber harvesting (e.g., some National Parks). Based on this observation, they concluded that lag effects of past timber harvesting poorly explain continuing population declines. Yet, it is possible that historical timber harvesting does continue to contribute to population declines but that this effect is obscured by that of other stressors, such as competition with invasive barred owls (see Ch. 4). Regardless of potential lag effects of historical harvesting on NSOs, timber harvesting continues to occur at high rates on private lands and is one of the primary sources of habitat loss for the subspecies (Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012; reviewed below).

Habitat Lost to Contemporary Timber Harvesting (1994-2007)

Davis and Dugger (2011) estimated NSO habitat trends following implementation of the Northwest Forest Plan. Their analyses were mostly limited to federal lands within the Plan area but they also estimated habitat trends on non-federal lands, as reported in the 2011 revised NSO recovery plan (USFWS 2011a). In addition to these analyses, the following review includes results of research by Moeur et al. (2011), which provide additional insight into recent habitat trends for NSOs on non-federal lands. This review does not include habitat trend estimates based on federal ESA Section 7 consultation records (Bigley and Franklin 2004, USFWS 2012b). These records provide a less consistent and complete data source than those used by Davis and Dugger (2011) (see Bigley and Franklin 2004). They may also overestimate habitat changes since they evaluate effects of planned projects, which may be greater than what is actually implemented (Bigley and Franklin 2004).

Davis and Dugger (2011) used remotely sensed (satellite imagery) and forest inventory plot vegetation data to model changes in habitat suitability for NSOs during the first 15 years of the Northwest Forest Plan (1994-2007 in California and 1996-2006 in Oregon and Washington). They modeled habitat suitability based on habitat attributes surrounding thousands of NSO pair locations. Suitable breeding habitat was defined as having both a probability of owl presence greater than expected based on random chance and environmental conditions typical of those found around nesting and roosting pairs. Habitat loss was defined as a change in suitability rank from suitable or highly suitable to marginal or unsuitable due to vegetation changes caused by forest disturbances. Davis and Dugger (2011) did not estimate recruitment of, or net changes, in breeding habitat. They felt that their remotely sensed data poorly captured the kinds of slow and subtle habitat changes that occur during development of intermediate-aged and older stands. However, Moeur et al. (2011) estimated trends in mature and old forests during the same time period, which could provide insight into net changes in breeding habitat for NSOs.

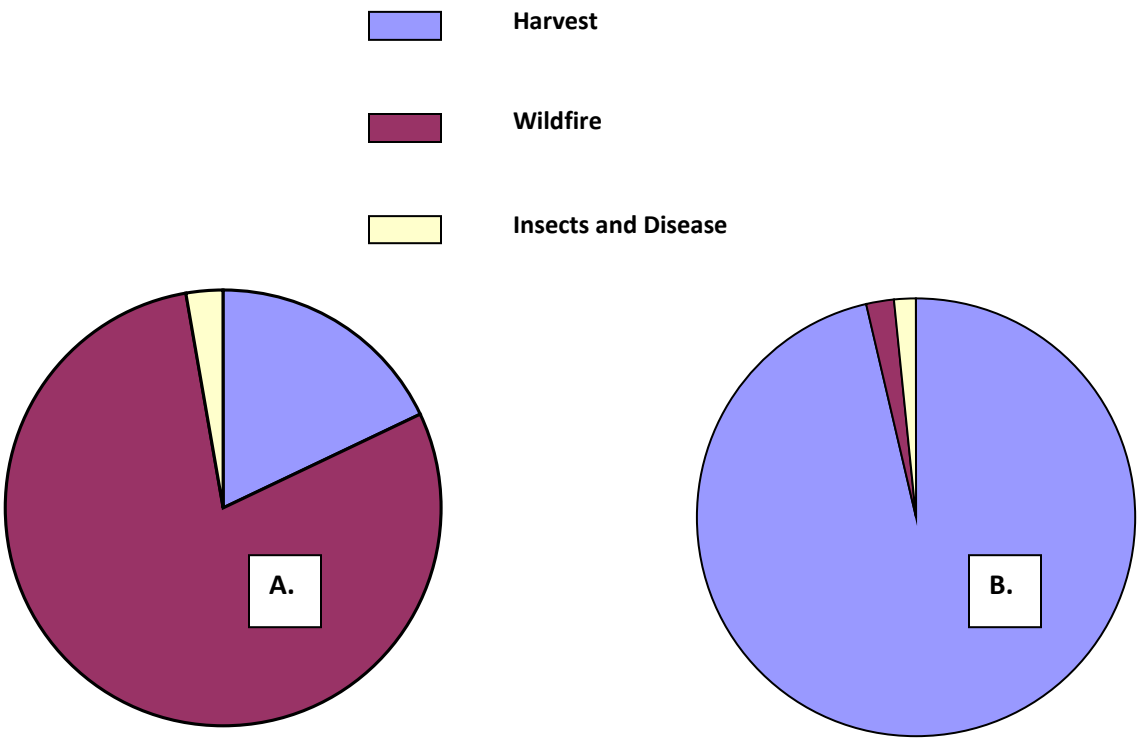
Table 2.2 shows estimated gross losses of suitable NSO breeding habitat to timber harvesting on federal and non-federal lands during the first 15 years of the Northwest Forest Plan (Davis and Dugger 2011, USFW 2011a). Timber harvesting was responsible for a gross loss of about 54,000 acres (0.6%) of suitable breeding habitat on federal lands. This loss likely had little rangewide effect on NSOs but could have impacted the subspecies at local or regional scales. For example, harvesting resulted in a 3% gross loss of suitable breeding habitat on federal lands in the California Cascades, where habitat was already relatively limited. Approximately 92% of total suitable breeding habitat lost to timber harvesting occurred on non-federal lands. In contrast with federal lands, nearly all estimated gross habitat loss on

non-federal lands was due to timber harvesting rather than natural disturbances (Figure 2.1; see Ch. 3). In just 11-13 years, timber harvesting caused an estimated rangewide gross loss of 625,600 acres (15%) of suitable breeding habitat on non-federal lands. The largest losses on non-federal lands occurred in Oregon (301,200 ac, 22%) and Washington (234,200 ac, 19%). Non-federal lands in California experienced lower gross losses of suitable breeding habitat to harvesting (90,200 acres, 6%). Nonetheless, losses in all three states were substantial given the short time frame during which they occurred and the likelihood that little of the loss was offset by recruitment of suitable breeding habitat during that period (see below).

Table 2.2: Estimated gross losses of suitable NSO breeding habitat on federal and non-federal lands due to timber harvesting during 1994-2007 in California and 1996-2006 in Oregon and Washington (adapted from Davis and Dugger 2011, USFWS 2011a).

State	Ownership	Province	1994/1996 Ac	Harvest Ac	Harvest %
California	**Federal**	CA Cascades	213,200	6,500	3.0%
		CA Klamath	1,489,800	4,400	0.3%
		CA Coast	145,400	300	0.2%
		CA Federal Total	**1,848,400**	**11,200**	**0.6%**
	Non-Federal		**1,556,700**	**90,200**	**5.8%**
	Combined		**3,405,100**	**101,400**	**3.0%**
Oregon	**Federal**	OR Coast Range	611,200	3,300	0.5%
		Western OR Cascades	2,258,700	13,900	0.6%
		Eastern OR Cascades	402,900	5,800	1.4%
		Willamette Valley	3,400	100	2.9%
		OR Klamath	985,000	6,800	0.7%
		OR Federal Total	**4,261,200**	**29,900**	**0.7%**
	Non-Federal		**1,382,400**	**301,200**	**21.8%**
	Combined		**5,643,600**	**331,100**	**5.9%**
Washington	**Federal**	Olympic Peninsula	763,100	500	0.1%
		Eastern WA Cascades	673,600	8,100	1.2%
		Western WA Cascades	1,283,000	3,700	0.3%
		Western WA Lowlands	24,700	400	1.6%
		WA Federal Total	**2,744,400**	**12,700**	**0.5%**
	Non-Federal		**1,258,900**	**234,200**	**18.6%**
	Combined		**4,003,300**	**246,900**	**6.2%**
Rangewide	**Federal**		**8,853,800**	**53,800**	**0.6%**
	Non-Federal		**4,198,000**	**625,600**	**14.9%**
	Combined		**13,051,800**	**679,400**	**5.2%**

Figure 2.1: Proportions of suitable breeding habitat loss attributed to harvesting, wildfire, and insects and diseases on (A) federal lands and (B) non-federal lands during 1994-2007 (adapted from Davis and Dugger 2011 and USFWS 2011a).



The USFWS (2011a) and Davis and Dugger (2011) did not describe regional habitat trends for non-federal lands. However, insight into regional habitat trends on non-federal lands can be obtained from trends in mature and old forest during the same time period. Moeur et al. (2011) reported substantial gross losses of mature and old forest (mean DBH ≥20 in) on non-federal lands during the first 15 years of the Northwest Forest Plan. The largest gross losses, in terms of acreage, occurred in the Western Washington Lowlands (387,200 ac, 49%), Oregon Coast Range (362,500 ac, 50%), and California Coast Range (259,000 ac, 35%). All provinces and states within the NSO's range experienced large proportional losses, ranging from 31% in the Eastern Washington Cascades to 48% and 52% in the Klamath and Eastern Cascades of Oregon. Confirming the results of Davis and Dugger (2011; Figure 2.1), Moeur et al. (2011) found that gross losses of mature and old forest on non-federal lands were almost entirely due to timber harvesting (also see Kennedy et al. 2012).

Moeur et al. (2011) reported that gross loss of mature and old forest was substantially offset by recruitment into that habitat class. They noted, however, that given the short length of the monitoring period (10-14 yrs), recruitment was "likely due to incremental stand growth over the 20-in diameter threshold, or from understory disturbances that removed smaller diameter trees and raised the average stand diameter above the threshold, rather than from an increase in forests of much larger and older trees." Thus, it is unlikely that there was substantial recruitment of suitable and highly suitable breeding habitat for NSOs during this time period. This conclusion is supported by Davis and Dugger (2011), who found that most of the detectable habitat recruitment during their monitoring period occurred in the marginal suitability class, which more closely resembled their definition for dispersal habitat than for breeding habitat. Even if all mature and old forest recruited during the first 15 years of the Plan provided suitable breeding habitat for NSOs, non-federal lands in California still experienced a net decline in area of mature and old forest during that period, and those in Washington and Oregon fared substantially worse (Moeur et al. 2011).

Future Harvesting in California

It is impossible to provide reliable projections of future timber harvesting or its effects on NSOs in California. Federal agencies have expressed support for widespread thinning to address wildfire risk on public lands in the state but there do not appear to be any projections of future harvest volume or effects on NSOs from these activities (USFS and BLM 1994, USFWS 2011a, 2012a). Documents associated with Habitat Conservation Plans for private timberlands in California project substantial impacts of harvesting on some ownerships and relatively low impacts on others. Many landowners, in the state, including some large industrial timber companies, conduct timber harvesting outside of Habitat Conservation Plans. The state requires evaluation of potential environmental impacts of all Timber Harvest Plans but both landowners and responsible agencies have used inconsistent methods for conducting these evaluations. For example, some entities have strictly adhered to the state's Forest Practice Rules (CAL FIRE 2014), others have relied on poorly described and vetted variants of those rules (e.g., "option g+"), and still others have opted to follow the Yreka or Arcata U.S. Fish and Wildlife Service Offices' (2009, 2011b) recommendations. Based on an in-depth review of research concerning the NSO's habitat and spatial relationships, the U.S. Fish and Wildlife Service Yreka Office (2009) recommended sweeping changes to NSO habitat retention guidelines in the Forest Practice Rules for California's northern interior. These recommendations are more scientifically supportable than are habitat retention guidelines in the Forest Practice Rules (CAL FIRE 2014), as they incorporate the large body of research of NSO-habitat relationships conducted since 1992 when guidelines in the Forest Practice Rules were created. In addition they were designed to enable CAL FIRE personnel lacking expertise with NSO-habitat relationships to properly determine if take would occur. However, the state

has not officially adopted these recommendations or any other changes that incorporate the tremendous body of research and biological expertise concerning NSO-habitat relationships developed since 1992 (USFW 2009). Furthermore, since 2008, when the US Fish and Wildlife Service largely ceased providing technical assistance with timber harvest reviews in northern California, relatively few Timber Harvest Plans have been reviewed by personnel with sufficient biological expertise to evaluate whether or not take will occur. Lacking reliable harvest and take projections, and barring a major change in the legal or regulatory framework protecting NSOs, there is currently no reason to conclude that timber harvest effects on NSOs in California will substantially decline in the near future.

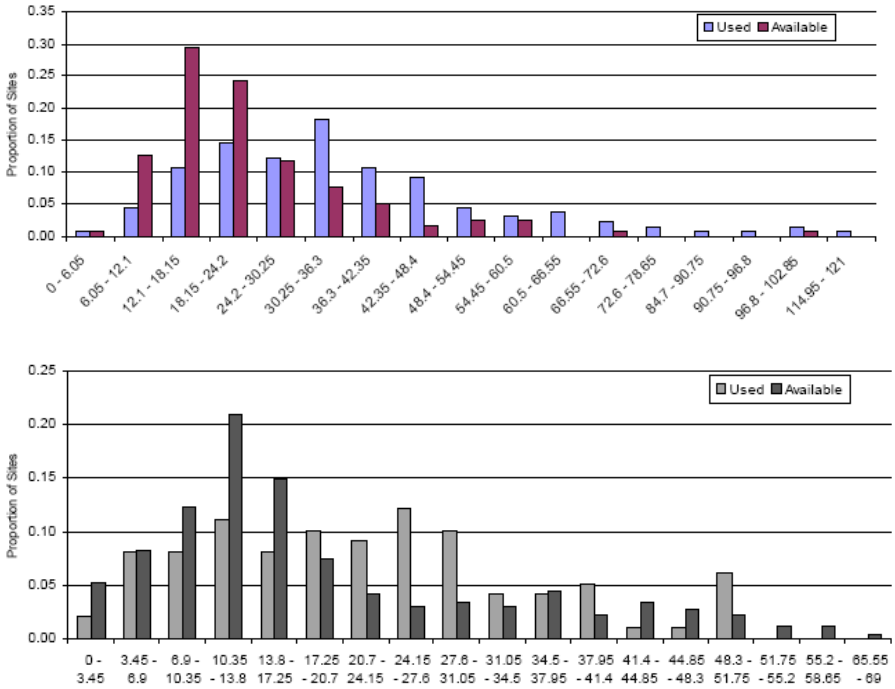
Acknowledgements

I am grateful to Ray Davis and Ken Hoffman for their insightful reviews of this chapter.

Appendix 2.1

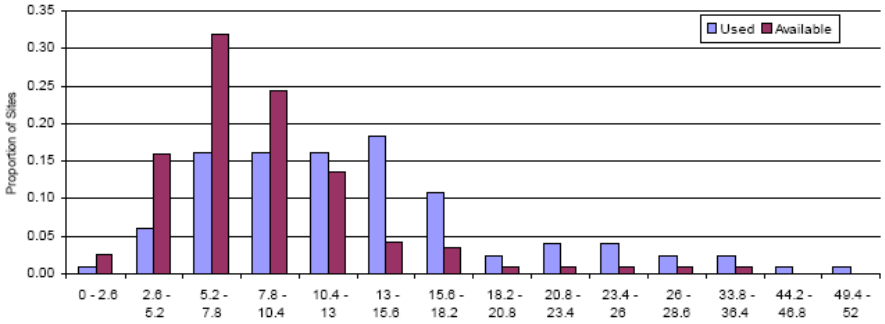
USFWS GNN (see USFWS 2011a) histograms showing use by NSOs versus availability of select habitat attributes at a landscape-scale (200 ha, 494 ac) on Mendocino Redwood Co. (left column) and Green Diamond Resource Co. lands (right column).

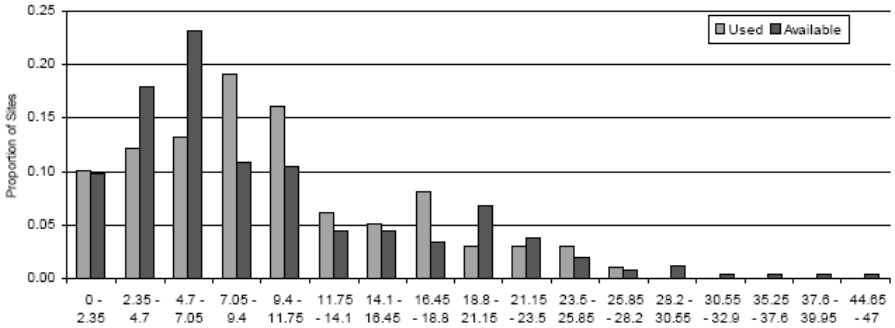
Live conifer trees per hectare ≥20 inches DBH:



Appendix 2.1 (continued)

Basal area of live conifers ≥20 inches DBH:

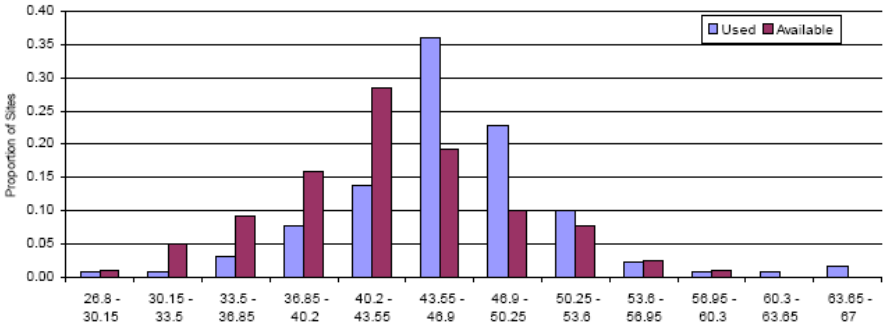


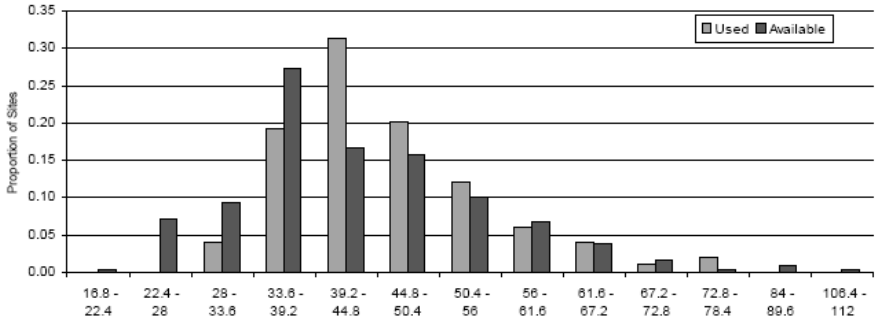


Appendix 2.1 (continued)

USFWS GNN (see USFWS 2011a) histograms showing use by NSOs versus availability of select habitat attributes at a landscape-scale (200 ha, 494 ac) on Mendocino Redwood Co. (left column) and Green Diamond Resource Co. lands (right column).

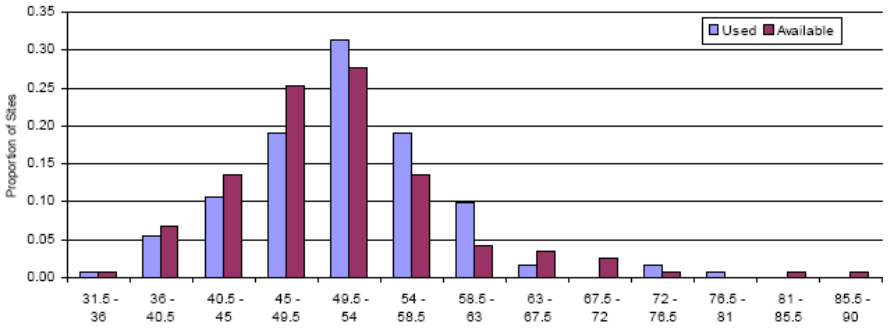
Basal area weighted mean diameter of all live conifers:

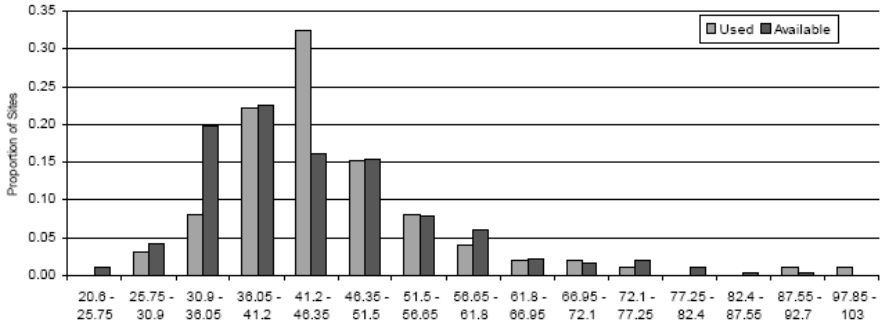




Appendix 2.1 (continued)

Basal area weighted stand age:

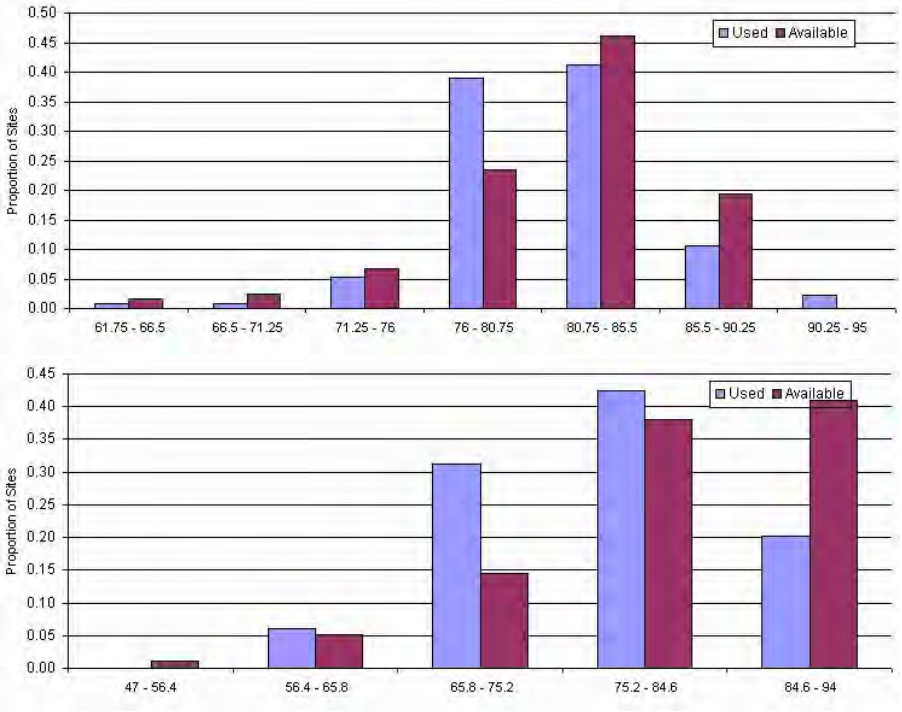




Appendix 2.1 (continued)

USFWS GNN (see USFWS 2011a) histograms showing use by NSOs versus availability of select habitat attributes at a landscape-scale (200 ha, 494 ac) on Mendocino Redwood Co. (left column) and Green Diamond Resource Co. lands (right column).

Canopy cover:



Appendix 2.2

"Deconstructed" habitat suitability modeling (see text) for NSOs in the Redwood Province showing mean (SD, CV) values of select habitat structural attributes at the 200 ha (494 ac) scale by relative habitat suitability rank (USFWS 2011a, unpubl. data).

Variable	Relative Habitat Suitability					
	Very Low	**Low**	**Med. Low**	**Med.**	**Med. High**	**High**
Strength of Selection*	-9.2	-2.9	-1.3	1.6	3.2	8.6
Percent of Region	16.3	24.5	26.2	22.4	9.7	0.9
Nesting-Roosting (ha)	57.9 (43.2, 75)	69.4 (40.8, 59)	79.9 (37.3, 47)	87.6 (33.6, 38)	94.3 (31.1, 33)	105.5 (30.8, 29)
Canopy Cover All Trees (%)	71.2 (23.2, 33)	75.2 (20.7, 28)	78.9 (18.1, 23)	81.0 (16.2, 20)	82.1 (15.5, 19)	82.9 (15.7, 19)
Canopy Cover Conifer (%)	43.9 (31.8, 72)	48.8 (30.0, 61)	53.4 (28.3, 53)	57.4 (27.2, 47)	61.4 (26.5, 43)	64.6 (26.4, 41)
BA Conifers ≥50 cm (m^2/ha)	10.6 (20.7, 195)	12.5 (23.0, 184)	14.1 (24.8, 176)	15.2 (25.6, 168)	17.6 (30.1, 171)	25.2 (45.9, 182)
BA Live Trees ≥75cm (m^2/ha)	7.3 (17.6, 241)	8.5 (20.1, 236)	9.3 (21.8, 234)	9.3 (22.4, 241)	10.4 (27.1, 261)	17.0 (44.0, 259)
Density Trees ≥50 cm (no./ha)	32.3 (37.3, 115)	36.1 (38.4, 106)	39.8 (40.0, 101)	42.5 (42.1, 99)	45.4 (44.5, 98)	50.0 (46.1, 92)
Density Trees ≥75 cm (no./ha)	8.2 (14.8, 180)	9.2 (15.6, 170)	9.9 (16.0, 162)	10.0 (15.5, 155)	10.4 (15.3, 147)	12.8 (16.8, 131)
Density Conifers ≥50 cm (no./ha)	22.1 (34.7, 157)	25.5 (36.4, 143)	28.9 (38.3, 133)	32.6 (40.7, 125)	37.3 (43.6, 117)	43.1 (45.6, 106)
Density Conifers ≥ 75 cm (no./ha)	6.6 (14.5, 220)	7.6 (15.4, 203)	8.4 (15.7, 187)	8.7 (15.2, 175)	9.4 (15.1, 161)	12.0 (16.7, 139)
Density Conifers ≥100 cm (no./ha)	2.5 (7.7, 308)	2.9 (8.4, 290)	3.2 (8.8, 275)	3.1 (8.3, 268)	3.2 (8.5, 266)	4.7 (10.4, 221)
Mean DBH Conifers by BA (cm)	42.8 (34.5, 81)	48.5 (35.5, 73)	51.7 (35.4, 68)	52.1 (34.0, 65)	52.9 (36.1, 68)	60.8 (51.1, 84)
QMD Dominant/Codominant Conifers (cm)	35.7 (29.1, 82)	40.2 (29.9, 74)	42.7 (29.7, 70)	42.6 (28.3, 66)	42.7 (29.7, 70)	48.1 (41.5, 86)

*Calculated as the proportion of activity centers in a habitat suitability class divided by the proportion of the modeling region in that class.

Ch. 3: Wildfire and Salvage Logging

Introduction

Recent status reviews have identified wildfire as a primary threat to the recovery of the NSO (Courtney et al. 2004, Davis et al. 2011, USFWS 2011a). Much of this concern was based on recent loss of suitable breeding habitat to wildfires and to the risk of extensive severe fires occurring in the future (Davis and Dugger 2011, USFWS 2011a). Other researchers and stakeholders have questioned the scientific basis of claims that wildfires pose a threat to NSOs and have expressed distrust of agency recommendations for widespread use of forest thinning to reduce fire risk (e.g., Hanson et al. 2009, Heiken 2010, DellaSala et al. 2013).

There is currently limited information with which to evaluate responses of spotted owls to wildfires and post-fire salvage logging. This research suggests that wildfires have variable and complex effects on the species (Table 3.1; reviewed below). This is unsurprising given differences in wildfires, research methods, study areas, and spotted owl subspecies and populations. Nonetheless, patterns are evident in the literature concerning spotted owl responses to wildfires and salvage logging and these can be evaluated in light of the species' habitat and prey relationships. Currently available research suggests that low-to-moderate, mixed-severity, or patchy wildfires have limited effects on spotted owls (Table 3.1). In fact, such fires may benefit NSOs in the southern portion of their range by contributing to landscape-level habitat heterogeneity associated with high fitness (Franklin et al. 2000). In contrast, large-scale severe (stand-replacing) wildfires appear to have strong negative effects on spotted owls (Table 3.1; reviewed below). This likely occurs when fires excessively modify, reduce, or fragment concentrations of suitable nesting, roosting, and foraging habitat needed for survival and reproduction (Franklin et al. 2000, Dugger et al. 2005, Schilling et al. 2013; reviewed below and in Ch. 2). Negative effects of extensive severe wildfires appear to be exacerbated by post-fire salvage logging, which structurally simplifies burned areas and removes important habitat legacies for prey (Clark 2007, Lee et al. 2012, 2013, Clark et al. 2013, Comfort 2013; reviewed below).

Regardless of scientific uncertainty concerning spotted owl responses to wildfire, it is clear that recent large wildfires have caused tremendous loss, degradation, and fragmentation of suitable breeding habitat for NSOs on federal lands (Davis and Dugger 2011, USFWS 2011a; also see Healey et al. 2008, Moeur et al. 2011). This is cause for concern because recovery of the subspecies largely relies on habitat protection on federal lands (USFWS 2011a). Furthermore, much of the climate change research indicates that wildfires will be an increasing source of large-scale habitat change in California and other western states during coming decades (Westerling et al. 2006, Lenihan et al. 2008, Westerling and Bryant 2008, Littell et al. 2009, Moritz et al. 2012, Stavros et al. 2014). These concerns have prompted ecologists and federal agencies to advocate widespread forest thinning and other forms of active management to reduce wildfire risk within the range of the NSO (USFS and BLM 1994, USFWS 2008, 2011a, 2012a, Franklin and Johnson 2012). However, the limited information currently available suggests that spotted owls often respond negatively to forest thinning in the short-term (reviewed in Hansen and Mazurek 2010, USFWS 2011a; see Ch. 2); and possibly in the long-term as well (Matthews et al. 2008, Tempel et al. *in press*). Further research is needed to determine how best to balance

potential tradeoffs in objectives for NSO conservation and fuels reduction at multiple spatial and temporal scales. Currently available information suggests that spotted owls tolerate and possibly benefit from low severity, mixed severity, or patchy fire, suggesting that prescribed fire and allowing wildfires to burn under favorable conditions is compatible with conservation objectives for the species (Bond et al. 2002, 2009, Roberts and van Wagtendonk 2006, Roberts et al. 2011, Keane et al. 2011, 2012, Lee et al. 2012, 2013, Comfort 2013, Eyes 2014).

Wildfire Effects on Spotted Owls

Indirect Evidence

Research of associations between landscape-scale habitat attributes and the demography and presence of NSOs has consistently found that the subspecies benefits from some form of habitat heterogeneity in the southern portion of its range (e.g., ecotones or edges between different vegetation classes) (Franklin et al. 2000, Zabel et al. 2003, Olson et al. 2004, Dugger et al. 2005, Carroll and Johnson 2008, Diller et al. 2010, Schilling et al. 2013; reviewed in Ch. 2, including studies' definitions of spotted owl habitat). Yet, these same studies have also strongly demonstrated the importance of large concentrations of suitable breeding habitat around activity centers (reviewed in Ch. 2). Based on this research, wildfires likely have positive effects on NSOs in California when they contribute to beneficial forms of habitat heterogeneity and negative effects when they substantially reduce or degrade suitable habitat around breeding season activity centers. Extensive stand-replacing wildfires have the potential to remove or fragment core concentrations of suitable breeding habitat across multiple NSO territories. These fires, therefore, have the greatest likelihood of substantially impacting NSO populations. Smaller, less severe, or patchy wildfires may impact fewer NSO territories and have weaker negative effects on populations, burn in a manner that contributes to beneficial forms of habitat heterogeneity, or have variable effects among territories.

Direct Evidence

Several studies have investigated responses of NSOs to wildfires (Table 3.1). These studies provide crucial information for evaluating wildfire as a potential threat to the subspecies. However, their inferences are limited due to small sample sizes and short time frames in all cases, the confounding effects of post-fire salvage logging in one case, and pooling of data from all three spotted owl subspecies in another case (Table 3.1; see below). In order to supplement these studies, research of wildfire effects on California spotted owls (*S. o. occidentalis*; CSOs) and Mexican spotted owls (*S. o. lucida*; MSOs) is also included in the following review (Table 3.1). Because inferences from these studies are likewise limited, and given differences among fires, spotted owl subspecies and populations, and research methods, each project is reviewed as a "case study". Relatively thorough descriptions of these studies allow identification of patterns in the literature, which could provide insights into general effects of wildfires on the species.

Table 3.1: Apparent effects of wildfires on spotted owls. See text for additional descriptions of study methods and findings.

Response Metric	Study†	Subspecies	Location*	Apparent Effect**	Notes/Caveats
Survival	*Bond et al. 2002*	NSO, CSO, MSO	CA, AZ, NM	0	Only one post-fire survey season
	Clark et al. 2011	NSO	OR KLA	-	Likely cumulative effect of timber harvesting, severe fire, and salvage logging
Productivity	Gaines et al. 1997	NSO	E WA CAS	0	Apparently no decline but possibly obscured by low reproduction year across population; Possibly lower total reproduction in burned landscapes due to lower pair occupancy; Only one post-fire season
	Bond et al. 2002	NSO, CSO, MSO	CA, AZ, NM	0	Only one post-fire season
	Clark 2007	NSO	OR KLA	0	Apparently no decline but low statistical power; Possibly lower total reproduction in burned landscapes due to lower pair occupancy
	Roberts and van Wagtendonk 2006	CSO	CA SIERRA	+	Apparent higher productivity by four pairs nesting in low-to-moderate severity burns than by 18 pairs in unburned areas
Site Fidelity	*Bond et al. 2002*	NSO, CSO, MSO	CA, AZ, NM	0	Site fidelity similar to other studies
Occupancy	Elliot 1985	CSO	CA COAST	-	Apparent abandonment by two pairs
	Gaines et al. 1997	NSO	E WA CAS	-	Post-fire occupancy was lowest found during five-year study; Only one post-fire season
	Jenness et al. 2004	MSO	AZ, NM	-	Near-significant negative trend; Pooled all fire types and severities
	Keane et al. 2011, 2012	CSO	CA SIERRA/CAS	-/0	Extensive high severity fire apparently had a strong negative effect; Extensive low severity fire apparently had a neutral or weak negative effect; Possibly confounded by salvage logging
	Roberts et al. 2011	CSO	CA SIERRA	-	Modeled-occupancy lower in burned areas but not statistically analyzed; Pooled all fire types and severities
	Lee et al. 2012	CSO	CA SIERRA	0	Similar occupancy at burned vs. unburned
	Lee et al. 2013	CSO	SO CA	-/0	Similar occupancy at burned vs. unburned; Significant reduction with extensive high severity fire in core area
	Clark et al. 2013	NSO	OR KLA	-	Cumulative effect of timber harvesting, severe fire, and salvage logging
	Tempel et al. In Press	CSO	CA SIERRA	-	Site colonization probability negatively associated with area of wildfire; Relatively large sample size and long time frame
Home Range	Clark 2007	NSO	OR KLA	-	Larger home ranges post-fire
	Bond et al. 2013	CSO	CA SIERRA	0	Similar home range sizes to unburned areas
Roosting	King et al. 1997	NSO	E WA CAS	-	Apparent avoidance of moderate and severe burns
	Bond et al. 2009	NSO	CA SIERRA	-	Significant avoidance of moderate and severe burns during breeding season
Foraging	Clark 2007	NSO	OR KLA	+	Apparent weak selection of moderately burned suitable habitat; Possible weak selection for severely burned suitable habitat; Very low use and availability of both moderately and severely burned suitable habitat
	Bond et al. 2009	NSO	CA SIERRA	+	Significant selection of severe burns
	Eyes 2014	CSO	CA SIERRA	-/+	Preference for edges created by fire (particularly high contrast); Avoidance of severely burned areas
Roosting and Foraging	Comfort 2013	NSO	OR KLA	-/+	Preference for small patches of severely burned/salvage logged and avoidance of larger patches; Weak preference for low contrast edges created by fire

†Peer-reviewed publications shown in italics. * Locations: California Klamath (CA KLA); Eastern Washington Cascades (E WA CAS); Oregon Klamath (OR KLA); California, Arizona and New Mexico (CA, AZ, NM); California Central Coast Range (CA COAST); California at margin of northern Sierra Nevada and southern Cascades (CA SIERRA/CAS); California Sierra Nevada (CA SIERRA); southern California San Bernardino and San Jacinto Mountains (SO CA). **Apparent Effect: negative (-), positive (+), neutral (0), varied with fire severity and/or scale (/)—see Notes column and text for further explanations.

Survival

Wildfires may influence spotted owl survival in both the short- and long-term. For example, spotted owls, like other wildlife, could be injured or killed by smoke during fires (Singer and Schullery 1989, Smith 2000). Due to their poor mobility, young spotted owls with undeveloped flight feathers may be at particular risk of mortality during wildfires (Smith 2000). In addition to potential immediate effects, extensive moderate or severe wildfires might influence spotted owl survival over the longer-term by modifying habitat for roosting, foraging, or prey (see below).

Only two studies are currently available for evaluating effects of wildfires on spotted owl survival rates (Bond et al. 2002, Clark et al. 2011; Table 3.1). Bond et al. (2002) reported that 18 of 21 (86%) marked spotted owls were resighted one year after wildfires occurred in California, Arizona, and New Mexico. This minimum survival rate was similar to survival estimates found by long-term studies of the three spotted owl subspecies in unburned landscapes (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data). Of the eight territories for which fire severity was mapped, two experienced severe fire within 50-88% of their areas, two experienced 36-50% severe fire, and the remaining four experienced <36% severe fire. Thus, mixed severity wildfires did not appear to have a substantial effect on spotted owl survival in this study one year post-fire.

Clark et al. (2011) found evidence of a negative effect of wildfires and/or post-fire salvage logging on survival of 23 NSOs in the Oregon Klamath Province. Severe fire and/or post-fire salvage logging occurred in 30% and 41% of suitable NSO habitat in the two study areas (suitability score >25: Davis and Lint 2005 [essentially nesting-roosting-foraging habitat; QMD generally > ca. 12 in]). Estimated mean annual survival rates for NSOs located inside fire perimeters (0.69) and apparently displaced by fires and post-fire salvage logging (0.66) were lower than in areas just outside the fire perimeters (0.85) and in an unburned reference study area in the neighboring southern Cascades (0.85: Anthony et al. 2006). The degree to which post-fire salvage logging in the study areas influenced NSO survival rates is unknown. The study's occupancy analyses indicated that pre-fire timber harvesting, high severity wildfire, and post-fire salvage logging cumulatively impacted NSOs through reductions of suitable breeding habitat (Clark et al. 2013; see below).

The findings of Bond et al. (2002) and Clark et al. (2011) regarding effects of moderate-to-extensive amounts of severe wildfire (>36% of the area in half of the territories: Bond et al. 2002; 30-41% of the study area: Clark et al. 2011) appear to be contradictory. Several factors may explain this apparent inconsistency. The most obvious difference between the studies is that the areas studied by Clark et al. (2011) experienced post-fire salvage logging while those studied by Bond et al. (2002) did not. The limited available information suggests that salvage logging negatively affects spotted owls (reviewed below). Additionally, the populations studied by Clark et al. (2011) may have been particularly sensitive to habitat loss to wildfires due to intensive pre-fire timber harvesting across a checkerboard ownership. It should also be noted that Bond et al. (2002) only examined wildfire effects one year post-fire. Fire injuries and post-fire outbreaks of insects and pathogens can continue to result in tree mortality for up to several years after a wildfire (Ryan and Amman 1996, Gaines et al. 1997, Hood et al. 2007).

Reproduction

The spotted owl is a relatively long-lived species (up to 12-17+ yrs in the wild: Gutiérrez et al. 1995) that exhibits a bet-hedging life history strategy (Noon and Biles 1990, Franklin et al. 2000). This means that individuals often forego breeding during poor environmental conditions in order to maximize their chance of surviving and reproducing in the future. Given the species' life history strategy, spotted owl reproductive rates are likely sensitive to environmental changes, including those brought about by wildfires. However, annual fluctuations in spotted owl reproduction caused by variation in weather, prey populations, or breeding condition could obscure effects of wildfires or other factors on reproduction (e.g., Franklin et al. 2000).

At least four studies have examined potential effects of wildfires on spotted owl reproduction (Gaines et al. 1997, Clark 2007, Bond et al. 2002, Roberts and van Wagtendonk 2006 [also Roberts 2008]; Table 3.1). None of these studies found substantive evidence of a wildfire-induced decline in reproduction by the species and one indicated a potentially positive effect. In the eastern Washington Cascades, Gaines et al. (1997) found little or no difference in productivity (number of young per pair) at burned (0.2; n = 5 or 6/ yr) and unburned sites (0.3; n = 13-17/yr) one year after a predominantly moderate to severe wildfire. However, the post-fire survey season clearly occurred during a poor reproduction year, potentially making it difficult to detect a difference between burned and unburned sites. Clark (2007) found no significant differences in productivity in burned areas in the Oregon Klamath Province (n = 31 territories) and an unburned study area in the neighboring southern Cascades (Anthony et al. 2006). He noted, however, that his study likely lacked the statistical power to detect a difference if one occurred. Bond et al. (2002) found that seven pairs of spotted owls produced an average of 1.0 offspring during a single breeding season following wildfires in California, Arizona, and New Mexico. This was similar to productivity rates found in unburned areas during long-term studies of the three spotted owl subspecies (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data). In the Sierra Nevada of California, Roberts and van Wagtendonk (2006) reported that four CSO pairs in areas that experienced extensive low-to-moderate severity fire produced eight fledglings, compared with 17 fledglings produced at 18 nests in unburned areas (i.e., burned = 18% of pairs and 32% of fledglings). The authors did not statistically analyze the apparent positive effect of low-to-moderate severity fire on productivity (note: it is possible that Roberts [2008] statistically analyzed this effect but I was unable to obtain a copy of her dissertation for inclusion in this synthesis).

Currently available studies suggest that wildfires generally have minimal short-term effects on spotted owl reproduction and that primarily low-to-moderate severity fire could positively affect reproduction (Gaines et al. 1997, Bond et al. 2002, Roberts and van Wagtendonk 2006, Clark 2007). As noted above, it might be difficult to capture fire effects on spotted owl reproduction (whether positive or negative) during short-term studies, particularly with only a single year of post-fire data (Franklin et al. 2000). In addition, it is possible that solely comparing productivity (e.g., offspring per pair) in burned and unburned areas could obscure a change in total reproduction in burned areas. Studies in Washington and Oregon reported post-fire declines in occupancy by pairs, suggesting that extensive severe fires can reduce reproductive opportunities for spotted owls (Gaines et al. 1997, Clark 2007; see below).

Occupancy

Potential wildfire effects on NSO population rates are most directly evaluated with measures of survival and reproduction. However, occupancy data are often more logistically and economically feasible to collect than are demographic data and could provide an early indication of population trends (MacKenzie 2005, Olson et al. 2005). Spotted owl occupancy is sensitive to environmental factors (Blakesley et al. 2005, Olson et al. 2005) so it is a potentially valuable measure of wildfire effects on the species. Nonetheless, occupancy data must be interpreted carefully since they can be strongly influenced by survey effort, analytical methods, and the presence of barred owls (*Strix varia*) (Olson et al. 2005).

I evaluated 10 studies of wildfire effects on spotted owl occupancy (Table 3.1). As summarized below and in Table 3.1, eight of these provided evidence of a negative effect of either severe wildfires or wildfires in general.

Two studies indicated potentially negative effects of wildfires on spotted owl occupancy but included few territories (Elliot 1985, Gaines et al. 1997). In Monterey County, California, informal yearly surveys suggested that two pairs of CSOs abandoned their territories for at least four years following a wildfire (Elliot 1985). The author did not describe the fire other than noting that it was extensive and caused substantial damage to understories and oaks in the previously occupied areas. In the eastern Washington Cascades, Gaines et al. (1997) found that two of six NSO sites were occupied one year after a predominantly moderate to severe wildfire. This was the lowest occupancy rate found during the five-year study period.

Two studies found statistically weak evidence of a negative effect of fire on spotted owl occupancy, but their methods may have precluded detection of stronger effects (Jenness et al. 2004, Roberts et al. 2011). Jenness et al. (2004) found a statistically insignificant tendency (p = 0.11) for higher occupancy rank (in ascending order: no owls, singles, pairs, reproductive pairs) in unburned sites than in paired burned sites in Arizona and New Mexico (paired sites were close to each other and had similar habitat and topography). Of the 29 paired-site comparisons, 14 (48%) had a higher occupancy rank in unburned sites, 6 (21%) had a higher rank in burned sites, and 9 (31%) were tied. In the Sierra Nevada of California, Roberts et al. (2011) found lower occupancy rates for CSOs in burned areas than in unburned areas, but the difference was not statistically analyzed (modeled-occupancy = 0.46 in burned and 0.72 in unburned). Modeling by both studies indicated that spotted owl occupancy was more strongly influenced by habitat composition or structure than by whether or not fire had recently occurred in territories. However, both studies may have underestimated the impacts of severe wildfires due to pooling of diverse fire types and severities for analysis (including prescribed fires, wildfires, and wildfires allowed to burn under prescribed conditions).

Another study found stronger evidence of a negative effect of wildfires on occupancy by CSOs. Tempel et al. (*in press*) collected occupancy data at 74 CSO territories during long-term (1993/1997-2012) density and regional studies in the central Sierra Nevada. Twelve (16%) territories experienced wildfire during the studies, including nine (12%) that were affected by a mostly-severe wildfire in 2001. The best performing model explaining site colonization during the studies included area of wildfire within estimated territories (988 ac). In this model, wildfire

had a strong negative effect on the probability of colonization, even though relatively few territories were affected by fire. Only three site colonization events were observed in burned territories during six post-fire years. However, CSOs exhibited variable responses to wildfire. For example, five of the territories affected by a largely severe wildfire in 2001 were occupied every year post-fire.

Two studies found evidence of strong declines in occupancy in areas recently burned by extensive severe wildfire but both may have been confounded by post-fire salvage logging (Keane et al. 2011, 2012, Clark et al. 2013). In southwestern Oregon, Clark et al. (2013) examined how extensive wildfires and subsequent salvage logging affected occupancy dynamics of NSO pairs. In their first analysis, the authors compared pre- and post-fire occupancy dynamics in a burned study area in the Oregon Klamath Province (n = 22) to those in an unburned area in the nearby southern Cascades (Anthony et al. 2006). Combined, high severity fire and salvage logging removed or modified 26% of suitable habitat (suitability score >25: Davis and Lint 2005 [essentially nesting, roosting, and foraging habitat; generally QMD > ca. 12 in DBH in study area] in landscapes surrounding NSO activity centers in this area. The burned and salvage-logged study area experienced a 64% reduction in site occupancy during the post-fire period, compared with a 25% reduction in the unburned study area (difference not statistically analyzed). In the second analysis, the authors examined possible effects of severe wildfire and salvage logging on occupancy dynamics in 40 territories located in three burned study areas in the Oregon Klamath Province. In these areas, 19-26% of suitable habitat was burned at high severity and/or salvage logged. During the study's three-year post-fire period, site extinction probabilities were as high as 72% in two combined study areas and 92% in the third area. Site extinction probabilities in the burned study areas were best explained by a model that included extents of high severity fire, salvage logging, and early seral forest. Models that included these variables separately were not competitive with the model containing all three variables, suggesting that NSO occupancy declined due to cumulative habitat loss from severe fire and pre- and post-fire timber harvesting (see Table 6 in Clark et al. 2013). The relative influence of these factors on occupancy is unknown, but the role of severe wildfire cannot be dismissed. For example, the highest extinction probability (92%) occurred in a study area with little salvage logging (<2%) of previously suitable habitat.

Keane et al. (2011, 2012) estimated occupancy of CSOs in two recently burned study areas near the margin of the Sierra Nevada and southern Cascades of California. One wildfire complex, and an unreported amount of post-fire salvage logging, resulted in an almost complete loss of potentially suitable CSO habitat in the area (forest with mean canopy cover $\geq$40% and mean DBH $\geq$11 comprised 70% of the area pre-fire vs. 6% post-fire). Pre-fire occupancy in this study area was unknown but the Forest Service identified 23 CSO activity centers in the area prior to the fires. Rigorous landscape survey coverage by Keane et al. (2011, 2012) confirmed occupancy in only one territory within the fire perimeter during each of two post-fire years, whereas approximately seven to nine territories were found post-fire in a surrounding one-mile survey buffer (total survey area and buffer survey area sizes not reported). The other area studied by Keane et al. (2011, 2012) primarily burned at low severity (ca. 60% of the area). Pre-fire occupancy was likewise unknown in this area but Forest Service pre-project surveys indicated the presence of about 10 territories. Surveyors confirmed occupancy of six territories in this area during the first and second years post-fire. However, the number of occupied

territories in this study area could have been higher during the second post-fire season as survey effort was hindered by safety concerns associated with extensive illegal marijuana cultivation (see Ch. 5 for further discussion of this topic). While the study's findings are preliminary and may have been influenced by post-fire salvage logging, they suggest that effects of large wildfires on CSOs are dependent on the extent of high severity wildfire.

Another study provided further evidence that effects of wildfires on spotted owl occupancy depend on the extent and location of high severity wildfire. Lee et al. (2013) compared occupancy dynamics of CSOs in 71 recently burned sites and 97 unburned sites in the San Bernardino Mountains and San Jacinto Mountains of southern California. An average of 23% of the forest within burned "core areas" (500 ac around activity centers) experienced high severity fire (this percent is based on an assumption that the amount of pre-fire forest in burned core areas was the same as that reported for burned and unburned core areas combined). Mean annual probability of occupancy was 0.48 in unburned sites and 0.31 in burned sites. This difference was not statistically significant. However, Lee et al. (2013) did detect a statistically significant negative effect on occupancy when high severity fire burned more than 125 acres of forest within estimated core areas.

Two studies found that wildfires had little or no effect on spotted owl occupancy (Bond et al. 2002, Lee et al. 2012). Bond et al. (2002) calculated site fidelity for spotted owls in 11 territories burned by wildfires in California, Arizona, and New Mexico. The fires burned most of the area within each estimated territory (territory size = half the nearest neighbor distance in each study area, based on previous studies). Half of the eight territories for which fire severity was mapped primarily burned at low to moderate severity (<36% high severity) and the other half experienced moderate to extensive amounts of severe fire (36-88%). Of 21 color-banded owls in the study, 18 (86%) were resighted the year after the fires and 16 (89%) of these were located in their pre-fire territory. Site fidelity in this study was comparable to that in long-term studies of the three subspecies in unburned areas (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data). In the Sierra Nevada, Lee et al. (2012) compared post-fire occupancy in 41 recently burned and 145 unburned historical CSO territories. An average of 32% of forest in burned territories experienced high severity fire. The authors found no significant association between CSO occupancy and whether or not territories had recently experienced wildfire within a 494-acre circle around activity centers (mean occupancy was 0.76 at unburned sites and 0.80 at burned sites).

The studies reviewed above are not directly comparable due to differences in methods, spotted owl subspecies and populations, fire extents and severities, and the presence or absence of post-fire salvage logging. The preponderance of evidence suggests that spotted owls in dry, fire-prone forests are generally resilient to wildfires (Bond et al. 2002, Jenness et al. 2004, Roberts and van Wagtendonk 2006, Keane et al. 2011, 2012, Roberts et al. 2011, Lee et al. 2012, 2013). However, wildfires that severely burn large areas of potentially suitable habitat can substantially impact spotted owl occupancy, particularly when they occur in breeding-season core areas (Elliot 1985, Gaines et al. 1997, Clark et al. 2013, Keane et al. 2011, 2012, Lee et al. 2013, Tempel et al. *in press*). Post-fire salvage logging appears to increase the negative effects of extensive severe wildfires on spotted owl occupancy, most likely by reducing suitability of burned areas for prey and foraging (Lee et al. 2012, 2013, Clark et al. 2013, Comfort 2013; reviewed below).

Home Range Size and Habitat Use

Changes in the behavior of individual spotted owls may provide insight into the mechanisms by which wildfires affect populations. For example, post-fire changes in home range size may reflect wildfire effects on spotted owl energy budgets through changes in travel distances and prey availability. Changes in energy intake and output could, in turn, influence survival, reproduction, and occupancy of spotted owls. Patterns of habitat use may also be informative. For example, selection or avoidance of burned areas may reflect changes in availability of prey or roosting habitat, which could, in turn, influence occupancy, reproduction, or survival of spotted owls.

To my knowledge, only two studies have evaluated spotted owl home range sizes in relation to wildfires (Clark 2007, Bond et al. 2013; Table 3.1). Clark (2007) found that annual home range sizes of NSOs inside two fire perimeters in the Oregon Klamath Province were larger after wildfires than before them (n = 14 owls pre-fire and 20 post-fire). He attributed this difference to owls expanding their home ranges in response to habitat fragmentation caused by severe wildfire and post-fire salvage logging. This hypothesis is supported by other research in the region, which found that NSOs had larger home ranges in fragmented forests than in areas with larger, more intact patches of habitat (Carey et al. 1992, Schilling et al. 2013). Another study in the region suggested that the energetic cost of increased travel in fragmented forest was greater than the energetic benefit of increased access to prey associated with early-successional habitats (Carey and Peeler 1995).

Bond et al. (2013) compared the breeding season home ranges of seven CSOs (from four territories) during a single post-fire year in the Sierra Nevada of California with those in other studies during the same year in other parts of the subspecies range (D. Call, T. Munton, and G. Zimmerman unpubl. data). An average of 23% of forest burned at moderate severity and 9% at high severity within a 1.2 mile radius of the four nests. Pre-fire home range sizes were unknown but CSOs in the four territories did not appear to have unusually large home ranges following predominantly low to moderate severity wildfire.

At least five studies have described patterns of habitat use by spotted owls in burned areas (King et al. 1997, Clark 2007, Bond et al. 2009, Comfort 2013, Eyes 2014; Table 3.1).

King et al. (1997; also Bevis et al. 1997) described initial effects of wildfires on NSOs in two territories in the eastern Washington Cascades. One territory primarily experienced low to moderate severity fire and the other mostly burned at high severity. Both territories experienced an unreported amount of salvage logging in “unsuitable” or severely burned habitat. Most NSO locations (84% and 89%) in the two territories were daytime roosts. In the territory primarily burned at low to moderate severity, 80% of the pair’s post-fire locations were in unburned habitat, 16% were in low severity burns, and 4% were in moderate severity burns. The pair did not appear to roost in severely burned areas. The second territory studied by King et al. (1997) was occupied by a single male. After the wildfire, the male shifted his activity to an unburned area two to three miles away but continued to occasionally use areas near his former activity center. Of those locations, 74% were in unburned habitat, 17% were in low severity burns, 5% were in moderate severity burns, and 4% were in high severity burns. Maps of burn severity

classes and NSO locations indicate that owls in these two territories strongly selected unburned areas for roosting.

Clark (2007) evaluated habitat selection by 12 NSOs (7 territories) inside a wildfire perimeter in the Oregon Klamath Province. NSO locations were primarily nocturnal and may therefore, have largely represented foraging activity. Individuals in this area used all habitat classes, including moderate and severe burns and areas that had been salvage logged. However, when the data from individuals were pooled for analysis, the owls exhibited a strong preference for nesting-roosting habitat (suitability score >50: Davis and Lint 2005 [QMD generally > ca. 27 in DBH in study area]) that was unburned or burned at low severity (unburned and low severity were combined into a single class for analyses). NSOs in the study also selectively used moderately burned, previously-suitable habitat; although both use and availability of this habitat class were low compared with unburned or lightly burned habitat. Owls' use of burned areas was concentrated closer to activity centers, which was expected, given that spotted owls are central place foragers during the breeding season (see Rosenberg and McKelvey 1999).

In the Sierra Nevada, California, Bond et al. (2009) described the habitat associations of seven CSOs from four territories during a single post-fire season. Of the four nests found during the study, one was approximately 0.3 mile outside the fire perimeter, one was in forest burned at low severity, and two were in forest burned at moderate severity. One of the two nest trees found in moderate severity burns was apparently killed by the fire and one produced the only fledgling detected during the study. It is unclear from the paper whether these events occurred at the same nest or different nests. The four pairs roosted in all burn severity classes but exhibited statistically significant selection of low severity burns and avoidance of moderate and high severity burns. Only one of 60 roost sites was located in a high severity burn. Burned roost sites generally resembled unburned roost sites (>60% canopy cover and large-diameter trees). Bond et al. (2009) also evaluated CSO selection of foraging habitat in the area. Probability of use for foraging was highest when sites were burned and within 0.6 mile of nests or roosts. Probability of use was also positively associated with presence of edge between burn severity classes. Five of the owls foraged in high severity burns within 0.9 mile of nests or roosts more often than in other burn severity classes. Bond et al. (2009) suggested that CSOs in these four territories selectively foraged in high severity burns in order to access abundant prey in those areas. This hypothesis was supported by their finding that high severity burns had the highest herb and shrub cover and highest basal area of snags of any burn severity class, including unburned. These features are key resources for spotted owl prey communities (Carraway and Verts 1991, Carey et al. 1999, Holloway and Smith 2011).

Comfort (2013) evaluated habitat selection (roost and foraging locations combined) by 23 NSOs in a burned area in the Oregon Klamath Province. Her best performing model for explaining habitat selection included habitat suitability, disturbance severity, high contrast edge, and low contrast edge. Habitat selection varied with spatial scale but NSOs exhibited a strong preference for higher habitat suitability and avoidance of patches affected by higher severity disturbance (high severity wildfire and/or salvage logging). NSOs showed a preference for high contrast edge at small spatial scales (2-8 ac) and avoidance at medium and large scales (32-2,049 ac). NSOs also exhibited a weak preference for low contrast edge. Comfort (2013) concluded that patchy, mixed severity fire (small patches of high severity fire within a matrix of unburned and

low-to-moderate severity fire) created conditions favored by NSOs in her study, whereas large patches created by high severity fire and subsequent salvage logging were strongly avoided. Salvage logging apparently contributed to conditions avoided by NSOs by structurally homogenizing burned areas, which increased the sizes of high severity patches and amounts of high contrast edge (Comfort 2013). However, the relative influence of high severity wildfire and post-fire salvage logging on habitat selection by NSOs in this study is unknown.

Eyes (2014) evaluated foraging habitat selection by 13 CSOs (8 territories) during three breeding seasons in a recently burned landscape (1-15 yrs prior) in Yosemite National Park in the Sierra Nevada. On average, 25% of the home range (minimum convex polygon) had recently experienced low severity fire, 16% moderate severity fire, and 4% high severity fire. Three of Eye's (2014) four best performing models explaining habitat selection by foraging CSOs included a fire severity metric (Fire Severity Index). These models indicated that the probability of an area's use by foraging CSOs decreased with increasing fire severity. However, foraging CSOs were more likely to use edge sites than non-edge sites and exhibited a tendency for greater use of high contrast edges created by severe fire than for lower contrast edges created by low/moderate severity fire or other disturbances. Eye's (2014) findings that CSOs avoided the interiors of high severity burns and favored high contrast edges created by severe fire is consistent with Comfort's (2013) findings at smaller spatial scales around NSO locations.

The limited available information concerning spotted owl habitat use following wildfires indicates that the species avoids roosting in moderate and high severity burns (King et al. 1997, Clark 2007, Bond et al. 2009). This finding is concordant with the spotted owl's close association with densely-canopied older forest for roosting (Blakesley 2004). Little is known about the effects of wildfire on selection of nest sites. Bond et al. (2009) found three CSO nests in forest recently burned at low and moderate severity, and young fledged from one nest in a moderate severity burn. Moderate severity fire killed one of the four CSO nest trees in their study. Eyes (2014) found a CSO nest adjacent to a high severity burn but the nest failed during her study. Based on the species' nesting habitat requirements (Blakesley 2004), long-term use of severely burned areas for nesting is likely uncommon. Three studies specifically examined selection of foraging habitat by spotted owls. All three found use of all burn severity classes, but Clark (2007) and Eyes (2014) found a preference for foraging in unburned to moderately burned areas (also see Comfort 2013, which combined foraging and roost locations in analyses) while Bond et al. (2009) found a preference for severe burns. It is unclear if this difference was due to differences in the studies' methods, effects of fire and timber harvesting on vegetation, or the composition of prey communities and spotted owl diets. Findings by Comfort (2013) and Eyes (2014) suggest that foraging spotted owls avoid large patches recently burned by high severity fire but benefit from some amount of high contrast habitat edge created by patchy high severity fire.

Wildfire Effects on Prey

In New Mexico, Ganey et al. (2014) found that species richness, relative abundance, and biomass of small mammals were greater in four MSOs' burned wintering areas than in their nest core areas. Abundances of deer mice, pocket gophers (*Thomomys* spp.), and other "pioneer" or "early-successional" prey often increase following fires (Ream 1981, Zwolak and Foresman

2007, Zwolak 2009, Bond et al. 2013). Dusky-footed woodrats appear to initially respond negatively to severe fires (Schwilk and Keeley 1998, Smith 2000) but not to patchy low severity fire, although loss of nest houses might have a brief negative effect on reproduction (Lee and Tietje 2005). However, it is possible that severe fire benefits dusky-footed woodrats over longer time periods (e.g., ≥5-20 yrs) through creation of brushy habitat. Stand-replacing fires should negatively affect abundances of prey associated with well-canopied forest, such as northern flying squirrels and tree voles. These taxa, along with dusky-footed woodrats, are the primary prey for NSOs in California (reviewed in Ch. 2). Low severity fires could also have negative effects on northern flying squirrels and other prey associated with closed canopy forests by reducing dead woody materials, fire-intolerant understory plants, and truffles (Lehmkuhl et al. 2006, Meyer et al. 2007). Thus, wildfires likely have complex effects on NSO prey communities, depending on local or regional differences in prey community composition; wildfire size, severity, and configuration; and the length of time vegetation has had to regenerate following fire.

Post-Fire Salvage Logging

While salvage logging might be judiciously used to meet certain conservation objectives (e.g., generating downed wood to minimize erosion or create wildlife habitat), it is generally conducted to meet economic goals or remove hazard trees (Peterson et al. 2009). Intensive or poorly planned salvage logging can have a variety of negative effects on ecosystems, such as soil compaction, increased erosion, and impacts on insectivorous and cavity-nesting and -denning animals (reviewed in McIver and Starr 2000, Noss et al. 2006, Peterson et al. 2009).

At least three studies have directly evaluated effects of post-fire salvage logging on spotted owls (Clark 2007 and Clark et al. 2013, Lee et al. 2012, 2013). Clark (2007) conducted a radio-telemetry study in areas recently burned by wildfires in the Oregon Klamath Province. He recorded limited use of salvage logged areas; presumably for foraging since locations were primarily nocturnal. Use of salvage logged areas was slightly lower than expected based on its abundance in territories (not statistically analyzed), indicating weak avoidance of salvage logged areas by NSOs. However, avoidance might have been stronger since some of the study's telemetry locations were potentially recorded prior to the occurrence of salvage logging. Most (60%) NSO locations in salvage logged areas occurred in riparian buffers, thinned areas, and patches of wildlife leave trees, rather than intensively salvaged areas. During the same study, Clark et al. (2013) found that post-wildfire declines in NSO occupancy were best explained by a model that included extents of pre-fire timber harvesting, severe wildfire, and post-fire salvage logging. Models that included these factors separately were not competitive with this model, indicating that severe fire and pre- and post-fire harvesting collectively contributed to declines in NSO occupancy; most likely through cumulative habitat loss or degradation.

In the Sierra Nevada, Lee et al. (2012) recorded occupancy for eight CSO territories that experienced wildfire and post-fire salvage logging. Seven of the territories were occupied during the two-year period between the occurrence of wildfire and post-fire salvage logging, whereas none of the territories were occupied following salvage logging.

Lee et al. (2013) evaluated effects of salvage logging on CSOs in the San Bernardino and San Jacinto Mountains of Southern California. They noted that salvage logging in their study area was modest compared with commercial salvage logging typically employed in the Pacific Northwest and Sierra Nevada (salvage logging in their study area mostly consisted of firewood cutting on private in-holdings and hazard tree removal along Forest Service roads). Lee et al. (2013) did not find a statistically significant effect of post-fire salvage logging on CSO occupancy dynamics. However, site extinction probability was slightly higher, and mean annual probability of occupancy was slightly lower, in salvage logged areas than in other burned areas. Weak negative effects of light salvage logging were apparent during all eight post-fire study years.

The limited available evidence suggests that salvage logging decreases the probability that spotted owls will use burned areas (Comfort 2013) and increases the probability that they will abandon their territories following wildfires (Clark 2007, Lee et al. 2012, 2013, Clark et al. 2013). This could occur because salvage logging reduces suitability of burned areas for foraging spotted owls and their prey. Stands recently burned by moderate or severe fire often contain high biodiversity due to the presence of both early-successional conditions and key biological legacies in the form of snags, logs, and residual live trees (Noss et al. 2006). Due to fire suppression and salvage logging, stands with these conditions are currently rare in many fire-prone forests within the spotted owl's range (Noss et al. 2006). Selective use of burned areas for foraging is likely due to spotted owls exploiting short-term increases in prey associated with both early-successional vegetation (e.g., shrubs) and legacy habitat elements (e.g., large diameter snags, logs, and live trees) (Ream 1981, Zwolak 2009, Bond et al. 2013). Salvage logging removes legacy elements, while associated use of herbicides reduces shrubs and grasses important to many prey species (Bond et al. 2013, Comfort 2013). In the longer-term, spotted owls can continue to benefit from the contributions of legacy habitat elements to regenerating stands. For example, large legacy snags, trees, and logs can provide valuable habitat elements for northern flying squirrels and other prey (Holloway and Smith 2011). Removal of these elements through salvage logging could therefore reduce the value of subsequent regenerating stands as prey habitat. Harvesting of legacy snags and live trees could also directly affect spotted owls by reducing availability of foraging perches in the short-term and suitable nest trees during later successional stages.

Summary of Direct Evidence Concerning Wildfire and Salvage Logging Effects

Inferences from studies of direct effects of wildfires and salvage logging on spotted owls are limited due to inclusion of only a small number of spotted owls or territories. The preponderance of currently available evidence indicates that spotted owls are often resilient to low-, moderate-, or mixed-severity wildfires but can be strongly impacted by extensive severe wildfires. Following wildfire, many spotted owls may remain in their territories, exploit short-term increases in prey in burned areas, and continue to reproduce at reasonably high rates. However, wildfires that result in substantial loss or fragmentation of suitable habitat, particularly within breeding core areas, can cause spotted owls to increase their home range sizes, abandon their territories, and possibly, emigrate from burned landscapes or die of starvation or disease. Negative effects of severe wildfires appear to be greatest when suitable habitat is already limited

(e.g., due to widespread intensive timber harvesting) and when post-fire salvage logging reduces suitability of burned areas for foraging and prey.

Wildfire Effects on Recent Habitat Trends

Past and continuing habitat loss was a primary reason for listing the NSO under the federal Endangered Species Act (USFWS 1990). At the time of listing, the Fish and Wildlife Service estimated that 60-88% of the subspecies' habitat had already been lost (USFWS 1990; also see Ch. 2). They attributed most of this loss to widespread intensive timber harvesting. Since listing of the NSO and subsequent adoption of the Northwest Forest Plan, timber harvesting has declined and wildfire has been identified as the primary source of forest disturbance and habitat loss on federal lands (Courtney et al. 2004, Healey et al. 2008, Davis and Dugger 2011, Moeur et al. 2011, USFWS 2011a, Kennedy et al. 2012). Nonetheless, timber harvesting continues to be the primary source of habitat loss on non-federal lands (Healey et al. 2008, Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012; see below).

Estimates of recent trends in amounts of NSO habitat, and of older forest in general, have been produced as part of monitoring efforts for the Northwest Forest Plan; and are therefore, largely restricted to the Plan's area and time span (Davis and Lint 2005, Moeur et al. 2005, 2011, Healey et al. 2008, Davis and Dugger 2011). I have focused on estimates by Davis and Dugger (2011) because they replaced those of Davis and Lint (2005) and are more specific to NSO habitat than those of Moeur et al. (2005, 2011) and Healey et al. (2008). I did not review habitat trend estimates based on federal ESA Section 7 consultation records (Bigley and Franklin 2004, USFWS 2012b) due to greater scientific uncertainty and methodological bias associated with those data (see Bigley and Franklin 2004). Trends described by Bigley and Franklin (2004), Moeur et al. (2005, 2011), Healey et al. (2008), and the US Fish and Wildlife Service (2012b) quantitatively differ from those of Davis and Dugger (2011) but similarly indicate that wildfires have been the primary source of recent habitat loss on federal lands.

Davis and Dugger (2011) used remotely sensed vegetation data (satellite imagery) to model changes in habitat suitability across the NSO's range during the first 15 years of the Northwest Forest Plan (1994-2007 in California and 1996-2006 in Oregon and Washington). Habitat suitability was based on characteristics surrounding thousands of NSO pair locations across the Plan area. Suitable breeding habitat was defined as having both a probability of owl presence greater than expected based on random chance and environmental conditions typical of those found around nesting and roosting pairs. Estimated habitat trends included gross loss of both suitable breeding ("nesting/roosting") habitat and interior ("core") suitable breeding habitat (>330 ft from edge). Davis and Dugger (2011) considered habitat loss to have occurred when an area classified as suitable at the beginning of Northwest Forest Plan was later downgraded to a lower suitability rank (unsuitable or marginal) due to vegetation changes caused by forest disturbances. Davis and Dugger (2011) did not estimate recruitment of, or net changes in, breeding habitat because their remotely sensed data was incapable of accurately capturing relatively slow and subtle habitat changes during development of intermediate-aged and older stands. They did, however, estimate net trends in NSO dispersal habitat, which they defined as forest with a mean conifer canopy cover of at least 40% and a mean conifer DBH of at least 11 inches. Recruitment of dispersal habitat was more detectable than that of breeding habitat due to

more rapid and measurable growth in younger forest (some recruitment also occurred due to degradation of suitable breeding habitat by forest disturbances).

Estimated gross losses of suitable breeding habitat on federal and non-federal lands are presented in Tables 3.2 and 3.3, respectively. During the first 15 years of the Northwest Forest Plan, wildfires were responsible for an estimated gross loss of 236,700 acres (2.7%) of suitable breeding habitat on federal lands rangewide and 13,100 acres (0.3%) on non-federal lands (1.9% of federal and non-federal lands combined). Estimated habitat loss on federal lands was similar to that expected at the time of the Northwest Forest Plan's implementation; however, relatively high rates of habitat loss in relatively dry, fire-prone regions have been a source of conservation concern for NSOs in those areas (Davis and Dugger 2011). In California, wildfires removed an estimated 75,500 acres (4.1%) of suitable breeding habitat on federal lands and 5,600 acres (0.4%) on non-federal lands (2.4% combined). Approximately 70% of habitat loss to wildfires on federal lands occurred within the Oregon and California Klamath Provinces (Table 3.2). Most of this habitat loss was caused by the 1999 Megram Fire and 2002 Biscuit Fire (Table 3.4). Fires in the Eastern Cascades Provinces of Washington, Oregon, and California contributed less to total habitat loss than did fires in the Klamath Provinces, but were often more destructive in terms of proportion of suitable habitat lost within individual fire perimeters. In contrast with federal lands, wildfires were responsible for very little habitat loss on non-federal lands; rather, timber harvesting accounted for most losses in these areas (Figure 3.1).

Table 3.2: Estimated gross losses of suitable NSO breeding habitat on federal lands due to wildfires during 1994-2007 in California and 1996-2006 in Oregon and Washington (adapted from Davis and Dugger 2011, USFWS 2011a).

State	Province	Initial Acres	Acres Lost	Percent Lost
California	CA Cascades	213,200	1,800	0.8%
	CA Klamath	1,489,800	71,600	4.8%
	CA Coast	145,400	2,100	1.4%
Oregon	OR Coast Range	611,200	0	0.0%
	Western OR Cascades	2,258,700	28,900	1.3%
	Eastern OR Cascades	402,900	17,800	4.4%
	Willamette Valley	3,400	0	0.0%
	OR Klamath	985,000	93,600	9.5%
Washington	Olympic Peninsula	763,100	200	0.0%
	Eastern WA Cascades	673,600	20,000	3.0%
	Western WA Cascades	1,283,000	700	0.1%
	Western WA Lowlands	24,700	0	0.0%
Rangewide Total		8,854,000	236,700	2.7%

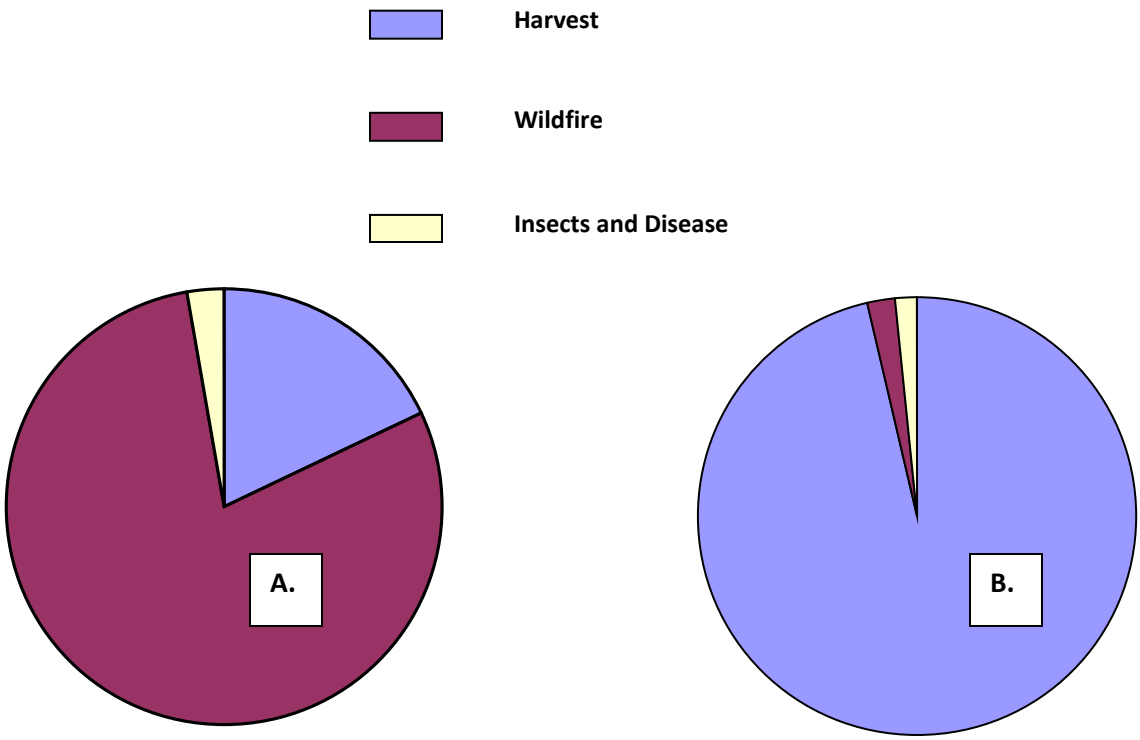
Table 3.3: Estimated gross losses of suitable NSO breeding habitat on non-federal lands due to wildfires during 1994-2007 in California and 1996-2006 in Oregon and Washington (adapted from Davis and Dugger 2011, USFWS 2011a).

State	Initial Acres	Acres Lost	Percent Lost
California	1,556,700	5,600	0.4%
Oregon	1,382,400	5,100	0.4%
Washington	1,258,900	2,400	0.2%
Total	4,198,000	13,100	0.3%

Table 3.4: Estimated gross losses of suitable NSO breeding habitat to individual wildfires during 1994-2007 (note: "habitat degraded" describes areas downgraded from highly suitable to suitable; from Davis and Dugger 2011).

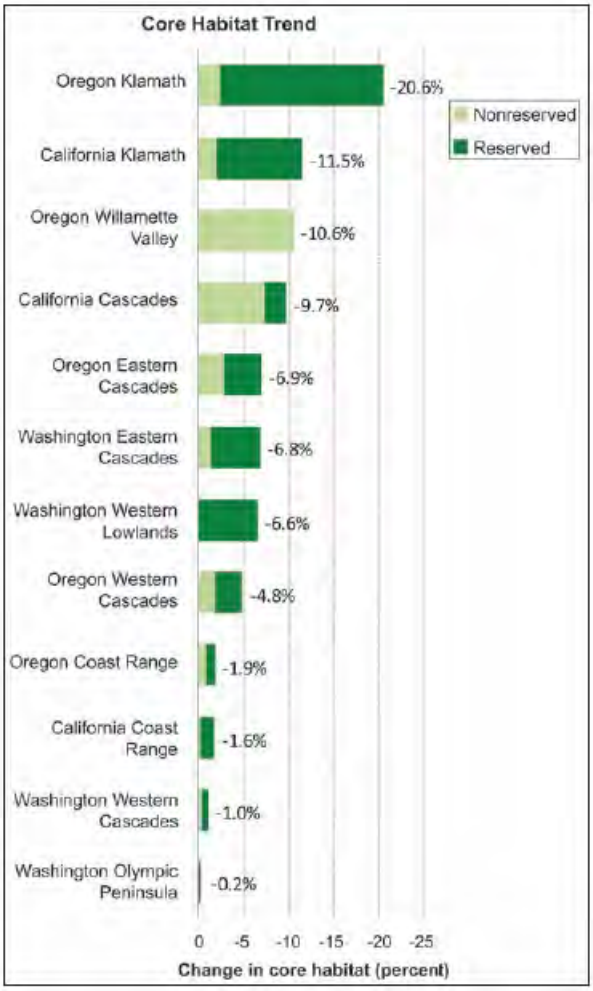
Fire name	Year	Broad physiographic province	Habitat in wildfire perimeter	Habitat lost		Habitat degraded	
			Acres	*Acres*	*%*	*Acres*	*%*
Biscuit Fire	2002	Klamath Mountains	226,230	93,730	41	12,019	5
Megram Fire	1999	Klamath Mountains	76,337	27,520	36	4,589	6
B&B Complex	2003	East Cascades	26,269	16,403	62	907	3
Bake-oven Fire	2006	Klamath Mountains	23,946	8,873	37	581	2
Boulder Fire	2002	West Cascades	34,059	8,460	25	2,074	6
Davis Fire	2003	East Cascades	8,050	6,943	86	5	0
Pigeon Fire	2006	Klamath Mountains	13,896	5,634	41	327	2
Rex Complex	2001	East Cascades	8,548	4,750	56	278	3
Timbered Rock	2002	West Cascades	10,216	4,539	44	569	6
Spring Fire	1996	West Cascades	13,504	3,931	29	858	6
Deep Harbor Fire	2004	East Cascades	5,761	3,930	68	64	1
Hancock Fire	2006	Klamath Mountains	12,712	3,132	25	336	3
Apple Fire 2	2002	West Cascades	12,227	2,810	23	928	8
Fischer Fire	2004	East Cascades	4,479	2,340	52	34	1
Fork Fire	1996	Klamath Mountains	2,962	2,113	71	14	0
Needles Fire	2003	East Cascades	1,946	874	45	1	0
Trough Fire	2001	Klamath Mountains	1,851	798	43	4	0
Hunter Fire	2006	Klamath Mountains	2,236	789	35	40	2
Deer Point Fire	2002	East Cascades	505	380	75	0	0
Tatoosh Complex	2006	East Cascades	666	378	57	0	0

Figure 3.1: Proportions of suitable breeding habitat loss attributed to harvesting, wildfire, and insects and diseases on (A) federal lands and (B) non-federal lands during 1994-2007 (adapted from Davis and Dugger 2011 and USFWS 2011a).



Davis and Dugger (2011) reported substantial losses of interior (>330 ft from edge) breeding habitat on federal lands during the first 15 years of the Northwest Forest Plan (Figure 3.2). These losses primarily occurred in reserved areas. Changes in ratios of interior and edge habitat classes indicated that increased fragmentation of suitable breeding habitat on federal lands was greatest in the Oregon and California Klamath Provinces and California Cascades Province (see Table 3-3 in Davis and Dugger 2011). Increased fragmentation in these regions was primarily due to wildfires.

Figure 3.2: Gross losses of interior suitable breeding habitat on reserved and non-reserved federal lands during 1994-2007 in California and 1996-2006 in Oregon and Washington (from Davis and Dugger 2011).



Davis and Dugger (2011) estimated a 5.2% net gain in NSO dispersal habitat. Much of this gain was due to succession in young forests in non-reserved lands at the margins of federal forests. However, accounting for forest connectivity and NSO dispersal distances, Davis and Dugger (2011) reported a 1% net loss of "dispersal-capable landscape". Much of the loss of dispersal-capable landscape in the Klamath and Eastern Cascades Provinces was due to large wildfires,

whereas timber harvesting on non-federal lands was responsible for much of the loss in other regions.

Loss and fragmentation of breeding habitat to wildfires was likely at least partially offset by recruitment of new habitat through succession of mature and old forest. However, Davis and Dugger (2011) found that detectable recruitment of breeding habitat primarily occurred in the marginal suitability class. This finding was supported by Moeur et al. (2005), who found that about 90% of recruitment of older forest (mature and old-growth combined) during the first 10 years of the Northwest Forest Plan was at the lower end of the class' diameter range (i.e., mean DBH 20-30 in). In their subsequent report, Moeur et al. (2011) noted that given the short length of the monitoring period (10-14 yrs), recruitment was "likely due to incremental stand growth over the 20-in diameter threshold, or from understory disturbances that removed smaller diameter trees and raised the average stand diameter above the threshold, rather than from an increase in forests of much larger and older trees." It is likely that some newly recruited mature forest provides suitable habitat for NSOs but much if it could lack the canopy layering, large diameter snags and logs, and other structural attributes typical of nesting and roosting habitat (Blakesley et al. 2004).

Loss and fragmentation of suitable breeding habitat does not necessarily equate to negative impacts on NSOs (Franklin and Gutiérrez 2002; e.g., Bond et al. 2002, 2009, Lee et al. 2012). Studies in southern Oregon and northern California found that the presence and fitness of NSOs are generally highest in landscapes with a mix of both large amounts of suitable breeding habitat and other habitat classes, such as foraging habitat or "non-habitat" (Franklin et al. 2000, Zabel et al. 2003, Olson et al. 2004, Dugger et al. 2005; reviewed above and in Ch. 2 [see Ch. 2 for studies' habitat definitions]). Fitness is also generally highest when suitable breeding habitat occurs in large or clustered patches with large amounts of ecotone or edge between vegetation classes (Franklin et al. 2000, Dugger et al. 2005). This combination of conditions is important because it provides NSOs with a balance of resources needed for both survival and reproduction (Franklin et al. 2000). Active fire regimes in dry forests within the NSO's range in California (e.g., mixed-conifer and interior mixed-evergreen) historically contributed to these conditions by generally sparing older forest and maintaining some form of habitat heterogeneity at both stand and landscape scales (Skinner and Taylor 2006, Skinner et al. 2006, Stuart and Stephens 2006). Some contemporary wildfires may still burn in this manner and thereby continue to perform an important ecosystem function in these forests. However, large severe wildfires have contributed, along with fire suppression and timber harvesting, to homogenization of some forests in interior northern California (Skinner et al. 2006). Thus, large severe wildfires may impact NSOs in California through loss of habitat heterogeneity, as well as reduced amounts and connectivity of suitable breeding habitat.

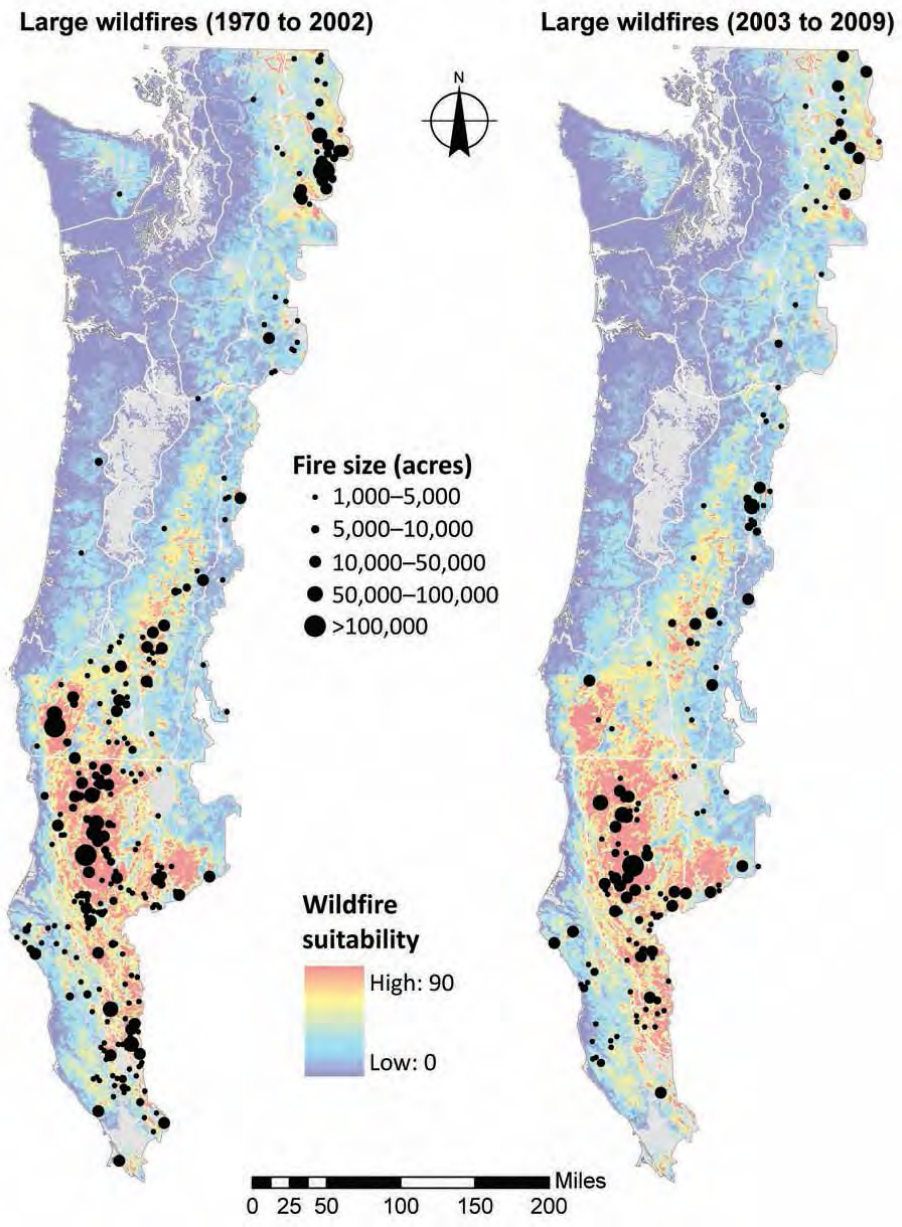
Fire Risk in California

Prior to Euro-American settlement, dry forests in California generally experienced relatively frequent, low-to-moderate or mixed severity fire regimes (Skinner and Taylor 2006, Skinner et al. 2006, Stuart and Stephens 2006, Van de Water and Safford 2011). Mean pre-settlement fire return intervals in California were 11 years in yellow pine forests (e.g., *Pinus ponderosa*, *P. jeffreyi*), 11-16 years in mixed-conifer forests, and 29 years in mixed-evergreen forests (Van de

Water and Safford 2011). Mean fire return intervals in redwood forests south of Del Norte County were also relatively frequent (6-44 yrs: Stuart and Stephens 2006). Frequent fire during the pre-settlement period generally maintained forests with less dense and more clumped tree distributions, higher proportions of fire-resistant trees (i.e., larger size classes and more fire-tolerant species), and lighter and less continuous fuel beds than occur today (Skinner and Taylor 2006, Skinner et al. 2006, Stuart and Stephens 2006). In northern California, this characteristic fine-scale structural heterogeneity was often overlaid with coarser variability created by effects of elevation, terrain, soils, and other physiographic factors on fire and vegetation patterns (Skinner and Taylor 2006, Skinner et al. 2006, Sawyer 2007). For example, in areas of deeply incised terrain in the Klamath Mountains and southern Cascades of California, upper slopes and south and west facing aspects typically experienced more frequent and severe fire than did other areas (Skinner and Taylor 2006, Skinner et al. 2006). Due to fire suppression, early-successional vegetation communities formerly maintained by frequent, small-scale severe wildfire have greatly declined in some areas of California (Skinner 1995, Nagel and Taylor 2005). Overall, research indicates that fire suppression and other human activities have led to decreased forest heterogeneity at both stand and landscape scales and have contributed to substantial changes in fire regimes in California's dry forests (Skinner and Taylor 2006, Skinner et al. 2006, Stuart and Stephens 2006).

Due to fire suppression, fire-free periods have dramatically increased in California's interior forests (Skinner and Taylor 2006, Skinner et al. 2006). For example, fire rotation near Hayfork in the Klamath Mountains increased more than 10-fold (from 19 to 238 yrs) during the post-settlement period (Taylor and Skinner 2003). Abnormally long fire-free periods have facilitated increased accumulation and continuity of fuels in dry, fire-prone forests (Skinner and Taylor 2006, Skinner et al. 2006, Stuart and Stephens 2006). When wildfires do occur there is often an increased risk of them becoming very large and for suppression forces to be overwhelmed by their size and number (e.g., CAL FIRE 2008). As in other dry forests across the western U.S., the mean and maximum sizes of wildfires, and the total annual area burned, significantly increased in California's dry montane forests during the 20th and early 21st Centuries (Miller et al. 2009, 2012). CAL FIRE (2008) noted that more than half of the 26 largest fires recorded in California during 1932-2008 occurred during the last eight years of that period. Based on recent (1970-2002) fire behavior, most of northern California's interior can be classified as highly prone to large (>1,000 ac) wildfires (Davis et al. 2011; Figure 3.3).

Figure 3.3: Relative probability of large (>1,000 ac) wildfires ("wildfire suitability") across the NSO's range (from Davis et al. 2011). Modeling was based on landscape and climatic characteristics of locations at which large wildfires occurred during 1970-2002 (left) and was compared with subsequent (2003-2009) locations (right).



Studies of recent trends in extents of high severity wildfire in California have found conflicting results. For example, Miller et al. (2009) and Miller and Safford (2012) reported a substantial increase in the extent of high severity wildfire in the Sierra Nevada and southern Cascades of California during 1984-2010; while Hanson and Odion (2014) did not find an increase in the Sierra Nevada during the same period. Similarly conflicting results have been found for the California Klamath Province. Hanson et al. (2009) found a significant increase in high severity wildfire in the California and Oregon Klamath Provinces during 1984-2005; whereas Miller et al. (2012) did not find an increase in the California Klamath Province during a similar period (1987-2008). Scientific debate ensued regarding the appropriateness of methods used in various studies to determine trends in high severity fire (e.g., Hanson et al. 2009, 2010 vs. Spies et al. 2010).

Differences in findings regarding trends in high severity wildfire are related to variation in studies' temporal and spatial scales of analysis, as well as in methods for determining fire severity (Courtney et al. 2008, Miller et al. 2012, Hanson and Odion 2014). For example, Miller et al. (2012) noted that both their own study and those of Odion et al. (2004, 2010) may have underestimated trends in high severity wildfire in the California Klamath Province due to inclusion of unusual fire years. Studies by Odion et al. (2004, 2010) were based on fire effects during a single year (1987), which Miller et al. (2012) described as unusual. Large areas burned at below-average severity during 1987 due to abnormally strong inversions, and the fact that some of the wildfires burned well into fall when conditions often favor lower severity fire. Miller et al. (2012) also noted that their own ability to detect a trend in wildfire severity could have been compromised by inclusion of both this year and 2008, which likewise experienced unusually large, low severity wildfires. Differences in the area analyzed could also affect evaluations of trends in high severity wildfire. For example, the Biscuit Fire, which was predominantly located in Oregon, included extensive areas of high severity fire and therefore could have influenced results of trends analyses for the Oregon and California Klamath Provinces combined versus the California Klamath alone (Miller et al. 2012).

Regardless of whether or not the extent of high severity wildfire increased in California during the last two decades, large severe wildfires have recently occurred in these areas, and they were responsible for most loss, degradation, and fragmentation of suitable breeding habitat for NSOs on federal lands (Davis and Dugger 2011, Davis et al. 2011; see above). These data cannot be used to project how fires in the future will affect NSOs since they do not necessarily represent past or future fire conditions or effects. However, it is highly unlikely that wildfires will cease to be a major source of habitat loss for NSOs in the future. Rather, climate change research has generally projected a continued increase in the number and sizes of wildfires and the annual area burned in California and other western states during coming decades (Westerling et al. 2006, Lenihan et al. 2008, Westerling and Bryant 2008, Littell et al. 2009, Moritz et al. 2012, Stavros et al. 2014). There is scientific uncertainty regarding recent and future trends in the extent of high severity wildfire in California. Nonetheless, large severe wildfires will at least occasionally occur in the future and will continue to be a source of habitat loss and modification for NSOs in the state.

Increases in the number and sizes of wildfires, and effects of wildfires on NSO habitat trends, have led to calls for widespread use of thinning and other forms of active management in dry, fire-prone forests within the Northwest Forest Plan area (USFS and BLM 1994, USFWS 2008,

2011, 2012a, Franklin and Johnson 2012). Some researchers and stakeholders, however, have expressed doubts regarding estimates of wildfire risk and effects on NSOs, concerns about potential effects of thinning on NSOs, and distrust of federal agency intentions (Hanson et al. 2009, Heiken 2010, DellaSala et al. 2013, Odion et al. 2014). As discussed in Chapter 2 (also Hansen and Mazurek 2010, USFWS 2011a), there is currently little known about the effects of forest thinning on spotted owls but the preponderance of evidence indicates that commercial thinning can have negative short-term effects on the species (also see Tempel et al. *in press* regarding potential long-term effects). Federal agencies should carefully consider this information, as well as apparent effects of wildfires on NSOs, when formulating land management policies and prescriptions aimed at reducing wildfire risk in landscapes occupied by the subspecies. Land managers should also consider greater use of prescribed fire and allowing wildfires to burn under favorable conditions; particularly at lower elevations in the California Klamath Province, where summertime inversions often minimize fire severity (Miller et al. 2012).

Acknowledgements

I am grateful to Ray Davis and Derek Lee for their helpful comments on earlier drafts of this chapter. I recognize that many of the topics reviewed in this chapter are scientifically or politically contentious. The approach and conclusions in this review are my own and do not necessarily reflect those of the reviewers.

Ch. 4: Barred Owls

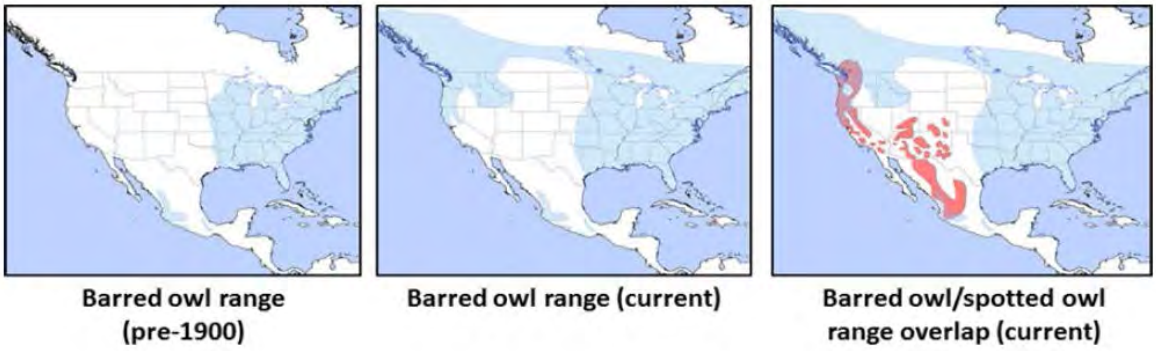
Introduction

At the time of the NSO's federal listing, the barred owl was recognized as a potential threat to the subspecies (USFWS 1990, Thomas et al. 1990). Since then, barred owls have continued to invade the range of the NSO and are apparently increasing in numbers (USFWS 2013). As reviewed herein, a large body of correlational and anecdotal evidence, supplemented by preliminary findings from barred owl removal experiments, indicates that barred owls are negatively impacting NSO populations across their range and that this is due to competition between the two species for space, habitat, and food. Research reviewed below indicates that the barred owl is a superior competitor to the NSO due to its larger size, more aggressive behavior, higher reproductive potential, higher population densities, and broader ecological niche (e.g., USFWS 2013, Wiens et al. 2014). The USFWS (2011a) recently listed the barred owl invasion as one of three main threats currently faced by NSOs (along with timber harvesting and wildfires). The USFWS (2011a) described this threat as "extremely pressing and complex" and "requiring immediate consideration." Information reviewed below suggests that lethal control of barred owls is a viable management option for some areas, although it may be difficult to overcome emotional and ethical resistance to killing one charismatic species to save another (Diller et al. 2013, Higley 2014). Habitat conservation for NSOs appears to be of increasing importance because the negative effects of habitat loss and fragmentation on NSOs can be exacerbated by the presence of barred owls (Dugger et al. 2011).

The Barred Owl's Expansion

Prior to the mid-1900s, the barred owl's range was confined to southeastern Canada, the eastern U.S., and portions of Mexico (Gutiérrez et al. 2004, 2007; Figure 4.1). By the mid-20th century the barred owl's range began expanding westward across North America and currently includes the southern boreal forest zone and British Columbia in Canada and the northern Rocky Mountains, Pacific Northwest, and northern California in the U.S. (Livezey 2009, USFWS 2013; Figure 4.1). The barred owl's range now completely overlaps that of the NSO and partially overlaps that of the California spotted owl (*S. o. occidentalis*) (Figure 4.1). It is unclear whether the barred owl's westward range expansion occurred via the Great Plains or Canada's boreal forests (USFWS 2013). It is also uncertain whether this range expansion was facilitated by natural factors, human activities, or a combination of the two. Hypotheses concerning the cause of the barred owl's range expansion include increased adaptation by the species to coniferous forests; natural climate change; environmental changes associated with widespread intensive timber harvesting; and conversion of open areas to forest due to fire suppression, planting parks and woodlands, removal of keystone species, or other human activities (Gutiérrez et al. 2004, USFWS 2013).

Figure 4.1: Historical and current range of the barred owl and comparison of the current ranges of the barred owl and spotted owl (from USFWS 2013).



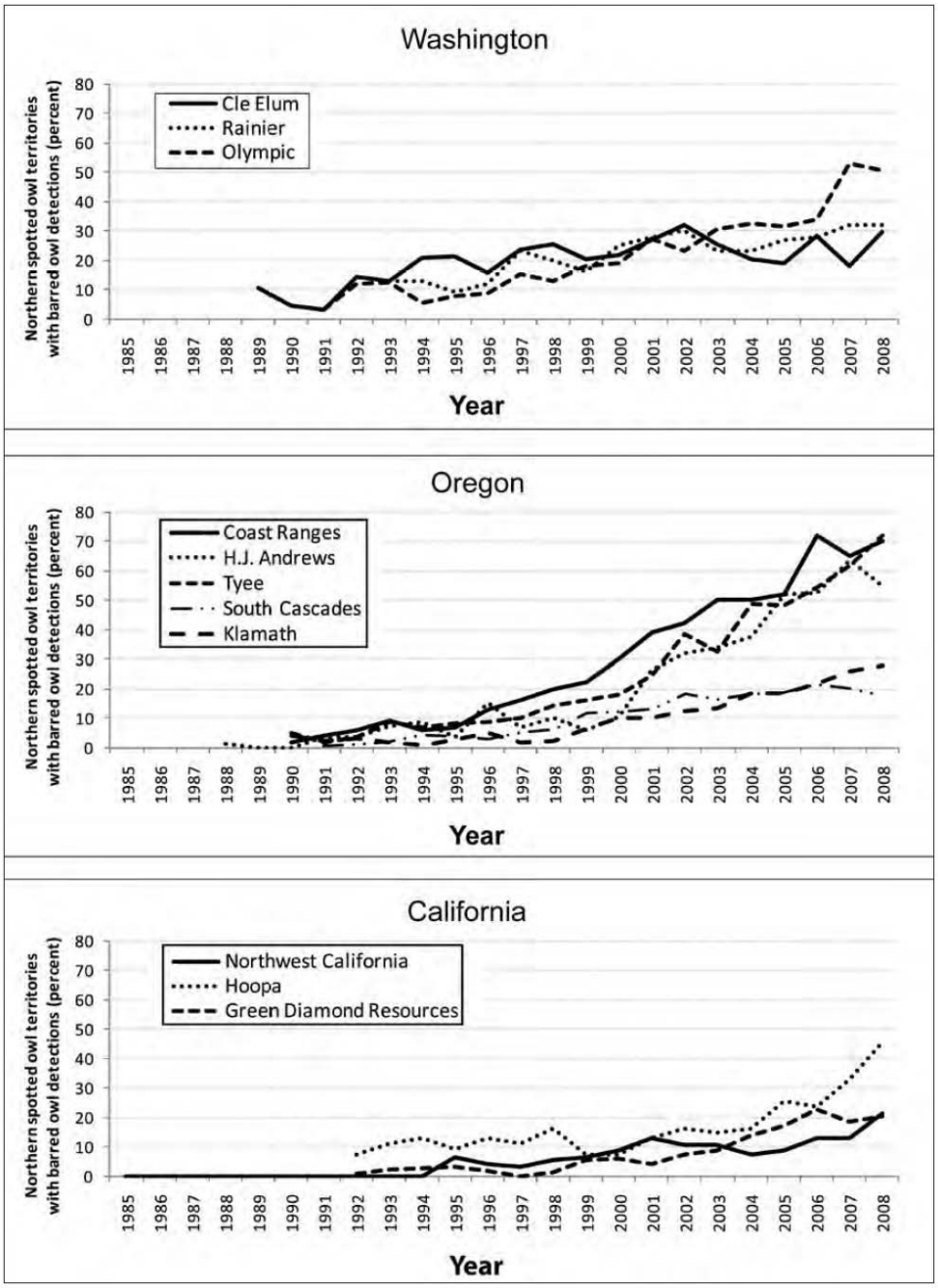
Reliable data concerning current barred owl densities and population trends are unavailable. Most information about barred owl trends in the Pacific Northwest and California is based on incidental detections during surveys for spotted owls (USFWS 2013). Researchers have estimated that only 1/2 to 2/3 of barred owls present are detected during NSO surveys (Gutiérrez et al. 2004, Bailey et al. 2009, Wiens et al. 2011). Researchers have only recently begun to systematically survey for barred owls within the range of the NSO and only in limited areas. In California, the Northwest California, Green Diamond, and Hoopa NSO demographic studies initiated systematic surveys for barred owls in 2009 (Franklin et al. 2014, Green Diamond Resource Company 2014).

Some early studies of barred owls within the NSO's range likely overestimated barred owl numbers by focusing on cumulative and nighttime detections (Gutiérrez et al. 2004). However, barred owl trends are now more frequently evaluated in terms of the number of spotted owl territories in which barred owls have been detected (USFWS 2013; e.g., Forsman et al. 2011, Calforests 2014). Reports of the number of spotted owl territories with barred owl detections probably underestimate barred owl densities and population trends (USFWS 2013). Barred owls often have substantially smaller home ranges than spotted owls so it is possible for a single spotted owl home range to encompass multiple barred owl home ranges (Singleton et al. 2010, Wiens 2012; see below). Without color-banding or follow-up surveys to determine the identity and occupancy status of barred owls, it is often unclear if multiple detections within spotted owl territories represent one or multiple barred owls. Furthermore, a lack of barred owl-specific surveys in many areas has likely led to underestimates of barred owl presence. For example, in 2013, NSO-specific surveys on the Hoopa reservation in northwestern California indicated that barred owls were present in 43% of NSO territories on the reservation, whereas barred owl-specific surveys revealed that barred owls were present in 75% of NSO territories (Higley and Mendia 2013).

Despite uncertainty regarding barred owl densities and population trends, incidental detections clearly indicate that the species rapidly expanded its range into that of the NSO (USFWS 2013). For example, barred owls expanded their range from western Washington to northern California in less than 10 years (Gutiérrez et al. 2004). Incidental detections also suggest that barred owl densities are continuing to increase within the range of the NSO. From 1985-2008, the

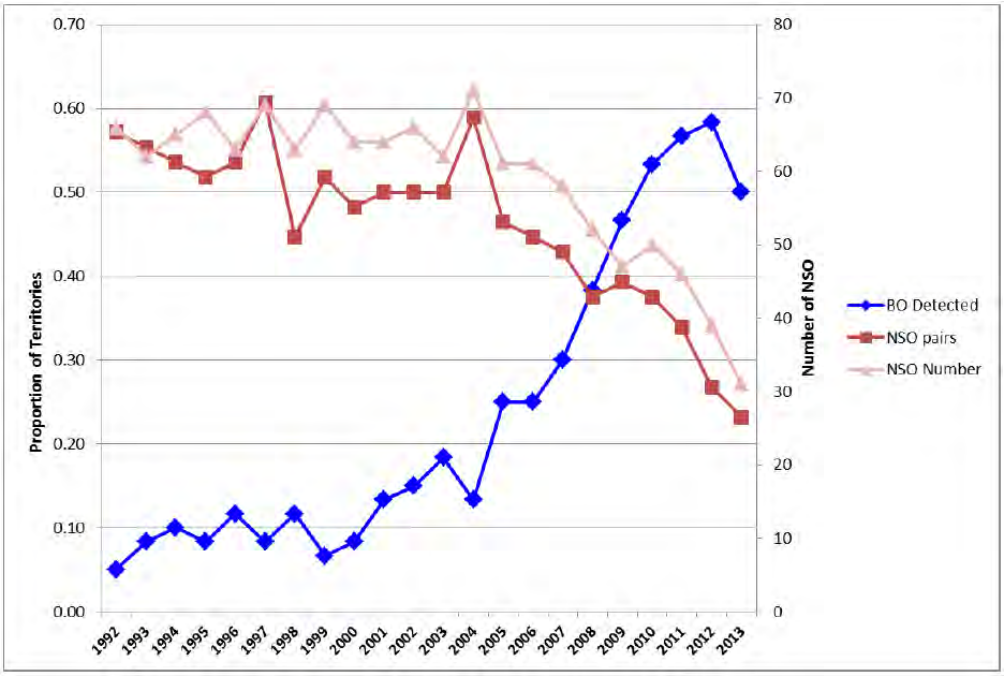
proportion of NSO territories with known barred owl presence increased in demographic study areas throughout the NSO's range, suggesting increasing barred owl populations (Forsman et al. 2011; Figure 4.2). Until the mid-2000s, barred owl increases in Washington and Oregon were steeper than those in California (Forsman et al. 2011; Figure 4.2), which is consistent with the species' later colonization of California (USFWS 2013). However, barred owls are currently increasing at an accelerated pace in at least some portions of northwestern California (see below).

Figure 4.2: Annual proportion of northern spotted owl territories with barred owl detections (≤0.62 mi from spotted owl activity center) on demographic study areas in Washington, Oregon, and California (from Dugger and Davis 2011, adapted from Forsman et al. 2011).



Recent reports from California's demographic studies indicate that barred owls continued to increase in numbers and to invade additional NSO territories during 2009-2013 (Higley and Mendia 2013, Franklin et al. 2014, Green Diamond 2014). As noted above, California's demographic studies initiated barred owl-specific surveys in 2009. The Green Diamond Resource Company also began a barred owl removal experiment in a portion of their demographic study area during the same year (see below). Detection and occupancy data reported here for 2009-2013 are not directly comparable to previously collected data, except for from the Hoopa demographic study, which separately reported data from NSO- and barred owl-specific surveys. In the Northwest California demographic study area and nearby Regional Study Area, the number of NSO territories with barred owl detections increased by 76% (from 21 to 37) during 2009-2013 and the estimated number of barred owl sites increased by 170% (10 to 27) (Franklin et al. 2014). On Green Diamond Resource Company lands, the total estimated number of barred owl sites increased by 57% (numbers not reported) during 2011-2013 (Green Diamond 2014). In the Hoopa demographic study area, NSO-specific surveys indicated that the percent of NSO territories with barred owl presence increased from 47% to 58% during 2009-2012 and dropped to 50% in 2013 for unreported reasons (Higley and Mendia 2013; Figure 4.3).

Figure 4.3: Total number of northern spotted owls detected (NSO Number), percentage of territories occupied by spotted owl pairs (NSO Pairs) and percent of historical spotted owl territories with at least one barred owl detection (BO Detected) received during spotted owl surveys, annually within the Hoopa Valley Indian Reservation demographic study area during 1992-2013 (from Higley and Mendia 2013).



Cumulative detections in the California Natural Diversity Database (CNDDB) from 1978 through 1990, 1998, 2006, and 2013 provide a crude picture of the barred owl's expansion in California (Figure 4.4). These detection data suggest that the species expanded its range into the state along the northern coast and southern Cascades and more rapidly increased in wetter regions (Figures 4.4 and 4.5). Earlier and more rapid colonization of relatively mesic forests by barred owls is consistent with observations from studies in Washington (Gutiérrez et al. 2007). While cumulative detections cannot be used to evaluate the abundance or densities of barred owls, they suggest that the species is relatively abundant along the coast and in the adjacent Six Rivers National Forest and vicinity (including the Northwest California and Hoopa demographic study areas), whereas they appear to still be in the process of colonizing the Mendocino, Klamath, and Shasta-Trinity National Forests and other interior areas of northern California. However, it is possible that this pattern is biased by the fact that most barred owl detections occur during surveys for spotted owls, which may be more densely concentrated or better surveyed in northwestern California. Concentrations of barred owl detections in northwestern California may be partly associated with intensive survey effort for spotted owls in the region's three demographic study areas. Furthermore, the Six Rivers National Forest conducted forest-wide surveys for NSOs in 2010 and subsequently continued to survey large areas associated with forest projects. Barred owls have a broader ecological range than do spotted owls, so they may be more widely distributed than is shown in Figure 4.4 (USFWS 2013).

Figure 4.4: Cumulative northern California barred owl detections in the California Natural Diversity Database from 1978 through A) 1990, B) 1998, C) 2006, and D) 2013 (note: dark red symbols denote higher concentrations of detections).

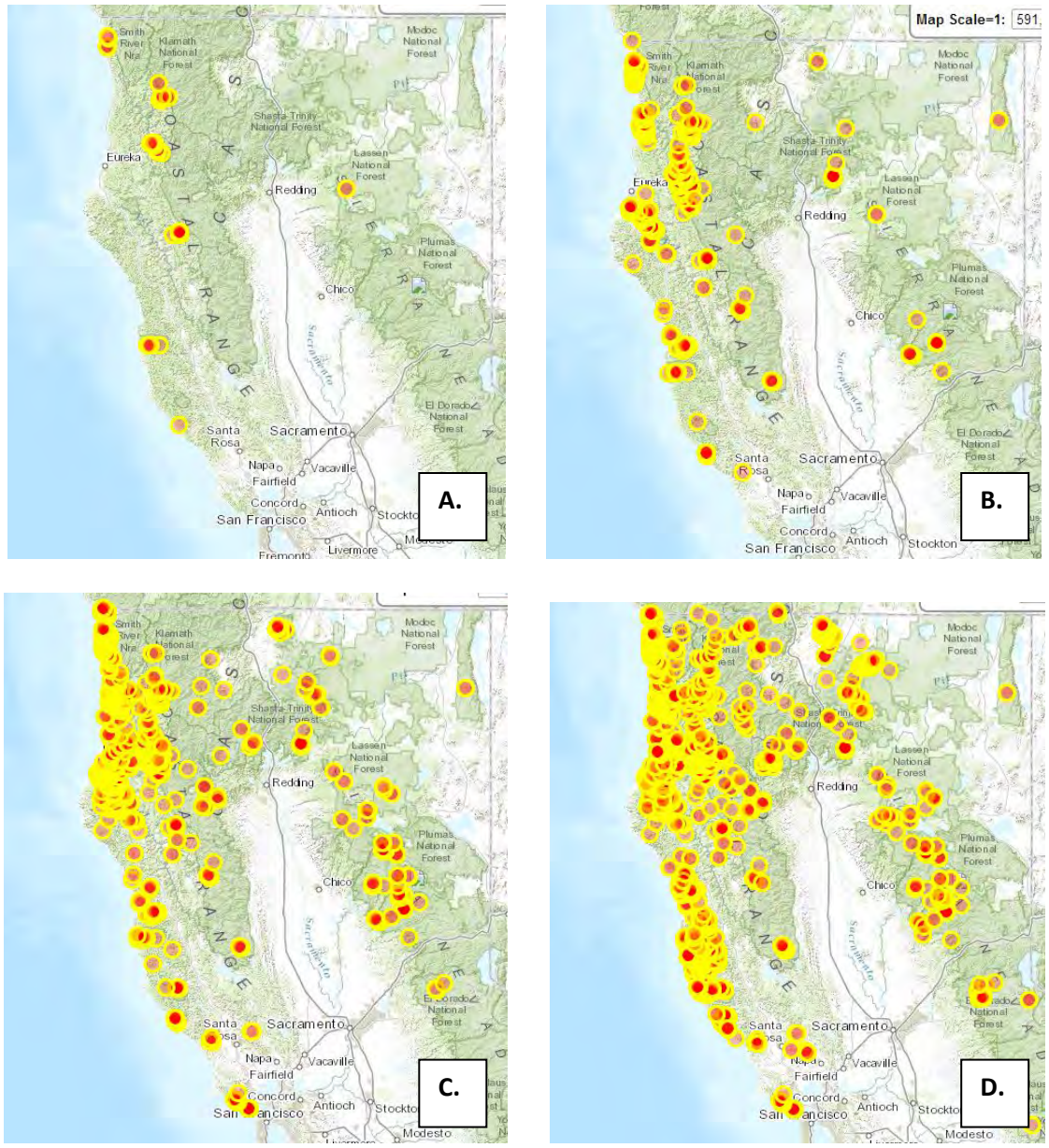
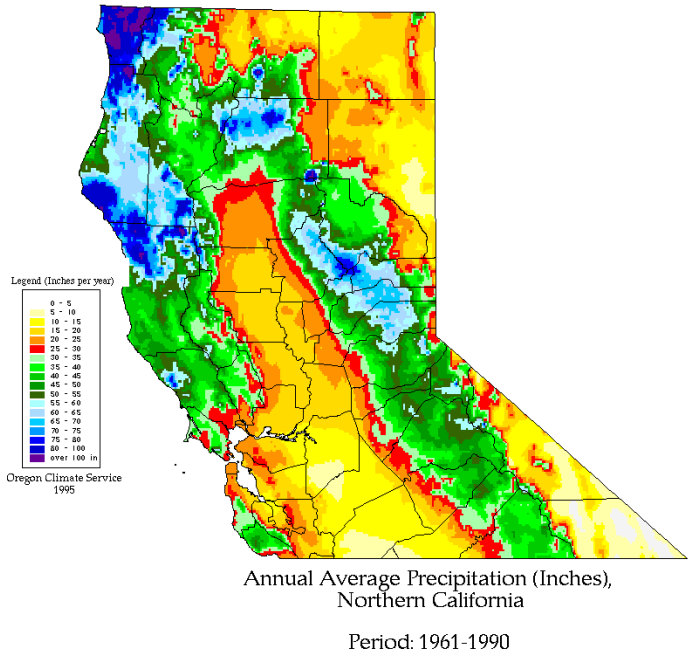


Figure 4.5: PRISM precipitation map for northern California (1961-1990) (Western Regional Climate Center).



Barred owls have increased dramatically in California's Redwood National and State Parks (Gutiérrez et al. 2004). In 2012 alone, NSO surveyors detected at least 17 barred owls at 10 different sites (Schmidt 2013). In contrast, NSOs were detected at only four historical territories in 2012. It is possible that more NSO territories were active during that year as relatively little of the landscape was surveyed. However, Schmidt (2013) noted that the Redwood National and State Parks have discontinued surveying many areas due to what appears to be almost complete displacement of NSOs by barred owls. Based on clusters of barred owl detections ($\leq$1 mi apart) during 1993-2012, Schmidt (2013) estimated that the Redwood National and State Parks contain a total of 58 barred owl territories. Barred owls have only recently invaded National Park lands in Marin County, California and have been slow to increase in numbers thus far (Ellis et al. 2013). Barred owls were first detected in Marin County in 2002 and were detected at only four (13%) NSO monitoring sites in the area in 2012 (Ellis et al. 2013). Ellis et al. (2013) hypothesized that the barred owl's expansion into Marin County has been limited due to extensive agricultural and urban lands surrounding the area. They also stated however, that barred owl numbers would likely continue to increase in the area over time and could eventually pose a substantial conservation problem for this small and relatively isolated population.

Most information about barred owls on private timberlands in California is from ownerships in the Redwood Province. Data provided by the Green Diamond Resource Company are described above, along with those from other NSO demographic studies in California. Reports from both the Humboldt Redwood Company (Humboldt County) and Mendocino Redwood Company (Mendocino and Sonoma Counties) suggest that barred owls are currently rapidly increasing on those lands. Despite a marked decline in annual numbers of nighttime NSO surveys, Humboldt

Redwood Company (2013) found an overall increase in barred owl detections within 0.5 mile of NSO activity centers during 2003-2013 (Figure 4.6). However, some of the increase in barred owl detections between 2010 and 2011 could have been due to greater survey effort associated with adoption of the USFWS (2012c) revised survey protocol for NSOs. Mendocino Redwood Company (2014) data suggest that barred owls increased substantially on their lands during 2005-2013 (Figure 4.7). Barred owls were detected within one mile of 47 (45%) NSO activity centers on these lands in 2013. The number of NSO territories with barred owl detections increased by 113% during 2010-2013. Mendocino Redwood Company (2014) noted that barred owls have been detected within one mile of 71 NSO activity centers on their lands since 2005. The Conservation Fund (in Calforests 2014), which manages lands in Mendocino and Sonoma Counties, stated that barred owls have been detected "across their ownership" since 2009. They currently have four sites at which barred owls are "regularly detected" and another area in which they are "occasionally detected".

Figure 4.6: Number of barred owl detections within 0.5 mile of northern spotted owl activity centers on Humboldt Redwood Company lands during 2003-2013 (from Humboldt Redwood Company 2013).

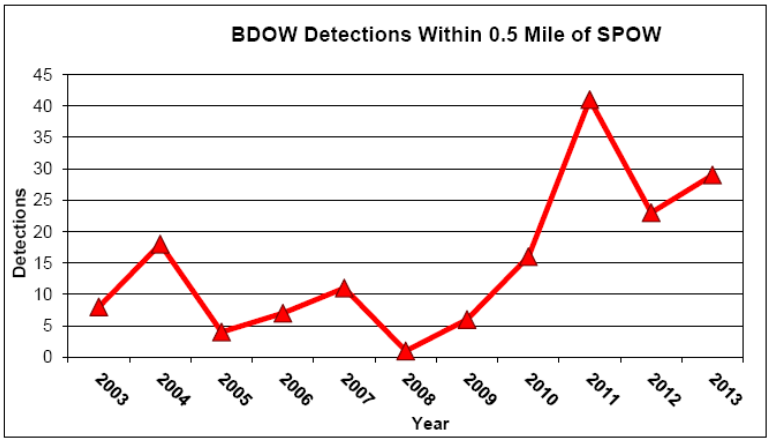
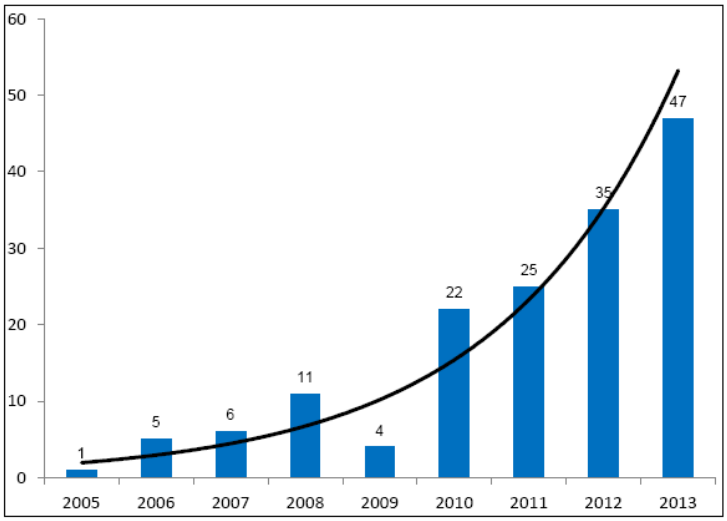


Figure 4.7: Percent (y-axis) and number of northern spotted owl territories (1 mi radius around activity centers) on Mendocino Redwood Company lands with barred owl detections during 2005-2013 (note: the apparent decline in NSO territories with barred owl detections in 2009 coincided with a substantial dip in NSO survey effort) (from Mendocino Redwood Company 2014).



There is relatively little information concerning barred owl numbers on private timberlands in California's Eastern Klamath and Southern Cascade regions. In 2013, Sierra Pacific Industries confirmed barred owl occupancy at 14 of 28 known/historical barred owl sites within their Redding and Weaverville Districts (eastern Klamath and Southern Cascades regions) and located two additional sites (SPI 2014). I was unable to locate any reports of barred owl presence or trends within NSO territories on Sierra Pacific lands. Fruit Growers Supply Company (in Calforests 2014) reported barred owl detections within or "nearby" (distance not reported) five NSO activity centers in Siskiyou County. It was unclear whether these numbers were cumulative or from 2013 alone. Michigan-California Timber Company (in Calforests 2014) reported that barred owls were detected at one site on their lands in Siskiyou County in 2010 and 2012 and two sites in 2009 and 2013. Crane Mills (in Calforests 2014) has detected only one barred owl on their lands in Shasta County. Roseburg Resource Company (in Calforests 2014) has never detected a barred owl during their NSO surveys on lands in Siskiyou and Shasta Counties. The low numbers of barred owl detections on some private timberlands in California's Eastern Klamath and Southern Cascades regions is surprising given the numbers of detections on the Shasta-Trinity and Klamath National Forests and on Sierra Pacific Industries lands in those regions (Figure 4.4), as well as in the Klamath and Southern Cascades demographic study areas in southern Oregon (Davis et al. 2013, Dugger et al. 2014). It is unclear if this is due to differences in survey effort, ecological conditions, management histories, or other factors.

In summary, the barred owl's range now completely overlaps the NSO's range and partially overlaps the California spotted owl's range. Barred owls rapidly expanded their range southward from British Columbia, through Washington and Oregon, and into northern California. The species' range expansion into California appears to have occurred first and most rapidly in northern coastal forests and near the margin of the southern Cascades and northern Sierra

Nevada. The available information suggests that there is currently a high potential for interactions between NSOs and barred owls throughout much of NSO's range in California. The barred owl invasion does not appear to have peaked in the state. Rather, the information reviewed above suggests that the species is continuing to expand into drier, interior portions of California and that their presence in NSO territories is increasing at accelerating rates in the Western Klamath and Redwood regions.

Effects on NSOs

Scientific Uncertainty

There is currently little reliable information concerning trends in barred owl densities or population numbers. Most of what is known about the potential for barred owl interactions with NSOs is based on incidental detections of barred owls during NSO surveys (USFWS 2013). Reliance on NSO surveys limits many studies' inferences concerning barred owl numbers. Gutiérrez et al. (2004) noted that some studies found large numbers of historical NSO territories apparently vacant of both NSOs and barred owls. It is unclear if these vacancies were primarily due to inadequate survey effort for one or both species or if they were caused by some other factor (Gutiérrez et al. 2004). Some of this uncertainty has been reduced due to increased survey effort required by revised survey protocols for NSOs (e.g., USFWS 2012c) and implementation of barred owl-specific surveys in some areas. Inferences from studies of barred owl effects on NSOs are further limited by the observational and retrospective nature of most research of this topic (Livezey and Fleming 2007, USFWS 2013). Most studies of barred owl effects on NSOs have examined correlations between changes in NSO occupancy or demography and barred owl presence near NSO activity centers (see below). These studies do not definitively prove that barred owl presence causes changes in NSO occupancy or demography. However, preliminary results of barred owl removal experiments more directly support conclusions that barred owl presence negatively affects NSOs in a variety of ways (see below).

Hybridization

At the time of the NSO's listing there was concern among some researchers that hybridization between spotted owls and barred owls would lead to the loss of the spotted owl as a distinct species (Gutiérrez et al. 2004). Despite genetic, morphological, ecological, and behavioral differences between spotted owls and barred owls, there appear to be few strong isolating mechanisms to prevent them from interbreeding (Gutiérrez et al. 2007). Yet, hybridization between the two species appears to be relatively rare. For example, an extensive review of NSO survey and banding records from 1970-1999 in Oregon and Washington found reports of only 47 NSO-barred owl hybrids (Kelly and Forsman 2004). Hybridization therefore appears to pose little threat to NSOs compared with the effects of competition (Kelly and Forsman 2004; see below). However, hybridization could become a more serious issue in the future as NSOs continue to decline and become less able to locate conspecific mates (Gutiérrez et al. 2007).

Demography

Forsman et al. (2011) evaluated demographic trends for NSOs in 11 demographic study areas during 1985-2008. They found that NSO reproduction (fecundity) was negatively associated with the presence of barred owls (≤0.62 mi from NSO activity centers) in four study areas, including Green Diamond's in California. Inclusion of the barred owl covariate in one of the best performing models in the meta-analysis of reproduction across all study areas provided weak support for an effect of barred owl presence on reproduction throughout the NSO's range (Forsman et al. 2011). The negative association between reproduction and barred owl presence was likely underestimated since researchers often cannot relocate NSOs displaced by barred owls, and many displaced NSOs may be unable to find new territories and reproduce (Forsman et al. 2011). Apparent survival of NSOs was negatively associated with the presence of barred owls in six of the study areas, including Northwest California and Green Diamond (95% confidence intervals did not overlap zero or only slightly overlapped zero). The meta-analysis for all study areas showed a negative association between barred owl presence and apparent survival and recruitment, although the evidence for an effect on recruitment was statistically weak. Populations in seven study areas, including Northwest California and Green Diamond, declined during the latter portion of the study period (95% confidence intervals did not overlap zero or only slightly overlapped zero for these areas). Model selection results for the meta-analysis of population change indicated support for models that included the barred owl covariate. Forsman et al. (2011) noted that, of the various factors evaluated for potential effects on NSO vital rates, negative associations with the presence of barred owls were the strongest and most consistent among study areas. Forsman et al. (2011) also noted that they likely underestimated these negative associations by applying the barred owl covariate at the population scale rather than the territory scale. Studies of associations between NSO occupancy rates and barred owl presence suggest that the territory is a more appropriate spatial scale for detecting effects of barred owls on NSOs (see below).

Annual reports from NSO demographic studies in the southern portion of the subspecies' range indicate that negative effects of barred owls on NSO demographic and occupancy rates continued to increase following the study period covered by Forsman et al. (2011) (Davis et al. 2013b, Higley and Mendia 2013, Dugger et al. 2014, Franklin et al. 2014, Green Diamond Resource Company 2014; see Ch. 1). The Northwest California and Hoopa study areas experienced dramatic declines in demographic rates subsequent to the end of the 2011 meta-analysis study period and the declines appeared to be largely driven by increasing competition from barred owls (Higley and Mendia 2013, Franklin et al. 2014). Strong negative effects of barred owls on NSO demography will likely be evident for most or all demographic study areas in the forthcoming meta-analysis, which is due for release in 2015.

Occupancy

Numerous studies distributed across the NSO's range have found evidence of a negative effect of barred owl presence on occupancy by the subspecies (Kelly 2001, Kelly et al. 2003, Pearson and Livezey 2003, Gremel 2005, Olson et al. 2005, Kroll et al. 2010, Dugger et al. 2011, Higley and Mendia 2013, Franklin et al. 2014, Green Diamond Resource Company 2014). These findings

suggest that barred owls are causing large-scale displacement of NSOs and that negative effects of barred owls are largely due to interference competition between the two species (see below).

Gremel (2005) found that occupancy by pairs of NSOs in the Olympic National Park in Washington declined significantly at sites with barred owl presence, whereas pair occupancy remained stable at sites without barred owl detections. During 1992-2003 in this study area, the number of barred owl detections in NSO sites per number of survey days increased by 15% per year. During the same period, mean occupancy by NSOs declined from 61% to 42% in sites with barred owl detections.

In the southwestern Washington Cascades, Pearson and Livezey (2003) found a 9% annual increase in the number of barred owl detections relative to the number of NSO detections during 1982-2003. Unoccupied historical NSO core areas (500 ac) had significantly more barred owl activity centers at three spatial scales (0.5, 1.0, 1.8 mi) than did occupied core areas.

Kelly et al. (2003) evaluated potential effects of barred owl presence on NSO occupancy in five demographic study areas in Washington and Oregon. Their analyses indicated that barred owls had a stronger negative effect on NSO occupancy when located closer to activity centers than when farther away. Occupancy by NSOs exhibited a highly significant decline when barred owls were detected within 0.5 mile of activity centers ($P = 0.001$), compared with a lower tendency to decline when barred owls were detected farther away ($P = 0.06$).

Olson et al. (2005) examined associations between NSO occupancy dynamics and the presence of barred owls near activity centers (distance not reported) in three study areas in western Oregon. Barred owl presence was low (detected near <10% of NSO sites each year) in all three study areas during the first eight years of the study (1990-1997), increased substantially in one of the study areas thereafter (maximum of 28% of sites in 2001), and more gradually in the other two (ca. 10% of sites in 2001). Despite relatively low barred owl presence (e.g., compared with Forsman et al. 2011, Figure 4.2), site occupancy probabilities for NSO pairs decreased by 5-15% with increasing barred owl presence.

In one of the western Oregon demographic study areas evaluated by Olson et al. (2005) (Tyee), Bailey et al. (2009) found no evidence of an effect of barred owl presence on NSO occupancy during 2002-2003. They cautioned however, that their study's inferences were weak since barred owl presence was relatively low at the time of the study (detections in <12% of NSO territories based on Olson et al. 2005). Just five years after their study period ended, barred owls were detected in 70% of NSO territories (0.62 mi around activity centers) in the study area (Forsman et al. 2011; Figure 4.2).

In the eastern Cascades of Washington, Kroll et al. (2010) found that the mean probability of occupancy by NSOs was significantly lower for sites with barred owl presence (0.50) than without it (0.76) (presence not spatially defined in the paper). Although the percent of NSO sites with barred owl detections was moderate compared with some areas (max. ca. 33% [estimated from graph] vs. Figure 4.2), site occupancy probabilities for NSOs declined by about 50% during 1990-2003.

In the southwestern Cascades of Oregon, Dugger et al. (2011) found significant differences in mean annual occupancy for NSO pairs with nearby barred owl detections (presence not spatially defined) than in those without. During the latter 13 years of the study, mean annual site occupancy was approximately 10-15% at sites with barred owl presence compared with about 58-78% at sites without barred owl presence (estimated from graph).

Both the Northwest California and Hoopa demographic studies reported dramatic recent declines in NSO occupancy coincident with rapid increases in the percent of NSO territories with barred owl presence (Higley and Mendia 2013, Franklin et al. 2014; e.g., Figure 4.3). Both studies reported sharp declines in NSO numbers and occupancy in the mid-2000s subsequent to a longer period of gradual decline (e.g., Figure 4.3). These observations suggest that the barred owl expansion and its effects on NSOs in the Western Klamath rapidly changed after a post-colonization lag period elapsed or when a crucial threshold in barred owl density was reached.

Green Diamond Resource Company is currently conducting an experiment to evaluate the effects of lethally removing barred owls from NSO territories in California's Redwood Province. Preliminary results from this study suggest that removal of barred owls results in rapid recolonization of sites by NSOs. Green Diamond Resource Company (2014) reported a 43% increase in the number of sites occupied by NSOs in their treatment (barred owl removal) area during the first year (2008 to 2009) and an additional 9% increase the following year (2009 to 2010). In contrast, the number of sites occupied by NSOs in an adjacent control portion of the study area (no barred owl removal) was virtually unchanged from 2008 to 2009 and declined by 23% from 2009 to 2010. However, the degree to which barred owl removal positively affected NSO occupancy in this study is difficult to evaluate. The beginning of Green Diamond's removal study roughly coincided with implementation of a new survey protocol which likely resulted in greater detections of both NSOs and barred owls. Future analyses from this study should provide clearer insight into the effects of barred owl presence and removal on NSO occupancy.

Habitat Use

Dugger and Davis (2011) stated that "the relationship between spotted owl fitness and habitat characteristics may have become disconnected through interspecific competition with barred owls." They based this hypothesis on their finding that mean habitat suitability at NSO pair locations within the Northwest Forest Plan area decreased by approximately 9% between 1994/1996 and 2006/2007 (Davis and Dugger 2011). This decline in mean habitat suitability at NSO pair locations did not appear to be solely due to a loss of suitable breeding habitat, which declined by about 3% in this area during the study period. This hypothesis is also supported by findings that NSOs in the northern portion of their range are often displaced by barred owls into steeper and higher elevation areas (Pearson and Livezey 2003, Gremel 2005, Hamer et al. 2007). Hamer et al. (2007) suggested that displacement of NSOs to higher elevation forests could result in reduced survival or reproduction during years with severe winters. Wiens et al. (2014) found a high degree of overlap in the habitat associations of NSOs and barred owls in western Oregon (e.g., strong selection of old conifer forest). Their best model of habitat use indicated that NSOs were less likely to use locations within or in close proximity to the core-use area of a barred owl.

This finding provides further evidence that barred owls displace NSOs from their preferred habitat.

Territorial Behavior

Barred owl presence and calling is associated with reduced responsiveness of spotted owls to conspecific calls, including survey broadcasts (Olson et al. 2005, Crozier et al. 2006, Bailey et al. 2009, Kroll et al. 2010). This is partially of interest to researchers and land managers because it influences the field and analytical methods required for measuring occupancy by NSOs (Olson et al. 2005, USFWS 2012c). Reduced vocalizing by NSOs in the presence of barred owls is also of concern because NSOs rely on vocalizations to defend their territories, locate vacant territories and potential mates, form pair bonds, and announce prey deliveries (Gutiérrez et al. 1995). Widespread disruption of these activities could impact NSO demographic rates.

Interspecific Competition

Gutiérrez et al. (2004) described the ecological and morphological separation that exists among sympatric owls worldwide. Their review found that species within the same genus are generally segregated by geographic range or habitat associations. It also showed that sympatric congeneric owls are usually strongly divergent in size, which varies with diet and possibly, hunting mode. Spotted owls and barred owls are both members of the genus *Strix*. Gutiérrez et al. (2004) noted that the two species only differ in body mass by 18%, which is likely too little to allow coexistence. A building body of evidence indicates that barred owls indeed negatively affect spotted owls (reviewed above), and that this occurs through both direct (interference) and indirect (exploitative) competition (Gutiérrez et al. 2004, 2007, USFWS 2013; see below). Wiens (2012) stated that "when viewed collectively, the behavioral and life history traits exhibited by barred owls may give them a significant advantage over spotted owls when competing for critical resources such as space, habitat, and food."

Surveyors have observed barred owls attacking spotted owls and have themselves been attacked while imitating spotted owl calls (Gutiérrez et al. 2004). There is also limited evidence of barred owl predation of NSOs. Leskiw and Gutiérrez (1998) provided strong circumstantial evidence that a barred owl killed and partially consumed an NSO in Redwood National Park, California. Johnston (2002 cited in Gutiérrez et al. 2004) found circumstantial evidence of barred owl predation of a juvenile NSO in the southern Oregon Cascades. However, most cases of barred owl aggression toward NSOs appear to be a related to territorial defense, rather than predation (USFWS 2013).

Studies in Washington found that barred owl home ranges are relatively small and tend to have little overlap, which is consistent with aggressive territorial behavior (Hamer et al. 2007, Singleton et al. 2010). In contrast, neighboring NSO home ranges often broadly overlap, particularly during winter (Hamer et al. 2007). There is limited anecdotal evidence of spotted owls aggressively interacting with barred owls (Gutiérrez et al. 2004), and spotted owls appear to reduce detection probabilities for barred owls (Bailey et al. 2009). Nonetheless, barred owls generally exhibit higher levels of vocal and physical aggression than do NSOs and are typically dominant during interactions between the two species (Van Lanen et al. 2011). Significantly

reduced detection probabilities for NSOs in the presence of barred owls provides further evidence of the larger, more aggressive barred owl's behavioral dominance over NSOs (see above).

Barred owls are dietary generalists compared with NSOs (USFWS 2013, Wiens et al. 2014). As dietary generalists, barred owls may be better able to colonize a wider variety of habitats than NSOs and may be more resilient to fluctuations in prey populations (USFWS 2013). The barred owl's generalist diet is likely a primary reason for the species' relatively small home ranges and associated ability to occur at high densities (see below). Furthermore, because barred owl diets overlap with those of NSOs, it is possible that they negatively affect NSOs by depressing populations of key prey, such as northern flying squirrels and woodrats (Gutiérrez et al. 2007, USFWS 2013).

The barred owl's habitat associations in the Pacific Northwest and California are poorly understood. As discussed earlier, most barred owl detections are incidental to spotted owl surveys so relatively little is known about the ecology of barred owls outside of areas occupied by spotted owls. Early studies of the barred owl's habitat associations in the Pacific Northwest suggested that the species is more associated with younger forest types than are NSOs (Gutiérrez et al. 2007). However, subsequent research has found that barred owls use a variety of habitats and, like NSOs, often show a preference for old forest (Gutiérrez et al. 2007, USFWS 2011a, Wiens et al. 2014). Thus, barred owls appear to be capable of occupying a broader variety of habitat types than NSOs but the two species likely compete for access to mature and old forest. The two species may also compete for nest sites since they both rely on the same kinds of pre-existing nest structures (Gutiérrez et al. 2007). Together, overlapping habitat associations with NSOs, use of a broader range of habitat types, and the ability to occur at relatively high densities allows barred owls to form large source populations in close proximity to NSOs (USFWS 2013).

Perhaps due to their generalist diet, barred owls often have substantially smaller home ranges than do NSOs (Gutiérrez et al. 2007, USFWS 2013). Estimates of barred owl home ranges in Washington were three to nine times smaller than those of NSOs in the state (Hamer et al. 2007, Singleton et al. 2010). Barred owl home ranges in the Oregon Coast Ranges were two to four times smaller than those of NSOs (Wiens et al. 2014). There does not appear to be any existing research comparing the home range sizes of barred owls and NSOs in California (Gutiérrez et al. 2007). Annual home range sizes for NSOs (100% minimum convex polygon) in the California and Oregon Klamath Provinces varied among studies and with forest types and contiguity but were similar to or somewhat larger (0-60% larger) than those for barred owls in the Oregon Coast Ranges (Sisco 1990, Carey et al. 1992, Zabel et al. 1993, Irwin et al. 2006). The NSO's smaller home ranges in California suggest that they may have lower encounter rates with barred owls than occurs in Oregon and Washington. However, it is possible that barred owls also have smaller home ranges in California. Estimates of barred owl home range sizes in California are needed.

Wiens et al. (2014) found that barred owls in the Oregon Coast Ranges had a slightly higher annual survival probability than sympatric NSOs (0.92 vs. 0.81; not statistically significant) and that pairs produced an average of 4.4 times as many young. Barred owls have a wider range of clutch sizes than NSOs (1-5 vs. 1-3), are capable of laying additional clutches within a season if

the first is lost, and appear to exhibit lower annual fluctuations in reproduction (USFWS 2013). The USFWS (2013) noted that "the ability of barred owls to forage on a wider diversity of prey species and in a wider diversity of habitats may explain their reproductive success in comparison with spotted owls." There is a need for further research of the barred owl's natural history and ecology within the range of the NSO (Gutiérrez et al. 2007, Livezey and Fleming 2007). However, the currently available information indicates that the demographic performance of barred owls is superior to that of NSOs.

Overall, barred owls appear to primarily impact NSOs through interference competition for space, habitat, and food, although they may also indirectly affect NSOs by depressing prey populations (Gutiérrez et al. 2007, Hamer et al. 2007, Van Lanen et al. 2011, USFWS 2013, Wiens et al. 2014). Barred owls are generally superior competitors to NSOs in terms of size, aggression, demographic performance, and ability to exploit a wider array of habitats and prey (Gutiérrez et al. 2007, USFWS 2013, Wiens et al. 2014).

Barred Owl Management

The information reviewed above indicates that barred owls pose a serious and increasing threat to NSOs throughout their range, including in California. Barred owl presence in NSO territories has continued to increase across the NSO's range and appears to have strongly contributed to declining NSO demographic and occupancy rates. Barred owl presence can also reduce the ability of biologists and land managers to effectively locate and conserve NSOs. Given the negative effects of barred owls on NSOs, it is clear that policymakers and land managers must address the barred owl threat if successful recovery of the NSO is to remain a conservation priority. Current proposals for addressing the barred owl threat include barred owl removal and habitat conservation.

Some researchers have expressed concern that barred owl removal experiments would be costly, ineffective, and distracting (Livezey 2010, Rosenberg et al. 2012). However, preliminary results from barred owl removal experiments indicate that lethal removal of barred owls is effective, relatively inexpensive, and conforms to animal welfare standards (Diller 2013, Diller et al. 2013, Higley 2014). Other objections to barred owl removal are primarily ethical or emotional (Gutiérrez et al. 2007, Diller 2013). There is substantial emotional resistance to lethal removal of barred owls, even among scientists and land managers involved with barred owl removal experiments (e.g., Diller 2013). Relocation of barred owls to zoos or their native forests in the eastern U.S. is logistically and politically unfeasible, so killing barred owls appears to be the only viable removal option (USFWS 2013). Primary ethical concerns regarding barred owl removal include whether or not it is appropriate to remove or control a native species or to intervene in its potentially natural range expansion (USFWS 2013). The USFWS (2013) reviewed scientific literature regarding the barred owl's status as a native or nonnative species and whether its range expansion was natural or human caused. It found that the literature was inconclusive regarding both issues. However, it concluded that humans are responsible for intervening in the barred owl's expansion because the NSO's vulnerability to barred owl competition and other stressors is due to timber harvesting and other past and continuing human activities. Regardless, the currently available evidence suggests that NSOs will continue to

decline, and could ultimately become extinct, without widespread or strategic barred owl control measures.

The barred owl's increasing impact on NSOs in Late Successional Reserves, National Parks, and other reserved lands demonstrates that habitat protection alone is insufficient for addressing the barred owl threat (Gutiérrez et al. 2004). Nonetheless, habitat conservation remains crucial to the NSO's conservation (USFWS 2011a). The importance of retaining suitable breeding habitat for NSOs has been well demonstrated at individual, territory, and population scales (e.g., Solis and Gutiérrez 1990, Franklin et al. 2000, Forsman et al. 2011; see Ch. 2). Habitat conservation might also be important for minimizing barred owl impacts on NSOs (USFWS 2011a). Habitat loss and fragmentation due to timber harvesting or other disturbances could intensify competition between NSOs and barred owls by bringing them into closer proximity (Gutiérrez et al. 2007, USFWS 2011a). Dugger et al. (2011) found some support for this hypothesis in their study of NSO occupancy in southern Oregon. Their results indicated that barred owl presence and landscape-level habitat characteristics have additive effects on NSO occupancy rates. Specifically, the presence of barred owls appeared to exacerbate the negative effects of habitat loss and fragmentation on NSO occupancy. The USFWS (2011a) suggested that retaining and restoring habitat may provide displaced or recruited NSOs with refugia from negative interactions with barred owls (USFWS 2011a). Dugger et al. (2011) did not find direct support for this hypothesis. In their study, higher amounts and lower fragmentation of older forest did not reduce the negative effects of barred owls on NSO occupancy. However, they noted that some NSOs in their study continued to survive and successfully reproduce in areas with barred owl presence, possibly indicating that there are ecological conditions under which the two species can coexist. Additional and more direct research of the potential value of habitat refugia for NSOs is needed.

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Ch. 5: Outdoor Marijuana Cultivation

Introduction

Although marijuana is perhaps the largest cash crop in California (Gettman 2006), little is known about environmental effects associated with its cultivation. Recent research has indicated that outdoor marijuana cultivation is currently having widespread and profound environmental impacts in California (Gabriel et al. 2012, 2013, Thompson et al. 2014, Bauer et al. 2015). Negative impacts of outdoor marijuana cultivation include wildlife deaths caused by pesticide exposure and poaching; habitat degradation caused by logging, road construction, pollution, and water diversion; and heightened safety concerns for research and resource personnel (Gabriel et al. 2012, 2013, Thompson et al. 2014, Bauer et al. 2015). The specific effects of outdoor marijuana cultivation on NSOs are unknown. Recent findings of widespread pesticide exposure among fishers (*Pekania pennanti*) and barred owls in northwestern California suggest that NSOs within the state are likewise exposed and could be experiencing the same effects seen in fishers (Gabriel et al. 2012, 2014). NSOs could also be directly affected by environmental degradation from outdoor marijuana cultivation via habitat modification (e.g., clearing or logging) or suppression of rodent populations (poisoning), or indirectly affected through ecological changes caused by reduced streamflows or pollution (e.g., impacts on vegetation or prey from reduced water availability). Safety concerns associated with illegal marijuana cultivation may also be impacting NSOs and other wildlife through reduced research and survey efficiency and effort (Gabriel et al. 2013).

Pesticides

Pesticide application is usually intended to suppress populations of rodents, insects, mollusks, and other agricultural and urban pests, but can have inadvertent negative impacts on humans, pets, and other non-target animals (Erickson and Urban 2004, Albert et al. 2010, Mnif et al. 2011, Gabriel et al. 2012). Widespread secondary exposure to pesticides has been reported for raptors, carnivores, and other wildlife that consume poisoned rodents around farms and human dwellings (Albert et al. 2010, Murray 2013). Researchers have generally assumed that pesticides pose little threat to wildlife outside of agricultural and urban areas (Gabriel et al. 2013). However, a recent publication reported that 79% of fishers tested in two study areas on federal and tribal forest lands in California had been exposed to anticoagulant rodenticides (ARs), including four that died from lethal toxicosis (Gabriel et al. 2012; note: at least two more fishers in California died from AR poisoning following publication of this study: Gabriel et al. 2013). Most fishers in the study had been exposed to multiple AR compounds (range = 1-4, mean = 1.6). These findings not only raised concern for the West Coast fisher population, which the U.S. Fish and Wildlife Service recently proposed to list as threatened under the federal Endangered Species Act, but for the NSO, which overlaps the fisher in terms of distribution, habitat associations, and diet (Gabriel et al. 2013, Calforests 2014, USFWS 2014). Subsequently, ARs have been detected in a dead NSO recovered in Mendocino County (Calforests 2014) and 34 of 84 (40%) barred owls tested for exposure in Humboldt County (Gabriel et al. 2014). Although barred owls were tested as a proxy for NSOs, NSOs may be more widely exposed to ARs given their greater dietary specialization on rodents (see USFWS 2013). Strong circumstantial evidence implicates pervasive illegal outdoor marijuana cultivation

as the primary source of pesticide exposure for forest predators in California (Gabriel et al. 2012, 2013, Thompson et al. 2014).

ARs detected in fishers in northwestern California include brodifacoum, bromadiolone, chlorophacinone, diphacinone, and warfarin (Gabriel et al. 2012). Brodifacoum and bromadiolone are classified as second-generation anticoagulant rodenticides (SGARs). SGARs were introduced in the 1970s due to widespread development of resistance among rodents to first-generation anticoagulant rodenticides (FGARs), such as warfarin, chlorophacinone, and diphacinone (Buckle et al. 1994). SGARs are more acutely toxic than FGARs and generally require only a single dose to kill rodents (Erickson and Urban 2004). However, rodents usually survive 5-10 days after consuming a lethal dose, during which time they may continue to consume additional rodenticide and remain available to predators (Cox and Smith 1992, Erickson and Urban 2004). SGARs are more persistent in animal tissues than FGARs and insecticides, which are more rapidly metabolized and excreted (Erickson and Urban 2004). Thus, exposure to FGARs and other non-SGAR pesticides is more difficult to detect than for SGARs and exposure to them could be underestimated (Albert et al. 2010, Thompson et al. 2014). Rodents, such as dusky-footed woodrats (*Neotoma fuscipes*) and deer mice (*Peromyscus* spp.), may be the primary source of AR exposure for NSOs because they are targeted by AR application and because they generally comprise most of the biomass in NSO diets (Forsman et al. 2004). Insects may be an additional source of AR exposure for NSOs and other wildlife. In terms of frequency of consumption, insects can substantially contribute to NSO diets regionally, locally, or seasonally (e.g., 1-14% of prey items in various regions of Oregon: Forsman et al. 2004). Insects are not killed by ARs and may therefore continue to accumulate them in their tissues, essentially becoming small “packets” of AR (Gabriel et al. 2014).

Large quantities of ARs, particularly SGARs, are often spread across large areas in and around illegal outdoor marijuana grow sites (Gabriel et al. 2012, Thompson et al. 2014; Figure 5.1). Gabriel et al. (2012) noted that thousands of pounds of pesticides were found at illegal outdoor marijuana grow sites in California in 2008 and that 150 pounds of pesticide were found during a single three-week eradication operation on the Mendocino National Forest in 2011. Three sites raided in Humboldt County in 2013 contained a total of at least 17 pounds of SGAR bait, which researchers estimated was sufficient to kill 2,753 woodrats, 14 fishers, or five spotted owls (Humboldt County Sheriff’s Office press release). Other pesticides, such as organochlorine, organophosphate, and carbamate insecticides, some of which are banned in the U.S., are also frequently found at illegal outdoor marijuana grow sites (HSVTC 2012, Thompson et al. 2014). Pesticides are often applied along with large quantities of fertilizer at the base of marijuana plants grown outdoors (Thompson et al. 2014; Figure 5.1), suggesting that marijuana and surrounding plants may be taking up pesticidal compounds from the soil. If this occurs, then rodents and insects may accumulate pesticides through consumption of plants as well as pesticidal bait. Investigation of pathways of pesticide exposure for NSOs, as well as levels of exposure and potential physiological, behavioral, and population impacts, is needed.

Figure 5.1: (A) Rodenticide and other pesticides found at a trespass outdoor marijuana grow site in Humboldt County (photo: Humboldt County Sheriff's Office) and (B) rodenticide bait and dry fertilizer strewn together below approximately 2,000 marijuana plants at a trespass outdoor grow site in Humboldt County (from Gabriel et al. 2012).

ARs are vitamin K antagonists, which cause impairment of the blood's ability to clot (Murray 2013). A lethal dose of AR causes animals to die from hemorrhage (Erickson and Urban 2004). Animals may also exhibit weakness prior to death or with a sublethal dose (Erickson and Urban 2004). Rodents exposed to ARs show altered behavior, such as spending more time in the open, freezing rather than bolting when threatened, and staggering (Cox and Smith 1992). These behaviors may increase predation risk for affected rodents and the opportunity for secondary exposure of predators to ARs (Cox and Smith 1992). Owls and other raptors with sublethal secondary exposure to ARs may often have reduced blood-clotting activity and can die from minor wounds such as those commonly inflicted by prey (Erickson and Urban 2004, Murray 2013, Thompson et al. 2014). Non-AR pesticides have a variety of physiological effects, such as disrupting endocrine function or damaging the central nervous system (Grue et al. 1997, Mnif et al. 2011). Chronic or sublethal exposure to carbamate or organophosphate pesticides has been shown to reduce immune response, cause neurological disorders, reduce thermoregulatory control, and impair anti-predator behavior in wildlife (Grue et al. 1997; reviewed in Thompson et al. 2014). Pesticides can also have additive or synergistic effects on animals (Larsen et al. 2003 cited in Mnif et al. 2011, Relyea 2009). This is a source of additional concern for NSOs and

other forest predators active near outdoor marijuana cultivation sites, where multiple types of pesticide are often present (HSVTC 2012, Thompson et al. 2014). Mortalities associated with exposure to pesticides are likely underestimated because carcasses are often predated or scavenged before biological samples can be obtained and because sublethal exposure can predispose wildlife to death from other causes (Albert et al. 2010).

There is no information available concerning population-level impacts of secondary pesticide exposure for NSOs in California. As reviewed above, secondary exposure to pesticides can kill raptors and other wildlife both through lethal toxicosis and by increasing the risk of mortality due to other factors such as predation, hypothermia, disease, parasites, or injury. NSO population rates are particularly sensitive to changes in adult survival (Noon and Biles 1990) so it is possible that direct and indirect mortalities associated with pesticide exposure could contribute to population declines (Sibly et al. 2000, Thompson et al. 2014). Pesticide exposure could also negatively impact NSO reproduction. Gabriel et al. (2012) noted that fisher mortalities caused by AR poisoning occurred between mid-April and mid-May. The timing of these deaths coincided with the planting phase of outdoor marijuana cultivation, when seedlings are most vulnerable to rodent pests and AR use is likely highest (Gabriel et al. 2012). This time of year is also when NSOs incubate and brood young (Gutiérrez et al. 1995). Reduced parental care during this phase, for example due to compromised behavior or death of one or both parents, could result in death of offspring due to exposure, undernourishment, or predation (Grue et al. 1997). NSO populations could also be negatively impacted by pesticide suppression of prey populations or changes in community ecology caused by reductions of insects, small mammals, carnivores, raptors, amphibians, and aquatic animals. For example, pesticide impacts on plants, herbivores, or predators could cause wider ecological effects through trophic cascades (Relyea and Diecks 2008).

Other Environmental Effects

Activities related to outdoor marijuana cultivation can have a variety of environmental impacts beyond exposure of wildlife to pesticides, including negative effects of illegal and poorly planned water diversion, logging, and road construction; pollution of water and soils; poaching of wildlife; and ignition of wildfires (reviewed below). Negative impacts occur on both public and private lands (Gabriel et al. 2013, Bauer et al. 2015). However, the potential environmental impacts of marijuana cultivation could vary considerably, depending on the operation's location, scale, and practices. For example, some marijuana industry organizations and growers advocate growing practices aimed at minimizing environmental damage from outdoor cultivation (e.g., http://emeraldgrowers.org/). There does not appear to be any information available at this time regarding effects of ecological degradation from marijuana cultivation on NSOs. Negative effects on NSOs are possible given the subspecies' sensitivity to habitat modification (see Ch. 2 and 3) and close association with riparian areas (e.g., Hamer et al. 2007, Irwin et al. 2012), where the impacts of marijuana cultivation are often concentrated. Furthermore, safety concerns associated with marijuana cultivation can substantially impact the ability of land managers to effectively survey and manage spotted owls and other sensitive wildlife (Keane et al. 2011, Gabriel et al. 2013, D. Hansen pers. obs.; see below).

Personnel with the California Department of Fish and Wildlife recently estimated hydrologic impacts of marijuana cultivation in northwestern California using high-resolution aerial imagery in Google Earth (Bauer et al. 2015; e.g., Figure 5.2) and marijuana industry estimates of marijuana plant water requirements. Using these methods, they estimated that more than 112,000 marijuana plants were cultivated in 2011/2012 in just four watersheds in Humboldt and Mendocino Counties (Table 5.1). Based on estimated numbers of marijuana plants and assumed water usage of 6 gallons per day per plant, they calculated that marijuana cultivation uses between 2% and 173% of the water that flows in the Redwood Creek and Salmon Creek watersheds per day during periods of minimum streamflow (Table 5.2). Although based on several assumptions (marijuana cultivation water sources and usage, complete visibility of cultivation sites in aerial imagery, complete usage of greenhouses), these estimates have raised considerable concern about potential negative impacts of marijuana cultivation on watershed health and aquatic animals. NSOs often exhibit a preference for nesting, roosting, and foraging in and near riparian areas (e.g., Hamer et al. 2007, Irwin et al. 2007). Thus, it is plausible that ecological changes caused by widespread water diversion for marijuana cultivation have negative indirect effects on NSOs.

Figure 5.2: Outdoor (A) and greenhouse (B) marijuana cultivation sites identified with Google Earth (from S. Bauer, unpubl.).

Table 5.1: Estimated numbers of outdoor marijuana plants, marijuana greenhouses, marijuana plants in greenhouses, total number of marijuana plants, and water use per day for marijuana cultivation in four watersheds in Humboldt and Mendocino Counties (from Bauer et al. 2015).

Watershed	Outdoor Plants	Green-houses (counted)	Total area, m^2 (Green-houses)	Estimated Plants in Green-houses	Estimated Total Plants in Watershed	Estimated Water Use per Day (Liters)
Upper Redwood Creek	4,434	220	20749.4	18,612	23,046	523,144
Salmon Creek	11,697	302	20557.5	18,440	30,137	684,110
Redwood Creek South	10,475	324	18703.9	16,777	27,252	618,620
Outlet Creek	15,165	266	18651.1	16,730	31,895	724,016

Table 5.2: Estimated percent of low stream flow used for marijuana cultivation in four watersheds in Humboldt and Mendocino Counties (from Bauer et al. 2015).

Watershed	Area (km^2)	Plants per km^2	Demand as percent of seven-day low flow	
			Percent of low flow maximum	Percent of low flow minimum
Upper Redwood Creek	175.3	131.6	2%	23%
Salmon Creek	95.1	316.9	36%	173%
Redwood Creek South	64.7	421.2	34%	165%
Outlet Creek	419.1	76.1	17%	>100%*

* The seven-day low flow minimum was measured as 0.0 CMS at the gage.

Marijuana growers on both public and private lands often illegally clearcut vegetation in order to create growing space for marijuana plants and room for artificial ponds and other structures (Gabriel et al. 2013, Bauer et al. 2015; Figure 5.3). Illegal cutting, along with creation of roads to access grow sites, can increase sedimentation in streams and creeks and thereby degrade habitat quality for aquatic and amphibious animals (Bauer et al. 2015). The effect of illegal vegetation clearing on NSOs is unknown. Given the close association of both marijuana cultivation and NSOs with riparian areas and surrounding uplands (e.g., Hamer et al. 2007, Irwin et al. 2007), it is plausible that widespread marijuana cultivation results in habitat loss or fragmentation for NSOs.

Figure 5.3: Areas cleared for outdoor marijuana cultivation on private and public lands, respectively.

Unidentified source.

C. Thompson.

Widespread outdoor marijuana cultivation can further damage watershed health by polluting water and soils. In addition to pesticides, tremendous quantities of fertilizer are often applied at marijuana grow sites (HSVTC 2012, Thompson et al. 2014). Fertilizers, along with low flows caused by drought conditions and water diversion, might contribute to algae blooms and reduced oxygen levels in creeks and rivers. Other pollution, including human waste, trash, and spilled diesel fuel from generators, is also frequently observed in and around streams at raided outdoor marijuana grow sites (HSVTC 2012, C. Thompson, pers. comm.). Like water diversion and increased stream sedimentation, pollution from outdoor marijuana cultivation is primarily a source of concern for aquatic and amphibious animals but could have indirect ecological effects on NSOs and other wildlife.

Multiple recent wildfires in California have been attributed to marijuana growers. For example, in 2014, a marijuana grower was indicted on charges of starting the Nicolls Fire that burned

nearly 1,700 acres in the Sequoia National Forest (SacBee 2014b). This grower allegedly set multiple fires in an attempt to avoid capture by other growers that he claimed were trying to kill him. Another marijuana grower was recently arrested for igniting the 2014 Bully Fire that burned nearly 13,000 acres in Shasta County (SacBee 2014a). This fire was apparently started when the grower's rental truck ignited dry grass when driven off-road in order to deliver soil amendments to a grow site. In 2009, a marijuana grower's camp stove ignited the 90,000-acre La Brea Fire in the Los Padres National Forest in southern California (inciweb). Large wildfires (e.g., thousands of acres) can burn through multiple NSO territories and can negatively affect NSOs in a variety of ways, particularly when they burn large areas at moderate to high severity (see Ch. 3).

Illegal marijuana growers are often heavily armed in order to protect their crops and for poaching wildlife for food or to prevent wildlife damage to plants, equipment, or food caches (Gabriel et al. 2013, Boehm 2014; Figure 5.4). Many biologists and other field personnel working in California's forests have been interrogated, pursued, or shot at by marijuana growers (Gabriel et al. 2013, D. Hansen pers. obs.). Safety concerns associated with widespread illegal marijuana cultivation can substantially curtail the ability of researchers and land managers to effectively locate, study, and manage spotted owls and other wildlife. For example, Six Rivers National Forest biologists were repeatedly excluded from entire pre-project NSO survey units in 2013 due to evidence of trespass outdoor marijuana cultivation (D. Hansen pers. obs.). Similarly, Keane et al. (2011) stated that their California spotted owl (*S. o. occidentalis*) survey crew was excluded from large portions of a study area in the Sierra Nevada in 2010 due to extensive illegal marijuana cultivation operations. Gabriel et al. (2013; M. Gabriel unpubl. data) estimated that safety concerns due to trespass outdoor marijuana cultivation resulted in exclusion of researchers from 15-25% of one fisher study area in California and a projected additional cost of $500,000-750,000 for the life of the combined budgets of two of California's fisher research projects. Wildlife surveyors who were able to work alone in the past must now frequently work in pairs for safety reasons, reducing survey efficiency and increasing project costs (Gabriel et al. 2013, D. Hansen pers. obs.). Exclusion from study areas can also compromise the ability of researchers to properly design and complete research investigating important conservation issues, such as effects of pesticides on fishers (Gabriel et al. 2013) and wildfires on spotted owls (Keane et al. 2011).

Figure 5.4: Armed marijuana growers posing in front of a poached deer (from Gabriel et al. 2013).

Magnitude and Location of Threat

Estimates of marijuana production and value are generally based on either federal marijuana seizure data (e.g., assuming that seizures represent 10 or 15% of the total amount produced) or marijuana consumption surveys and estimates of plant yields and market value (Gettman 2006) (reviewed in PBS 2014). Estimates from both of these methods indicate that California is, by far, the primary marijuana-producing state in the U.S. and that most of this production is from outdoor cultivation (NDIC 2011, Gettman 2006). Gettman (2006) estimated that, in 2006 alone, California produced an estimated 8.6 million pounds of marijuana with a value of more than 13.8 billion dollars. An estimated 89% of this product and value was from outdoor cultivation. If correct, marijuana is the largest cash crop in California (Gettman 2006), which is remarkable given that California is the most productive agricultural state in the U.S. (USDA 2014).

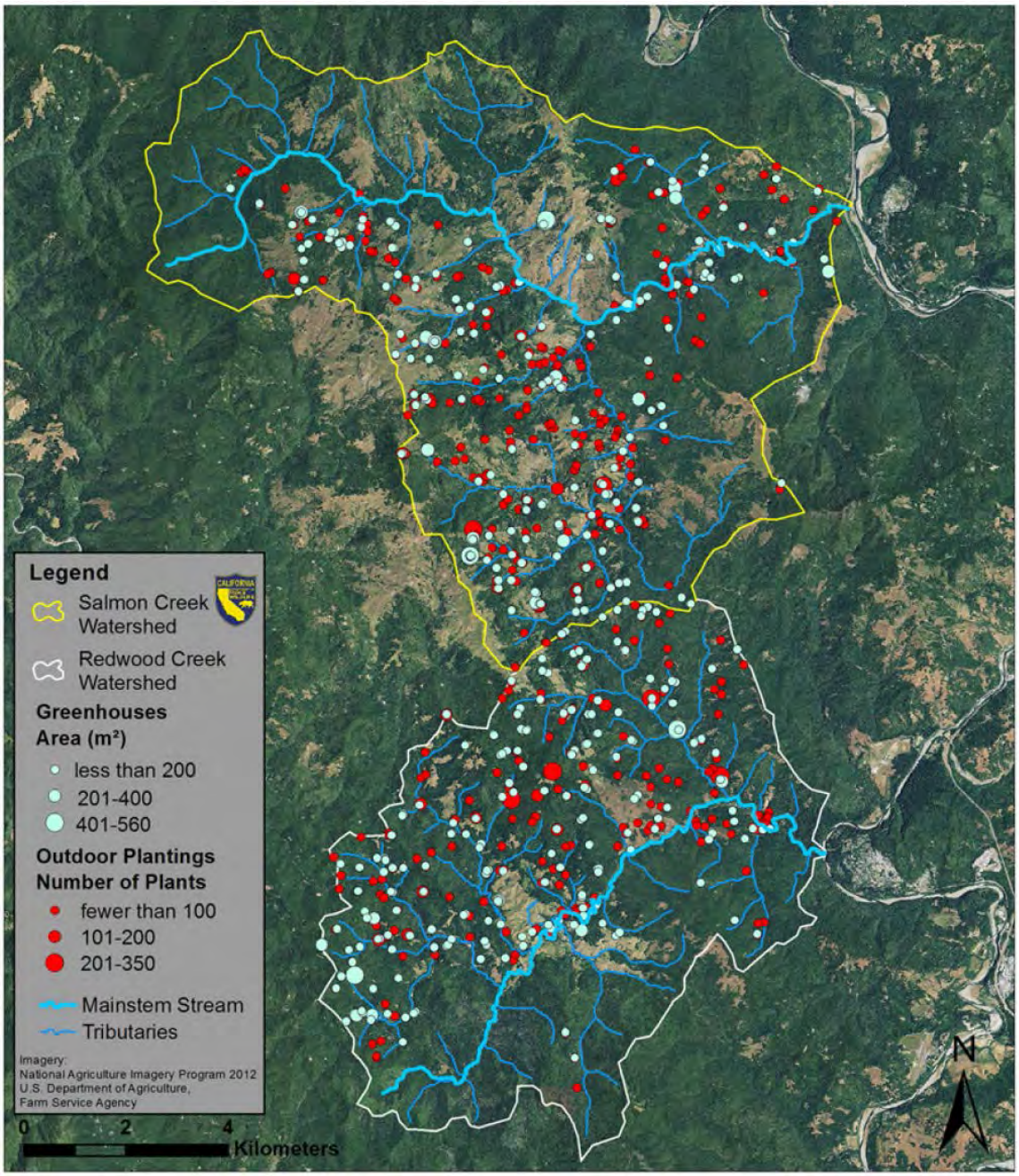
Outdoor marijuana cultivation in California has increased dramatically in recent years, including on both public and private lands (NDIC 2011, S. Bauer, unpubl. data). This rapid growth was due to increased demand for domestically grown marijuana; possibly driven by state legalization of marijuana for medical use, changes in public perception of health or legal risk associated with marijuana use, or reduced imports from other countries due to tighter border control measures implemented after 9/11 (NDIC 2007, 2011, SacBee 2012). However, rapid growth of marijuana production in California apparently outstripped consumer demand in the last few years, particularly following federal crackdowns on medical marijuana dispensaries in the state (SacBee 2012). Desire among growers to maintain high profits in the face of increasing supply and decreasing prices could be a factor driving recent increases in the size and intensity (e.g., use of pesticides, fertilizer, and water) of many outdoor marijuana cultivation operations.

The number of outdoor marijuana plants eradicated in the U.S. increased by 250% between 2005 and 2010 (NDIC 2011). Federal eradication data suggest that trespass outdoor marijuana cultivation is increasing particularly rapidly on National Forests in California (NDIC 2011).

Between 2005 and 2013, over 16 million marijuana plants were eradicated at approximately 3,356 sites on National Forests in California (Boehm 2014). Federal agencies have largely attributed increased numbers of trespass outdoor marijuana cultivation sites to expansion of operations by international drug trafficking organizations (e.g., Mexican drug cartels) into remote mountainous areas (particularly in northern California) in order to avoid detection by law enforcement personnel (NDIC 2007, Boehm 2014). However, the degree to which increases in amounts of eradicated or seized marijuana reflect increased production versus increased drug enforcement effort is unclear, as is the scale of international drug trafficking organizations' role in outdoor marijuana cultivation in California (NDIC 2010).

Outdoor marijuana production in California is also growing rapidly on private lands (NDIC 2007, S. Bauer, unpubl. data). Personnel with the California Department of Fish and Wildlife (S. Bauer, unpubl. data) used aerial imagery in Google Earth to estimate changes in the number and sizes of marijuana cultivation operations in four watersheds in Humboldt and Mendocino Counties during 2009-2012. In 2011 and 2012 they identified nearly 1,300 outdoor grow sites and more than 1,100 greenhouses likely used for marijuana cultivation in these watersheds (Table 5.1, S. Bauer, unpubl. data; e.g., Figure 5.5). The number and size of marijuana cultivation operations identified increased in all four watersheds by 68-104% between 2009 and 2012 (S. Bauer, unpubl. data). The total number of greenhouses and the number of greenhouses greater than 1,000 ft^2 increased by 69% and 87%, respectively. Continued use of aerial imagery and flyovers will shed greater light on the number, size, and location of outdoor marijuana operations on both public and private lands. For example, the California Department of Fish and Wildlife (2012) noted that law enforcement officers spotted more than 200 new marijuana grow operations in the Mattole Watershed in Humboldt County during a single flyover.

Figure 5.5: Locations and sizes of marijuana cultivation operations identified in the Salmon Creek and Redwood Creek South Watersheds using aerial imagery in Google Earth (from Bauer et al. 2015).



Summary and Management Implications

There is currently little direct information regarding potential impacts of illegal outdoor marijuana cultivation on NSOs. However, widespread application of ARs and other toxicants at outdoor grow sites are negatively impacting fishers, which have overlapping home ranges and

diets with NSOs in northwestern California (Gabriel et al. 2012, 2013, Thompson et al. 2014). There is also evidence of widespread exposure to toxicants among barred owls in Humboldt County, and an NSO from Mendocino County recently tested positive for ARs (Calforests 2014, Gabriel et al. 2014). Thus, it is likely that NSOs in California are widely exposed to toxicants applied at illegal outdoor marijuana grow sites. ARs and other pesticides can directly kill owls and other raptors or increase their vulnerability to other sources of mortality such as predation, disease, parasites, hypothermia, or injury (reviewed above). Furthermore, illegal outdoor marijuana cultivation is apparently causing widespread environmental degradation through toxicant exposure in other animals, reduced streamflows, pollution, poorly planned logging and road construction, and wildlife poaching (Gabriel et al. 2013, Bauer et al. 2015). Safety concerns associated with the widespread presence of heavily armed marijuana growers may also be impacting conservation of spotted owls and other wildlife by reducing the efficiency and effectiveness of research and survey efforts (Keane et al. 2011, Gabriel et al. 2013, D. Hansen pers. obs.).

Increased funding and effort are needed for evaluation of effects of outdoor marijuana cultivation on NSOs, other wildlife, and ecosystems. Greater funding and coordination are also needed for interdiction, clean-up, and restoration at illegal outdoor grow sites. These efforts require a substantial, multi-agency law enforcement presence, experts capable of identifying and properly disposing of toxicants, personnel and equipment for removing large amounts of trash and other material, and natural resource specialists for rehabilitating or restoring sites (Gabriel et al. 2013, Boehm 2014). Even if marijuana is legalized in California, tremendous resources, effort, and coordination may still be needed to regulate the industry and to continue to locate, clean up, and restore abandoned or interdicted illegal grow sites. Only a small portion of interdicted outdoor grow sites in California have been cleaned up thus far and even less have been restored. Many of these sites may continue to pose an environmental threat long after they are abandoned by growers (Gabriel et al. 2013). For example, water-resistant packaging can keep ARs and other toxicants viable for years, which bears can eventually find and open, allowing further poisoning and exposure of wildlife even after growing operations have ceased at the site (HSVTC 2012, M. Gabriel, pers. comm.).

The Environmental Protection Agency (EPA) and California Department of Pesticide Regulation (CDPR) have recently taken steps to reduce threats from SGARs to wildlife, children, and pets. Since 2011, EPA regulations have prohibited the sale of SGARs to the general consumer. Under EPA regulations, SGARs may only be purchased at agricultural stores, in bait station form rather than as loose pellets, and in relatively small quantities (Bradbury 2008). Most AR manufacturers quickly complied with these regulations and brought replacement products to market containing FGARs or neurotoxins, rather than SGARs (CDPR 2013, Murray 2013). However, the EPA only recently reached an agreement with Reckitt Benckiser to end distribution of their popular d-Con® products containing SGARs and sold without a protective bait station by March 31, 2015 (EPA 2014). On July 1, 2014, the CDPR further limited access to SGAR products in California by classifying them as restricted materials (California Department of Consumer Affairs 2014). In California, products containing SGARs can only be purchased from CDPR-licensed pest control dealers by certified applicators (California Department of Consumer Affairs 2014). Increased restrictions on public access to products containing SGARs should help to reduce exposure of wildlife to these compounds. However, considering that banned pesticides are

commonly found at trespass outdoor marijuana cultivation sites (HSVTC 2012, Gabriel et al. 2013, Thompson et al. 2014) growers will likely continue to widely apply SGARs in forests occupied by NSOs, fishers, and other sensitive wildlife. Furthermore, reduced availability of SGARs could simply contribute to greater application of other pesticides, including newly emerging toxicants or large amounts of legal FGARs.

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Management Recommendations

Below I provide a brief list of management recommendations and research needs. This list is solely based on information reviewed in this report. Additional management and research needs may exist for northern spotted owls (*Strix occidentalis caurina*; NSOs). Furthermore, land managers, land agencies, and policymakers may need to consider other management information and objectives alongside those for NSOs. These recommendations are mine alone and do not necessarily reflect the positions of the Environmental Protection Information Center (EPIC) or any of the document's reviewers.

1. The NSO is rapidly declining across its range. The subspecies' rate of decline has recently accelerated in California. The NSO faces an array of threats to its persistence in California and elsewhere within its range. Therefore, I recommend that:
    a. The California Fish and Game Commission list the NSO as threatened or endangered under the California Endangered Species Act.
    b. The U.S. Fish and Wildlife Service uplist the NSO from threatened to endangered under the federal Endangered Species Act.

2. Habitat retention guidelines for NSOs in the California Forest Practice Rules (CAL FIRE 2014) should be revised. The U.S. Fish and Wildlife Service's (2009) recommended guidelines for portions of California outside the redwood zone should be adopted as soon as possible. The U.S. Fish and Wildlife Service's (2011b) recommendations for the redwood zone are based on less extensive and rigorous scientific information but also appear to reflect a more accurate and current understanding of the NSO's ecology than do the California Forest Practice Rules. Recommendations for the redwood zone could potentially be revised based on modeling of Habitat Fitness Potential (Diller et al. 2010), as were those for the state's northern interior (USFWS 2009).

3. The California Department of Fish and Wildlife should continue to hire biologists with expertise in NSO-habitat relationships to assist with reviews of Timber Harvest Plans. I am under the impression that few CAL FIRE biologists have specialized knowledge of raptor ecology and conservation. Qualified wildlife biologists with the U.S. Fish and Wildlife Service formerly consulted on Timber Harvest Plans but the agency has not been regularly involved in the review process since 2008.

4. Industrial timber companies required to monitor NSOs (e.g., as part of Habitat Conservation Plans) should, whenever possible, provide modeled occupancy rates that account for detectability of NSOs and other factors that can obscure occupancy trends (e.g., see Ch. 1, Figure 1.5). Unmodeled occupancy rates are frequently cited as evidence of stable NSO populations on industrial timberlands in California (Calforests 2014). Claims of population stability or increase on industrial timberlands conflict with evidence from more rigorous research projects that have found declines in occupancy and population vital rates on federal, tribal, and private lands in northwestern California (Forsman et al. 2011, Franklin et al. 2013, 2014, Higley and Mendia 2013, Green Diamond Resource Company 2014); interior northern California (Farber and Kroll 2012);

and the Oregon Klamath and southern Cascades (Forsman et al. 2011, Davis et al. 2013, 2014, Dugger et al. 2014).

5. Barred owl removal experiments should be continued and more widespread removal programs should be planned for both public and private lands. Without barred owl removal programs, the NSO is likely to continue to spiral toward extinction, regardless of habitat protection measures.

6. Rigorous studies of effects of forest thinning and partial harvesting on NSOs and their key prey (especially dusky-footed woodrats) are needed (e.g., using a before-after-control-impact study design and an adequate sampling framework). Ideally, the silvicultural prescriptions would resemble those proposed for widespread use on federal lands. Meanwhile, land managers should assume that commercial thinning and partial harvesting negatively affect NSOs and their primary prey in California; as the currently available information generally supports this assumption. If land managers or agencies deem that thinning is necessary to address wildfire risk or meet other objectives, it should be focused outside of core patches of mature and old forest (i.e., those surrounding NSO activity centers). Thinning and other fuels reduction activities could potentially be focused in portions of the landscape that are least likely to receive use by NSOs and that are most likely to experience fire (e.g., upper and southwesterly slopes).

7. Additional research is needed to evaluate effects of severe wildfires on NSOs. This issue is scientifically and politically contentious; although there is fairly broad consensus that extensive severe fires pose a threat to NSOs in dry, fire-prone forests, such as those that occur within much of northern California outside the redwood zone (USFWS 2011a). Land agencies could better support research of wildfire effects on spotted owls by avoiding or postponing post-fire salvage logging in burned study areas. The confounding effects of salvage logging are often cited as reason to ignore research indicating that extensive severe wildfires negatively affect spotted owls. Both territory and population/landscape level and multi-year studies of severe fire effects would be useful.

8. Additional research is needed to investigate effects of post-fire salvage logging on NSOs. However, the limited available evidence suggests that salvage logging negatively affects both spotted owls and their prey. Salvage logging does not appear to be generally concordant with conservation of NSOs, as it removes important biological legacies and structurally simplifies burned areas.

9. Prescribed fire appears to have neutral or positive effects on spotted owls and therefore, appears to be consistent with the species' conservation. Allowing wildfires to burn under favorable conditions could also hold promise for reducing understory densities and reducing risk of severe fire, fostering growth of fire-adapted vegetation favored by NSO prey communities, and maintaining or restoring habitat heterogeneity in landscapes homogenized by fire suppression and timber harvesting. Favorable conditions could often exist early or late in the season or in areas where deeply incised topography creates inversions that trap smoke and minimize risk of severe fire.

10. Studies evaluating effects of marijuana cultivation on NSOs are needed. Potential research topics include investigating exposure to anti-coagulant rodenticides and other toxicants, determining effects of rodenticides on prey populations around grow sites, and examining whether or not marijuana growing on private lands potentially affects NSOs (e.g., proximity to activity centers, potential negative effects of illegal water diversion and logging on riparian areas and watersheds used by NSOs).

11. Increased financial and logistical support is likely needed for interdiction, clean-up, and restoration at trespass marijuana grow sites on public lands. Increased law enforcement could also potentially alleviate financial strains and safety concerns for NSO research and monitoring projects.

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Tom Wheeler <tom@wildcalifornia.org>

NSO in CA Reviews

Dan Hansen <danhansen03@gmail.com> Fri, Jul 3, 2015 at 4:14 PM
To: Tom Wheeler <tom@wildcalifornia.org>

Tom,

I'm also pasting email contents in some emails as they also contain comments from the reviewers.

Dan

Hi Dan,

I did not have much to comment on this one. Again, you did a very thorough review of the information out there, and your summary of the work I've been involved with (on both timber and fire) was good. I added a few minor clarifications here and there. I suggested one more paper by Wilson and Forsman, this link:

http://www.fs.fed.us/pnw/pubs/pnw_gtr880/pnw_gtr880_009.pdf

On both papers, I recommend you be careful in the use of the general term "habitat" as it can mean many different things, and tends to confuse the issue if used without providing good definitions.

Good luck on this and best regards,

Ray

Raymond J. Davis

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Hi Dan,

Attached is my review and comments of your wildfire writeup. I'm still reviewing the timber writeup and will aim to get that to you by this afternoon.

Overall, a very thorough review, but there are a few more articles that I would add. In particular a paper by Tempel et al (in press). Effects of forest management on California Spotted Owls:

implications for reducing wildfire risk in fire-prone forests. Ecological Applications. Other papers that might provide good info:

1. Dennison, P. E., S. C. Brewer, J. D. Arnold, and M. A. Moritz (2014), Large wildfire trends in the western United States, 1984–2011, Geophys. Res. Lett., 41, 2928–2933

2. Moritz, M. A., M.-A. Parisien, E. Batllori, M. A. Krawchuk, J. Van Dorn, D. J. Ganz, and K. Hayhoe. 2012. Climate change and disruptions to global fire activity. Ecosphere 3(6):49.

3. Stavros et al. 2014. Regional projections of the likelihood of very large wildland fires under a changing climate in the contiguous Western United States. Climatic Change

4. 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, California, USA. Ecosphere 4(12):15

5. Ganey et al. 2014. Relative abundance of small mammals in nest core areas and burned wintering areas of Mexican spotted owls in the Sacramento Mountains, New Mexico. The Wilson Journal of Ornithology 126(1):47–52

6. Willey and Ripper. 2014. Home range characteristics of Mexican spotted owls in the Rincon Mountains, Arizona. The Wilson Journal of Ornithology 126(1):53–59

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NSO in CA Reviews

Dan Hansen <danhansen03@gmail.com> Fri, Jul 3, 2015 at 4:19 PM
To: Tom Wheeler <tom@wildcalifornia.org>

Diller emails pasted below....

Hi Dan,

I completed the review of the barred owl chapter and I hope to complete the timber section by Saturday. Overall, I thought you did a great job with a thorough and comprehensive review of the barred owl issues in the NW. I have some specific comments on the attached copy, but they mostly related to the emphasis on certain publications. In particular, Dave Wiens study in the Oregon coast range is the best data available on habitat use, competitive interactions, food habits and reproduction. It is superior to any other study to date, because he had radio transmitters on both species simultaneously using the same landscape meaning we know they had equal opportunity to select habitat, prey and etc. When you wrote this, you only had it available in the more cumbersome dissertation, but you could now use the recently published monograph.

Good luck with this.

Lowell

I agree that the old meta-analysis (Forsman et al. 2011) is very dated at this point. I would rely on the annual reports from all the various study areas to provide the best current status.

Lowell

Hi Lowell,

I have a quick question about the site density estimates in Green Diamond's 2014 report. Would you call them empirical or mark-recapture estimates? Although most of the owls were likely banded, I didn't see any mention of mark-recapture methods for estimating density as was done in Diller and Thome 1999.

Thanks!

Hi Dan,

Yes, they were empirical counts based on marked birds. So the marking prevents double counting birds, which could happen frequently for non-nesting birds that move around a lot, but the empirical counts don't account for missed birds due to less than perfect detection probabilities. So these empirical counts of marked owls is equivalent to what used to be called "minimum number alive." However, spotted owls have such high detection probabilities that the estimate from using mark-recapture techniques would only provide a minor inflation of the empirical counts. The trends from spotted owls on Green Diamond will be available soon from the most recent 2015 meta-analysis.

Lowell

Hi Dan,

I reviewed the status and trends chapter, and like the barred owl chapter, I thought it was very thorough and well written. I inserted some comments for you to consider, but I didn't have any major concerns. Probably my most substantial comment is that I think modeling exercises are primarily useful for developing testable hypotheses, and although I haven't actually reviewed it in detail, I don't put a lot of credence in the source-sink model you cited. Obviously, you could really benefit from the new meta-analysis, but you pretty much guessed what it is going to say.

Lowell

Tom Wheeler <tom@wildcalifornia.org>

NSO in CA Reviews

Dan Hansen <danhansen03@gmail.com> Fri, Jul 3, 2015 at 4:33 PM
To: Tom Wheeler <tom@wildcalifornia.org>

Hi Rob,

I've marked this doc up in track changes and with comments. I assume you're trying to say fire is a real threat as part of your listing petition, but you should reconsider that position.

I read most of the section you sent me, but was irritated by the overall bias and anti-fire tone throughout, and gave up with my careful review about 1/3 of the way through. It didn't read like an objective review of existing owl and fire data. It seemed the author assumed fire could only be bad for owls. It also failed to properly weigh studies according to sample size and whether or not they were peer-review publications. There were too many instances where stats in a paper said something (or said there was no effect there), then the author used an anecdote to refute the stats and advance a 'fire is bad' position. Also, author speculation in discussion sections shouldn't be reported as results.

I feel it also mischaracterized the risk of severe fire as a forgone conclusion with some minor uncertainty, while completely ignoring the threats posed by logging in the name of fire risk reduction. If the threat from logging is expounded upon in other sections, it should also reverberate in the wildfire and salvage section. Furthermore, the author fails to establish whether fuels thinning projects have any effect on fire severity during the extreme fire weather that accompanies the vast majority of big fires (typically they don't).

I think continuing in the current anti-fire tone might alienate potential allies of your petition in the environmental and scientific communities. I suggest a focus on logging as the main threat of the past, and the continued threat of the present even though it is now sold as 'fuels thinning'.

Best,
-Derek Lee

Tom Wheeler <tom@wildcalifornia.org>

NSO in CA Reviews

Dan Hansen <danhansen03@gmail.com> Fri, Jul 3, 2015 at 4:34 PM
To: Tom Wheeler <tom@wildcalifornia.org>

Dan,

Attached is the draft that you sent a while back. With a few edits. Not many, I think you did a pretty good job of outlining the potential risks given the lack of information available. I couldn't really comment much on the environmental degradation issues, only pesticide exposure. I tried to fill in a number of your citations and made a few changes to the text. I do have a number of photos as well, if you want to highlight anything.

Craig

Craig Thompson

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Barred Owls

Introduction

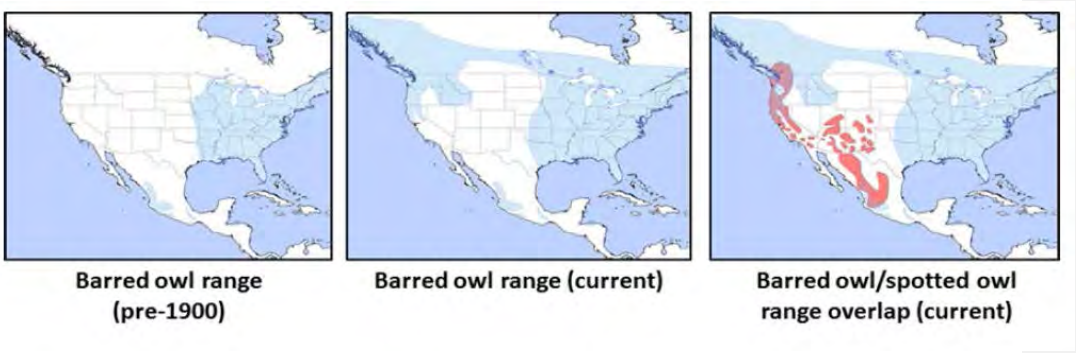
At the time of the northern spotted owl's (*Strix occidentalis caurina*; NSO) federal listing, the barred owl was recognized as a potential threat to the subspecies (USFWS 1990, Thomas et al. 1990). Since then, barred owls have continued to invade the range of the NSO and are apparently increasing in numbers (USFWS 2013). As reviewed herein, a large body of correlational and anecdotal evidence, supplemented by preliminary findings from barred owl removal experiments, indicates that barred owls are negatively impacting NSO populations across their range and that this is due to competition between the two species for space, habitat, and food. Research reviewed below indicates that that the barred owl is a superior competitor to the NSO due to its larger size, more aggressive behavior, higher reproductive potential, and broader ecological niche. The USFWS (2011) recently listed the barred owl invasion as one of three main threats currently faced by NSOs (along with timber harvesting and wildfire). The USFWS (2011) described this threat as "extremely pressing and complex" and "requiring immediate consideration." Information reviewed below suggests that lethal control of barred owls is a viable management option for some areas, although it may be difficult to overcome emotional and ethical resistance to killing one charismatic species to save another. Habitat conservation for NSOs appears to be of increasing importance because the negative effects of habitat loss and fragmentation on NSOs can be exacerbated by the presence of barred owls (Dugger et al. 2011).

Comment [LVD1]: It may not have been available when you were writing this, but the Wiens et al. 2014 monograph would be a good citation here.

The Barred Owl's Expansion

Prior to the mid-1900s, the barred owl's range was confined to southeastern Canada, the eastern U.S., and portions of Mexico (Gutiérrez et al. 2004, 2007; Figure 1). By the mid-20th century the barred owl's range began expanding westward across North America and currently includes the southern boreal forest zone and British Columbia in Canada and the northern Rocky Mountains, Pacific Northwest, and northern California in the U.S. (Livezey 2009, USFWS 2013; Figure 1). The barred owl's range now completely overlaps that of the NSO and partially overlaps that of the California spotted owl (*S. o. occidentalis*) (Figure 1). It is unclear whether the barred owl's westward range expansion occurred via the Great Plains or Canada's boreal forests (USFWS 2013). It is also uncertain whether this range expansion was facilitated by natural factors, human activities, or a combination of the two. Hypotheses concerning the cause of the barred owl's range expansion include increased adaptation by the species to coniferous forests; natural climate change; environmental changes associated with widespread intensive timber harvesting; and conversion of open areas to forest due to fire suppression, planting parks and woodlands, removal of keystone species, or other human activities (Gutiérrez et al. 2004, USFWS 2013).

Figure 1: Historical and current range of the barred owl and comparison of the current ranges of the barred owl and spotted owl (from USFWS 2013).



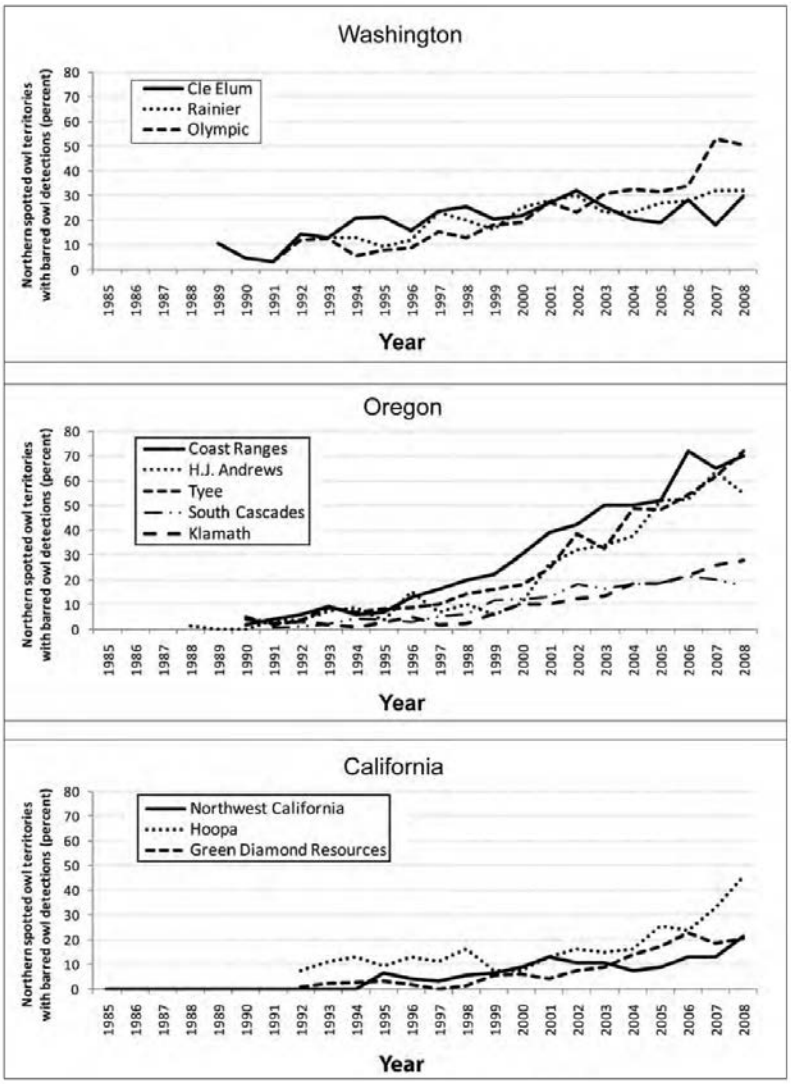
Reliable data concerning current barred owl densities and population trends are unavailable. Most information about barred owl trends in the Pacific Northwest and California is based on incidental detections during surveys for spotted owls (USFWS 2013). Researchers have estimated that only 1/2 to 2/3 of barred owls present are detected during NSO surveys (Gutiérrez et al. 2004, Bailey et al. 2009, Wiens et al. 2011). Researchers have only recently begun to systematically survey for barred owls within the range of the NSO and only in limited areas. In California, the Northwest California, Green Diamond, and Hoopa NSO density studies initiated systematic surveys for barred owls in 2009 (Franklin et al. 2014, Green Diamond Resource Company 2014, *Hoopa citation*).

Some early studies of barred owls within the NSO's range likely overestimated the species' numbers by focusing on cumulative and nighttime detections (Gutiérrez et al. 2004). However, barred owl trends are now more frequently evaluated in terms of the number of spotted owl territories in which barred owls have been detected (USFWS 2013; e.g., Forsman et al. 2011, Calforests 2014). Reports of the number of spotted owl territories with barred owl detections

probably underestimate barred owl densities and population trends (USFWS 2013). Barred owls often have substantially smaller home ranges than spotted owls so it is possible for a single spotted owl home range to encompass multiple barred owl home ranges (Singleton et al. 2010, Wiens 2012; see below). Without color-banding or follow-up surveys to determine the identity and occupancy status of barred owls, it is often unclear if multiple detections within spotted owl territories represent one or multiple barred owls.

Despite uncertainty regarding barred owl densities and population trends, incidental detections clearly indicate that the species rapidly expanded its range into that of the NSO (USFWS 2013). For example, barred owls expanded their range from western Washington to northern California in less than 10 years (Gutiérrez et al. 2004). Incidental detections also suggest that barred owl densities are continuing to increase within the range of the NSO. From 1985-2008, the proportion of NSO territories with known barred owl presence increased in density study areas throughout the NSO's range, suggesting increasing barred owl populations (Forsman et al. 2011; Figure 2). Barred owl increases in Washington and Oregon have been steeper than those in California (Forsman et al. 2011; Figure 2), which is consistent with the species' later colonization of California (USFWS 2013). More recent information suggests that barred owl increases are also currently accelerating in northwestern California (see below).

Figure 2: Annual proportion of northern spotted owl territories with barred owl detections (≤0.62 mi from spotted owl activity center) on density study areas in Washington, Oregon, and California (from Dugger and Davis 2011, adapted from Forsman et al. 2011).



Recent reports from California's density studies suggest that barred owls continued to increase in numbers and to invade additional NSO territories during 2009-2013 (Franklin et al. 2014, Green Diamond 2014, *Hoopa citation*). As noted above, California's density studies initiated barred owl-specific surveys in 2009. The Green Diamond Resource Company *(and Hoopa?)* also began a barred owl removal experiment in a portion of their density study area during the same year (see below). Thus, detection and occupancy data from 2009-2013 are not directly comparable to previously collected data. In the Northwest California density study area and nearby Regional Study Area, the number of NSO territories with barred owl detections increased by 76% (from 21 to 37) during 2009-2013 and the estimated number of barred owl sites increased by 170% (10 to 27) (Franklin et al. 2014). On Green Diamond Resource Company lands, the total estimated number of barred owl sites increased by 57% (numbers not reported) during 2011-2013 (Green Diamond 2014). *Hoopa 2009-2013 information…* The degree to which estimated increases in barred owl sites and NSO territories with barred owl detections reflect growing barred owl populations as opposed to increased and cumulative survey effort is unclear. However, the available data indicate that barred owls are continuing to invade NSO territories in California's density study areas and that this is occurring at an increasing rate.

Comment [LVD2]: Hoopa's study was initiated in September 2013 following signing of the ROD for the barred owl removal experiment. Their study is one of four planned for the FWS removal experiments, but lack of funding has delayed the implementation of the other study areas until this year (2015).

Comment [LVD3]: There are still comparable surveys that are being done using the original protocol and those data are kept separate from new barred owl-specific surveys.

Cumulative detections in the California Natural Diversity Database (CNDDB) from 1978 through 1990, 1998, 2006, and 2013 provide a crude picture of the species' expansion in California (Figure 3). These detection data suggest that barred owls expanded their range into the state along the northern coast and southern Cascades and more rapidly increased in wetter regions (Figures 3 and 4). Earlier and more rapid colonization of relatively mesic forests by barred owls is consistent with observations from studies in Washington (Gutiérrez et al. 2007).

While cumulative detections cannot be used to evaluate the barred owl's densities or population trends, they suggest that barred owls are relatively abundant along the coast and in the adjacent Six Rivers National Forest, whereas they appear to still be in the process of colonizing the Mendocino, Klamath, and Shasta-Trinity National Forests and other interior areas of northern California. However, it is possible that this pattern is ~~due to~~biased by the fact that most barred owl detections occur during surveys for spotted owls, which may be more densely concentrated or better surveyed in northwestern California. Concentrations of barred owl detections in northwestern California may be partly associated with intensive survey effort for spotted owls in the Green Diamond, Northwest California, and Hoopa density study areas. Furthermore, the Six Rivers National Forest conducted forest-wide surveys for NSOs in 2010 and 2011 and subsequently continued to survey large areas associated with forest projects (cite). Barred owls have a broader ecological range than do spotted owls, so they may be more widely distributed than is shown in Figure 3 (USFWS 2013).

Comment [LVD4]: The detections can be used to establish general trends, but they don't allow for estimates of population density or abundance.

Comment [LVD5]: THP surveys throughout the region are also reporting barred owl detections.

Figure 3: Cumulative northern California barred owl detections in the California Natural Diversity Database from 1978 through A) 1990, B) 1998, C) 2006, and D) 2013 (note: dark red symbols denote higher concentrations of detections).

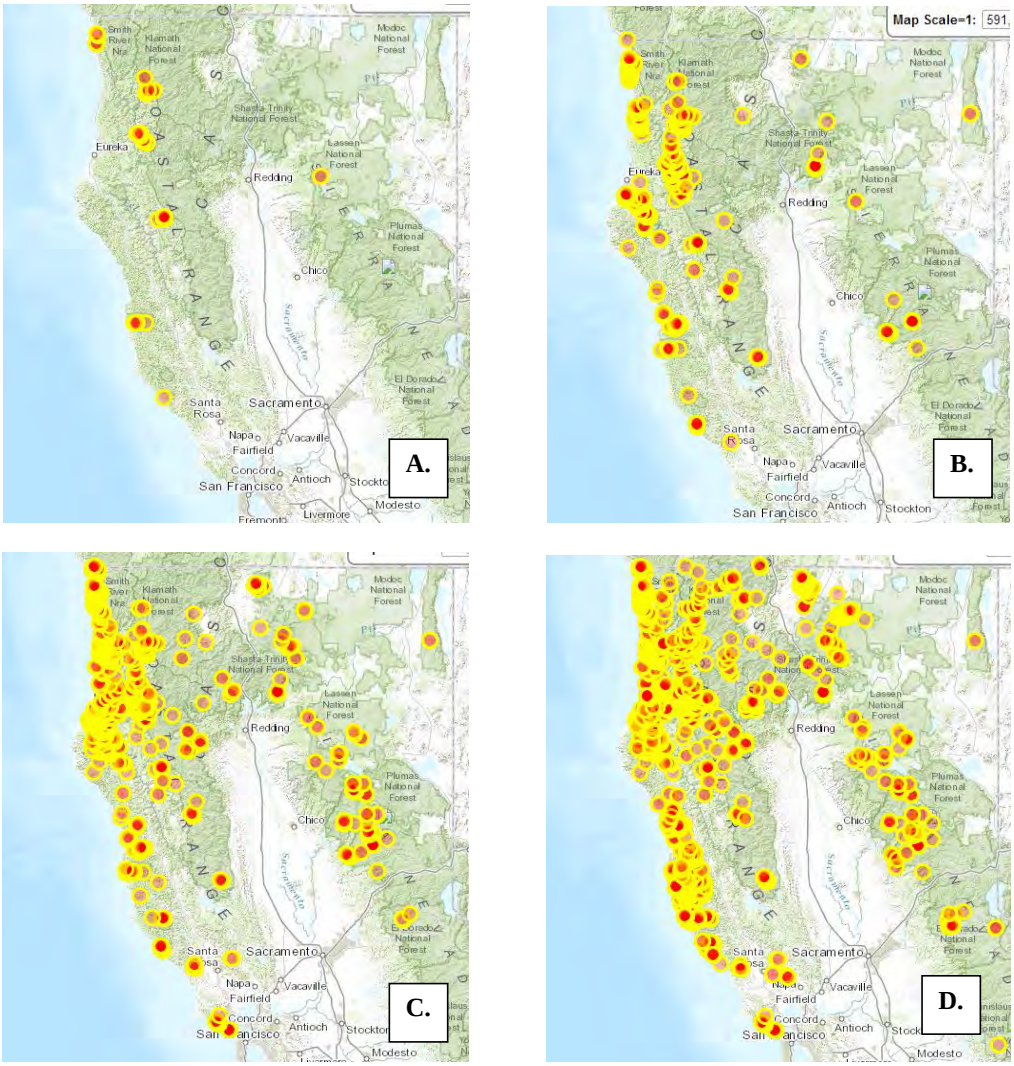
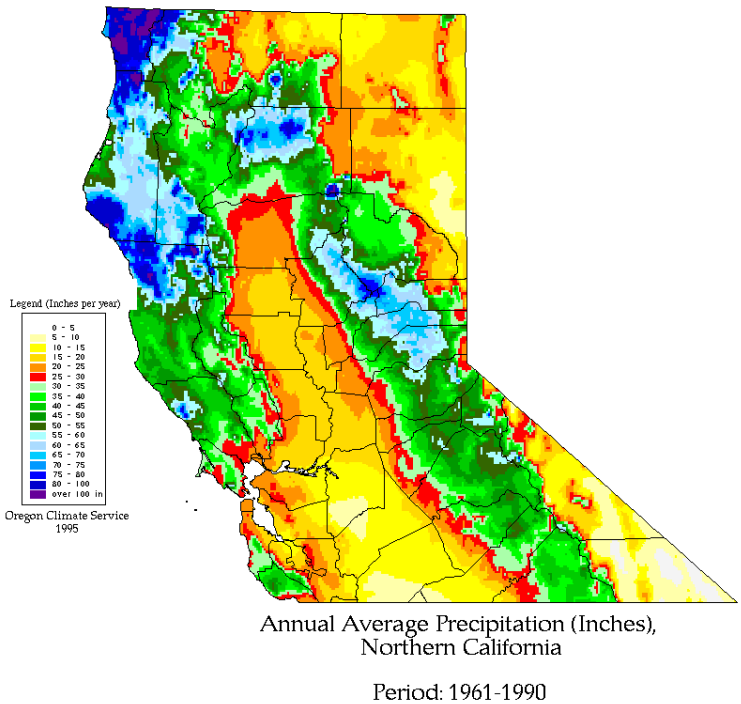


Figure 4: PRISM precipitation map for northern California (1961-1990) (Western Regional Climate Center).



Barred owls have increased dramatically in California's Redwood National and State Parks (Gutiérrez et al. 2004). In 2012 alone, NSO surveyors detected at least 17 barred owls at 10 different sites (Schmidt 2013). In contrast, NSOs were detected at only four historical territories in 2012. It is possible that more NSO territories were active during that year as relatively little of the landscape was surveyed. However, Schmidt (2013) noted that the Redwood National and State Parks have discontinued surveying many areas due to what appears to be almost complete displacement of NSOs by barred owls. Based on clusters of barred owl detections ($\leq$1 mi apart) during 1993-2012, Schmidt (2013) estimated that the Redwood National and State Parks contain a total of 58 barred owl territories. Barred owls have only recently invaded National Park lands in Marin County, California and have been slow to increase in numbers thus far (Ellis et al. 2013). Barred owls were first detected in Marin County in 2002 and were detected at only four (13%) NSO monitoring sites in the area in 2012 (Ellis et al. 2013). Ellis et al. (2013) hypothesized that the barred owl's expansion into Marin County has been limited due to extensive agricultural and urban lands surrounding the area. They also stated however, that barred owl numbers would likely continue to increase in the area over time and could eventually pose a substantial conservation problem for this small and relatively isolated population.

Most information about barred owls on private timberlands in California is from ownerships in the Redwood Province. Data provided by the Green Diamond Resource Company are described above, along with those from other NSO density studies in California. Reports from both the Humboldt Redwood Company (Humboldt County) and Mendocino Redwood Company (Mendocino and Sonoma Counties) suggest that barred owls are currently rapidly increasing on those lands. Despite a marked decline in annual numbers of nighttime surveys, Humboldt

Redwood Company (2013) found an overall increase in barred owl detections within 0.5 mile of NSO activity centers during 2003-2013 (Figure 5). However, some of the increase in barred owl detections between 2010 and 2011 was likely due to greater survey effort associated with adoption of the USFWS (2012) revised survey protocol for NSOs. Mendocino Redwood Company (2014) data suggest that barred owls increased dramatically on their lands during 2005-2013 (Figure 6). Barred owls were detected within one mile of 47 (45%) NSO activity centers on these lands in 2013. The number of NSO territories with barred owl detections increased by 113% during 2010-2013. Mendocino Redwood Company (2014) noted that barred owls have been detected within one mile of 71 NSO activity centers on their lands since 2005. The Conservation Fund (in Calforests 2014), which manages lands in Mendocino and Sonoma Counties, stated that barred owls have been detected "across their ownership" since 2009. They currently have four sites at which barred owls are "regularly detected" and another area in which they are "occasionally detected".

Figure 5: Number of barred owl detections within 0.5 mile of northern spotted owl activity centers on Humboldt Redwood Company lands during 2003-2013 (from Humboldt Redwood Company 2013).

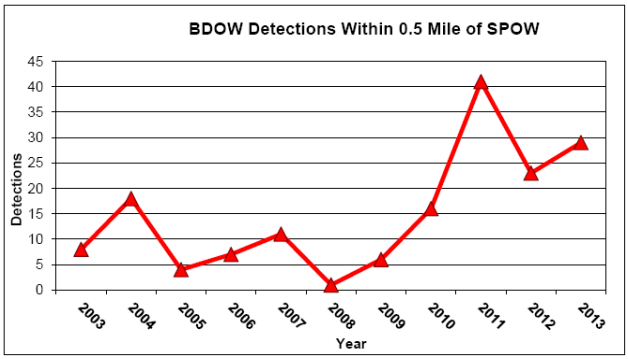
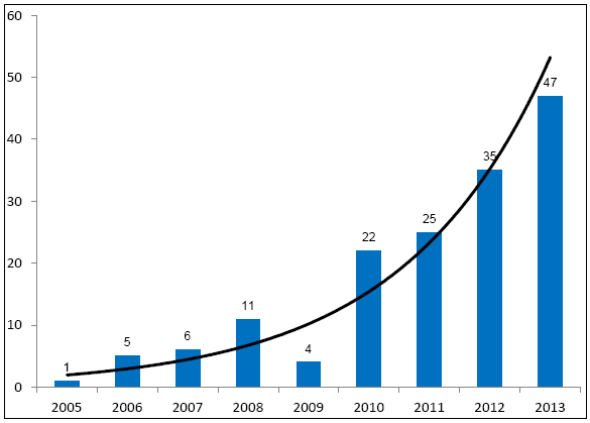


Figure 6: Percent (y-axis) and number of northern spotted owl territories (1 mi radius around activity centers) on Mendocino Redwood Company lands with barred owl detections during 2005-2013 (note: the apparent decline in NSO territories with barred owl detections in 2009 coincided with a substantial dip in NSO survey effort) (from Mendocino Redwood Company 2014).



There is relatively little information concerning barred owl numbers on private timberlands in California's eastern Klamath and Southern Cascade regions. In 2013, Sierra Pacific Industries confirmed barred owl occupancy at 14 of 28 known/historical barred owl sites within their Redding and Weaverville Districts (eastern Klamath and Southern Cascades regions) and located two additional sites (SPI 2014). We are unaware of any reports of barred owl trends or presence in NSO territories on Sierra Pacific lands. Fruit Growers Supply Company (in Calforests 2014) reported barred owl detections within or "nearby" (distance not reported) five NSO activity centers in Siskiyou County. It was unclear whether these numbers were cumulative or were from 2013 alone. Michigan-California Timber Company (in Calforests 2014) reported that barred owls were detected at one site on their lands in Siskiyou County in 2010 and 2012 and two sites in 2009 and 2013. Crane Mills (in Calforests 2014) has detected only one barred owl on their lands in Shasta County. Roseburg Resource Company (in Calforests 2014) has never detected a

barred owl during their NSO surveys on lands in Siskiyou and Shasta Counties. The low numbers of barred owl detections on some private timberlands in California's eastern Klamath and Southern Cascades regions is somewhat surprising given the numbers of detections on the Shasta-Trinity and Klamath National Forests and on Sierra Pacific Industries lands (Figure 3). It is unclear if this is due to a difference in survey effort, ecological conditions, management history, or some other factor.

In summary, the barred owl's range now completely overlaps the NSO's range and partially overlaps the California spotted owl's range. Barred owls rapidly expanded their range southward from British Columbia, through Washington and Oregon, and into northern California. The species' range expansion into California appears to have occurred first and most rapidly in northern coastal forests and near the margin of the southern Cascades and northern Sierra Nevada. However, it is unclear if these patterns actually reflect the species' expansion or are merely an artifact of higher survey effort for spotted owls in these areas. Regardless, the available information suggests that there is currently a high potential for interactions between NSOs and barred owls throughout much of NSO's range in California. The barred owl invasion does not appear to have peaked in the state. Rather, the information reviewed above suggests that the species is continuing to expand into drier, interior portions of the Klamath and Southern Cascades Provinces and that their presence in NSO territories is increasing at accelerating rates in the Redwood Province and western Klamath.

Comment [LVD6]: I don't think there is any doubt that it is a reflection of the species' expansion, because it mimics what happened in WA and OR as well. That said, I agree that the magnitude of the expansion is likely somewhat biased by the greater survey effort on the coast.

Effects on NSOs

Scientific Uncertainty

As discussed above, there is currently little reliable information concerning trends in barred owl densities or population numbers. Most of what is known about the potential for barred owl interactions with NSOs is based on incidental detections of barred owls during NSO surveys (Gutiérrez et al. 2004). Reliance on NSO surveys limits many studies' inferences concerning barred owl numbers. Gutiérrez et al. (2004) noted that some studies have found large numbers of historical NSO territories apparently vacant of both NSOs and barred owls. It is unclear if these vacancies were primarily a reflection of inadequate survey effort for one or both species or if they are caused by some other factor (Gutiérrez et al. 2004). Some of this uncertainty has been reduced due to increased survey effort required by revised survey protocols for NSOs (e.g., USFWS 2012) and implementation of barred owl-specific surveys in some areas. Inferences from studies of barred owl effects on NSOs are further limited by the observational and retrospective nature of most research of this topic (Livezey and Fleming 2007). Most studies of barred owl effects on NSOs have examined correlations between changes in NSO occupancy or demography and barred owl presence near NSO activity centers (see below). These studies do not definitively prove that barred owl presence causes changes in NSO occupancy or demography. However, preliminary results of barred owl removal experiments more directly support conclusions that barred owl presence negatively affects NSOs in a variety of ways (see below).

Comment [LVD7]: That assessment is over 10 years out of date, and as rapidly as the barred owl science is advancing, I would not consider it appropriate to cite for scientific uncertainty. You should be using the barred owl EIS, Wiens et al. 2014 and other more recent studies.

Comment [LVD8]: This is way out of date and irrelevant at this point.

Comment [LVD9]: But the Wiens study does – you could cite his dissertation or the 2014 monograph.

Hybridization

At the time of the NSO's listing there was concern among some researchers that hybridization between spotted owls and barred owls would lead to the loss of the spotted owl as a distinct species (Gutiérrez et al. 2004). Despite genetic, morphological, ecological, and behavioral differences between spotted owls and barred owls, there appear to be few strong isolating mechanisms to prevent them from interbreeding (Gutiérrez et al. 2007). Yet, hybridization between the two species appears to be relatively rare. For example, an extensive review of NSO survey and banding records from 1970-1999 in Oregon and Washington found reports of only 47 NSO-barred owl hybrids (Kelly and Forsman 2004). Hybridization therefore appears to pose little threat to NSOs compared with the effects of competition (Kelly and Forsman 2004; see below). However, hybridization could become a more serious issue in the future as NSOs continue to decline and become less able to locate conspecific mates (Gutiérrez et al. 2007).

Demography

Forsman et al. (2011) evaluated demographic trends for NSOs in 11 density study areas during 1985-2008. They found that NSO reproduction (fecundity) was negatively associated with the presence of barred owls ($\leq$0.62 mi from NSO activity centers) in four study areas, including Green Diamond's in California. Inclusion of the barred owl covariate in one of the best performing models in the meta-analysis of reproduction across all study areas provided weak support for an effect of barred owl presence on reproduction throughout the NSO's range (Forsman et al. 2011). The negative association between reproduction and barred owl presence

was likely underestimated since researchers often cannot relocate NSOs displaced by barred owls, and many displaced NSOs may be unable to find new territories and reproduce (Forsman et al. 2011). Apparent survival of NSOs was negatively associated with the presence of barred owls in six of the study areas, including Northwest California and Green Diamond (95% confidence intervals did not overlap zero or only slightly overlapped zero). The meta-analysis for all study areas showed a negative association between barred owl presence and apparent survival and recruitment, although the evidence for an effect on recruitment was statistically weak. Populations in seven study areas, including Northwest California and Green Diamond, declined during the latter portion of the study period (95% confidence intervals did not overlap zero or only slightly overlapped zero for these areas). Model selection results for the meta-analysis of population change indicated support for models that included the barred owl covariate. Forsman et al. (2011) noted that, of the various factors evaluated for potential effects on NSO vital rates, negative associations with the presence of barred owls were the strongest and most consistent among study areas. Forsman et al. (2011) also noted that they likely underestimated these negative associations by applying the barred owl covariate at the population scale rather than the territory scale. Studies of associations between NSO occupancy rates and barred owl presence suggest that the territory is a more appropriate spatial scale for detecting effects of barred owls on NSOs (see below).

Occupancy

Several studies distributed across the NSO's range have found evidence of a negative effect of barred owl presence on occupancy by the subspecies (Kelly 2001, Kelly et al. 2003, Pearson and

Livezey 2003, Gremel 2005, Olson et al. 2005, Kroll et al. 2010, Dugger et al. 2011, Green Diamond Resource Company 2014, *Hoopa citation*). These findings suggest that barred owls are causing large-scale displacement of NSOs and that negative effects of barred owls are largely due to interference competition between the two species (see below).

Gremel (2005) found that occupancy by pairs of NSOs in the Olympic National Park in Washington declined significantly at sites with barred owl presence, whereas pair occupancy remained stable at sites without barred owl detections. During 1992-2003 in this study area, the number of barred owl detections in NSO sites per number of survey days increased by 15% per year. During the same period, mean occupancy by NSOs declined from 61% to 42% in sites with barred owl detections.

In the southwestern Washington Cascades, Pearson and Livezey (2003) found a 9% annual increase in the number of barred owl detections relative to the number of NSO detections during 1982-2003. Unoccupied historical NSO core areas (500 ac) had significantly more barred owl activity centers at three spatial scales (0.5, 1.0, 1.8 mi) than did occupied core areas.

Kelly et al. (2003) evaluated potential effects of barred owl presence on NSO occupancy in five density study areas in Washington and Oregon. Their analyses indicated that barred owls had a stronger negative effect on NSO occupancy when located closer to activity centers than when farther away. Occupancy by NSOs exhibited a highly significant decline when barred owls were detected within 0.5 mile of activity centers ($P = 0.001$), compared with a lower tendency to decline when barred owls were detected farther away ($P = 0.06$).

Olson et al. (2005) examined associations between NSO occupancy dynamics and the presence of barred owls near activity centers (distance not reported) in three study areas in western Oregon. Barred owl presence was low (detected near <10% of NSO sites each year) in all three study areas during the first eight years of the study (1990-1997), increased substantially in one of the study areas thereafter (maximum of 28% of sites in 2001), and more gradually in the other two (ca. 10% of sites in 2001). Despite relatively low barred owl presence (e.g., compared with Forsman et al. 2011, Figure 2), site occupancy probabilities for NSO pairs decreased by 5-15% with increasing barred owl presence.

In one of the western Oregon density study areas evaluated by Olson et al. (2005) (Tyee), Bailey et al. (2009) found no evidence of an effect of barred owl presence on NSO occupancy during 2002-2003. They cautioned however, that their study's inferences were weak since barred owl presence was relatively low at the time of the study (detections in <12% of NSO territories based on Olson et al. 2005). Just five years after their study period ended, barred owls were detected in 70% of NSO territories (0.62 mi around activity centers) (Forsman et al. 2011; Figure 2).

In the eastern Cascades of Washington, Kroll et al. (2010) found that the mean probability of occupancy by NSOs was significantly lower for sites with barred owl presence (0.50) than without it (0.76) (presence not spatially defined). Although the percent of NSO sites with barred owl detections was moderate compared with some areas (max. ca. 33% [estimated from graph] vs. Figure 2), site occupancy probabilities for NSOs declined by about 50% during 1990-2003.

In the southwestern Cascades of Oregon, Dugger et al. (2011) found significant differences in mean annual occupancy for NSO pairs with nearby barred owl detections (presence not spatially defined) than in those without. During the latter 13 years of the study, mean annual site occupancy was approximately 10-15% at sites with barred owl presence compared with about 58-78% at sites without barred owl presence (estimated from graph).

Green Diamond Resource Company (2014) is currently conducting an experiment to evaluate the effects of lethally removing barred owls from NSO territories in California's Redwood Province. Preliminary results from this study suggest that removal of barred owls results in rapid recolonization of sites by NSOs. Green Diamond reported a 43% increase in the number of sites occupied by NSOs in their treatment (barred owl removal) area during the first year (2008 to 2009) and an additional 9% increase the following year (2009 to 2010). In contrast, the number of sites occupied by NSOs in an adjacent control portion of the study area (no barred owl removal) was virtually unchanged from 2008 to 2009 and declined by 23% from 2009 to 2010. However, the degree to which barred owl removal positively affected NSO occupancy in this study is difficult to evaluate. The beginning of Green Diamond's removal study roughly coincided with implementation of a new survey protocol which likely resulted in greater detections of both NSOs and barred owls. Future analyses from this study should provide clearer insight into the effects of barred owl presence and removal on NSO occupancy.

Add Hoopa barred owl removal preliminary results if obtainable…

Habitat Use

Comment [LVD10]: You should include Wiens dissertation or the recent monograph in the section on habitat use.

Dugger and Davis (2011) stated that "the relationship between spotted owl fitness and habitat characteristics may have become disconnected through interspecific competition with barred owls." They based this hypothesis on their finding that mean habitat suitability at NSO pair locations within the Northwest Forest Plan area decreased by approximately 9% between 1994/1996 and 2006/2007 (Davis and Dugger 2011). This decline in mean habitat suitability at NSO pair locations did not appear to be solely due to a loss of suitable breeding habitat, which declined by about 3% in this area during the study period. This hypothesis is also supported by findings that NSOs in the northern portion of their range are often displaced by barred owls into steeper and higher elevation areas (Pearson and Livezey 2003, Gremel 2005, Hamer et al. 2007). Hamer et al. (2007) suggested that displacement of NSOs to higher elevation forests could result in reduced survival or reproduction during years with severe winters.

Territorial Behavior

Barred owl presence and calling is associated with reduced responsiveness of spotted owls to conspecific calls, including survey broadcasts (Olson et al. 2005, Crozier et al. 2006, Bailey et al. 2009, Kroll et al. 2010). This is partially of interest to researchers and land managers because it influences the field and analytical methods required for measuring occupancy by NSOs (Olson et al. 2005, MacKenzie et al. 2006, USFWS 2012). Accurate assessments of occupancy are needed for evaluating effects of barred owls and other potential stressors on NSOs, and for avoiding inappropriate management activities, such as timber harvesting near nests in occupied territories.

Comment [LVD11]: This is true, but reduced detection probabilities don't necessarily mean reduced ability to detect NSO. The number of surveys required have been increased so that overall detection probabilities are >95%.

Reduced vocalizing by NSOs in the presence of barred owls is also of concern because NSOs rely on vocalizations to defend their territories, locate vacant territories and potential mates, form pair bonds, and announce prey deliveries (Gutiérrez et al. 1995). Widespread disruption of these activities could impact NSO demographic rates.

Interspecific Competition

Gutiérrez et al. (2004) described the ecological and morphological separation that exists among sympatric owls worldwide. Their review found that species within the same genus are generally segregated by geographic range or habitat associations. It also showed that sympatric congeneric owls are usually strongly divergent in size, which varies with diet and possibly, hunting mode. Spotted owls and barred owls are both members of the genus *Strix*. Gutiérrez et al. (2004) noted that the two species only differ in body mass by 18%, which is likely too little to allow coexistence. A building body of evidence indicates that barred owls indeed negatively affect spotted owls (reviewed above), and that this occurs through both direct (interference) and indirect (exploitative) competition (Gutiérrez et al. 2004, 2007, USFWS 2013; see below). Wiens (2012) stated that "when viewed collectively, the behavioral and life history traits exhibited by barred owls may give them a significant advantage over spotted owls when competing for critical resources such as space, habitat, and food."

Surveyors have observed barred owls attacking spotted owls and have themselves been attacked while imitating spotted owl calls (Gutiérrez et al. 2004). There is also limited evidence of barred owl predation of NSOs. Leskiw and Gutiérrez (1998) provided strong circumstantial evidence

that a barred owl killed and partially consumed an NSO in Redwood National Park, California. Johnston (2002 cited in Gutiérrez et al. 2004) found circumstantial evidence of barred owl predation of a juvenile NSO in the southern Oregon Cascades. However, most cases of barred owl aggression toward NSOs appear to be a related to territorial defense, rather than predation (USFWS 2013).

Studies in Washington found that barred owl home ranges are relatively small and tend to have little overlap, which is consistent with aggressive territorial behavior (Hamer et al. 2007, Singleton et al. 2010). In contrast, neighboring NSO home ranges often broadly overlap, particularly during winter (Hamer et al. 2007). There is limited anecdotal evidence of spotted owls aggressively interacting with barred owls (Gutiérrez et al. 2004), and spotted owls appear to reduce detection probabilities for barred owls (Bailey et al. 2009). Nonetheless, barred owls generally exhibit higher levels of vocal and physical aggression than do NSOs and are typically dominant during interactions between the two species (Van Lanen et al. 2011). Significantly reduced detection probabilities for NSOs in the presence of barred owls provides further evidence of the larger, more aggressive barred owl's behavioral dominance over NSOs (see above).

Barred owls are dietary generalists compared with NSOs (USFWS 2013). As dietary generalists, barred owls may be better able to colonize a wider variety of habitats than NSOs and may be more resilient to fluctuations in prey populations (USFWS 2013). The barred owl's generalist diet is likely a primary reason for the species' relatively small home ranges and associated ability to occur at high densities (see below). Furthermore, because barred owl diets overlap with those

of NSOs, it is possible that they negatively affect NSOs by depressing populations of key prey, such as northern flying squirrels and woodrats (Gutiérrez et al. 2007, USFWS 2013).

The barred owl's habitat associations in the Pacific Northwest and California are poorly understood. As discussed earlier, most barred owl detections are incidental to spotted owl surveys so relatively little is known about the ecology of barred owls outside of areas occupied by spotted owls. Early studies of the barred owl's habitat associations in the Pacific Northwest suggested that the species is more associated with younger forest types than are NSOs (Gutiérrez et al. 2007). However, subsequent research has found that barred owls use a variety of habitats and that some individuals prefer densely canopied mature and old forest (Gutiérrez et al. 2007, USFWS 2011). That is, barred owls appear to be capable of occupying a broader variety of habitat types than NSOs but the two species likely compete for access to mature and old forest. The two species may also compete for nest sites since they both rely on the same kinds of pre-existing nest structures (Gutiérrez et al. 2007). Together, overlapping habitat associations with NSOs, use of a broader range of habitat types, and the ability to occur at relatively high densities allows barred owls to form large source populations in close proximity to NSOs (USFWS 2013).

Comment [LVD12]: The only real definitive data on habitat use of NSO and BO is the Wiens study, because he was radio tracking both species simultaneously on the same landscape. This study showed that the two species have almost identical selection for different aged stands with the only difference being that BO tend to use riparian areas more than NSO.

Perhaps due to their generalist diet, barred owls often have substantially smaller home ranges than do NSOs (Gutiérrez et al. 2007, USFWS 2013). Estimates of barred owl home ranges in Washington were three to nine times smaller than those of NSOs in the state (Hamer et al. 2007, Singleton et al. 2010). Barred owl home ranges in the Oregon Coast Ranges were two to four times smaller than those of NSOs (Wiens 2012). There does not appear to be any existing research comparing the home range sizes of barred owls and NSOs in California (Gutiérrez et al.

2007). Annual home range sizes for NSOs (100% minimum convex polygon) in the California and Oregon Klamath Provinces varied among studies and with forest types and contiguity but were similar to or somewhat larger (0-60% larger) than those for barred owls in the Oregon Coast Ranges (Sisco 1990, Carey et al. 1992, Zabel et al. 1993, Irwin et al. 2006). The NSO's smaller home ranges in California suggest that they may have lower encounter rates with barred owls than occurs in Oregon and Washington. However, it is possible that barred owls also have smaller home ranges in California. Estimates of barred owl home range sizes in California are needed.

Wiens (2012) found that barred owls in the Oregon Coast Ranges had a higher annual survival probability (0.92 vs. 0.81) and produced over six times as many young as sympatric NSOs. Barred owls have a wider range of clutch sizes than NSOs (1-5 vs. 1-3), are capable of laying additional clutches within a season if the first is lost, and appear to exhibit lower annual fluctuations in reproduction (USFWS 2013; but see Mazur and James 2000). The USFWS (2013) noted that "the ability of barred owls to forage on a wider diversity of prey species and in a wider diversity of habitats may explain their reproductive success in comparison with spotted owls." There is a need for further research of the barred owl's natural history and ecology within the range of the NSO (Gutiérrez et al. 2007, Livezey and Fleming 2007). However, the currently available information indicates that the demographic performance of barred owls is superior to that of NSOs.

Overall, barred owls appear to primarily impact NSOs through interference competition for space, habitat, and food, although they may also indirectly affect NSOs by depressing prey

populations (Gutiérrez et al. 2007, Hamer et al. 2007, Van Lanen et al. 2011, Wiens 2012, USFWS 2013). Barred owls are generally superior competitors to NSOs in terms of size, aggression, demographic performance, and ability to exploit a wider array of habitats and prey (Gutiérrez et al. 2007, USFWS 2013).

Barred Owl Management

The information reviewed above indicates that barred owls pose a serious and increasing threat to NSOs throughout their range, including in California. Barred owl presence in NSO territories has continued to increase across the NSO's range and appears to be partially responsible for declining NSO demographic and occupancy rates. Barred owl presence can also reduce the ability of biologists and land managers to effectively locate and conserve NSOs. Given the negative effects of barred owls on NSOs, it is clear that policymakers and land managers must address the barred owl threat if successful recovery of the NSO is to remain a conservation priority. Current proposals for addressing the barred owl threat include barred owl removal and habitat conservation.

Some researchers have expressed concern that barred owl removal experiments would be costly, ineffective, and distracting (Livezey 2010, Rosenberg et al. 2012). However, preliminary results from barred owl removal experiments indicate that lethal removal of barred owls is effective, relatively inexpensive, and conforms to animal welfare standards (Diller 2013, Diller et al. 2013, *Hoopa/other experiment area citations*). Other objections to barred owl removal are primarily ethical or emotional (Gutiérrez et al. 2007, Diller 2013). There is substantial emotional

resistance to lethal removal of barred owls, even among scientists and land managers involved with barred owl removal experiments (e.g., Diller 2013). Relocation of barred owls to zoos or their native forests in the eastern U.S. is logistically and politically unfeasible, so killing barred owls appears to be the only viable removal option (USFWS 2013). Primary ethical concerns regarding barred owl removal include whether or not it is appropriate to remove or control a native species or to intervene in its potentially natural range expansion (USFWS 2013). The USFWS (2013) reviewed scientific literature regarding the barred owl's status as a native or nonnative species and whether its range expansion was natural or human caused. It found that the literature was inconclusive regarding both issues. However, it concluded that humans are responsible for intervening in the barred owl's expansion because the NSO's vulnerability to barred owl competition and other stressors is due to timber harvesting and other past and continuing human activities. Regardless, the currently available evidence suggests that NSOs will continue to decline, and could ultimately become extinct, without widespread or strategic barred owl control measures.

The barred owl's increasing impact on NSOs in Late Successional Reserves, National Parks, and other reserved lands demonstrates that habitat protection alone is insufficient for addressing the barred owl threat (Gutiérrez et al. 2004). Nonetheless, habitat conservation remains crucial to the NSO's conservation (USFWS 2011). The importance of retaining suitable breeding habitat for NSOs has been well demonstrated at individual, territory, and population scales (e.g., Solis and Gutiérrez 1990, Franklin et al. 2000, Forsman et al. 2011; see *Threats: Timber Harvesting*). Habitat conservation might also be important for minimizing barred owl impacts on NSOs (USFWS 2011). Habitat loss and fragmentation due to timber harvesting or other disturbances

could intensify competition between NSOs and barred owls by bringing them into closer proximity (Gutiérrez et al. 2007, USFWS 2011). Dugger et al. (2011) found some support for this hypothesis in their study of NSO occupancy in southern Oregon. Their results indicated that barred owl presence and landscape-level habitat characteristics have additive effects on NSO occupancy rates. Specifically, the presence of barred owls appeared to exacerbate the negative effects of habitat loss and fragmentation on NSO occupancy. The USFWS (2011) suggested that retaining and restoring habitat may provide displaced or recruited NSOs with refugia from negative interactions with barred owls (USFWS 2011). Dugger et al. (2011) did not find direct support for this hypothesis. In their study, higher amounts and lower fragmentation of older forest did not reduce the negative effects of barred owls on NSO occupancy. However, they noted that some NSOs in their study continued to survive and successfully reproduce in areas with barred owl presence, possibly indicating that there are ecological conditions under which the two species can coexist. Additional and more direct research of the potential value of habitat refugia for NSOs is needed.

Acknowledgements

Xxxx

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Outdoor Marijuana Cultivation

Introduction

Although marijuana is perhaps the largest cash crop in California (Gettman 2006), its cultivation is largely unregulated and little is known about ~~its~~ environmental effects associated with its cultivation ~~environmental effects~~. Recent research has indicated that outdoor marijuana cultivation is currently having widespread and profound environmental impacts in California (Bauer cite, Gabriel et al. 2012, 2013, Thompson et al. 2014). Negative impacts of outdoor marijuana cultivation include wildlife deaths caused by pesticide exposure and poaching; habitat degradation caused by logging, road construction, pollution, and water diversion; and heightened safety concerns for research and resource personnel (Bauer cite, Gabriel et al. 2012, 2013, Thompson et al. 2014). The specific effects of outdoor marijuana cultivation on northern spotted owls (*Strix occidentalis caurina*; NSOs) are unknown. Recent findings of widespread pesticide exposure among fishers (~~*Martes*~~ *Pekania pennanti*) and barred owls (*Strix varia*) in northwestern California suggest that NSOs ~~in~~ within the state are likewise exposed and could be ~~negatively affected at both territory and population levels~~experiencing the same effects seen in fishers (~~Gabriel cite, Gabriel et al. 2012; reviewed below~~). NSOs could also be directly affected by environmental degradation from outdoor marijuana cultivation, ~~such as through~~via habitat modification ~~or suppression of rodent prey populations~~, or indirectly affected through ecological changes caused by reduced streamflows or pollution. Safety concerns associated with illegal marijuana cultivation may also be impacting NSOs and other wildlife through reduced research and survey efficiency and effort (Gabriel et al. 2013).

Comment [MWG1]: The plant itself is not hazardous, it's the activities associated with its cultivation.

Comment [MWG2]: New genus for the species.

Comment [MWG3]: Anticoagulant Rodenticide Exposure in Barred Owls, a Proxy for the Northern Spotted Owl in California Managed Forests: Implications of Food Web Contamination

Gabriel, M.W.1*, L. Diller2, J. Dumbacher3, J.M. Higley4, G.M. Wengert1, S. Mendia4, D. Lamphear2, D. Early2,K. Hamm2, and R. Poppenga5.
1*

The exposure of wildlife to anticoagulant rodenticides (AR) has been well documented in non-forest settings. Until recently with the discovery of rampant use of ARs within trespass marijuana sites, exposure to ARs in remote forest wildlife was unknown and unexpected. We investigated the landscape-wide AR contamination in 84 Barred Owls, a proxy species for the Northern Spotted Owl (NSO), within NSO suitable habitat on northwestern California managed timberlands. Additionally, we investigated whether owl prey sampled in owl habitat were exposed to ARs. A total of 40% of all tested owls were exposed to ARs while 37 rodents sampled within NSO habitat were negative. However, all invertebrate samples (100%) from trespass grows were positive for ARs. Due to the inherent and swift lethality of ARs, negative rodent data was anticipated; however this is the first report of AR exposure to field collected invertebrates. These results demonstrate that AR contamination within NSO populations in NW California is likely and that food web contamination for these owls and numerous forest wildlife species is concerning.

The Wildlife Society Presentation: Humboldt State University 2014

Comment [MWG4]: Will still need to cite it as unpublished presented data.

Comment [MWG5]: Mentioned above

Comment [MWG6]: How would NSO be affected by reduced wateflows? They do not use inverts >10% of their diet. Barred owls, possible, but NSO impact's due to streamflow's would need to have some substantial premise to make this point.

Pesticides

Pesticide application is usually intended to suppress populations of rodents, insects, mollusks, and other agricultural and urban pests, but can have inadvertent negative impacts on humans, pets, and other non-target animals (Erickson and Urban 2004, Albert et al. 2010, Mnif et al. 2011, Gabriel et al. 2012). Widespread secondary exposure to pesticides has been reported for raptors, carnivores, and other wildlife that consume poisoned rodents around farms and human dwellings (Albert et al. 2010, Murray 2013, ~~Thompson et al. 2014).~~ Researchers have generally assumed that pesticides pose little threat to wildlife outside of agricultural and urban areas (Gabriel et al. 2013). However, a recent publication reported that 79% of fishers tested in two study areas on federal and tribal forest lands in California had been exposed to anticoagulant rodenticides (ARs), including four that ~~apparently~~ died from lethal toxicosis (Gabriel et al. 2012; note: at least two more fishers in California died from AR poisoning following publication of this study: Gabriel et al. 2013). Most fishers in the study had been exposed to multiple AR compounds (range = 1-4, mean = 1.6). These findings not only raised concern for the West Coast fisher population, which the U.S. Fish and Wildlife Service recently proposed to list as threatened under the federal Endangered Species Act, but for the NSO, which has an overlapping distribution and diet with the fisher (Gabriel et al. 2013, Calforests 2014, USFWS 2014). Subsequently, ARs have been detected in a dead NSO recovered in Mendocino County (Calforests 2014) and xx of xx (xx%) barred owls tested for exposure in Humboldt County (Gabriel cite). Although barred owls are being tested as a proxy for NSOs (Gabriel cite), NSOs may be more widely exposed to ARs given their greater dietary specialization on rodents (see

Comment [MWG7]: Cite primary literature, Gabriel and Thompson are primary for fisher but not for other species.

Comment [MWG8]: More of habitat characteristics and some diet overlap.

Comment [MWG9]: See above presentation

USFWS 2013). Strong circumstantial evidence implicates pervasive illegal outdoor marijuana cultivation as the primary source of pesticide exposure for forest predators in California (Gabriel et al. 2012, 2013, Thompson et al. 2014).

ARs detected in forest predators in northern California include brodifacoum, bromadiolone, difethialone, chlorophacinone, diphacinone, warfarin, and coumachlor (Gabriel cite, Gabriel et al. 2012). Brodifacoum, bromadiolone, difethialone are classified as second-generation anticoagulant rodenticides (SGARs). SGARs were introduced in the 1970s due to widespread development of resistance among rodents to first-generation anticoagulant rodenticides (FGARs), such as warfarin, chlorophacinone, and diphacinone (Buckle et al. 1994). SGARs are more acutely toxic than FGARs and generally require only a single dose to kill rodents (Erickson and Urban 2004). However, rodents usually survive 5-10 days after consuming a lethal dose, during which time they may continue to consume additional rodenticide and remain available to predators (Cox and Smith 1992, Erickson and Urban 2004). SGARs are more persistent in animal tissues than FGARs and insecticides, which are more rapidly metabolized and excreted (Erickson and Urban 2004). Thus, exposure to FGARs and other non-SGAR pesticides is more difficult to detect than for SGARs and exposure to them could be underestimated (Albert et al. 2010, Thompson et al. 2014). Rodents such as dusky-footed woodrats (*Neotoma fuscipes*) and deer mice (*Peromyscus* spp.) are likely the primary source of AR exposure for NSOs because they are targeted by AR application and because they generally comprise most of the biomass in NSO diets (Forsman et al. 2004). Insects may be an additional source of AR exposure for NSOs and other wildlife. In terms of frequency of consumption, insects can substantially contribute to NSO diets regionally, locally, or seasonally (Forsman et al. 2004). Insects are not killed by ARs

Comment [MWG10]: Not all were detected, see 2012 Plos paper

Comment [MWG11]: Are they? I would rewrite with a general blanket statement that rodents are the primary source, however the main rodents most likely affected are…

Comment [MWG12]: Please see John Weins 2012 dissertation and publication https://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/28475/WiensJohnD2012.pdf?sequence=2

Comment [MWG13]: See weins study of minimal insect use by NSO

and may therefore continue to accumulate them in their tissues, essentially becoming small "packets" of AR (~~C. Thompson, pers. comm~~This would be primary data from Gabriel un published.).

Large quantities of ARs, particularly SGARs, are often spread across large areas in and around illegal outdoor marijuana grow sites (Gabriel et al. 2012, Thompson et al. 2014; Figure 1). Gabriel et al. (2012) noted that thousands of pounds of pesticides were found at illegal outdoor marijuana grow sites in California in 2008 and that 150 pounds of pesticide were found during a single three-week eradication operation on the Mendocino National Forest in 2011. Three sites raided in Humboldt County in 2013 contained a total of at least 17 pounds of SGAR bait, which researchers estimated was sufficient to kill 2,753 woodrats, 14 fishers, or five spotted owls (Humboldt Sentinel August 2, 2013). Other pesticides, such as organochlorine, organophosphate, and carbamate insecticides, some of which are banned in the U.S., are also frequently found at illegal outdoor marijuana grow sites (HSVTC 2012, Thompson et al. 2014). Pesticides are often applied along with large quantities of fertilizer at the base of marijuana plants grown outdoors (Thompson et al. 2014; Figure 1), suggesting that marijuana and surrounding plants may be taking up pesticidal compounds from the soil. If this occurs, then rodents and insects may accumulate pesticides through consumption of plants as well as pesticidal bait. Investigation of pathways of pesticide exposure for NSOs, as well as levels of exposure and potential physiological, behavioral, and population impacts, is needed.

Comment [MWG14]: Primary source was Humboldt county sheriffs office which we provided them the data for the press release. Cite HCSO

Figure 1: (A) Rodenticide and other pesticides found at a trespass outdoor marijuana grow site in Humboldt County (photo: Humboldt County Sheriff's Office) and (B) rodenticide bait and dry fertilizer strewn together below approximately 2,000 marijuana plants at a trespass outdoor grow site in Humboldt County (from Gabriel et al. 2012).

ARs are vitamin K antagonists, which cause impairment of the blood's ability to clot (Murray 2013). A lethal dose of AR causes animals to die from hemorrhage (Erickson and Urban 2004). Animals may also exhibit weakness prior to death or with a sublethal dose (Erickson and Urban 2004). Rodents exposed to ARs show altered behavior, such as spending more time in the open, freezing rather than bolting when threatened, and staggering (Cox and Smith 1992). These behaviors may increase predation risk for affected rodents and the opportunity for secondary exposure of predators to ARs (Cox and Smith 1992). Owls and other raptors with sublethal secondary exposure to ARs may often have reduced blood-clotting activity and can die from

minor wounds such as those commonly inflicted by prey (Erickson and Urban 2004, Murray 2013, Thompson et al. 2014). Non-AR pesticides have a variety of physiological effects, such as disrupting endocrine function or damaging the central nervous system (Grue et al. 1997, Mnif et al. 2011). Chronic or sublethal exposure to carbamate or organophosphate pesticides has been shown to reduce immune response, cause neurological disorders, reduce thermoregulatory control, and impair anti-predator behavior in wildlife (Grue et al. 1997; reviewed in Thompson et al. 2014). Pesticides can also have additive or synergistic effects on animals (Larsen et al. 2003 cited in Mnif et al. 2011, Relyea 2009). This is a source of additional concern for NSOs and other forest predators active near outdoor marijuana cultivation sites, where multiple types of pesticide are often present (HSVTC 2012, Thompson et al. 2014). Mortalities associated with exposure to pesticides are likely underestimated because carcasses are often predated or scavenged before biological samples can be obtained and because sublethal exposure can predispose wildlife to death from other causes (Albert et al. 2010).

There is no information available concerning population-level impacts of secondary pesticide exposure for NSOs in California. As reviewed above, secondary exposure to pesticides can kill raptors and other wildlife both through lethal toxicosis and by increasing the risk of mortality due to other factors such as predation, hypothermia, disease, parasites, or injury. NSO population rates are particularly sensitive to changes in adult survival (Noon and Biles 1990) so it is possible that direct and indirect mortalities associated with pesticide exposure could contribute to population declines (Sibly et al. 2000, Thompson et al. 2014). Pesticide exposure could also negatively impact NSO reproduction. Gabriel et al. (2012) noted that fisher mortalities caused by AR poisoning occurred between mid-April and mid-May. The timing of

these deaths coincided with the planting phase of outdoor marijuana cultivation, when seedlings are most vulnerable to rodent pests and AR use is likely highest (Gabriel et al. 2012). This time of year is also when NSOs incubate and brood young (Gutiérrez et al. 1995). Reduced parental care during this phase, for example due to compromised behavior or death of one or both parents, could result in death of offspring due to ~~chilling~~exposure, undernourishment, or predation (Grue et al. 1997). NSO populations could also be negatively impacted by pesticide suppression of prey populations or changes in community ecology caused by reductions of insects, small mammals, carnivores, raptors, amphibians, and aquatic animals (Relyea and Diecks 2008).

Comment [MWG15]: Why would NSO populations decrease if a carnivore population decreases, or for the other examples mentioned. It is plausible for the small mammals due to them being prey items. Explain for the reader

Other Environmental Effects

Activities related to outdoor marijuana cultivation can have a variety of environmental impacts beyond exposure of wildlife to pesticides, including negative effects of illegal and poorly planned water diversion, logging, and road construction; pollution of water and soils; poaching of wildlife; and ignition of wildfires (reviewed below). Negative impacts occur on both public and private lands (Bauer cite, Gabriel et al. 2013). However, the potential environmental impacts of marijuana cultivation could vary considerably, depending on the operation's location, scale, and practices. For example, some marijuana industry organizations and growers advocate growing practices aimed at minimizing environmental damage from outdoor cultivation (e.g., http://emeraldgrowers.org/). ~~No~~ there does not appear to be any information available at this time regarding effects of ecological degradation from marijuana cultivation on NSOs. Negative effects on NSOs are possible given the subspecies' sensitivity to habitat modification (see *Timber Harvesting* and *Wildfires*, this volume) and close association with riparian areas (e.g.,

Hamer et al. 2007, Irwin et al. 2012), where the impacts of marijuana cultivation are often concentrated. Furthermore, safety concerns associated with marijuana cultivation can substantially impact the ability of land managers to effectively survey and manage spotted owls and other sensitive wildlife (Keane et al. 2011, Gabriel et al. 2013, D. Hansen pers. obs.; see below).

Personnel with the California Department of Fish and Wildlife (Bauer cite) recently estimated hydrologic impacts of marijuana cultivation in northwestern California using high-resolution aerial imagery in Google Earth™ (e.g., Figure 2) and marijuana industry estimates of marijuana plant water requirements. Using these methods, they estimated that more than 82,000 marijuana plants were cultivated in 2012 in just four watersheds in Humboldt and Mendocino Counties (Table 1). Based on estimated numbers of marijuana plants and assumed water usage of 6 gallons per day per plant, they calculated that marijuana cultivation uses approximately 29% and 21% of the water that flows in the Redwood Creek and Salmon Creek watersheds per day during periods of minimum streamflow (Table 2). Although based on several assumptions (marijuana cultivation water sources and usage, complete visibility of cultivation sites in aerial imagery, complete usage of greenhouses), these estimates raised considerable concern about potential negative impacts of marijuana cultivation on watershed health and aquatic animals (cite). NSOs often exhibit a preference for nesting, roosting, and foraging in and near riparian areas (e.g., Hamer et al. 2007, Irwin et al. 2007). Thus, it is plausible that ecological changes caused by widespread water diversion for marijuana cultivation have negative indirect effects on NSOs.

Comment [MWG16]: This sentence fits the concern that I had above about water usage. But this should definitely be mentioned above

Figure 2: Outdoor (A) and greenhouse (B) marijuana cultivation sites identified with Google Earth™ (from Bauer cite). *Add Google Earth image(s) of trespass grow site(s).*

Table 1: Estimated numbers of outdoor marijuana cultivation sites, outdoor marijuana plants, marijuana greenhouses, marijuana plants in greenhouses, and total number of marijuana plants in four watersheds in Humboldt and Mendocino Counties (from Bauer cite).

	Redwood Creek (67.3 km²)	Salmon Creek (95.6 km²)	Redwood Creek North (730 km²)	Outlet Creek (419 km²)
Total outdoor cultivation sites	231	306	120	633
Total outdoor plants	10,475	11,697	5,984	16,843
Plant : Land area $\left(\frac{1}{km^2}\right)$	173.7	122.4	8.2	40.2
Total Greenhouses	324	302	273	320
Estimated Total Plants in Greenhouses	8,053	8,851	11,029	9,180
Greenhouse : Land Area $\left(\frac{1}{km^2}\right)$	4.8	3.1	0.4	0.8
Total Plants per Watershed*	**18,528**	**20,548**	**17,013**	**26,023**

**Field data indicate these totals may be underestimates.*

Table 2: Estimated daily water use for marijuana cultivation per day and during an entire growing season compared with minimum streamflow in four watersheds in Humboldt and Mendocino Counties (from Bauer cite).

	Redwood Creek	Salmon Creek	Redwood Creek North	Outlet Creek
Daily Water Use (gpd)	111,167	123,289	102,078	156,138
Minimum Streamflow (gpd)	387,763	581,645	---	---
Percent Use	**28.7%**	**21.2%**	---	---
Water Use per 150 Day Season (gal)	16,675,308	18,493,344	15,311,700	23,420,700

Marijuana growers on both public and private lands often illegally clearcut vegetation in order to create growing space for marijuana plants and room for artificial ponds and other structures (Bauer cite, Gabriel et al. 2013; Figure 3). Illegal cutting, along with creation of roads to access grow sites, can increase sedimentation in streams and creeks and thereby degrade habitat quality for aquatic and amphibious animals (Bauer cite). The effect of illegal vegetation clearing on NSOs is unknown. Given the close association of both marijuana cultivation and NSOs with riparian areas and surrounding uplands (e.g., Hamer et al. 2007, Irwin et al. 2007), it is plausible that widespread marijuana cultivation results in habitat loss or fragmentation for NSOs.

Figure 3: Areas cleared for outdoor marijuana cultivation.

From cite.

Clearing of a riparian area for marijuana cultivation at a trespass grow site.
Courtesy of Craig Thompson.

Widespread outdoor marijuana cultivation can further damage watershed health by polluting water and soils. In addition to pesticides, tremendous quantities of fertilizer are often applied at marijuana grow sites (HSVTC 2012, Thompson et al. 2014). Fertilizers, along with low flows caused by drought conditions and water diversion, may contribute to algae blooms and reduced oxygen levels in creeks and rivers (cite). Other pollution, including human waste, trash, and spilled diesel fuel from generators, is also frequently observed in and around streams at raided

outdoor marijuana grow sites (HSVTC 2012, C. Thompson, pers. comm.). Like water diversion and increased stream sedimentation, pollution from outdoor marijuana cultivation is primarily a source of concern for aquatic and amphibious animals but could have indirect ecological effects on NSOs and other wildlife.

Multiple recent wildfires in California have been attributed to marijuana growers. For example, in 2014, a marijuana grower was indicted on charges of starting the Nicolls Fire that burned nearly 1,700 acres in the Sequoia National Forest (SacBee 2014b). This grower allegedly set multiple fires in an attempt to avoid capture by other growers that he claimed were trying to kill him. Another marijuana grower was recently arrested for igniting the 2014 Bully Fire that burned nearly 13,000 acres in Shasta County (SacBee 2014a). This fire was apparently started when the grower's rental truck ignited dry grass when driven off-road in order to deliver soil amendments to a grow site. In 2009, a marijuana grower's camp stove ignited the 90,000-acre La Brea Fire in the Los Padres National Forest in southern California (inciweb). Large wildfires (e.g., thousands of acres) can burn through multiple NSO territories and can negatively affect NSOs in a variety of ways, particularly when they burn large areas at moderate to high severity (reviewed in *Threats: Wildfires*).

Illegal marijuana growers are often heavily armed in order to protect their crops and for poaching wildlife for food or to prevent wildlife damage to plants, equipment, or food caches (Gabriel et al. 2013, Boehm 2014; Figure 4). Many biologists and other field personnel working in California's forests have been interrogated, pursued, or shot at by marijuana growers (Gabriel et al. 2013, D. Hansen pers. obs.). Safety concerns associated with widespread illegal marijuana

cultivation can substantially curtail the ability of researchers and land managers to effectively locate, study, and manage spotted owls and other wildlife. For example, Six Rivers National Forest biologists were repeatedly excluded from entire pre-project NSO survey units in 2013 due to evidence of trespass outdoor marijuana cultivation (D. Hansen pers. obs.). Similarly, Keane et al. (2011) stated that their California spotted owl (*S. o. occidentalis*) survey crew was excluded from large portions of a study area in the Sierra Nevada in 2010 due to extensive illegal marijuana cultivation operations. Gabriel et al. (2013; Gabriel cite) estimated that safety concerns due to trespass outdoor marijuana cultivation resulted in exclusion of researchers from 15-25% of one fisher study area in California and a projected additional cost of $500,000-750,000 for the life of the combined budgets of two of California's fisher research projects. Wildlife surveyors who were able to work alone in the past must now frequently work in pairs for safety reasons, reducing survey efficiency and increasing project costs (Gabriel et al. 2013, D. Hansen pers. obs.). Exclusion from study areas can also compromise the ability of researchers to properly design and complete research investigating important conservation issues, such as effects of pesticides on fishers (Gabriel et al. 2013) and wildfires on spotted owls (Keane et al. 2011).

Figure 4: Armed marijuana growers posing in front of a poached deer (from Gabriel et al. 2013).

Magnitude and Location of Threat

Estimates of marijuana production and value are generally based on either federal marijuana seizure data (e.g., assuming that seizures represent 10 or 15% of the total amount produced) or marijuana consumption surveys and estimates of plant yields and market value (Gettman 2006) (reviewed in PBS 2014). Estimates from both of these methods indicate that California is, by far, the primary marijuana-producing state in the U.S. and that most of this production is from outdoor cultivation (NDIC 2011, Gettman 2006). Gettman (2006) estimated that, in 2006 alone, California produced an estimated 8.6 million pounds of marijuana with a value of more than 13.8 billion dollars. An estimated 89% of this product and value was from outdoor cultivation. If correct, marijuana is the largest cash crop in California (Gettman 2006), which is remarkable given that California is the most productive agricultural state in the U.S. (USDA 2014).

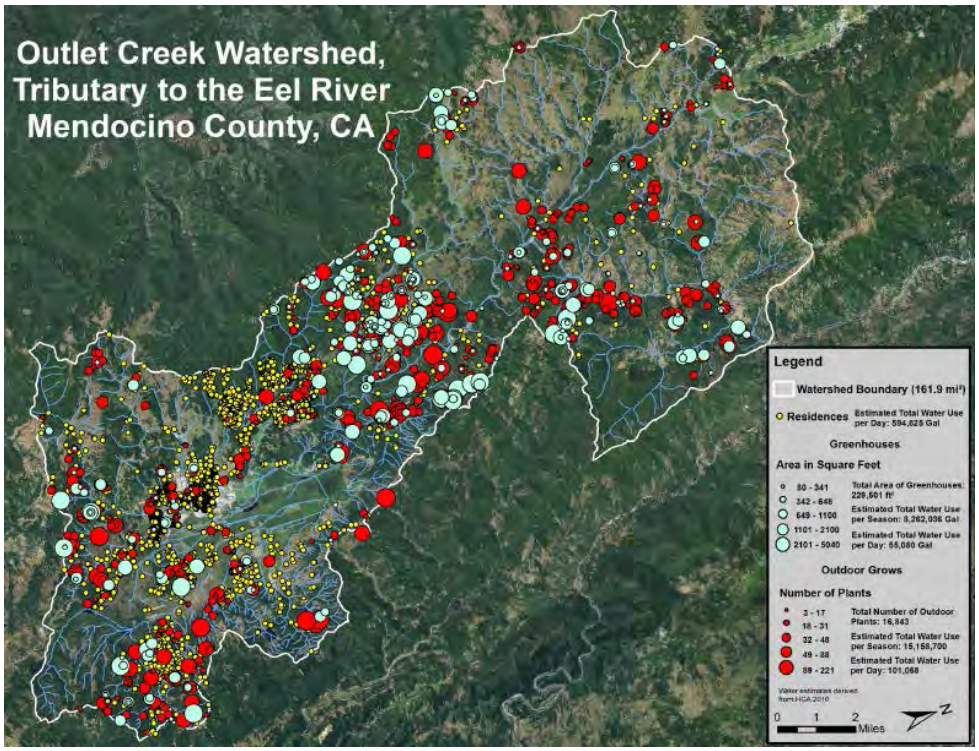
Outdoor marijuana cultivation in California has increased dramatically in recent years, including on both public and private lands (Bauer cite, NDIC 2011). This rapid growth was due to increased demand for domestically grown marijuana; possibly driven by state legalization of marijuana for medical use, changes in public perception of health or legal risk associated with marijuana use, or reduced imports from other countries due to tighter border control measures implemented after 9/11 (NDIC 2007, 2011, SacBee 2012). However, rapid growth of marijuana production in California apparently outstripped consumer demand in the last few years, particularly following federal crackdowns on medical marijuana dispensaries in the state (SacBee 2012). Desire among growers to maintain high profits in the face of increasing supply and decreasing prices could be a factor driving recent increases in the size and intensity (e.g., use of pesticides, fertilizer, and water) of many outdoor marijuana cultivation operations (cite, Bauer cite).

The number of outdoor marijuana plants eradicated in the U.S. increased by 250% between 2005 and 2010 (NDIC 2011). Federal eradication data suggest that trespass outdoor marijuana cultivation is increasing particularly rapidly on National Forests in California (NDIC 2011). Between 2005 and 2013, over 16 million marijuana plants were eradicated at approximately 3,356 sites on National Forests in California (Boehm 2014). Federal agencies have largely attributed increased numbers of trespass outdoor marijuana cultivation sites to expansion of operations by international drug trafficking organizations (e.g., Mexican drug cartels) into remote mountainous areas (particularly in northern California) in order to avoid detection by law enforcement personnel (NDIC 2007, Boehm 2014). However, the degree to which increases in amounts of eradicated or seized marijuana reflect increased production versus increased drug

enforcement effort is unclear, as is the scale of international drug trafficking organizations' role in outdoor marijuana cultivation in California (cite, NDIC 2010).

Outdoor marijuana production in California is also growing rapidly on private lands (NDIC 2007, Bauer cite). Personnel with the California Department of Fish and Wildlife (Bauer cite) used aerial imagery in Google Earth™ to estimate changes in the number and sizes of marijuana cultivation operations in four watersheds in Humboldt and Mendocino Counties during 2009-2012. In 2012 they identified nearly 1,300 outdoor grow sites and more than 1,200 greenhouses likely used for marijuana cultivation in these watersheds (Table 1; e.g., Figure 5). The number and size of marijuana cultivation operations identified increased in all four watersheds by 68-104% between 2009 and 2012. The total number of greenhouses and the number of greenhouses greater than 1,000 ft^2 increased by 69% and 87%, respectively. Continued use of aerial imagery and flyovers will shed greater light on the number, size, and location of outdoor marijuana operations on both public and private lands. For example, the California Department of Fish and Wildlife (2012) noted that law enforcement officers spotted more than 200 new marijuana grow operations in the Mattole Watershed in Humboldt County during a single flyover. *Describe proportion of marijuana cultivation sites identified by Bauer which were located on properties owned by private citizens vs. trespass grows on federal and/or timber co. lands. Incorporate other law enforcement information (e.g., any additional FOIA information from USFS law enforcement).*

Figure 5: Locations and sizes of marijuana cultivation operations identified in the Outlet Creek Watershed in Mendocino County using aerial imagery in Google Earth™ (from Bauer cite).



Summary and Management Implications

There is currently little direct information regarding potential impacts of illegal outdoor marijuana cultivation on NSOs. However, widespread application of ARs and other toxicants at outdoor grow sites are negatively impacting fishers, which have overlapping home ranges and diets with NSOs in northwestern California (Gabriel et al. 2012, 2013, Thompson et al. 2014). There is also evidence of widespread exposure to toxicants among barred owls in Humboldt County, and an NSO from Mendocino County recently tested positive for ARs (Gabriel cite, Calforests 2014). Thus, it is likely that NSOs in California are widely exposed to toxicants

applied at illegal outdoor marijuana grow sites. ARs and other pesticides can directly kill owls and other raptors or increase their vulnerability to other sources of mortality such as predation, disease, parasites, hypothermia, or injury (reviewed above). Furthermore, illegal outdoor marijuana cultivation is apparently causing widespread environmental degradation through toxicant exposure in other animals, reduced streamflows, pollution, poorly planned logging and road construction, and wildlife poaching (Bauer cite, Gabriel et al. 2013). Safety concerns associated with the widespread presence of heavily armed marijuana growers may also be impacting conservation of spotted owls and other wildlife by reducing the efficiency and effectiveness of research and survey efforts (Keane et al. 2011, Gabriel et al. 2013, D. Hansen pers. obs.).

Increased funding and effort are needed for evaluation of effects of outdoor marijuana cultivation on NSOs, other wildlife, and ecosystems (cite). Greater funding and coordination are also needed for interdiction, clean-up, and restoration at illegal outdoor grow sites (cite). These efforts require a substantial, multi-agency law enforcement presence, experts capable of identifying and properly disposing of toxicants, personnel and equipment for removing large amounts of trash and other material, and natural resource specialists for rehabilitating or restoring sites (Gabriel et al. 2013, Boehm 2014). Even if marijuana is legalized in California, tremendous resources, effort, and coordination may still be needed to regulate the industry and to continue to locate, clean up, and restore abandoned or interdicted illegal grow sites. Only a small portion of interdicted outdoor grow sites in California have been cleaned up thus far and even less have been restored (cite). Many of these sites may continue to pose an environmental threat long after they are abandoned by growers (Gabriel et al. 2013). For example, trespass

outdoor growers often cache ARs and other toxicants in water-proof containers, which bears can eventually find and open, allowing further poisoning and exposure of wildlife even after growing operations have ceased at the site (cite, HSVTC 2012).

Comment [MWG17]: They don't really cache these toxicants, the toxicants are manufactured in child proof or waterproof/resistance containers that leave the material still viable for years. This is citable by percom from many folks, including myself and craig.

The Environmental Protection Agency (EPA) and California Department of Pesticide Regulation (CDPR) have recently taken steps to reduce threats from SGARs to wildlife, children, and pets. Since 2011, EPA regulations have prohibited the sale of SGARs to the general consumer. Under EPA regulations, SGARs may only be purchased at agricultural stores, in bait station form rather than as loose pellets, and in relatively small quantities (Bradbury 2008). Most AR manufacturers quickly complied with these regulations and brought replacement products to market containing FGARs or neurotoxins, rather than SGARs (CDPR 2013, Murray 2013). However, the EPA only recently reached an agreement with Reckitt Benckiser to end distribution of their popular d-Con® products containing SGARs and sold without a protective bait station by March 31, 2015 (EPA 2014). On July 1, 2014, the CDPR further limited access to SGAR products in California by classifying them as restricted materials (California Department of Consumer Affairs 2014). In California, products containing SGARs can only be purchased from CDPR-licensed pest control dealers by certified applicators (California Department of Consumer Affairs 2014). Increased restrictions on public access to products containing SGARs should help to reduce exposure of wildlife to these compounds. However, considering that banned pesticides are commonly found at trespass outdoor marijuana cultivation sites (HSVTC 2012, Thompson et al. 2014) growers will likely continue to widely apply SGARs in forests occupied by NSOs, fishers, and other sensitive wildlife.

Comment [MWG18]: Cite Gabriel 2013 for banned pesiticides too. Showing a 3 years of publications documenting these toxicants.

Comment [MWG19]: Or other new emerging toxicants, or massive amounts of legal , high poundage FGARs.

Acknowledgements

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Outdoor Marijuana Cultivation

Introduction

Although marijuana is perhaps the largest cash crop in California (Gettman 2006), its cultivation is largely unregulated and little is known about its environmental effects. Recent research has indicated that outdoor marijuana cultivation is currently having widespread and profound environmental impacts in California (Bauer cite, Gabriel et al. 2012, 2013, Thompson et al. 2014). Negative impacts of outdoor marijuana cultivation include wildlife deaths caused by pesticide exposure and poaching; habitat degradation caused by logging, road construction, pollution, and water diversion; and heightened safety concerns for research and resource personnel (Bauer cite, Gabriel et al. 2012, 2013, Thompson et al. 2014). The specific effects of outdoor marijuana cultivation on northern spotted owls (*Strix occidentalis caurina*; NSOs) are unknown. Recent findings of widespread pesticide exposure among fishers (*Martes pennanti*) and barred owls (*Strix varia*) in northwestern California suggest that NSOs in the state are likewise exposed and could be negatively affected at both territory and population levels (Gabriel cite, Gabriel et al. 2012; reviewed below). NSOs could also be directly affected by environmental degradation from outdoor marijuana cultivation, such as through habitat modification or suppression of rodent prey populations, or indirectly affected through ecological changes caused by reduced streamflows or pollution. Safety concerns associated with illegal marijuana cultivation may also be impacting NSOs and other wildlife through reduced research and survey efficiency and effort (Gabriel et al. 2013).

Pesticides

Pesticide application is usually intended to suppress populations of rodents, insects, mollusks, and other agricultural and urban pests, but can have inadvertent negative impacts on humans, pets, and other non-target animals (Erickson and Urban 2004, Albert et al. 2010, Mnif et al. 2011, Gabriel et al. 2012). Widespread secondary exposure to pesticides has been reported for raptors, carnivores, and other wildlife that consume poisoned rodents around farms and human dwellings (Albert et al. 2010, Murray 2013, Thompson et al. 2014). Researchers have generally assumed that pesticides pose little threat to wildlife outside of agricultural and urban areas (Gabriel et al. 2013). However, a recent publication reported that 79% of fishers tested in two study areas on federal and tribal forest lands in California had been exposed to anticoagulant rodenticides (ARs), including four that apparently died from lethal toxicosis (Gabriel et al. 2012; note: at least two more fishers in California died from AR poisoning following publication of this study: Gabriel et al. 2013). Most fishers in the study had been exposed to multiple AR compounds (range = 1-4, mean = 1.6). These findings not only raised concern for the West Coast fisher population, which the U.S. Fish and Wildlife Service recently proposed to list as threatened under the federal Endangered Species Act, but for the NSO, which has an overlapping distribution and diet with the fisher (Gabriel et al. 2013, Calforests 2014, USFWS 2014). Subsequently, ARs have been detected in a dead NSO recovered in Mendocino County (Calforests 2014) and xx of xx (xx%) barred owls tested for exposure in Humboldt County (Gabriel cite). Although barred owls are being tested as a proxy for NSOs (Gabriel cite), NSOs may be more widely exposed to ARs given their greater dietary specialization on rodents (see USFWS 2013). Strong circumstantial evidence implicates pervasive illegal outdoor marijuana

cultivation as the primary source of pesticide exposure for forest predators in California (Gabriel et al. 2012, 2013, Thompson et al. 2014).

ARs detected in forest predators in northern California include brodifacoum, bromadiolone, difethialone, chlorophacinone, diphacinone, warfarin, and coumachlor (Gabriel cite, Gabriel et al. 2012). Brodifacoum, bromadiolone, difethialone are classified as second-generation anticoagulant rodenticides (SGARs). SGARs were introduced in the 1970s due to widespread development of resistance among rodents to first-generation anticoagulant rodenticides (FGARs), such as warfarin, chlorophacinone, and diphacinone (Buckle et al. 1994). SGARs are more acutely toxic than FGARs and generally require only a single dose to kill rodents (Erickson and Urban 2004). However, rodents usually survive 5-10 days after consuming a lethal dose, during which time they may continue to consume additional rodenticide and remain available to predators (Cox and Smith 1992, Erickson and Urban 2004). SGARs are more persistent in animal tissues than FGARs and insecticides, which are more rapidly metabolized and excreted (Erickson and Urban 2004). Thus, exposure to FGARs and other non-SGAR pesticides is more difficult to detect than for SGARs and exposure to them could be underestimated (Albert et al. 2010, Thompson et al. 2014). Pesticides are often applied along with large quantities of fertilizer at the base of marijuana plants grown outdoors, suggesting that marijuana plants may be taking up pesticidal compounds from the soil (Thompson et al. 2014; Figure 1). ~~If this occurs, NSOs and other wildlife could be exposed to pesticides through consumption of insects and rodents that eat marijuana plants, as well as by eating rodents that ingest AR bait (cite).~~

Comment [UFS1]: Can't cite me here, I did not talk about uptake in the paper. As far as I know, this is strongly suspected but hasn't been proven.

Large quantities of ARs, particularly SGARs, are often spread across large areas in and around illegal outdoor marijuana grow sites (Gabriel et al. 2012, Thompson et al. 2014; Figure 1). Gabriel et al. (2012) noted that thousands of pounds of pesticides were found at illegal outdoor marijuana grow sites in California in 2008 and that 150 pounds of pesticide were found during a single three-week eradication operation on the Mendocino National Forest in 2011. Three sites raided in Humboldt County in 2013 contained a total of at least 17 pounds of SGAR bait, which researchers estimated was sufficient to kill 2,753 woodrats, 14 fishers, or five spotted owls (Humboldt Sentinel August 2, 2013). Other pesticides, such as organochlorine, organophosphate, and carbamate insecticides, some of which are banned in the U.S., are also frequently found at illegal outdoor marijuana grow sites (~~cite~~HSVTC 1012, Thompson et al. 2014).

Figure 1: (A) Rodenticide and other pesticides found at a trespass outdoor marijuana grow site in Humboldt County (photo: Humboldt County Sheriff's Office) and (B) rodenticide bait and dry fertilizer strewn together below approximately 2,000 marijuana plants at a trespass outdoor grow site in Humboldt County (from Gabriel et al. 2012).

ARs are vitamin K antagonists, which cause impairment of the blood's ability to clot (Murray 2013). A lethal dose of AR causes animals to die from hemorrhage (Erickson and Urban 2004). Animals may also exhibit weakness prior to death or with a sublethal dose (Erickson and Urban 2004). Rodents exposed to ARs show altered behavior, such as spending more time in the open, freezing rather than bolting when threatened, and staggering (Cox and Smith 1992). These behaviors may increase predation risk for affected rodents and the opportunity for secondary exposure of predators to ARs (Cox and Smith 1992). Owls and other raptors with sublethal secondary exposure to ARs may often have reduced blood-clotting activity and can die from

minor wounds such as those commonly inflicted by prey (Erickson and Urban 2004, Murray 2013, Thompson et al. 2014). It is also worth noting that invertebrates respond differently and are not negatively impacted by the uptake of vitamin K antagonists. They are therefore capable of accumulating both FGAR and SGAR compounds either through direct consumption or potentially or the consumption of vegetation where uptake of pesticidal compounds has occurred. NSOs and other wildlife may therefore be exposed to pesticides through consumption of live or dead insects in the vicinity of grow sites.

Non-AR pesticides have a variety of physiological effects, such as disrupting endocrine function or damaging the central nervous system (Grue et al. 1997, Mnif et al. 2011). Chronic or sublethal exposure to carbamate or organophosphate pesticides has been shown to reduce immune response, cause neurological disorders, reduce thermoregulatory control, and impair anti-predator behavior in wildlife (Grue et al. 1997; reviewed in Thompson et al. 2014). Pesticides can also have additive or synergistic effects on animals (Larsen et al. 2003 cited in Mnif et al. 2011). This is a source of additional concern for NSOs and other forest predators active near outdoor marijuana cultivation sites, where multiple types of pesticide are often present (HSVTC 2012, Thompson et al. 2014). Mortalities associated with exposure to pesticides are likely underestimated because carcasses are often predated or scavenged before biological samples can be obtained and because sublethal exposure can predispose wildlife to death from other causes (cite, Albert et al. 2010).

There is no information available concerning population-level impacts of secondary pesticide exposure for NSOs in California. As reviewed above, secondary exposure to pesticides can kill

raptors and other wildlife both through lethal toxicosis and by increasing the risk of mortality due to other factors such as predation, hypothermia, disease, parasites, or injury. NSO population rates are particularly sensitive to changes in adult survival (Noon and Biles 1990) so it is possible that direct and indirect mortalities associated with pesticide exposure could contribute to population declines (Sibley et al. 2000~~cite~~, Thompson et al. 2014). Pesticide exposure could also negatively impact NSO reproduction. Gabriel et al. (2012) noted that fisher mortalities caused by AR poisoning occurred between mid-April and mid-May. The timing of these deaths coincided with the planting phase of outdoor marijuana cultivation, when seedlings are most vulnerable to rodent pests and AR use is likely highest (Gabriel et al. 2012). This time of year is also when NSOs incubate and brood young (cite). Reduced parental care during this phase, for example due to compromised behavior or death of one or both parents, could result in death of offspring due to chilling, undernourishment, or predation (Grue et al. 1997~~cite~~). NSO populations could also be negatively impacted by pesticide suppression of prey populations or changes in community ecology caused by reductions of insects, small mammals, carnivores, raptors, amphibians, and aquatic animals (Relyea and Diecks 2008~~cite~~).

Other Environmental Effects

Activities related to outdoor marijuana cultivation can have a variety of environmental impacts beyond exposure of wildlife to pesticides, including negative effects of illegal and poorly planned water diversion, logging, and road construction; pollution; poaching; and ignition of wildfires (reviewed below). Negative impacts occur on both public and private lands (cite, Bauer cite, Gabriel et al. 2013). The potential environmental impacts of marijuana cultivation

could vary considerably, depending on the operation's location, scale, and practices. We are unaware of any information regarding effects of ecological degradation from marijuana cultivation on NSOs. Negative effects on NSOs are possible given the subspecies' sensitivity to habitat modification (cite) and close association with riparian areas (cite), where the impacts of marijuana cultivation are often concentrated. Furthermore, safety concerns associated with marijuana cultivation can substantially impact the ability of land managers to effectively survey and manage spotted owls and other sensitive wildlife (Keane et al. 2011, Gabriel et al. 2013, D. Hansen pers. obs.).

Personnel with the California Department of Fish and Wildlife (Bauer cite) recently estimated hydrologic impacts of marijuana cultivation in northwestern California using high-resolution aerial imagery in Google Earth™ (e.g., Figure 2) and marijuana industry estimates of marijuana plant water requirements. Using these methods, they estimated that more than 82,000 marijuana plants were cultivated in 2012 in just four watersheds in Humboldt and Mendocino Counties (Table 1). Based on estimated numbers of marijuana plants and assumed water usage of 6 gallons per day per plant, they calculated that marijuana cultivation uses approximately 29% and 21% of the water that flows in the Redwood Creek and Salmon Creek watersheds per day during periods of minimum streamflow (Table 2). Although based on several assumptions (marijuana cultivation water sources and usage, complete visibility of cultivation sites in aerial imagery, complete usage of greenhouses), these estimates raised considerable concern about potential negative impacts of marijuana cultivation on watershed health and aquatic animals (cite). This concern is currently heightened given California's ongoing severe drought (cite). NSOs often exhibit a preference for nesting, roosting, and foraging in and near riparian areas (cite). Thus, it

is plausible that ecological changes caused by widespread water diversion for marijuana cultivation have negative indirect effects on NSOs.

Figure 2: Outdoor (A) and greenhouse (B) marijuana cultivation sites identified with Google Earth™ (from Bauer cite). *Add Google Earth image(s) of trespass grow site(s).*

Table 1: Estimated numbers of outdoor marijuana cultivation sites, outdoor marijuana plants, marijuana greenhouses, marijuana plants in greenhouses, and total number of marijuana plants in four watersheds in Humboldt and Mendocino Counties (from Bauer cite).

	Redwood Creek (67.3 km²)	Salmon Creek (95.6 km²)	Redwood Creek North (730 km²)	Outlet Creek (419 km²)
Total outdoor cultivation sites	231	306	120	633
Total outdoor plants	10,475	11,697	5,984	16,843
Plant : Land area $\left(\frac{1}{km^2}\right)$	173.7	122.4	8.2	40.2
Total Greenhouses	324	302	273	320
Estimated Total Plants in Greenhouses	8,053	8,851	11,029	9,180
Greenhouse : Land Area $\left(\frac{1}{km^2}\right)$	4.8	3.1	0.4	0.8
Total Plants per Watershed*	**18,528**	**20,548**	**17,013**	**26,023**

**Field data indicate these totals may be underestimates.*

Table 2: Estimated daily water use for marijuana cultivation per day and during an entire growing season compared with minimum streamflow in four watersheds in Humboldt and Mendocino Counties (from Bauer cite).

	Redwood Creek	Salmon Creek	Redwood Creek North	Outlet Creek
Daily Water Use (gpd)	111,167	123,289	102,078	156,138
Minimum Streamflow (gpd)	387,763	581,645	---	---
Percent Use	**28.7%**	**21.2%**	---	---
Water Use per 150 Day Season (gal)	16,675,308	18,493,344	15,311,700	23,420,700

Marijuana growers on both public and private lands often illegally clearcut vegetation in order to create growing space for marijuana plants and room for artificial ponds and other structures (cite, Gabriel et al. 2013; Figure 3). Illegal cutting, along with creation of roads to access grow sites, can increase sedimentation in streams and creeks and thereby degrade habitat quality for aquatic and amphibious animals (cite). The effect of illegal vegetation clearing on NSOs is unknown. Given the close association of both marijuana cultivation and NSOs with riparian areas and surrounding uplands, it is plausible that widespread marijuana cultivation results in habitat loss or fragmentation for NSOs.

Figure 3: Area cleared for outdoor marijuana cultivation (from cite). *Find and add photo from trespass grow site adjacent to creek.*

Widespread outdoor marijuana cultivation can further damage watershed health by polluting water and soils. In addition to pesticides, tremendous quantities of fertilizer are often applied at marijuana grow sites (~~cite~~HSVTC 2012, Thompson et al. 2014). Fertilizers, along with low flows caused by drought conditions and water diversion, can contribute to algae blooms and reduced oxygen levels in creeks and rivers (cite). Other pollution, including human waste, trash, and spilled diesel fuel from generators, is also frequently observed in and around streams at raided outdoor marijuana grow sites (~~cite~~HSVTC 2012, C. Thompson pers com). Like water diversion and increased stream sedimentation, pollution from outdoor marijuana cultivation is primarily a source of concern for aquatic and amphibious animals but could have indirect ecological effects on NSOs and other wildlife.

Multiple recent wildfires in California have been attributed to marijuana growers. For example, in 2014, a marijuana grower was indicted on charges of starting the Nicolls Fire that burned nearly 1,700 acres in the Sequoia National Forest (SacBee 2014b). This grower allegedly set

multiple fires in an attempt to avoid capture by other growers that he claimed were trying to kill him. Another marijuana grower was recently arrested for igniting the 2014 Bully Fire that burned nearly 13,000 acres in Shasta County (SacBee 2014a). This fire was apparently started when the grower's rental truck ignited dry grass when driven off-road in order to deliver soil amendments to a grow site. In 2009, a marijuana grower's camp stove ignited the 90,000-acre La Brea Fire in the Los Padres National Forest in southern California (inciweb). Large wildfires (e.g., thousands of acres) can burn through multiple NSO territories and can negatively affect NSOs in a variety of ways, particularly when they burn large areas at moderate to high severity (reviewed in *Threats: Wildfires*).

Illegal marijuana growers are often heavily armed in order to protect their crops and for poaching wildlife for food or to prevent damage to plants, equipment, or food caches (Boehm cite, Gabriel et al. 2013; Figure 4). Many biologists and other field personnel working in California's forests have been interrogated, pursued, or shot at by marijuana growers (cite, Gabriel et al. 2013, D. Hansen pers. obs.). Safety concerns associated with widespread illegal marijuana cultivation can substantially curtail the ability of researchers and land managers to effectively locate, study, and manage spotted owls and other wildlife. For example, Six Rivers National Forest biologists were repeatedly excluded from entire pre-project NSO survey units in 2013 due to evidence of trespass outdoor marijuana cultivation (D. Hansen pers. obs.). Similarly, Keane et al. (2011) stated that their California spotted owl (*S. o. occidentalis*) survey crew was excluded from large portions of a study area in the Sierra Nevada in 2010 due to extensive illegal marijuana cultivation operations. Gabriel et al. (2013; Gabriel cite) estimated that safety concerns due to trespass outdoor marijuana cultivation resulted in exclusion of researchers from 15-25% of one

fisher study area in California and a projected additional cost of $500,000-750,000 for the life of the combined budgets of two of California's fisher research projects. Wildlife surveyors who were able to work alone in the past must now frequently work in pairs for safety reasons, reducing survey efficiency and increasing project costs (Gabriel et al. 2013, D. Hansen pers. obs.). Exclusion from study areas can also compromise the ability of researchers to properly design and complete research investigating important conservation issues, such as effects of pesticides on fishers (Gabriel et al. 2013) and wildfires on spotted owls (Keane et al. 2011).

Figure 4: Armed marijuana growers posing in front of a poached deer (from Gabriel et al. 2013).

Magnitude and Location of Threat

Estimates of marijuana production and value are generally based on either federal marijuana seizure data (e.g., assuming that seizures represent 10% of the total amount produced) or marijuana consumption surveys and estimates of plant yields and market value (Gettman 2006) (reviewed in PBS 2014). Estimates from both of these methods indicate that California is, by

far, the primary marijuana-producing state in the U.S. and that most of this production is from outdoor cultivation (cite, NDIC 2011, Gettman 2006). Gettman (2006) estimated that, in 2006 alone, California produced an estimated 8.6 million pounds of marijuana with a value of more than 13.8 billion dollars. An estimated 89% of this product and value was from outdoor cultivation. If correct, marijuana is the largest cash crop in California (Gettman 2006), which is remarkable given that California is the most productive agricultural state in the U.S. (USDA 2014).

Outdoor marijuana cultivation in California has increased dramatically in recent years, including on both public and private lands (cite, Bauer cite, NDIC 2011). This rapid growth was due to increased demand for domestically grown marijuana; possibly driven by state legalization of marijuana for medical use, changes in public perception of health or legal risk associated marijuana use, or reduced imports from other countries due to tighter border control measures implemented after 9/11 (cite, NDIC 2007, 2011, SacBee 2012). However, rapid growth of marijuana production in California apparently outstripped consumer demand in the last few years, particularly following federal crackdowns on medical marijuana dispensaries in the state (SacBee 2012). Desire among growers to maintain high profits in the face of increasing supply and decreasing prices could be a factor driving recent increases in the size and intensity (e.g., use of pesticides, fertilizer, and water) of many outdoor marijuana cultivation operations (cite, Bauer cite).

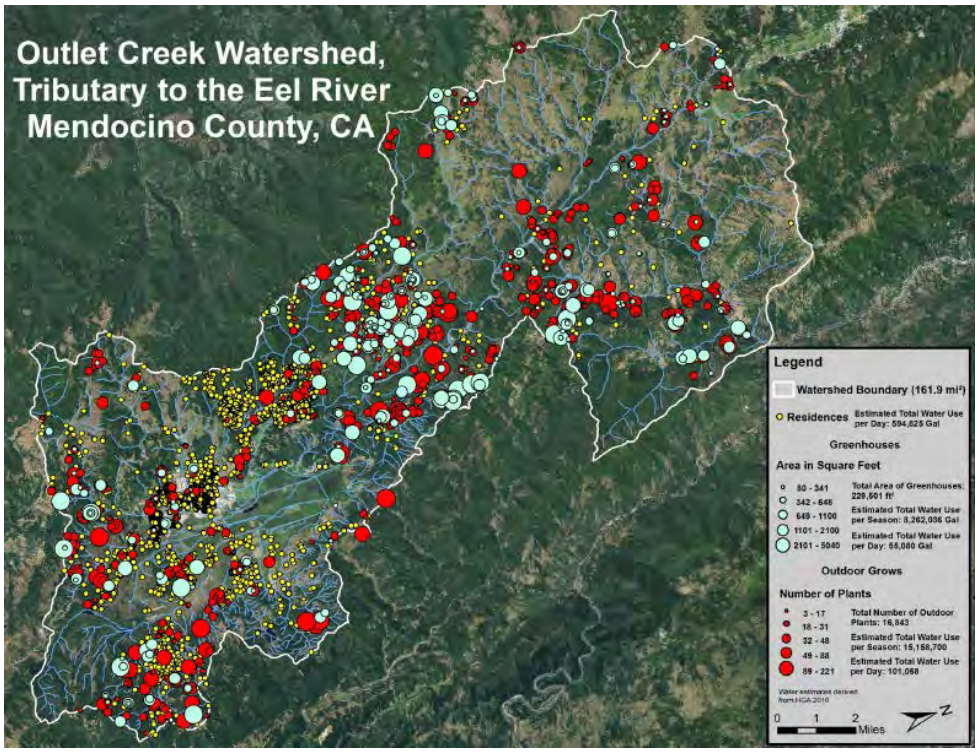
The number of outdoor marijuana plants eradicated in the U.S. increased by 250% between 2005 and 2010 (NDIC 2011). Federal eradication data suggest that trespass outdoor marijuana

cultivation is increasing particularly rapidly on National Forests in California (NDIC 2011). Between 2005 and 2013, over 16 million marijuana plants were eradicated at approximately 3,356 sites on National Forests in California (Boehm 2014). Federal agencies have largely attributed increased numbers of trespass outdoor marijuana cultivation sites to expansion of operations by international drug trafficking organizations (e.g., Mexican drug cartels) into remote mountainous areas (particularly in northern California) in order to avoid detection by law enforcement (NDIC 2007, Boehm cite). However, the degree to which increases in amounts of eradicated or seized marijuana reflect increased production versus increased drug enforcement effort is unclear, as is the scale of international drug trafficking organizations' role in outdoor marijuana cultivation in California (cite, NDIC 2010).

Outdoor marijuana production in California is also growing rapidly on private lands (NDIC 2007, Bauer cite). Personnel with the California Department of Fish and Wildlife (Bauer cite) used aerial imagery in Google Earth™ to estimate changes in the number and sizes of marijuana cultivation operations in four watersheds in Humboldt and Mendocino Counties during 2009-2012. In 2012 they identified nearly 1,300 outdoor grow sites and more than 1,200 greenhouses likely used for marijuana cultivation in these watersheds (Table 1; e.g., Figure 5). The number and size of marijuana cultivation operations identified increased in all four watersheds by 68-104% between 2009 and 2012. The total number of greenhouses and the number of greenhouses greater than 1,000 ft^2 increased by 69% and 87%, respectively. Continued use of aerial imagery and flyovers will shed greater light on the number, size, and location of outdoor marijuana operations on both public and private lands. For example, the California Department of Fish and Wildlife (2012) noted that law enforcement officers spotted more than 200 new marijuana grow

operations in the Mattole Watershed in Humboldt County during a single flyover. *Describe proportion of marijuana cultivation sites identified by Bauer which were located on properties owned by private citizens vs. trespass grows on federal and/or timber co. lands. Incorporate other law enforcement information (e.g., FOIA information from USFS law enforcement).*

Figure 5: Locations and sizes of marijuana cultivation operations identified in the Outlet Creek Watershed in Mendocino County using aerial imagery in Google Earth™ (from Bauer cite).



Summary and Management Implications

There is currently little direct information regarding potential impacts of illegal outdoor marijuana cultivation on NSOs. However, widespread application of ARs and other toxicants at

outdoor grow sites are negatively impacting fishers, which have overlapping home ranges and diets with NSOs in northwestern California (Gabriel et al. 2012, 2013, Thompson et al. 2014). There is also evidence of widespread exposure to toxicants among barred owls in Humboldt County, and an NSO from Mendocino County recently tested positive for ARs (Gabriel cite, Calforests 2014). Thus, it is likely that NSOs in California are widely exposed to toxicants applied at illegal outdoor marijuana grow sites. ARs and other pesticides can directly kill owls and other raptors or increase their vulnerability to other sources of mortality such as predation, disease, parasites, hypothermia, or injury (reviewed above). Furthermore, illegal outdoor marijuana cultivation is apparently causing widespread environmental degradation through toxicant exposure in other animals, reduced streamflows, pollution, poorly planned logging and road construction, and wildlife poaching (cite, Bauer cite, Gabriel et al. 2013). Safety concerns associated with the widespread presence of heavily armed marijuana growers may also be impacting conservation of spotted owls and other wildlife by reducing the efficiency and effectiveness of research and survey efforts (Keane et al. 2011, Gabriel et al. 2013, D. Hansen pers. obs.).

Increased funding and effort are needed for evaluation of effects of outdoor marijuana cultivation on NSOs, other wildlife, and ecosystems (cite). Greater funding and coordination are also needed for interdiction, clean-up, and restoration at illegal outdoor grow sites (cite). These efforts require a substantial, multi-agency law enforcement presence, experts capable of identifying and properly disposing of toxicants, personnel and equipment for removing large amounts of trash and other material, and natural resource specialists for rehabilitating or restoring sites (Gabriel et al. 2013, Boehm 2014). Even if marijuana is legalized in California,

tremendous resources, effort, and coordination may still be needed to regulate the industry and to continue to locate, clean up, and restore abandoned or interdicted illegal grow sites. Only a small portion of interdicted outdoor grow sites in California have been cleaned up thus far and even less have been restored (cite). Many of these sites may continue to pose an environmental threat long after they are abandoned by growers (Gabriel et al. 2013). For example, trespass outdoor growers often cache ARs and other toxicants in water-proof containers, which bears can eventually find and open, allowing further poisoning and exposure of wildlife even after growing operations have ceased at the site (cite).

The Environmental Protection Agency (EPA) and California Department of Pesticide Regulation (CDPR) have recently taken important steps to reduce threats from SGARs to wildlife, children, and pets. Since 2011, EPA regulations have prohibited the sale of SGARs to the general consumer. Under EPA regulations, SGARs may only be purchased at agricultural stores, in bait station form rather than as loose pellets, and in relatively small quantities (Bradbury 2008). Most AR manufacturers quickly complied with these regulations and brought replacement products to market containing FGARs or neurotoxins, rather than SGARs (CDPR 2013, Murray 2013). However, the EPA only recently reached an agreement with Reckitt Benckiser to end distribution of their popular d-Con® products containing SGARs and sold without a protective bait station by March 31, 2015 (EPA 2014). On July 1, 2014, the CDPR further limited access to SGAR products in California by classifying them as restricted materials (California Department of Consumer Affairs 2014). In California, products containing SGARs can only be purchased from CDPR-licensed pest control dealers by certified applicators (California Department of Consumer Affairs 2014). Increased restrictions on public access to products containing SGARs

should help to reduce exposure of wildlife to these compounds. However, considering that banned pesticides are commonly found at trespass outdoor marijuana cultivation sites (HSVTC 2012~~cite~~, Thompson et al. 2014), growers will likely continue to apply SGARs in forests occupied by NSOs, fishers, and other sensitive wildlife.

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Ch. 1: Status and Trends in California

Introduction

Several lines of evidence are available for evaluating the northern spotted owl's (*Strix occidentalis caurina*; NSO) status and trends in California. These include changes in the subspecies' geographic range and distribution, density and abundance, occupancy and demographic rates, meta-population dynamics, and genetics. The most reliable information available for examining the NSO's status and trends is provided by long-term demographic studies. Data from these studies are periodically analyzed together in meta-analyses for describing larger demographic patterns within ecoregions and states. A new demographic meta-analysis is expected to be released in mid-2015. This document will provide the best available information for determining the NSO's current status and trends. However, only a small portion of the NSO's range in California occurs within demographic study areas and those study areas all occur in relatively productive forests in the northwestern part of the state. It is therefore important to consider other sources of information, such as data collected for monitoring NSOs in National Parks and on industrial timber company lands located in different regions of northern California. The NSO's status and trends likely vary among regions, forest types, and ownerships and could be influenced by a host of factors, such as differences in forest ecology, management history, and stressors such as competition with invasive barred owls (*Strix varia*). It is also important to remember that available sources of information for evaluating the NSO's status and trends in California vary substantially in terms of their purpose and scientific rigor.

Range

The current range of the NSO includes southwestern British Columbia and the Cascade Mountains, coastal ranges, and intervening forests of Washington, Oregon, and California (USFWS 2011a). In California, the NSO's range extends from the Oregon border through the Northern Coast Ranges to Marin County, across the Klamath Mountains, and down the southern Cascades to the vicinity of the Pit River, where it contacts the range of the California spotted owl (*S. o. occidentalis*) (Figure 1.1).

The precise historical range of the NSO is unknown. Thus, despite substantial loss, degradation, and fragmentation of NSO habitat (see Chapters 2 and 3 of this volume), there is no evidence that the subspecies' range has contracted since Euro-American settlement (Thomas et al. 1990). However, British Columbia's NSO population has declined to very low numbers and is highly vulnerable to extirpation (Chutter et al. 2004). NSO populations in the Cascades and Olympic Peninsula of Washington and the Northern Coast Range of Oregon are also rapidly declining and may become vulnerable to extirpation (Forsman et al. 2011; see *Demography*, below). Loss of NSO populations could cause substantial contraction of the subspecies' range. For example, extirpation of NSOs from British Columbia alone would reduce the subspecies' range by approximately 8% (Cooper 2006).

Comment [LVD1]: Yes, and we also can't rule out that there may have been some localized expansions of the species range. Historically, prairies were much more extensive in coastal CA (see Redwood National Parks prairie management plan). In fact, the coastal prairies that occur primarily on the ridges and south-facing slopes in the redwood region are part of the California coast grassland that was ranked as one of the most endangered ecosystems in America (Noss and Peters 1995 report on endangered ecosystems). Currently, there are NSO living in prairie intrusion forests throughout coastal CA that would not have been forest lands at all 100+ years ago.

Distribution

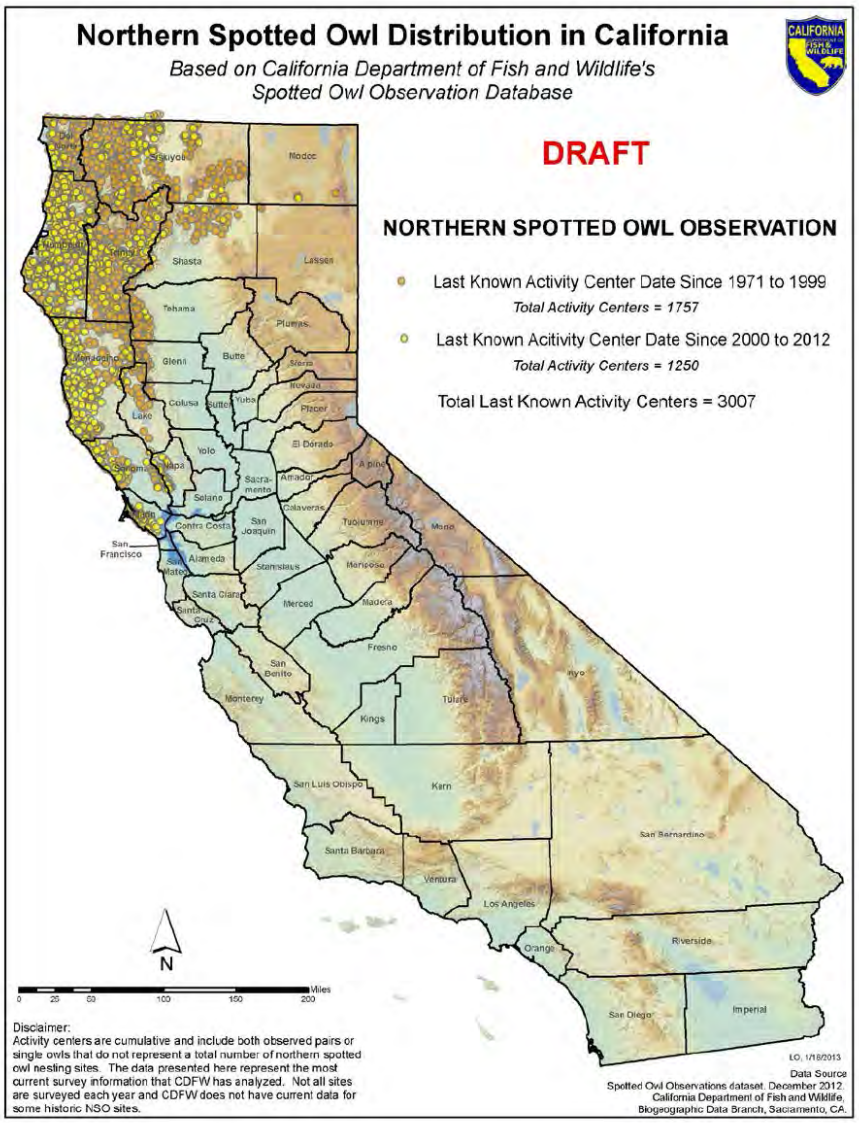
NSOs are thought to have been well distributed throughout most coniferous forests in the Pacific Northwest and northwestern California prior to Euro-American settlement (USFWS 2011a). The abundance and distribution of NSOs have likely declined due to removal of most (ca. 60-88%) old forest within its range (USFWS 1990; see Chapter 2 of this volume). For example, the Puget Trough in Washington and the Willamette Valley in Oregon no longer support NSOs due to land conversion and timber harvesting and very few NSOs remain in British Columbia (Thomas et al. 1990). The NSO's distribution has decreased in other areas of Washington and Oregon as well, due primarily to negative effects of timber harvesting, wildfires, and competition with barred owls (*Strix varia*) (Thomas et al. 1990).

Comment [LVD2]: I think the statement is accurate, but it doesn't seem like a 1990 publication would be the best source to support the conclusion. I would recommend using several publications including the status review (Courtney et al. 2004), Revised NSO recovery plan and possibly Forsman et al. 2011.

It is unknown if the NSO's distribution has changed in California. A difference is evident in the distribution of known historically (1971-1999) and recently (2000-2012) occupied activity centers (ACs) in the Eastern Klamath, Interior Northern Coast Ranges, and Southern Cascades regions of the state (Figure 1.1; see USFWS 2011a Appendix C for ecoregional boundaries generally followed in this synthesis). It is unclear from these data, however, whether the distribution of NSOs has in fact decreased in these areas or if the apparent decline in distribution is due to some other factor such as decreased survey effort or reporting of detections. It is also possible that this difference is due to the greater number of years included in the historical period than in the recent period (29 vs. 13 yrs). However, the two periods are similar in length relative to federal listing of the NSO (10 vs. 13 yrs) when survey effort presumably became more intensive and widespread. Some portions of the Klamath, Interior Northern Coast Ranges, and Southern Cascades have experienced widespread intensive timber harvesting or large wildfires, which could have reduced the NSO's distribution (see Chapters 2 and 3 of this volume). These forms of disturbance, along with competition with invasive barred owls, have likely contributed to declining occupancy by NSOs in some areas of California (see *Occupancy*, below). Nonetheless, the Klamath and Interior Northern Coast Ranges (but not the Southern Cascades) still appear to contain relatively large amounts of well connected suitable habitat and likely function as crucial population sources for NSOs (Schumaker et al. 2014; see *Source-Sink Dynamics*, below).

Comment [LVD3]: In balance, I think it should be mentioned that some level of disturbance in portion of the NSO range in CA contributes to increased habitat heterogeneity that actually improves habitat fitness for NSO (Franklin et al. 2000). This same phenomenon has been demonstrated by Olson et al. 2004, Hoopa and Green Diamond (10-year status review).

Figure 1.1: Distribution of northern spotted owl activity centers in the California Department of Fish and Wildlife's Spotted Owl Observation Database (from California Department of Fish and Wildlife 2013).



Density and Abundance

Species are rarely uniformly distributed across their range. Knowledge of variation in the density and abundance of NSOs is of potential conservation value because it can help identify areas where limited conservation resources should be focused. For example, while declines in low-abundance areas may be more likely to cause contraction of a species' range or distribution (see *Range* and *Distribution*, above), declines in high-abundance areas may disproportionately impact the species' probability of long-term persistence; particularly when high-abundance areas function as population sources (Pulliam 1988, Rodríguez 2002, Schumaker et al. 2014; see *Source-Sink Dynamics*, below).

Several studies have estimated either crude densities (owls or occupied territories per unit area) or ecological densities (owls per unit area of specified habitat class[es]) of NSOs in California (Blakesley et al. 2004; Table 1.1). These estimates are interesting in that they appear to reflect geographic variation in the ecology of NSOs (see below). However, they have limited utility for evaluating the NSO's status or trends in California. Available density estimates for the state are largely restricted to relatively mesic areas of northwestern California, which differ ecologically from drier interior forests (e.g., in terms of climate, forest productivity, and prey communities). Inferences from most density estimates are also limited because they are based on empirical counts of unmarked NSOs, which can bias estimates (Franklin et al. 1990, Diller and Thome 1999). Many of the currently available density and occupancy estimates for NSOs in California were provided by timber companies (Tables 1.1 and 1.2). While potentially useful for evaluating effects of management activities on timber company lands, these estimates do not describe population trends. Rigorous evaluation of NSO population trends require~~s~~ ~~adequate~~ long term statistically valid sampling designs ~~effort~~ from which with estimates of abundance or population lambda with confidence intervals can be repeatedly obtained within the same study area ~~year after year~~. In contrast, timber companies generally shift their NSO survey areas over time as timber harvest projects are completed in some areas and begun in others.

Based on limited information, both crude and ecological densities of NSOs appear to be substantially higher in northwestern California than in the Oregon Coast Ranges (Blakesley et al. 2004; Table 1.1). Lower densities in the Oregon Coast Ranges could be partially related to widespread intensive timber harvesting, which apparently contributed to a major decline in densities during the early 1990s (Thrailkill et al. 1998). Some areas of northwestern California have also experienced widespread intensive timber harvesting (see Chapter 2 of this volume) but its effect on NSOs might have differed from that in the Oregon Coast Ranges. In general, NSOs in California primarily subsist on dusky-footed woodrats (*Neotoma fuscipes*) (in terms of biomass contribution to diets). NSOs that primarily subsist on dusky-footed woodrat often have smaller home ranges, and apparently occur at higher densities, than those that primarily rely on smaller-bodied prey (Carey et al. 1992, Zabel et al. 1995). Furthermore, in contrast with other primary prey species, such as northern flying squirrels (*Glaucomys sabrinus*) and tree voles (*Arborimus* spp.), dusky-footed woodrats seem to respond positively, albeit temporarily, to some forms of intensive timber harvesting (see Chapter 2 of this volume).

Comment [LVD4]: Again this is where the issue of habitat heterogeneity (Franklin et al. 2000) should be mentioned in terms of the differential NSO response in NW CA versus areas where NSO feed primarily on flying squirrels. The mixture of older stands for roosting and nesting and young stands for woodrats provides the best habitat. As you noted, this woodrat response is only temporary, which makes the best NSO habitat highly dynamic in this region.

Densities of NSOs are also thought to be higher in northwestern California than in the state's interior (Calforests 2014). However, there are apparently only two density estimates currently

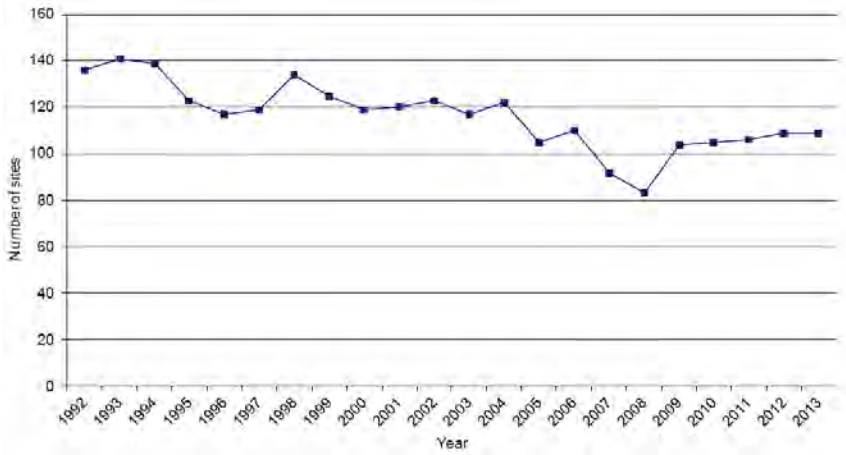
available for interior northern California and both of these were for crude densities of occupied territories, rather than for individual owls as estimated by most studies in northwestern California (Table 1.1). These crude territory densities are substantially lower than those found on two timber companies' lands in the Redwood Region (Table 1.1). NSO densities may be relatively low in the Southern Cascades of California due to the prevalence of drier, less productive forests, a history of widespread intensive harvesting, and effects of recent large wildfires (see Chapters 2 and 3 of this volume). Additional density estimates are needed for the Eastern Klamath of California. It is uncertain whether Sierra Pacific Industries' (2013) estimates are representative of densities across the region as a whole. Most NSO activity centers (ACs) included in Sierra Pacific's density estimates were located near the margins of the company's lands or on adjacent ownerships, rather than within the interiors of the company's holdings (see Maps 2-5 in Sierra Pacific Industries 2013, which are copyrighted and cannot be reproduced without permission). This pattern suggests that densities could be higher on neighboring lands such as the Shasta-Trinity National Forest.

Comment [LVD5]: This may also be a case where the adjacent FS lands provide the roosting and nesting habitat while SPI is producing the woodrats.

The California Forestry Association cited annual density estimates in timber company monitoring reports as evidence of stable or increasing NSO populations on private timberlands in the state (Calforests 2014). Reported crude densities on Humboldt Redwood Company, Mendocino Redwood Company, and The Conservation Fund lands in the Redwood Region were indeed relatively similar among years (Calforests 2014). However, it is unclear how changing survey methods and survey areas, as well as changing detectability of NSOs, influenced these companies' estimates over time (see Franklin et al. 1990). For example, recent adoption of survey protocols requiring more survey passes and use of electronic callers likely increased detection rates, and thus density estimates, on some of these lands. Estimates of crude densities of NSOs and numbers of ACs on Green Diamond Resource Company lands in the Redwood Region suggest that NSO densities have declined on that ownership (Figure 1.2; Table 1.1). The number of NSO ACs on Green Diamond lands briefly increased in 1998, apparently due to the company's acquisition of 70,000 acres of timberland that year (Green Diamond Resource Company 2014). Following a substantial decline during 2004-2008, the number of ACs began to gradually increase in 2009 (Figure 1.2). This increase appears to have been due to the company's adoption of a more rigorous survey protocol and implementation of a barred owl removal experiment during that same year (Green Diamond Resource Company 2014; see Chapter 4 of this volume). Sierra Pacific Industries' (2013) density trends for its ownerships in the Eastern Klamath are difficult to evaluate and are therefore not included here. Sierra Pacific Industries' (2013) estimates are empirical, potentially influenced by changing survey effort and areas, mostly descriptive of ACs at the margin of or outside the company's ownership, and were compared among blocks of years, rather than annually.

Comment [LVD6]: It would be useful to know which estimates are empirical counts with no statistical estimates of variance (i.e., no confidence intervals and therefore no way to assess the probability that the estimate represents the true value of the parameter).

Figure 1.2: Number of NSO activity centers ("sites") on Green Diamond Resource Co. lands during 1992-2013 (from Green Diamond Resource Co. 2014).



Rigorous ecological density estimates can be used to estimate population sizes for ecologically similar areas (Franklin et al. 1990). However, there are currently insufficient data for producing such an estimate for California or any of its regions. The California Forestry Association estimated that as many as 6,000 NSO territories currently exist in the state (Calforests 2014). This figure was based on an estimated statewide crude density of 0.28 territories per mile². This density estimate was, in turn, based on the cumulative number of known NSO ACs in California (see *Distribution*, above) and the proportion of "potential" habitat in the state that has been surveyed. The number of ACs known to have been recently occupied is substantially lower than the cumulative number that have been identified since the early 1970s (USFWS 2011a; see *Distribution*, above). This could be due to multiple factors, including declining occupancy rates (see *Occupancy*, below) and NSOs' use of different ACs over time. Thus, the timber industry's estimate provides little or no insight into the current number of NSOs or occupied ACs in the state. Furthermore, while reasonable projections of suitable habitat exist for NSOs in California (Davis and Dugger 2011, USFWS 2011a, Schumaker et al. 2014), the California Forestry Association did not cite these data and it is unclear how it estimated the total and surveyed areas of suitable habitat in the state.

Table 1.1: Density estimates for NSOs in California and Oregon.

Study	Region	Owner	Method	Crude Density (owls/ mi²)*	Crude Density (occupied territories/ mi²)*	Ecological Density (owls/ mi²)**†
Diller and Thome 1999	N Redwood	Green Diamond	Mark-Recapture	0.54 (0.24-0.91)		0.97-2.72
Green Diamond Resource Co. 2014	N Redwood	Green Diamond	Empirical (marked)	0.34 (0.12-0.53)		
Tanner and Gutierrez 1995 cited in Diller and Thome 1999	N Redwood	Redwood National Park	Empirical	0.57		
Humboldt Redwood Co. 2013	N Redwood	Humboldt Redwood	Empirical	0.53-1.01	0.36-0.50	
Mendocino Redwood Co. 2014	N Redwood	Mendocino Redwood	Empirical	0.47-.077		
The Conservation Fund unpubl. data in Calforests 2014	N Redwood	The Conservation Fund	Empirical		0.29-.036	
Chow 2001	S Redwood	Public (Various)	Empirical	0.97		2.09
Franklin et al. 1990	W Klamath	Six Rivers National Forest, Other	Mark-Recapture	0.61		1.41-1.71
Sierra Pacific Industries 2013	E Klamath	Sierra Pacific Industries	Empirical		0.17-0.18	
Woodbridge and Cheyne 1995	So Cascades	Klamath National Forest	Empirical		0.05-0.20	
Thrailkill et al. 1998	OR Coast Ranges	Bureau of Land Management	Empirical	0.07-0.25		0.57-0.90
Anthony et al. 2000 cited in Blakesley et al. 2004	OR Coast Ranges	Oregon Dept. of Forestry	Empirical	0.13-0.27		

*Ranges = low-high survey areas (Woodbridge and Cheyn 1995, Thraillkill et al. 1998, Diller and Thome 1999, Anthony et al. 2000, Green Diamond Resource Co. 2014), low-high survey years (Humboldt Redwood Co. 2013, Mendocino Redwood Co. 2014). **Habitat definitions used to calculate ecological densities: Franklin et al. 1990: all conifer cover classes weighted by NSO use (based on telemetry), but mostly ≥20.6 in DBH; Diller and Thome 1999: all forest classes weighted by NSO use (based on nest locations) but mostly >40 yrs; Chow 2001: all forested area; Thrailkill et al. 1998: old, mature, old over young, mature over young. †Ranges of ecological densities: Franklin et al. 1990: with two different habitat definitions; Diller and Thome 1999: low-high survey areas.

Occupancy

NSO population trends are most directly evaluated with demographic data (see *Demography*, below). However, occupancy data are often more logistically and economically feasible to collect than demographic data and, with proper accounting of detection probability, can provide a useful index of spotted owl population rates (MacKenzie 2005, Olson et al. 2005, Mackenzie et al. 2012, Tempel 2014). Occupancy data that inadequately incorporate detection probabilities for spotted owls must be interpreted carefully since they can be strongly influenced by survey effort, habitat attributes, social and reproductive status of NSOs, presence of barred owls, and other factors (Mackenzie 2005, Olson et al. 2005). Recent research in NSO demographic study

areas suggests that competition with barred owls is driving NSOs to move large distances (several miles) between different territories within the same season (Davis et al. 2013, Higley and Mendia 2013). Higley and Mendia (2013) warned that occupancy estimates for unmarked populations may therefore be inflated (i.e., the same individual could appear to occupy multiple territories within the same season) and suggested using the presence of pairs, rather than individuals, to determine occupancy.

There is limited information available for describing occupancy trends for NSOs in California. Much of the available information is from annual monitoring reports provided by industrial timber companies (Table 1.2). These data show trends in annual proportions of known, surveyed, or previous year's ACs found to be occupied (see Table 1.2 footnote). It is important to acknowledge that much of the data presented in Table 1.2 provide only crude indices of occupancy in California and that most of them cannot be compared among ownerships due to differences in monitoring and analytical methods. Future efforts to evaluate the status of NSOs in California would benefit from greater consistency in occupancy monitoring and from reporting of modeled occupancy rates, which account for detectability of NSOs and other factors that can obscure occupancy trends (e.g., Figure 1.5).

Recent occupancy estimates are unavailable for the Redwood National and State Parks in the northern portion of the Redwood Region. The National Park Service has discontinued surveying most historical territories in these parks due to apparent widespread displacement of NSOs by barred owls (Schmidt 2013; see Chapter 4 of this volume). In contrast with an apparently strong decline in occupancy in the Redwood National and State Parks, NSO occupancy rates on National Park Service lands in the southern portion of the Redwood Region have fluctuated annually but suggest a stable trend over time (Ellis et al. 2013; Table 1.2; Figure 1.3). Perhaps due to the area's geographic isolation, barred owls are still relatively uncommon the southern Redwood Region (Ellis et al. 2013; see Chapter 4 of this volume). Occupancy by NSOs appears to be gradually declining on industrial timberlands in the northern Redwood Region (Table 1.2; Figures 1.2, 1.4, 1.5, and 1.7). Given the substantial and increasing presence of barred owls in NSO territories on these lands (see Chapter 4 of this volume), it is surprising that more dramatic declines in NSO occupancy are not evident (e.g., see Table 1.2 for occupancy rates in Washington and Oregon). It is possible that NSOs respond differently to barred owls on these lands than elsewhere within their range. It is also possible that a more rapid decline is currently occurring than is indicated by the crude data presented in these companies' reports. Yet another possibility is that a more rapid decline will occur on these lands after a post-colonization lag period has elapsed or a critical threshold level of barred owl presence is reached (USFWS 2013).

NSO occupancy in the Northwestern California demographic study in the Western Klamath Region has declined dramatically in recent years (Franklin et al. 2013, 2014; Table 1.2). This decline has coincided with increasing barred owl presence in the study area, suggesting that NSOs are being displaced by barred owls (see Chapter 4 of this volume). The recently increased rate of declining occupancy by NSOs in this study area appears to support the hypothesis that barred owls can have lag or threshold effects on NSO populations. Recent declines in occupancy in the Northwestern California study area may also be related to effects of multiple consecutive years of poor weather conditions on demographic rates (see *Demography*, below). Recent annual reports from the Hoopa demographic study did not include analyses of occupancy data for

NSOs (Higley and Mendia 2012, 2013). However, unmodeled occupancy rates in 2012 and 2013 were low (0.40 and 0.35, respectively). Low occupancy rates on the Hoopa Reservation may be related to substantial declines in numbers of NSOs, likely due to decreasing demographic rates (see *Demography*, below) and increasing numbers of NSO territories with barred owl detections (see Chapter 4 of this volume). Greater declines in numbers of NSOs and increases NSO territories with barred owl detections beginning in 2005 provide additional support for the hypothesis that barred owls have lag or threshold effects on NSOs.

There is currently no clear pattern in occupancy data available for the Eastern Klamath and Southern Cascades of California. Timber companies in those regions have reported evidence of stable occupancy rates (Sierra Pacific Industries 2013, Michigan-California Timber Company 2014; Figure 1.6; note: Sierra Pacific's estimates are not provided in Table 1.2 for reasons discussed in *Density and Abundance*, above). However, more rigorous, published research conducted primarily on industrial timberlands in the Eastern Klamath and Southern Cascades found substantial declines in both simple (total) and pair occupancy (Farber and Kroll 2012; Figure 1.7). The barred owl invasion appears to still be in the early colonization phase in the Eastern Klamath, where this study was primarily conducted (Farber and Kroll 2012; see Chapter 4 of this volume). Thus, declining occupancy during the study was likely caused by some other factor, such as timber harvesting on the industrial timberlands that comprised much of the study area or wildfires on neighboring public lands (see Chapters 2 and 3 of this volume). Research in other areas of the NSO's range indicates that occupancy is negatively affected by habitat loss and fragmentation (Dugger et al. 2011, Sovern et al. 2014).

Table 1.2: Estimates and indices of occupancy by northern spotted owls in California, Oregon, and Washington.

Study	Region	Owner	Years	Number of Sites	Proportion Occupied (Total)	Proportion Occupied (Pairs)	Modeled Occupancy (Total)	Modeled Occupancy (Pairs)	Apparent Trend
Mendocino Redwood Company 2013	N Redwood	Private	2001-2013 (proportion); 2001-2008 (modeled)		0.75 - 0.69*		0.88 - 0.78*†		Declining (weak)
Humboldt Redwood Company 2014	N Redwood	Private	2003-2013		0.81 - 0.63*†				Declining (weak)
Green Diamond Resource Company 2014	N Redwood	Private	1999-2013 (no. sites); 2009-2013 (occupancy)	135 - 108*†	0.88 - 0.83*‡				Declining (weak)
Ellis et al. 2013	S Redwood	NPS	1999-2012		0.86 - 0.94*	0.72 - 0.87*			Stable
Franklin et al. 2002, 2003, 2010-2014	W Klamath	USFS, BLM, Private	2001-2013		0.67 - 0.37*	0.59 - 0.28*			Declining (strong)
Farber and Kroll 2012	E Klamath, S Cascades	Private, USFS	1995-2009				0.81 - 0.50*	0.75 - 0.46*	Declining (strong)
Michigan-California Timber Company 2014	E Klamath, S Cascades	Private	2000-2013		0.35 - 0.52 (2001-2013: 0.66 - 0.52)*†				Stable
Davis et al. 2013a	OR Klamath	BLM, State, Private	2001-2013		0.86 - 0.49*	0.62 - 0.30*			Declining (strong)
Dugger et al. 2011	OR S Cascades	USFS	1991/1992-2006				w/o barred owls: 0.86 - 0.71*†; w/ barred owls: 0.87 - 0.11*†		Declining (strong)
Kroll et al. 2010	WA E Cascades	NPS, USFS, Private	1990/1-2003				w/o barred owls: 0.83 - 0.64*†; w/ barred owls: 0.73 - 0.30*†	w/o barred owls: 074 - 0.36*†	Declining (strong)

*Start and end values. †Estimated from graph. ‡Occupancy of previous year's sites.

Figure 1.3: Occupancy status at monitored northern spotted activity centers on National Park Service lands in Marin County, California during 1999-2012 (from Ellis et al. 2013).

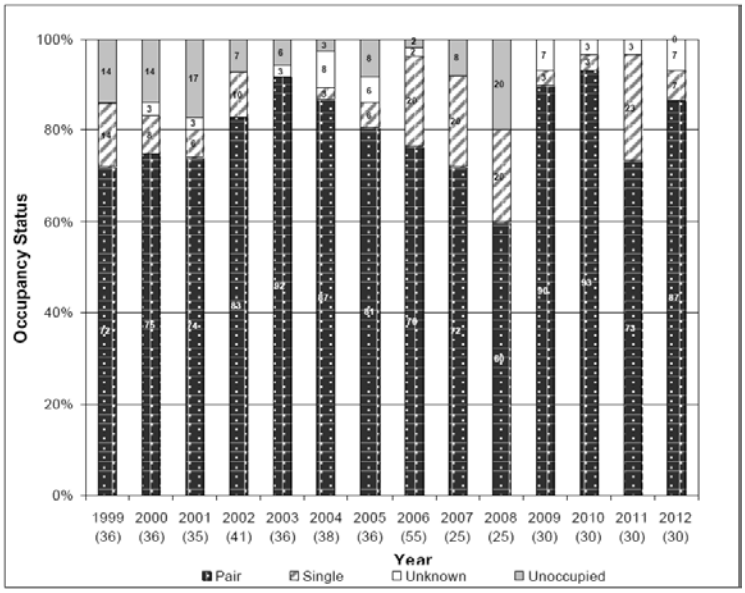


Figure 1.4: Annual numbers of known and occupied northern spotted owl activity sites (activity centers) on Humboldt Redwood Company lands during 2003-2013 (from Humboldt Redwood Company 2014).

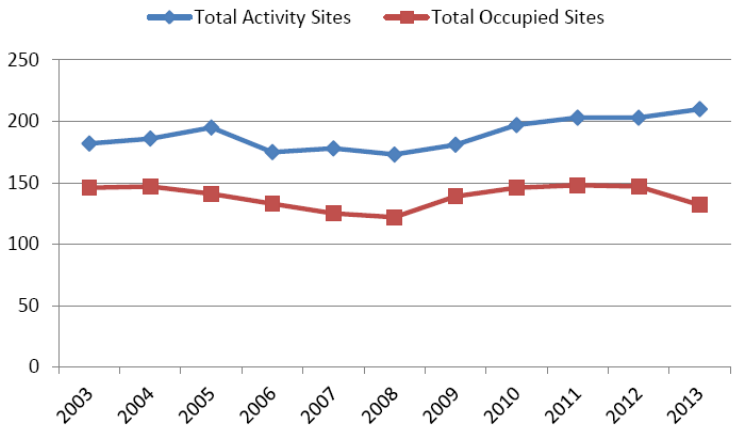


Figure 1.5: Annual proportion of northern spotted owl activity centers occupied (blue line) and modeled occupancy probability (red line) on Mendocino Redwood Company lands (from Mendocino Redwood Company 2013).

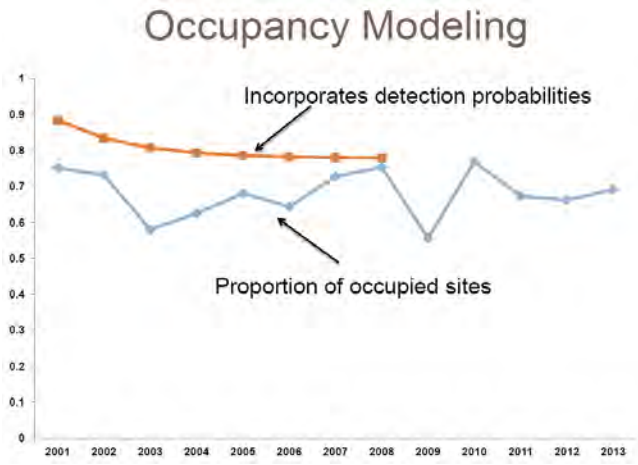


Figure 1.6: Percent of surveyed northern spotted owl sites occupied on Michigan-California Timber Company lands during 2000-2013 (from Michigan-California Timber Company 2014).

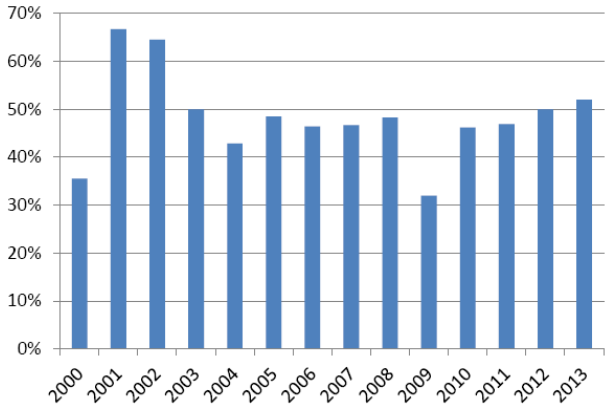
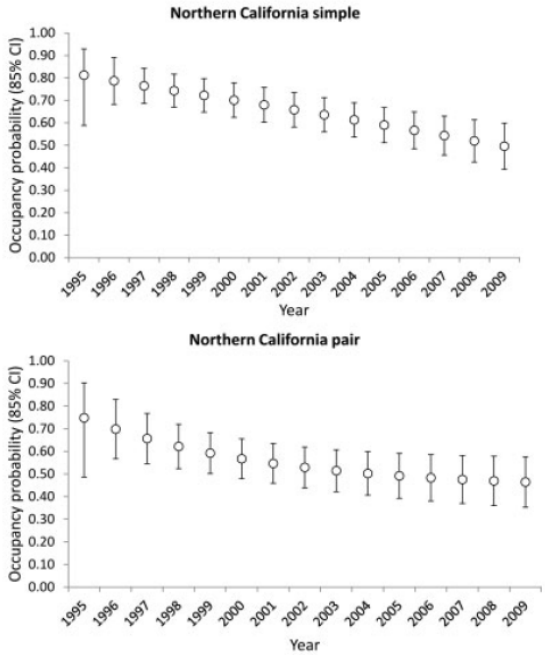


Figure 1.7: Estimated annual simple (total) and pair occupancy probabilities (with 85% confidence intervals) for northern spotted owls in the Eastern Klamath Region of California during 1995-2009 (from Farber and Kroll 2012).



Demography

Reproduction

Reproductive data are commonly collected as part of monitoring efforts for NSOs (e.g., Calforests 2014). They are easier and more cost-effective to obtain than those required for estimating survival or population trends. NSOs exhibit considerable annual fluctuations in reproduction (Forsman et al. 2011, Calforests 2014). Given often large annual fluctuations in reproduction, evaluation of trends in reproduction could require longer-term datasets than are available for many monitoring areas.

The 2011 demographic meta-analysis reported that fecundity of NSOs (number of female fledglings per female) significantly declined during 1985-2008 in four of 11 density study areas, may have declined in three other areas, and was stable in four areas (Forsman et al. 2011). Two of the four study areas with significant declines in fecundity were located in California (Northwestern California in the Western Klamath Region and Green Diamond in the Redwood Region). Two others were located in portions of southwestern Oregon (Klamath and South Cascades) that are nearby and ecologically similar to the Eastern Klamath and Southern Cascades of California (see USFWS 2011a and 2012a for regions). Also, the one area in

California with stable fecundity (Hoopa) had low fecundity estimates compared to other areas. Together these data, which represent the most reliable evidence currently available, indicate that NSO reproduction could be declining across much of California and southwestern Oregon.

Annual fluctuations in fecundity were evident in all three demographic studies in California and were remarkably synchronous (Forsman et al. 2011; Figure 1.8). Forsman et al. (2011) found that variation in fecundity was associated with a variety of variables, including the age of breeding females, whether the year was even or odd, weather or climate (e.g., early nesting season temperature or precipitation), percent cover of suitable habitat, and the presence of barred owls. Franklin et al. (2013) noted a pattern of "good" and "bad" reproductive years in the Northwestern California demographic study area, which is likely associated with annual variation in weather during the early nesting season (also see Franklin et al. 2000). Franklin et al. (2013) also observed that particularly poor reproductive years have occurred in their study area at four-year intervals, suggesting that "some other extrinsic factor may be operating, such as seed production governing small mammal populations." Forsman et al. (2011) reported that barred owl presence was in the top models explaining fecundity in the Green Diamond study area, suggesting that competition with barred owls contributed to declining reproduction on that ownership. Reports from the Klamath and South Cascades demographic studies in southern Oregon noted negative associations between reproduction and rainfall during the early nesting season (Davis et al. 2013b, Dugger et al. 2014). Declining reproduction in these study areas also appears to be related to increasing presence of barred owls.

Following publication of the 2011 meta-analysis, California's demographic studies reported three consecutive years (2011-2013) of very low reproduction (Franklin et al. 2013, Higley and Mendia 2013, Green Diamond Resource Company 2014). This dip in reproduction might have been partially driven by high rainfall during the early nesting season during 2010-2012 (see below). Those three consecutive years of low reproduction exacerbated the negative long-term trend that was already occurring on Green Diamond lands (Green Diamond Resource Company 2014; Figure 1.9). Negative trends in reproduction also occurred in the Klamath and South Cascades demographic study areas subsequent to the end of the 2011 meta-analysis study period (Davis et al. 2013b, Dugger et al. 2014; Figures 1.10 and 1.11). Davis et al. (2013b) concluded that particularly poor reproduction during recent years "…may indicate potentially serious problems with maintaining a stable population. This is even more alarming since these results are following a long term downward trend."

Figure 1.8: Mean annual fecundity in California's three northern spotted owl demographic studies during 1985-2008 (from Forsman et al. 2011).

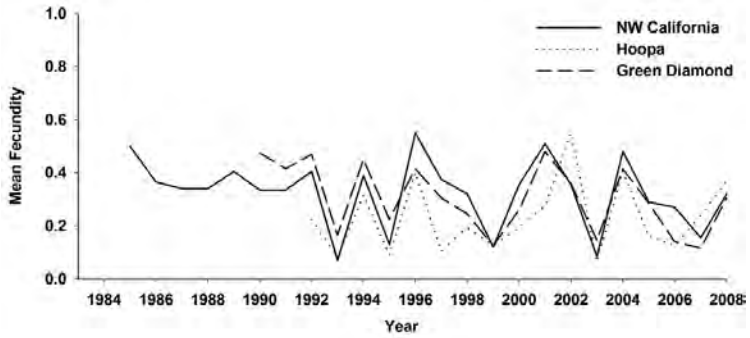


Figure 1.9: Number of fledglings produced per monitored pair of northern spotted owls on Green Diamond Resource Company lands during 1992-2013 (from Green Diamond Resource Company 2014).

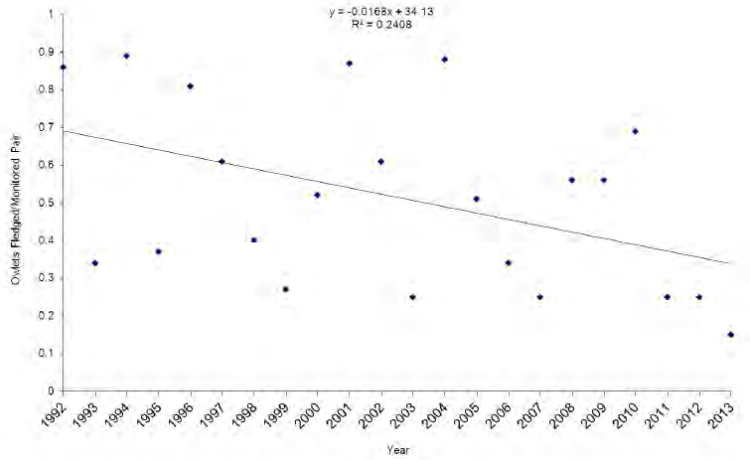


Figure 1.10: Fecundity of northern spotted owls ("STOC") in the Klamath demographic study area during 1990-2013 (from Davis et al. 2013a). Dashed line is a polynomial trend line (r^2 = 0.419). Vertical line represents the first year in which barred owls ("STVA") were detected in more than 10% of spotted owl territories.

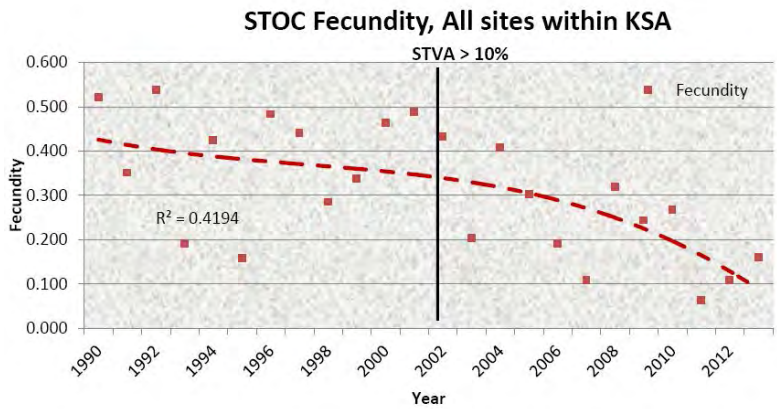
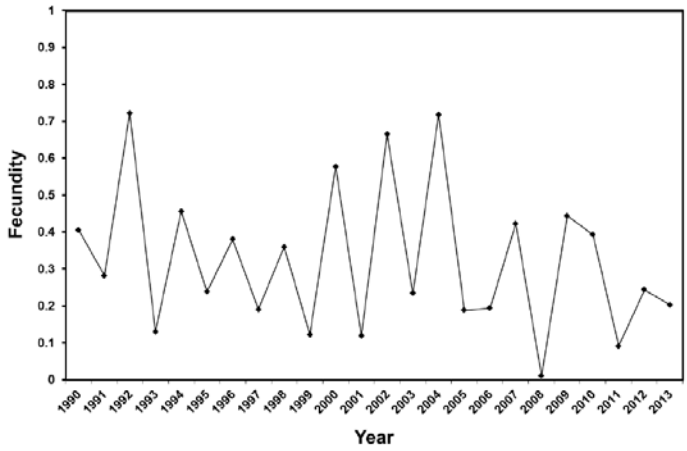


Figure 1.11: Fecundity of northern spotted owls in the South Cascades demographic study area during 1990-2013 (from Dugger et al. 2014).



Information is also available for describing recent trends in NSO reproduction in portions of California outside of demographic study areas. Ellis et al. (2013) found below average fecundity during 2007 and 2010-2012 on National Park Service lands in the southern Redwood Region (Figure 1.12). Humboldt Redwood Company (2013) and Mendocino Redwood Company (2014) likewise reported low reproduction during those years (Figures 1.13 and 1.14). These observations, along with those from demographic studies in California and southern Oregon described above, suggest that low reproduction during recent years was primarily driven by a

factor that acted at a very large spatial scale, rather than at the scale of individual ownerships or ecological regions. As noted above, high rainfall during the early nesting season was likely a primary cause of low reproduction during recent years. This apparent relationship is illustrated by the negative association between NSO reproductive success and early season rainfall observed on Mendocino Redwood Company lands (Figure 1.13).

Monitoring results suggest a stable long-term trend in reproduction on National Park Service lands in the southern Redwood Region (Figure 1.12). In the northern Redwood Region, Humboldt Redwood Company (2013) data likewise suggest little or no trend, although the period covered could be too short to capture long-term trends in reproduction (Figure 1.14). Mendocino Redwood Company (2014) provided a longer-term data set that suggests that a shallow decline in reproduction has occurred on their lands, primarily due to below average reproduction during seven of eight years during 2006-2013 (Figure 1.13). Data provided by the Fruit Grower's Supply Company (2014) suggests that a decline in reproduction occurred on their lands in the Eastern Klamath and Southern Cascades regions of California during 1990-2005 (Figure 1.15). It is important to note, however, that these are only descriptions of apparent trends based on patterns in relatively crude data. A more rigorous analysis of the data is needed to support strong conclusions about reproductive trends on industrial timberlands in the Redwood Region.

Figure 1.12: Fecundity of northern spotted owls on National Park Service lands in Marin County during 1999-2005 and 2007-2012 (from Ellis et al. 2013). The solid line indicates mean fecundity during these periods combined, the dashed lines are one standard deviation from the mean, error bars indicate ±1 standard error, and n is the total number of spotted owl territories.

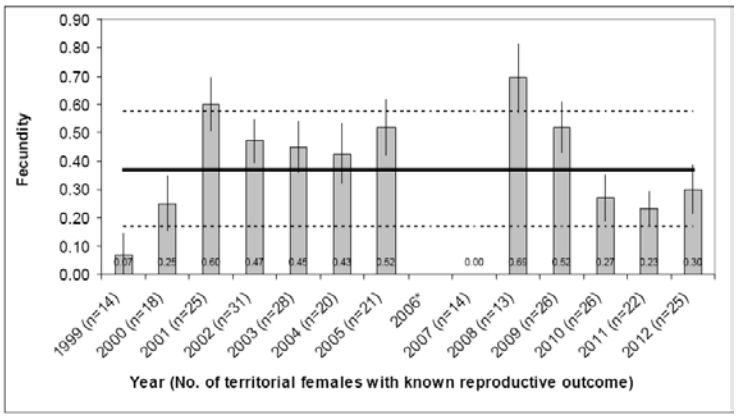


Figure 1.13: Reproductive success (average number of fledglings/pair) of northern spotted owls and amounts of rainfall during the early nesting season on Mendocino Redwood Company lands during 1989-2013 (from Mendocino Redwood Company 2014).

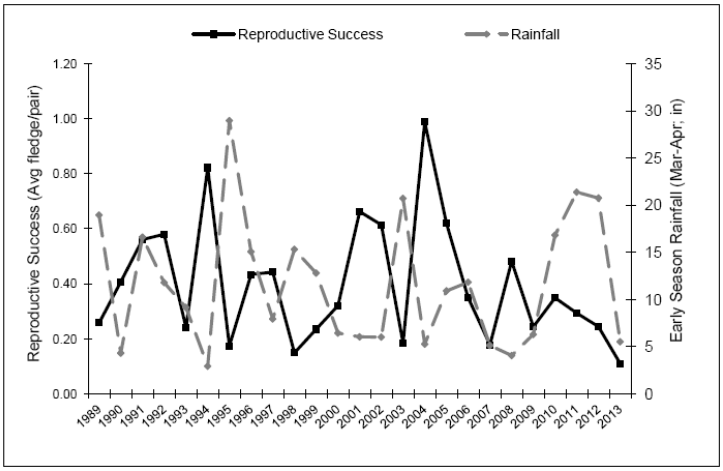


Figure 1.14: Reproductive rate and numbers of nesting pairs and juveniles on Humboldt Redwood Company lands during 2003-2012 (from Humboldt Redwood Company 2013).

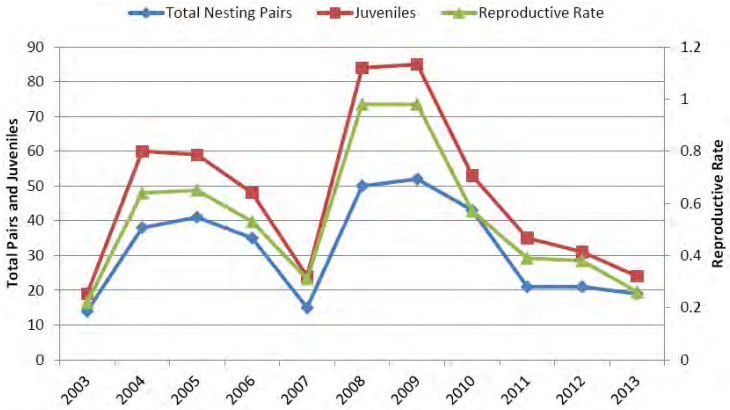
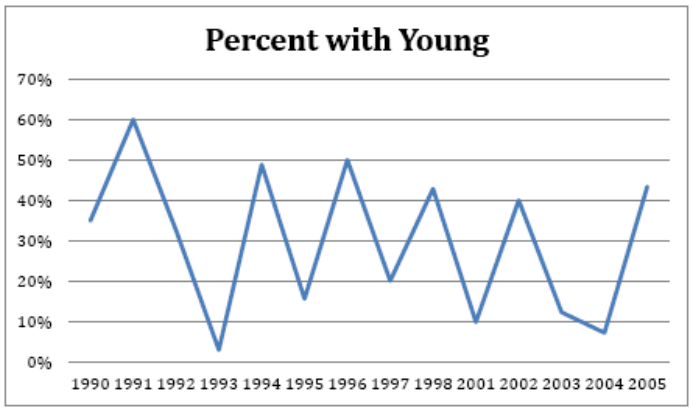


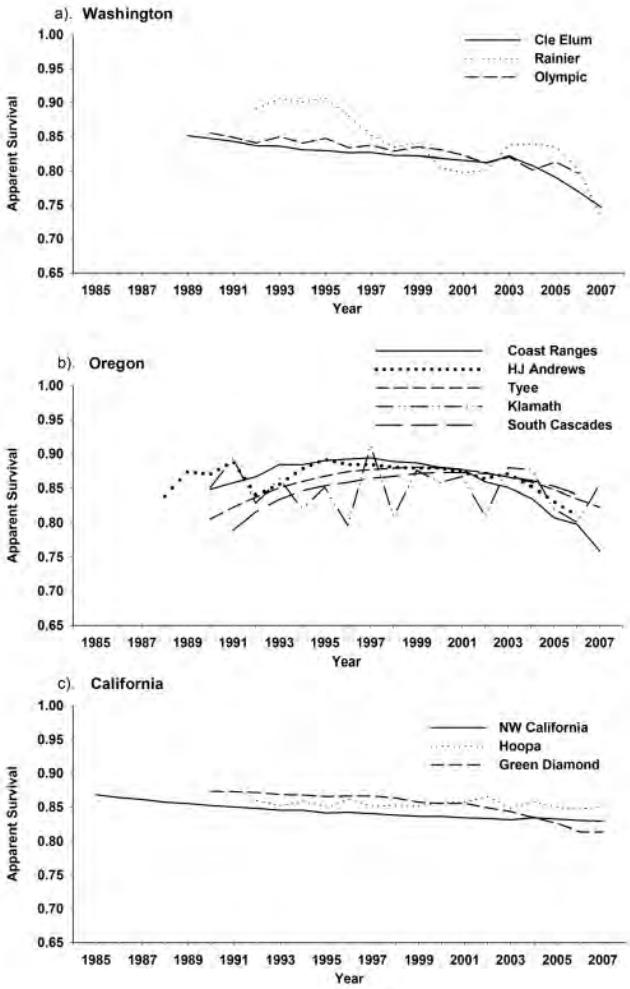
Figure 1.15: Fecundity of northern spotted owls on Fruit Growers Supply Company land during 1990-2005 (from Fruit Growers Supply Company 2014).



Survival

Available information concerning recent survival rates of NSOs is mostly limited to that provided in the 2011 demographic meta-analysis (Forsman et al. 2011). Survival data are not collected by timber companies other than Green Diamond Resource Company, which submits its data for analysis and reporting in the demographic meta-analyses. Forsman et al. (2011) reported statistically significant declines in apparent survival for 10 of 11 NSO demographic study areas, including all three study areas in California (Figure 1.16). Declines in many study areas were most precipitous during the last five years of the study period (i.e., 2003-2007 for survival; Figure 1.16). The Klamath in southern Oregon was the only study area that did not have a significantly declining survival rate through 2007. Forsman et al. (2011) stated that "collectively, the declines in apparent survival of Northern Spotted Owls across much of the subspecies' range are cause for concern because Spotted Owl populations are most sensitive to changes in adult survival rates (Noon and Biles 1990, Lande 1991)."

Figure 1.16: Model averaged estimates of apparent survival of adult female northern spotted owls three study areas in Washington (a), five study areas in Oregon (b), and three study areas in California (c) during 1985-2007 (from Forsman et al. 2011).



NSO demographic studies have largely deferred reporting of more recent survival data to the forthcoming meta-analysis, which is expected to be released in 2015. The limited information available prior to release of that meta-analysis suggests that survival has continued to decline since the 2011 meta-analysis study period. Davis et al. (2013b) reported that subsequent "…data regarding occupancy (in the Klamath study area) has shown a rapid decline, which suggests the stability of the survival rate may no longer be valid." Franklin et al. (2013) reported an alarming drop in apparent survival in 2011 on the Northwestern California demographic study area (Figure 1.17). Their subsequent annual report deferred reporting of 2012-2013 survival data to the forthcoming meta-analysis (Franklin et al. 2014). Higley and Mendia (2013) reported a statistically non-significant decline in survival of NSOs on the Hoopa Valley Indian Reservation in the Western Klamath (Figure 1.18). Their best model explaining survival of NSOs suggested that the decline was at least partially related to increasing numbers of barred owls in the study area.

Figure 1.17: Annual estimates (solid dots with 95% confidence intervals) of, and trend in (solid line), apparent survival for subadult and adult northern spotted owls in northwestern California during 1985-2012 (from Franklin et al. 2013).

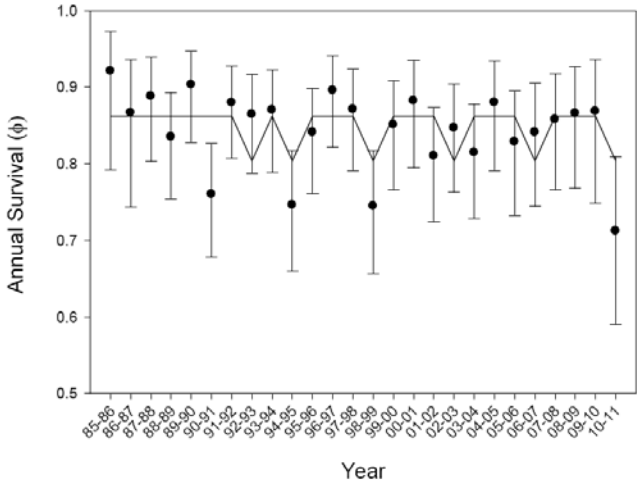
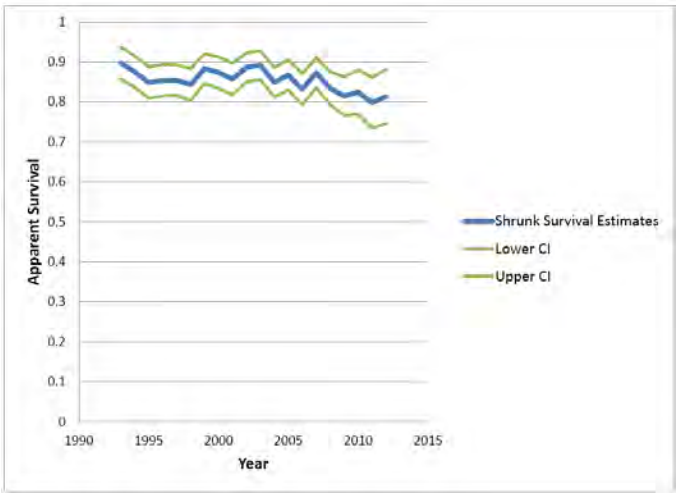


Figure 1.18: Estimates and 95% confidence intervals for NSO apparent survival on the Hoopa Valley Indian Reservation, Humboldt County, California during 1994-2012 (from Higley and Mendia 2013).



Forsman et al. (2011) reported that the presence of barred owls was included in the best model structures for several study areas, including the Green Diamond and Klamath, and was in a competitive model for Northwestern California (Forsman et al. 2011). Given evidence that barred owl presence continued to increase after the study period covered by Forsman et al. (2011) (see Chapter 4 of this volume), it is likely that the forthcoming meta-analysis will report continued declines in apparent survival for many, if not all, demographic study areas. Franklin et al. (2013) noted that apparent survival in the Northwestern California study area, like reproduction, is influenced by annual variation in weather during the early spring. Thus, recent consecutive years with poor weather during the early spring further suggest that survival has likely continued to decline since the period analyzed by Forsman et al. (2011).

Population Change

A new demographic meta-analysis is expected to be released in 2015. Until then, the 2011 meta-analysis (Forsman et al. 2011) provides the most current available estimates of population change for NSOs across their range. Except for the Green Diamond Resource Company, which submits its data for analysis and reporting in periodic meta-analyses, timber companies do not estimate population change for NSOs. Forsman et al. (2011) stated that their results likely "…reflected conditions on federal lands and areas of mixed federal and private lands within the range of the Northern Spotted Owl because the study areas were (1) large, covering ≈ 9% of the range of the subspecies, (2) distributed across a broad geographic region and within most of the geographic provinces occupied by the owl, and (3) the percent cover of owl habitat was similar between our study areas and the surrounding landscapes." Only one of the study areas included in the meta-analysis was entirely located on private lands (Green Diamond). Thus, it is unclear whether results from the 2011 meta-analysis reflect demographic trends on private lands across

the range of the NSO. Given weaker habitat conservation measures for NSOs on many private ownerships compared with federal lands, Forsman et al. (2011) stated that, "if anything, our results depict an optimistic view of the overall population status of the Northern Spotted Owl."

Forsman et al. (2011) reported estimates of the annual finite rate of population change (λ) for 11 study areas located across the NSO's range. Estimates of λ ranged from 0.929 to 0.996 (i.e., declines of 0.4 to 7.1% per year) for these study areas during the period of 1990-2006. There was strong evidence of population declines on seven of the study areas, including the Northwestern California (-1.7% per year) and Green Diamond (-2.8% per year) study areas in California. Negative population trends were also found on the Hoopa study area in California (-1.1% per year) and on the Klamath and South Cascades in southern Oregon (-1.0% and -1.8% per year, respectively) but they were not statistically significant. The weighted mean estimate of λ for all study areas combined was 0.971, indicating an average population decline of 2.9% per year during the study. Variables included in the best model in the meta-analysis of λ indicated effects of ecoregion (geographic location and major forest type) and the proportion of NSO territories with barred owl detections.

In addition to estimates of annual rate of population change, Forsman et al. (2011) provided estimates of realized population change, which describes population change over the study period (Figure 1.19). NSO populations in Washington and northern Oregon declined by approximately 40-60% during 1990-2006. Populations on the Northwestern California and Green Diamond study areas declined by 20-30% during the study period, although the 95% confidence intervals for these estimates slightly overlapped zero (Figure 1.19). Declines of 5-15% were evident on the Hoopa, Klamath and South Cascades study areas but these trends were not statistically significant (Figure 1.19).

Figure 1.19: Estimates of realized population change with 95% confidence intervals for northern spotted owls in California and southern Oregon (from Forsman et al. 2011).

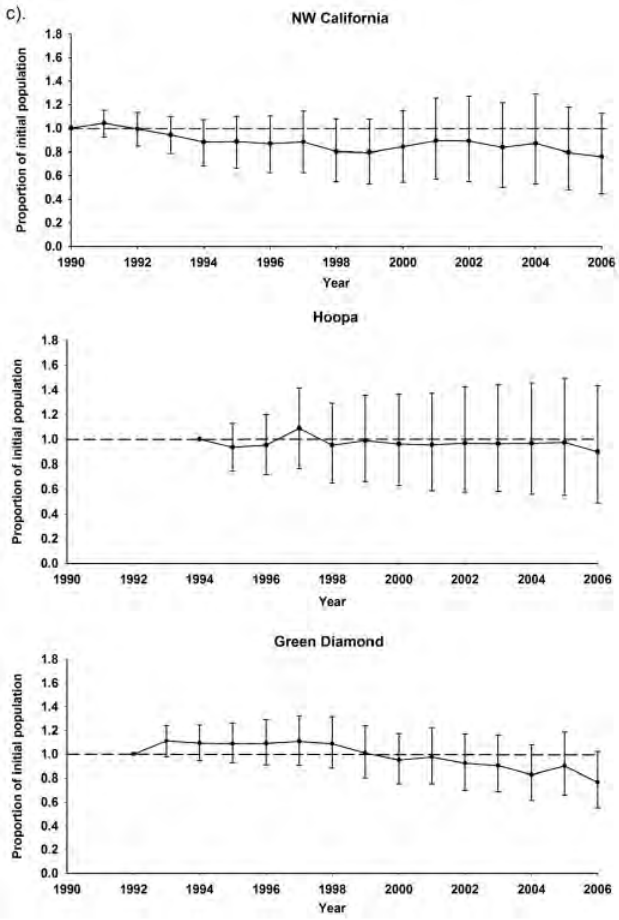
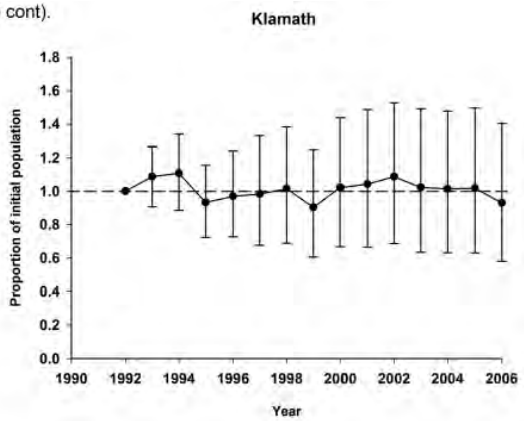
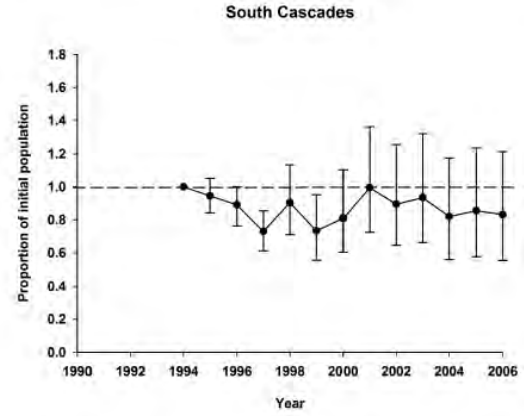


Figure 1.19 (cont.).

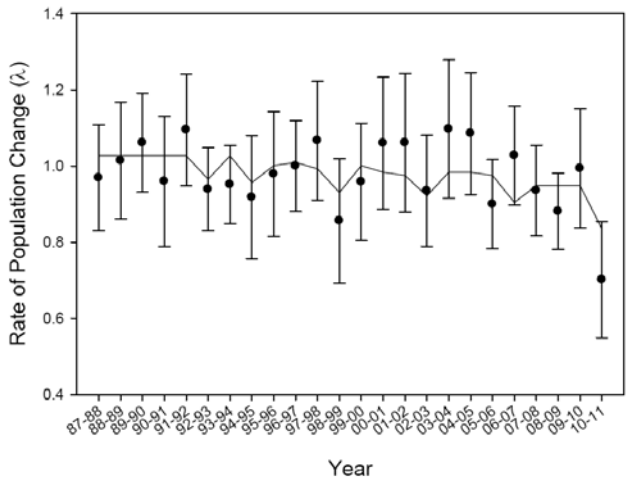
b cont).





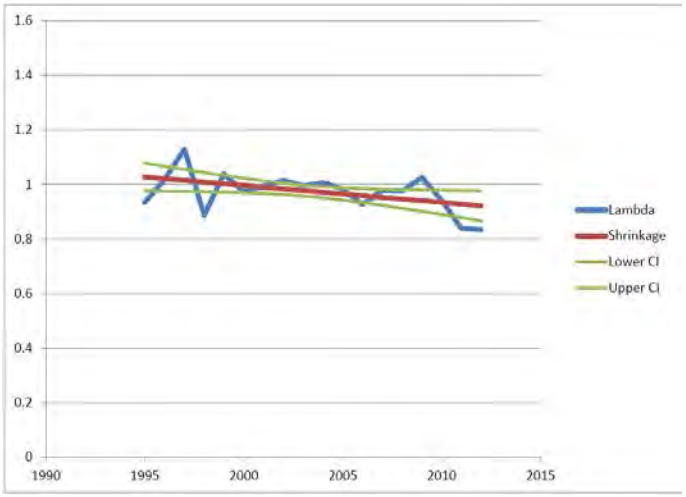
Following the 2011 meta-analysis study period (i.e., >2007), NSOs in the Northwestern California study area experienced a further decline in λ (mean = 0.978 or -2.2% per year) (Figure 1.20). The last year included in this analysis (2011) had the lowest annual estimate of λ found during the 24-year analysis period (Figure 1.20). The forthcoming meta-analysis should reveal whether the substantial drops in apparent survival and λ in the Northwestern California study area in 2011 were anomalous or indicative of an increased rate of population decline in the study area. Franklin et al. (2013) found that fecundity, apparent survival, and λ in the study area fluctuated during "good" and "bad" years, which was likely at least partially related to weather (see above). Annual rate of population change was also apparently negatively affected by increasing presence of barred owls. Given continued increases in barred owls (see Chapter 4 of this volume), poor weather during the early spring during 2010-2012, and poor reproduction by NSOs during 2011-2013 (see above), it is likely that λ continued to decline on this study area and probably others in California and southern Oregon.

Figure 1.20: Annual estimates of (dots with 95% confidence intervals) and trend in (solid line) rate of population change in the Northwestern California study area (from Franklin et al. 2013).



Higley and Mendia (2013) reported that the estimate of λRJS (Jolly-Seber Capture-Recapture model) for the Hoopa demographic study during 1995-2012 was 0.977, indicating a mean annual population decline of 2.3%. The decline was statistically significant in 2011 and 2012 (point estimates of λRJS not included in the 95% CI; Figure 1.20). Higley and Mendia (2013) noted that "the recent decline in survival, the point estimate of λRJS and the actual number of birds detected this past season all point to a population that is in fact, declining. This apparent decline in spotted owls corresponds with an increase in total annual barred owl detections and proportion of spotted owl territories with barred owl detections." They further noted that the forthcoming meta-analysis will show that it is "...very clear that northern spotted owls are in decline across all 11 study areas and that in many cases the decline is accelerating."

Figure 1.21: Trend in rate of population change on the Hoopa Valley Indian Reservation, Humboldt County, California during 1994-2012 (from Higley and Mendia 2013).



Source-Sink Dynamics

As described by Gutiérrez and Harrison (1996), source-sink dynamics exist for species "…that occupy both high-quality habitats (sources) where populations grow and produce emigrants, and low-quality habitats (sinks) where populations cannot sustain themselves in the absence of immigration." Population sinks potentially function as reservoirs for repopulation of sources that go extinct but may also reduce population growth rates (Pulliam 1988, Gutiérrez and Harrison 1996). Identifying source and sink areas is therefore, an important component of conservation research and planning.

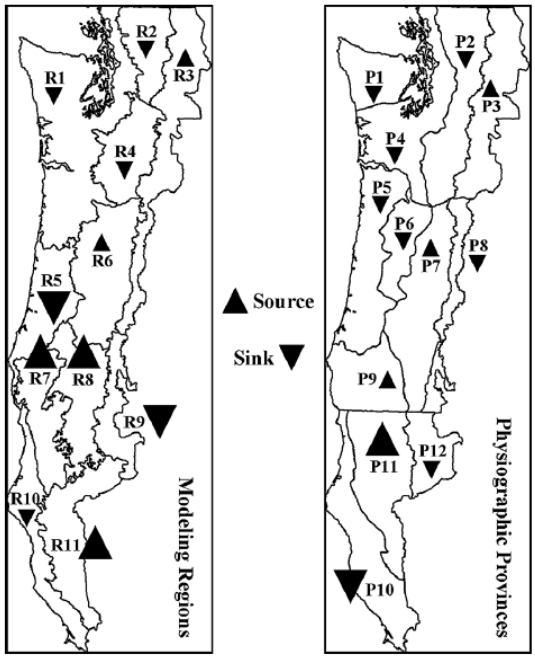
Schumaker et al. (2014) recently published a rangewide study of source-sink dynamics for NSOs. Their source-sink simulation modeling incorporated an array of regional data for NSO occupancy rates, movement distances and rates, life history attributes, habitat suitability and connectivity, encounter rates with barred owls, and environmental stochasticity. Source-sink dynamics in this study emerged from simulated interactions between individual NSOs and landscapes, rather than being predefined based on habitat suitability as was done in previous studies. The simulation models by Schumaker et al. (2014) ~~found~~ predicted that most ecological regions and physiographic provinces currently function as population sinks for NSOs (Figures 1.22 and 1.23). The study's results ~~indicated~~ projected that the Klamath Provinces of California and Oregon and the Interior Northern Coast Ranges of California are the subspecies' strongest population sources (Figure 1.23). The Klamath Provinces appear to be particularly important for maintaining NSO population stability due not only to being net population sources but to their high levels of population connectivity with multiple surrounding regions (Schumaker et al. 2014; Figure 1.23). The Redwood and Southern Cascades regions in California were both classified as moderate population sinks. Schumaker et al. (2014) identified the Klamath Provinces and

Comment [LVD7]: I think this section should also include a discussion of habitat fitness (Franklin et al. 2000), which is another method to quantify source versus sink habitats.

Comment [LVD8]: I personally don't think a simulation model should be used to draw management conclusions. In my opinion, they require so many assumptions to generate the necessary model parameters that they should only be used to develop testable hypotheses. The data we have accumulated over the years on population recruitment through immigration of subadults indicates that most of the birds are coming from within the redwood region. We don't have the data, but my guess is that the redwood region has contributed more recruits to the Klamath region than the reverse.

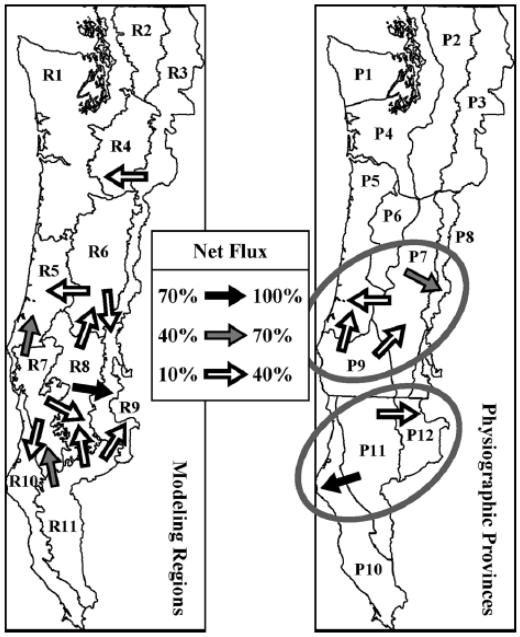
California Cascades as areas in which it could be particularly important to focus habitat protection and restoration efforts, respectively.

Figure 1.22: Relative source and sink values in northern spotted owl modeling regions and physiographic provinces (from Schumaker et al. 2014). The sizes of symbols denote major versus minor or moderate sources and sinks.



R7: Klamath West, R8: Klamath East, R9: Eastern Cascades South, R10: Redwood Coast, R11: Inner California Coast Ranges, P10: California Coast Range, P11: California Klamath, P12: California Cascades. See Schumaker et al. (2014) for other modeling regions and physiographic provinces.

Figure 1.23: Graphical representation of net movement ("Net Flux") of individual (simulated) northern spotted owls from one modeling region or physiographic province to another (from Schumaker et al. 2014). The largest Net Flux values are shown in black, intermediate values in gray, and smallest values in white. Gray ovals highlight two areas with strong patterns of Net Flux.

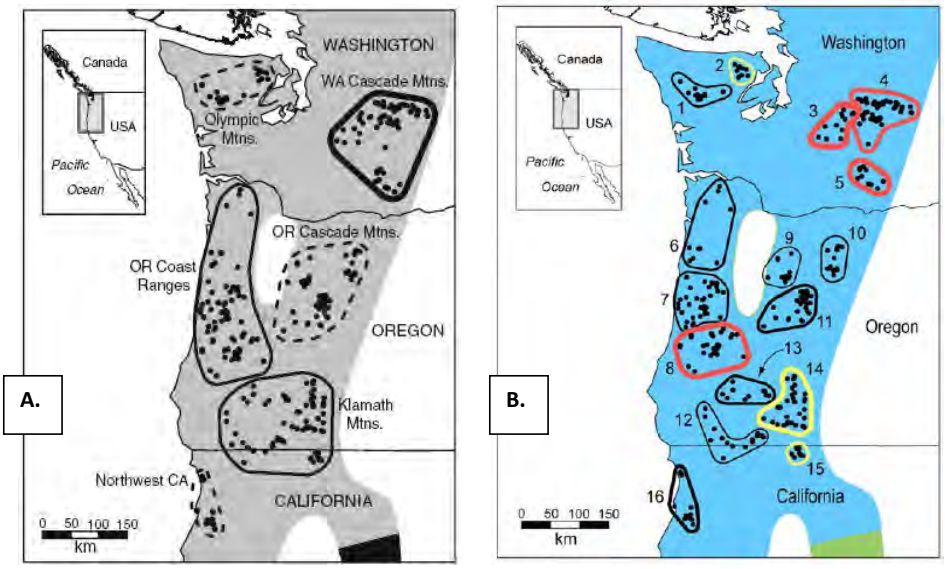


Genetics

Funk et al. (2010) found statistically significant evidence that NSOs have experienced genetic bottlenecks during recent decades in the Washington Cascades, Oregon Coast Ranges, and "Klamath Mountains" of Oregon and California (Figure 1.24). An earlier report on this study indicates that evidence of a bottleneck in the Klamath Mountains analysis area was primarily driven by data from the southern Cascades of Oregon and California, rather than from the Klamath Provinces (Funk et al. 2008; Figure 1.24). Evidence of recent genetic bottlenecks in the Washington Cascades, Oregon Coast Ranges, and southern Cascades are concordant with recent demographic declines in these regions (Forsman et al. 2011; see *Demography*, above). Surprisingly, Funk et al. (2010) did not find evidence of a genetic bottleneck in the Olympic Mountains of Washington, where NSOs have recently experienced dramatic population declines (Forsman et al. 2011). However, they noted that their small sample size for this region limited their power to detect a genetic bottleneck if one occurred. Funk et al. (2010) did not find statistically significant evidence of a recent genetic bottleneck in northwestern California (Western Klamath and Redwood regions). They suggested that this could likewise have been due to low statistical power or to the relatively gradual population declines reported for that area at the time (see *Demography*, above). The analyses of Funk et al. (2010) did not address whether

genetic bottlenecks were solely a result of population declines or were also contributing to them. Genetic declines can contribute to reduced demographic rates through effects of inbreeding depression and loss of adaptive genetic variation (reviewed in Funk et al. 2010).

Figure 1.24: Recent population bottlenecks in NSOs. Points represent 352 individual owls included in the analysis which are grouped into six (A) and 16 (B) regions. Statistically significant bottlenecks are represented by solid lines (A) or yellow ($p = 0.05$) and red ($p = 0.01$) lines (B). (A) represents significant bottlenecks under 5, 10, and 15% multi-step mutation models as solid bold lines and under 10 and 15% multi-step mutation models as finer solid lines (see Funk et al. 2010). (B) indicates greater magnitude bottlenecks with bolder lines. From Funk et al. 2010 (A) and 2008 (B).



Summary of Current Status and Trends

Rigorous long-term research has indicated that NSO populations are dramatically declining in Washington and northern Oregon and more gradually declining in southern Oregon and California (Forsman et al. 2011). Yet, while less precipitous than those in the northern portion of the NSO's range, the rapidity of population declines in southern Oregon and California are cause for grave concern regarding the subspecies' status and trends. A new demographic meta-analysis, which is due for public release during 2015, will replace the 2011 meta-analysis and provide the most reliable information for evaluating the NSO's current status and trends. Based on information available in annual research reports, it is clear that the forthcoming meta-analysis will show that populations in southern Oregon and California are declining more rapidly than was evident in the 2011 meta-analysis (Davis et al. 2013a, Franklin et al. 2013, Higley and Mendia 2013, Dugger et al. 2014, Green Diamond Resource Company 2014).

The NSO's status and trends are less clear in portions of California outside the state's three demographic study areas. Much of the information for these areas is provided by industrial timber companies, which have uniformly concluded that NSO populations on their lands are stable (Calforests 2014). However, the data provided by these companies are insufficient for drawing strong conclusions about the NSO's status and trends, and may in fact indicate gradual declines in occupancy and reproduction on some ownerships (see *Occupancy* and *Demography*, above). Forsman et al. (2011) suggested that, due to weaker habitat protection, NSO demographic trends could generally be worse on non-federal lands than on the federal and mixed federal/non-federal lands on which most demographic studies are conducted. This appears to be true in California, where NSOs experienced greater declines on Green Diamond Resource Company lands than on nearby tribal and Forest Service lands (Forsman et al. 2011; see *Occupancy* and *Demography*, above). However, the degree to which these differences were due to variation in land management, effects of competition with barred owls, or other factors is unclear.

It is likewise unclear if demographic trends in California's three demographic study areas accurately represent those in drier, less productive forests in the state's interior. An occupancy study in California's Eastern Klamath and Southern Cascades (Farber and Kroll 2012) and demographic studies in ecologically similar areas of southern Oregon (Davis et al. 2013a, Dugger et al. 2014) could provide the most reliable information currently available for evaluating NSO's status and trends in interior California (see *Occupancy* and *Demography*, above). These studies indicate that NSOs are currently declining in at least some portions of the Eastern Klamath and Southern Cascades regions (note: these regions cover portions of both California and southern Oregon as they are ecologically rather than politically defined; see USFWS 2011a Appendix C). Evidence of population declines in the Klamath regions (Forsman et al. 2011, Farber and Kroll 2012, Davis et al. 2013a, and Franklin et al. 2013) are particularly concerning in light of the critical contributions these areas likely provide to the NSO's long-term persistence (Schumaker et al. 2014; see *Source-Sink Dynamics*, above).

Although the Redwood Region ~~appears to currently~~is projected to function as a population sink, it still retains high densities and abundances of NSOs and is therefore important to the subspecies' conservation (Schumaker et al. 2014; see *Density and Abundance* and *Source-Sink Dynamics*, above). There is limited information available for evaluating the NSO's status and trends in portions of the Redwood Region outside of Green Diamond's lands. Monitoring on National Park Service lands and adjacent ownerships suggest that the population in Marin County is stable while NSOs in the Redwood National and State Parks have substantially declined. These differences appear to be largely due to negative effects of high barred owl densities in the Redwood National and State Parks and the relatively slow rate of the barred owl invasion in Marin County (see *Occupancy*, above). In contrast with the Green Diamond Resource Company, other timber companies in the northern portion of the Redwood Region have concluded that their NSO populations are stable (Calforests 2014). It is possible that NSOs have indeed fared better on these ownerships than on Green Diamond lands; for example, due to less intensive timber harvesting or more recent colonization by barred owls. However, the data provided by these companies are insufficient for drawing firm conclusions about the NSO's status and trends on these lands, and actually appear to indicate gradual declines in some areas. More consistent and rigorous monitoring (e.g., consistent survey areas and protocols; reporting

Comment [LVD9]: There are no data to support this assertion so I think simulation model projections need to be reported with the uncertainty they deserve. As the great statistician George E. P. Box stated: "All models are wrong, but some are useful."

of modeled occupancy rates) would assist future evaluations of the NSO's status and trends on industrial timberlands in California.

Acknowledgements

Source-Sink Dynamics

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Comment [JRD1]: They also may help identify areas where restoration of habitat, or management of barred owls, could be warranted.

Comment [JRD2]: I think Lowell's comment is reasonable here – maybe the point is that source-sink evaluations, and subsequently identifying sources and sinks is absolutely scale dependent. Thus, the sources and sinks we found in the Schumaker et al. paper, because the scale was so big (regions/provinces were millions of acres each) means that they were comprised of both sources and sinks. If we were to have looked at a smaller scale we would have more nuanced descriptions of sources/sinks – it is an important point.

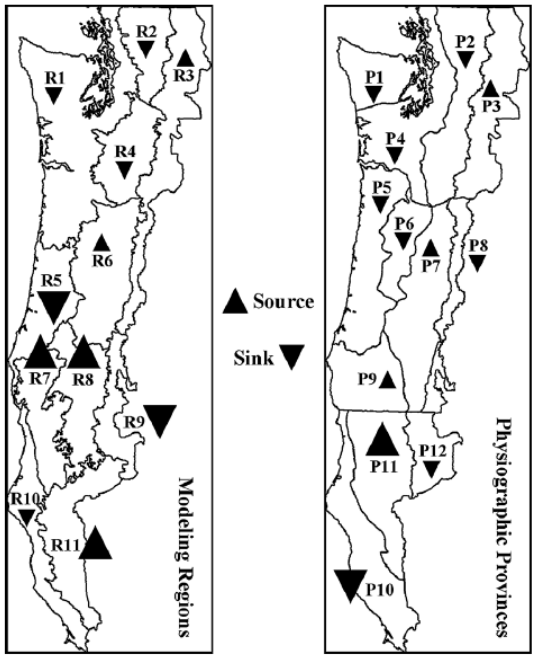
Comment [JRD3]: I might add to that sentence "…for NSO at the (large) spatial scale of modeling regions and ecogeographic provinces.

Comment [JRD4]: We didn't really use "occupancy rates" but we did include habitat suitability.

Comment [JRD5]: See previous comment on spatial scale.

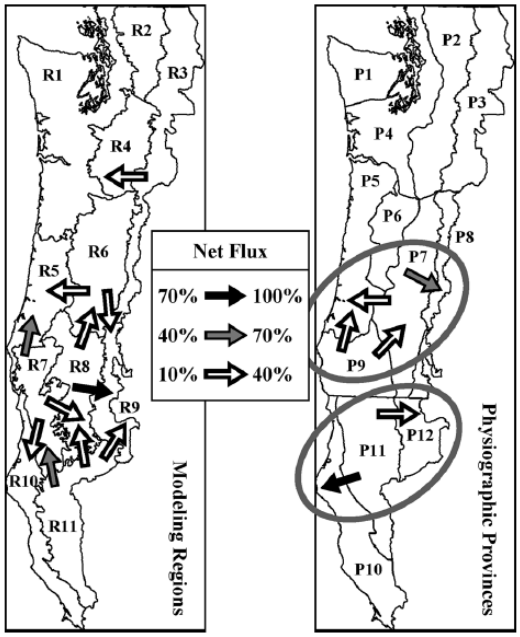
Comment [JRD6]: Lowell's comment on not drawing management conclusions from simulations/models. I see his point, but none of the demographic studies is near big enough to do what he's saying – we did a range-wide analyses (not a tiny portion of the range, like individual DSAs are…and even cumulatively they're <12% of the range). Thus, I kind of think that saying the source/sink stuff should "only be used to develop testable hypotheses" – really means that it will never happen at the range-wide scale. We either go with the higher uncertainty simulation data, or simply leave it a "blank spot on the map."

Figure 1.22: Relative source and sink values in northern spotted owl modeling regions and physiographic provinces (from Schumaker et al. 2014). The sizes of symbols denote major versus minor or moderate sources and sinks.



R7: Klamath West, R8: Klamath East, R9: Eastern Cascades South, R10: Redwood Coast, R11: Inner California Coast Ranges, P10: California Coast Range, P11: California Klamath, P12: California Cascades. See Schumaker et al. (2014) for other modeling regions and physiographic provinces.

Figure 1.23: Graphical representation of net movement ("Net Flux") of individual (simulated) northern spotted owls from one modeling region or physiographic province to another (from Schumaker et al. 2014). The largest Net Flux values are shown in black, intermediate values in gray, and smallest values in white. Gray ovals highlight two areas with strong patterns of Net Flux.



Timber Harvesting

Timber harvesting was a primary impetus for federal listing of the NSO and is still regarded as one of the major threats to the subspecies (Thomas et al. 1990, USFWS 1990, Courtney et al. 2004, USFWS 2011a). Timber harvesting can directly impact NSO populations by removing, degrading, or fragmenting habitat for them or their prey (reviewed below). Harvesting might also indirectly affect NSOs by increasing effects of other stressors, such as competitive pressure from barred owls (*Strix varia*) (Dugger et al. 2011, Forsman et al. 2011; see *Threats: Cumulative and Interactive Effects*). However, timber harvesting likely has complex effects on NSOs in the southern part of their range due to divergent effects of habitat conditions on survival versus reproduction (Franklin et al. 2000, Olson et al. 2004, Diller et al. 2010). The information reviewed herein suggests that some forms and amounts of harvesting are sustainable in northern California but that large-scale removal or fragmentation of habitat around activity centers can strongly impact NSOs (reviewed below and in USFWS 2009).

Comment [UFS1]: As in fire review… should define habitat in more specific terms when warranted.

The kinds of habitat concentrations associated with high survival and fitness of NSOs may be limited in some parts of the subspecies' range due to removal of the majority of old forest during the 19th and 20th centuries (USFWS 1990, Strittholt et al. 2006). Harvesting has been substantially reduced on federal lands since implementation of the Northwest Forest Plan (Healey et al. 2008, Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012). However, removal of suitable NSO habitat continues on federal lands and is occurring at higher rates on non-federal lands (Davis and Dugger 2011). Habitat loss to logging is only partially offset by recruitment of new habitat ~~on non-federal lands~~ (Davis and Dugger 2011, Moeur et al. 2011;

Comment [UFS2]: Not just federal

reviewed below). This is cause for concern since non-federal lands contain a considerable portion of remaining suitable breeding habitat for the subspecies and because recovery of the NSO partially depends on voluntary conservation efforts on these lands (USFWS 2011a; see *Legal and Regulatory Framework*). The timber industry has cited relatively strict harvest regulations in California as evidence that listing of the NSO under the California Endangered Species Act is unnecessary (California Forestry Association 2014). Yet, contemporary harvesting has still resulted in a net loss of suitable breeding habitat for NSOs on non-federal lands in California (Davis and Dugger 2011, Moeur et al. 2011; reviewed below). Furthermore, the U.S. Fish and Wildlife Service (2009) recently concluded that California's regulations for avoiding take inadequately protect the subspecies and do not reflect the best available science (reviewed below; also see *Threats: Inadequacy of Regulatory Mechanisms*).

Comment [UFS3]: How much is "considerable"? Perhaps state as a percentage of total.

Responses of NSOs to Timber Harvesting

Interior Northern California

NSOs in interior northern California show a strong general preference for relatively old, structurally complex forest. This is illustrated by studies describing both plots around NSO locations (Solis and Gutierrez 1990, Rissler 1995, White 1996, Hershey et al. 1998; but see Irwin et al. 2013) and landscape-scale analysis areas around activity centers (Chávez-León 1989, Solis and Gutierrez 1990, Hunter et al. 1995, Gutierrez et al. 1998). This body of research can be used to inform conservation measures for NSOs in interior northern California (e.g., for evaluating appropriate habitat definitions in take-avoidance guidelines: USFWS 2009). However, the

following review is focused on studies of associations between landscape-scale habitat attributes and NSO demography in interior forests (Franklin et al. 2000, Olson et al. 2004, Dugger et al. 2005, Schilling et al. 2013). These studies are based on rigorous demographic data and provide the best available insight into potential effects of timber harvesting on NSO populations (USFWS 2009). We supplement this review with information from studies of associations between landscape-level habitat characteristics in southern interior forests and the NSO's home range sizes (Carey et al. 1992, Carey and Peeler 1995, Schilling et al. 2013) and probability of occurrence (Zabel et al. 2003, Carroll and Johnson 2008).

Comment [UFS4]: Tempel et al in press might also be good here.

In the California Klamath, Franklin et al. (2000) found that NSO survival was highest when estimated breeding core areas (390 ac) contained large amounts of both "core" (>326 ft from edge) older forest (conifer or mixed forest with conifer QMD ≥21 in and canopy cover ≥70%) and edge with other vegetation classes. In contrast, reproduction was typically highest with lower amounts of core older forest and greater amounts of edge. Estimated core areas supporting high fitness for NSOs (a function of both survival and reproduction) contained both a large concentration of core older forest and considerable habitat edge provided by a mosaic of other vegetation patches with convoluted shapes. Franklin et al. (2000) emphasized the difference between total area of older forest versus area of core older forest. For example, they noted that large amounts of older forest edge cannot occur with low total amounts of older forest. This study did not directly address effects of timber harvesting on NSOs. Vegetation other than older forest was combined into a single class and edges occurred wherever that class and older forest met. Franklin et al. (2000) noted, however, that the dominant silvicultural system in their study

area at that time was large-scale clearcutting, which they concluded was unlikely to contribute to the kinds of habitat mosaics found in territories supporting high fitness.

In the interior of the Oregon Coast Range, Olson et al. (2004) found that NSO survival was positively associated with greater amounts of both "mid-seral" (9.5-31.5 in DBH) and "late-seral" (>31.5 in DBH) forest in landscapes around activity centers (≤4,921 ft) and lower amounts of early-seral forest and non-forest (<9.5 in DBH). Reproduction, in contrast, was negatively associated with area of mid- and late-seral forest and positively associated with edge between early-seral and non-forest and other vegetation classes. Olson et al. (2004) encountered technical difficulties with the habitat fitness potential portion of their modeling but noted that territories supporting high fitness must contain attributes associated with both high survival and high reproduction. This was supported by diagrams made from aerial photos of landscapes around activity centers, which showed remarkably similar habitat mosaics to those presented by Franklin et al. (2000).

Dugger et al. (2005) found a positive association between NSO survival in the Oregon Klamath Province and greater amounts of mature and old forest (≥100 yrs) within estimated core areas (413 ac) and a moderate amount of non-habitat (non-forest, early-seral vegetation, and older forest with harvest entries ≥40% basal area) in the landscape beyond the core area (3,430-ac ring). The specific contribution of timber harvesting (and of different harvest types and intensities) to the non-habitat class and thus, its effects on NSO fitness, were not reported. This study's findings differed from others in that reproduction was positively, rather than negatively, associated with greater amounts of older forest within estimated core areas. These findings

Comment [UFS5]: Differentiate between "core area" and "core habitat".

suggest that widespread harvesting of older forest within NSO core areas would negatively effect both survival and reproduction in this area but that some level of harvesting might be sustainable in the broader landscape (to the degree that it contributes to "optimal" amounts of non-habitat in the 3,430-ac ring surrounding estimated core areas).

Schilling et al. (2013) found additional evidence of a positive influence of both older forest and habitat heterogeneity on NSO survival in the Oregon Klamath. Their best performing model indicated that monthly survival probabilities for NSOs were highest when home ranges (based on radio-telemetry) contained more patches of mature and old forest (≥20 in DBH and ≥40% canopy cover). The second best performing model indicated a positive association between survival and clustering of (i.e., close distances between) older forest patches. Unlike other studies, they did not find an association between survival and total amount of older forest. They noted that this could have occurred due to their small sample size or because most NSO home ranges in their study had amounts of mature and old forest (mean = 72%) that likely exceeded threshold amounts required for survival. A third competitive model suggested that survival was also positively associated with a moderate amount of edge between forest (mean DBH ≥5 in) and other cover classes; thus providing additional support for the value of habitat heterogeneity for NSOs in southern interior forests.

Zabel et al. (2003) modeled probability of NSO occurrence (i.e., habitat suitability) across interior northern California based on habitat conditions at an estimated core area scale (500 ac). The best performing model in their study indicated that the probability of NSOs occurring in a given location was highest with large amounts of suitable nesting-roosting habitat (generally ≥17

in DBH and canopy cover ≥60%) and intermediate amounts of foraging habitat (≥10 in DBH and canopy cover ≥40%) at the core area scale. The second and third best performing models at the core area scale included habitat edge. The results of this modeling study provide further support for conclusions that a combination of both a large concentration of suitable habitat and some form of habitat heterogeneity is important to NSOs in interior northern California.

Carroll and Johnson (2008) also modeled probability of NSO occurrence in interior northern California. Based on their best model, predicted abundance of NSOs in the area was highest when most of the landscape (5,930-ac areas) consisted of mature and old forest (>50 yrs). However, predicted abundance slightly declined when area of mature and old forest increased beyond about 80% of the landscape. This study therefore, provides evidence of at least a slight positive effect of other vegetation classes on probability of NSOs occurring in a given area. These results contrasted with the study's findings for more northern parts of the NSO's range, where the probability of occurrence continued to increase (albeit diminishingly) with greater amounts of older forest.

Studies of home range sizes provide another line of evidence concerning habitat and harvesting influences on NSOs in interior southern forests. Home range studies in the Oregon Klamath found that home range size increased with habitat fragmentation (Carey et al. 1992, Schilling et al. 2013). NSOs in the area are known to use regenerating harvest units for foraging, particularly when closer to the activity center or outside the breeding season (Carey and Peeler 1995, Irwin et al. 2013). However, Carey and Peeler (1995) concluded that the energetic benefit of increased

access to dusky-footed woodrats (*Neotoma fuscipes*) in heavily fragmented forest is often outweighed by the energetic cost of increased travel.

In summary, studies in interior northern California have found that NSOs in the region benefit from both large amounts of older forest concentrated around activity centers and some form of habitat heterogeneity (Franklin et al. 2000, Zabel et al. 2003, Carroll and Johnson 2008). Similar results have been found in the Klamath (Dugger et al. 2005, Schilling et al. 2013) and interior Coast Range of Oregon (Olson et al. 2004). These findings suggest that timber harvesting is sustainable in southern interior forests, provided that suitable breeding habitat is retained in sufficiently large concentrations around NSO activity centers (USFWS 2009). However, whether and how timber harvesting contributes to beneficial habitat heterogeneity in interior southern forests is unclear. Available studies differed in their findings of types, amounts, and locations of beneficial heterogeneity and did not directly evaluate whether timber harvesting contributed to it. In contrast, it is clear from research of associations between landscape-level habitat attributes and NSO demography, presence, and home range size that harvesting within core concentrations of suitable habitat has the potential to strongly impact populations in southern interior forests (USFWS 2009). Despite the volume, rigor, and applicability of research showing associations between landscape-level habitat attributes and NSO fitness, California has yet to integrate it into take-avoidance regulations for interior timberlands (see *Threats: Inadequacy of Regulatory Mechanisms*).

Comment [UFS6]: Is this the proper word? It implies even flow through time. I think you mean compatible or something along those lines.

Comment [UFS7]: Positively or negatively? Be clear

Redwood Province

Most of what is known about NSOs in the Redwood Province is based on research on intensively harvested lands owned by the Green Diamond Resource Co. Studies on these lands found a preference among NSOs for landscapes with greater amounts of intermediate-age or older forest than expected based on general availability of those forest classes (Thome et al. 1999, Folliard et al. 2000, Keithley and Motroni 2000, Gonzales 2005, Diller et al. 2010). However, site fidelity and reproduction on these lands were positively associated with presence of younger forest classes and measures of habitat heterogeneity (e.g., edge) (Thome et al. 1999, 2000, Diller et al. 2010). Studies of the habitat associations of dusky-footed woodrats on these lands appear to provide additional support for the value of younger forest and habitat heterogeneity to NSOs in the area (Hamm et al. 2007, Hamm and Diller 2009). Unpublished but relatively rigorous modeling of associations between landscape-level habitat attributes and NSO fitness and population growth rate has confirmed that NSOs on Green Diamond lands have complex relationships with timber harvesting (Diller et al. 2010). NSOs in this area indeed appear to benefit from some level of habitat heterogeneity, which is currently maintained on Green Diamond lands through small-patch clearcutting (Diller et al. 2010). Yet, habitat quality on these lands (measured as habitat fitness potential *sensu* Franklin et al. 2000) is positively associated with protection of suitable breeding habitat and both habitat quality and population growth rate are negatively associated with harvesting of suitable habitat (i.e., take) (Diller et al. 2010). Thus, appropriate management of NSOs on Green Diamond lands appears to include avoiding take, setting aside suitable habitat from harvesting, and focusing economically-driven harvest requirements in relatively homogeneous blocks of unsuitable forest. Diller et al. (2010)

did not describe habitat conditions associated with habitat fitness potential ≥1 (i.e., conditions associated with NSOs replacing themselves or contributing to a population surplus). Peer reviewed reporting of these conditions is needed in order to identify appropriate take-avoidance guidelines for the northern part of the Redwood Province (see *Threats: Inadequacy of Regulatory Mechanisms*).

Less is known about the ecology and appropriate management of NSOs on other ownerships within the Redwood Province. Habitat selection by NSOs appears to vary among ownerships in the region (Keithley and Motroni 2000, see Appendix 1). The USFWS (2011a, 2012a) recently conducted habitat suitability modeling based on attributes of landscapes (494 ac) surrounding 392 activity centers distributed across much of the province. The model selected for the region included a suite of habitat variables and performed well in terms of its ability to discriminate between areas around NSO activity centers and random sites. The resulting map of relative habitat suitability was incorporated into the USFWS (2012a) process for designating critical habitat for NSOs but has limited utility for characterizing habitat selection by the subspecies. However, "deconstruction" of the habitat suitability modeling outputs (cf. Dunk and Hawley 2009, Woodbridge et al. 2012, Zielinski et al. 2012) allows evaluation of associations between habitat suitability and the full range of candidate variables, including ones not included in the best performing model. Deconstruction of the habitat modeling output for the Redwood Province shows that the probability of NSOs occurring in a given area in the region increases with larger amounts of forest with relatively dense canopy cover and large diameter trees (Appendix 2). Compared with those in the lowest suitability class, landscapes in the highest suitability class contained an average of 1.8 times more nesting-roosting habitat; 2.4 times higher

basal area of conifers ≥20 inches DBH; 2.3 times higher basal area of live trees ≥30 inches DBH; and 2.0, 1.8 and 1.9 times higher densities of conifers ≥20, 30, and 39 inches DBH, respectively. There was a high degree of variability (standard deviation) in terms of structural attributes within habitat suitability classes, particularly for rare habitat elements such as very large diameter trees. This variability likely reflects the high diversity of forest types, management histories, and natural disturbance regimes in the region (see Sawyer 2006, 2007, Stuart and Stephens 2006). Nonetheless, consistent patterns of association between habitat suitability and mean amounts of these variables are evident. In addition, variability in amounts of many of these habitat attributes (coefficient of variation) declined with increasing habitat suitability, further indicating that they are often important to NSOs in the province. These results suggest that timber harvesting that reduces availability of these structural attributes would generally reduce the probability of NSOs occurring in a given area within the Redwood Province. Changes in availability of these structural attributes can occur with a variety of silvicultural approaches and are not solely caused by even-age harvesting.

Effects of Uneven-Age Harvesting and Thinning

Comment [UFS8]: There is a recent pub (GTR) that has a section on this. See Wilson and Forsman. 2013. Thinning Effects on Spotted Owl Prey and Other Forest-Dwelling Small Mammals, in:

Anderson, Paul D.; Ronnenberg, Kathryn L., eds. 2013. Density Management in the 21st Century: West Side Story. Gen. Tech. Rep. PNW-GTR-880. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 249 p.

Some private timberlands in northern California currently emphasize uneven-age regeneration, which typically causes less visually dramatic changes to forests than does even-age harvesting. This form of harvesting nonetheless has the potential to cause substantial changes to forest structure or composition. For example, intensive selective logging of Douglas-fir (*Pseudotsuga mensiesii*) has resulted in extensive conversion of mixed-evergreen forest to hardwood-dominated forest in parts of the Redwood Province (Sawyer 2006). Relatively little harvesting

has occurred on federal lands within the NSO's range since adoption of the Northwest Forest Plan (Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012; see below). However, federal agencies have recently expressed support for widespread thinning to reduce wildfire risk in interior forests in the Plan area (USFWS 2011a, 2012a).

Effects of contemporary uneven-age harvesting and thinning on NSOs are difficult to evaluate due to the paucity of rigorous research on the topic. Most of the available information about NSO responses to these silvicultural systems is based on the behavior of very small numbers of telemetered owls and was gathered in an opportunistic fashion during studies of other topics (reviewed in Hansen and Mazurek 2010, USFWS 2011a; see below). Evaluation of this topic is further complicated by poor descriptions of harvest methods, locations and intensities and, perhaps more importantly, post-harvest habitat conditions. The terms uneven-age harvesting and thinning encompass a tremendous variety of harvest types, objectives, and effects (Smith 1986). Harvesting described in relation to NSO telemetry consisted of a variety of commercial thinning or partial harvesting (leaving residual trees) prescriptions, including understory thinning of various intensities, removal of most trees up to a relatively large diameter class, and shelterwood harvests prior to or without removal of residual trees (see Hansen and Mazurek 2010).

In a synthesis prepared for the 2011 revised recovery plan for the NSO (USFWS 2011a), Hansen and Mazurek (2010) provided detailed summaries of data concerning responses of both NSOs and California spotted owls (CSOs) to uneven-age harvesting, partial harvesting, and thinning. This information was gleaned from both peer-reviewed and gray literature and was based on small sample sizes. The authors therefore, opted to review each data source as a "case study" so

that relatively detailed descriptions of harvesting and post-harvest conditions could be provided and so that the methodological strengths and weaknesses of studies could be evaluated. We summarize their review below, with the addition of one subsequent citation (Gallagher 2010).

Each of the 12 studies that we reviewed documented at least some use by NSOs or CSOs of areas harvested with uneven-age harvesting, partial harvesting, or thinning. At least four of the studies found owls nesting in harvest areas (Forsman et al. 1984, Zabel et al. 1992, King 1993, and Buchanan et al. 1995) and at least five recorded roosting in them (Solis 1983, Sisco 1990, King 1993, Hicks et al. 1999, and Meiman et al. 2003). It is important to note, however, that older forest structural attributes had been retained or regenerated in most of the harvest areas used for nesting or roosting. Three of the four studies that documented nesting in harvest areas described the nest stands as mature or old forest or an equivalent classification (USFS Region 5 "suitable habitat"; "understory reinitiation phase…of stand development"). The other study did not describe the harvest area used for nesting (King 1993). Harvest areas used for roosting in three studies likewise were either classified as mature or old forest (Solis 1983) or contained some older-forest structural characteristics, such as relatively high basal area or dense canopy cover (King 1993, Meiman et al. 2003). Two studies observed roosting in harvested stands that appeared to differ from this pattern; but one of the authors thought that the deaths of three birds that roosted in them were due to higher predation risk in the more open stands (Sisco 1990, Hicks et al. 1999).

Most of the reviewed studies found that spotted owls foraged to some degree in uneven-age harvested, partially harvested, or thinned areas. Irwin et al. (2005, 2008) stated that some NSOs

in their study areas selectively used certain harvest units but not others. However, they did not provide quantitative comparisons of prescriptions, post-harvest conditions, or proximities of harvest units to activity centers. Two other studies found that spotted owls generally avoided foraging in areas that recently experienced moderate to intensive partial harvesting or thinning, whereas use of lightly harvested areas varied among individuals (Anthony and Wagner 1999, Gallagher 2010). Anthony and Wagner (1999) found that NSOs (n = 15) in southern Oregon foraged in heavy and moderate partial-cuts less than expected (old stands with ≥30-40% of the original basal area removed and ≥"moderate" canopy cover reduction). Light partial-cuts (old forest with ≤20% of the original basal area removed and "small" reductions of "crown cover" [not described]) were used more than expected by two owls, as often as expected by five, and less than expected by eight. In the northern Sierra Nevada, Gallagher (2010) found that CSOs (n = 9) used heavily thinned "defensible fuel profile zones" (canopy cover reduced to 40%, removal of trees <30 in DBH, reduction of tree density and ladder and surface fuels) less than expected based on availability. She also reported a near-significant tendency ($p = 0.08$, n = 5) for avoidance of areas recently treated with understory thinning. Use and availability of harvest areas varied among individuals. Most individuals exhibited avoidance of defensible fuel profile zones and understory thins but one male showed strong selection for thinned areas (primarily understory thins). It is possible that thinning improved prey availability or otherwise benefited this male. However, Gallagher (2010) noted that thinning treatments were located unusually close to this male's activity center, which potentially increased his likelihood of using them due to central place foraging. She also noted that an unusually large proportion of understory thin units in the male's home range were also treated with prescribed fire, which could have temporarily increased abundances of deer mice (*Peromyscus* spp.) or other prey.

The limited available information suggests that thinning and uneven-age harvesting causes some spotted owls to increase their home range sizes, which could impose energetic costs on individuals (Meiman et al. 2003, Gallagher 2010). Meiman et al. (2003) reported that a male NSO's breeding season home range in the Oregon Coast Range was slightly larger before commercial thinning than afterward but that its nonbreeding season home range was 2.3 times larger. The individual appeared to shift its breeding season core area to include less of the thinned area and its nonbreeding season core area was more than twice as large following thinning as it was prior to thinning. In the northern Sierra Nevada, Gallagher (2010) found that the home range sizes of CSOs (n = 9) significantly increased with greater total area of fuels treatments (defensible fuel profile zones and understory thinning). She also reported near-significant trends of increasing home range size with greater area of defensible fuel profile zone ($p = 0.08$) and group selection harvesting ($p = 0.06$).

Four studies reported that thinning or partial harvesting near nests or roosts displaced spotted owls from those areas (Forsman et al. 1984, King 1993, Hicks et al. 1999, Meiman et al. 2003; also J. Reid, pers. comm.). The only study to describe this effect for more than two NSOs suggested that pairs' responses to harvesting near their nests depended on the intensity of the harvest, whether or not habitat in the nest area was excluded from harvesting, and whether or not suitable alternative habitat was available within the home range (Forsman et al. 1984).

The US Fish and Wildlife Service has expressed support for widespread thinning to reduce the risk of severe wildfire in dry forests within the NSO's range (USFWS 2011a, 2012a). Our

review suggests that spotted owls are often resilient to wildfire (and may benefit from low severity or patchy fire in southern forests) but that extensive severe fire can negatively affect the species by reducing amounts and contiguity of nesting and roosting habitat (see *Threats: Wildfire*). This conclusion might appear to support widespread thinning to reduce the risk of large severe fires. However, preliminary findings of negative effects of thinning on the species and the overall lack of reliable information on the topic suggest that more research is needed before thinning is employed at broad scales within the NSO's range. If widespread thinning is applied prior to rigorous study of its effects, our review suggests that it should be conducted well away from NSO activity centers and focused in young, homogeneous stands that are less suitable for NSOs and where thinning might increase habitat heterogeneity or accelerate development of complex, older-forest structure for prey (Carey 2006; but see below regarding effects of thinning on primary prey species). Planning of treatments should also integrate regional or local information about relationships between wildfires and topography (see *Threats: Wildfire*), the composition of NSO diets or prey communities, and other ecological factors that could influence how thinning affects wildfires and NSOs.

Timber Harvest Effects on Prey

The primary prey for NSOs in California are dusky-footed woodrats (*Neotoma fuscipes*), northern flying squirrels (*Glaucomys sabrinus*), and tree voles (*Arborimus* spp.) (Zabel et al. 1995, White 1996, Ward et al. 1998, Farber and Whitaker 2005, Diller et al. 2010, Klamath National Forest, unpubl. data). Other important prey in the state (either in terms of frequency or biomass contributions to diets) include other voles (*Myodes californicus*, *Phenacomys* spp., and

Microtus spp.), deer mice (*Peromyscus* spp.), pocket gophers (*Thomomys* spp.), broad-footed moles (*Scapanus latimanus*), and juvenile brush rabbits (*Sylvilagus bachmani*) and snowshoe hares (*Lepus americanus*). These species have a broad array of habitat associations and thus, respond quite differently to timber harvesting and other forest disturbances (Zeiner et al. 1990). Below we focus solely on timber harvest effects on the three primary prey species for NSOs in California. It is important to acknowledge, however, that NSOs typically have broad diets (see diet studies cited above) and that other prey species may also influence spotted owl demographic rates (Ward and Block 1995, Rosenberg et al. 2003).

Dusky-footed woodrats can occur in relatively high abundances in old forest, particularly in riparian areas and other locations with a well developed understory or brush layer (Carey et al. 1992, 1999). However, they generally reach their highest abundances in stands of brushy pole-timber that develop following severe disturbances (Carey et al. 1992, 1999, Sakai and Noon 1993, Anthony et al. 2003, Hamm et al. 2007). Thus, intensive harvesting of intermediate-age stands can result in temporary increases in abundance of dusky-footed woodrats. There is little information regarding effects of less intensive harvesting on dusky-footed woodrats. Hamm and Diller (2009) rarely found dusky-footed woodrats in thinned stands on private timberlands in the Redwood Region. They suggested that thinning without prescribed burning was insufficient for promoting growth of the disturbance-adapted shrubs locally favored by the species (see *Threats: Wildfire* regarding short-term effects of fire on prey).

Densities and demographic rates of northern flying squirrels are positively associated with habitat elements found in forests (e.g., arboreal lichens, truffles, and snags: Rosenberg and

Anthony 1992, Carey 1995, Waters and Zabel 1995, Gomez et al. 2005, Meyer et al. 2005, Lehmkuhl et al. 2006). Thus, they are likely to respond negatively to intensive forms of timber harvesting (e.g., Waters and Zabel 1995). Northern flying squirrels are also generally sensitive to habitat fragmentation caused by intensive harvesting (Smith 2007). For example, Rosenberg and Raphael (1986) found that densities of northern flying squirrels in the California Klamath Province were substantially lower in the smallest and most insular habitat patches (due to surrounding clearcut harvesting) than in the largest and best connected patches.

Research concerning the effects of thinning and other lower-intensity forms of harvesting on northern flying squirrels has generated inconsistent results (e.g., Carey 2000, Ransome and Sullivan 2002, Ransome et al. 2004, Gomez et al. 2005, Manning et al. 2012). Some of the inconsistency appears to be due to whether treated young stands are compared with structurally simple young stands (e.g., Gomez et al. 2005), structurally complex young stands (e.g., Carey 2000), or stands that have not recently experienced harvesting (Holloway and Smith 2011). The available research suggests that treated stands are more likely to contain relatively low abundances of northern flying squirrels when compared with structurally complex or mature and old stands, whereas they may exhibit similar or even higher abundances when compared with structurally simple young stands. Harvest intensity and levels of retention appear to be another major determinant of thinning effects on northern flying squirrels, with higher intensity thinning (lower retention levels) having stronger negative effects (Meyer et al. 2007, Holloway and Smith 2011, Manning et al. 2012; but see Ransome et al. 2004). Whether thinning is patchy or uniform (in terms of location and intensity) might also be important. For example, thinning can reduce the availability of truffles, the northern flying squirrel's primary food, for more than 10-20 years;

but variable-density thinning appears to be less harmful than commercial thinning (Waters et al. 1994, Colgan et al. 1999, Luoma et al. 2003, Meyer et al. 2005).

Tree voles generally occur at higher densities in old forests than in young forests (reviewed in Sztukowski and Courtney 2004, USFWS 2011b) and selectively use forests containing higher concentrations of habitat elements typically found in older stands (e.g., older stand age, larger diameter downed wood, greater basal area: Dunk and Hawley 2009). Tree voles are thought to be highly vulnerable to logging and other disturbances that reduce the extent and contiguity of old forests (Carey 1991, Huff et al. 1992, Hayes 1996, Adam and Hayes 1998, USFWS 2011b). Some tree vole populations occur in intensively managed landscapes with little or no old forest (e.g., Thompson and Diller 2002). However, the US Fish and Wildlife Service (2011b) noted that "the limited evidence available suggests that tree vole occupation of younger forest stands may be relatively short-lived (Diller 2010, pers. comm.) or intermittent (Hopkins 2010, pers. comm.)." Based on the natural histories of these species, reducing or fragmenting older forest could negatively affect them; but retention of older Douglas-fir (*Pseudotsuga menziesii*) trees and patches of well-connected canopy might ameliorate those impacts (Hayes 1996, Adam and Hayes 1998, USFWS 20011b). Clear-cutting and other severe disturbances should have the strongest effects on tree voles, due to the species' diet, nesting habitat associations, arboreal mode of travel, and apparently poor mobility (USFWS 2011b).

Habitat Lost to Past Timber Harvesting (1800s to 1994)

Rigorous research has shown that the fitness of NSOs in the southern part of their range is highest in landscapes with large concentrations of suitable breeding habitat (reviewed above). Herein we review information showing that the current availability of suitable breeding habitat was strongly affected by past timber harvesting, which removed or modified the majority of old forest that existed historically.

We are unaware of any estimates of the amount of suitable NSO habitat that existed at the time of Euro-American settlement (early to mid-1800s). Nesting-roosting habitat for NSOs generally occurs in relatively old, structurally complex conifer forest (Blakesley 2004). It is therefore, reasonable to evaluate historical trends in old conifer forest as a rough proxy for changes in amounts of suitable NSO habitat (USFWS 1990). Estimates reviewed for the NSO's federal listing determination indicated that approximately 18-24 million acres of old forest existed in western Oregon and Washington and northwestern California during the early to mid-1800s (USFWS 1990). These estimates did not include all regions or potentially suitable forest types within the subspecies' range. After including all regions and conifer forests, Strittholt et al. (2006) estimated that about 40 million acres of old conifer forest (>150 yrs) existed at the time of Euro-American settlement (Table 2). This is a crude approximation, as it is based on incomplete historical information and an assumption that nearly all pre-settlement conifer forest was old (i.e., had not experienced severe disturbance within the previous 150 years). However, Strittholt et al. (2006) noted that their regional estimates closely matched previous estimates for similar

regions and forest types, suggesting that they provide a reasonable baseline for comparison with contemporary forest conditions.

Using satellite imagery, Strittholt et al. (2006) estimated that 11.5 million acres of old conifer forest existed in 2000 (Table 2). Thus, approximately 72% of old conifer forest was lost in the Pacific Northwest during the 19th and 20th centuries (Table 2). This estimated post-settlement loss of old conifer forest is similar to earlier estimates of 60-88% reviewed in the NSO's federal listing determination (USFWS 1990). Strittholt et al. (2006) did not provide estimates of old forest declines by political boundaries so we cannot report their estimates for California alone. Old conifer forests declined by 62% in the Klamath provinces ("Klamath-Siskiyou Forests") and 79% in the eastern Cascades provinces ("Eastern Cascades Forests"), both of which substantially overlap with the NSO's range in northern California. Other than in two small regions surrounding major population centers in Washington and Oregon, declines in old conifer forest were primarily caused by widespread intensive logging (Strittholt et al. 2006). Mountainous terrain in the Klamath and eastern Cascades limited timber harvesting compared with more accessible areas but major losses of old conifer forest nonetheless occurred in those areas (Strittholt et al. 2006). Strittholt et al. (2006) did not evaluate trends in amounts of old forest for the Redwood Province but other sources estimated that 85-96% of old redwood forest was lost to intensive timber harvesting during the post-settlement period (USFWS 1992).

Table 2: Area (ha) of Pacific Northwest ecoregions and estimated historical (early to mid-1800s) and contemporary (2000) extents of old (>150 yrs) and mature (50-150 yrs) conifer forest within them (from Strittholt et al. 2006).

	Cascade Mountain Leeward Forests	*North Cascades Forests*	*Puget Lowland Forests*	*Central Pacific Coastal Forests*	*Central & Southern Cascades Forests*	*Eastern Cascades Forests*	*Klamath-Siskiyou Forests*	*Willamette Valley Forests*
Ecoregion area	1,600,444	1,278,056	1,719,726	4,267,988	4,481,279	5,398,139	5,033,181	1,487,769
Historical old conifer area	960,279	766,844	1,289,794	3,627,790	3,361,005	3,238,883	2,516,625	371,942
Percentage of ecoregion	60	60	75	85	75	60	50	25
Current old conifer area	420,394	511,396	67,353	668,281	1,328,796	687,836	946,394	34,993
Percentage of historical old conifer	44	67	5	18	39	18	38	9
Percent change	−56	−33	−95	−82	−61	−79	−62	−91
Mature conifer area	285,441	203,994	229,634	683,098	899,266	947,215	1,239,586	270,362
Percentage of historical old conifer	30	27	18	19	27	25	49	73
Combined area	705,835	715,391	296,987	1,351,379	2,228,063	1,635,051	2,185,980	305,355
Percentage of historical old conifer	74	93	23	37	66	43	87	82

Strittholt et al. (2006) reported that the majority of old (78%) and mature (50%) conifer forest in 2000 existed on public lands. Nearly all of the remaining old redwood forest likewise occurs on public lands (cite *[http://www.nps.gov/redw/faqs.htm]*). Much of the current difference among ownerships in amounts of older forest and suitable breeding habitat is due to past timber harvest rates. For example, loss of forest to harvesting during the 1970s through early 1990s occurred at substantially higher rates on private timberlands than on federal lands (e.g., >2 times faster in western Oregon) (Cohen et al. 2002, Staus et al. 2002, Healey et al. 2008). Nonetheless, an estimated 32% of suitable breeding habitat for NSOs occurred on non-federal lands at the time of the Northwest Forest Plan's implementation (1994), so conservation efforts for NSOs on non-federal lands remain important.

Although timber harvesting was substantially curtailed on federal lands following implementation of the Northwest Forest Plan (Healey et al. 2008, Kennedy et al. 2012; reviewed below), biologists noted the possibility that NSOs would continue to decline for many years due to lag effects of past harvesting (Courtney et al. 2004). The NSO has a relatively low

reproductive rate and might therefore be unable to immediately recover following removal or reduction of threats (Noon and Biles 1990). Furthermore, substantial recruitment of old forest and suitable nesting-roosting habitat could take multiple decades in areas that formerly experienced widespread intensive harvesting (Moeur et al. 2011; see below). Past harvesting could therefore be among the causes of continuing poor demographic performance of some NSO populations (Courtney et al. 2004). Forsman et al. (2011) noted, however, that some populations are declining on lands not previously subjected to widespread intensive timber harvesting (e.g., some National Parks). Based on this observation, they concluded that lag effects of past timber harvesting poorly explain continuing population declines. Yet, it is possible that lag effects of past timber harvesting do contribute to some population declines but that these effects are obscured by those of other stressors, such as competition with barred owls or large severe wildfires. Lag effects from past harvesting might be similarly obscured on private timberlands by impacts from barred owls and continuing timber harvesting. Timber harvesting continues to occur at high rates on private lands and is still the primary source of habitat loss for NSOs in those areas (Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012).

Comment [UFS9]: Define "high" rate

Habitat Lost to Contemporary Timber Harvesting (1994-2007)

Davis and Dugger (2011) estimated NSO habitat trends following implementation of the Northwest Forest Plan. Their analyses were mostly limited to federal lands within the Plan area but they also estimated habitat trends on non-federal lands, as reported in the current NSO recovery plan (USFWS 2011a). In addition to these analyses, we review results presented by Moeur et al. (2011) because they provide some additional insight into recent habitat trends for

NSOs on non-federal lands. We do not review habitat trend estimates based on federal ESA Section 7 consultation records (Bigley and Franklin 2004, USFWS 2012b). These records provide a less consistent and complete data source than those used by Davis and Dugger (2011) (see Bigley and Franklin 2004). They may also overestimate habitat changes since they evaluate effects of planned projects, which may be greater than what is actually implemented (Bigley and Franklin 2004).

Davis and Dugger (2011) used remotely sensed (satellite imagery) vegetation data to model changes in habitat suitability for NSOs during the first 15 years of the Northwest Forest Plan (1994-2007 in California and 1996-2006 in Oregon and Washington). They modeled habitat suitability based on habitat attributes surrounding thousands of NSO pair locations. Suitable breeding habitat was defined as having both a probability of owl presence greater than expected based on random chance and environmental conditions typical of those found around nesting and roosting pairs. Habitat loss was defined as a change in suitability rank from suitable or highly suitable to marginal or unsuitable due to vegetation changes caused by forest disturbances. Davis and Dugger (2011) did not estimate recruitment of, or net changes, in breeding habitat. They felt that their remotely sensed data poorly captured the kinds of slow and subtle habitat changes that occur during development of intermediate-aged and older stands. However, Moeur et al. (2011) estimated trends in mature and old forests during the same time period, which could provide insight into net changes in breeding habitat for NSOs.

Comment [UFS10]: And forest inventory plot data

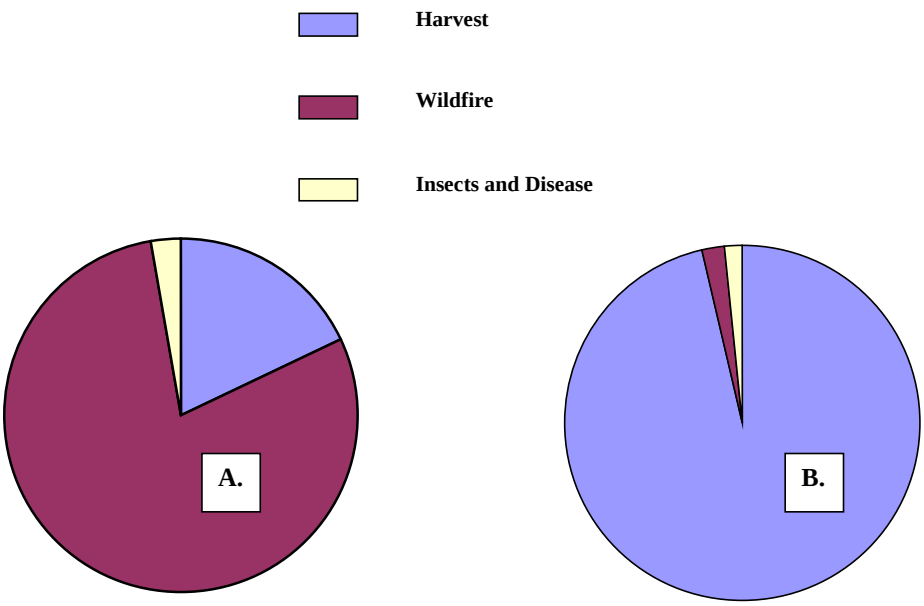
Table 3 shows estimated gross losses of suitable NSO breeding habitat to timber harvesting on federal and non-federal lands during the first 15 years of the Northwest Forest Plan (Davis and

Dugger 2011, USFW 2011a). Timber harvesting was responsible for a gross loss of about 54,000 acres (0.6%) of suitable breeding habitat on federal lands. This loss likely had little rangewide effect on NSOs but could have impacted the subspecies at local or regional scales. For example, harvesting resulted in a 3% gross loss of suitable breeding habitat on federal lands in the California Cascades, where habitat was already relatively limited. Approximately 92% of total suitable breeding habitat lost to timber harvesting occurred on non-federal lands. In contrast with federal lands, nearly all estimated gross habitat loss on non-federal lands was due to timber harvesting rather than natural disturbances (Figure 1; see *Threats: Wildfires*). In just 11-13 years, timber harvesting caused an estimated rangewide gross loss of 625,600 acres (15%) of suitable breeding habitat on non-federal lands. The largest losses on non-federal lands occurred in Oregon (301,200 ac, 22%) and Washington (234,200 ac, 19%). Non-federal lands in California experienced lower gross losses of suitable breeding habitat to harvesting (90,200 acres, 6%). Nonetheless, losses in all three states were substantial given the short time frame during which they occurred and the likelihood that little of the loss was offset by recruitment of suitable breeding habitat during that period (see below).

Table 3: Estimated gross losses of suitable NSO breeding habitat on federal and non-federal lands due to timber harvesting during 1994-2007 in California and 1996-2006 in Oregon and Washington (adapted from Davis and Dugger 2011, USFWS 2011a).

State	Ownership	Province	1994/1996 Ac	Harvest Ac	Harvest %
California	**Federal**	CA Cascades	213,200	6,500	3.0%
		CA Klamath	1,489,800	4,400	0.3%
		CA Coast	145,400	300	0.2%
		CA Federal Total	**1,848,400**	**11,200**	**0.6%**
	Non-Federal		**1,556,700**	**90,200**	**5.8%**
	Combined		**3,405,100**	**101,400**	**3.0%**
Oregon	**Federal**	OR Coast Range	611,200	3,300	0.5%
		Western OR Cascades	2,258,700	13,900	0.6%
		Eastern OR Cascades	402,900	5,800	1.4%
		Willamette Valley	3,400	100	2.9%
		OR Klamath	985,000	6,800	0.7%
		OR Federal Total	**4,261,200**	**29,900**	**0.7%**
	Non-Federal		**1,382,400**	**301,200**	**21.8%**
	Combined		**5,643,600**	**331,100**	**5.9%**
Washington	**Federal**	Olympic Peninsula	763,100	500	0.1%
		Eastern WA Cascades	673,600	8,100	1.2%
		Western WA Cascades	1,283,000	3,700	0.3%
		Western WA Lowlands	24,700	400	1.6%
		WA Federal Total	**2,744,400**	**12,700**	**0.5%**
	Non-Federal		**1,258,900**	**234,200**	**18.6%**
	Combined		**4,003,300**	**246,900**	**6.2%**
Rangewide	**Federal**		**8,853,800**	**53,800**	**0.6%**
	Non-Federal		**4,198,000**	**625,600**	**14.9%**
	Combined		**13,051,800**	**679,400**	**5.2%**

Figure 1: Proportions of suitable breeding habitat loss attributed to harvesting, wildfire, and insects and diseases on (A) federal lands and (B) non-federal lands during 1994-2007 (adapted from Davis and Dugger 2011 and USFWS 2011a).



The USFWS (2011a) and Davis and Dugger (2011) did not describe regional habitat trends for non-federal lands. However, insight into regional habitat trends on non-federal lands can be obtained from trends in mature and old forest during the same time period. Moeur et al. (2011) reported substantial gross losses of mature and old forest (mean DBH ≥20 in) on non-federal lands during the first 15 years of the Northwest Forest Plan. The largest gross losses, in terms of acreage, occurred in the Western Washington Lowlands (387,200 ac, 49%), Oregon Coast Range (362,500 ac, 50%), and California Coast Range (259,000 ac, 35%). All provinces and states within the NSO's range experienced large proportional losses, ranging from 31% in the Eastern Washington Cascades to 48% and 52% in the Klamath and Eastern Cascades of Oregon. Confirming the results of Davis and Dugger (2011; Figure 1), Moeur et al. (2011) found that gross losses of mature and old forest on non-federal lands were almost entirely due to timber harvesting (also see Kennedy et al. 2012).

Moeur et al. (2011) reported that gross loss of mature and old forest was substantially offset by recruitment into that habitat class. They noted, however, that given the short length of the monitoring period (10-14 yrs), recruitment was "likely due to incremental stand growth over the 20-in diameter threshold, or from understory disturbances that removed smaller diameter trees and raised the average stand diameter above the threshold, rather than from an increase in forests of much larger and older trees." Thus, it is unlikely that there was substantial recruitment of suitable and highly suitable breeding habitat for NSOs during this time period. This conclusion is supported by Davis and Dugger (2011), who found that most of the detectable habitat recruitment during their monitoring period occurred in the marginal suitability class, which more closely resembled their definition for dispersal habitat than for breeding habitat. Even if all

mature and old forest recruited during the first 15 years of the Plan provided suitable breeding habitat for NSOs, non-federal lands in California still experienced a net decline in area of mature and old forest during that period, and those in Washington and Oregon fared substantially worse (Moeur et al. 2011).

Future Harvesting in California

It is impossible to provide reliable projections of future timber harvesting or its effects on NSOs in California. Federal agencies have expressed support for widespread thinning to address wildfire risk on public lands in the state but we are unaware of any projections for harvest volume or effects on NSOs from these activities (USFWS 2011a, 2012a). Documents associated with Habitat Conservation Plans for private timberlands in California project substantial impacts of harvesting on some ownerships and relatively low impacts on others (see *Legal and Regulatory Framework* and *Threats: Inadequacy of Regulatory Mechanisms*). However, many landowners, in the state, including some large industrial timber companies, conduct timber harvesting outside of Habitat Conservation Plans. The state requires evaluation of potential environmental impacts of all Timber Harvest Plans but both landowners and responsible agencies have used inconsistent methods for conducting these evaluations. For example, some entities have strictly adhered to the state's Forest Practice Rules (CAL FIRE 2013), others have relied on poorly described and vetted variants of those rules (e.g., option "g+"), and still others have opted to follow US Fish and Wildlife Service (2009) recommendations. Based on an in-depth review of research concerning the NSO's habitat and spatial relationships, the US Fish and Wildlife Service (2009) recommended sweeping changes to NSO habitat retention guidelines in

the Forest Practice Rules for California's northern interior (CAL FIRE 2013). These recommendations are more scientifically supportable than are habitat retention guidelines in the Forest Practice Rules (CAL FIRE 2013), as they incorporate the large body of research of NSO-habitat relationships conducted since 1992 when guidelines in the Forest Practice Rules were created. In addition they were designed to enable CAL FIRE personnel lacking expertise with NSO-habitat relationships to properly determine if take would occur. However, the state has not officially adopted these recommendations or any other changes that incorporate the tremendous body of information about NSO-habitat relationships produced since 1992 (USFW 2009; see *Threats: Inadequacy of Regulatory Mechanisms*). Furthermore, since 2008, when the US Fish and Wildlife Service largely ceased providing technical assistance with timber harvest reviews in northern California, relatively few Timber Harvest Plans have been reviewed by personnel with sufficient biological expertise to evaluate whether or not take will occur (see *Threats: Inadequacy of Regulatory Mechanisms*). Lacking reliable harvest and take projections, and barring a major change in the legal or regulatory framework protecting NSOs, there is currently no reason to conclude that timber harvest effects on NSOs in California will substantially decline in the near future.

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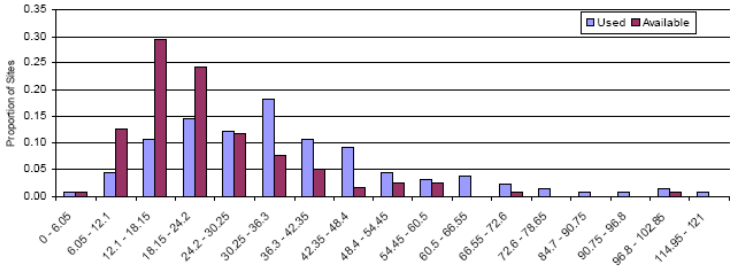
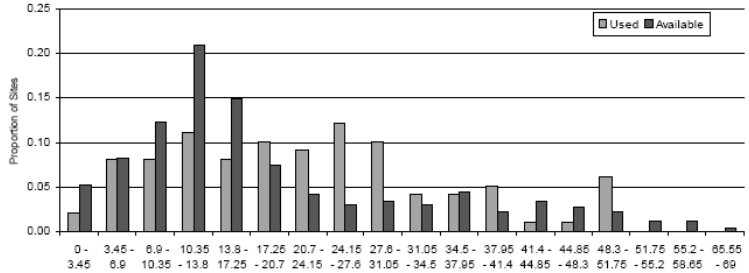
Appendix 1

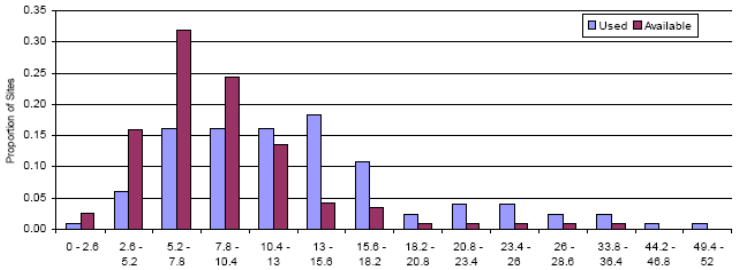
USFWS GNN (see USFWS 2011) histograms showing use by NSOs versus availability of select habitat attributes at a landscape-scale (200 ha, 494 ac) on Mendocino Redwood Co. (left column) and Green Diamond Resource Co. lands (right column).

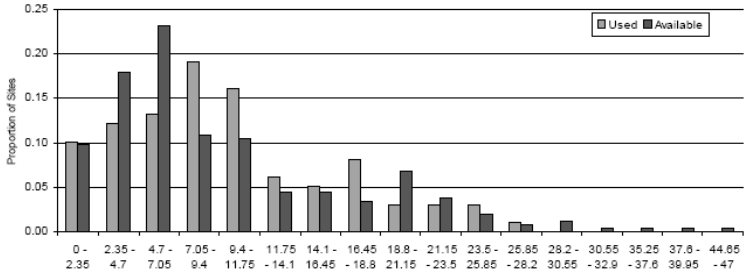
Live conifer trees per hectare ≥20 inches DBH:





Basal area of live conifers ≥20 inches DBH:

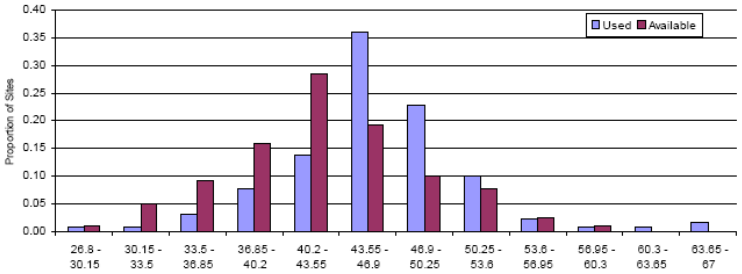


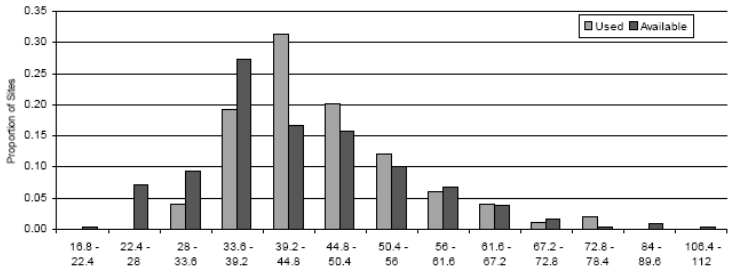


Appendix 1 (continued)

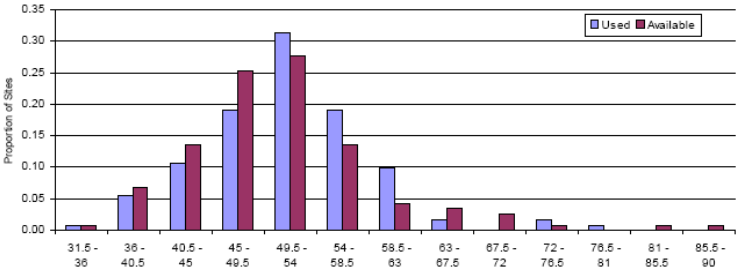
USFWS GNN (see USFWS 2011) histograms showing use by NSOs versus availability of select habitat attributes at a landscape-scale (200 ha, 494 ac) on Mendocino Redwood Co. (left column) and Green Diamond Resource Co. lands (right column).

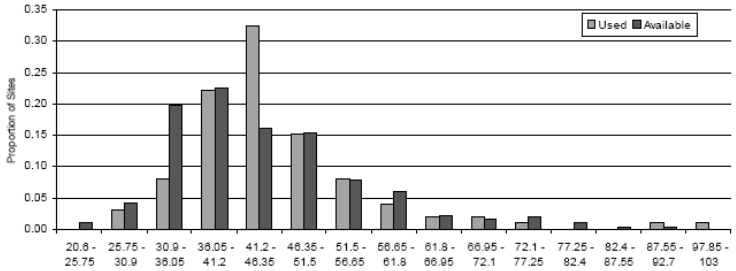
Basal area weighted mean diameter of all live conifers:





Basal area weighted stand age:

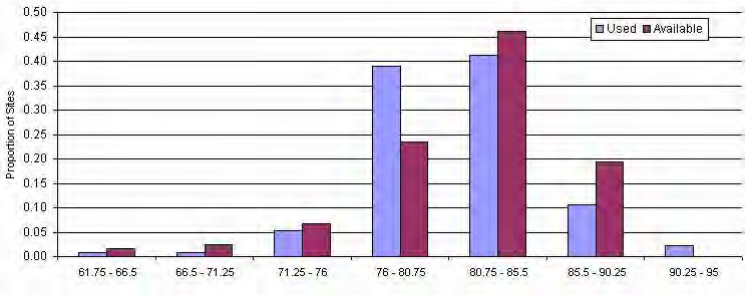


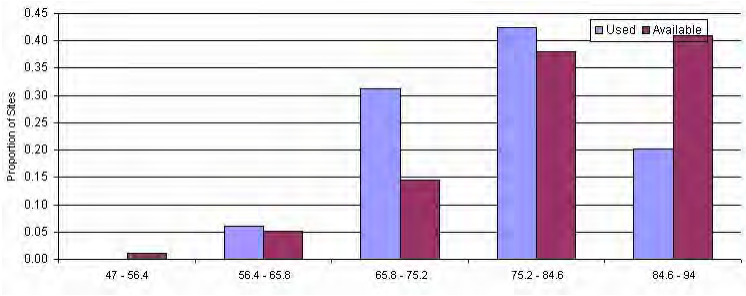


Appendix 1 (continued)

USFWS GNN (see USFWS 2011) histograms showing use by NSOs versus availability of select habitat attributes at a landscape-scale (200 ha, 494 ac) on Mendocino Redwood Co. (left column) and Green Diamond Resource Co. lands (right column).

Canopy cover:





Appendix 2

"Deconstructed" habitat suitability modeling (see text) for NSOs in the Redwood Province showing mean (SD, CV) values of select habitat structural attributes at the 200 ha (494 ac) scale by relative habitat suitability rank (USFWS 2011, unpubl. data).

Variable	Relative Habitat Suitability					
	Very Low	**Low**	**Med. Low**	**Med.**	**Med. High**	**High**
Strength of Selection*	-9.2	-2.9	-1.3	1.6	3.2	8.6
Percent of Region	16.3	24.5	26.2	22.4	9.7	0.9
Nesting-Roosting (ha)	57.9 (43.2, 75)	69.4 (40.8, 59)	79.9 (37.3, 47)	87.6 (33.6, 38)	94.3 (31.1, 33)	105.5 (30.8, 29)
Canopy Cover All Trees (%)	71.2 (23.2, 33)	75.2 (20.7, 28)	78.9 (18.1, 23)	81.0 (16.2, 20)	82.1 (15.5, 19)	82.9 (15.7, 19)
Canopy Cover Conifer (%)	43.9 (31.8, 72)	48.8 (30.0, 61)	53.4 (28.3, 53)	57.4 (27.2, 47)	61.4 (26.5, 43)	64.6 (26.4, 41)
BA Conifers ≥50 cm (m^2/ha)	10.6 (20.7, 195)	12.5 (23.0, 184)	14.1 (24.8, 176)	15.2 (25.6, 168)	17.6 (30.1, 171)	25.2 (45.9, 182)
BA Live Trees ≥75cm (m^2/ha)	7.3 (17.6, 241)	8.5 (20.1, 236)	9.3 (21.8, 234)	9.3 (22.4, 241)	10.4 (27.1, 261)	17.0 (44.0, 259)
Density Trees ≥50 cm (no./ha)	32.3 (37.3, 115)	36.1 (38.4, 106)	39.8 (40.0, 101)	42.5 (42.1, 99)	45.4 (44.5, 98)	50.0 (46.1, 92)
Density Trees ≥75 cm (no./ha)	8.2 (14.8, 180)	9.2 (15.6, 170)	9.9 (16.0, 162)	10.0 (15.5, 155)	10.4 (15.3, 147)	12.8 (16.8, 131)
Density Conifers ≥50 cm (no./ha)	22.1 (34.7, 157)	25.5 (36.4, 143)	28.9 (38.3, 133)	32.6 (40.7, 125)	37.3 (43.6, 117)	43.1 (45.6, 106)
Density Conifers ≥ 75 cm (no./ha)	6.6 (14.5, 220)	7.6 (15.4, 203)	8.4 (15.7, 187)	8.7 (15.2, 175)	9.4 (15.1, 161)	12.0 (16.7, 139)
Density Conifers ≥100 cm (no./ha)	2.5 (7.7, 308)	2.9 (8.4, 290)	3.2 (8.8, 275)	3.1 (8.3, 268)	3.2 (8.5, 266)	4.7 (10.4, 221)
Mean DBH Conifers by BA (cm)	42.8 (34.5, 81)	48.5 (35.5, 73)	51.7 (35.4, 68)	52.1 (34.0, 65)	52.9 (36.1, 68)	60.8 (51.1, 84)
QMD Dominant/Codominant Conifers (cm)	35.7 (29.1, 82)	40.2 (29.9, 74)	42.7 (29.7, 70)	42.6 (28.3, 66)	42.7 (29.7, 70)	48.1 (41.5, 86)

*Strength of selection calculated as the proportion of activity centers in a habitat suitability class divided by the proportion of the modeling region in that class.

September 5, 2014

Ken Hoffman's Peer Review of Timber Harvesting threat section:

Pg. 2

Non-federal lands contain the majority of the remaining breeding pairs of NSO. Not just the breeding habitat. There are more NSO in the Redwood zone on private land in Cali9fornia than the rest of the species range combined. Redwood NSOs are the last source population.

Pg. 7

"Most of the published research" or "a large amount of research" should replace "most of what is known"

'Diller et, al. 2010' is an unpublished document. Non-peer reviewed annual report.

Pg. 8

"Small patch clear-cutting"? WTF?

"Harvesting of suitable habitat (i.e. take)" should say "occupied" habitat.

Pg. 9

"Less is known"? A great deal is known. Less is published.

Pg. 10

Private timberland is divided almost equally between industrial and non-industrial. Most non-industrial timberland is uneven-aged managed – not uneven-aged regenerated.

Pg. 10-14

Thinning on National Forests occurs in even-aged stands surrounded by a sea of suitable habitat. Thinning on private land occurs either in long-term NTMPs or on industrial timberland which is a sea of unsuitable habitat.

Pg. 27

Market conditions drive harvest on non-industrial timberland. Industrial timberland is harvested on a schedule to keep mills in material.

-Thinning on Public land is insignificant for two reasons:

#1 Most NSO are on private land is in the Redwood zone

#2 Most Forest Service thinning occurs in a sea of suitable habitat.

HCPs all result in substantial impacts to NSO habitat and individuals through permitted take.

No mention of the USFWS guidance for the coast?

USFWS Technical Assistance almost immediately increased NSO habitat protections starting in 1999. Coastal guidance also far exceeds FPRs.

-Technical Assistance continued through 2008.

-Paper fails to recognize difference between industrial and non-industrial timber management.

Three Major Points

1. Redwood zone NSO is the last source population.
2. Redwood zone timberland is almost 50/50 industrial/non-industrial.
3. Inadequate regulatory mechanism and process for private land has been obvious since at least 1999.

Wildfire and Salvage Logging

Introduction

Recent status reviews have identified wildfire as a primary threat to the recovery of the northern spotted owl (NSO) (Courtney et al. 2004, USFWS 2011). Much of this concern was based on recent loss of suitable breeding habitat to wildfires and to the risk of extensive severe fires occurring in the future (Davis and Dugger 2011, USFWS 2011). Other researchers and stakeholders have questioned the scientific basis of claims that wildfires pose a threat to NSOs and have expressed distrust of agency recommendations for widespread use of forest thinning to reduce fire risk (e.g., Hanson et al. 2009, Heiken 2010, DellaSala et al. 2013).

There is currently limited information with which to evaluate responses of spotted owls to wildfires and post-fire salvage logging. This research suggests that wildfires have variable and complex effects on the species (Table 1). This is unsurprising given differences in wildfires, research methods, study areas, and spotted owl subspecies and populations. Nonetheless, patterns are evident in the literature concerning spotted owl responses to wildfires and salvage logging and these can be evaluated in light of the species' habitat and prey relationships. Currently available research suggests that low-to-moderate or mixed-severity wildfires have limited effects on spotted owls (Table 1). In fact, such fires could benefit NSOs in southern forests by contributing to landscape-level habitat heterogeneity associated with high fitness (Franklin et al. 2000). In contrast, large-scale severe (stand-replacing) fire can have strong negative effects on spotted owls (Table 1). This likely occurs when fires excessively modify,

reduce, or fragment concentrations of suitable nesting and roosting habitat needed for reproduction and survival (Franklin et al. 2000, Dugger et al. 2005, Schilling et al. 2013). Negative effects of extensive severe wildfires appear to be exacerbated by post-fire salvage logging, which structurally simplifies burned areas, removes important habitat legacies for prey, and creates high contrast habitat edges that educe spotted owls' use of burned areas (Clark 2007, Lee et al. 2012, 2013, Clark et al. 2013, Comfort 2013).

Regardless of scientific uncertainty regarding spotted owl responses to wildfire, it is clear that recent large wildfires have caused tremendous loss, degradation, and fragmentation of suitable habitat for NSOs on federal lands (Davis and Dugger 2011, USFWS 2011; also see Healey et al. 2008, Moeur et al. 2011). This is cause for concern since recovery of the subspecies largely relies on habitat protection on federal lands (USFWS 2011). Furthermore, much of the climate change research indicates that wildfires will continue to be a source of large-scale habitat change during coming decades (Westerling et al. 2006, Lenihan et al. 2008, Westerling and Bryant 2008, Littell et al. 2009). These concerns have prompted ecologists and federal agencies to advocate widespread forest thinning to reduce wildfire risk within the range of the NSO (USFWS 2008, 2011, 2012a, Franklin and Johnson 2012). However, the limited information currently available suggests that spotted owls often respond negatively to forest thinning (reviewed in Hansen and Mazurek 2010, USFWS 2011; see *Threats: Timber Harvesting*). Further research is needed to determine whether and how widespread thinning should be used in forests occupied by NSOs. Currently available information suggests that spotted owls tolerate, and possibly benefit from, low severity or patchy fire (Bond et al. 2002, 2009, Roberts 2008, Roberts et al. 2011, Keane et al. 2011, 2012, Lee et al. 2012, 2013, Comfort 2013). Thus, the current body of research

Comment [UFS1]: Not just continue, but become an increasing source…See Moritz et al. 2012, Dennison et al. 2014, Stavros et al. 2014 as additional references.

Comment [UFS2]: Perhaps couch NSO effects in terms of duration/time (e.g., short-term vs long-term). Much of the problem you write about here will be on how to balance the two.

Comment [UFS3]: Timber harvesting, which has mostly shifted from regeneration to thinning, was and is planned to occur under the NWFP (owl's range). Thinning is not always proposed by the land management agencies to reduce risks of large wildfires and future fire loss of habitat. It is also designed to accelerate development of old forest structure and species composition. Also, it is important to remember that it is also proposed to provide economic inputs to the local economies, another NWFP objective.

So, this statement should read that **research is needed to help land managers understand the effects of thinning on NSO**. Not to determine whether the agencies should thin. The NWFP calls for it.

supports use of prescribed fire and allowing wildfires to burn under prescribed conditions in dry forests within the NSO's range, provided sufficient concentrations of suitable habitat are retained.

Comment [UFS4]: This conclusion seems out of place. You have not made the argument yet.

Wildfire Effects on Spotted Owls

Indirect Evidence

Research of associations between landscape-scale habitat attributes and the demography and presence of NSOs has consistently found that the subspecies benefits from some form of habitat heterogeneity in the southern portion of its range (e.g., ecotones or edges between different vegetation classes) (Franklin et al. 2000, Zabel et al. 2003, Olson et al. 2004, Dugger et al. 2005, Carroll and Johnson 2008, Diller et al. 2010, Schilling et al. 2013; reviewed in *Threats: Timber Harvesting*). Yet, these same studies have also strongly demonstrated the importance of large concentrations of suitable breeding habitat around activity centers (reviewed in *Threats: Timber Harvesting*). Based on this research, wildfires likely have positive effects on NSOs in California when they contribute to beneficial forms of habitat heterogeneity and negative effects when they substantially reduce or degrade suitable habitat around activity centers. Extensive severe wildfires have the potential to remove or fragment core concentrations of suitable breeding habitat across multiple NSO territories. These fires, therefore, have the greatest likelihood of substantially impacting NSO populations. ~~Other~~ Smaller, less severe wildfires may impact fewer territories and have weaker negative effects on populations, burn in a manner that contributes to

Comment [UFS5]: I think it is more "fire-prone" portions rather than southern. The east side of the Cascades in Washington as example.

Comment [UFS6]: Delete?

Comment [UFS7]: Might want to define what you mean by "severe". Studies have used different definitions, which sometimes causes confusion.

Comment [UFS8]: Be careful on use of the term "habitat", should also define this too… nesting/roosting?

beneficial forms of habitat heterogeneity in some territories, or have a combination of these effects.

Direct Evidence

Several studies have investigated responses of NSOs to wildfires (Table 1). These studies provide crucial information for evaluating ~~fire~~ wildfire as a potential threat to the subspecies. However, their inferences are limited due to small sample sizes in all cases, the confounding effects of post-fire salvage logging in one case, and pooling of data from all three spotted owl subspecies in another case (Table 1; see below). In order to supplement these studies, we also reviewed research of fire effects on California spotted owls (*S. o. occidentalis*; CSOs) and Mexican spotted owls (*S. o. lucida*; MSOs) (Table 1). Because inferences from these studies are also limited, and given differences among fires, spotted owl populations, and research methods, we reviewed each project as a "case study". Relatively thorough descriptions of these studies allow identification of patterns in the literature, which could provide insights into general effects of wildfires on the species.

Table 1: Apparent effects of wildfires on spotted owls. See text for additional descriptions of study methods and findings.

Response Metric	Study†	Subspecies	Location*	Apparent Effect**	Notes
Survival	*Bond et al. 2002*	NSO, CSO, MSO	CA, AZ, NM	0	Only one post-fire survey season
	Clark et al. 2011	NSO	OR KLA	-	Likely cumulative effect of timber harvesting, severe fire, and salvage logging
Productivity	Gaines et al. 1997	NSO	E WA CAS	0 (-?)	Apparently no decline but possibly obscured by low reproduction year across population; Possibly lower total reproduction in burned landscapes due to lower pair occupancy; Only one post-fire season
	Bond et al. 2002	NSO, CSO, MSO	CA, AZ, NM	0 (+?)	Slightly higher than in other studies; Only one post-fire season
	Clark 2007	NSO	OR KLA	0 (-?)	Apparently no decline but low statistical power; Possibly lower total reproduction in burned landscapes due to lower pair occupancy
	Roberts 2008	CSO	CA SIERRA		
Site Fidelity	*Bond et al. 2002*	NSO, CSO, MSO	CA, AZ, NM	0	Site fidelity similar to other studies
Occupancy	Elliot 1985	CSO	CA COAST	-	Apparent abandonment by two pairs
	Gaines et al. 1997	NSO	E WA CAS	-	Post-fire occupancy was lowest found during five-year study; Only one post-fire season
	Jenness et al. 2004	MSO	AZ, NM	-	Statistically insignificant effect; Pooled all fire types and severities
	Keane et al. 2011, 2012	CSO	CA SIERRA/CAS	-/0	Extensive high severity fire apparently had a strong negative effect; Extensive low severity fire apparently had a neutral or weak negative effect; Possibly influenced by salvage logging
	Roberts et al. 2011	CSO	CA SIERRA	-	Authors concluded weak effect but pooled all fire types and severities
	Lee et al. 2012	CSO	CA SIERRA	0 (-?)	Similar occupancy at burned vs. unburned; Possibly lower occupancy at severely burned vs. other burned
	Lee et al. 2013	CSO	SO CA	-/0	Similar occupancy at burned vs. unburned; Significant reduction with extensive high severity fire in core area
	Clark et al. 2013	NSO	OR KLA	-	Cumulative effect of timber harvesting, severe fire, and salvage logging
Home Range	Clark 2007	NSO	OR KLA	-	Larger home ranges post-fire
	Bond et al. 2013	CSO	CA SIERRA	0(?)	Similar home range sizes to unburned areas
Roosting	King et al. 1997	NSO	E WA CAS	-	Apparent avoidance of moderate and severe burns
	Bond et al. 2009	NSO	CA SIERRA	-	Significant avoidance of moderate and severe burns during breeding season
Foraging	Clark 2007	NSO	OR KLA	+(?)	Apparent weak selection of moderately burned suitable habitat; Possible weak selection for severely burned suitable habitat; Very low use and availability of both moderately and severely burned suitable habitat
	Bond et al. 2009	NSO	CA SIERRA	+	Significant selection of severe burns
	Eyes 2014	CSO	CA SIERRA		
Roosting and Foraging	Comfort 2013	NSO	OR KLA	-/+ (?)	Preference for small patches of severely burned/salvage logged and avoidance of larger patches; Weak preference for low contrast edges (ecotones) created by fire

†Peer-reviewed publications shown in italics. * Locations: California Klamath (CA KLA); Eastern Washington Cascades (E WA CAS); Oregon Klamath (OR KLA); California, Arizona and New Mexico (CA, AZ, NM); California Central Coast Range (CA COAST); California at margin of northern Sierra Nevada and southern Cascades (CA SIERRA/CAS); California Sierra Nevada (CA SIERRA); southern California San Bernardino and San Jacinto Mountains (SO CA). **Apparent Effect: negative (-), positive (+), neutral (0), varied with fire severity and/or scale (/)—see Notes column and text for further explanations.

Comment [UFS9]: Not statistically, I'd keep the "0" here and delete the "+"

Survival

Wildfires may influence spotted owl survival in both the short- and long-term. For example, spotted owls, like other wildlife, could be injured or killed by smoke during fires (Singer and Schullery 1989, Smith 2000). Due to their poor mobility, young spotted owls with undeveloped flight feathers may be at particular risk of mortality during wildfires (Smith 2000). In addition to potential immediate effects, extensive moderate or severe wildfire might influence spotted owl survival over the longer-term by modifying habitat for roosting, foraging, or prey (see below).

Only two studies are currently available for evaluating effects of wildfires on spotted owl survival rates (Bond et al. 2002, Clark et al. 2011; Table 1). Bond et al. (2002) reported that 18 of 21 (86%) marked spotted owls were resighted one year after wildfires occurred in California, Arizona, and New Mexico. This minimum survival rate was similar to survival estimates found by long-term studies of the three spotted owl subspecies in unburned landscapes (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data). Extensive severe fire (36-88%) occurred in four of the eight territories for which fire severity was mapped and the other half primarily burned at low to moderate severity. Thus, even extensive severe fire did not appear to have a large effect on spotted owl survival one year post-fire.

Clark et al. (2011) found evidence of a negative effect of wildfires and/or salvage logging on survival of 23 NSOs in the Oregon Klamath Province. Severe fire and/or post-fire salvage logging occurred in 30% and 41% of suitable NSO habitat in the two study areas. Estimated mean annual survival rates for NSOs located inside fire perimeters (0.69) and apparently

Comment [UFS10]: You should include "in press" results from Tempel et al.

High severity fire had negative effect on survival.

Their results suggest that reductions in the area of high-canopy forest (>70%) resulting from either logging or high-severity wildfire could reduce the viability of California spotted owl populations and may be contributing to ongoing declines in abundance and territory occupancy.

They recommended fuels Rx in dense stands while trying to avoid decreasing canopy too much.

This is good one for short vs long term effects.

Comment [UFS11]: Page 1026 of the paper states this, "Most (6 of 8) territories burned >50% at low to moderate severity."

So, two of the four that had 36-80% were <50%.

Comment [UFS12]: I disagree with this conclusion. Extensive, yes… severe, no.

They concluded that "spotted owls may have the ability to withstand the immediate, short-term (1-year) effects of fire **occurring at primarily low to moderate severities** within their territory.

displaced by fires and post-fire salvage logging (0.66) were lower than in areas just outside the fire perimeters (0.85) and in an unburned reference study area in the neighboring southern Cascades (0.85: Anthony et al. 2006). The degree to which post-fire salvage logging in the study areas influenced NSO survival rates is unknown. The study's occupancy analyses indicated that pre-fire timber harvesting, high severity wildfire~~s~~, and post-fire salvage logging cumulatively impacted NSOs through reductions of suitable nesting/roosting habitat (Clark et al. 2013; see below).

Apparently contradictory findings by Bond et al. (2002) and Clark et al. (2011) may be due to several factors. The most obvious difference between the studies is that the areas studied by Clark et al. (2011) experienced post-fire salvage logging while those studied by Bond et al. (2002) did not. The limited information currently available indicates that salvage logging negatively affects spotted owls (reviewed below). Additionally, the populations studied by Clark et al. (2011) may have been particularly sensitive to habitat loss to wildfires due to intensive pre-fire timber harvesting across a checkerboard ownership. It should also be noted that Bond et al. (2002) only examined wildfire effects one year post-fire. Fire injuries and post-fire outbreaks of insects and pathogens can continue to result in tree mortality for up to several years after a wildfire (Ryan and Amman 1996, Gaines et al. 1997, Hood et al. 2007).

Reproduction

The spotted owl is a relatively long-lived species that exhibits a bet-hedging life history strategy (Noon and Biles 1990, Franklin et al. 2000). This means that individuals often forego breeding

Comment [UFS13]: Based on this, their recommendation was to:
1) Increase protection of older forest in dry forest ecosystems to prevent future habitat loss to timber harvest and
2) Mitigate potential losses of older forest to stand-replacing fire and subsequent salvage logging

I assume that recommendation #1 refers to "nesting/roosting" habitat (a.k.a. older forest)

Comment [UFS14]: I hear and read this a lot. Upon careful reading of Bond et al. (2002), these two papers actually don't contradict each other. Bond et al. (2002) make no conclusion on high-severity wildfire. They only summarized effect (or lack thereof) on low-moderate severity wildfire.

In fact, Clark and Bond actually corroborate on low-moderate wildfire.

Please end this misconception here!

Comment [UFS15]: This is very misleading. I suggest deleting this sentence.

Clark et al. clearly present that high severity wildfire is 1 of 3 causes of loss of NSO N/R habitat.

Bond et al. show no effect from low-mod severity fire.

Comment [UFS16]: One reason why mitigation to reduce future wildfire losses is more important now.

If we had landscapes similar to what they were historically, prior to extensive harvesting, then large wildfires would not be so worrisome.

Comment [UFS17]: Good point. Another potential effect (from anecdotal observations in some of the demographic study areas) could be that sometimes a pair will stick around for a year or two after a wildfire removes extensive amounts of nesting/roosting habitat in their territory. Then eventually, the move on or disappear. We have observed this in a few cases. But again, that was due to high severity, not low-moderate.

Comment [UFS18]: Maybe put years here? It might give some needed context to "short-term" vs "long-term" effects.

during poor environmental conditions in order to maximize their chance of surviving and reproducing in the future. Given the species' life history strategy, spotted owl reproductive rates are likely sensitive to environmental changes, including those brought about by wildfires. However, annual fluctuations in spotted owl reproduction caused by variation in weather, prey populations, or breeding condition could obscure effects of wildfires or other factors on reproduction (e.g., Franklin et al. 2000).

We are aware of four studies that examined potential effects of wildfires on spotted owl reproduction (Gaines et al. 1997, Clark 2007, Bond et al. 2002, Roberts 2008; Table 1). None of these studies found substantive evidence of a wildfire-induced decline in reproduction by the species and one indicated a potentially positive effect. In the eastern Washington Cascades, Gaines et al. (1997) found little difference in productivity (number of young per pair) between burned (0.2; n = 5 or 6/ yr) and unburned sites (0.3; n = 13-17/yr) one year after a predominantly moderate to severe wildfire. However, the post-fire survey season clearly occurred during a poor reproduction year, potentially making it difficult to detect a difference between burned and unburned sites. Clark (2007) found no significant differences in productivity in burned areas in the Oregon Klamath Province (n = 31 territories) and an unburned study area in the neighboring southern Cascades (Anthony et al. 2006). He noted, however, that his study likely lacked the statistical power to detect a difference if one occurred. Bond et al. (2002) found that seven pairs of spotted owls produced an average of 1.0 offspring during a single breeding season following wildfires in California, Arizona, and New Mexico. This was higher than productivity rates found in unburned areas during long-term studies of the three spotted owl subspecies (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data). *Add discussion of Roberts (2008)…*

Comment [UFS19]: Not significantly higher, and they cautioned against drawing conclusions from this given high annual variation in reproduction as you state above.

You need to clarify this as it implies that burned areas resulted in higher reproduction. Or delete it and stick to findings that have some statistical backing, otherwise you chance confusing the readers.

Currently available studies suggest that wildfires generally have minimal short-term effects on spotted owl reproduction (Gaines et al. 1997, Clark 2007, Bond et al. 2002) and that primarily low-to-moderate severity fire could positively affect reproduction (Roberts 2008). However, it might be difficult to capture fire effects on spotted owl reproduction (whether positive or negative) during short-term studies, particularly with only a single year of post-fire data (Franklin et al. 2000). In addition, it is possible that solely comparing productivity (e.g., offspring per pair) in burned and unburned areas could obscure a change in total reproduction in burned areas. Studies in Washington and Oregon reported post-fire declines in occupancy by pairs, suggesting that extensive severe fire can reduce reproductive opportunities for spotted owls (Gaines et al. 1997, Clark 2007; see below).

Comment [UFS20]: Apparently no effect.

Comment [UFS21]: Repetitious, already stated

The limited research investigating spotted owl-prey relationships has found positive associations between spotted owl reproduction and abundances or consumption of dusky-footed woodrats (*Neotoma fuscipes*) (White 1996), deer mice (*Peromyscus* spp.) (Ward 2001 cited in Ward and Block 1995, Rosenberg et al. 2003), or a suite of prey with diverse habitat associations (Ward and Block 1995). Abundances of deer mice, pocket gophers (*Thomomys* spp.), and other "pioneer" or "early-successional" prey often increase following fires (Ream 1981, Zwolak and Foresman 2007, Zwolak 2009, Bond et al. 2013). Dusky-footed woodrats appear to initially respond negatively to severe fires (Schwilk and Keeley 1998, Smith 2000) but not to patchy low severity fire, although loss of nest houses might have a brief negative effect on reproduction (Lee and Tietje 2005). However, it is possible that severe fire benefits dusky-footed woodrats over longer time periods (e.g., ≥5-20 yrs) through creation of brushy habitat. Crown fires should

Comment [UFS22]: There's a new paper by Ganey et al. 2014. Relative abundance of small mammals in nest core Areas and burned wintering areas of Mexican spotted Owls in the Sacramento Mountains New Mexico

Species richness and relative abundance of small mammals were greater in the burned wintering areas than in the associated unburned nest core areas

Comment [UFS23]: You jump straight from reproduction to prey… might want to add new section or make connection to reproduction as it also affects other demographic parameters.

negatively affect abundances of prey associated with well-canopied forest, such as northern flying squirrels (*Glaucomys sabrinus*) and tree voles (*Arborimus* spp.). These, along with dusky-footed woodrats, are the primary prey for NSOs in California (reviewed in *Threats: Timber Harvesting*). Low severity fires could also negatively affect northern flying squirrels and other prey associated with closed canopy forests by reducing dead woody materials, fire-intolerant understory plants, and truffles (Lehmkuhl et al. 2006, Meyer et al. 2007). Thus, wildfires likely have complex effects on NSO prey communities, depending on local or regional differences in prey community composition; wildfire size, severity, and configuration; and the length of time vegetation has had to regenerate following fire.

Occupancy

Potential wildfire effects on NSO population rates are most directly evaluated with measures of survival and reproduction. However, occupancy data are often more logistically and economically feasible to collect than are demographic data and could provide an early indication of population trends (MacKenzie 2005, Olson et al. 2005). Spotted owl occupancy is sensitive to environmental factors (Blakesley et al. 2005, Olson et al. 2005) so it is a potentially valuable measure of wildfire effects on the species. Nonetheless, occupancy data must be interpreted carefully since they can be strongly influenced by survey effort, analytical methods, and the presence of barred owls (Olson et al. 2005).

We evaluated nine studies of wildfire effects on spotted owl occupancy (Table 1). As described below and in Table 1, seven of these provided evidence of a negative effect of either severe fire or fire in general.

Two studies indicated potentially negative effects of wildfires on spotted owl occupancy but included few territories (Elliot 1985, Gaines et al. 1997). In Monterey County, California, informal yearly surveys suggested that two pairs of CSOs abandoned their territories for at least four years following a wildfire (Elliot 1985). The author did not describe the fire other than noting that it was extensive and caused substantial damage to understories and oaks in the previously occupied areas. In the eastern Washington Cascades, Gaines et al. (1997) found that two of six NSO sites were occupied one year after a predominantly moderate to severe wildfire. This was the lowest occupancy rate found during the five-year study period.

Two studies found statistically weak evidence of a negative effect of fire on spotted owl occupancy, but their methods may have precluded detection of stronger effects (Jenness et al. 2004, Roberts et al. 2011). Jenness et al. (2004) found a statistically insignificant tendency (p = 0.11) for higher occupancy rank (in ascending order: no owls, singles, pairs, reproductive pairs) in unburned sites than in paired burned sites in Arizona and New Mexico (paired sites were close to each other and had similar habitat and topography). Of the 29 paired-site comparisons, 14 (48%) had a higher occupancy rank in unburned sites, 6 (21%) had a higher rank in burned sites, and 9 (31%) were tied. In the Sierra Nevada of California, Roberts et al. (2011) found lower occupancy rates for CSOs in burned areas than in unburned areas, but the difference was not statistically analyzed (unmodeled occupancy = 0.50 in burned and 0.69 in unburned; modeled

occupancy = 0.46 in burned and 0.72 in unburned). Modeling by both studies indicated that spotted owl occupancy was more strongly influenced by habitat composition or structure than by whether or not fire had recently occurred in territories. However, both studies may have underestimated the impacts of severe fire due to pooling of diverse fire types and severities for analysis (including prescribed fires, wildfires, and wildfires allowed to burn under prescribed conditions).

Two studies found evidence of strong declines in occupancy in areas recently burned by extensive severe wildfire but both may have been confounded by post-fire salvage logging (Keane et al. 2011, 2012, Clark et al. 2013). In southwestern Oregon, Clark et al. (2013) examined how extensive wildfires and subsequent salvage logging affected occupancy dynamics of NSO pairs. In their first analysis, the authors compared pre- and post-fire occupancy dynamics in a burned study area in the Oregon Klamath Province (n = 22) to those in an unburned area in the nearby southern Cascades (Anthony et al. 2006). Combined, high severity fire and salvage logging removed or modified 26% of suitable nesting/roosting habitat in landscapes surrounding NSO activity centers in this area. The burned and salvage-logged study area experienced a 64% reduction in site occupancy during the post-fire period, compared with a 25% reduction in the unburned study area (difference not statistically analyzed). In the second analysis, the authors examined possible effects of severe fire and salvage logging on occupancy dynamics in 40 territories located in three burned study areas in the Oregon Klamath Province. In these areas, 19-26% of suitable habitat was burned at high severity and/or salvage logged. During the study's three-year post-fire period, site extinction probabilities were as high as 72% in two combined study areas and 92% in the third area. Site extinction probabilities in the

Comment [UFS24]: Always state what kind of habitat. Nesting/roosting, foraging, or dispersal?

burned study areas were best explained by a model that included extents of high severity fire, salvage logging, and early seral forest. Models that included these variables separately were not competitive with the model containing all three variables, suggesting that NSO occupancy declined due to cumulative habitat loss from severe fire and pre- and post-fire timber harvesting (see Clark et al. 2013: Table 6). The relative influence of these factors on occupancy is unknown, but the role of severe fire cannot be dismissed. For example, the highest extinction probability (92%) occurred in a study area with little salvage logging (<2%) of previously suitable habitat.

Keane et al. (2011, 2012) estimated occupancy of CSOs in two recently burned study areas near the margin of the Sierra Nevada and southern Cascades of California. One wildfire complex, and an unreported amount of post-fire salvage logging, resulted in an almost complete loss of potentially suitable CSO habitat in the area (70% of the area pre-fire vs. 6% post-fire consisted of mean canopy cover ≥40% and mean DBH ≥11 in). Pre-fire occupancy in this study area was unknown but the Forest Service identified 23 CSO activity centers in the area prior to the fires. Rigorous landscape survey coverage by Keane et al. (2011, 2012) confirmed occupancy in only one territory within the fire perimeter during each of two post-fire years, whereas approximately seven to nine territories were found post-fire in a surrounding one-mile survey buffer. The other area studied by Keane et al. (2011, 2012) primarily burned at low severity (ca. 60% of the area). Pre-fire occupancy was likewise unknown in this area but Forest Service pre-project surveys indicated the presence of about 10 territories. Surveyors confirmed occupancy of six territories in this area during the first and second years post-fire. While the study's findings are

preliminary and may have been influenced by post-fire salvage logging, they suggest that effects of large wildfires on CSOs are dependent on the extent of high severity fire.

Another study provided further evidence that effects of wildfires on spotted owl occupancy depend on the extent and location of high severity fire. Lee et al. (2013) compared occupancy dynamics of CSOs in 71 recently burned sites and 97 unburned sites in the San Bernardino Mountains and San Jacinto Mountains of southern California. An average of 23% of forest within burned "core areas" (500 ac around activity centers) experienced high severity fire (this percent is based on an assumption that the amount of pre-fire forest in burned core areas was the same as that reported for burned and unburned core areas combined). Mean annual probability of occupancy was 0.48 in unburned sites and 0.31 in burned sites. This difference was not statistically significant. However, Lee et al. (2013) did detect a statistically significant negative effect on occupancy when high severity fire burned more than 125 acres of forest within estimated core areas.

Two studies found that wildfires had neutral or positive effects on spotted owl occupancy (Bond et al. 2002, Lee et al. 2012). Bond et al. (2002) calculated site fidelity for spotted owls in 11 territories burned by wildfires in California, Arizona, and New Mexico. The fires burned most of the area within each estimated territory (territory size = ½ the nearest neighbor distance in each study area, based on previous studies). Half of the eight territories for which fire severity was mapped primarily burned at low to moderate severity and the other half experienced extensive severe fire (36-88%). Of 21 color-banded owls in the study, 18 (86%) were resighted the year after the fires and 16 (89%) of these were located in their pre-fire territory. Site fidelity

in this study was comparable to that in long-term studies of the three subspecies in unburned areas (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data). In the Sierra Nevada, Lee et al. (2012) compared post-fire occupancy in 41 recently burned and 145 unburned historical CSO territories. An average of 32% of forest in burned territories experienced high severity fire. The authors found no significant association between CSO occupancy and whether or not territories had recently experienced wildfire within a 494-acre circle around activity centers (mean occupancy was 0.76 at unburned sites and 0.80 at burned sites).

The studies reviewed above are not directly comparable due to differences in methods, spotted owl subspecies and populations, fire extents and severities, and the presence or absence of post-fire salvage logging. The preponderance of evidence suggests that spotted owls in fire-prone forests are generally resilient to wildfires (Bond et al. 2002, Jenness et al. 2004, Keane et al. 2011, 2012, Roberts et al. 2011, Lee et al. 2012, 2013). However, wildfires that severely burn large areas of suitable habitat can substantially impact spotted owl occupancy, particularly when it occurs in breeding-season core areas (Elliot 1985, Gaines et al. 1997, Clark et al. 2013, Keane et al. 2011, 2012, Lee et al. 2013). Post-fire salvage logging appears to increase the negative effects of extensive severe fire on spotted owl occupancy; most likely by reducing suitability of burned areas for prey and foraging (Lee et al. 2012, 2013, Clark et al. 2013; reviewed below).

Home Range Size and Habitat Use

Changes in the behavior of individual spotted owls may provide insight into the mechanisms by which wildfires affect populations. For example, post-fire changes in home range size may

reflect fire effects on spotted owl energy budgets through changes in travel distances and prey availability. Changes in energy intake and output could, in turn, influence survival, reproduction, and occupancy of spotted owls. Patterns of habitat use may also be informative. For example, selection or avoidance of burned areas may reflect changes in availability of prey or roosting habitat, which could, in turn, influence occupancy, reproduction, or survival of spotted owls.

To our knowledge, only two studies have evaluated spotted owl home range sizes in relation to wildfires (Clark 2007, Bond et al. 2013; Table 1). Clark (2007) found that annual home range sizes of NSOs inside two fire perimeters in the Oregon Klamath Province were larger after wildfires than before them (n = 14 owls pre-fire and 20 post-fire). He attributed this difference to owls expanding their home ranges in response to habitat fragmentation caused by severe fire and post-fire salvage logging. This hypothesis was supported by other research in the region, which found that NSOs had larger home ranges in fragmented forests than in areas with larger, more intact patches of habitat (Carey et al. 1992, Schilling et al. 2013). Another study in the region suggested that the energetic cost of increased travel in fragmented forest was greater than the energetic benefit of increased access to prey associated with early-successional habitats (Carey and Peeler 1995).

Bond et al. (2013) compared the breeding season home ranges of seven CSOs (from four territories) during a single post-fire year in the Sierra Nevada of California with those in other studies during the same year in other parts of the subspecies range (D. Call, T. Munton, and G. Zimmerman unpubl. data). An average of 23% of forest burned at moderate severity and 9% at

high severity within a 1.2 mile radius of the four nests. Pre-fire home range sizes were unknown but CSOs in the four territories did not appear to have unusually large home ranges following predominantly low to moderate severity wildfire.

Five studies have described patterns of habitat use by spotted owls in burned areas (King et al. 1997, Clark 2007, Bond et al. 2009, Comfort 2013, Eyes 2014; Table 1). King et al. (1997; also Bevis et al. 1997) described initial effects of wildfires on NSOs in two territories in the eastern Washington Cascades. One territory primarily experienced low to moderate severity fire and the other mostly burned at high severity. Both territories experienced an unreported amount of salvage logging in unsuitable or severely burned habitat. Most NSO locations (84% and 89%) in the two territories were daytime roosts. In the territory primarily burned at low to moderate severity, 80% of the pair's post-fire locations were in unburned habitat, 16% were in low severity burns, and 4% were in moderate severity burns. The pair did not appear to roost in severely burned areas. The second territory studied by King et al. (1997) was occupied by a single male. After the fire, the male shifted his activity to an unburned area two to three miles away but continued to occasionally use areas near his former activity center. Of those locations, 74% were in unburned habitat, 17% were in low severity burns, 5% were in moderate severity burns, and 4% were in high severity burns. Maps of burn severity classes and NSO locations indicate that owls in these two territories strongly selected unburned areas for roosting.

Clark (2007) evaluated habitat selection by 12 NSOs (7 territories) inside a wildfire perimeter in the Oregon Klamath Province. NSO locations were primarily nocturnal and may therefore, have largely represented foraging activity. Individuals in this area used all habitat classes, including

moderate and severe burns and areas that had been salvage logged. However, when the data from individuals were pooled for analysis, the owls exhibited a strong preference for nesting-roosting habitat that was unburned or burned at low severity (unburned and low severity were combined into a single class). NSOs in the study also selectively used moderately burned, previously-suitable habitat; although both use and availability of this habitat class were low compared with unburned or lightly burned habitat. Owls' use of burned areas was concentrated closer to activity centers, which was expected, given that spotted owls are central place foragers during the breeding season (Rosenberg and McKelvey 1999).

In the Sierra Nevada, California, Bond et al. (2009) described the habitat associations of seven CSOs from four territories during a single post-fire season. Of the four nests found during the study, one was approximately 0.3 mile outside the fire perimeter, one was in forest burned at low severity, and two were in forest burned at moderate severity. One of the two nest trees found in a moderate severity burn was apparently killed by the fire and one produced the only fledgling detected during the study. It is unclear from the paper whether these events occurred at the same nest or different nests. The four pairs roosted in all burn severity classes but exhibited statistically significant selection of low severity burns and avoidance of moderate and high severity burns. Only one of 60 roost sites was located in a high severity burn. Burned roost sites generally resembled unburned roost sites (>60% canopy cover and large-diameter trees). Bond et al. (2009) also evaluated CSO selection of foraging habitat in the area. Probability of use for foraging was highest when sites were burned and within 0.6 mile of nests or roosts. Probability of use was also positively associated with presence of edge between burn severity classes. Five of the owls foraged in high severity burns within 0.9 mile of nests or roosts more often than in

other burn severity classes. Bond et al. (2009) suggested that CSOs in these four territories selectively foraged in high severity burns in order to access abundant prey in those areas. This hypothesis was supported by their finding that high severity burns had the highest herb and shrub cover and highest basal area of snags of any burn severity class, including unburned. These features are key resources for spotted owl prey communities (Carraway and Verts 1991, Carey et al. 1999, Holloway and Smith 2011).

Comfort (2013) evaluated habitat selection (roost and foraging locations combined) by 23 NSOs in a burned area in the Oregon Klamath Province. Her best performing model for explaining habitat selection included habitat suitability, disturbance severity, high contrast edge, and low contrast edge. Habitat selection varied with spatial scale but NSOs exhibited a strong preference for higher habitat suitability and avoidance of higher severity disturbance (high severity fire and/or salvage logging). NSOs showed a preference for high contrast edge at small spatial scales (2-8 ac) and avoidance at medium and large scales (32-2,049 ac). NSOs also exhibited a weak preference for low contrast edge. Comfort (2013) concluded that patchy, mixed severity fire (small patches of high severity fire within a matrix of unburned and low-to-moderate severity fire) created conditions favored by NSOs in her study, whereas large patches created by high severity fire and salvage logging were strongly avoided. Salvage logging apparently contributed to conditions avoided by NSOs by structurally homogenizing burned areas, which increased the sizes of high severity patches and amounts of high contrast edge. However, the relative influence of high severity fire and salvage logging on habitat selection by NSOs in this study is unknown.

Add discussion of Eyes (2014) (selection of low severity burned edges and proportional use of high severity burned edges)…

The limited available information concerning spotted owl habitat use following wildfires indicates that the species avoids roosting in moderate and high severity burns (King et al. 1997, Clark 2007, Bond et al. 2009). This finding is concordant with the spotted owl's close association with densely-canopied older forest for roosting (Blakesley 2004). Little is known about the effects of wildfire on selection of nest sites. Bond et al. (2009) found three CSO nests in forest recently burned at low and moderate severity, and young fledged from one nest in a moderate severity burn. Moderate severity fire killed one of the four CSO nest trees in their study. We are unaware of any reports of spotted owls nesting in severely burned areas. Based on the species' nesting habitat requirements (Blakesley 2004), long-term use of severely burned areas for nesting is likely uncommon. Two studies specifically examined selection of foraging habitat by spotted owls *(adding Eyes 2014 will make three studies)*. Both found use of all burn severity classes, but Clark (2007) found a preference for foraging in unburned to moderately burned older forest while Bond et al. (2009) found a preference for severe burns. It is unclear if this difference was due to differences in the studies' methods, spotted owl diets, or effects of fire and timber harvesting (including post-fire salvage logging) on vegetation. Comfort's (2013) research suggested that NSOs respond positively to the presence of severe burns when they occur in small patches within a matrix of unburned or low-to-moderate severity burns. However, she combined roost and foraging locations in her analysis, which might have obscured differences in NSO use of burn severity classes for different functions. Furthermore, hers and Clark's (2007) studies were confounded by post-fire salvage logging, which appears to negatively affect spotted

owls (reviewed below). *Discussion of use of fire-created edges in Comfort 2013 and Eyes 2014…*

Salvage Logging

While salvage logging might be judiciously used to meet certain conservation objectives (e.g., generating downed wood to minimize erosion or create wildlife habitat), it is generally conducted to meet financial goals or remove hazard trees (Peterson et al. 2009). Intensive or poorly planned salvage logging can have a variety of negative effects on ecosystems, such as soil compaction, increased erosion, and impacts on insectivorous and cavity-nesting and -denning animals (reviewed in McIver and Starr 2000, Noss et al. 2006, Peterson et al. 2009).

Comment [UFS25]: Economic?

We know of three studies that have directly evaluated effects of post-fire salvage logging on spotted owls (Clark 2007 and Clark et al. 2013, Lee et al. 2012, 2013). Clark (2007) conducted a radio-telemetry study in areas recently burned by wildfires in the Oregon Klamath Province. He recorded limited use of salvage logged areas; presumably for foraging since locations were primarily nocturnal. Use of salvage logged areas was slightly lower than expected based on its abundance in territories (not statistically analyzed), indicating weak avoidance of salvage logged areas by NSOs. However, avoidance might have been stronger since some of the study's telemetry locations were potentially recorded prior to the occurrence of salvage logging. Most (60%) NSO locations in salvage logged areas occurred in riparian buffers, thinned areas, and patches of wildlife leave trees, rather than intensively salvaged areas. During the same study, Clark et al. (2013) found that post-wildfire declines in NSO occupancy were best explained by a

model that included extents of pre-fire timber harvesting, severe fire, and post-fire salvage logging. Models that included these factors separately were not competitive with this model, indicating that severe fire and pre- and post-fire harvesting collectively contributed to declines in NSO occupancy; most likely through cumulative habitat loss or degradation.

In the Sierra Nevada, Lee et al. (2012) recorded occupancy for eight CSO territories that experienced wildfire and post-fire salvage logging. Seven of the territories were occupied during the two-year period between the occurrence of wildfire and salvage logging, whereas none of the territories were occupied following salvage logging.

Lee et al. (2013) evaluated effects of salvage logging on CSOs in the San Bernardino and San Jacinto Mountains of Southern California. They noted that salvage logging in their study area was modest compared with commercial salvage logging typically employed in the Pacific Northwest and Sierra Nevada (salvage logging in their study area mostly consisted of firewood cutting on private in-holdings and hazard tree removal along Forest Service roads). Lee et al. (2013) did not find a statistically significant effect of post-fire salvage logging on CSO occupancy dynamics. However, site extinction probability was slightly higher, and mean annual probability of occupancy was slightly lower, in salvage logged areas than in other burned areas. Weak negative effects of light salvage logging were evident during all eight post-fire study years.

The limited available evidence suggests that salvage logging decreases the probability that spotted owls will use burned areas (Comfort 2013) and increases the probability that they will

abandon their territories following wildfires (Clark 2007, Lee et al. 2012, 2013, Clark et al. 2013). This likely occurs because salvage logging reduces suitability of burned areas for foraging spotted owls and their prey. Stands recently burned by moderate or severe fire often contain high biodiversity due to the presence of both early-successional conditions and key biological legacies in the form of snags, logs, and live trees (Noss et al. 2006). Due to fire suppression and salvage logging, stands with these conditions are currently rare in many fire-prone forests within the spotted owl's range (Noss et al. 2006). Selective use of moderate or high severity burns for foraging is likely due to spotted owls exploiting short-term increases in prey associated with both early-successional vegetation (e.g., shrubs) and legacy habitat elements (e.g., large diameter snags, logs, and live trees) (Ream 1981, Zwolak 2009, Bond et al. 2013). Salvage logging removes legacy elements, while associated use of herbicides reduces shrubs and grasses important to many prey species (Bond et al. 2013, Comfort 2013). In the longer-term, spotted owls can continue to benefit from the contributions of legacy habitat elements to regenerating stands. For example, large legacy snags, trees, and logs can provide valuable habitat elements for northern flying squirrels and other prey (Holloway and Smith 2011). Removal of these elements through salvage logging could therefore reduce the value of subsequent regenerating stands as prey habitat. Harvesting of legacy snags and live trees could also directly affect spotted owls by reducing availability of foraging perches in the short-term and suitable nest trees during later successional stages. Large-scale salvage logging could also reduce NSOs' use of burned areas by extensively replacing low contrast (diffuse) edges with less favorable high contrast (hard) edges (Comfort 2013).

Summary

Inferences from studies of direct effects of wildfires and salvage logging on spotted owls are limited due to inclusion of only a small number of spotted owls or territories. Nonetheless, more information is available concerning this topic than is generally acknowledged. The preponderance of currently available evidence indicates that spotted owls are often resilient to wildfires but can be strongly impacted by extensive severe fire. Following wildfire, many spotted owls may remain in their territories, exploit short-term increases in prey in burned areas, and continue to reproduce at reasonably high rates. However, wildfires that result in substantial loss or fragmentation of suitable habitat, particularly within breeding core areas, can cause spotted owls to increase their home range sizes, abandon their territories, and possibly, emigrate from burned landscapes or die of starvation or disease. Negative effects of severe fire appear to be greatest when suitable habitat is already limited (e.g., due to widespread intensive timber harvesting) and when post-fire salvage logging reduces suitability of burned areas for foraging and prey.

Comment [UFS26]: Seems to contradict previous sentence. Is the unacknowledged info in this paper? Suggest deleting this sentence.

Wildfire Effects on Recent Habitat Trends

Past and continuing habitat loss was a primary reason for listing the NSO under the federal Endangered Species Act (USFWS 1990). At the time of listing, the Fish and Wildlife Service estimated that 60-88% of the subspecies' habitat had already been lost (USFWS 1990; also see *Threats: Timber Harvesting*). They attributed most of this loss to widespread intensive timber harvesting. Since listing of the NSO and subsequent adoption of the Northwest Forest Plan,

timber harvesting has declined and wildfire has been identified as the primary source of forest disturbance and habitat loss on federal lands (Courtney et al. 2004, Healey et al. 2008, USFWS 2011, Kennedy et al. 2012). Nonetheless, timber harvesting continues to be the primary source of habitat loss on non-federal lands (Healey et al. 2008, Davis and Dugger 2011, Moeur et al. 2011, Kennedy et al. 2012).

Comment [UFS27]: This and Kennedy focused on LSOG. Not all late-successional/old-growth forest is NSO habitat (e.g., ponderosa pine, subalpine forests, etc.)

You should put in Lint 2005 and Davis et al. 2011 as they focused on NSO habitat status and trends.

Comment [UFS28]: Or include "older forests and" before "habitat loss".

Estimates of recent trends in amounts of NSO habitat, and of older forest in general, have been produced as part of monitoring efforts for the Northwest Forest Plan; and are therefore, largely restricted to the Plan's area and time span (Davis and Lint 2005, Moeur et al. 2005, 2011, Healey et al. 2008, Davis and Dugger 2011). We focus on estimates by Davis and Dugger (2011) because they replaced those of Davis and Lint (2005) and are more specific to NSO habitat than those of Moeur et al. (2005, 2011) and Healey et al. (2008). We do not review habitat trend estimates based on federal ESA Section 7 consultation records (Bigley and Franklin 2004, USFWS 2012) due to greater scientific uncertainty and methodological bias associated with those data (see Bigley and Franklin 2004). Trends described by Bigley and Franklin (2004), Moeur et al. (2005, 2011), Healey et al. (2008), and the US Fish and Wildlife Service (2012) quantitatively differ from those of Davis and Dugger (2011) but similarly indicate that wildfires have been the primary source of recent habitat loss on federal lands.

Comment [UFS29]: Like this is stated

Comment [UFS30]: Good! Finally, this is clarified. Thank you.

Davis and Dugger (2011) used remotely sensed (satellite imagery) vegetation data to model changes in habitat suitability across the NSO's range during the first 15 years of the Northwest Forest Plan (1994-2007 in California and 1996-2006 in Oregon and Washington). Habitat suitability was based on characteristics surrounding thousands of NSO pair locations across the

Plan area. Suitable breeding habitat was defined as having both a probability of owl presence greater than expected based on random chance and environmental conditions typical of those found around nesting and roosting pairs. Estimated habitat trends included gross loss of both suitable breeding habitat and "core" suitable breeding habitat (>330 ft from edge). Davis and Dugger (2011) considered habitat loss to have occurred when an area classified as suitable at the beginning of Northwest Forest Plan was later downgraded to a lower suitability rank (unsuitable or marginal) due to vegetation changes caused by forest disturbances. Davis and Dugger (2011) did not estimate recruitment of, or net changes in, breeding habitat because their remotely sensed data was incapable of accurately capturing relatively slow and subtle habitat changes during development of intermediate-aged and older stands. They did, however, estimate net trends in NSO dispersal habitat, which they defined as forest with a mean ~~canopy~~conifer cover of at least 40% and a mean conifer DBH of at least 11 inches. Recruitment of dispersal habitat was more detectable than that of breeding habitat due to more rapid and measurable growth in younger forest (some recruitment also occurred due to degradation of suitable breeding habitat by forest disturbances).

Comment [UFS31]: Nesting/roosting

Estimated gross losses of suitable breeding habitat on federal and non-federal lands are presented in Tables 2 and 3, respectively. During the first 15 years of the Northwest Forest Plan, wildfires were responsible for an estimated gross loss of 236,700 acres (2.7%) of suitable breeding habitat on federal lands rangewide and 13,100 acres (0.3%) on non-federal lands (1.9% combined). In California, wildfires removed an estimated 75,500 acres (4.1%) of suitable breeding habitat on federal lands and 5,600 acres (0.4%) on non-federal lands (2.4% combined). Approximately 70% of habitat loss to wildfire on federal lands occurred within the Oregon and California

Klamath Provinces (Table 2). Most of this habitat loss was caused by the 1999 Megram Fire and 2002 Biscuit Fire (Table 4). Fires in the Eastern Cascades Provinces of Washington, Oregon, and California contributed less to total habitat loss than did fires in the Klamath, but were often more destructive in terms of proportion of suitable habitat lost within individual fire perimeters. In contrast with federal lands, wildfires were responsible for very little habitat loss on non-federal lands; rather, timber harvesting accounted for most losses in these areas (Figure 1).

Table 2: Estimated gross losses of suitable NSO breeding habitat on federal lands due to wildfires during 1994-2007 in California and 1996-2006 in Oregon and Washington (adapted from Davis and Dugger 2011, USFWS 2011).

State	Province	Initial Acres	Acres Lost	Percent Lost
California	CA Cascades	213,200	1,800	0.8%
	CA Klamath	1,489,800	71,600	4.8%
	CA Coast	145,400	2,100	1.4%
Oregon	OR Coast Range	611,200	0	0.0%
	Western OR Cascades	2,258,700	28,900	1.3%
	Eastern OR Cascades	402,900	17,800	4.4%
	Willamette Valley	3,400	0	0.0%
	OR Klamath	985,000	93,600	9.5%
Washington	Olympic Peninsula	763,100	200	0.0%
	Eastern WA Cascades	673,600	20,000	3.0%
	Western WA Cascades	1,283,000	700	0.1%
	Western WA Lowlands	24,700	0	0.0%
Rangewide Total		8,854,000	236,700	2.7%

Comment [UFS32]: Initial assumption at implementation of the NWFP was that about 2.5% per decade would be lost to wildfire. We are seeing this exceeded in some provinces, but the reserve network was designed to be large enough to function with losses from large wildfires.

There was not "trigger" to review this in the NWFP but the large amounts lost in some areas is concerning. Most if this loss is also occurring in the reserved land use allocations. This may be a focus of future review after the 20yr monitoring reports are finished (2015).

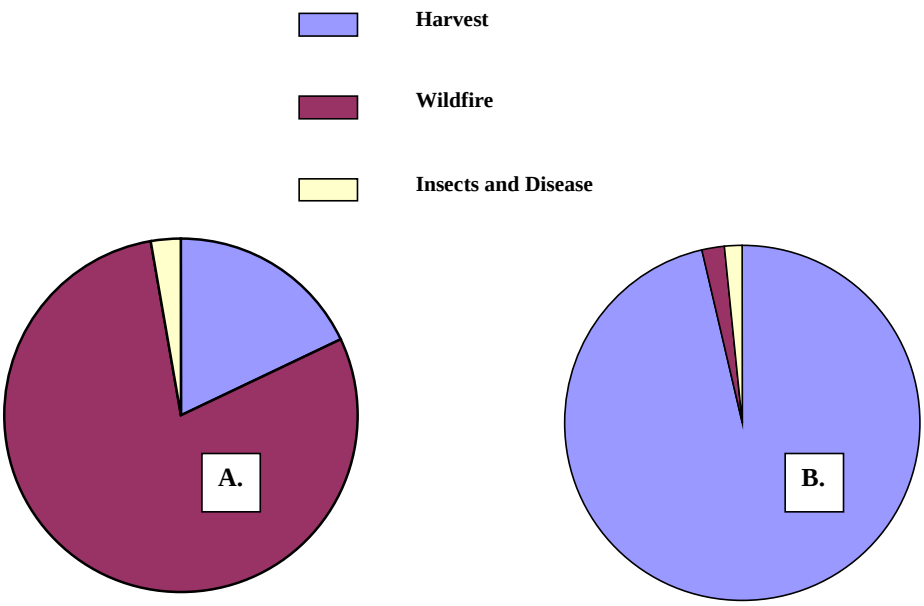
Table 3: Estimated gross losses of suitable NSO breeding habitat on non-federal lands due to wildfires during 1994-2007 in California and 1996-2006 in Oregon and Washington (adapted from Davis and Dugger 2011, USFWS 2011).

State	Initial Acres	Acres Lost	Percent Lost
California	1,556,700	5,600	0.4%
Oregon	1,382,400	5,100	0.4%
Washington	1,258,900	2,400	0.2%
Total	4,198,000	13,100	0.3%

Table 4: Estimated gross losses of suitable NSO breeding habitat to individual wildfires during 1994-2007 (note: "habitat degraded" describes areas downgraded from highly suitable to suitable; from Davis and Dugger 2011).

Fire name	Year	Broad physiographic province	Habitat in wildfire perimeter	Habitat lost		Habitat degraded	
			Acres	*Acres*	*%*	*Acres*	*%*
Biscuit Fire	2002	Klamath Mountains	226,230	93,730	41	12,019	5
Megram Fire	1999	Klamath Mountains	76,337	27,520	36	4,589	6
B&B Complex	2003	East Cascades	26,269	16,403	62	907	3
Bake-oven Fire	2006	Klamath Mountains	23,946	8,873	37	581	2
Boulder Fire	2002	West Cascades	34,059	8,460	25	2,074	6
Davis Fire	2003	East Cascades	8,050	6,943	86	5	0
Pigeon Fire	2006	Klamath Mountains	13,896	5,634	41	327	2
Rex Complex	2001	East Cascades	8,548	4,750	56	278	3
Timbered Rock	2002	West Cascades	10,216	4,539	44	569	6
Spring Fire	1996	West Cascades	13,504	3,931	29	858	6
Deep Harbor Fire	2004	East Cascades	5,761	3,930	68	64	1
Hancock Fire	2006	Klamath Mountains	12,712	3,132	25	336	3
Apple Fire 2	2002	West Cascades	12,227	2,810	23	928	8
Fischer Fire	2004	East Cascades	4,479	2,340	52	34	1
Fork Fire	1996	Klamath Mountains	2,962	2,113	71	14	0
Needles Fire	2003	East Cascades	1,946	874	45	1	0
Trough Fire	2001	Klamath Mountains	1,851	798	43	4	0
Hunter Fire	2006	Klamath Mountains	2,236	789	35	40	2
Deer Point Fire	2002	East Cascades	505	380	75	0	0
Tatoosh Complex	2006	East Cascades	666	378	57	0	0

Figure 1: Proportions of suitable breeding habitat loss attributed to harvesting, wildfire, and insects and diseases on (A) federal lands and (B) non-federal lands during 1994-2007 (adapted from Davis and Dugger 2011 and USFWS 2011).

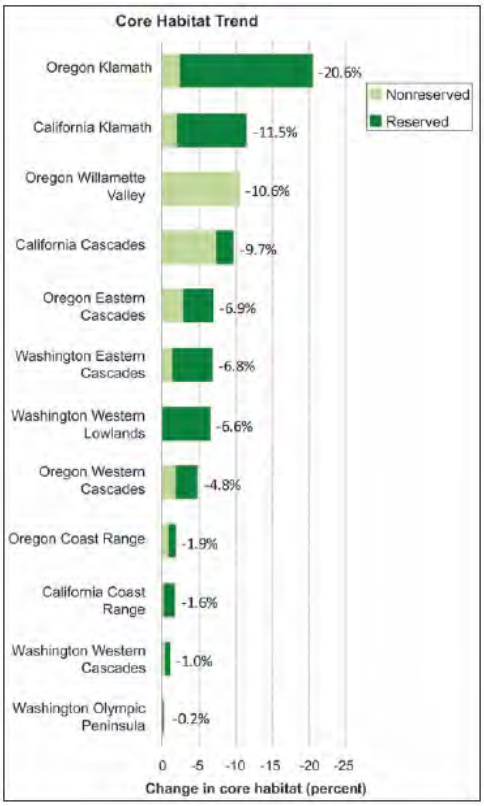


Davis and Dugger (2011) reported substantial losses of core breeding habitat on federal lands during the first 15 years of the Northwest Forest Plan (Figure 2). These losses primarily occurred in reserved areas. Changes in ratios of core and edge habitat classes indicated that increased fragmentation of suitable breeding habitat on federal lands was greatest in the Oregon and California Klamath Provinces and California Cascades Province (see Table 3-3 in Davis and Dugger 2011). Increased fragmentation in these regions was primarily due to wildfires.

Comment [UFS33]: Should define this as there are numerous uses of the term "core" in the literature.

Describe how it differs from the other habitat (e.g., nesting./roosting). Make it clear that the previous numbers above relate to N/R and not "core".

Figure 2: Gross losses of "core" suitable breeding habitat on reserved and non-reserved federal lands during 1994-2007 in California and 1996-2006 in Oregon and Washington (from Davis and Dugger 2011).



Davis and Dugger (2011) estimated a 5.2% net gain in NSO dispersal habitat. Much of this gain was due to succession in young forests in non-reserved lands at the margins of federal forests. However, accounting for forest connectivity and NSO dispersal distances, Davis and Dugger (2011) reported a 1% net loss of "dispersal-capable landscape". Much of the loss of dispersal-capable landscape in the Klamath and Eastern Cascades Provinces was due to large wildfires, whereas timber harvesting on non-federal lands was responsible for much of the loss in other regions.

Loss and fragmentation of breeding habitat to wildfires was likely at least partially offset by recruitment of new habitat through succession of mature and old forest. However, Davis and Dugger (2011) found that detectable recruitment of breeding habitat primarily occurred in the marginal suitability class. This finding was supported by Moeur et al. (2005), who found that about 90% of recruitment of older forest (mature and old-growth combined) during the first 10 years of the Northwest Forest Plan was at the lower end of the class' diameter range (i.e., mean DBH 20-30 in). In fact, Moeur et al. (2011) noted that given the short length of the monitoring period (10-14 yrs), recruitment was "likely due to incremental stand growth over the 20-in diameter threshold, or from understory disturbances that removed smaller diameter trees and raised the average stand diameter above the threshold, rather than from an increase in forests of much larger and older trees." It is likely that some newly recruited mature forest provides suitable habitat for NSOs but much if it could lack the canopy layering, large diameter snags and logs, and other structural attributes typical of nesting and roosting habitat (Blakesley et al. 2004).

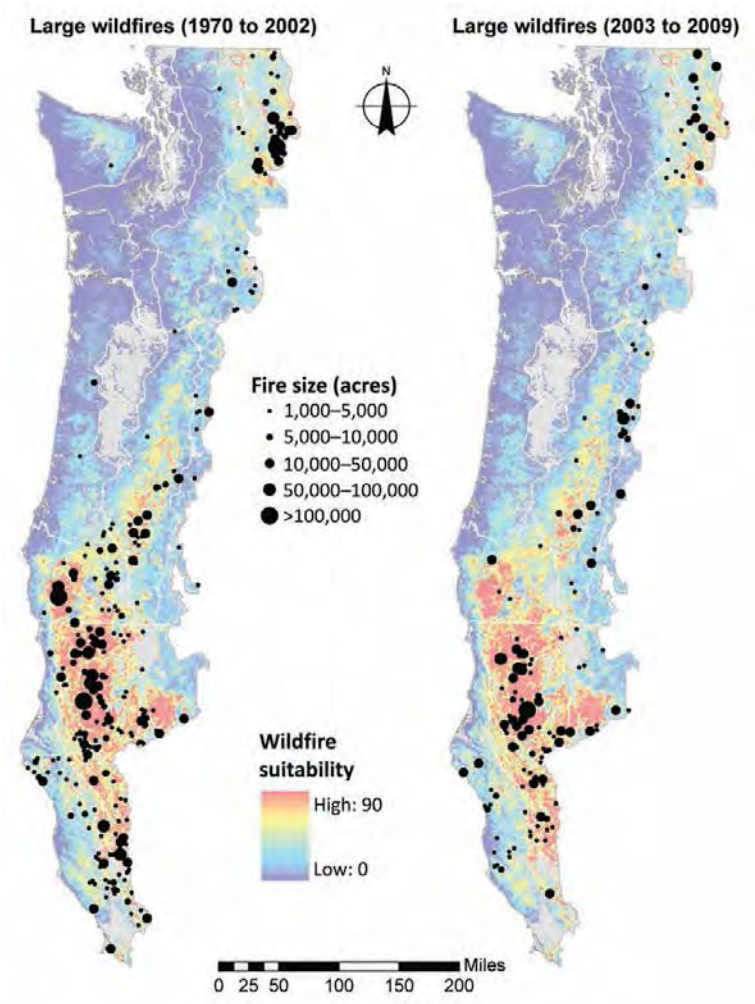
Loss and fragmentation of suitable breeding habitat does not necessarily equate to negative impacts on NSOs (Franklin and Gutiérrez 2002; e.g., Bond et al. 2002, 2009, Lee et al. 2012). Studies in southern Oregon and northern California found that the presence and fitness of NSOs are generally highest in landscapes with a mix of both large amounts of suitable breeding habitat and other habitat classes, such as foraging habitat or "non-habitat" (Franklin et al. 2000, Zabel et al. 2003, Olson et al. 2004, Dugger et al. 2005; reviewed above and in *Threats: Timber Harvesting*). Fitness is also generally highest when suitable breeding habitat occurs in large or clustered patches with large amounts of ecotone or edge between vegetation classes (Franklin et al. 2000, Dugger et al. 2005). This combination of conditions is important because it provides NSOs with a balance of resources needed for both survival and reproduction (Franklin et al. 2000). Active fire regimes in dry forests within the NSO's range in California (e.g., mixed-conifer and interior mixed-evergreen) historically contributed to these conditions by generally sparing older forest and maintaining some form of habitat heterogeneity at both stand and landscape scales (Sugihara et al. 2006). Some contemporary wildfires may still burn in this manner and thereby continue to perform an important ecosystem function in these forests. However, large severe wildfires have contributed, along with fire suppression and timber harvesting, to homogenization of some forests in interior northern California (Skinner et al. 2006). Thus, large severe fires may impact NSOs in California through loss of habitat heterogeneity, as well as reduced amounts and connectivity of suitable breeding habitat.

Fire Risk in California

Prior to Euro-American settlement, dry forests in the western U.S. generally experienced relatively frequent, low-to-moderate or mixed severity fire regimes (Agee 1993, Sugihara et al. 2006, Van de Water and Safford 2011). Mean pre-settlement fire return intervals in California were 11 years in yellow pine forests (e.g., *Pinus ponderosa*, *P. jeffreyi*), 11-16 years in mixed-conifer forests, and 29 years in mixed-evergreen forests (Van de Water and Safford 2011). Mean fire return intervals in redwood forests south of Del Norte County were also relatively frequent (6-44 yrs: Stuart and Stephens 2006). Frequent fire during the pre-settlement period generally maintained forests with less dense and more clumped tree distributions, higher proportions of fire-resistant trees (i.e., larger size classes and more fire-tolerant species), and lighter and less continuous fuel beds than occur today (Sugihara et al. 2006). In northern California, this characteristic fine-scale structural heterogeneity was often overlaid with coarser variability created by effects of elevation, terrain, soils, and other physiographic factors on fire and vegetation patterns (Skinner and Taylor 2006, Skinner et al. 2006, Sawyer 2007). For example, in areas of deeply incised terrain in the Klamath Mountains and southern Cascades of California, upper slopes and south and west facing aspects typically experienced more frequent and severe fire than did other areas (Skinner and Taylor 2006, Skinner et al. 2006). Due to fire suppression, early-successional vegetation communities formerly maintained by frequent, small-scale severe fire have greatly declined in some areas of California (Skinner 1995, Nagel and Taylor 2005). Overall, research indicates that fire suppression and other human activities have led to decreased forest heterogeneity at both stand and landscape scales and have contributed to substantial changes in fire regimes in California's dry forests (Sugihara et al. 2006).

Due to fire suppression, fire-free periods have dramatically increased in California's interior forests (Sugihara et al. 2006). For example, fire rotation near Hayfork in the Klamath Mountains increased more than 10-fold (from 19 to 238 yrs) during the post-settlement period (Taylor and Skinner 2003). Abnormally long fire-free periods have facilitated increased accumulation and continuity of fuels in dry, fire-prone forests (Sugihara et al. 2006). When wildfires do occur there is often an increased risk of them becoming very large and for suppression forces to be overwhelmed by their size and number (e.g., CAL FIRE 2008). As in other dry forests across the western U.S., the mean and maximum sizes of wildfires, and the total annual area burned, significantly increased in California's dry montane forests during the 20th and early 21st Centuries (Miller et al. 2009, 2012). CAL FIRE (2008) noted that more than half of the 26 largest fires recorded in California during 1932-2008 occurred during the last eight years of that period. Based on recent (1970-2002) fire behavior, most of northern California's interior can be classified as highly prone to large (>1,000 ac) wildfires (Davis et al. 2011; Figure 3).

Figure 3: Relative probability of large (>1,000 ac) wildfires ("wildfire suitability") across the NSO's range (from Davis et al. 2011). Modeling was based on landscape and climatic characteristics of locations at which large wildfires occurred during 1970-2002 (left) and was compared with subsequent (2003-2009) locations (right).



Studies of recent trends in extents of high severity fire in California have found conflicting results. For example, Miller et al. (2009) and Miller and Safford (2012) reported a substantial increase in the extent of high severity fire in the Sierra Nevada and southern Cascades of California during 1984-2010; while Hanson and Odion (2014) did not find an increase in the Sierra Nevada during the same period. Similarly conflicting results have been found for the California Klamath Province. Hanson et al. (2009) found a significant increase in high severity fire in the California and Oregon Klamath Provinces during 1984-2005; whereas Miller et al. (2012) did not find an increase in the California Klamath Province during a similar period (1987-2008). Scientific debate ensued regarding the appropriateness of methods used in various studies to determine trends in high severity fire (e.g., Hanson et al. 2009, 2010 vs. Spies et al. 2010).

Differences in findings regarding trends in high severity fire are related to variation in studies' temporal and spatial scales of analysis, as well as in methods for determining fire severity (Courtney et al. 2008, Miller et al. 2012, Hanson and Odion 2014). For example, Miller et al. (2012) noted that both their own study and those of Odion et al. (2004, 2010) may have underestimated trends in high severity fire in the California Klamath Province due to inclusion of unusual fire years. Studies by Odion et al. (2004, 2010) were based on fire effects during a single year (1987), which Miller et al. (2012) described as unusual. Large areas burned at below-average severity during 1987 due to abnormally strong inversions, and the fact that some of the fires burned well into fall (when conditions often favor lower severity fire). Miller et al. (2012) also noted that their own ability to detect a trend in fire severity could have been compromised by inclusion of both this year and 2008, which likewise experienced unusually large, low severity fires. Differences in the area analyzed could also affect evaluations of trends

in high severity fire. For example, the Biscuit Fire, which was predominantly located in Oregon, included extensive areas of high severity fire and therefore could have influenced results of trends analyses for the Oregon and California Klamath Provinces combined versus the California Klamath alone (Miller et al. 2012).

Regardless of whether or not the extent of high severity fire increased in California during the last two decades, large severe fires have recently occurred in these areas, and they were responsible for most loss, degradation, and fragmentation of suitable breeding habitat for NSOs on federal lands (Davis and Dugger 2011, Davis et al. 2011; see above). These data cannot be used to project how fires in the future will affect NSOs since they do not necessarily represent past or future fire conditions or effects. However, it is highly unlikely that wildfires will cease to be a major source of habitat loss for NSOs in the future. Rather, climate change research has generally projected a continued increase in the number and sizes of wildfires and the annual area burned during coming decades (Westerling et al. 2006, Lenihan et al. 2008, Westerling and Bryant 2008, Littell et al. 2009). There is scientific uncertainty regarding recent and future trends in the extent of high severity fire in California. Nonetheless, large severe fires will at least occasionally occur in the future and will continue to be a source of habitat loss and modification for NSOs in the state.

Increases in the number and sizes of wildfires, and effects of fires on NSO habitat, have led to calls for widespread use of thinning and other forms of active management in dry, fire-prone forests (USFWS 2008, 2011, 2012a, Franklin and Johnson 2012). Some researchers and stakeholders, however, have expressed doubts regarding estimates of fire risk and effects on

Comment [UFS34]: The trend in large wildfires has increased, and seems to be continuing (Happy Camp, July Complex…etc). With increased area burned, you get increased area burned in high severity.

Comment [UFS35]: Moritz et al. 2012, Stavros et al. 2014, Dennison et al. 2013

Comment [UFS36]: Perhaps it would be informative to include what was originally planned in the NWFP? The way this reads, and in general, the perception is that this is something newly proposed in response to recent large wildfires.

The NWFP (1994) actually called for widespread thinning in the fire prone portions of the owl's range to reduce risks of stand-replacing wildfires. And this was not just for NSO, it also focused on other late-successional species.

In fact, the agencies developed a specific Land Use Allocation called the "Managed Late Successional Area". Managed Late-Successional Areas are similar to Late- Successional Reserves (LSR) but were identified for certain owl locations in the drier provinces where regular and frequent fire is a natural part of the ecosystem. Certain silvicultural treatments and fire hazard reduction treatments are allowed to help prevent complete stand destruction from large catastrophic events such as high intensity, high severity fires; or disease or insect epidemics.

Even in regular LSRs in the Eastern Cascades or Klamath Provinces, silviculture aimed at reducing the risk of stand-replacing fires may be appropriate. Treatments may include thinning and underburning. Such activities in older stands in westside provinces may be warranted when levels of fire risk are high. (Record of Decision, B-7 to B-8).

Many of these treatments may reduce the quality of habitat for late-successional organisms. Thus, managers need to seek a balanced approach that reduces risk of fire while protecting large areas of fire-prone late-successional forest (B-8).

NSOs, concerns about potential effects of thinning on NSOs, and distrust of federal agency intentions (Hanson et al. 2009, Heiken 2010, DellaSala et al. 2013). As discussed in *Threats: Timber Harvesting* (also Hansen and Mazurek 2010, USFWS 2011), there is currently little known about the effects of forest thinning on spotted owls but the preponderance of evidence indicates that commercial thinning can have negative short-term effects on the species. Federal agencies should carefully consider this information when formulating land management policies and prescriptions aimed at reducing wildfire risk. Land managers should also consider greater use of prescribed fire and allowing wildfires to burn under favorable conditions; particularly at lower elevations in the California Klamath Province, where summertime inversions often minimize fire severity (Miller et al. 2012).

Comment [UFS37]: But how is this balanced with potential long-term beneficial effects? This is what needs to be determined in my opinion.

Again, from NWFP ROD - Many of these treatments may reduce the quality of habitat for late-successional organisms. Thus, managers need to seek a balanced approach that reduces risk of fire while protecting large areas of fire-prone late-successional forest (B-8).

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Wildfire and Salvage Logging

Comment [M1]: The entire document is written within a framework that assumes fire is bad. This biased treatment is unfortunate. I assume you've made fire a threat to the species as reason to list, but this synthesis of fire and owls is biased and poorly done. I stopped reading closely on page 15 because I was tired of correcting the errors and biased statements.

Recent status reviews have identified wildfire as a primary threat to the recovery of the northern spotted owl (NSO) (Courtney et al. 2004, USFWS 2011). Much of this concern is based on recent loss of suitable breeding habitat to wildfires and to the risk of extensive severe fires occurring in the future. Other researchers and stakeholders have questioned the scientific basis of claims that wildfires pose a threat to NSOs and have expressed distrust of agency recommendations for widespread use of forest thinning to reduce fire risk (Hanson et al. 2009, Heiken 2010, DellaSala et al. 2013). Surprisingly, existing reviews supporting both sides of this debate have only considered a portion of the available information concerning spotted owl responses to wildfires, and mostly in regard to their limitations and inconsistent findings. Our review confirms these limitations and suggests that wildfires have variable and complex effects on spotted owls. Fire is a crucial ecosystem process in dry forests within the species' range, and some spotted owl populations are known to benefit from a mix of habitat conditions resembling those historically maintained by active fire regimes (e.g., Franklin et al. 2000). However, the preponderance of currently available evidence indicates that large severe wildfires can have strong negative effects on spotted owls. Wildfires may also negatively affect spotted owls through cumulative or interactive effects with other environmental stressors, such as timber harvesting, salvage logging, and competition with barred owls (see *Potential Threats: Cumulative and Interactive Effects*).

Comment [M2]: unclear

Comment [M3]: wording ?

Comment [M4]: hmmmm.

Wildfire Effects on Spotted Owls

Several studies have investigated responses of NSOs to wildfires (Table A). These studies provide crucial information for evaluating fire as a potential threat to the subspecies. However, their inferences are limited due to small sample sizes in all cases, the potentially confounding effects of post-fire salvage logging in one case, and pooling of data from all three spotted owl subspecies in another case (Table A; see below). In order to supplement these studies, we also reviewed research of fire effects on California spotted owls (CSOs) and Mexican spotted owls (MSOs) (Table A). Because inferences from these studies are also limited, and given differences among fires, spotted owl populations, and research methods, we review each project as a "case study". Relatively thorough descriptions of these studies allow identification of patterns in the literature, which could provide insights into general effects of wildfires on the species.

Comment [M5]: ??

Table A: Apparent effects of wildfires on spotted owls. See text for additional descriptions of study methods and findings.

Response Metric	Study	Subspecies	Location*	Apparent Effect**	Notes
Mortalities	~~Paton et al. 1991~~	~~NSO~~	~~CA KLA~~	~~(?)~~	~~Likely due to heavy radio tags~~
	King et al. 1997	NSO	E WA CAS	-(?)	Only one individual; Possibly due to wildfire also logging
	Clark 2007	NSO	OR KLA	-(?)	Possibly due to wildfire and logging (unpublished grey lit.; analysis has problems)
Survival	Bond et al. 2002	NSO, CSO, MSO	CA, AZ, NM	0	Only one post-fire survey season
	Clark et al. 2011	NSO	OR KLA	-	~~Possible cumulative~~ Cumulative effect of timber harvesting, severe fire, and salvage logging
Productivity	~~Paton et al. 1991~~	~~NSO~~	~~CA KLA~~	~~(?)~~	~~Possible decline; Likely due to heavy radio tags~~
	Gaines et al. 1997	NSO	E WA CAS	0	Apparently no decline but possibly obscured by low reproduction year across population; Possibly lower total reproduction in burned landscapes due to lower pair occupancy; Only one post-fire season Anecdotal, no statistical power!
	Bond et al. 2002	NSO, CSO, MSO	CA, AZ, NM	0 (+?)	Slightly higher than in other studies; Only one post-fire season
	Clark 2007	NSO	OR KLA	0 ?	Apparently no decline but low statistical power; Possibly lower total reproduction in burned and logged landscapes due to lower pair occupancy
	Roberts 2008	CSO	CA SIERRA	+	Repro higher in burned.
Site Fidelity	Bond et al. 2002	NSO, CSO, MSO	CA, AZ, NM	0	Site fidelity similar to other studies
Occupancy	Elliot 1985	CSO	CA COAST	-?	Apparent abandonment by two pairs (this is anecdotal)
	Gaines et al. 1997	NSO	E WA CAS	-?	Post-fire occupancy was lowest found during five-year study; Only one post-fire season (anecdotal, no stats)
	Jenness et al. 2004	MSO	AZ, NM	0	Statistically ~~weak but pooled all fire types and severities~~no difference
	Keane et al. 2011, 2012	CSO	CA SIERRA/CAS	-?	Extensive high severity fire apparently had a strong negative effect; Extensive low severity fire apparently had a neutral or weak negative effect; Result influenced by extensive salvage logging
	Roberts et al. 2011	CSO	CA SIERRA	0	~~Authors concluded weak effect but pooled all fire types and severities~~No difference between burned and unburned
	Lee et al. 2012	CSO	CA SIERRA	0 (+?)	Similar occupancy at burned vs. unburned; Possibly ~~lower~~ higher occupancy at ~~severely~~ burned vs. ~~other~~ unburned
	Lee et al. 2013	CSO	SO CA	0/-	Similar occupancy at burned vs. unburned; Significant reduction with extensive high severity fire in core area
	Clark et al. 2013	NSO	OR KLA	-?	Cumulative effects of timber harvesting, severe fire, and salvage logging
Home Range	Clark 2007	NSO	OR KLA	-?	Larger home ranges post-fire and salvage logging
	Bond et al. 2013	CSO	CA SIERRA	0	Similar home range sizes to unburned areas
Roosting	King et al. 1997	NSO	E WA CAS	-	Apparent avoidance of moderate and severe burns
	Bond et al. 2009	NSO	CA SIERRA	-	Significant avoidance of moderate and severe burns
Foraging	Clark 2007	NSO	OR KLA	+(?)	Apparent weak selection of moderately burned suitable habitat; Possible weak selection for severely burned suitable habitat; Very low use and availability of both moderately and severely burned suitable habitat

Comment [M6]: This study says nothing about fire effects, should be omitted.

Comment [M7]: Always confounded fire and salvage logging. Don't assume or report that the effects were from fire!

Comment [M8]: This study says nothing about fire effects, should be omitted.

Comment [M9]: Always confounded fire and salvage logging. Don't assume or report that the effects were from fire!

Comment [M10]: Leave this to occupancy

Comment [M11]: Always confounded fire and salvage logging. Don't assume or report that the effects were from fire!

Comment [M12]: Always confounded fire and salvage logging. Don't assume or report that the effects were from fire!

	Bond et al. 2009	NSO	CA SIERRA	+	Significant selection of severe burns

* Locations: California Klamath (CA KLA); Eastern Washington Cascades (E WA CAS); Oregon Klamath (OR KLA); California, Arizona and New Mexico (CA, AZ, NM); California Central Coast Range (CA COAST); California at margin of northern Sierra Nevada and southern Cascades (CA SIERRA/CAS); California Sierra Nevada (CA SIERRA); southern California San Bernardino and San Jacinto Mountains (SO CA). **Apparent Effect: negative (-), positive (+), neutral (0), varied with fire severity (/)—see Notes column and text for further explanations.

Survival

Although adult spotted owls are capable of rapid and sustained flight, it is possible that they are occasionally killed by large or fast moving fires. Young owls with undeveloped flight feathers may be at particular risk of mortality during wildfires due to poor mobility (Smith 2000). Even in unburned areas, spotted owls could be injured or killed by smoke (Singer and Schullery 1989, Smith 2000). In addition to these potential immediate effects, extensive moderate or severe wildfire could influence spotted owl survival over the longer-term by ~~removing or~~ modifying habitat for roosting, foraging, or prey (see below).

Comment [M13]: Data-free statement, recommend deletion

Comment [M14]: Could be positive or negative modification, author should avoid judgmental language when speculating.

Only two studies are currently available for evaluating effects of wildfires on spotted owl survival rates (Table A). Bond et al. (2002) reported that 18 of 21 (86%) marked spotted owls were resighted one year after wildfires occurred in California, Arizona, and New Mexico. This minimum survival rate was similar to survival estimates in unburned areas found by other, longer-term studies of the three spotted owl subspecies (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data). Extensive severe fire (36-88%) occurred in four of the eight territories for which fire severity was mapped and the other half primarily burned at low to moderate severity. Thus, even extensive severe fire did not appear to have a large effect on spotted owl survival one year post-fire. ~~In contrast,~~ Clark et al. (2011) found evidence of a negative effect of combined wildfires and salvage logging on survival of 23 NSOs in the Oregon Klamath Province. Severe fire and salvage logging occurred in 30% and 41% of suitable NSO habitat in the two study areas. Estimated mean annual survival rates for NSOs located inside fire perimeters (0.69) and apparently displaced by fires and post-fire salvage logging (0.66) were

lower than in areas just outside the fire perimeters (0.85) and in an unburned reference study area in the neighboring southern Cascades (0.85: Anthony et al. 2006). The degree to which post-fire salvage logging in the study areas influenced NSO survival rates is unknown, but we know salvage logging has a documented negative effect on occupancy (Lee et al. 2013).~~.~~ The study's occupancy analyses indicated that pre-fire timber harvesting, wildfires, and post-fire salvage logging cumulatively impacted NSOs through reductions of suitable habitat (Clark et al. 2013; see below).

Apparently contradictory findings by Bond et al. (2002) and Clark et al. (2011) may be due to several factors. The most obvious difference between the studies is that the areas studied by Clark et al. (2011) experienced post-fire salvage logging while those studied by Bond et al. (2002) did not. Additionally, the populations studied by Clark et al. (2011) may have been particularly sensitive to habitat loss to wildfires due to intensive pre-fire timber harvesting across a checkerboard ownership. ~~It is also possible that Bond et al. (2002) failed to detect a negative effect of wildfires on spotted owls due to their reliance on data collected one year after fires occurred.~~It should be noted that Bond et al (2002) only examined effects 1 year post fire. Fire injuries and post-fire outbreaks of insects and pathogens can continue to result in tree mortality for up to several years after a wildfire (Ryan and Amman 1996, Gaines et al. 1997, Hood et al. 2007).

Comment [M15]: Bad language

Comment [M16]: Why assume tree death can only negatively affect SPOW? What about small mammal prey increases post fire?

There is relatively little information about the causes of spotted owl mortalities in recently burned areas. Not all spotted owl projects include radio-telemetry, which enables researchers to

recover dead birds. Even with radio-telemetry, only a portion of owl carcasses are recovered before they are too scavenged or decomposed to conduct a necropsy.

We reviewed three studies that described the condition of dead spotted owls found in areas recently burned by wildfire (Table A). In the Western Klamath Region of California, Paton et al. (1991) reported that one telemetered NSO died during a wildfire and that four more died within seven weeks. There was no evidence that any of the birds died from smoke inhalation or burns; rather, survival in the study area appeared to have declined due to the energetic costs of radio packs that were quite heavy by current standards. However, the authors noted that the telemetered owls in their study were exposed to high levels of carbon monoxide and total suspended particulates when an inversion trapped a dense layer of smoke near the ground for more than three weeks. In the eastern Washington Cascades, King et al. (1997; also Bevis et al. 1997) described a female NSO's behavior and death following a wildfire. The female and her fledgling survived when a low to moderate severity fire burned through the nest grove and produced thick smoke. Shortly after her offspring dispersed, the female moved to a new location outside the burned area and then died less than a month later. Her carcass was emaciated, indicating that she died from starvation or illness. King et al. (1997) speculated that this spotted owl died due to a post-fire decline in prey availability, but no prey data were presented. Clark (2007) reported that a total of eight NSOs died during his telemetry study in the Oregon Klamath Province. Six of the owls were recovered, all of which were emaciated. He likewise suggested that the deaths were related to a ~~post-fire~~ decline in prey availability due to combined effects of fire and salvage logging, but no prey data were presented. ~~This hypothesis was indirectly supported by the study's finding that NSOs' annual home ranges increased after wildfires~~

Comment [M17]: Without presenting examples direct mortality detected in telemetry studies of unburned areas, these anecdotes are biased and misleading.

Comment [M18]: Delete, this paper does not provide any data to judge fire effects on SPOW

Comment [M19]: Data-free anecdotes are dangerous.

Comment [M20]: But like King he had no data to support this speculation.

~~occurred (see below).~~ It is also possible that a factor other than fire caused a decline in prey availability or that the wildfires affected NSO survival in other ways. For example, loss or degradation of suitable roosting habitat could stress NSOs by limiting their ability to thermoregulate (Barrows 1981, Ganey et al. 1993, Ting 1998, Weathers et al. 2001).

Reproduction

The spotted owl is a relatively long-lived species that exhibits a bet-hedging life history strategy (Noon and Biles 1990, Franklin et al. 2000). This means that individuals often forego breeding during poor environmental conditions in order to maximize their chance of surviving and reproducing in the future. Given the species' life history strategy, spotted owl reproductive rates are likely sensitive to environmental changes, including those brought about by wildfires. However, annual fluctuations in spotted owl reproduction caused by variation in weather, prey populations, or breeding condition could obscure effects of wildfires on reproduction (e.g., Franklin et al. 2000).

We are aware of four studies that examined potential effects of wildfires on spotted owl reproduction (Table A). None of these studies found substantive evidence of a wildfire-induced decline in reproduction by the species. In the Western Klamath Region of California, ~~Paton et al. (1991) noted a possible difference in reproduction by NSOs in two areas burned by the same wildfire. Reproduction and fire effects were poorly described for burned versus unburned areas (e.g., number of eggs vs. number of fledglings; inversion-trapped smoke vs. understory burning in different areas of the fire), but demographic rates in the study appeared to be influenced by whether or not owls were fitted with heavy radio tags, rather than by variation in fire effects~~. In

the eastern Washington Cascades, Gaines et al. (1997) found little difference in productivity (number of young per pair) between burned (0.2; n = 5 or 6/ yr) and unburned sites (0.3; n = 13-17/yr) one year after a predominantly moderate to severe wildfire. However, it is possible that coincidentally low reproduction across the population during the post-fire year made it difficult to detect a difference between burned and unburned sites; particularly with such a small sample size. Clark (2007) found no significant differences in productivity in burned areas in the Oregon Klamath Province (n = 31 territories) and an unburned study area in the neighboring southern Cascades (Anthony et al. 2006). He noted, however, that his study likely lacked the statistical power to detect a difference if one occurred. Bond et al. (2002) found that seven pairs of spotted owls produced an average of 1.0 offspring during a single breeding season following wildfires in California, Arizona, and New Mexico. This was higher than productivity rates ~~found~~ found in unburned areas during long~~er~~-term studies of the three spotted owl subspecies (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data).

Comment [M21]: No statistics were presented.

Comment [M22]: Why speculate that a difference ought to be there?

Currently available studies suggest that wildfires generally have little or no short-term effects on spotted owl reproduction. However, it might be difficult to capture fire effects on spotted owl reproduction during short-term studies, particularly those with only a single year of post-fire data. In addition, it is possible that solely comparing productivity (e.g., offspring per pair) in burned and unburned areas could obscure a decline in total reproduction in burned areas. Studies in Washington and Oregon reported post-fire declines in occupancy by pairs, suggesting that wildfires may reduce reproductive opportunities for spotted owls (Gaines et al. 1997, ~~Clark 2007;~~ see below). Alternatively, it is possible that wildfires sometimes contribute to higher reproduction by spotted owls. For example some pairs or populations may experience higher

reproduction following wildfires due to short-term increases in availability of deer mice (*Peromyscus* spp.), pocket gophers (*Thomomys* spp.), and other prey (Ream 1981, Zwolak 2009, Bond et al. 2013).

Comment [M23]: Finally, the potential positive effects are mentioned.

Occupancy

Potential wildfire effects on NSO population rates are most directly evaluated with measures of survival and reproduction. However, occupancy data are often more logistically and economically feasible to collect than are demographic data and could provide an early indication of population trends (MacKenzie 2005, Olson et al. 2005). Spotted owl occupancy is sensitive to environmental factors (Blakesley et al. 2005, Olson et al. 2005) so it is a potentially valuable measure of wildfire effects on the species. Nonetheless, occupancy data must be interpreted carefully since they can be strongly influenced by survey effort, analytical methods, and the presence of barred owls (Olson et al. 2005).

We evaluated nine studies of wildfire effects on spotted owl occupancy (Table A). As described below and in Table A, all but one of these provided at least weak evidence of a negative effect of either severe fire or fire in general.

Two studies indicated potentially ~~strong declines~~ negative effects in spotted owl occupancy but included very few territories (Elliot 1985, Gaines et al. 1997). In Monterey County, California, informal yearly surveys suggested that two pairs of CSOs abandoned their territories for at least four years following a wildfire (Elliot 1985). The author did not describe the fire other than

noting substantial damage to understories and oaks in the previously occupied areas. In the eastern Washington Cascades, Gaines et al. (1997) found that ~~only~~ two of six NSO sites were occupied one year after a predominantly moderate to severe wildfire. This was the lowest occupancy rate found during the five-year study period.

Two studies found ~~only weak~~no evidence of ~~a negative~~any effect of fire on spotted owl occupancy, but their methods may have precluded detection of stronger effects (Jenness et al. 2004, Roberts et al. 2011). Jenness et al. (2004) found a statistically insignificant tendency for higher occupancy rank (no owls, singles, pairs, reproductive pairs) in unburned sites than in paired burned sites in Arizona and New Mexico (paired sites were close to each other and had similar habitat and topography). Of the 29 paired-site comparisons, 14 (48%) had a higher rank in unburned sites, 6 (21%) had a higher occupancy rank in burned sites, and 9 (31%) were tied. In the Sierra Nevada of California, Roberts et al. (2011) found ~~lower occupancy estimates for CSOs in burned areas (0.46) than in unburned areas (0.72); but the difference was not statistically analyzed~~no difference in occupancy between burned and unburned sites. Modeling by both studies indicated that spotted owl occupancy was more strongly influenced by habitat composition or structure than by whether or not fire had recently occurred in territories. However, both studies may have underestimated the impacts of severe fire due to pooling of diverse fire types and severities for analysis (including prescribed fires, wildfires, and wildfires allowed to burn under prescribed conditions). Roberts et al. (2011) may also have underestimated shorter-term effects of wildfires due to inclusion of data collected up to 15 years post-fire.

Formatted: Highlight

Comment [M24]: Exactly corrrect

Comment [M25]: Why are you reaching for reasons that bad fire effects were absent rather than presenting the data in an unbiased voice?

Two studies found evidence of strong declines in occupancy in areas recently burned by extensive severe wildfire but both ~~may have been~~were seriously confounded by post-fire salvage logging (Keane et al. 2011, 2012, Clark et al. 2013). In southwestern Oregon, Clark et al. (2013) examined how extensive wildfires and subsequent salvage logging affected occupancy dynamics of NSO pairs. In their first analysis, the authors compared pre- and post-fire occupancy dynamics in a burned study area in the Oregon Klamath Province (n = 22) to those in an unburned area in the nearby southern Cascades (Anthony et al. 2006). High severity fire and salvage logging removed or modified 26% of suitable habitat in landscapes surrounding NSO sites in this area. The burned and salvage logged study area experienced a 64% reduction in site occupancy during the post-fire period, compared with a 25% reduction in the unburned study area (difference not statistically analyzed). In the second analysis, the authors examined possible effects of severe fire and salvage logging on occupancy dynamics in 40 territories located in three burned study areas in the Oregon Klamath Province. In these areas, 19-26% of suitable habitat was burned at high severity and~~/or~~ salvage logged. During the study's three-year post-fire period, site extinction probabilities were as high as 72% in two combined study areas and 92% in the third area. Site extinction probabilities in the burned and logged study areas were best explained by a model that included extents of high severity fire, salvage logging, and early seral forest. Models that included these variables separately were not competitive with the model containing all three variables, suggesting that NSO occupancy declined due to cumulative habitat loss from severe fire and pre- and post-fire timber harvesting. ~~The relative influence of these factors on occupancy is unknown, but the role of severe fire cannot be dismissed. For example, the highest extinction probability (92%) occurred in a study area with little salvage logging (<2%) of previously suitable habitat.~~

Comment [M26]: Incorrect. Their model structures were not organized to differentiate among these effects.

Comment [M27]: Using anecdotal examples as refutation of statistics is wrong and should be avoided.

Keane et al. (2011, 2012) estimated occupancy of CSOs in two recently burned study areas near the margin of the Sierra Nevada and southern Cascades of California. One wildfire complex, and an unreported amount of post-fire salvage logging, resulted in an almost complete loss of potentially suitable CSO habitat in the area (70% of the area pre-fire vs. 6% post-fire consisted of mean canopy cover ≥40% and mean DBH ≥11 in). Pre-fire occupancy in this study area was unknown but the Forest Service identified 23 CSO activity centers in the area prior to the fires. Rigorous landscape survey coverage by Keane et al. (2011, 2012) confirmed occupancy in only one territory within the fire perimeter during each of two post-fire years, whereas approximately seven to nine territories were found post-fire in a surrounding one-mile survey buffer. The other area studied by Keane et al. (2011, 2012) primarily burned at low severity (ca. 60% of the area). Pre-fire occupancy was likewise unknown in this area but Forest Service pre-project surveys indicated the presence of about 10 territories. Surveyors confirmed occupancy of six territories in this area during the first and second years post-fire. While the study's findings are preliminary and may have been influenced by post-fire salvage logging, they suggest that effects of large wildfires on CSOs are strongly dependent on the extent of high severity fire.

Comment [M28]: This study is weak, unpublished, and uninterpretable due to the unquantified salvage logging. Use with care, or not at all.

~~Another study provided further~~ The only published study that accounted for effects of logging and fire separately documented evidence that effects of wildfires on spotted owl occupancy depend on the extent of high severity fire. Lee et al. (2013) compared occupancy dynamics of CSOs in 71 recently burned sites and 97 unburned sites in the San Bernardino Mountains and San Jacinto Mountains of southern California. An average of 23% of forest within burned "core areas" (500 ac around activity centers) experienced high severity fire (this percent is based on an

assumption that the amount of pre-fire forest in burned core areas was the same as that reported for burned and unburned core areas combined). Mean annual probability of occupancy was 0.48 in unburned sites and 0.31 in burned sites. This difference was not statistically significant. ~~However, probability of occupancy was consistently lower in burned sites during all eight post-fire years, suggesting that wildfire had a biologically meaningful effect on CSO occupancy. Furthermore, a~~A statistically significant negative effect on occupancy was detected~~, particularly for pairs,~~ when more than 125 acres of forest within core areas burned at high severity.

~~Finally, t~~Two studies found that wildfires had ~~little~~ positive or no effect on spotted owl occupancy (Bond et al. 2002, Lee et al. 2012). Bond et al. (2002) calculated site fidelity for spotted owls in 11 territories burned by wildfires in California, Arizona, and New Mexico. The fires burned most of the area within each estimated territory (territory size = ½ the nearest neighbor distance in each study area, based on previous studies). Half of the eight territories for which fire severity was mapped primarily burned at low to moderate severity and the other half experienced extensive severe fire (36-88%). Of 21 color-banded owls in the study, 18 (86%) were resighted the year after the fires and 16 (89%) of these were located in their pre-fire territory. Site fidelity in this study was comparable to that in other, longer-term studies of the three subspecies (Seamans et al. 1999, Franklin et al. 2000, W.S. LaHaye unpubl. data).

In the Sierra Nevada, Lee et al. (2012) compared post-fire occupancy in 41 recently burned and 145 unburned historical CSO territories. An average of 32% of forest in burned territories experienced high severity fire. The authors found no significant association between CSO occupancy and whether or not territories had recently experienced wildfire within a 494-acre

circle around activity centers (but mean occupancy was higher in burned sites: 0.76 at unburned sites and 0.80 at burned sites). ~~Of the nine sites in which at least 50% of forest was severely burned within larger 988-acre areas around activity centers, eight were surveyed post-fire and CSOs were detected in five of those (63%). This level of occupancy appears to have been lower than that of burned sites as a whole (not statistically analyzed), but it also indicates that CSOs can persist in areas with extensive severe fire.~~

The studies reviewed above are not directly comparable due to differences in methods, spotted owl subspecies and populations, fire extents and severities, and the presence or absence of post-fire salvage logging. ~~Nonetheless, the weight of currently available evidence indicates that, while spotted owls can persist in burned landscapes, wildfires may often reduce occupancy.~~Current data (weighted by sample sizes, statistical power, and confounding effects of salvage logging) indicate that wildfire does not significantly affect occupancy except rarely, in the most extreme situations, when most suitable habitat in the nest core area is severely burned. ~~The studies further suggest that the magnitude of wildfire effects on occupancy depends on the extent of severe fire. However, even mixed severity wildfires may substantially reduce occupancy when suitable habitat is already limited (e.g., due to intensive timber harvesting: Clark et al. 2013)~~. Post-fire salvage logging can increase the negative effects of extensive severe fire on spotted owl occupancy; most likely by reducing suitability of burned areas for prey and foraging (see below).

Home Range Size and Habitat Use

Changes in the behavior of individual spotted owls may provide insight into the mechanisms by which wildfires affect populations. For example, post-fire changes in home range size may reflect fire effects on spotted owl energy budgets through changes in travel distances and prey availability. Changes in energy intake and output could, in turn, influence survival, reproduction, and occupancy of spotted owls. Patterns of habitat use may also be informative. For example, selection or avoidance of burned areas may reflect changes to availabilities of prey or roosting habitat, which could, in turn, influence occupancy, reproduction, or survival of spotted owls.

To our knowledge, only two studies have evaluated spotted owl home range sizes in relation to wildfires (Clark 2007, Bond et al. 2013). Clark (2007) found that annual home range sizes of NSOs inside two fire perimeters in the Oregon Klamath Province were larger after the fires than before them (n = 14 owls pre-fire and 20 post-fire). He attributed this difference to owls expanding their home ranges in response to habitat fragmentation caused by severe fire and salvage logging. This hypothesis was supported by other research in the region, which found that NSOs had larger home ranges in fragmented forests than in areas with larger, more intact patches of habitat (Carey et al. 1992, Schilling et al. 2013). Another study in the region suggested that the energetic cost of increased travel in fragmented forest was greater than the energetic benefit of increased access to prey associated with early-successional habitats (Carey and Peeler 1995).

Comment [M29]: Whenever you mention this Clark 2007study you must call any affects due to"fire and salvage logging" because they did not discriminate between these thing, but lumped all together.

Bond et al. (2013) compared the breeding season home ranges of seven CSOs (from four territories) during a single post-fire year in the Sierra Nevada of California with those in other studies during the same year in other parts of the subspecies range (D. Call, T. Munton, and G. Zimmerman unpubl. data). An average of 23% of forest burned at moderate severity and 9% at high severity within a 1.2 mile radius of the four nests. Pre-fire home range sizes were unknown but CSOs in the four territories did not appear to have unusually large home ranges following predominantly low to moderate severity wildfire.

Three studies have described patterns of habitat use by spotted owls in burned areas (Table A). King et al. (1997; also Bevis et al. 1997) described initial effects of wildfires on NSOs in two territories in the eastern Washington Cascades. One territory primarily experienced low to moderate severity fire and the other mostly burned at high severity. Both territories experienced an unreported amount of salvage logging in unsuitable or severely burned habitat. Most NSO locations (84% and 89%) in the two territories were daytime roosts. In the territory primarily burned at low to moderate severity, 80% of the pair's post-fire locations were in unburned habitat, 16% were in low severity burns, and 4% were in moderate severity burns. The pair did not appear to use severely burned areas. The second territory studied by King et al. (1997) was occupied by a single male. After the fire, the male shifted his activity to an unburned area two to three miles away but continued to occasionally use areas near his former activity center. Of those locations, 74% were in unburned habitat, 17% were in low severity burns, 5% were in moderate severity burns, and 4% were in high severity burns. Maps of burn severity classes and NSO locations indicate that owls in these two territories strongly selected unburned areas for roosting.

Clark (2007) evaluated habitat selection by 12 NSOs (7 territories) inside a wildfire perimeter in the Oregon Klamath Province. NSO locations were primarily nocturnal and may therefore, have largely represented foraging activity. Individuals in this area used all habitat classes, including moderate and severe burns and areas that had been salvage logged. However, when the data from individuals were pooled for analysis, the owls exhibited a strong preference for nesting-roosting habitat that was unburned or burned at low severity (unburned and low severity were combined into a single class). NSOs in the study also selectively used moderately burned, previously-suitable habitat; although both use and availability of this habitat class were low compared with unburned or lightly burned habitat. Clark (2007) speculated that selection of moderately burned habitat was related to increased prey availability following fire in those areas. Owls' use of burned areas was concentrated closer to activity centers, which was expected, given that spotted owls are central place foragers during the breeding season (Rosenberg and McKelvey 1999).

In the Sierra Nevada, California, Bond et al. (2009) described the habitat associations of seven CSOs from four territories during a single post-fire season. Of the four nests found during the study, one was approximately 0.3 mile outside the fire perimeter, one was in forest burned at low severity, and two were in forest burned at moderate severity. One of the two nest trees found in a moderate severity burn was apparently killed by the fire and one produced the only fledgling detected during the study. It is unclear from the paper whether these events occurred at the same nest or different nests. The four pairs roosted in all burn severity classes but exhibited statistically significant selection of low severity burns and avoidance of moderate and high

severity burns. Only one of 60 roost sites was located in a high severity burn. Burned roost sites generally resembled unburned roost sites (>60% canopy cover and large-diameter trees). Bond et al. (2009) also evaluated CSO selection of foraging habitat in the area. Probability of use for foraging was highest when sites were burned and within 0.6 mile of nests or roosts. Probability of use was also positively associated with presence of edge between burn severity classes. Five of the owls foraged in high severity burns within 0.9 mile of nests or roosts more often than in other burn severity classes. Bond et al. (2009) suggested that CSOs in these four territories selectively foraged in high severity burns in order to access abundant prey in those areas. This hypothesis was supported by their finding that high severity burns had the highest herb and shrub cover and highest basal area of snags of any burn severity class, including unburned. These features are key resources for spotted owl prey communities (Carraway and Verts 1991, Carey et al. 1999, Holloway and Smith 2011).

The limited available information concerning spotted owl habitat use following wildfires indicates that the species ~~strongly~~ avoids roosting in moderate and high severity burns. This is unsurprising, given the spotted owl's close association with densely-canopied older forest for roosting (*section_xxx*). Little is known about the effects of wildfire on selection of nest sites. Bond et al. (2009) found three CSO nests in forest recently burned at low and moderate severity, and young fledged from one nest in a moderate severity burn. Moderate severity fire killed one of the four CSO nest trees in their study. We are unaware of any reports of spotted owls nesting in severely burned areas. Because of the species' nesting habitat requirements (*section_xxx*), it is likely uncommon. Two studies examined selection of foraging habitat by spotted owls. Both found use of all burn severity classes, but Clark (2007) found a preference for foraging in

Comment [M30]: Always confounded fire and salvage logging. Don't assume or report that the effects were from fire! Maybe move all mention of Clark 2007 to salvage logging section.

unburned to moderately burned older forest while Bond et al. (2009) found a preference for severe burns. It is unclear if this difference was due to differences in the studies' methods, spotted owl diets, or effects of fire and timber harvesting on vegetation.

Salvage Logging

Salvage logging further modifies recently burned forests and could exacerbate negative effects of severe fire on spotted owls. While salvage logging might be judiciously used to meet certain conservation objectives (e.g., generating downed wood to minimize erosion or create wildlife habitat), it is generally conducted to meet financial goals or remove hazard trees (Peterson et al. 2009). Intensive or poorly planned salvage logging can have a variety of negative effects on ecosystems, such as soil compaction, increased erosion, and impacts on insectivorous and cavity-nesting and -denning animals (reviewed in McIver and Starr 2000, Noss et al. 2006, Peterson et al. 2009).

We know of three studies that have directly evaluated effects of post-fire salvage logging on spotted owls (Clark 2007 and Clark et al. 2013, Lee et al. 2012, 2013). Clark (2007) conducted a radio-telemetry study in areas recently burned by wildfires in the Oregon Klamath Province. He recorded limited use of salvage logged areas; presumably for foraging since locations were primarily nocturnal. Use of salvage logged areas was slightly lower than expected based on its abundance in territories (not statistically analyzed), indicating weak avoidance of salvage logged areas by NSOs. However, avoidance might have been stronger since some of the study's telemetry locations were potentially recorded prior to the occurrence of salvage logging. Most

Comment [M31]: These papers confound fire and salvage.

(60%) NSO locations in salvage logged areas occurred in riparian buffers, thinned areas, and patches of wildlife leave trees, rather than intensively salvaged areas. During the same study, Clark et al. (2013) found that post-wildfire declines in NSO occupancy were best explained by a model that included extents of pre-fire timber harvesting, severe fire, and post-fire salvage logging. Models that included these factors separately were not competitive with this model, indicating that severe fire and pre- and post-fire harvesting collectively contributed to declines in NSO occupancy; most likely through cumulative habitat loss or degradation.

In the Sierra Nevada, Lee et al. (2012) recorded occupancy for eight CSO territories that experienced wildfire and post-fire salvage logging. Seven of the territories were occupied during the two-year period between the occurrence of wildfire and salvage logging, whereas none of the territories were occupied following salvage logging.

Lee et al. (2013) evaluated effects of salvage logging on CSOs in the San Bernardino and San Jacinto Mountains of Southern California. They noted that salvage logging in their study area was modest compared with commercial salvage logging typically employed in the Pacific Northwest and Sierra Nevada (salvage logging in their study area mostly consisted of firewood cutting on private in-holdings and hazard tree removal along Forest Service roads). Lee et al. (2013) did not find a statistically significant effect of post-fire salvage logging on CSO occupancy dynamics. However, site extinction probability was slightly higher, and mean annual probability of occupancy was slightly lower, in salvage logged areas than in other burned areas. Weak negative effects of light salvage logging were evident during all eight post-fire study years, suggesting that they were biologically, if not statistically, significant.

The limited available evidence suggests that salvage logging increases the probability that spotted owls will abandon their territories following wildfires. This likely occurs because salvage logging reduces suitability of burned areas for foraging spotted owls and their prey. Stands recently burned by moderate or severe fire often contain high biodiversity due to the presence of both early-successional conditions and key biological legacies in the form of snags, logs, and live trees (Noss et al. 2006). Due to fire suppression and salvage logging, stands with these conditions are currently rare in many fire-prone forests within the spotted owl's range (Noss et al. 2006). Selective use of moderate or high severity burns for foraging is likely due to spotted owls exploiting short-term increases in prey associated with both early-successional vegetation (e.g., shrubs) and legacy habitat elements (e.g., large diameter snags, logs, and live trees) (Ream 1981, Zwolak 2009, Bond et al. 2013). Salvage logging removes legacy elements, while associated use of herbicides reduces shrubs and grasses important to many prey species (Bond et al. 2013). In the longer-term, spotted owls can continue to benefit from the contributions of legacy habitat elements to regenerating stands. For example, large legacy snags, trees, and logs can provide valuable habitat elements for northern flying squirrels and other prey (Holloway and Smith 2011). Removal of these elements through salvage logging could therefore reduce the value of subsequent regenerating stands as prey habitat. Harvesting of legacy snags and live trees could also directly affect spotted owls by reducing availability of foraging perches in the short-term and suitable nest trees during later successional stages.

<u>Summary</u>

Research of direct effects of wildfires and salvage logging on spotted owls have been opportunistic and have therefore, lacked the ability to compare pre- and post-fire data. Most studies' inferences are also limited due to inclusion of only a small number of spotted owls or territories. Nonetheless, more information is available concerning this topic than is generally acknowledged. The preponderance of currently available evidence indicates that spotted owls are often resilient to wildfires but can be strongly impacted by extensive severe fire. Following wildfire, many spotted owls may remain in their territories, exploit short-term increases in prey in burned areas, and continue to reproduce at reasonably high rates. However, wildfires that result in substantial loss or fragmentation of habitat can cause spotted owls to increase their home range sizes, abandon their territories, and possibly, die of starvation or disease. Negative effects of severe fire appear to be greatest when suitable habitat is already limited (e.g., due to widespread intensive timber harvesting) and when post-fire salvage logging reduces suitability of burned areas for foraging and prey.

Comment [M32]: Lee et al 2012 and 2013 do look pre- and post-fire!

Wildfire Effects on Recent Habitat Trends

Past and continuing habitat loss was a primary reason for listing the NSO under the federal Endangered Species Act (USFWS 1990). At the time of listing, the Fish and Wildlife Service estimated that 60-88% of the subspecies' habitat had already been lost (USFWS 1990; also see *Potential Threats: Timber Harvesting*). They attributed most of this loss to timber harvesting and land conversion but also acknowledged the roles of wildfire and other natural disturbances. Since listing of the NSO and subsequent adoption of the Northwest Forest Plan, timber harvesting has declined and wildfire has been identified as the primary source of forest

Comment [M33]: How is habitat lost? Define how suitable habitat is defined, and how it is lost.

disturbance and habitat loss on federal lands (Courtney et al. 2004, USFWS 2011, Kennedy et al. 2012).

Estimates of recent trends in amounts of NSO habitat, and of older forest in general, have been produced as part of monitoring efforts for the Northwest Forest Plan; and are therefore, largely restricted to the Plan's area and time span (Davis and Lint 2005, Davis and Dugger 2011, Moeur et al. 2005, 2011). We focus on estimates by Davis and Dugger (2011) because they replaced those of Davis and Lint (2005) and are more specific to NSO habitat than those of Moeur et al. (2005, 2011). We do not review habitat trend estimates based on federal ESA Section 7 consultation records (Bigley and Franklin 2004, USFWS 2012) due to greater scientific uncertainty and methodological bias associated with those data (see Bigley and Franklin 2004). Trends described by Bigley and Franklin (2004), Moeur et al. (2005, 2011), and USFWS (2012) quantitatively differ from those of Davis and Dugger (2011) but similarly indicate that wildfires have been the primary source of recent habitat loss on federal lands (see below).

Comment [M34]: There is a problem of bias in how suitable habitat is defined, and the criteria for 'loss' or 'degraded'.

Davis and Dugger (2011) used remotely sensed (satellite imagery) vegetation data to model changes in habitat suitability across the NSO's range during the first 15 years of the Northwest Forest Plan (1994-2007 in California and 1996-2006 in Oregon and Washington). Habitat suitability was based on characteristics surrounding thousands of NSO pair locations across the Plan area. Suitable breeding habitat was defined as having both a probability of owl presence greater than expected based on random chance and environmental conditions typical of those found around nesting and roosting pairs. Estimated habitat trends included gross loss of both suitable breeding habitat and "core" suitable breeding habitat (>330 ft from edge). Davis and

Comment [M35]: But rarely include burned sites, so definition of 'suitable habitat' is biased against burned forest.

Dugger (2011) considered habitat loss to have occurred when an area classified as suitable at the beginning of Northwest Forest Plan was later downgraded to a lower suitability rank (unsuitable or marginal) due to vegetation changes caused by forest disturbances. Davis and Dugger (2011) did not estimate recruitment of, or net changes in, breeding habitat because their remotely sensed data was incapable of accurately capturing relatively slow and subtle habitat changes during development of intermediate-aged and older stands. They did, however, estimate net trends in NSO dispersal habitat, which they defined as forest with a mean canopy cover of at least 40% and a mean DBH of at least 11 inches. Recruitment of dispersal habitat was more detectable than that of breeding habitat due to more rapid and measurable growth in younger forest (some recruitment also occurred due to degradation of suitable breeding habitat brought about by forest disturbances).

Estimated gross losses of suitable breeding habitat on federal and non-federal lands are presented in Tables B and C, respectively. During the first 15 years of the Northwest Forest Plan, wildfires were responsible for an estimated gross loss of 236,700 acres (2.7%) of suitable breeding habitat on federal lands rangewide and 13,100 acres (0.3%) on non-federal lands (1.9% combined). In California, wildfires removed an estimated 75,500 acres (4.1%) of suitable breeding habitat on federal lands and 5,600 acres (0.4%) on non-federal lands (2.4% combined). Approximately 70% of habitat loss to wildfire on federal lands occurred within the Oregon and California Klamath Provinces (Table B). Most of this habitat loss was caused by the1999 Megram Fire and 2002 Biscuit Fire (Table D). Fires in the Eastern Cascades Provinces of Washington, Oregon, and California contributed less to total habitat loss than did fires in the Klamath, but were often more destructive in terms of proportion of suitable habitat lost within individual fire perimeters.

In contrast with federal lands, wildfires were responsible for very little habitat loss on non-federal lands; rather, timber harvesting accounted for most losses in these areas (Figure A).

Table B: Estimated gross losses of suitable NSO breeding habitat on federal lands due to wildfires during 1994-2007 in California and 1996-2006 in Oregon and Washington (adapted from Davis and Dugger 2011, USFWS 2011).

State	Province	Initial Acres	Acres Lost	Percent Lost
California	CA Cascades	213,200	1,800	0.8%
	CA Klamath	1,489,800	71,600	4.8%
	CA Coast	145,400	2,100	1.4%
Oregon	OR Coast Range	611,200	0	0.0%
	Western OR Cascades	2,258,700	28,900	1.3%
	Eastern OR Cascades	402,900	17,800	4.4%
	Willamette Valley	3,400	0	0.0%
	OR Klamath	985,000	93,600	9.5%
Washington	Olympic Peninsula	763,100	200	0.0%
	Eastern WA Cascades	673,600	20,000	3.0%
	Western WA Cascades	1,283,000	700	0.1%
	Western WA Lowlands	24,700	0	0.0%
Rangewide Total		8,854,000	236,700	2.7%

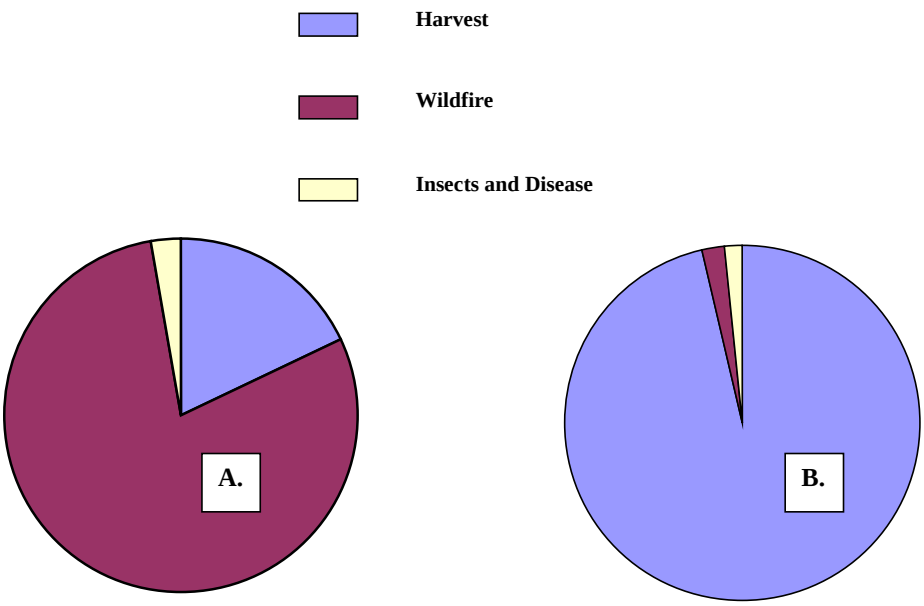
Table C: Estimated gross losses of suitable NSO breeding habitat on non-federal lands due to wildfires during 1994-2007 in California and 1996-2006 in Oregon and Washington (adapted from Davis and Dugger 2011, USFWS 2011).

State	Initial Acres	Acres Lost	Percent Lost
California	1,556,700	5,600	0.4%
Oregon	1,382,400	5,100	0.4%
Washington	1,258,900	2,400	0.2%
Total	4,198,000	13,100	0.3%

Table D: Estimated gross losses of suitable NSO breeding habitat to individual wildfires during 1994-2007 (note: "habitat degraded" describes areas downgraded from highly suitable to suitable; from Davis and Dugger 2011).

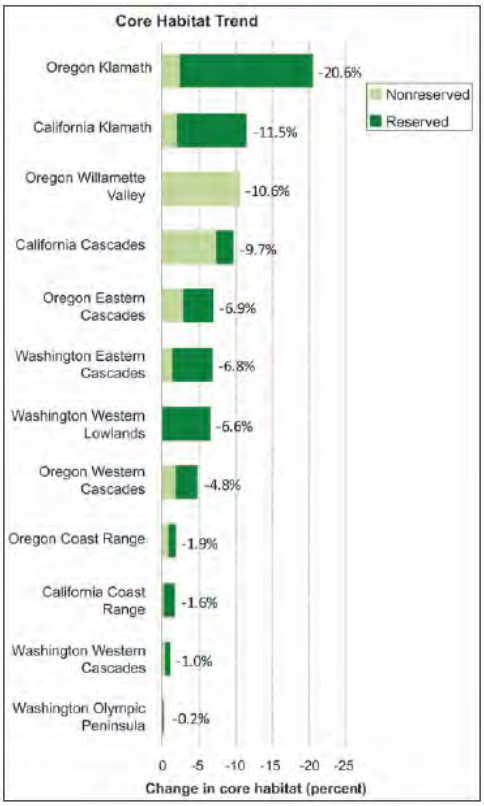
Fire name	Year	Broad physiographic province	Habitat in wildfire perimeter	Habitat lost		Habitat degraded	
			Acres	*Acres*	*%*	*Acres*	*%*
Biscuit Fire	2002	Klamath Mountains	226,230	93,730	41	12,019	5
Megram Fire	1999	Klamath Mountains	76,337	27,520	36	4,589	6
B&B Complex	2003	East Cascades	26,269	16,403	62	907	3
Bake-oven Fire	2006	Klamath Mountains	23,946	8,873	37	581	2
Boulder Fire	2002	West Cascades	34,059	8,460	25	2,074	6
Davis Fire	2003	East Cascades	8,050	6,943	86	5	0
Pigeon Fire	2006	Klamath Mountains	13,896	5,634	41	327	2
Rex Complex	2001	East Cascades	8,548	4,750	56	278	3
Timbered Rock	2002	West Cascades	10,216	4,539	44	569	6
Spring Fire	1996	West Cascades	13,504	3,931	29	858	6
Deep Harbor Fire	2004	East Cascades	5,761	3,930	68	64	1
Hancock Fire	2006	Klamath Mountains	12,712	3,132	25	336	3
Apple Fire 2	2002	West Cascades	12,227	2,810	23	928	8
Fischer Fire	2004	East Cascades	4,479	2,340	52	34	1
Fork Fire	1996	Klamath Mountains	2,962	2,113	71	14	0
Needles Fire	2003	East Cascades	1,946	874	45	1	0
Trough Fire	2001	Klamath Mountains	1,851	798	43	4	0
Hunter Fire	2006	Klamath Mountains	2,236	789	35	40	2
Deer Point Fire	2002	East Cascades	505	380	75	0	0
Tatoosh Complex	2006	East Cascades	666	378	57	0	0

Figure A: Proportions of suitable breeding habitat loss attributed to harvesting, wildfire, and insects and diseases on (A) federal lands and (B) non-federal lands during 1994-2007 (adapted from Davis and Dugger 2011, USFWS 2011).



Davis and Dugger (2011) reported substantial losses of core breeding habitat on federal lands during the first 15 years of the Northwest Forest Plan (Figure B). These losses primarily occurred in reserved areas. Changes in ratios of core and edge habitat classes indicated that increased fragmentation of suitable breeding habitat on federal lands was greatest in the Oregon and California Klamath Provinces and California Cascades Province (see Table 3-3 in Davis and Dugger 2011). Increased fragmentation in these regions was primarily due to wildfires.

Figure B: Gross losses of "core" suitable breeding habitat on reserved and non-reserved federal lands during 1994-2007 in California and 1996-2006 in Oregon and Washington (from Davis and Dugger 2011).



Davis and Dugger (2011) estimated a 5.2% net gain in NSO dispersal habitat. Much of this gain was due to succession in young forests in non-reserved lands at the margins of federal forests. However, accounting for forest connectivity and NSO dispersal distances, Davis and Dugger (2011) reported a 1% net loss of "dispersal-capable landscape". Much of the loss of dispersal-capable landscape in the Klamath and Eastern Cascades Provinces was due to wildfires, whereas timber harvesting on non-federal lands was responsible for much of the loss in other regions.

Loss and fragmentation of breeding habitat to wildfires was likely at least partially offset by recruitment of new habitat through succession of mature and old forest. However, Davis and Dugger (2011) found that detectable recruitment of breeding habitat primarily occurred in the marginal suitability class. This finding was supported by Moeur et al. (2005), who found that about 90% of recruitment of older forest (mature and old-growth combined) during the first 10 years of the Northwest Forest Plan was at the lower end of the class' diameter range (i.e., mean DBH 20-30 in). It is likely that some newly recruited mature forest provides suitable habitat for NSOs but much if it could lack the canopy layering, large diameter snags and logs, and other structural attributes typical of nesting and roosting habitat (*section_xxx*).

Loss and fragmentation of suitable breeding habitat does not necessarily equate to negative impacts on NSOs (Franklin and Gutiérrez 2002; e.g., Bond et al. 2002, 2009, Lee et al. 2012). Studies in southern Oregon and northern California found that the presence and fitness of NSOs are generally highest in landscapes with a mix of both large amounts of suitable breeding habitat and other habitat classes, such as foraging habitat or "non-habitat" (Franklin et al. 2000, Zabel et al. 2003, Olson et al. 2004, Dugger et al. 2005; reviewed in *section_xxx*). Fitness is also

generally highest when suitable breeding habitat occurs in large or clustered patches with large amounts of ecotone or edge (Franklin et al. 2000, Dugger et al. 2005). This combination of conditions is likely important because it provides NSOs with a balance of resources needed for survival and reproduction (Franklin et al. 2000). Active fire regimes in dry forests within the NSO's range in California historically contributed to these conditions by generally sparing older forest and maintaining some form of habitat heterogeneity at both stand and landscape scales (Sugihara et al. 2006). Some contemporary wildfires may still burn in this manner and thereby continue to perform an important ecosystem function in these forests. However, large severe wildfires have contributed, along with fire suppression and timber harvesting, to homogenization of some dry forests within the NSO's range (Skinner et al. 2006). Thus, large severe fires may impact NSOs through loss of habitat heterogeneity, as well as reduced amounts and connectivity of suitable breeding habitat.

Fire Risk in California

Prior to Euro-American settlement, dry forests in the western U.S. generally experienced relatively frequent, low-to-moderate or mixed severity fire regimes (Agee 1993, Sugihara et al. 2006, Van de Water and Safford 2011). Mean pre-settlement fire return intervals in California were 11 years in yellow pine forests (e.g., *Pinus ponderosa*, *P. jeffreyi*), 11-16 years in mixed-conifer forests, and 29 years in mixed-evergreen forests (Van de Water and Safford 2011). Mean fire return intervals in redwood forests south of Del Norte County were also relatively frequent (6-44 yrs: Stuart and Stephens 2006). Frequent fire during the pre-settlement period generally maintained forests with less dense and more clumped tree distributions, higher proportions of

fire-resistant trees (i.e., larger size classes and more fire-tolerant species), and lighter and less continuous fuel beds than occur today (Sugihara et al. 2006). This characteristic fine-scale structural heterogeneity was often overlaid with coarser variability created by effects of elevation, terrain, soils, and other physiographic factors on fire and vegetation patterns (Sawyer 2007). For example, in areas of deeply incised terrain in the Klamath Mountains and southern Cascades of California, upper slopes and south and west facing aspects typically experienced more frequent and severe fire than did other areas (reviewed in Skinner and Taylor 2006, Skinner et al. 2006). Due to fire suppression, early-successional vegetation communities formerly maintained by frequent, small-scale severe fire have greatly declined in some areas of California (Skinner 1995, Nagel and Taylor 2005). Overall, research indicates that fire suppression and other human activities have led to decreased forest heterogeneity at both stand and landscape scales and have contributed to substantial changes in fire regimes in California's dry forests (Sugihara et al. 2006).

Due to fire suppression, fire-free periods have dramatically increased in California's dry forests (Sugihara et al. 2006). For example, fire rotation near Hayfork in the Klamath Mountains increased more than 10-fold (from 19 to 238 yrs) during the post-settlement period (Taylor and Skinner 2003). Abnormally long fire-free periods have facilitated increased accumulation and continuity of fuels in dry forests (Sugihara et al. 2006). When wildfires do occur there is often an increased risk of them becoming very large and for suppression forces to be overwhelmed by their size and number (e.g., CAL FIRE 2008). As in other dry forests across the western U.S., the mean and maximum sizes of wildfires, and the total annual area burned, significantly increased in California's dry montane forests during the 20th and early 21st Centuries (Miller et

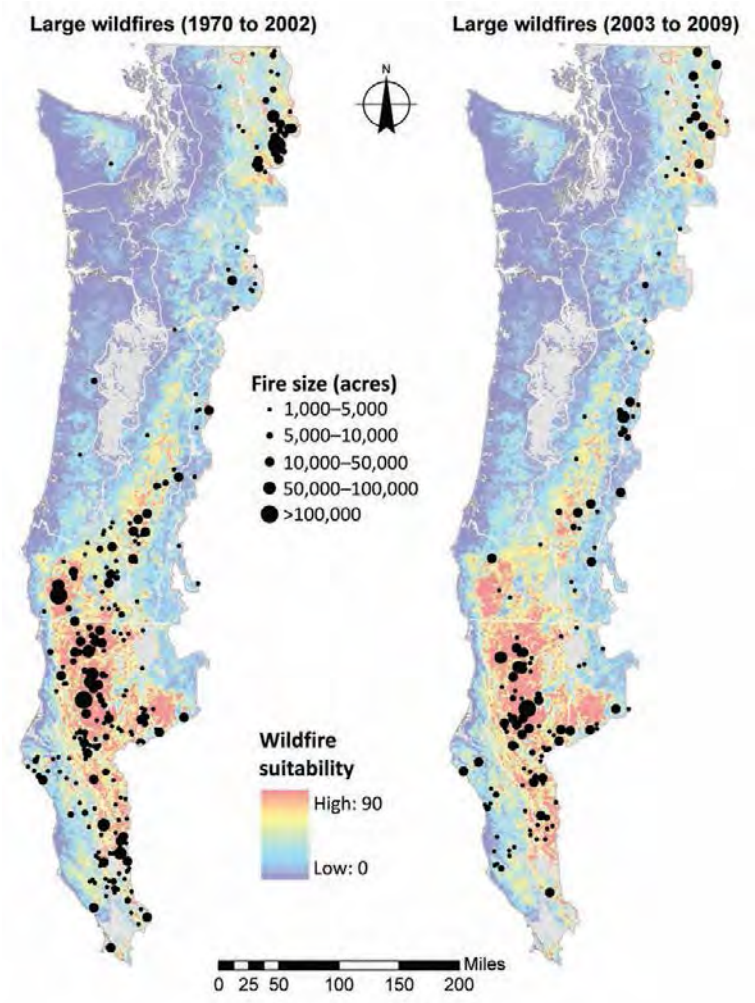
al. 2009, 2012). CAL FIRE (2008) noted that more than half of the 26 largest fires recorded in California during 1932-2008 occurred during the last eight years of that period. Based on recent (1970-2002) fire behavior, the majority of northern California's interior can be classified as highly prone to large (>1,000 ac) wildfires (Davis et al. 2011; Figure C).

Studies of recent trends in extents of high severity fire in California have found conflicting results. For example, Miller et al. (2009) reported a substantial increase in the extent of high severity fire in the Sierra Nevada and southern Cascades of California during 1984-2006; while Hanson and Odion (2014) did not find an increase in the Sierra Nevada during nearly the same period (1984-2010). Similarly conflicting results have been found for the California Klamath Province. Hanson et al. (2009) found a significant increase in high severity fire in the California and Oregon Klamath Provinces during 1984-2005; whereas Miller et al. (2012) did not find an increase in the California Klamath Province during a similar period (1987-2008). Scientific debate ensued regarding the appropriateness of methods used to determine fire severity (e.g., Hanson et al. 2009, 2010 vs. Spies et al. 2010).

Differences in findings regarding trends in high severity fire are related to variation in studies' temporal and spatial scales of analysis, as well as in methods for determining fire severity (Courtney et al. 2008, Miller et al. 2012, Hanson and Odion 2014). For example, Miller et al. (2012) noted that both their own study and those of Odion et al. (2004, 2010) may have underestimated trends in high severity fire in the California Klamath Province due to inclusion of unusual fire years. Studies by Odion et al. (2004, 2010) were based on fire effects during a single year (1987), which Miller et al. (2012) described as unusual. Large areas burned at

below-average severity during 1987 due to abnormally strong inversions, and the fact that some of the fires burned well into fall (when conditions often favor lower severity fire). Miller et al. (2012) also noted that their own ability to detect a trend in fire severity could have been compromised by inclusion of both this year and 2008, which likewise experienced unusually large, low severity fires. Differences in the area analyzed could also affect evaluations of trends in high severity fire. For example, the Biscuit Fire, which was predominantly located in Oregon, included extensive areas of high severity fire and therefore could have influenced results of trends analyses for the Oregon and California Klamath Provinces combined versus the California Klamath alone (Miller et al. 2012).

Figure C: Relative probability of large (>1,000 ac) wildfires ("wildfire suitability") across the NSO's range (from Davis et al. 2011). Modeling was based on landscape and climatic characteristics of locations at which large wildfires occurred during 1970-2002 (left) and was compared with subsequent (2003-2009) locations (right).



Regardless of whether or not the extent of high severity fire increased in California during the last two decades, large severe fires have recently occurred in these areas, and they were responsible for most loss, degradation, and fragmentation of suitable breeding habitat for NSOs on federal lands (Davis and Dugger 2011, Davis et al. 2011; see above). These data cannot be used to project how fires in the future will affect NSOs since they do not necessarily represent past or future fire conditions or effects. However, it is highly unlikely that wildfires will cease to be a major source of habitat loss for NSOs in the future. Rather, climate change research has generally projected a continued increase in the number and sizes of wildfires and the annual area burned during coming decades (see *Potential Threats: Climate Change*). There is scientific uncertainty regarding recent and future trends in the extent of high severity fire in California. Nonetheless, large severe fires will at least occasionally occur in the future and will therefore continue to be a source of habitat loss and modification for NSOs in the state.

Comment [M36]: These aren't peer reviewed. More accurately USFS biologists are responsible for loss and degradation when they redraw PACS and re-designate habitat post fire.

Increases in the number and sizes of wildfires, and effects of fires on NSO habitat, have led to calls for widespread use of thinning and other forms of active management in dry forests (USFWS 2008, 2011, 2012a, Franklin and Johnson 2012). Some researchers and stakeholders, however, have expressed doubts regarding estimates of fire risk and effects on NSOs; concerns about potential effects of thinning on NSOs; and distrust of federal agency intentions (Hanson et al. 2009, Heiken 2010, DellaSala et al. 2013). As discussed in *Potential Threats: Timber Harvesting* (also Hansen and Mazurek 2010, USFWS 2011), there is currently little known about the effects of forest thinning on spotted owls. The available information suggests that low intensity thinning and prescribed fire could be judiciously used to reduce fire risk or restore habitat for NSOs. In contrast, poorly planned thinning could have unintended consequences for

Comment [M37]: This is wrong and biased. Where's Seamans and Gutierrez 2007, Williams et al. 2011. Whre is your citation for how thinning reduced fire risk and 'restores' habitat?

the subspecies. If thinning is used in landscaped occupied by NSOs, it should generally be limited to strategic locations outside of owl core areas and its effects should be monitored within an adaptive management framework. Land managers should also consider allowing more wildfires to burn under prescribed conditions; particularly at lower elevations in the California Klamath Province, where summertime inversions often minimize fire severity (Miller et al. 2012).

Comment [M38]: Where is your evidence that thinning affects fire behavior? This is an enormous leap in logic

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From:	National Audubon Society on behalf of [redacted]
To:	FGC
Subject:	Speak up for Northern Spotted Owls
Date:	Wednesday, March 30, 2016 4:46:44 AM

Mar 30, 2016

California Fish and Game Commissioners California Fish and Game Commissioners
1416 Ninth Street, Room 1320
Sacramento, CA 95814

Dear California Fish and Game Commissioners Commissioners,

As someone who cares deeply about the protection of California's natural treasures, I encourage you to vote in favor of listing the Northern Spotted Owl as Threatened under the California Endangered Species Act. This concurs with the recommendation of California Department of Fish and Wildlife staff.

The Northern Spotted Owl has flown through the old-growth forests of the Pacific Northwest for thousands of years. But in recent years it has faced mounting threats from the competing Barred Owl, habitat loss, climate change, wildfire, and other factors. Northern Spotted Owls are declining throughout their range, and in some places those declines are accelerating. According the California Department of Fish and Wildlife, the species is estimated to have declined by nearly 4% a year since 1985. At some survey points in California, the rates of decline have been particularly severe, some as much as 50% or more.

These losses are continuing despite its listing under the Federal Endangered Species Act in 1990 and state protections that have been in place since the Northern Spotted Owl was elevated to a candidate species in 2013. Listing under the California Endangered Species Act will provide additional protections that the species sorely needs. A state listing will result in greater scrutiny of logging and development within the bird's range, increased coordination among public agencies, and the likelihood of additional funding for protection and recovery efforts.

Again, I ask that you agree with the staff of the California Department of Fish and Wildlife, and vote in favor of listing the Northern Spotted Owl as Threatened under the California Endangered Species Act.

Sincerely,

Ms. Monalisa Rigo Post
[redacted]

GREEN DIAMOND
RESOURCE COMPANY

California Timberlands Division
P.O. Box 68 Korbel, California 95550-0068
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March 30, 2016

Mr. Eric Sklar, President
California Fish and Game Commission
P.O. Box 944209
Sacramento, CA 94244-2090

Re: Proposed listing of the Northern Spotted Owl – Comment on "Report to the Fish & Game Commission – A Status Review of the Northern Spotted Owl (*Strix occidentalis caurina*) in California"

Dear President Sklar and Members of the Commission:

Thank you for the opportunity to comment on the Department's status review and proposed listing of the Northern Spotted Owl (NSO). I have spent the past 27 years studying NSO and implementing conservation measures for NSO on the north coast of California, primarily in Humboldt, Del Norte, Trinity and Mendocino Counties. The majority of this time has been spent working with the first federally approved Habitat Conservation Plan (HCP) for the NSO (Simpson Timber Company 1992 – now Green Diamond Resource Company). Green Diamond currently owns and manages approximately 380,000 acres in Humboldt and Del Norte Counties, and since initiation of its studies on the NSO in 1990, Green Diamond has amassed the largest demographic dataset for NSO (Diller et al. 2010, Forsman et al. 2011, Dugger et al. 2016). Green Diamond also was first to voluntarily implement a field experiment to investigate the demographic response of NSO to lethal removal of barred owls (*Strix varia*) (Diller et al. 2016). All of this work and commitment has greatly contributed to the body of knowledge for NSO and was included in your status review. We believe Green Diamond's HCP and Consistency Determination issued by the Department in 2014 provide one of the best examples of an effective conservation partnership among federal and state agencies and a private company. Therefore, the focus of this comment letter is to provide one perspective on establishment of effective conservation partnerships with all forest landowners that result in measurable conservation benefits to the NSO.

The federal listing of the NSO in 1990 was primarily due to threats from past and ongoing habitat loss on public and private lands (USFWS 1990). That single threat has been dramatically reduced on private lands in California since the NSO listing in 1992 due to federal and state oversight of pre-project surveys for NSO and implementation of habitat protection measures for NSO through the California Forest Practice Rules and federal Habitat Conservation Plans. The extraordinary number of locations of NSO on private lands since 1992 as documented in the California Natural Diversity Database, along with other published studies (Diller and Thome 1999) and reports demonstrates the abundance of NSO on private lands in California. The overwhelming majority of these NSO locations occur on private managed lands that were completely harvested once and regenerated with young-growth forest. The unregulated harvesting of the coastal old growth forests and subsequent regeneration of the young-growth forests resulted in colonization events by NSO and some of the highest reported densities of NSO within the range (e.g., Diller and Thome 1999). These forests are not simply providing dispersal habitat for NSO; they are providing demographic support to the regional NSO population (Green

Diamond 2016) equivalent to NSO on adjacent federal lands. The key point here is that past unregulated harvest (prior to the California Forest Practice Rules and listing of the NSO) and forest regrowth after that initial harvest resulted in habitat for NSO. Therefore, current practices that protect NSO and its habitat should be superior to unregulated practices that "produced" an abundant NSO population. The current trend in the owl population on Green Diamond lands, and likely other lands within north coastal California, do not appear to be linked to trends in habitat. In fact, Green Diamond's predictions are that habitat conditions for NSO are improving through time via implementation of the California Forest Practice Rules, riparian zone protection measures under an approved Aquatic Habitat Conservation Plan and voluntary retention of important biological legacy elements (i.e., "green wildlife trees") (Green Diamond 2010). The best analytical support for declines in NSO appears to be the negative influence of barred owls on NSO occupancy (Dugger et al. 2016). The increase in barred owls and their negative influence on NSO is becoming well documented (Forsman et al. 2011, Dugger et al. 2016, Diller et al. 2016) A six-year experiment comparing demographic response of NSO to lethal removal of barred owls showed that NSO exhibited a rapid positive population response in areas where barred owls were removed (Diller et al. 2016). Green Diamond has been developing a multi-species terrestrial Habitat Conservation Plan (the Forest HCP) that will replace the 1992 NSO HCP that expires in 2022. Along with habitat conservation commitments, species protection commitments, monitoring and reporting commitments and adaptive management commitments, Green Diamond has proposed a three-phase experiment on barred owls. Phase one was completed in 2014 and results are reported in Diller et al. (2016). The continued implementation of the experiments that will provide recovery benefits to the NSO are planned to occur upon approval by the USFWS. Green Diamond would also be seeking concurrence from the Department that the Forest HCP is consistent with CESA requirements for the candidate or listed species.

We encourage the Department and Commission to utilize the existing regulatory framework and process for protecting NSO while finding opportunities to encourage landowner participation in feasible regional efforts to control the threat from barred owls that will provide additional information on NSO response to these efforts and immediate conservation benefits to the species (CA DFW Management Action 29, 30 & 32). The preponderance of research on NSO in the last decade has demonstrated that in the absence of a concerted effort to control barred owls, it will be impossible to measure the effectiveness of existing regulatory measures to protect NSO habitat, let alone any new measures that could result from a CESA listing (CA DFW Management Action 10).

Sincerely,

Keith A. Hamm

Keith A. Hamm
Manager, Conservation Planning
Green Diamond Resource Company
California Timberlands

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determination of threatened status for the northern Spotted Owl. Federal Register 55:26114–26194.

Cc: Mr. Charlton H. Bonham
Director, California Department of Fish and Wildlife
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State of California – Natural Resources Agency
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EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

February 20, 2014

Mike Miles, Director, Forest Science
Humboldt Redwood Company, LLC
P.O. Box 712
Scotia, CA 95565

Dear Mr. Miles:

REQUEST FOR CONSISTENCY DETERMINATION FOR NORTHERN SPOTTED OWL HABITAT CONSERVATION PLAN FOR CALIFORNIA TIMBERLANDS (2080-2014-001-01)

On February 11, 2014, the California Department of Fish and Wildlife (CDFW) received notification from Humboldt Redwood Company, LLC (Humboldt Redwood) that on February 24 1999, the United States Fish and Wildlife Service (Service) issued a Biological Opinion (Service Ref. No. 1-14-99-18; BO) for the Pacific Lumber Company Northern Spotted Owl Habitat Conservation Plan (Project) referenced above. The BO describes the Project and sets forth a series of measures to minimize and mitigate the incidental take of northern spotted owl (NSO; *Strix occidentalis caurina*), a species designated as candidate pursuant to the California Endangered Species Act (CESA) (Fish & G. Code, § 2050 et seq). (See Cal. Code Regs., tit. 14, § 670. 1, subd. (e)(2).)

Humboldt Redwood's notification includes a request, pursuant to Fish and Game Code Section 2080.1, that CDFW determine that the BO, including its Incidental Take Statement (ITS), and ITP (Service Ref. No.TE828950-0), which includes the requirement to fully implement the HCP is consistent with CESA as to the Project.

CDFW has determined that the BO and its related ITS, the ITP, and the HCP, including the minor modification of the HCP issued by the Service on February 5, 2014 (Service Ref. No. AFWO-14B0117-14TA0026) are consistent with CESA with respect to the Project. A copy of the CDFW determination is enclosed for your records (See also Fish & G. Code, § 2080.1, subd. (d).).

If you have questions regarding CDFW's consistency determination, please contact Joe Croteau, Environmental Program Manager at (530) 842-0882, or joe.croteau@wildlife.ca.gov.

Sincerely,

Sandra Morey
Deputy Director

Enclosure

ec: California Department of Fish and Wildlife

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CALIFORNIA ENDANGERED SPECIES ACT CONSISTENCY DETERMINATION NO. 2080-2014-001-01

Project: Northern Spotted Owl Conservation Plan of the Pacific Lumber Company Habitat Conservation Plan

Location: Humboldt County, California

Applicant: Humboldt Redwood Company, LLC

Background

Humboldt Redwood Company, LLC (Humboldt Redwood) is currently implementing a fifty-year Habitat Conservation Plan (HCP) (Project) that covers forest management activities including timber operations on Humboldt Redwood's commercial timberlands. In 2008, Humboldt Redwood acquired all assets from Pacific Lumber Company (PALCO), including all permits and authorizations associated with forest management activities issued to PALCO. Humboldt Redwood's timberlands covered by the company's HCP encompass approximately 211,000 acres within Humboldt County, California.

The Project activities covered by Humboldt Redwood's HCP are timber operations and related management activities which include, but are not limited to: timber management; road and landing construction, reconstruction and upgrading, storm-proofing, inspections, maintenance, closure, decommissioning and use; water drafting; burning; development and operation of borrow pits; commercial rock quarry operations; and scientific surveys and studies.

The Project activities described above are expected to incidentally take[1] northern spotted owl (*Strix occidentalis caurina;* hereafter NSO), a species designated as threatened pursuant to the federal Endangered Species Act (ESA) (16 U.S.C. § 1531 *et seq.*) and as a candidate[2] for listing under the California Endangered Species Act (CESA) (Fish & G. Code, § 2050 *et seq.*). In particular, NSO could be incidentally taken as a result of the Project activities that cause direct or indirect mortality including engaging in timber harvesting within or near occupied NSO nest sites or activity centers, and removing or reducing the quality of occupied

[1]Pursuant to Fish and Game Code section 86, "'Take' means hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." See also *Environmental Protection Information Center v. California Department of Forestry and Fire Protection* (2008) 44 CAL.4th 459,507 (for purposes of incidental take permitting under Fish and Game Code section 2081, subdivision (b), "'take'...means to catch, capture or kill").

[2]The species' status may change following the decision of the Fish and Game Commission to designate the species as threatened or endangered but if there is such a designation, the species will remain a Covered Species. (Cal. Code Regs., tit. 14, § 670. 1, subd. (e)(2).)

owl habitat which displaces NSO from suitable habitat into unsuitable or already occupied habitat. However, a portion of unoccupied but suitable NSO habitat has been and is projected to be available on the Humboldt Redwood ownership for displaced owls to occupy.

NSO individuals occupy the Project site and other unoccupied but suitable habitat occurs within the Project site. Because of the presence of NSO on site, dispersal and other movement patterns of the species, and the presence of other suitable habitat within the Project site, the United Stated Fish and Wildlife Service (Service) determined that Project activities are expected to result in the incidental take of NSO.

According to the Service, the Project will remove or modify the following acres of mid- and late-seral forests (including old-growth and residual Douglas-fir or redwood), by the following silvicultural prescriptions: clearcut - 18,474 acres; commercial thin- 3,232 acres; selection harvest- 20,032 acres; shelterwood removal– 400 acres; and shelterwood seed step - 105 acres. All canopy cover classes are included in this estimate; therefore, these data may overestimate the effect. Both mid- and late-seral forests are suitable habitat for NSO.

Because the Project was expected to result in take of a species designated as threatened under the federal ESA, PALCO prepared an HCP in support of an application for an incidental take permit (ITP) pursuant to section 10(a)(1)(B) of the ESA. On March 1, 1999, the Service issued ITP No. TE828950-0. The ITP requires full implementation of, and compliance with, all conservation measures listed in the HCP for avoidance, minimization, and mitigation for impacts to NSO, as well as compliance with the terms and conditions in the associated Implementation Agreement (IA), all of which were incorporated by reference as conditions of the ITP. On February 24, 1999, the Service issued a biological and conference opinion (Service Ref. No. 1-14-99-18) (BO) for the Project based on the following documents: (1) the 1999 PALCO Sustained Yield Plan (SYP) and HCP, (2) the 1999 Final Environmental Impact Statement/Environmental Impact Report for the Headwaters Forest Acquisition; and (3) the final IA signed by the Service, California Department of Fish and Wildlife (CDFW), and PALCO on February 26, 1999. The BO describes the Project, requires the Applicant to comply with terms of the BO and its associated incidental take statement (ITS), and incorporates additional measures.

As successor Permittee, Humboldt Redwood is required by the ITP to conduct timber harvesting and related operations in accordance with existing state and federal regulations, including the California Forest Practice Rules, the minor modification of the HCP (Minor Mod) issued by the Service on February 5, 2014 (Service Ref. No. AFWO-14B0117-14TA0026), and other operational and policy management actions currently being implemented by Humboldt Redwood, as well as the company's NSO HCP and ITP.

On February 11, 2014, the Director of CDFW received notification from Humboldt Redwood requesting a determination pursuant to Fish and Game Code section 2080.1, that the ITP, which requires implementation of and compliance with, the BO, IA, HCP, and Minor Mod is consistent with CESA for purposes of the Project and the anticipated incidental take of NSO.

Determination

CDFW has determined that the BO, its associated ITS, and ITP, which includes the requirement to fully implement the HCP, are consistent with CESA as to the Project and the anticipated incidental take of NSO. CDFW makes this determination because the mitigation measures contained in the HCP, the ITP, the IA, the conditions of the HCP, the timing of NSO surveys for new operations and adjusting surveys to maintain a high probability of detecting NSO during pre-project surveys as described in the Minor Mod, and other operational and policy management actions currently implemented by Humboldt Redwood, as well as the conditions in the environmental assessment and the associated finding of no significant impact (See 40 C.F.R. § 1508.13), meet the conditions set forth in Fish and Game Code section 2081, subdivisions (b) and (c), for authorizing incidental take of CESA-listed species. Specifically, CDFW finds that: (1) take of NSO will be incidental to an otherwise lawful activity; (2) the mitigation measures identified in the ITP and HCP will minimize and fully mitigate the impacts of the authorized take; (3) adequate funding is ensured to implement the required avoidance minimization and mitigation measures and to monitor compliance with, and effectiveness of those measures; and (4) the Project will not jeopardize the continued existence of NSO. The mitigation measures in the ITP, IA, and HCP include, but are not limited to, the following:

- Humboldt Redwood will sell the Headwaters Forest, Owl Creek Reserve, and Grizzly Creek Reserve to the state and federal governments to ensure their functions as wildlife reserves in perpetuity.

- Humboldt Redwood will set aside, for the life of the HCP, some of the most valuable NSO and marbled murrelet nesting habitat in a series of Marbled Murrelet Conservation Areas (MMCAs).

- Humboldt Redwood will conduct a combination of night and daytime surveys and stand searches to locate both known, and any new, NSO activity sites.

- Humboldt Redwood will comply with the NSO Conservation Strategy, which relies upon other conservation elements of the HCP for the retention and recruitment of potential foraging, roosting, and nesting habitat in watersheds across the ownership throughout the HCP period.

- Humboldt Redwood will maintain a minimum of 108 NSO activity sites each year over the life of the HCP.

- Humboldt Redwood will maintain an average reproductive rate of at least 0.61 fledged young per pair, over a five-year period, for the minimum of 108 activity sites on the ownership.

Monitoring and Reporting Measures

- Humboldt Redwood shall conduct complete annual censuses to monitor all activity sites on the ownership and to determine numbers of pairs, nesting pairs, and reproductive rates. Humboldt Redwood may use a sampling methodology, rather than a complete census, if the sampling proposal has been reviewed by the Northern Spotted Owl Scientific Review Panel (NSOSRP) and approved by the Service and CDFW. Humboldt Redwood shall provide monitoring data annually to the NSOSRP, the Service, and CDFW.

- Humboldt Redwood shall survey the THP area and a 1,000-foot buffer for new operations, except site preparation, initiated in the period beginning February 21 and ending on or before August 31. Three survey visits, each separated by at least one week, shall occur prior to the start of operations, but after March 1. At least one visit shall occur on or after April 1. Survey efforts may be modified pursuant to HCP Section 6.2.3, Item 8 within the constraints of a minimum of three visits, and a maximum of six visits range.

- In 2014, and at five-year intervals thereafter, Humboldt Redwood shall conduct an analysis of NSO occupancy and detection probabilities using their accumulated survey data. The analysis shall include appropriate covariates for other factors that explain detectability. The Service and CDFW will review the appropriateness of the analysis methods. The results will be evaluated to determine the appropriate number of night and/or daytime survey visits necessary to maintain ≥ .90 confidence interval, (e.g. $CI = 1 - (1 - P_{survey})^{n\ surveys}$ to detect NSO, if present, for new operations initiated in the period beginning February 21 and ending on or before August 31. Survey methods will be modified accordingly to maintain this confidence interval, with the constraints of a minimum of three visits, and a maximum of six visits range. Humboldt Redwood, the Service and CDFW, and/or the NSOSRP will meet to review the results and determine modifications, if necessary.

- By February 1 of each year, Humboldt Redwood will submit a report describing the activities undertaken, results of the Operating Conservation Program, and the proposed Operating Conservation Program activities for the next year for all lands covered by the HCP, including the MMCAs (the "Annual Report"), as described in the HCP's Operating Conservation Program. As applicable, the Annual Report will contain the results of the surveying and data collection for those species that have multi-year reporting protocols.

Financial Assurances

- Prior to initiating Project activities, Humboldt Redwood will provide CDFW with a performance security in the form of a surety bond executed by an admitted surety insurer, irrevocable letter of credit, trust fund, or other form determined by CDFW, in the amount of $2,000,000, as a financial assurance for implementation of the HCP.

Pursuant to Fish and Game Code section 2080.1, take authorization under CESA is not required for the Project for incidental take of NSO, provided Humboldt Redwood implements the Project as described in the BO, ITS, ITP, IA, HCP, and Minor Mod, including adherence to all measures contained therein, and complies with the mitigation and other conditions described in the BO and its associated ITS, as well as the HCP and ITP. If there are any substantive changes to the Project (e.g., amendments replacements, or termination of the Service's ITS, HCP, IA, or ITP as amended to date), Humboldt Redwood shall obtain a new consistency determination or a CESA incidental take permit for the Project from CDFW. (See generally Fish & G. Code, §§ 2080.1, 2081, subds. (b) and (c)).

By: _____ Date: 2/21/14

Sandra Morey, Deputy Director
Ecosystem Conservation Division
California Department of Fish and Wildlife

Northern Spotted Owl Annual Report

2015

February 1, 2016

SEVENTEENTH ANNUAL REPORT

Submitted to the United States Fish and Wildlife Service, the California Department of Fish and Wildlife, the NOAA Fisheries, and the California Department of Forestry and Fire Protection

By

Humboldt Redwood Company, LLC

To fulfill the requirements of the Habitat Conservation Plan, 6.2, Northern Spotted Owl Conservation Plan

February 1, 2016

Project Managers/ Primary Authors

Brad Mauney

Sal Chinnici

Project Description

Title: Northern Spotted Owl Annual Report 2015

Purpose: Northern spotted owl HCP monitoring

Date Initiated: March 1999

Projected End Date: Ongoing

Manager: Sal Chinnici Manager, Forest Sciences and Brad Mauney, Lead Wildlife Biologist

Report Summary:

During the 2015 northern spotted owl survey season a total of 800 calling stations were used to conduct nighttime surveys of the sample quadrats and Timber Harvesting Plans (THP). A total of 918 daytime status and follow-up visits were conducted. All core sites and all activity sites within the sample quadrats were visited to determine occupancy, reproductive status, and reproductive success (if applicable).

Management objective 1 of the HCP, which requires the maintenance of a minimum of 108 activity sites in the HCP area, was met in 2015 with 135 total occupied activity sites including the 108 core sites. There are currently 214 total activity sites (occupied and unoccupied) on the property. Management objective 2, which calls for maintenance of spotted owl pairs on a five-year running average of 80% of core activity sites, was met in 2015 with a five-year running average of 82%. The pair occupancy rate for 2015 alone was 84% (91 of the 108 cores sites were occupied by a pair of spotted owls). Management objective 3 requires the maintenance of a five-year running average reproductive rate of at least 0.61 fledged young per pair for the core sites (for those pairs monitored to determine reproductive output). Nesting activity was verified for 39 of the 91 pairs (of the 108 core sites), and a total of 49 young were fledged, resulting in a reproductive rate of 0.54 in 2015. The five-year running average of the reproductive rate for the seventeenth year of the HCP is 0.42, below the requirements of management objective 3.

In February of 2014 HRC and the U.S. Fish and Wildlife Service completed a minor modification to the HCP that resulted in a timing requirement for THP surveys and an adaptive

management requirement for occupancy and probability of detection analysis of HRC spotted owl surveys that will guide future survey methods.

Because the northern spotted owl was elevated to the status of a candidate for state listing, HRC requested and received a Consistency Determination from the California Department of Wildlife that the conservation measures of the HCP are consistent with the California Endangered Species Act.

HRC continues to have concerns about various threats to our spotted owl population, represented primarily by barred owls. The continuing invasion of barred owls has the potential to reduce or eliminate the HRC spotted owl population regardless of other effects.

We currently recommend continuing the same monitoring strategies for the 2016 season.

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EXECUTIVE SUMMARY

The year 2015 was the seventeenth year of surveys and monitoring under the Northern Spotted Owl Conservation Plan (Habitat Conservation Plan or HCP §6.2) of the Humboldt Redwood Company (HRC) HCP. The intent of this report is to briefly summarize the methods, results, and management objectives of this conservation plan. As with previous reports, relevant appendices have been copied to a CD along with this report.

During the 2015 survey season we continued to rely upon the changes in survey methods resulting from the HCP minor modifications of 2002. Monitoring surveys were accomplished using 380 calling stations to cover all potential spotted owl habitat within the 2015 sample quadrats. Overall, a total of 800 calling stations were used to conduct nighttime surveys of the quadrats and Timber Harvesting Plan (THP) surveys. Follow-up visits were conducted to the locale of night contacts to determine the status and location of the owls contacted. A total of 916 daytime status and follow-up visits were conducted. All core sites, and all activity sites within the sample quadrats, were visited to determine occupancy, reproductive status, and reproductive success (if applicable).

Management objective 1 of the HCP requires the maintenance of a minimum of 108 activity sites[1] in the HCP area over the life of the permit. There were 138 total occupied activity sites in 2015, including the 108 core sites. Therefore management objective 1 was met in 2015. Management objective 2 calls for maintenance of spotted owl pairs on a five-year running average of 80% of the core activity sites in the HCP area. In 2015, 91 of the 108 cores sites were occupied by a pair of spotted owls, for a pair occupancy rate of 84% (0.843).The five-year running average for the occupancy rate by pairs is now 82% (0.815). Management objective 3 requires the maintenance of a five-year running average reproductive rate of at least 0.61 fledged young per pair for the core sites (for those pairs monitored to determine reproductive output). During the 2015 breeding season, 91 pairs (of the 108 core sites) were monitored for nesting activity and reproductive output. Nesting activity was verified for 39 of the 91 pairs. A total of 49 young were fledged, resulting in a reproductive rate of 0.54. The five-year running average of

[1] **Activity site** (or activity center) is the area surrounding and including the nest tree or primary roost tree of a pair of spotted owls or single spotted owl, and where they are consistently located.

the reproductive rate for the seventeenth year of the HCP was 0.42 (0.416); therefore it does not meet the requirements of management objective 3.

In February of 2014 HRC and the U.S. Fish and Wildlife Service (Service) completed a minor modification to the HCP that resulted in an additional timing requirement for THP surveys and an adaptive management requirement for occupancy and probability of detection analysis of HRC spotted owl surveys that will guide future survey methods. Further detail is provided below.

Because the northern spotted owl was elevated to the status of a candidate for state listing, HRC requested and received a Consistency Determination from the California Department of Wildlife (Department) that the conservation measures of the HCP are consistent with the California Endangered Species Act.

HRC continues to have concerns about various threats to our spotted owl population, represented primarily by barred owls, but also including West Nile Virus, potential poisoning threats from trespass marijuana grows, and sudden oak death. Individually or in concert these stressors have the potential to reduce or eliminate the HRC spotted owl population or habitat regardless of HCP effects. At present, the actual effect of these threats on our population is unknown.

We currently recommend continuing the same monitoring strategies for the 2016 season, including the continued implementation of the revised THP survey requirements related to the occupancy and detection probability analysis completed in 2015.

INTRODUCTION

The purpose of this Northern Spotted Owl (spotted owl or NSO) seventeenth Annual Report is to present the results of surveys and analyses of management objectives for the northern spotted owl (*Strix occidentalis caurina*) on lands of the Humboldt Redwood Company, LLC (HRC) covered by the HRC Habitat Conservation Plan (HCP), U.S. Fish and Wildlife Service (USFWS, the Service) Permit TE828950-0.

The reporting period is from 1 January 2015 to 1 January 2016, and covers surveys conducted from March to August 2015. The year 2015 was the seventeenth year of surveys and monitoring

under the Northern Spotted Owl Conservation Plan (HCP §6.2). Regarding annual surveys, or censuses, HCP §6.2.2 # 2 states:

> *Monitoring data shall be provided annually to the NSOSRP (Northern Spotted Owl Scientific Review Panel), the USFWS, and CDFW (California Department of Fish and Wildlife, the Department).*

As stated in HCP §6.2, the overall conservation strategy for spotted owls is a habitat-based approach that includes the harvest, retention, and recruitment of habitat and essential habitat elements at both the landscape and activity site levels. The strategy also includes measures for disturbance minimization, population monitoring, and adaptive management techniques.

During the seventeenth year of HCP implementation, the northern spotted owl program continues to follow the "quadrat" sampling approach and minor modifications approved in 2002 to monitor the "core" owl sites for occupancy and reproduction.

These minor modifications approved in 2002 consisted of three primary components: 1) clarification that the HCP's spotted owl management objectives apply to the "core" (i.e., Level 1 and Level 2) owl sites, 2) modification of the census techniques to concentrate on sampling "quadrats" made up of watershed units on the covered lands, and 3) modification of survey methods for site preparation activities, recognizing that these activities are different in nature from timber harvesting relative to breeding season disturbance. These minor modifications to the HCP have been appended to previous reports, and are incorporated here by reference.

During a September 2003 meeting we also continued discussions with the USFWS and the CDFW regarding the evaluation for retention or removal of activity sites. These discussions eventually led to the development of a mutually agreed-upon survey methodology for removal of unoccupied sites from the list of activity sites.

In 2009 the Habitat Retention Area (HRA) strategy was fully implemented. The HRAs are intended to provide long-term nesting and roosting habitat around the *most productive* NSO activity centers. The USFWS, CDFW, and HRC reviewed habitat and other maps, aerial photography, and known NSO locations to identify HRAs for 80 Level 1 NSO activity centers. The HRAs were developed for activity centers that have a history of occupancy and reproduction. Because a proportion of these sites may be unoccupied in some years, the HRAs

are intended to continue to provide nesting and roosting habitat during these unoccupied years given the reasonably likely event they will be reoccupied over time. If a Level 1 HRA is unoccupied, a replacement Level 1 activity center is selected from other available sites meeting required criteria. There are currently eighteen unoccupied HRAs; consequently we are currently maintaining 98 Level One sites.

On 27 December, 2013 the California Fish and Game Commission adopted the Department's findings that the listing of the northern spotted owl as a threatened or endangered species under the California Endangered Species Act (CESA) may be warranted, resulting in candidate status for the spotted owl during the status review period. Under CESA, a candidate species receives protection from "take" as if it were listed, until such time as a status review is conducted and a final listing determination is made.

HRC, the Service, and the Department discussed NSO management and monitoring in light of this change in status, and agreed to a HCP minor modification regarding THP surveys and HCP adaptive management. HRC agreed to conduct an occupancy and probability of detection analysis of our NSO survey data from 2003 – 2014 to achieve a better understanding of how many day and/or nighttime surveys are necessary to detect spotted owls, considering the presence of barred owls in the region. The analysis was completed prior to the 2015 survey season, and will be revisited every five years, or as needed.

Subsequently, because the northern spotted owl is a federally covered species under the HRC HCP, HRC applied for a Consistency Determination through the Department and received a concurrence letter on 20 February 2014. As of the date of this report, the California Fish and Game Commission has not made a final determination on the listing of the NSO in California.

This brief introduction of the 2015 spotted owl program is expanded below. In particular, this report discusses: 1) the study area and methods used in the assessment of spotted owls within that study area, 2) results of the survey efforts, 3) the meaning of the results both biologically and with respect to the management objectives of the HCP, and 4) HRC's year 2016 action plan for the spotted owl conservation plan.

STUDY AREA AND METHODS

The HRC HCP covered lands currently encompass approximately 209,000 acres and are located in coastal Humboldt County in northern California (Map 1). The HCP area is characterized by mountainous terrain, a maritime climate, and dense coniferous forests, primarily dominated by the coast redwood (*Sequoia sempervirens*) and Douglas-fir (*Pseudotsuga menziesii*) forest-types.

In general, field survey methods for spotted owls are conducted following guidelines in the U.S. Fish and Wildlife Service protocol, "Protocol for Surveying Proposed Management Activities That May Impact Northern Spotted Owls" (USFWS 1992). During the 2011 survey season we began to incorporate changes proposed by the USFWS for northern spotted owl surveys in a revised protocol (2011 Northern Spotted Owl Survey Protocol, USFWS 2011a). For example, we used digitally recorded and amplified owl calls, and followed the typical 10 minutes of spotted owl calls with five minutes of barred owl (*Strix varia*) calls for a subset of surveys. Spotted owl and barred owl calls consisted of a mix of standard territorial calls (e.g. 4 and 5 note calls), contact hoots and whistles, and agitated calls digitally recorded and broadcast using Wildlife Technologies® MA-15 electronic callers, or Fox Pro ® "Fury" or "Firestorm" electronic callers.

For all survey methods, when a spotted owl response is evoked during the nighttime surveys, presence, and if possible, status is determined with a follow-up daytime visit. Follow-up visits were conducted using daytime walk-ins of the habitat to attempt to locate nesting or roosting owls. Owl sites were checked to determine occupancy and nesting status. The surveyor walks in to a known site, or returns to the site of a survey contact, and uses voice calling and/or amplified calls to contact the spotted owls which may be nesting or roosting at the site. The suitable habitat in an area roughly 0.5 mile around the previous contact is used as a search area. When a single owl, or a pair of spotted owls, is contacted on the follow-up visit the surveyor offers prey items (domestic mice) in an attempt to establish breeding status.

MONITORING, TIMBER HARVESTING PLAN (THP), AND SITE PREPARATION SURVEYS

As discussed above, minor modifications to the HCP that were approved by the CDFW and USFWS in 2002 affected the survey methodology for monitoring, THP, and site preparation activities. For monitoring, or census purposes, a quadrat sampling design was implemented to

replace a complete census. THP survey methods were refined as a result of experience from the first three years of HCP implementation. In addition, surveys for site preparation activities were modified in recognition of the characteristics and duration of activities that are involved, and also of the potential for disturbance to spotted owls during the breeding season.

Monitoring Surveys

The Northern Spotted Owl Conservation Plan, HCP §6.2.2, # 2 reads:

> *PALCO shall conduct complete annual censuses to monitor all activity sites on the ownership and to determine numbers of pairs, nesting pairs, and reproductive rates. PALCO may use a sampling methodology, rather than a complete census, provided that the sampling proposal has been reviewed by the NSOSRP and approved by the USFWS and CDFW. Monitoring data shall be provided annually to the NSOSRP, the USFWS, and CDFW.*

The USFWS, CDFW, NSOSRP, and PALCO had agreed that using a sampling methodology, rather than a complete census is likely to have several benefits for the population of spotted owls on HRC's covered lands as well as for HRC staff. Following agreement between PALCO, the USFWS, and the CDFW that the HCP management objectives (HCP §6.2.1) for pair occupancy and reproduction apply to the core sites as in HCP §6.2, Table 7, the objectives of a sampling methodology were therefore clarified. Thus, the objectives of sampling a subset of the covered lands each year via night surveys include:

- Tracking known sites within the quadrats surveyed,
- Finding new sites that may be used as part of the minimum level (core) sites,
- Inventorying sites related to management activities, and
- Tracking the number and location of sites within a given geographical area over time, to help provide information on the effects of management activities.

The quadrat approach relies on large hydrologic areas containing multiple owl territories as the basic sampling units (Map 1). The hydrologic units are based on significant watershed areas (e.g. Freshwater Creek, Elk River), using the dividing ridgelines as the boundaries between units. Where necessary to maximize sampling efficiency, hydrologic units were combined into logical units, resulting in a total of 20 quadrats. In other words, if a hydrologic unit on the periphery of the covered lands contained a relatively small portion of HRC covered property, then it was incorporated into an adjoining, logical unit. During the 2015 season, quadrats 4, 6, 10, and 17

were sampled (Cummings Creek, Bear River, Shively Ridge to Larabee, and Kneeland).The basic methods and reporting requirements of the quadrat sampling approach are as follows:

1. Using USFWS night survey protocol techniques, conduct three survey visits of all suitable habitat in the four quadrats for that sample year.

2. Use daytime follow-up visits (again using USFWS techniques) to check occupancy and reproductive status of all known sites in the quadrat (including any core sites).

3. In addition to the visits in item # 2, use daytime follow-up visits to check occupancy and status of any sites contacted on the night surveys.

4. In addition to calculating the values of pair occupancy and reproductive rate for the management objectives of HCP §6.2.1 for the core sites, also calculate the results of the same values for all sites monitored in the quadrats. These combined data will be used to track pair occupancy and reproductive trends over time, and will be compared to information gathered on spotted owls at other study sites in northern California.

5. Prior to 1 June each year HRC shall report to the USFWS and the CDFW on the quantity and distribution of suitable spotted owl habitat in the quadrats and on the covered lands as a whole. This information will be used to help understand potential reasons why management objectives may not be met, and potential means of correction (e.g., HCP §6.2.3 # 6).

6. All survey and status visit results, as well as habitat information from item # 5, will be reported annually in the HCP Annual Report, due each year on 1 February.

Timber Harvesting Plan (THP) Surveys

The methods for surveying THPs in HCP §6.2.2 # 3 also underwent minor modification in 2002, as a result of discussions and agreement between the CDFW, USFWS and PALCO. Refinements in the THP surveys were primarily in the areas of timing of surveys, and clarification in procedural language. The modifications have been included in previous reports and correspondence, and are incorporated here by reference.

Additions were made to the THP survey language in 2009, and again in 2012, to clarify the meaning of "continuous operations", as follows:

> *(a) Note: HRC and the Wildlife Agencies agree that in this context, "maintained continuously" means that:*
> *i) Operations can only be shut down for a maximum of 5 consecutive days, including weekends,*
> *ii) Only 3 of the 5 shut down days can be non-weather related,*
> *iii) Operations must occur for 3 consecutive days between any consecutive 5 day shut down period, and*
> *iv) During any consecutive fixed 10 day period beginning February 21 there must be at least 5 days of operations.*
> *v) If item iii) is applied, there must be 5 consecutive days of operations following the 5-day shutdown, 3-day operations, 5-day shutdown event.*
> *(b) In this context hauling of logs or equipment does not constitute "continuing operations".*

Most recently, the February 2014 HCP minor modification required a slight change in survey timing, and an adaptive management requirement for a survey analysis, with the results intended to guide future survey effort.

THP survey modification:

> *For new operations, except site preparation, initiated in the period beginning February 21 and ending on or before August 31, the THP area and a 1,000-foot buffer shall be surveyed. Three survey visits, each separated by at least one week, shall occur prior to the start of operations, but after March 1. At least one visit shall occur on or after April 1. Survey efforts may be modified pursuant to HCP Section 6.2.3, Item 8 within the constraints of a minimum of three visits, and a maximum of six visits range.* (Minor modification added language is underlined).

Adaptive management addition:

> 8. *In 2014, and at five-year intervals thereafter, HRC shall conduct an analysis of spotted owl occupancy and detection probabilities using their accumulated survey data. The analysis shall include appropriate covariates for other factors that explain detectability. The Wildlife Agencies will review the appropriateness of the analysis methods. The results will be evaluated to determine the appropriate number of night and/or daytime survey visits necessary to maintain $\geq .90$ confidence interval, (e.g., $CI = 1 - (1 - p_{survey})^{n.surveys}$) to detect a spotted owl, if present, for new operations initiated in the period beginning February 21 and ending on or before August 31. Survey efforts will be modified accordingly to maintain this confidence interval, within the constraints of a minimum of three visits, and a maximum of six visits range. HRC, the Wildlife Agencies, and/or the NSOSRP will meet to review the results and determine modifications, if necessary.*

During the 2015 survey season, for new timber operations, we conducted four nighttime surveys and one thorough daytime stand search of the THP. The stand searches were conducted on those THPs that were small enough that it was feasible to complete the stand search in a reasonable amount of time. If the THP consisted of a large of area of suitable habitat, we determined it would be more efficient to conduct six night time surveys and no stand searches. In 2015, there were 116 THPs that received four night surveys and one daytime stand search, four THPs that received six night time surveys and no daytime stand search, and two THPs for which we conducted three night time surveys with no stand searches since the planned operations were only to remove logs on landings, and no habitat was modified.

SITE PREPARATION SURVEYS

Site preparation activities, e.g. those activities undertaken following timber harvest and in preparation for reforestation of a site, typically have little potential for disturbance of breeding, and are of relatively short duration (the methods of surveying for spotted owls for these kinds of activities also were subject to minor modification during 2002). Again, the surveys as described in the modified HCP §6.2.2 # 3 have been appended to previous reports. There were no site preparation-specific surveys conducted in 2015.

ACTIVITY SITE DETERMINATION

As in past years under the HCP, occupancy and reproductive criteria used were consistent with those outlined by the USFWS protocol, along with guidance received from the USFWS and the CDFW. Further, in 2002 the CDFW, USFWS and PALCO discussed and agreed upon a method for determining the establishment and also possibly the location of activity centers based on audio contacts only, and in 2003 agreed upon standards for removal of unoccupied sites. These methods have been discussed and appended in previous reports.

Following a resolution meeting and discussion with the Department, Service and the HCP Monitors in the fall of 2013, Appendix D was modified to include additional information regarding unoccupied activity centers. Based on those discussions and using the guidance of the "Decision Tree", the following eight sites have been identified as unoccupied and removed from the GIS layer for 2015 (site location, watershed):

Site 12 (Mill C, North Fork Elk River), Site 55 (Keller Ranch, Van Duzen River), Site 290 (Grizzly Creek, Van Duzen River), Site 301 (Shively Road, Eel River), Site 323 (Black Creek, Mad River), Site 338 (Railroad Gulch, Elk River), Site 339 (Upper Harmonica Creek, Bear River), and Site 356 (Upper Freshwater Creek, Freshwater Creek).

RESULTS AND DISCUSSION

Monitoring surveys were accomplished using 380 calling stations to cover all potential spotted owl habitat within the 2015 sample quadrats. In comparison, during the 2014 season we used 394 calling stations to cover the habitat within the sample quadrats on HCP covered lands. Overall, a total of 800 calling stations were used to conduct nighttime surveys of the quadrats and THP surveys.

Surveys in 2015 resulted in the equivalent of 2,984 nighttime survey visits, in comparison to 2,425 survey visits in 2014. Reasons for increased overall night surveys in 2015 include: 1) an increase in the number of surveys required from three to four and in some cases six surveys, 2) an increase in the number of stations used per unit area, and 3) an increase in the number of stations and survey visits required to locate known sites or conduct occupancy level surveys.

BARRED OWLS

HRC has continued tracking detections of barred owls (*Strix varia*), as did the previous landowner, since the species began responding to spotted owl calls on surveys starting in about 1991. Mapping of the detections and nest sites illustrates: 1) greater activity to date in the northern areas of the ownership, as would be expected given the known movement of the barred owl invasion, 2) greater numbers of detections along riparian corridors, and 3) an indication of barred owl preference for the old growth MMCAs and reserves (Map 2).

Given the evidence from Washington, Oregon, and other regions of California that barred owls can have a very significant impact on occupancy and breeding of spotted owls (Anthony et al. 2004, Courtney et al. 2004, USFWS 2008, USFWS 2011b, Dugger et al. 2016), HRC remains concerned about the potential for barred owls to disrupt the management goals of the HCP for spotted owls. In fact, the Service has recognized that barred owls appear to be a greater threat to the recovery of spotted owls than was envisioned at the time of the spotted owl listing in 1990,

and as a result has recommended immediate and coordinated action (USFWS 2008, USFWS 2011b).

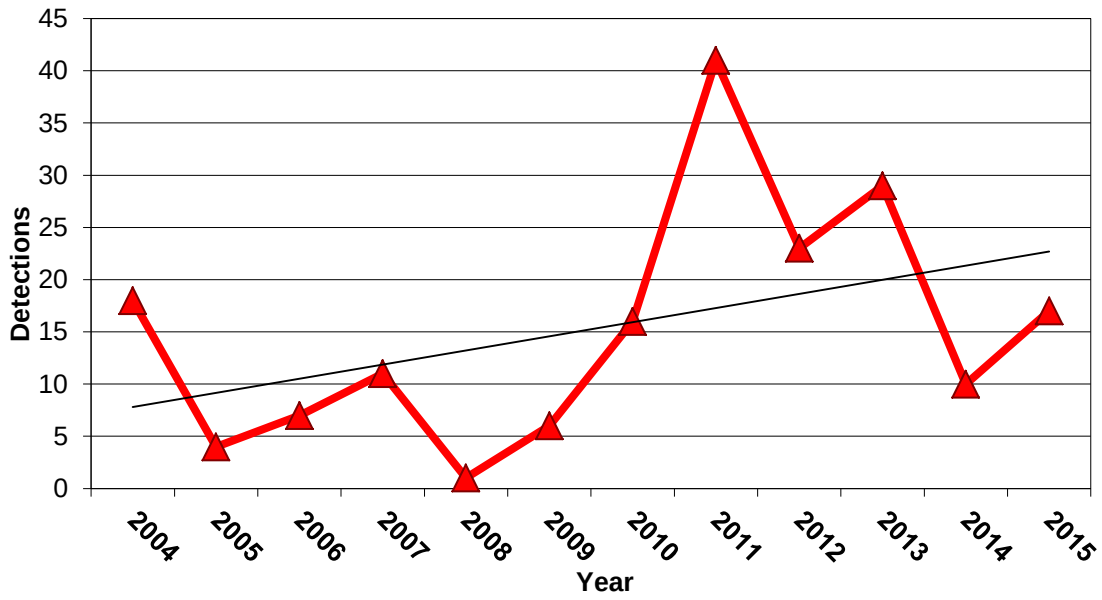
Barred owl activity in the study area continues to indicate that there are established barred owl territories that are reproductively active. In 2015, there was an increase in the total number of barred owl detections, with 40 total detections, compared to 27 total detections in 2014 (Figure 1). One barred owl nesting attempt was confirmed in upper Freshwater Creek in 2015. We also detected barred owls in Howe Creek and Blue Slide Creek. Both of these areas have had barred owl contacts within the general area but not within 0.5 mile of any known activity centers. Since we began tracking the barred owl invasion, there have been 35 Level 1 sites that have been displaced or otherwise affected in some way by barred owls, including those shown below:

Table 1. Summary of Level One sites that have been affected by barred owls.

Site	Level 2014	Level 2015	2014 Status	2015	Site Name
3	ONE	ONE	F	F	McKay Dump East
4	ONE	ONE	PNF	PNN	Graham Gulch
5	ONE	ONE	U	N/C	Gills Mill
9	ONE	ONE	PU	PN2J	Church Camp
11	ONE	ONE	F	F	Doe Creek
13	ONE	ONE	M	M	Lower Lake Crk
14	ONE	ONE	N/C	N/C	North Br. Elk River
28	ONE	ONE	PU	PNN	Strongs Creek
30	ONE	ONE	PU	PU	South Fork Strongs Crk
32	ONE	ONE	PU	PN1J	Upper Cooper Mill MMCA
33	ONE	ONE	PN1J	PU	Middle Cooper Mill MMCA
41	ONE	ONE	M	M	Allen Creek MMCA
47	ONE	ONE	F	PNF	Grizzly Creek MMCA
88	ONE	ONE	F	N/C	Greenlaw Creek
99	ONE	ONE	PU	N/C	Lower Chadd Creek
125	ONE	ONE	PN2J	PN2J	Lower Howe Creek
130	ONE	ONE	N/C	N/C	Corner Creek
147	ONE	ONE	N/C	N/C	Middle Bear Creek
154	ONE	ONE	F	PNN	Keller Ranch West
163	ONE	ONE	PNF	PU	Lower Road 3/Yager Crk
170	ONE	ONE	N/C	N/C	Blue Slide Creek
196	ONE	ONE	N/C	N/C	Nanning Creek
217	ONE	ONE	PNN	PN2J	SF Elk River
234	ONE	ONE	U	N/C	Elk River
254	ONE	ONE	PU	PU	Blue Slide Creek
260	ONE	ONE	PNN	PN2J	Little Salmon Creek
272	ONE	ONE	N/C	F	Lower McCloud Creek
278	ONE	ONE	PN1J	PNF	South Fork Strongs Creek
293	ONE	ONE	F	U	Lower Clapp Gulch
319	ONE	ONE	N/C	N/C	Substation South
320	ONE	ONE	U	N/C	East Br. Bridge Crk.
321	ONE	ONE	PU	PU	South Runenburg Camp
332	ONE	ONE	N/C	N/C	Yager Creek MMCA
540	ONE	ONE	PN2J	PU	Grizzly Crk MMCA
574	ONE	ONE	PU	F	Grizzly Creek Park

Numbers of barred owl detections over time within 0.5 mile of spotted owl activity centers is shown in Figure 1. A linear trend line indicates an apparent increase over time.

Figure 1. Barred owl detections within 0.5 mile of spotted owl activity sites.



In 2015 there were five detections of barred owls on night and daytime surveys at Level Three spotted owl sites including:

- 152 (Little Freshwater Creek)
- 7 (Dunlap Gulch)
- 358 Lower Elk River
- 371 Mill C (NF Elk River)
- 290 Grizzly Creek

In contrast, over the last several years there have also been eight activity sites that have been re-occupied by spotted owls after the apparent disappearance of barred owls: 9 (North Fork Elk River), 11 (Doe Creek), 28 (Strongs Creek), 167 (Corbett Ranch), 260 (Gas Wells), 38 (Yager Creek), 287 (McCready Gulch/Freshwater), and 574 (Mt. Bemis-Grizzly Creek). See Map 2 for a map of all barred owl detections and nest sites located on HRC property.

A spotted owl and barred owl telemetry study involving the National Council for Air and Stream Improvement, Inc. (NCASI), the Bureau of Land Management (BLM), Redwood National and

State Parks, Green Diamond Resource Company, and Mendocino Redwood Company, among others, is reaching a conclusion. The goals of the study included:

- Development of resource selection function models for spotted owl and barred owl habitat in relation to silvicultural applications.
- Promote integrated conservation or recovery of spotted owls across commercial and non-commercial forestlands.
- Clarify spotted owl and barred owl habitat relationships.
- Evaluate spotted owl responses to commercial thinning and partial harvesting in different parts of the owl's range.

Since spring 2010, four male and three female spotted owls, and one male and two female barred owls were captured, banded, and fitted with radio transmitters on HRC lands. Additional spotted and barred owls were captured, banded, and fitted with radio transmitters on adjacent BLM Headwaters Reserve lands.

Throughout the study area, beginning in 2012 and finishing in 2013, field crews conducted variable-radius plots to inventory habitat within home ranges of the radio-tagged owls. By comparing habitat use with availability the study hopes to identify specific influences on habitat selection behavior, such as vegetation structures, landforms, and tree and understory vegetation composition. This information will be useful in designing silvicultural applications that might improve the quality and overall quantity of spotted owl habitat (Adaptive Management Monitoring of Spotted Owls and Barred Owls, 2011 Progress Report, NCASI). Now that vegetative plot data collection is complete, the publication of results is expected in 2016.

West Nile Virus (WNV)

There is no new information on WNV to report for 2015; however, WNV continues to have the potential to be a very serious threat to the northern spotted owl range-wide, and specifically to the Klamath region population (Courtney et al. 2004). It is unclear what effect WNV will have on population viability of spotted owls, and so the scientists involved in the recent 5-year status review of the species discussed two scenarios: 1) an unlikely range-wide reduction, and 2) a likely range-wide reduction in population viability (Courtney et al. 2004).

WNV has been documented in other species in Humboldt County. Mosquitoes, the vector organism for WNV, are very prevalent in the area. WNV has the potential to disrupt HCP objectives regardless of the covered activities of the HCP; however, at the present time there are no avian diseases that appear to be significantly affecting spotted owl populations (USFWS 2008).

Blakesley *et al*. (2004) *In* USFWS (2010) offered two different scenarios for the possible outcomes of an infection by WNV of spotted owl populations:

- Spotted owls could tolerate severe, short-term population reductions caused by the virus because populations are widely distributed and number in the several thousands (see above also), and
- The virus will cause unsustainable mortality because of the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the current range.

SUDDEN OAK DEATH (SOD)

The infection of hardwood species, especially tanbark oak (*Notholithocarpus densiflora* var. *densiflora*), by the invasive plant pathogen *Phytophthora ramorum* (Pythiaceae) and subsequent deterioration of spotted owl habitat has been raised as a threat (Courtney et al. 2004, Courtney et al. 2008, USFWS 2008). The pathogen is not a fungus or a bacterium, but a member of a unique group of organisms called Oomycetes (water molds). Oomycetes share some characteristics of fungi but are biologically different and more closely related to yeasts and brown algae.

The effects of this disease, known as Sudden Oak Death (SOD), could be especially harmful to spotted owl habitat in the Bear and Mattole watersheds on HRC lands where the hardwood component of habitat is most prevalent. Although the most recent evaluations of the extent of SOD in southern Humboldt County show only sporadic incidence (Courtney et al. 2008), continued monitoring indicates that these infestations are spreading and have reached the Decker Creek and Bull Creek watersheds on the southern boundary of HRC lands. Yearly weather patterns are thought to significantly influence the reproduction and spread of this disease.

SOD survey and monitoring results from 2008 to 2015 on HRC lands indicate evidence (positive stream samples and known infected trees) of the pathogen in the Canoe Creek, Decker Creek, Bull Creek, Thompson Creek, and Elk Creek planning watersheds as well as positive stream

samples from the Lower Larabee planning watershed (the source of infection is likely off property to the east). All of these sites are located in the greater Upper Eel watershed. Additionally, there have been positive stream samples taken from the Grizzly Creek and Stevens Creek planning watersheds in the greater Van Duzen watershed, the location and extent of the infection there is still under investigation.

FOLLOW-UP VISITS

Timely follow-up visits were conducted to the locale of night contacts to determine the status and location of the owls contacted. All core spotted owl sites, and all activity sites within the sample quadrats ("quadrat sites") were visited to determine occupancy, reproductive status, and reproductive success (if applicable). Other sites were visited to determine occupancy prior to the August designation of Level 1 sites.

A total of 918 daytime status and follow up visits were conducted in 2015, compared to 849 in 2014. The increase in 2015 visits is most likely due to more barred owl influenced activity centers, which have led to more overall monitoring visits required in an attempt to locate the spotted owls. More quadrat activity sites this year also resulted in an increase in the number of site visits conducted to determine protocol status.

Surveys and daytime status visits were conducted in order to collect data to determine the HCP management objectives (HCP §6.2.1) for the core sites, as discussed above in the Study Area and Methods section.

MANAGEMENT OBJECTIVES 1 AND 4

Management objectives 1 and 4 of the HCP require the maintenance of a minimum of 108 activity sites in the HCP area over the life of the permit, and at least 108 total activity sites in the seventeenth year of the permit (2015). As noted above, the HCP management objectives apply to the 108 core sites, consisting of 80 Level 1 sites, and 28 Level 2 sites. Therefore, with the 108 core activity sites, management objectives 1 and 4 have been met for 2015 (Table 2). In 2015 eight activity centers met the criteria for removal from the active GIS layer according to the Decision Tree for Removal of Activity Centers (Appendix F).

Table 2. HCP northern spotted owl sites and occupancy status for 2015.

Parameter Description	All Sites	Core Sites	Quadrat Sites
A) HCP Occupied Sites	138	108	29
B) Occupied by Pairs	93	91	16
C) Occupied by Male	23	9	7
D) Occupied by Female	15	7	4
E) Occupied by Bird of unknown sex	7	1	2
F) Unoccupied (sites retained)	76	18	10
G) Unoccupied (sites removed)	8	0	3
H) Total HCP Property Sites	214	126	42
Occupancy rate by pairs* (HCP §6.2.1.2 target = 80%)	N/A	84%	55%

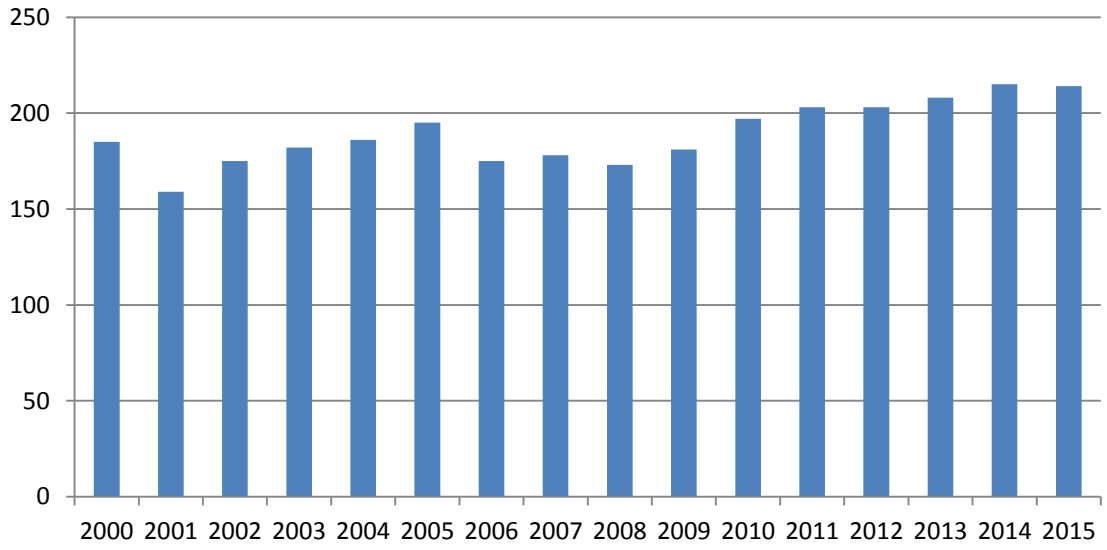
*Occupancy rate by pairs is determined by taking the number of sites occupied by pairs (B), and dividing it by the number of occupied sites: (A).

Core Sites include all Level 1 and Level 2 Sites.

The total number of HCP lands activity sites has remained relatively constant over the HCP years (Range 149-215, mean 189) (Figure 2). Only 149 activity sites were reported in the first year of HCP implementation (1999) when not all of the lands were surveyed. In 2000, several activity sites were included that were not occupied, were the result of take avoidance management prior to the HCP, and were subsequently removed from the inventory for 2001. It should be noted that not all Level 3 sites are surveyed for occupancy or non-occupancy every year, depending on which quadrats are being surveyed.

In 2015 there were seven new activity centers, compared to six in 2014, located by THP surveys, quadrat surveys or incidental contacts. In addition to these seven new 2015 activity centers, five spotted owl territories (sites 133, 230, 310, 537 and 568), formerly off of the HRC ownership, were established or re-established on HRC property and were occupied by a single or pair of spotted owls. One territory (site 284) that was previously removed from our GIS layers was re-established (reoccupied) by a single NSO. It is possible that the gradual increasing trend in spotted owl activity centers from 2008 – 2015 has been due to the movement of spotted owls as a result of increasing barred owl numbers, as well as the resulting barred owl influence on spotted owl activity centers. In 2015, there was an slight increase in the number of unoccupied sites that will be removed from the GIS layers based on protocol surveys as per the Decision Tree for Removal of Activity Centers (Appendix F).

Figure 1. Total NSO Activity Sites by HCP Year.



MANAGEMENT OBJECTIVE 2

Management objective 2 calls for maintenance of spotted owl pairs on an average of 80% of the core sites in the HCP area. During HCP development, 80% was selected as a target by taking the average number of occupied sites that contained pairs during the period of 1991 to 1998. As per HCP §6.2.3 # 6, the values pertaining to management objectives 2 and 3 are to be averaged over running five-year periods (see below). Site occupancy surveys verified pairs at 91 of the core 108 sites during the 2015 season (Table 2), giving an occupancy rate by pairs of 84% (0.843). The five-year running average for the pair occupancy rate is 82% (Table 3).

To address the agreed-upon reporting components of the quadrat sampling approach, we also calculated the pair occupancy rate for all sites monitored in the quadrats, for comparison of results to the core sites. The pair occupancy rate for the 29 (occupied) activity sites within quadrats was 55%. For the quadrat sites, the five-year running average for the pair occupancy rate is 66% (Tables 2 and 4).

MANAGEMENT OBJECTIVE 3

Management objective 3 requires the maintenance of a five-year running average reproductive rate of at least 0.61 fledged young per pair for the core sites (for those pairs monitored to

determine reproductive output). For establishment of a target reproductive rate during HCP development, 0.61 was selected as a target by taking the average number of young fledged per pair during the period of 1994 to 1998. However, only pairs that were determined to be nesting, or confirmed by protocol visits to be non-nesting, were used in the calculation. Spotted owl pairs with "status unknown" are now also used in the equation.

During the 2015 breeding season, 91 pairs (of the 108 core sites) were monitored for nesting activity and reproductive output. Nesting activity was verified for 39 of the 91 pairs. A total of 49 young were fledged, resulting in a reproductive rate of 0.54 for the year. Although the 2015 value represents an increased reproductive rate over the previous four years, this brings the five year running average reproductive rate for the seventeenth year of the HCP to 0.42 (Table 3), which does not meet the target for management objective 3. Since the rolling five-year average target for reproductive rate was not met in 2014 or 2015, the adaptive management measures of HCP § 6.2.3, #6 apply, and a discussion between HRC, USFWS, CDFW, and if necessary, the NSOSRP, shall occur to review potential reasons why the objective is not being met, and to determine potential corrective measures to implement.

Table 3. Northern Spotted Owl Yearly Summary 2015

Owl Status	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Single Unk Sex	4	8	8	1	1	3	3	2	7	3	6	1	4	4	4	4	1
Single Male	29	31	14	4	11	6	9	7	11	9	10	7	9	9	6	7	9
Single Female	6	3	4	8	11	5	5	9	12	10	5	7	6	13	11	6	7
Pair Status Unknown	66	43	39	38	42	38	38	45	47	21	30	44	51	49	52	50	42
Non-nesting Pairs	11	14	12	18	20	13	7	7	14	6	3	5	8	6	17	8	10
Nesting Pair (failed)	0	5	8	2	9	5	5	3	2	9	2	1	9	6	3	7	7
Nesting Pair (PN)	2	0	1	5	1	0	1	3	0	6	3	6	0	1	1	0	0
Nesting Pair (PN1J)	10	10	22	16	7	16	21	16	6	5	13	21	7	9	4	7	15
Nesting Pair (PN2J)	21	46	47	22	6	22	19	16	9	38	36	16	14	11	10	19	17
Nesting Pair (PN3J)	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Total Nesting Pairs	33	56	71	43	14	38	41	35	15	50	52	43	21	21	15	33	39
Total AC monitored (after 2003 only **108 "core sites"** are monitored for reproductive and pair rate)	149	160	156	114	**108**	**108**	**108**	**108**	**108**	**108**	**108**	**108**	**108**	**108**	**108**	**108**	**108**
Total Owls	311	380	405	275	212	262	258	246	210	278	280	254	232	221	219	244	248
Pairs	110	118	130	101	85	94	91	90	78	86	87	93	89	82	87	91	91
Juveniles	52	102	119	60	19	60	59	48	24	84	85	53	35	31	24	45	49
Pair Occupancy Rate	73.8%	73.8%	83.3%	88.6%	78.7%	87.0%	84.3%	83.3%	72.2%	79.6%	80.6%	86.1%	82.4%	75.9%	80.6%	84.3%	84.3%
Reproductive Rate	0.61	0.86	0.92	0.59	0.22	0.64	0.65	0.53	0.31	0.98	0.98	0.57	0.39	0.38	0.28	0.49	0.54
Rolling Average Occupancy Rate (5 Yr)	73.8%	73.8%	83.3%	88.6%	79.6%	82.3%	84.4%	84.4%	81.1%	81.3%	80.0%	80.4%	80.2%	80.9%	81.1%	81.9%	81.5%
Rolling Average Reproductive Rate (5 Yr)	0.61	0.86	0.92	0.59	0.64	0.65	0.60	0.53	0.47	0.62	0.69	0.67	0.64	0.66	0.52	0.42	0.42

Table 4. Northern Spotted Owl Yearly Quadrat Summary 2015.

Owl Status	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Single Unk Sex	1	2	2	1	2	3	0	0	2	2	6	0	2	1	3	0	2
Single Male	7	4	4	3	4	4	3	5	4	3	5	9	5	3	3	5	7
Single Female	1	0	2	1	3	1	0	3	1	3	1	2	4	7	7	3	4
Pair Status Unknown	12	12	8	6	13	13	7	15	11	3	9	4	22	9	18	13	9
Non-nesting Pairs	1	3	2	1	6	3	0	1	2	3	1	0	3	1	3	3	1
Nesting Pair (failed)	0	0	0	0	2	2	1	0	0	2	1	0	1	1	1	4	0
Nesting Pairs	12	10	18	10	7	12	9	4	2	17	19	9	3	5	0	11	6
Total Number of Activity Sites	34	31	36	22	37	38	20	28	22	33	42	24	40	27	35	39	29
Total Number of Owls	76	75	91	55	74	87	49	51	40	89	106	47	75	52	57	89	54
Total Number of Pairs	25	25	28	17	28	30	17	20	15	25	30	13	29	16	22	31	16
Total Number of Juveniles	17	19	27	16	9	19	12	3	3	31	34	10	6	9	0	19	9
Pair Occupancy Rate	73.5%	80.6%	77.8%	77.3%	75.7%	78.9%	85.0%	71.4%	68.2%	75.8%	71.4%	54.2%	72.5%	59.3%	62.9%	79.5%	55.2%
Reproductive Rate	0.68	0.76	0.96	0.94	0.32	0.63	0.71	0.15	0.20	1.24	1.13	0.77	0.21	0.56	0.00	0.61	0.56
Rolling Occupancy Rate (5 YR)	73.5%	80.6%	77.8%	77.3%	77.0%	78.1%	78.9%	77.7%	75.8%	75.9%	74.4%	68.2%	68.4%	66.6%	64.0%	65.7%	65.9%
Rolling Reproductive Rate (5YR)	0.68	0.76	0.96	0.94	0.73	0.72	0.71	0.55	0.40	0.59	0.69	0.70	0.71	0.78	0.53	0.43	0.39

In 2004 the Service clarified that the rolling averages, or running means, for pair occupancy and reproductive rates should be calculated by calculating a mean for each individual year, then calculating a mean of means, where n = 5 (Long 2004). This is the method used for Tables 3 and 4. For the quadrat sites, including all the Level 1-3 sites in the quadrat monitoring units, and using the number of pairs monitored for reproduction (n = 16), the 2015 reproductive rate was 0.56 (Table 4). The five-year running average for reproductive rate among quadrat sites is 0.39 (Table 4). The core site average reproductive rate is greater than the quadrat site rate, as would be expected given the selection of the core sites based on assumed habitat quality and history of successful reproduction.

The NSOSRP recommended monitoring both the core sites and quadrat sites for occupancy and reproduction, and comparing the results to other study sites within the region. Because the HRC core sites and quadrat sites are managed in ways that are specific to the HCP, a comparison of trends in occupancy and reproduction with other study sites that are managed under different strategies (e.g., intensive timber harvest, moderate harvest, little to no harvest) can provide insight as to how the HCP is working and possibly what other factors may be affecting the spotted owl population (e.g., barred owls, climate). The available information indicates that trends for both the core and quadrat sites continue to track the results of other study areas over time (Figure 4).

Per HCP § 6.2.3, #3, management objectives may be modified if new information becomes available following review of the NSOSRP recommendations and approval by the USFWS and CDFW.

ACTIVITY SITE LEVELS OF PROTECTION

HCP §6.2.2 # 4, Conservation Measures, requires that owl activity sites on the covered lands be assigned to one of three protection levels. Accordingly, in September of 2015, 80 activity sites were designated as Level 1 sites. HRC requested an extension of the 1 June requirement for Level 1 selection due to the continuing difficulty of surveying all of the available sites by that date. The difficulty has increased in recent years due to the presence of barred owls in the study

area. USFWS and CDFW again granted HRC's request to extend the selection to 31 August to allow more time to visit the owl sites and provide greater flexibility in selection.

Selection of Level 1 sites was guided by the parameters described in HCP §6.2.2.4: 1) having the requisite habitat levels within a 0.7 and 1.3 mile radius of the activity center; and 2) having supported spotted owls in the previous year (2014), and also in the year selected (2015).

In addition, as part of the minor modifications approved in 2002, further language regarding Level 1 sites was added to management objective 2:

> *Maintain spotted owl pairs on an average of 80 percent (over a five-year period) of the minimum of 108 activity sites on the ownership (as shown in Table 7, for 2002 this minimum number shall be 115 activity sites, then 108 for 2003 and all subsequent years).* ***At least 80 of these sites shall be Level One sites, and the balance shall be Level Two sites. PALCO intends to maintain these selected Level One and Level Two sites as the core sites for a period of from three to five years, or as long as possible, given other circumstances that may arise, and may preclude their maintenance as such. PALCO intends to select core sites that are historically stable, reproductively successful, and that have minimal disturbance, given that they occur in a managed landscape.*** *(Emphasis added).*

In keeping with the requirements of HCP §6.2.2 # 4 and # 5, if less than 500 acres of suitable habitat exists within 0.7 miles, or less than 1,336 acres of suitable habitat exists within 1.3 miles, the acreage of habitat cannot be reduced. HRC is currently protecting ***98*** Level One sites (83 Level One sites with an HRA and 15 replacement Level One sites, per the HRA language).

See the appendices for details and information on habitat acreage relative to Level 1 sites, THP activity, and quadrats (Appendices A-C).

Level 2 protection measures were afforded to 28 sites in 2015 (HCP §6.2.2.5). Level 2 sites receive 1,000-foot buffers during the breeding season. After the breeding season, or if a non-nesting status is determined, harvest may occur around a Level 2 activity site, as long as an 18-acre core area (the equivalent area of a 500-foot radius circle), with at least a 400-foot radius consisting of the best available habitat, is retained.

As with the Level 1 sites, as part of the minor modifications approved in 2002, further language regarding Level 2 sites was added to HCP §6.2.2 # 5, bullet # 4:

> *By 1 September of each year, PALCO shall designate the necessary number of Level Two sites, to make up the minimum number of activity sites as shown in Table 7.*

Accordingly, in late August we designated 28 Level 2 sites, which combined with the 80 Level One sites already designated made up the 108 core sites for 2015.

Level 3 protection was afforded the balance of the activity sites on the HCP covered lands in 2015 (HCP §6.2.2 # 6). Level 3 sites are those sites not needed to meet management objectives 1 or 4 (108 minimum activity sites). As with Level 2 sites, Level 3 sites receive 1,000-foot buffers during the breeding season.

Language was also added (in 2002) to HCP §6.2.2 # 6 regarding Level 3 sites:

> *During the breeding season, for activity sites which have been determined to be occupied by a non-nesting pair or single NSO, 18 acres around the activity site shall be maintained as suitable nesting habitat, if present. The protected 18 acres may conform to natural landscape features, as designated by PALCO's wildlife biologist or a designee, and the buffer protecting the activity site must have at least a 400 foot radius. At PALCO's discretion harvesting may occur during the breeding season, in the area adjoining the 18-acre habitat retention area.*

Thus, if a non-nesting status is determined, harvest may occur around a Level 3 activity site, so long as an 18-acre core area (the equivalent area of a 500-foot radius circle), with at least a 400-foot radius is retained. After the breeding season, harvest of the Level 3 sites may occur. If the activity site is harvested, any known nest trees are to be retained.

Habitat Conditions

The amount and type of spotted owl habitat as per HCP §6.2, Table 6 is reported annually (Table 5). Habitat information from the HRC Geographic Information System (GIS) is a "snapshot in time" of habitat conditions. For consistency and coordination with other forest inventory requirements the snapshot is currently taken on or around 1 January each year (Map 3). Thus, the information contained in this section of the report represents habitat conditions from approximately 1 January 2015 to 1 January 2016.

Ownership changes in and quantity of the HCP lands have occurred during the HCP period (i.e. since 1999). For example, certain lands have been sold to Federal or State entities or have been

"swapped" out of the HCP (following HCP agency review) for real estate sales and have been replaced with parcels similar in size and habitat value from our non-HCP ownership. However, the HRC ownership area has remained consistent since 2008.

As discussed in previous NSO annual reports, annual reports from 1999-2009 utilized forest stand information from 1999 and previous years to generate Wildlife Habitat Relationship (WHR) types and thus nesting, roosting and foraging (NRF) types based on HCP Table 6. Beginning in 2010 HRC embarked on a re-inventory project of the entire 209,000 acres of HRC lands. For the 2010 through 2012 habitat reports we included the most current forest inventory information resulting from 2002-2006 cruise information, harvest updates for each year from 2000 forward, and cruise information available to date from the re-inventory work. This information was the most current and reliable "stand" information and best reflected conditions on the ground, although field evaluations were occasionally needed to verify stand types.

Also noted in previous year's reports, HRC has revised procedures for assigning and tracking WHR and NRF types. Under the new procedures, WHR types are generated directly from tree data collected in HRC's current forest resource inventory; whereas under PALCO, WHR was a static property-wide GIS layer that was usually, but not always, updated for harvests and had not been grown forward since its creation in 1999.

The re-inventory project is now complete for all HRC lands. HRC uses FORSEE software – developed by the California Growth and Yield Modeling cooperative of private and agency organizations – to process field inventory data. To generate WHR habitat types HRC uses output from FORSEE (modeled crown widths and WHR habitat species calls) together with methodology consistent with procedures used for PALCO's 1999 HCP to develop WHR size classes. In future years these procedures will continue to be implemented on the current field inventory data set, which will be updated annually with new/replacement field plots, growth of trees in existing plot data via FORSEE, and changes in timber types resulting from harvest and growth.

The current inventory information has been applied to both the property-wide analysis of habitat (Table 5, Figure 3) and the 0.7 and 1.3 mile habitat radii pertaining to the Level 1 activity sites (Appendix C). A change in habitat trends corresponding with change in ownership, silviculture,

and harvest level can be seen beginning around 2009. The steady, anticipated trend of reduction in nesting habitat, resulting in part due to the even-age silviculture preferred by the previous landowner, has leveled out in recent years. Similarly, the observed recent decline in the previously increasing number of acres of non-habitat is also consistent with the change to uneven-age management, with a concurrent increase in foraging habitat post-harvest.

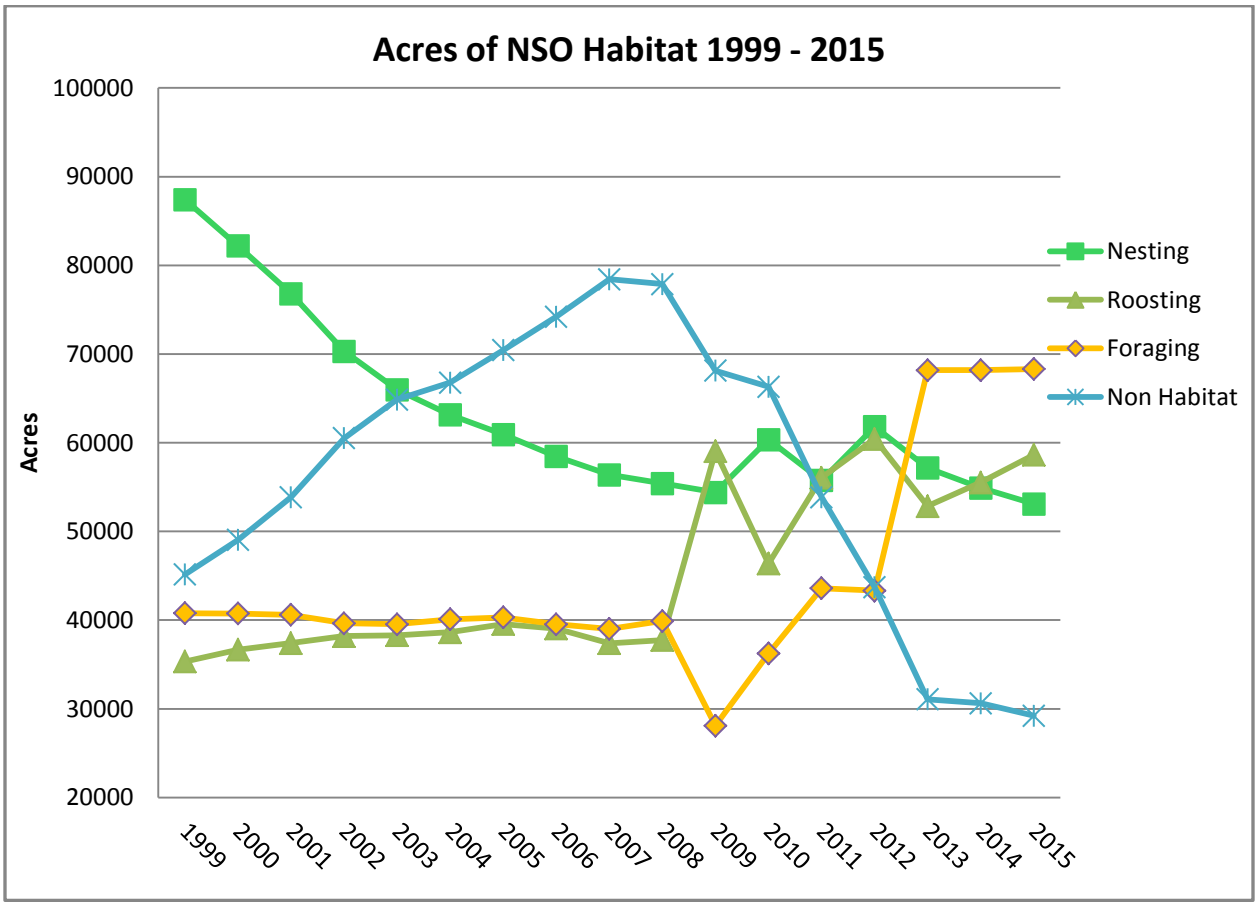
An ongoing concern that bears further investigation is whether or not the selection and group selection harvest will produce as much quality foraging habitat as the previous regime of even-age management.

Similar to previous annual reports, an analysis of patch sizes of suitable nesting habitat has been conducted on both the 18-acre and 80-acre polygon size, and included with this report (Table 5). The inventory changes discussed above also resulted in a change in the number of habitat patches. The acres of habitat in the Grizzly Creek Complex and Owl Creek MMCA are shown separately due to the unique nature of these parcels. No new inventory information has been applied to these parcels, although it is reasonable to assume that young stands in these reserves are growing and potentially increasing in habitat value for spotted owls.

Table 5. Acres of Habitat and Nesting Habitat Patches.

Year	Nesting (Acres)	Roosting (Acres)	Foraging (Acres)	Non Habitat (Acres)	18+ Acre Patches (Nesting)	80+ Acre Patches (Nesting)
1999	87,416	35,343	40,780	45,142	199	64
2000	82,205	36,670	40,753	49,053	204	68
2001	76,799	37,416	40,608	53,858	214	62
2002	70,309	38,209	39,642	60,521	226	72
2003	65,984	38,289	39,538	64,870	231	79
2004	63,153	38,641	40,103	66,784	238	83
2005	60,927	39,557	40,307	70,442	241	93
2006	58,453	39,043	39,533	74,204	244	92
2007	56,386	37,390	39,010	78,431	250	87
2008	55,412	37,747	39,890	77,886	251	88
2009	54,402	59,036	28,094	68,130	348	101
2010	60,348	46,372	36,236	66,300	332	105
2011	55,758	56,063	43,589	53,869	366	118
2012	61,817	60,424	43,330	43,708	311	102
2013	57,171	52,842	68,177	31,073	421	128
2014	54,909	55,514	68,177	30,625	424	125
2015	53,106	58,642	68,302	29,227	426	123
Grizzly_Owl	1,700	207	322	343	4	4

Figure 2. Northern spotted owl habitat types over time.



To put habitat growth and harvest on HRC lands in the context of regional habitat conditions within the range of the northern spotted owl, we've previously reviewed the Final and Revised Final Recovery Plans for the Northern Spotted Owl (USFWS 2008, 2011b). The USFWS (2008) reported on the loss of spotted owl habitat range-wide related to timber harvest and natural events. Specifically related to timber harvest, they cautioned readers that harvest estimates can only be used to infer rates of forest removal, and may or may not translate directly to a rate of suitable habitat loss, since not all forest may equate to suitable spotted owl habitat.

Relative to the loss of suitable habitat due to **timber harvest**, USFWS (2008, 2011b) noted that there are only a few available reports on the topic, and summarized them as follows:

Cohen et al. (2002) cited in Bigley and Franklin (2004) reported "a steep decline in harvest rates between the late 1980's and early 1990's on State and Federal and private industrial forestlands."

Habitat trends reported by the Service (USFWS 2004) indicated an overall decline of about 2% in the amount of suitable habitat on Federal lands as a result of management activities from 1994 to 2003. This rate is lower than the 2.5% per decade estimate of habitat loss resulting from management activities that was predicted in the Northwest Forest Plan (USDA and USDI 1994). Cohen et al. (2002) reported that from the early 1970's through the mid-1990's the harvest rates on private industrial forest lands were consistently about twice the average harvest rate on public lands.

Raphael (2006) estimated that since 1994, losses of NSO habitat from non-federal timber harvest have exceeded losses from Federal land, with a range-wide loss of approximately 8.0% (12% in Washington, 10.7% in Oregon, and 2.2% in California). Raphael (2006) also conducted an analysis looking only at regeneration harvest. This analysis estimates that nearly 3,000 acres of higher suitability spotted owl habitat was harvested on Federal reserved lands, and about 26,000 acres on non-reserved lands, between 1994 and 2004. This harvest represents less than 1% of the approximately 10 million acres of high suitability habitat thought to exist on both Federal and non-federal land in 1994.

Davis and Dugger (2011) estimated the amount of spotted owl nesting and roosting habitat lost due to harvest from the start of the Northwest Forest Plan (1994/1996) to 2006/2007 on non-federal lands in California to be about 90,200 acres (5.8% of total). However, Davis and Lint (2005) found that forest fragmentation in California *decreased* from the 1930's and 1940's to the current time, possibly due to fire suppression.

Regarding habitat loss from **natural events** the USFWS (2008) reported that the loss of spotted owl habitat from natural events during the 10-year period from 1994 to 2003 was 224,041 acres, or about a 3% decline in available habitat range-wide (USFWS 2004). The majority of the habitat loss was due to wildfire (75%) with insects and disease making up the remainder (25%). Approximately 7,500 acres (0.4%) in California were estimated to have been lost due to fire, insects and disease from (1994/1996) to 2006/2007 (Davis and Dugger 2011).

More recently, for private industrial forest lands in California within the range of the northern spotted owl that do not operate under a HCP, there have been changes in take avoidance measures that require more habitat to be retained adjacent to activity sites (e.g. USFWS 2011).

BANDING PROGRAM

Banding of spotted owls as part of our overall program is a long-term research and management tool to help monitor the spotted owl population on the HRC ownership. The primary purposes of the banding and re-sighting project include: defining stable activity sites (site fidelity and displacement); detection of changes in occupancy over time (turnover and replacement); documentation of movements of sites and nest areas; and assessment of habitat quality based on site occupancy and reproductive history.

We again request that the USFWS consider this report, with associated Map 1, to satisfy their request for information concerning HRC's banding program as discussed in their letter of 14 January 2004.

In 2015, there were 124 total band resights (Appendix H). Of the 108 core sites, 31 pairs were positively identified at occupied sites. Some interesting resight information includes: a male was banded in 2011 and had not been resighted since the banding occurred. In 2014, he was resighted at newly reoccupied site 38, downstream on Yager Creek two miles from the original activity center/banding location. Also, the historic site 41 banded male (banded in 2001) was subsequently resighted back at site 41 in 2014.

Since 2003 a total of 335 spotted owls have been banded, consisting of 287 adults and 48 juveniles. Data from HRC banded northern spotted owls with at least seven years of data (131 banded adults from 60 sites during the years 2000-2006) showed that spotted owl survival remained stable over that time period (Bigger et al. 2008). Continuing to collect and analyze banding and re-sight information is a key component of this program.

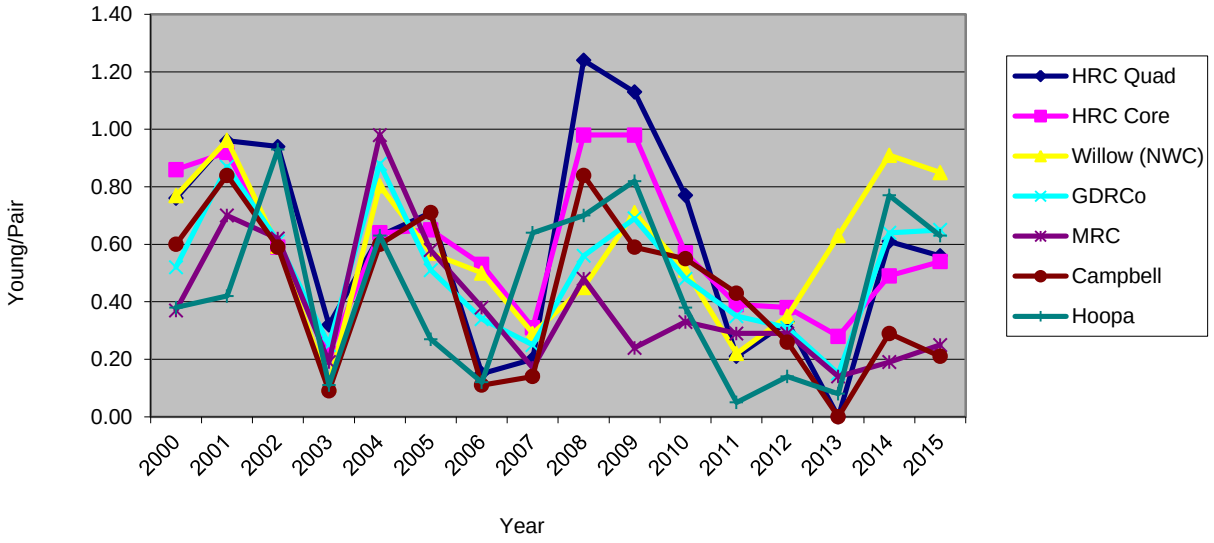
REGIONAL TRENDS

Following both the 2003 and 2007 survey seasons, PALCO, the NSOSRP, and the Agencies convened and discussed the HCP management objectives, potential reasons why they may not be met, and potential corrective measures to implement if necessary. On both occasions the NSOSRP recommended that HCP results be compared to those of other study areas in the region. Figure 4 below illustrates the regional northern spotted owl reproductive rates for several study areas of Northern California (Douglas, Early, Fullerton, Higley, Carlson, pers. comm. 2015).

As demonstrated in the figure, results for both the core and quadrat sites on HRC track the results of other study areas over the HCP period, with the exception of the Willow Creek Study Area (WCSA) for which positive or negative changes sometimes seem to "lag" a year or two behind other study areas. As with other studies in the region (Anthony, et al 2004, Franklin 1997, Franklin 2000) data indicates that reproductive results are strongly correlated to regional trends in climate (Franklin, et al. 2000, HRC, unpublished data). Glenn (2009) found that climate accounted for 78-84% of the temporal variation in population change in the Oregon coast range, and climate and barred owls together accounted for approximately 100% of the changes in spotted owl survival. Thus, there are good and bad reproductive years that appear to track precipitation early in the breeding season, and more recently, the barred owl influence on spotted owl reproduction.

All five cooperators reported mixed reproductive results for 2015. Typically, lower than average rainfall events of late spring results in higher than average reproduction. For the second year in a row, the Willow Creek Study Area had an excellent reproductive year (0.85 young/pair). Green Diamond reported (2014) a sharp increase in NSO sites within their barred owl removal experiment area in the Lower Mad River, providing what appears to be important information relative to spotted/barred owl interaction.

Figure 3. Comparison of Regional Reproductive Rates 2000-2015.



RECOMMENDATIONS

SURVEYS

Current plans call for continued surveys in 2016 for THPs and for monitoring with the quadrat sampling technique. In 2016, quadrats 8, 12, 14, and 19 are scheduled for monitoring (Monument to Jordan Creek, Larabee Creek, Petrolia, and Yager Creek respectively). These quadrats were initially surveyed in 2006 and again in 2011 and it will be interesting to compare them with the 2016 surveys, distribution of activity centers, reproduction, and location and activity level of barred owls. Timely follow-up visits (i.e., within 72 hours, weather permitting) will be conducted to all nighttime contacts. Following the season, the data gathered will be used to evaluate the efficacy of the HCP management objectives and conservation measures for the core sites, and also for the quadrat sites.

BANDING

In 2016 we intend to continue to work with the Service, CDFW, and adjacent study areas to make our banding efforts as efficient and effective as possible, keeping in mind the goals of the effort. The overall intent is to utilize the program as a complete mark and re-sight effort and to develop programs similar to other study sites in the region. As always, during any of our capture

and banding efforts, we will continue to be cautious in our efforts, keeping the care and safety of the birds first in mind.

BARRED OWLS

HRC continues to have significant concerns that the barred owl invasion will continue to cause declines in site occupancy and reproduction of our spotted owl population. In 2015, we suspended the use of barred owl calls (5 minutes of recorded barred owl calls at the end of the 10 minute spotted owl calls) on all of our quadrat monitoring stations. We intend to revisit the use of barred owl calls in light of any new information that becomes available. We will attempt to utilize any new techniques to monitor barred owl and spotted owls across the ownership. In addition, HRC continues to be interested in the results of barred owl removal projects as recommended by the Service (USFWS 2008), and will continue to monitor the results of ongoing studies as they are available.

SCIENTIFIC PANEL/MANAGEMENT OBJECTIVES

The HCP Northern Spotted Owl Conservation Plan §6.2.2, Conservation Measures, Item 1 refers to the NSO Scientific Review Panel (NSOSRP) and discusses the establishment and roles of the NSOSRP. The NSOSRP generally met every year for the first 5-6 years of implementation and provided review of monitoring results and recommendations for future monitoring and analyses.

Not meeting the HCP management objective for reproductive rate triggers the adaptive management measures of HCP § 6.2.3, #6, and a discussion between HRC, USFWS, CDFW, and the Panel shall occur to review potential reasons why the objective is not being met, and potential corrective measures to implement.

As stated earlier, in 2013, 2014, and 2015 the rolling five-year average reproductive rate for monitored pairs of northern spotted owls in our study area has not met the HCP objective of 0.61 fledglings per pair. The rolling average reproductive rates for 2013, 2014, and 2015 were 0.52, 0.42, and 0.42 respectively, and follow a period of five consecutive years (2008-2012) when the rolling average reproductive rate *did* meet the management objective.

During the 17 years of HCP implementation (1999-2015) the management objective for the rolling average reproductive rate was not met during the 2006 and 2007 seasons (0.53 and 0.47

respectively). And, similar to the 2013-2015 situation, followed 7 consecutive years when the rolling average was greater than 0.61, or not significantly different from 0.61 (e.g. 0.59, 2002).

Following the 2007 season the HRC, USFWS, CDFW, and Panel (Alan Franklin, Barry Noon, and Steven Courtney) convened via conference call to discuss the reproductive results. Consideration was given to whether there was a clear cause-and-effect relationship between management activities, or if results were within the range of annual variation.

At that time the forestlands were still owned by the Pacific Lumber Company and managed using primarily even-age (clear cut) management at a rate of harvest of approximately 150 mmbf/year, including harvest of old growth trees. The barred owl invasion of north coastal California had not yet been fully realized as a potential reason for a reduced reproductive rate.

Although there were no clear reasons for a reduced reproductive rate, for discussion on the conference call a Habitat Retention Area (HRA) strategy was proposed as a potential corrective measure, with the objective of retaining a polygon of the best habitat surrounding the most stable and reproductive spotted owl nest sites, rather than using the 500' and 1,000' radii as the standard habitat retention model. The USFWS, CDFW, Panel and HRC agreed on the strategy, and it was implemented beginning in 2009 (CDFG and USFWS 2009).

In 2008 the Humboldt Redwood Company (HRC) was formed from the Pacific Lumber Company bankruptcy proceedings and significant management changes followed, including in harvest techniques, rate of harvest, and retention of old growth components. Management of the Humboldt County forestlands was changed to reflect that of HRC's sister company, Mendocino Redwood Company (MRC), including the use of uneven-age (selection, group selection) harvest, a reduction in harvest level to an average of approximately 55 mmbf/year (over a ten-year period), and retention of all old growth trees meeting the company policy.

In 2008 and 2009 the annual reproductive rate was relatively high (0.98 both years), but has since declined from 2010-2015, and as the high rates have fallen out of the rolling average calculation and been replaced by lower rates, the rolling average has also declined to the point where it is below the management objective. So, although management on the forestlands has changed in a manner that results in harvest of less spotted owl habitat (i.e. Figure 3), and retains

more late successional habitat components on the landscape, the reproductive rate is in a current decline nonetheless.

As with other study sites in the region, HRC has tracked the presence of barred owls in our study area, and although there was a decrease in 2014, there was an *increase* in barred owl presence in 2015. There has been an overall increase over time in barred owl detections within 0.5-mile of spotted owl activity sites (Figure 1). Studies previously referenced have indicated that barred owl presence within spotted owl territories can disrupt spotted owl occupancy and reproduction.

During the HCP's early years the Panel recommended comparing the HRC HCP results to other study sites within the region. Because the HRC owl sites are managed in ways that are specific to the HCP, a comparison of trends in occupancy and reproduction with other study sites that are managed under different strategies (e.g., intensive timber harvest, moderate harvest, little to no harvest) can provide insight as to how the HCP is working and possibly what other factors may be affecting the spotted owl population (e.g., barred owls, climate). The available information indicates that trends for both the core and quadrat sites continue to track the results of other study areas over time (Figure 4).

Most cooperators reported average breeding activity and reproductive rates in 2015, but there appears to be a declining trend unlike the "every other" year pattern in spotted owl reproduction that had been historically observed. It should also be noted that increases in spotted owl occupancy and reproduction on the Hoopa and Green Diamond study areas have been at least in part attributed to lethal barred owl removal from spotted owl territories. 2015 was a "bounce-back" year for HRC as the reproductive rate was 0.54, and along with the 2014 rate of 0.49, represents an increasing trend from very low rates (for our study area) of the previous three years. However, since the relatively high rates for the years 2008 – 2010 have fallen out of the running average equation, the higher value in 2015 was not enough to return the five-year running average to the target of 0.61.

In light of the fact that management of the HRC forestlands has had a reduced impact on habitat since the change in ownership in 2008, the evidence from other study areas within the range of the northern spotted owl that barred owls can have a very significant impact on occupancy and reproduction of spotted owls, and the fact that HRC activity centers have been colonized by

barred owls, it seems to be clear that barred owls are now negatively impacting spotted owl occupancy and reproduction on HRC lands and are the primary cause of failure to meet HCP management objectives.

Another potential factor in declining spotted owl reproduction on HRC lands is a decline in prey base (e.g. dusky-footed woodrats) as a result of the change in silvicultural practice from even to uneven-age, in turn resulting in a decrease in brushy clearings favored by woodrats. Future prey base studies should focus on woodrat densities in selection, group selection, and variable retention harvest areas compared to clear cut harvest.

We anticipate that these topics would be the primary focus of any future discussion of HCP management objectives and potential corrective measures, pursuant to HCP § 6.2.3, #6.

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March 30, 2016

California Fish and Game Commission
Eric Sklar, President
Jacque Hostler-Carmesin, Vice President
Anthony C. Williams, Member

RE: Commission Agenda Item 25 for April 14, 2016 Meeting: Consider the petition, Department's evaluation report, and comments received to determine whether listing the northern spotted owl (*Strix occidentalis caurina*) as a threatened or endangered species is warranted.

Dear Commissioners:

The Humboldt Redwood Company (HRC) respectfully requests that you consider the following comments in your determination as to whether the listing of the northern spotted owl (*Strix occidentalis caurina*, NSO) as a threatened or endangered species is warranted.

HRC owns and actively manages approximately 209,200 acres of redwood and Douglas-fir forestland in Humboldt County, CA. Surveys, monitoring, and conservation of the NSO on this ownership by our biologists and foresters has continued for over 25 years. Although the NSO was thought to be quite rare and restricted to old growth forests at the time of its listing by the U.S. Fish and Wildlife Service in 1990, our surveys have revealed that the NSO is relatively common and well-distributed in our managed forests (Figure 1).

HRC currently manages our forestlands pursuant to a federal and state-approved Habitat Conservation Plan (HCP) that includes conservation plans for 17 covered species, of which the NSO is a focus species. The California Department of Fish and Wildlife (CDFW) has issued a Consistency Determination, pursuant to Fish and Game Code Section 2080.1, that the Biological Opinion and related HCP documents are consistent with the California Endangered Species Act (CESA) (Consistency Determination No. 2080-2014-001-01, attached).

The CDFW NSO status review (Report to the Fish and Game Commission – A Status Review of the Northern Spotted Owl (*Strix occidentalis caurina*) in California, January 27, 2016) has significant flaws, and therefore the Report's recommendation to list the NSO under CESA should be questioned. In addition, the process surrounding the publication of the Report and our ability to review and comment has been compromised

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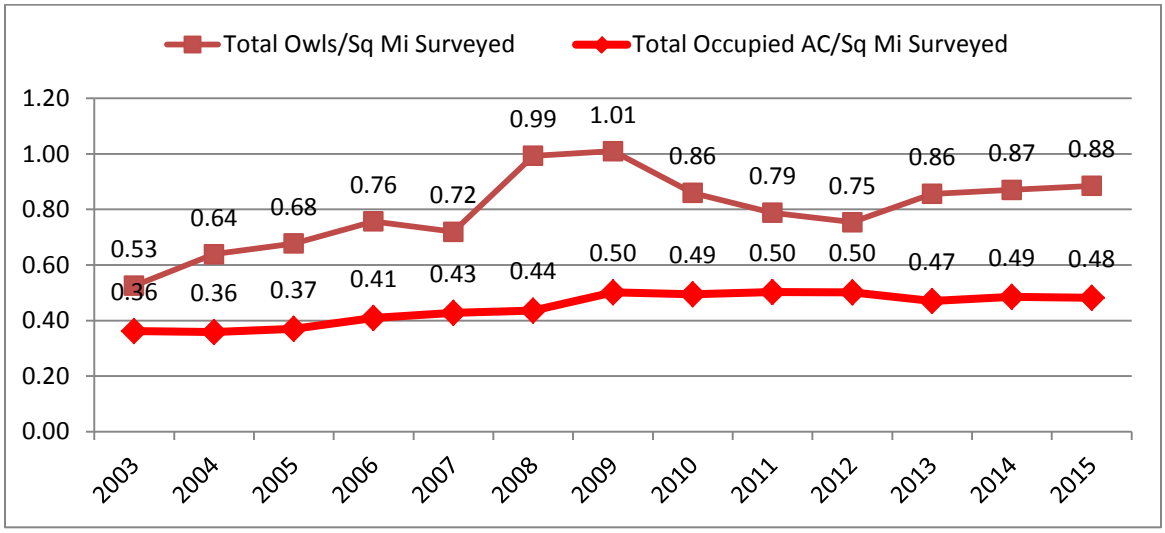
by the timing of its release, the deadline for comments, and the scheduled Commission hearing. We urge the Commission to postpone any listing decision, and to request that the CDFW reevaluate their conclusion in light of NSO population numbers on managed forestlands within the range of the NSO.

The CDFW NSO Status Review concludes that while the NSO is not presently threatened with extinction, it is likely to become an endangered species in the foreseeable future due to the current population trend and a combination of threat factors, including present or threatened modification or loss of habitat, competition from barred owls (*Strix varia*), and other natural occurrences or human-related activities, absent the special protections and management efforts required by CESA.

This conclusion is flawed because it is based primarily on data from only a small portion of the NSO range (the NSO demographic study areas) some of which are not actively managed for timber harvest. In contrast, the Report has discounted large, long-term data sets presented by large ownerships (including HRC) within the range of the NSO that demonstrate dynamic yet stable populations on actively managed landscapes.

For example, density estimates derived from our monitoring efforts for the total number of NSO, and total number of occupied activity centers (AC) on HRC lands (Figure 2) indicates a population that is stable or increasing over time.

Figure 2. Total Northern spotted owls and total occupied activity centers per square mile surveyed on HRC lands, 2003 to 2015.



While there has been a decline in apparent reproductive rates (number of young per pair of NSO monitored) in recent years, there was an increase in HRC's rate during the

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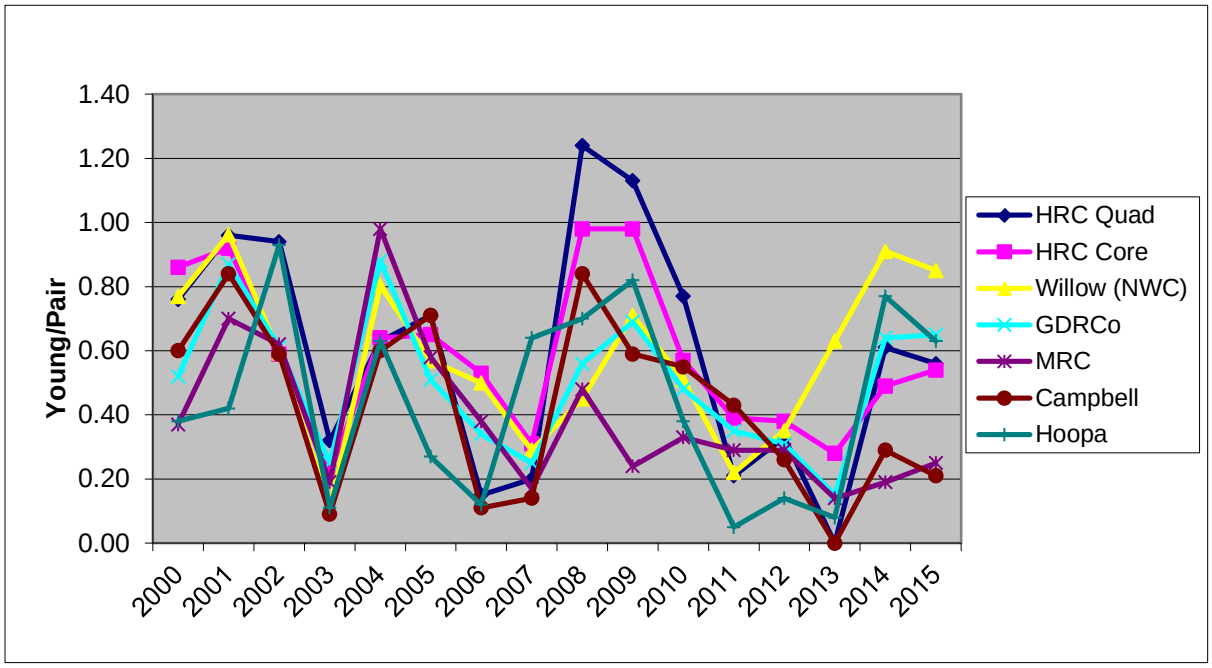
2015 NSO season, and HRC's reproductive rate continues to vary annually similar to other study areas in the region (Figure 3).

Figure 3. Comparison of regional reproductive rates from 1999 – 2015.



HRC's forestlands have been managed for more than 100 years and contain a mosaic of young regenerating stands, mature second growth, and unentered old growth stands that provide a diverse mix of vegetative types and habitat edges. Brushy young forest stands provide habitat for the NSO's primary prey in our region, the dusky-footed woodrat (*Neotoma fuscipes*). According to Franklin et al. (2000), landscapes such as provided by managed forestlands are able to optimize both apparent survival, and fecundity of the NSO. We urge the Commission to take this habitat information into consideration in their evaluation of the Report.

Listing the NSO under CESA would create an unnecessary, duplicative process that would not add to the protections already afforded the NSO by the federal listing. The CDFW refers to "the special protections and management efforts required by CESA" in their recommendation for listing. The Report includes a brief section, on pages 199-200, that discusses potential protection afforded to the NSO if listed under CESA, while concluding that:

"While the protections identified in this section would help to ensure the future conservation of Northern Spotted Owls, there are protections now in place that would continue if the owl were not listed under CESA. These include current protections afforded under the Northern Spotted Owl federal status, protections afforded under the

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Forest Practice Rules, coverage of the owl under HCPs and NCCPs, current CEQA requirements, and existing laws and regulations that make it illegal under State law to take owls in California."

It goes on to say that increased protection could occur with agency environmental review under CEQA, but also states that CEQA requires analysis of potential impacts to the NSO *regardless* of listing status under CESA. Finally, this section concludes that additional paperwork (Memoranda of Understanding) would be required to conduct research on the NSO, and that the CDFW would expect an increased level of coordination, and perhaps increased funding for protection and recovery actions.

We do not believe that CDFW's analysis of increased protection afforded by listing under CESA supports a decision by the Commission to make a change in the status of the NSO. Rather, we urge the Commission to direct the CDFW to continue to work within the current regulatory process to address significant threats to the NSO, including barred owls.

In summary, we urge the Commission to either reject the listing of the NSO as threatened under CESA, or to postpone any listing decision, and to request that the CDFW reevaluate their conclusion in light of NSO population numbers on managed forestlands within the range.

Thank you for the opportunity to comment on this important matter before the Commission.

Sincerely,

Sal Chinnici

Manager, Forest Sciences

Humboldt Redwood Company, LLC

References:

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.

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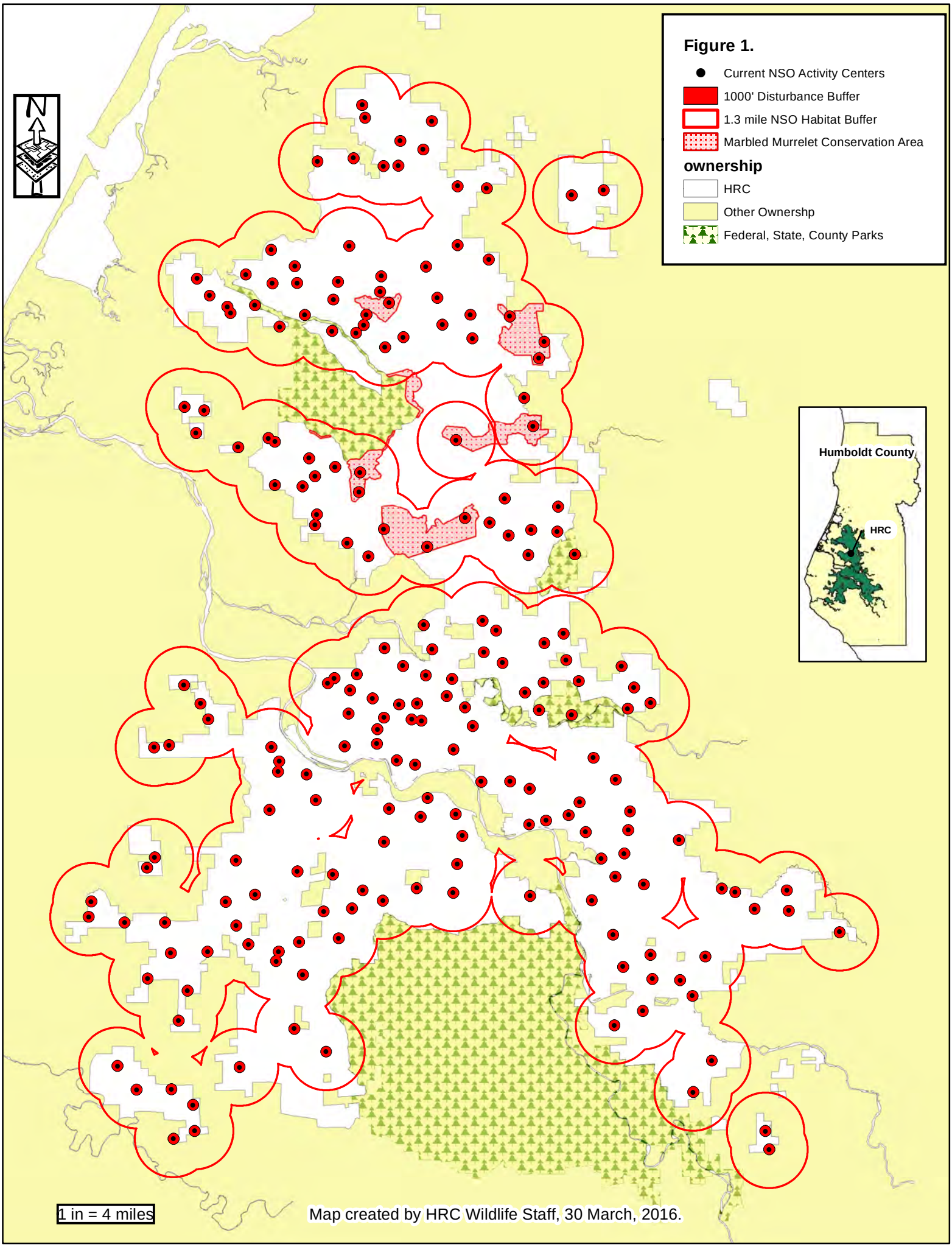
Figure 1.
Current NSO Activity Centers
1000' Disturbance Buffer
1.3 mile NSO Habitat Buffer
Marbled Murrelet Conservation Area
ownership
HRC
Other Ownershp
Federal, State, County Parks
N
Humboldt County
HRC
1 in = 4 miles
Map created by HRC Wildlife Staff, 30 March, 2016.

VIA EMAIL

FORESTLAND MANAGEMENT

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March 29, 2016

Mr. Eric Sklar, President
California Fish and Game Commission
PO Box 944209
Sacramento CA 94244-2090

Re: Proposed listing of Northern spotted owl

Dear Commissioners:

W.M. Beaty and Associates (WBA) manages approximately of 290,000 acres of private forestland in California with 43,234 acres within the range of Northern spotted owl (*Strix occidentalis caurina*). These private forests are managed under unevenaged forest management where trees are harvested under individual tree selection silviculture. These private forests are also third-party certified by Scientific Certification Systems (SCS) as meeting the rigorous forest, fisheries and wildlife management standards of the Forest Stewardship Council (FSC). In the California Department of Fish and Wildlife (CDFW) status review of the Northern spotted owl, several of my scientific publications were cited in their status review and I would to clarify those publications.

(1) Farber, S.L., and A.J. Kroll. 2012. Site Occupancy Dynamics of Northern Spotted Owls in Managed, Interior Douglas-Fir Forests, California, USA, 1995–2009. J. Wildl. Manage. 76(6):1145–1152.

The CDFW status review, beginning on Page 55, accurately cites some of the results of our publication. However, a key result and discussion point not reported in the status review was that "…site occupancy probabilities for spotted owl pairs appeared to have stabilized in the final 5 years of our study." Indeed, Figure 3 of the publication demonstrates that in the final 5 years of our study owl occupancy probabilities were not statistically different. In other words, owls within our study area were not continuing to decline. This key result is not reflected in the CDFW status review.

(2) Farber, S.L. and J. Whitaker. 2005. Diets of Northern Spotted Owls (Strix occidentalis caurina) in the Southern Cascades and Klamath Provinces of interior Northern California. Report prepared for US Fish and Wildlife Service for the review of the Spotted Owl Management Plan. Timber Products Company,Yreka, California.

The CDFW status review, beginning on Page 17, accurately cites some of the results of our white paper. However, a very important result was that while woodrats were the main prey species in both the Klamath mountains (60.6 % of biomass) and

Southern Cascades (46.6% of biomass), a wide variety of species were being consumed by owls. We concluded that habitat associations with each prey species, including woodrats, indicate that maintaining a variety of habitats (ie. not just mature, high canopy closure habitats) within owl sites maybe be beneficial for foraging owls. I don't believe this result and conclusion is accurately reflected in the CDFW status review.

Also, WBA manages forestlands under a Cal Fire approved Northern Spotted Owl Resource Plan (NSORP). In December 2013, the Commission accepted a petition to list the Northern spotted owl and the species became a candidate species under CESA. To ensure take of a candidate species would not occur from WBA proposed forest management activities, in 2014, the CDFW reviewed the NSORP and determined that take of the species would likely be avoided following measures in the NSORP. The CDFW status review (Page 97) needs to be corrected as it currently does not reflect this determination.

In conclusion, based on my suggested corrections to the CDFW status review, I would recommend that the Commission consider delaying a final decision on the status of the Northern spotted owl until all public comments are considered.

Thank for considering my comments and if you have any questions or need additional information, please contact me at stuf@wmbeaty.com or at (530)243-2783.

Sincerely,

W. M. BEATY & ASSOCIATES, INC.
Contract Manager

By:_____
Stuart L. Farber
Wildlife Biologist

SLF:klh

Calforests
California Forestry Association

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Sacramento, CA 95814
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March 30, 2016

Eric Sklar, President
California Fish and Game Commission
1416 9th Street, 12th Floor
Sacramento, CA 95814

Re: Report to the Fish & Game Commission – A Status Review of the Northern Spotted Owl (Strix occidentalis caurina) in California

Dear President Sklar:

The California Forestry Association (Calforests), which represents more than 4 million acres of family-owned and privately-held forests, provides the following comments related to Director Bonham's Memorandum dated February 10, 2016, and attached Status Review of the Northern Spotted Owl (NSO). We ask that this document with attachments, and our *Northern Spotted Owl Science Compendium* be incorporated into the Commission's record for this issue. Our 579-page Compendium provides a thorough discussion of many relevant issues associated with NSO on California's 2.4 million acres of large private ownerships within the NSO range. These include an overview of the extraordinary regulatory process in-place within California to protect the NSO; the status of private forestland NSO survey and monitoring efforts; the actual numbers of NSO present on these lands; as well as a discussion of threats to NSO in California. We have included citation to correspondence and science papers that provide significant additional information that support key findings of our Compendium, both of which were not fully vetted in the status review.

These include the following attachments:

1. Lowell V. Diller et al., January 16, 2016. *Demographic Response of Northern Spotted Owls to Barred owl Removal.* The Journal of Wildlife Management; DOI: 10.1002 / jwmg.1046 (see attached).
2. Sierra Pacific Industries, January 2016. *Northern Spotted Owls near Weaverville and Trinity County,* within the Landscape Survey Strategy Area (An Interim Report - see attached).
3. July 10, 2013 Board of Forestry (BOF) agenda and minutes wherein the BOF voted to support the regulatory decision affirming the adequacy of NSO regulations, Option g. (see attached Agenda Item 13).
4. Correspondence: CDFW Director to Cal Fire Director, 1/16/2014 (see attached).
5. Franklin, A.B. et al. 2000. *Climate, Habitat Quality, and Fitness in Northern Spotted Owl Populations in Northwestern California.* Ecological Monographs by the Ecological Society of America, 70(4). (Note attached cover page 539, and 573).

Extensive Regulatory Protections with Significant USFWS Oversight

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

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

Silvicultural Practices Can Help Create a Vegetative Mosaic That Optimizes NSO Habitat Fitness in California

Research in Northwest California (see pages 571-573 of attachment 5, (Franklin et al., 2000)) confirms that the optimum NSO habitat fitness in California is not simply late seral forests, nor simply early seral forests, but a vegetative mosaic of early and late seral vegetation with an extensive ecotone. The combination of these effects of landscape habitat characteristics can optimize both apparent survival and fecundity of the NSO. Figure 10 below demonstrates that landscape habitat characteristics with low NSO habitat fitness occur at both high percentages of late seral-nesting habitat with low percentages of early seral and other foraging vegetation; as well as landscape habitat characteristics with low percentages of late seral-nesting habitat combined with high percentages of early seral and other foraging vegetation. The circles in Figure 10 represent roughly 400 acres each, of territories of core habitat (95 territories were analyzed), the highest fitness level for both apparent survival and maximum fecundity occurred at close to a 50-50% split of late and early forest vegetation with a significant degree of heterogeneity. California's forest practice regulations are designed to take into account landscape-level vegetative characteristics, and help optimize their use by the NSO. The relative stability of NSO populations occupying large forest ownerships confirms their fitness as NSO habitat. These conclusions were supported by the Diller, 2010 study in California's redwood region.

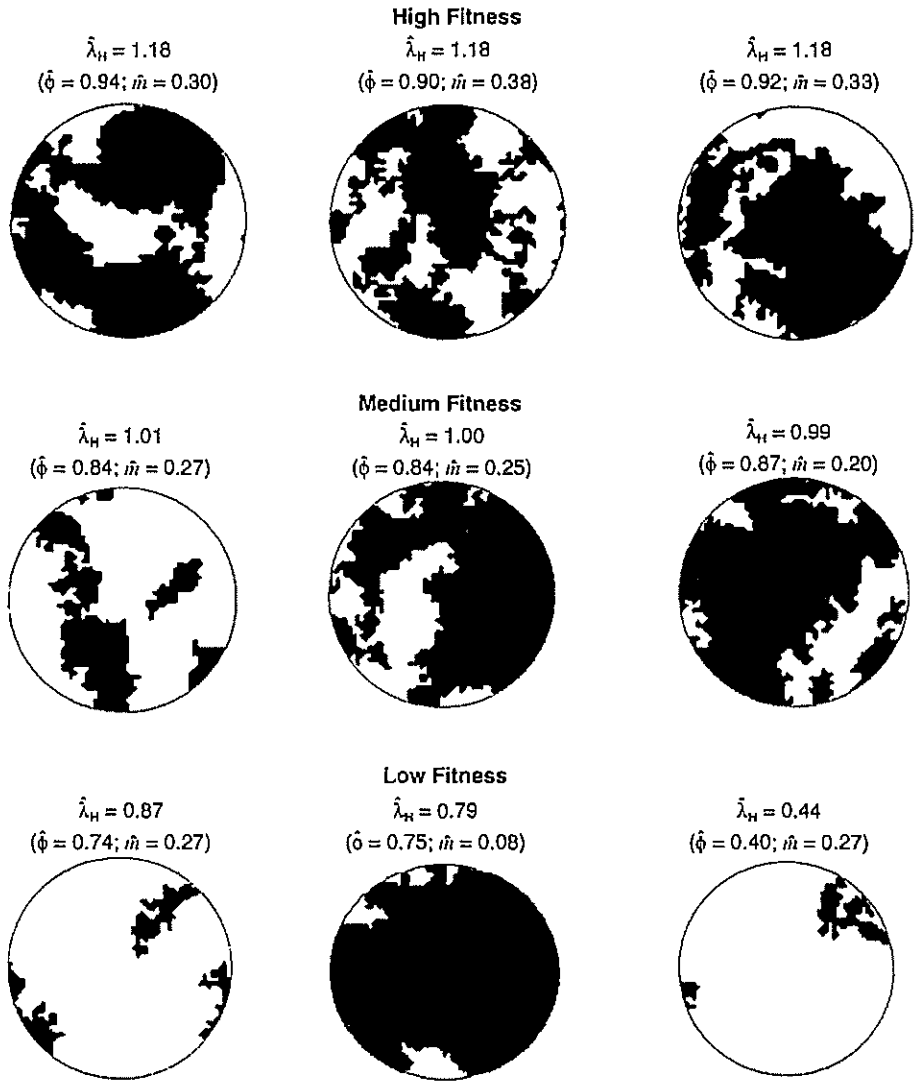


FIG. 10. Landscape habitat characteristics (within 0.71 km radius circles used to define Northern Spotted Owl territories) at three levels of habitat fitness potential in northwestern California. Dark areas are Northern Spotted Owl habitat; white areas are other vegetation types. Estimates of ϕ (apparent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

Surveys and Monitoring For Up to a Quarter Century

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

The results of this monitoring effort indicate that the population of NSO on California's private lands is dynamic yet stable. NSO are well-distributed within its range. The actual population estimates within the survey areas demonstrate that the population of NSO on large private timberlands is generally stable or increasing over time. This is in stark contrast to FWS estimates predicting that actual NSO numbers have decline 3.8% annually since 1985 throughout its entire range, including Oregon and Washington. The NSO on California's private lands have a strong reproductive output over time, producing young NSO to both replace the existing population and, in many cases, actually expand the population.

Density Estimates Demonstrate Well-Distributed, Dynamic yet Stable Population

Example density estimates of occupied NSO pair territories per-square mile indicate that coastal NSO densities are dynamic but stable ranging from 0.29 in 2001 to 0.44 in 2013 (*Mendocino Redwood Co., NSO Compendium page 220*); 0.29 in 2003 to 0.36 in 2013 (*Conservation Fund, NSO Compendium Exhibit C*); 0.36 in 2003 to 0.47 in 2013 (*Humboldt Redwood Co., NSO Compendium page 34*); inland densities are generally stable, with approximately 0.17 occupied NSO pair territories/sq. mi. based upon surveys conducted between 2003-07 and 2011-13 (*Sierra Pacific Industries, NSO Compendium page 51; see Jan 2016 updated SPI table below*). Inland regions show a lower but also stable density primarily as a factor of hotter/drier natural habitat conditions, and reflect the differential size of inland NSO territories (3,398 acres/site) vs. coastal NSO territories (965 acres per site). In both inland and coastal cases, the landowner-monitored NSO population trend on private timberlands is stable or increasing, while NSO population trends from demographic studies on public forests indicate declines of 3.8% per year.

Year	1989	80% (Recovery)	1989 - 2003	2003 - 2007	2011 - 2015
Occupied ACs	52 (max known 1974-1989)	42	47 (max)	47	57
Crude Density[1]	Not Applicable	0.1551[2]	0.1736[2]	0.1736	0.2105
Comment	Assumed 100% occupancy from CNDDB and SPI surveys since protocol surveys were not conducted.	Assume the population was a fully recovered population. (80% occupancy per 2008 NSO Recovery Plan)	Max estimate. Assumed all ACs occupied. (Removed 5 abandoned sites with USFWS concurrence)	Occupancy determined at all sites	Occupancy determined at all sites

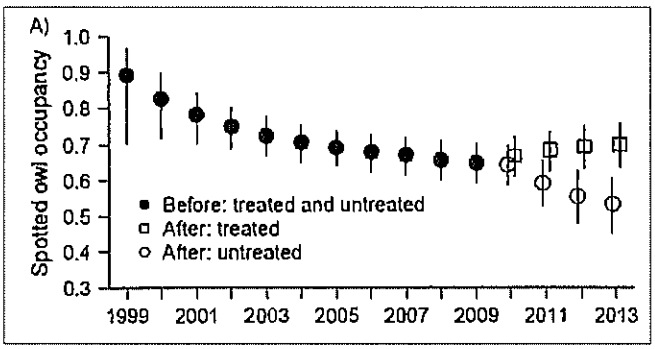
[1] Note: Crude density is based upon the 173,316 acre area within .5 mile of a survey station, since the larger area inside the general survey boundary includes the town of Weaverville and a significant area that as a result of wildfires or site quality would never be considered potential habitat. See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

"This study shows that for the period from 2003 through 2015, despite active timber harvest, there has been only an increase in population density for this portion of the range of the NSO."

Positive Response of NSO Population to Barred Owl Removal

There are several potential threats to NSO populations in California, but the most significant appears to be the increasing range of the barred owl, which is a larger, more aggressive cousin /competitor of the NSO. The Coastal Redwood Region has been the NSO region most susceptible and most impacted by this owl. Studies of NSO on both public and tribal lands have seen populations that are nearly over-run with barred owls. Drier/warmer interior forests have not been significantly impacted. A recent demographic study by Dr. Diller et al, published in the Journal of Wildlife Management, 01/16/2016, provided significant new research and insight into the interaction of these two owl species, with important management implications.

A BACI experimental design was used to investigate the demographic response of NSO to lethal removal of barred owls. As confirmed by the study, NSO quickly reoccupied the treated area, quickly and significantly increasing occupied NSO sites, with a concomitant increase in fledged young. What had been a pretreatment NSO population decline of approximately 0.02% per year became a post treatment average increase of 1.029 per year, while untreated areas continued to decline in NSO population.



A) Trend in spotted owl occupancy in treated and untreated areas before and after treatment (barred owl removal).

"The results from this first experiment demonstrated that lethal removal of barred owls allowed the recovery of Northern spotted owl populations in the treated portions of our study area. If additional federally funded barred owl removal experiments provide similar results, this could be the foundation for development of a long-term conservation strategy for Northern spotted owls. © The Wildlife Society."

This study took place on one of three forests with long-term demographic studies, and the only forest (Green Diamond Resources) in which timber harvest activities were occurring annually. The two other study areas were public or tribal lands, not subject to the rigorous regulatory standards of the FPA, and which have not undertaken any timber harvest during these NSO studies. The NSO territories in those two study areas are now nearly completely occupied by barred owls.

It is these two largely unmanaged study areas that have apparently contributed to the conclusion that the range-wide population of NSO is declining by 3.8% per year since 1985. **That would require two-thirds of all the NSO pairs in California to have perished in the last 30 years ... A conclusion that is completely inconsistent with the decades of research and monitoring done by the 2.4 million acres of large private forest owners within the range of the NSO.**

All NSO Threats Can Be Mitigated By Proactive Management

In total, there are four potential major threats to NSO populations identified by the CDFW evaluation in California. These include destruction of habitat from catastrophic wildfire, the use of rodenticides associated with marijuana grows, the increasing range of the barred owl, and the

alleged loss of habitat from timber harvest. All of these threats can be, and most cases are being addressed through the application of various management activities to reduce the occurrence of catastrophic wildfires, to reduce the number and size of illegal marijuana grows, and to expand the use and effectiveness of barred-owl control programs. Most importantly, timber harvest and its silvicultural applications can and have had a clearly positive roll maintaining the NSO's range and population in California.

Key Findings

Our previously submitted NSO Science Compendium, in combination with new information provided herein outlines several key findings as to why the NSO should not be listed pursuant to the California Endangered Species Act. It includes detailed monitoring and survey information from individual forest owners; highlights their NSO monitoring efforts over time, as well as their long-term NSO conservation strategies. In summary:

1. Our population and habitat data, which includes demographic studies and long-term operational monitoring efforts, show California's large private forest ownerships have carefully managed their ownerships over decades of time resulting in NSO habitat and populations that are dynamic but stable.
2. There is a robust and unparalleled regulatory process in place with direct FWS involvement that has provided strong protections and enhancements for the NSO (See attached BOF agenda and minutes from July 10, 2013 re-affirming the adequacy of the NSO regulations. Option g, and the attached DFW Director's memo to Cal Fire Director). California's regulatory system is both dynamic and protective of owls, while providing the full breadth of nesting, roosting and foraging habitat mandated by the federal listing and necessary for stable NSO populations. **Moreover, in the 25 years of operations pursuant to the federal listing in 1990, there has never been a single case of *NSO Take*.**
3. While the barred owl has proven to be a significant competitor with NSO in coastal regions, experimental barred owl removal has proven to be an effective control that results in NSO population that quickly reoccupy nests with increasing reproduction over time.
4. Proactive forest management has proven to be a positive benefit to NSO habitat fitness by creating more wildfire resilient forests, helping to protect and enhance NSO habitat. Listing would only preclude pro-active vegetation management necessary to protect NSO activity centers.

For decades, forest owners have willingly engaged in additional, effective voluntary science, monitoring and enhancement programs to further the knowledge about protecting the NSO. The net result is that NSO within its California range, and with a robust barred owl control program, is well-protected, well-distributed across the landscape, and is dynamic yet stable with quality nesting, roosting, and foraging habitat that moves across the landscape over time.

Thank you for your serious consideration of the issues we have brought forward today.

Sincerely,

David A Bischel, RPF 1746
President

The Journal of Wildlife Management; DOI: 10.1002/jwmg.1046

Research Article

Demographic Response of Northern Spotted Owls to Barred Owl Removal

LOWELL V. DILLER,[1] *Green Diamond Resource Company, Korbel, CA 95550, USA*
KEITH A. HAMM, *Green Diamond Resource Company, Korbel, CA 95550, USA*
DESIREE A. EARLY, *Green Diamond Resource Company, Korbel, CA 95550, USA*
DAVID W. LAMPHEAR, *Green Diamond Resource Company, Korbel, CA 95550, USA*
KATIE M. DUGGER, *U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR, USA*
CHARLES B. YACKULIC, *U.S. Geological Survey, Southwest Biological Science Center, Flagstaff, AZ, USA*
CARL J. SCHWARZ, *Department of Statistics and Actuarial Science, Simon Fraser University, Burnaby, British Columbia, Canada*
PETER C. CARLSON, *Colorado Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife and Conservation Biology, Colorado State University, Fort Collins, CO, USA*
TRENT L. MCDONALD, *Western EcoSystems Technology, Laramie, WY, USA*

ABSTRACT Federally listed as threatened in 1990 primarily because of habitat loss, the northern spotted owl (*Strix occidentalis caurina*) has continued to decline despite conservation efforts resulting in forested habitat being reserved throughout its range. Recently, there is growing evidence the congeneric invasive barred owl (*Strix varia*) may be responsible for the continued decline primarily by excluding spotted owls from their preferred habitat. We used a long-term demographic study for spotted owls in coastal northern California as the basis for a pilot barred owl removal experiment. Our demography study used capture–recapture, reproductive output, and territory occupancy data collected from 1990 to 2013 to evaluate trends in vital rates and populations. We used a classic before-after-control-impact (BACI) experimental design to investigate the demographic response of northern spotted owls to the lethal removal of barred owls. According to the best 2-species dynamic occupancy model, there was no evidence of differences in barred or northern spotted owl occupancy prior to the initiation of the treatment (barred owl removal). After treatment, barred owl occupancy was lower in the treated relative to the untreated areas and spotted owl occupancy was higher relative to the untreated areas. Barred owl removal decreased spotted owl territory extinction rates but did not affect territory colonization rates. As a result, spotted owl occupancy increased in the treated area and continued to decline in the untreated areas. Prior to and after barred owl removal, there was no evidence that average fecundity differed on the 2 study areas. However, the greater number of occupied spotted owl sites on the treated areas resulted in greater productivity in the treated areas based on empirical counts of fledged young. Prior to removal, survival was declining at a rate of approximately 0.2% per year for treated and untreated areas. Following treatment, estimated survival was 0.859 for the treated areas and 0.822 for the untreated areas. Derived estimates of population change on both study areas showed the same general decline before removal with an estimated slope of −0.0036 per year. Following removal, the rate of population change on the treated areas increased to an average of 1.029 but decreased to an average of 0.870 on the untreated areas. The results from this first experiment demonstrated that lethal removal of barred owls allowed the recovery of northern spotted owl populations in the treated portions of our study area. If additional federally funded barred owl removal experiments provide similar results, this could be the foundation for development of a long-term conservation strategy for northern spotted owls. © 2016 The Wildlife Society.

KEY WORDS barred owl, competition, demography, northern spotted owl, removal experiment.

The northern spotted owl (*Strix occidentalis caurina*) is a medium-sized owl that inhabits structurally complex forests in the coastal and Cascade ranges from southwestern British Columbia to northern California. It is primarily a nocturnal forager of small mammals, has relatively large home ranges, and actively defends space around its nest and roosting area from conspecifics (Courtney et al. 2004). Extensive research on northern spotted owl habitat requirements, conducted during the past 4 decades, focused on understanding the structural characteristics and spatial requirements of nesting, roosting, and foraging habitat for this species. These studies

Received: 12 May 2015; Accepted: 16 January 2016

[1]*E-mail: ldillerconsulting@gmail.com*

and various hardwood species, including tanoak (*Lithocarpus densiflorus*), madrone (*Arbutus menziesii*), California bay (*Umbellularia californica*), and red alder (*Alnus rubra*). These forests were primarily harvested on a 50–70-year rotation. The primary silviculture was even-aged with historical incidental and current programmatic retention of mature and late seral elements. Light single tree selection harvest occurred within riparian zones and other sensitive areas that constituted close to 30% of the study area. Many forest stands occupied by spotted owls contained a substantial component of older, residual trees (Thome et al. 1999, Folliard et al. 2000). The entire study area was within 30 km of the Pacific Ocean, and elevation on the study area ranged from 5 m to 1,400 m. Additional details of the study area are included in Diller and Thome (1999).

Because we were interested in the effect of the barred owl invasion on spotted owls, we divided our study area into treated areas where barred owls were removed and untreated areas where they were not removed. To account for geographic differences in the history of timber harvesting, physiographic patterns, and density of barred and spotted owl sites, the relatively linear Green Diamond study area was divided into 3 roughly equivalently sized paired treated and untreated areas totaling 84,205 ha and 72,711 ha, respectively (Fig. 1). Given complications of lethal removal of barred owls with firearms, assignment of treated versus untreated areas was based on logistics and minimizing potential conflicts with adjacent landowners. As in virtually all field studies, it was impossible to ensure that all parameters such as mean density of spotted and barred owl territories of the treated and untreated areas were the same. However, this potential lack of complete symmetry was offset by 19 years of pre-treatment data such that post-treatment changes in trends or means of demographic parameters in the treated versus untreated areas could be reliably assigned to a treatment effect (i.e., barred owl removal).

METHODS

Field Methods

From 1990 to 2013, we monitored spotted owls by surveying the entire density study area (i.e., central contiguous areas where spotted owl population density could be estimated) with 100% survey coverage and territory-specific surveys for all the remaining peripheral owl sites in the demographic study area. The objectives of the surveys were to document occupancy status of owl territories, locate and confirm previously banded owls, band unmarked owls, and document the number of young produced by each territorial female (Lint et al. 1999, Reid et al. 1999). We conducted surveys using vocal imitations or playback of owl calls to incite the owls to defend their territories, thereby revealing their presence (Reid et al. 1999).

The number of surveys of each potential owl territory (i.e., owl site) in each study area was normally ≥ 3 per year, although fewer visits were allowed in cases where females were located that had no brood patch or showed no evidence of nesting during the period when they should have been incubating or brooding young. After we became familiar with the distribution of owl territories in our study areas, it was often possible to locate owls by simply calling quietly while visually searching for owls in their traditional roost or nest areas during the day. If these diurnal surveys were unsuccessful, we surveyed the entire territory at night by calling from survey stations distributed throughout the area according to standard survey protocol. The field methods to capture, mark, and resight individual owls and to determine number of young fledged per female was the standard protocol used in all the northern spotted owl demographic study areas (Forsman et al. 2011, Dugger et al. 2016).

The pilot barred owl removal experiment within our spotted owl demographic study area was initiated on 15 February 2009 working under a permit to California Academy of Sciences that allowed 20 barred owls to be collected. Following an evaluation by the USFWS of our removal data from this pilot study, we were authorized to continue lethal removal in 2010 of ≤ 70 barred owls over a 3-year period, with ≤ 30 individuals removed in any given year.

We detected barred owls as a consequence of standard surveys to locate spotted owls from 1990 to 2009, but because these surveys were designed for detecting spotted owls, we likely underestimated the number and location of barred owls (Wiens et al. 2011). Therefore, we began barred owl-specific surveys in 2009. Barred owl-specific surveys, with similar spacing and number of visits as spotted owl surveys, included playing recordings of barred owl calls broadcast by a commercially available, remotely controlled, high-quality digital wildlife caller (Wildlife Technologies KAS-2030ML and MA 15, Manchester, NH). To reduce the potential of initiating interspecific interactions between the 2 species, we broadcast spotted owl lure calls for 8 minutes before transitioning to the barred owl-specific survey calls. If no spotted owls responded to the initial spotted owl lure broadcasts, we broadcast barred owl lure calls for 10 minutes. Following removal of barred owls from a site, we conducted additional barred owl-specific surveys to assess recolonization by barred owls at removal sites (adapted from Forsman 1983 and Bierregaard et al. 2008).

If a barred owl was detected during any survey, we returned to the site to locate it. If that location was in a known spotted owl territory, we first broadcast spotted owl calls during these follow-up visits. If spotted owls were present, we did not attempt to lure barred owls. If spotted owls did not respond within approximately 400 m of our location, we assumed there were no spotted owls present at the local site. We then broadcast a repertoire of barred owl lure calls, generally starting with male and female 2-phrased (8-note) hoots and progressed to more agitated ascending (series) hoots, pair duets, or cackling calls (Odom and Mennill 2010). We attempted to lethally remove all barred owls continuously in treatment areas that behaved in a territorial manner except barred owls that potentially had dependent nestlings or fledglings. Territoriality was assessed by aggressive hooting, flying to the source of the lure call, stooping on the calling device, and limb crashing (i.e., landing with force on a limb such that it made a loud sound). We only removed territorial

owls. We moused (i.e., placed a live laboratory mouse in a position to be taken by an owl; Forsman 1983) spotted owls that re-occupied (same individual owls resuming occupancy at a site that they previously occupied) or recolonized (new owls occupying a site previously occupied by different individuals) a site to determine their pair and nesting status and we captured and banded any new spotted owls.

Analytical Methods

Spatially delineated owl sites were important to the development of detection/non-detection data sets for our site occupancy analyses, and for estimation of habitat and barred owl covariates within study areas. We defined an owl site as a landscape patch that represented the cumulative area where a spotted owl or pair of spotted owls was detected. The process by which these sites were delineated using Thiessen polygons was described in Dugger et al. (2016).

Development of covariates.—We collected barred owl detection locations used in the population and site occupancy analyses incidentally during our annual northern spotted owl surveys. Barred owls were not specifically targeted during the calling surveys conducted as part of our long-term monitoring of spotted owls and detections associated with barred owl-specific surveys conducted with removal protocols were not used to develop this covariate. However, barred owls frequently responded to spotted owl calls during nocturnal surveys and, based on a calling experiment conducted by Wiens et al. (2011), we estimated that the cumulative annual detection probability of barred owls was >85% at territories in which we conducted ≥3 nocturnal surveys for spotted owls. For population (as opposed to occupancy) scale analyses, we calculated a barred owl covariate that was year-specific and reflected the proportion of spotted owl territories (i.e., Thiessen polygons) in which barred owls were detected ≥1 time per year. For occupancy analyses, we used detections at the site and survey scale to estimate barred owl detection probability and the probability of barred owl occupancy, colonization, and extinction at sites where barred owls may have been present but not detected.

We developed habitat covariates to represent the amount and distribution of northern spotted owl habitat within our study area. For population scale analyses, we calculated these covariates across the whole study area and they varied among years. For occupancy analyses, we calculated certain covariates at the scale of individual owl sites and they varied both spatially and temporally. For clarity, the covariates calculated at the population scale are capitalized and covariates calculated at the site scale are not. The covariates calculated were 1) the amount of northern spotted owl habitat (HAB for population scale; hab for individual owl site scale), 2) the change in the proportion of habitat during 3-year intervals prior to each survey year (HC/hc), 3) the proportion of the study area or owl site that contained ≥50% habitat within an 800-m-radius circle centered on each pixel in the study area (CORE/core), and 4) the total amount of edge habitat (in m; EDGE/edge), with edge as the interface between suitable owl habitat and all other cover types. Additional details on the development of the habitat covariates are in Dugger et al. (2016).

We used a variety of covariates to investigate possible effects of weather and climate on population-scale vital rates of northern spotted owls. All weather and climate covariates were time-specific and applied at the scale of the owl population on our study area. These variables included measures of seasonal and annual weather and long-term climatic conditions. Specific covariates included mean precipitation and temperature during various life-history stages, Palmer Drought Severity Index (PDSI), Southern Oscillation Index (SOI), and Pacific Decadal Oscillation (PDO; Franklin et al. 2000; Glenn et al. 2010, 2011*a*,*b*; Forsman et al. 2011). Additional details on the development of the weather and climate covariates are in Dugger et al. (2016).

Analysis of site occupancy.—Our analysis of site occupancy was based on 15 years (1999–2013) of detection data, including 10 years prior to initiation of treatment and 5 years during the treatment period. Detections occurred during surveys conducted from 1 March through 31 August within owl sites, but detection/non-detection was aggregated into 12 2-week periods. On a per survey visit basis, we defined a site as occupied by spotted owls when a mated pair was present. We considered a site unoccupied if no owls or only a single spotted owl was detected. However, we considered the site occupied by barred owls when 1 or a pair of territorial individuals were detected. The basis for this difference is that spotted owl pairs have the potential to reproduce and are the ecological sample unit of interest (i.e., sensu effective population size). However, either single or paired barred owls have the potential to negatively affect spotted owls; therefore, we estimated all territorial barred owls to fully quantify their impact. We used a multi-season 2-species occupancy model and Program MARK to generate estimates.

At the start of each breeding season, owl sites were in 1 of 4 mutually exclusive states: both species present (state 3), only northern spotted owls present (state 2), only barred owls present (state 1), and neither species present (state 0). As neither species was detected perfectly, the true state of a site was only known with certainty when both species were detected (state 3). When only a barred owl was detected (observed state 1), the site could also have been occupied by a spotted owl pair (state 3) or not (state 1). Likewise, when only a spotted owl pair was detected, the site could also have been occupied by barred owls (state 3) or not (state 2). When neither species was detected, the owl site could have been in any one of the 4 states.

We modeled the overall probability of detecting the state of a site, given its true state, using a matrix of probabilities, $\rho_{i,t,j}$, that varied by site (i), year (t), and sampling event (j). We assumed no false positives (e.g., detection of barred owl, but site is occupied by spotted owl only), reduced probabilities in the matrix, and modeled ρ as a function of 5 parameters that varied by site, year, and sampling event. Omitting subscripts for clarity, these 5 parameters were 1) detection probability of barred owls when spotted owls were not present, p^A (^{A} = barred owl), 2) detection probability of barred owls when spotted owls were present, r^A, 3) detection probability

where BA is the difference in extinction probability on the logit scale associated with barred owl occupancy. The primary hypotheses of interest regarding the effects of barred owl removal on spotted owl extinction probabilities are given below, after discussion of the background model.

Finally, the state of each owl site in the first year is modeled based on the probability of occupancy for barred owls, ψ_i^A, and spotted owls, ψ_i^B, where both probabilities vary based on site covariates, including potentially both habitat and pre-treatment groups. Although it is possible to differentiate between occupancy of spotted owls in sites where barred owls are present or absent, previous 2-species occupancy modeling of this dataset did not support this distinction, probably because of the low prevalence of barred owls at the beginning of the study period (Dugger et al. 2016).

Baseline model.—Dugger et al. (2016) analyzed data from our study area (and 10 other study areas) over the same time period but excluded sites in the treatment area after 2008. Their analysis tested a number of hypotheses about habitat covariates, interspecific interactions, and temporal trends in various parameters. We adopted their best model structure as the baseline model for all analyses presented here, and build on it to test hypotheses about the effects of barred owl removal. The baseline model identified by Dugger et al. (2016) contained the following sub-models: 1) barred owl detection probability included a linear temporal trend; 2) spotted owl detection probability included a year factor (i.e., year-specific intercepts), a within-year bi-week factor (different intercepts for each of the 12 2-week periods), a within-year survey effect (whether surveys had previously been done at the site in the same year), and differences depending on whether barred owls were present and not detected, β_A, or present and detected, β_{DA}; 3) initial occupancy of barred owls did not vary between sites, 4) initial occupancy of spotted owls included the habitat change (hc) covariate, 5) barred owl colonization was a function of the edge covariate and a linear temporal trend, 6) spotted owl colonization was a function of the edge covariate, 7) barred owl extinction probability was a function of the hab covariate and whether spotted owls co-occupied the patch, β_B, and 8) spotted owl extinction was a function of the core covariate and whether barred owls co-occupied the patch, β_A.

Specific hypotheses tested in this analysis.—Past 2-species dynamic occupancy models for these species indicated that barred owls primarily affect northern spotted owl occupancy parameters by increasing local extinction rates in co-occupied patches (Yackulic et al. 2014, Dugger et al. 2016). Because barred owls were actively removed from sites in the treated area, we hypothesized that northern spotted owl extinction in the presence of barred owls would decline in the treated area to a level similar to northern spotted owl extinction in the absence of barred owls. Therefore, we modeled spotted owl extinction in the presence of barred owls using the following formula:

$$logit(\varepsilon^{BA}) = \alpha_0 + \boldsymbol{\alpha X} + \alpha_A + \alpha_{AR}\boldsymbol{R}$$

where X contained baseline covariates identified by Dugger et al. (2016) and hypothesized that α_{AR} would be negative with absolute magnitude approximately the same as α_A. We also hypothesized that removals would lead to an increase in barred owl extinction in the treated area regardless of whether spotted owls were present. In other words, given:

$$logit(\varepsilon^{A}) = \alpha_0 + \boldsymbol{\alpha X} + \alpha_R\boldsymbol{R}$$

$$logit(\varepsilon^{AB}) = \alpha_0 + \boldsymbol{\alpha X} + \alpha_B + \alpha_R\boldsymbol{R}$$

we hypothesized that α_R would be positive.

It was more difficult to predict the effects of barred owl removals on colonization of both species because of uncertainty regarding movement rates of both species. If movement between treated and untreated was common, we reasoned that treatment effects on colonization would be difficult to detect. In addition, barred owl occupancy was steadily increasing before treatment, and it was reasonable to assume barred owl colonization rates were increasing as well (Yackulic et al. 2012). Given these uncertainties, we tentatively hypothesized that barred owl colonization rates would be lower in the treatment area than in the untreated area but had no a priori hypothesis concerning overall trends in barred owl colonization post-treatment. In addition, we hypothesized that spotted owl colonization would increase in the treatment area.

In addition to the above hypotheses regarding the effects of treatment on different groups, we also tested for pre-existing differences between the group's initial occupancy, colonization, or extinction prior to treatment. We also considered hypotheses about how detection probability may have changed either in response to treatment or to the use of digitally broadcasted northern spotted owl calls beginning in 2009. We hypothesized that the improved quality of the broadcast calls would result in an increase in detection probabilities for barred owls. We also hypothesized that improved quality of broadcast calls might affect the probability of detecting spotted owls at sites also occupied by barred owls, but we did not have an a priori expectation concerning the sign of this effect. In addition, we hypothesized that the detection probability of northern spotted owls in previously co-occupied patches within the treated areas would increase as barred owls were removed.

Occupancy model selection.—We began by fitting a full model that included all background effects and hypotheses of interest (Table 1). We then sequentially removed effects (except those included in the baseline model) and observed changes in corrected Akaike's Information Criterion (AIC_c) values. We determined the order of potential removals a priori using the following steps: 1) determine which of the hypothesized treatment effects were supported in the detection parameters; 2) determine whether there is support for any differences between treatment groups prior to initiation of treatment in the initial occupancy, colonization, or extinction of either species; 3) determine whether parameters associated with colonization and extinction changed in the untreated area after initiation of treatment; and 4) determine if parameters associated with colonization and extinction differ between treated and untreated areas

following initiation of treatment. Within each set, we decided a priori to always remove parameters related to barred owls before removing parameters related to northern spotted owls and we always removed parameters related to colonization before parameters related to extinction.

Analysis of fecundity.—We conducted analysis of fecundity on the number of female young produced per territorial female per year, defined as the number of young (M + F) produced per territorial female per year divided by 2 because the sex ratio of juvenile owls at hatching was assumed to be 1:1 (Fleming et al. 1996). Spotted owls are strongly territorial, with high site fidelity and detectability, even in years when they are not breeding (Franklin et al. 1996, Reid et al. 1999). Similar to other studies (Anthony et al. 2006, Forsman et al. 2011, Dugger et al. 2016), we assumed that sampling throughout the breeding season was not biased towards birds that reproduced, and that the sample of owls used in our analyses was representative of the territorial population. During 1990 to 2013 over all sites, 90% of fledged young were produced by adult females >2 years old (other age classes included 1% produced by first-year subadults (S1), 3% produced by second-year subadults (S2), and 6% produced by unknown age birds). In addition, the number of non-adult birds was low or 0 in some years, which reduced our ability to compare fecundity for these age classes. Consequently, we dropped non-adult age classes from analysis and considered only fecundity of adult females.

Similar to previous analyses (Anthony et al. 2006, Forsman et al. 2011, Dugger et al. 2016), we analyzed mean annual fecundity using standard regression based on a normal distribution. Analysis of average fecundity helped assure the homoscedastic error assumption inherent in normal models. Furthermore, the appropriate sample units for the analysis were geographical (the treated and untreated areas), not individual owls, because both experimental areas could respond annually to effects that influenced their entirety. In addition, by averaging over owl territories occupied by females and considering treatment areas as sampling units, we reduced ill-effects of autocorrelation in reproduction through time on individual owl territories (Dugger et al. 2016).

The distribution of the underlying data (no. fledglings/female; NYF) was consistent with a truncated Poisson or multinomial distribution because spotted owl pairs almost always raise 0, 1, or 2 young. However, annual fecundity averaged over territories was not Poisson (Forsman et al. 2011), and normal models are more accurate than Poisson models when data depart from Poisson (White and Bennetts 1996, McDonald and White 2010). In addition, normal models are just as accurate as multinomial models when averages are analyzed (McDonald and White 2010). Thus, we used regression models based on a normal distribution to model mean annual NYF for study area as described in Dugger et al. (2016).

Prior analysis has shown that the spatial covariance among territories tended to be small relative to temporal variance among years and other residual effects (Forsman et al. 2011). This justified disregarding spatial covariance because it would not seriously bias variance estimates. In addition, residual variation was relatively constant through time largely because residual variation was small relative to annual variation. Consistent with previous analyses (Anthony et al. 2006, Forsman et al. 2011, Dugger et al. 2016), we estimated the effect of barred owl removal and fit a large number of candidate models containing the effects of habitat, weather, climate, and various forms of interactions between study area (treated vs. untreated) and time period (pre-removal and post-removal). We determined the set of candidate models prior to estimation based on biologically plausible hypothesized effects. The full list included 574 models but we present only those models with a $\Delta AIC_c < 5$.

All models fitted here contained constraints on temporal trends pre- and post-removal that were, in fact, the primary goal of estimation. In addition to non-temporal covariates mentioned above, the models fitted here included year and treatment covariates that allowed the same, parallel, or non-parallel trends on the 2 study areas (treated and untreated) before treatment but parallel trends and differing magnitudes after treatment. If removal of barred owls on the treated area had no effect on average fecundity, the coefficient for the difference in magnitude between treated and non-treatment areas after removal would be 0. If the intercept coefficient measuring the mean difference post-treatment was not 0 (at $\alpha = 0.05$ level), we concluded the change in fecundity to be associated with removal of barred owls. That is, we concluded that fecundity on the 2 study areas was different following treatment.

Analysis of apparent survival.—We used capture–recapture (re-sighting) data to estimate capture probabilities and annual apparent survival probabilities of territorial owls using open population Cormack–Jolly–Seber models. We developed a set of models based on previous research and biological hypotheses (Dugger et al. 2016), and computed estimates of coefficients in those models using Program MARK (White and Burnham 1999). We considered both fixed and random effects models. Covariates considered in the fixed portion of the Cormack–Jolly–Seber model included sex and temporal effects. Covariates considered in the random portion of the model included reproduction, habitat, weather, climate, and generic time effects.

Based on the best-fitting fixed effects model, we included random effects to produce shrinkage estimates (Burnham and White 2002) of annual survival and standard error. Shrunk survival estimates were associated with the year of the field season that terminated the interval. For example, survival from field season 2011 to field season 2012 was associated with year 2012 for analysis. We discarded the final interval (2012–2013) because survival and capture were confounded during the final interval in time-dependent models (Forsman et al. 2011, Dugger et al. 2016).

We then tested for an effect of barred owl removal on survival. We exported the shrunk estimates of survival produced by the best fitting random effects model from MARK to R (R Foundation for Statistical Computing, Vienna, Austria) and used the estimates to test for an

occupancy rates substantially increased in the untreated areas, whereas they remained relatively constant and much lower in the treated areas (Fig. 2A); 2) colonization rates initially increased and then declined in both treated and untreated areas, but the increase was greater in the untreated areas (Fig. 2B); and 3) extinction rates increased in the treated areas but declined in the untreated areas (Fig. 2C).

Similar to barred owls, there was no evidence of different spotted owl occupancy rates between treated and untreated areas prior to the initiation of the treatment. Following treatment, there was a slow recovery in northern spotted owl occupancy in the treated areas even as occupancy continued to decline in the untreated areas (Fig. 3A). Barred owl removal decreased overall spotted owl extinction rates to levels equivalent to spotted owls sites that had never had barred owls present (Fig. 3B). The best model estimated spotted owl colonization rates at an average of 0.19 (95% CI: 0.15–0.24) and models with different spotted

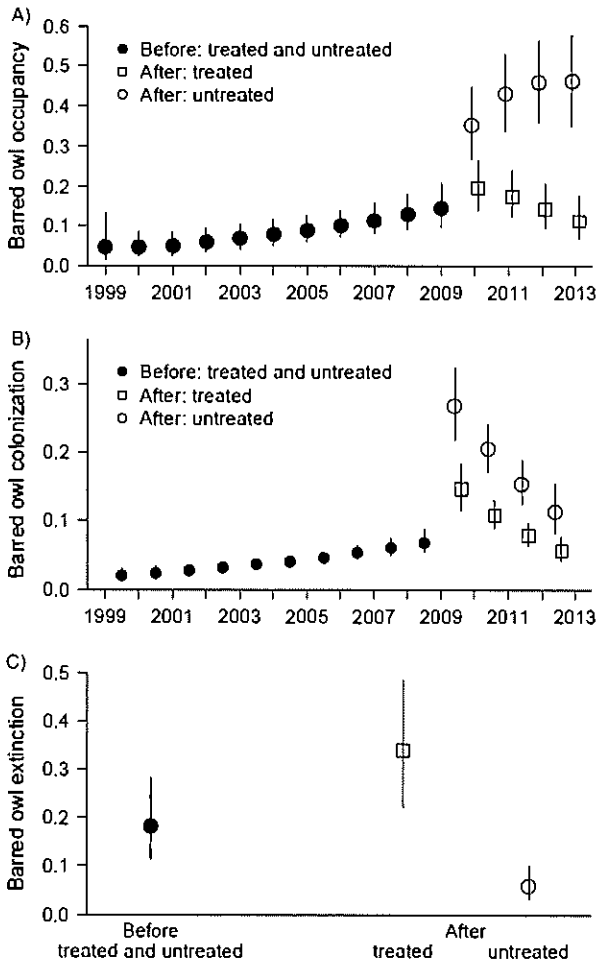


Figure 2. Changes in barred owl occupancy, colonization, and extinction on Green Diamond's northern spotted owl demographic study area in north coastal California, USA. (A) Trend in barred owl occupancy in treated and untreated areas before and after treatment (barred owl removal). (B) Trend in barred owl colonization in treated and untreated areas before and after treatment. (C) Barred owl extinction rate before treatment and after treatment in treated and untreated areas. Error bars represent 95% confidence intervals.

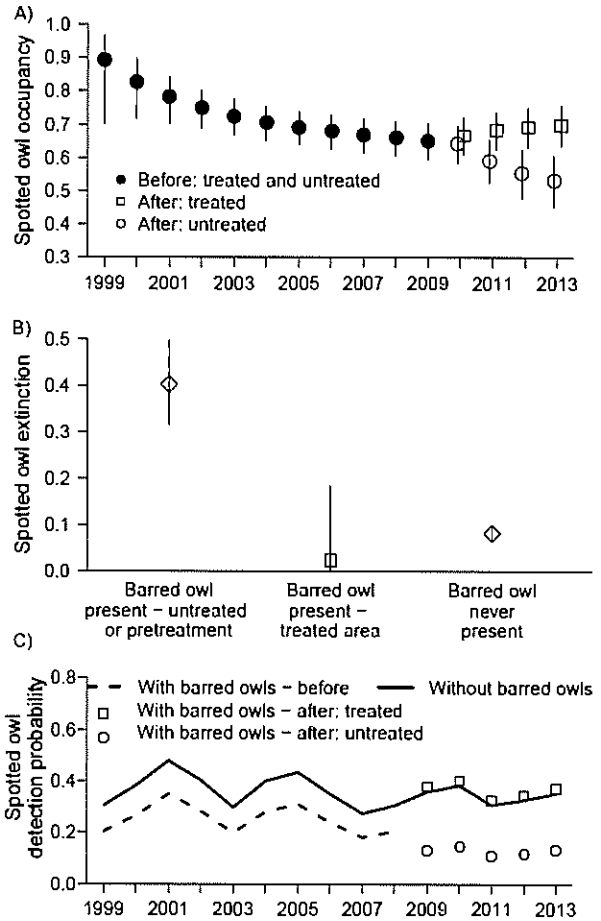


Figure 3. Changes in northern spotted owl occupancy, extinction, and detection probability on Green Diamond's demographic study area in north coastal California, USA. (A) Trend in spotted owl occupancy in treated and untreated areas before and after treatment (barred owl removal). (B) Spotted owl extinction rates when barred owls are present and not removed, barred owls are present and removed, and barred owls were never present. (C) Spotted owl detection probability with and without barred owls before treatment, without barred owls after treatment, and with barred owls after treatment in the treated and untreated areas. Error bars in panels A and B represent 95% confidence intervals.

owl colonization rates in treated and untreated areas were not supported. Northern spotted owl detection probability at sites not occupied by barred owls varied over time but showed no differences between treatments or over time (Fig. 3C). On the other hand, spotted owl detection probability at sites also occupied by barred owls increased in the treated area to the point where detection probability was nearly the same as at sites where barred owls were not present. At the same time, spotted owl detection probability in the untreated area at sites occupied by barred owls decreased to lower levels than were found prior to treatment (Fig. 3C). In agreement with Dugger et al. (2016), barred owl detection probability was estimated to be slowly increasing over the course of the study but did not show different trends with respect to treatment.

Fecundity

Estimates of fecundity (no. of female young produced/adult female/year) from 1990 to 2013 were based on records of

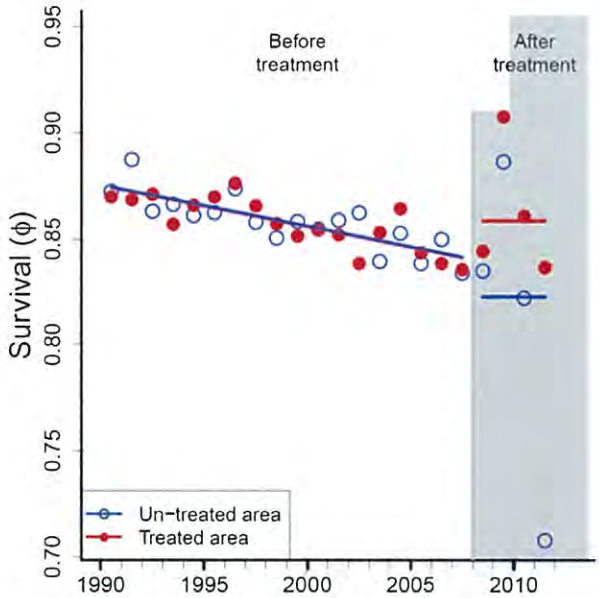


Figure 5. Shrinkage estimates of annual apparent survival from 1990 through 2013 on Green Diamond's northern spotted owl demographic study area in north coastal California, USA. Dots represent annual estimates of treated and untreated areas and trends are estimated from the weighted linear model. Survival on the treated area after removal of barred owls increased by 0.0366 (3.66%, $P = 0.016$) relative to survival on the untreated area.

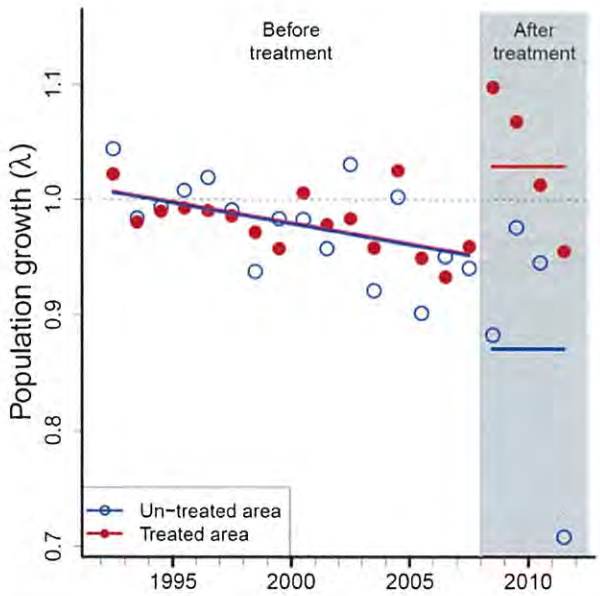


Figure 6. Shrinkage estimates of the rate of population change from 1990 through 2013 on Green Diamond's northern spotted owl demographic study area in north coastal California, USA. Shrinkage estimates are derived from the best-fitting reverse-time Cormack–Jolly–Seber model and calculated for treated and untreated areas (dots), with trends estimated from the weighted linear model. Dashed line represents a stable population, $\lambda = 1.0$. The rate of population change on the treated area increased by 0.159 ($P \leq 0.001$) after removal of barred owls relative to that on the untreated area.

studies. We documented that all were re-occupied by spotted owls with the time for re-occupation ranging from a minimum of 13 days to a maximum of 152 days after removal. Four of the sites were re-occupied by ≥ 1 of the previous resident spotted owls, including 1 female that had not been seen for 7 years. The remaining 3 sites were re-occupied by new or individuals of unknown status. Following re-occupation, the spotted owls were again displaced by barred owls at 3 sites.

There were additional barred owl removal sites that did not meet the criteria for a removal case study because the barred owls did not occupy the known spotted owl site, although they were immediately adjacent to occupied spotted owl nest sites or activity centers (i.e., the barred and spotted owl were neighbors with home ranges that likely overlapped). These neighbor case studies were more difficult to summarize, but the general pattern in all cases was for the spotted owls to either shift their territories away from the neighbor barred owls and not nest or become silent so that we had difficulty finding and determining the nesting status of the spotted owls.

DISCUSSION

The Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) noted the increasing threat of the barred owl on the northern spotted owl and called for removal experiments to quantify the impact of the invasive species on demographic parameters of spotted owls. A long-term demographic study of the spotted owl that spanned the interval when the expansion of barred owls transitioned from rare floaters on the landscape to occupying increasingly more of the available spotted owl habitat provided a unique opportunity to conduct a BACI removal experiment. However, relative to other northern spotted owl demographic study areas, the Green Diamond study area had among the lowest relative naive estimate of annual proportion of spotted owl territories with barred owl detections in Washington, Oregon, or California (Dugger et al. 2016). We hypothesized that this might reduce the magnitude of the treatment effect on all the demographic parameters, but it also facilitated the ability to remove resident barred owls from the treated areas because of their lower density compared to other areas within the range of the northern spotted owl (Diller et al. 2014).

Site Occupancy

In general, parameter estimates were consistent with our a priori hypotheses. Despite the potential for differences in physical and biological parameters, there were no differences between treated and untreated areas prior to initiation of treatment in the parameters governing either barred owl or northern spotted owl occupancy dynamics. This provides evidence that prior to treatment, the treated and untreated areas were sufficiently similar in important parameters such as occupancy, colonialization, and extinction that post-treatment differences could be assigned to the treatment effect (i.e., removal of barred owls). After the experimental removal experiment began, barred owl extinction rates

Oregon indicated that interference competition for territorial space limited availability of spotted owls to their preferred habitat (Wiens et al. 2014). We also made anecdotal observations of spotted owls that no longer vocalized following occupation by barred owls at or near their territory core, but we could still observed them when they flew up to take a proffered mouse. Thus, we hypothesize that release from barred owl influence creates the appearance of increasing apparent survival by allowing displaced spotted owls in the floater population to regain a territory and become more readily detected. Our empirical observations of spotted owls recolonizing sites within as little as 13 days provides support for this hypothesis.

Annual Rate of Population Change

Because of a declining rate in both fecundity and apparent survival with apparently insufficient immigration to compensate, there was evidence of a pre-treatment negative trend in λ for spotted owls in both the treated and untreated areas. Following initiation of the removal experiment, λ significantly increased in the treated areas with the mean rate greater than 1.0, suggesting a stable or increasing population. The population continued to decline in the untreated areas and was estimated at the lowest recorded level post-treatment.

As previously noted, the Green Diamond dataset was also used in the 2013 northern spotted owl meta-analysis. One of those analyses converted estimates of λ_t to estimates of realized population change ($\widehat{\Delta}_t$). This method provided a visual portrayal of the population trajectory ($\Delta_t = N_t/N_x$) in each year of the study relative to population size in year x, the first year that λ_t was estimated. The results of that analysis for Green Diamond indicated that the treated and untreated spotted owl populations were generally stable (95% CI broadly overlapped 1) until 2005 when a sharp population decline ensued. Following initiation of the experimental removal on the treated area in 2009, the treated area started to rebound and the 95% confidence interval broadly overlapped 1, whereas the trend in the untreated area continued to decline with no overlap of the 95% confidence interval (Dugger et al. 2016)

If the sharp increase in λ seen in this study were the result of increases in fecundity and actual survival within the treated population, we would have expected a delay or lag of several years in the λ response. Instead, the immediate increase suggested that similar to the effect on survival, much of the increase was probably due to displaced spotted owls in the floater population regaining territorial status and being detected. Furthermore, creating an area free of barred owls may have increased the probability that floater spotted owls rebuffed in adjacent untreated areas could colonize the treated areas.

In other areas where barred owls have been present in large numbers for a longer period of time and the population of spotted owls has been more suppressed, the demographic response of spotted owls may be protracted or delayed. If spotted owl abundance has decreased to the extent that comparatively few individuals are available on the landscape to rapidly recolonize territories, we predict there would be a lag of several years in a positive spotted owl demographic response as survival and fecundity increases in the absence of barred owls. Furthermore, differences in habitat and climate associated with different physiographic provinces throughout the species range may play a role in the time or strength of a demographic response.

Empirical Observations of Northern Spotted Owl Recolonization

Although based on a small number of case studies ($n = 7$), these results suggested that northern spotted owls were likely to re-colonize their former territories following removal of barred owls. The very rapid re-colonization of 4 sites by the original resident spotted owls also indicated that, at least in some cases, the resident owls apparently remain in the vicinity of, or regularly investigate their former territory for years after being displaced by barred owls. These results also suggest that barred owls are not simply colonizing areas vacated by declining spotted owl populations, but rather that barred owls are actively displacing spotted owls as described by Wiens et al. (2014). The high and sometimes rapid rate of re-colonization by both original resident and new spotted owls following barred owl removal suggests that at least in some cases, barred owls were keeping the spotted owls from preferred, high quality sites. The sites that were colonized by barred owls also had high continuous occupancy by pairs of spotted owls with high reproductive success before barred owls invaded, which is further evidence that these sites were in high demand by spotted owls. For our study area, located within an intensively managed landscape where many of our spotted owls occupy young-growth sites that differed relative to other demographic study areas, the barred owls tend to occupy the sites with more classic late seral habitat elements.

MANAGEMENT IMPLICATIONS

The results from this study demonstrate that lethal removal of barred owls can allow the recovery of northern spotted owl populations. However, removal experiments may be more difficult to implement and recovery may be slower in other areas where barred owls have been present in large numbers for a longer period of time and the population of spotted owls has been more suppressed. Nevertheless, this experiment provides evidence that future management options may be developed to assist in the recovery of the northern spotted owl in at least the southern portions of its range. Unlike the substantial challenge of this removal experiment in which the objective was to continuously remove all territorial barred owls from the treated areas, long-term management options could be developed that would only require reducing barred owl population densities in selected conservation areas to allow coexistence with spotted owls. Presumably this could be done with much less cost and effort per unit area treated through an incremental decrease in adult barred owl survival or by implementing less controversial methods to decrease barred owl fecundity. At a minimum, this removal experiment provides evidence that if spotted owl populations continue to decline in the face of the barred owl threat,

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Associate Editor: Marc Bechard.

Northern Spotted Owls Near Weaverville and Trinity Lake In Trinity County

Within the Landscape Survey Strategy Area

(An Interim Report)

Sierra Pacific Industries
January 2016

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Sierra Pacific Research & Monitoring

Sierra Pacific Industries

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

January 2016

Introduction

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

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

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

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

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

Results

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

In 2011, we began annual re-surveys of the LSS stations. During this five year effort, we found 57 occupied ACs within the original LSS area, 17 of which were in new locations (Figure 4). One activity center occupied during the 2003-2007 surveys was destroyed by wildfire prior to 2011. In addition, one occupied AC has continued to make minor movements throughout the resurvey period and has since been relocated outside the LSS boundary. Due to this bird originally being located within the LSS boundary and since it was included in the baseline and '03-07 analysis, it was included in the density calculations for this survey period even though it now falls just outside the LSS boundary.

Again, new ACs were usually near now unoccupied older ACs. Despite the single AC lost to wildfire, the estimated population density is stable to increasing. The raw density of 57 occupied ACs found on the 173,316 acre survey area results in 0.2105 occupied ACs per square mile. Up from 0.1736 in 2003-2007 based upon 47 occupied ACs and up from an estimated 0.1551 occupied ACs per sq. mi. in 1989 based upon an estimated 42 occupied ACs (80% of 52 known ACs). See table below:

Year	1989	80% (Recovery)	1989 - 2003	2003 - 2007	2011 - 2015
Occupied ACs	52 (max known 1974-1989)	42	47 (max)	47	57
Crude Density[1]	Not Applicable	0.1551[2]	0.1736[2]	0.1736	0.2105
Comment	Assumed 100% occupancy from CNDDB and SPI surveys since protocol surveys were not conducted.	Assume the population was a fully recovered population. (80% occupancy per 2008 NSO Recovery Plan)	Max estimate. Assumed all ACs occupied. (Removed 5 abandoned sites with USFWS concurrence)	Occupancy determined at all sites	Occupancy determined at all sites

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

In both of these survey periods, some ACs were determined to not have any responses and historically would have been declared abandoned by the USFWS. Service direction changed in this time period, and the 2012 protocol no longer included a definition for abandoning sites. Thus ACs from owls that may have moved on the landscape continue to increase in number while numbers of occupied ACs and density of owls increased.

In response to the Service's revision of the survey protocol in 2011, we switched to using electronic calling devices for these surveys, and also added over 180 new calling stations, extending geographic extent of the survey effort by about 40 percent, most of which is US Forest Service land within 1.3 miles of SPI ownership. This resulted in location of still more ACs outside the original LSS area; these sites have not been included in the summary

previously mentioned (Figure 5). Also, in 2011, we began banding all NSO on the ownership, so that in the future we will be able to ascertain whether birds in new locations are residents that have relocated, or whether they are immigrants. Since 2011, we have banded 178 NSO (118 adults/sub adults and 60 juveniles).

Reproduction

During this recent 2011- 2015 effort we were able to determine that 30 of these 57 occupied ACs were reproductive, producing at least 97 fledglings (Figure 6). This represents 60 individual successful nesting attempts as many of these AC's reproduced two to four times during this five year survey.

Summary and Conclusion

In summary, the uncertainty associated with the estimate of territories extant at the time of listing precludes precise comparison of numbers over the past 26 years. However, while we have seen some change in the location of occupied ACs, we see no indication of a population decline in the LSS area during the period between the 2003 - 2007 LSS surveys and the surveys being conducted now. While we recognize that this is a very small portion of the California population and our work is not a demographic study, it is worth noting that the LSS area apparently is not showing a similar decline as reported from the NSO demographics studies. The Willow Creek Study area (referred to as NWC) is the nearest USFS demographic study area to the LSS and they have an estimated annual decline of 3.0%. The current range wide demographic average is an estimated annual decline of 3.8% (Dugger et al, 2016).

Compared to those values our numbers of occupied ACs and density of owls appears to be increasing. If our study area NSOs were following these rates and assuming that our original 1989 AC count of 52 (minus those the service declared abandoned) we would have a 1989 starting estimate of 47 ACs. Applying the NWC demographic study estimated rate of decline our study area should have experienced a reduction to only 22.1 occupied ACs and based upon the NSO range wide estimated rate we should have only 18.1 occupied ACs today. Rather than those declines our LSS study area has had a net increase of 10 ACs from that estimated starting point.

Since the listing, over the past 26 years, all THPs have been conducted under no-take guidance in effect at the time of harvest. The increased survey effort, improved protocols, and initiation of banding should improve our understanding of the owl population in this area in the future.

In conclusion, to our knowledge, our LSS effort to determine the number of occupied ACs on a fixed area of land is the only existing dataset upon which to assess potential impacts over time of FPR - guided management on NSO density. This study shows that for the period from 2003 through 2015, despite active timber harvest, there has been only an increase in population density for this portion of the range of the NSO. While our current efforts have demonstrated movement of owls around this landscape, as described above, this has resulted in an increase in the number of ACs and a misleading percent occupied estimate. This resultant increase in overall AC count obscures the fact that actual numbers of "occupied" ACs and the density of owls have increased substantially since the listing of the owl.

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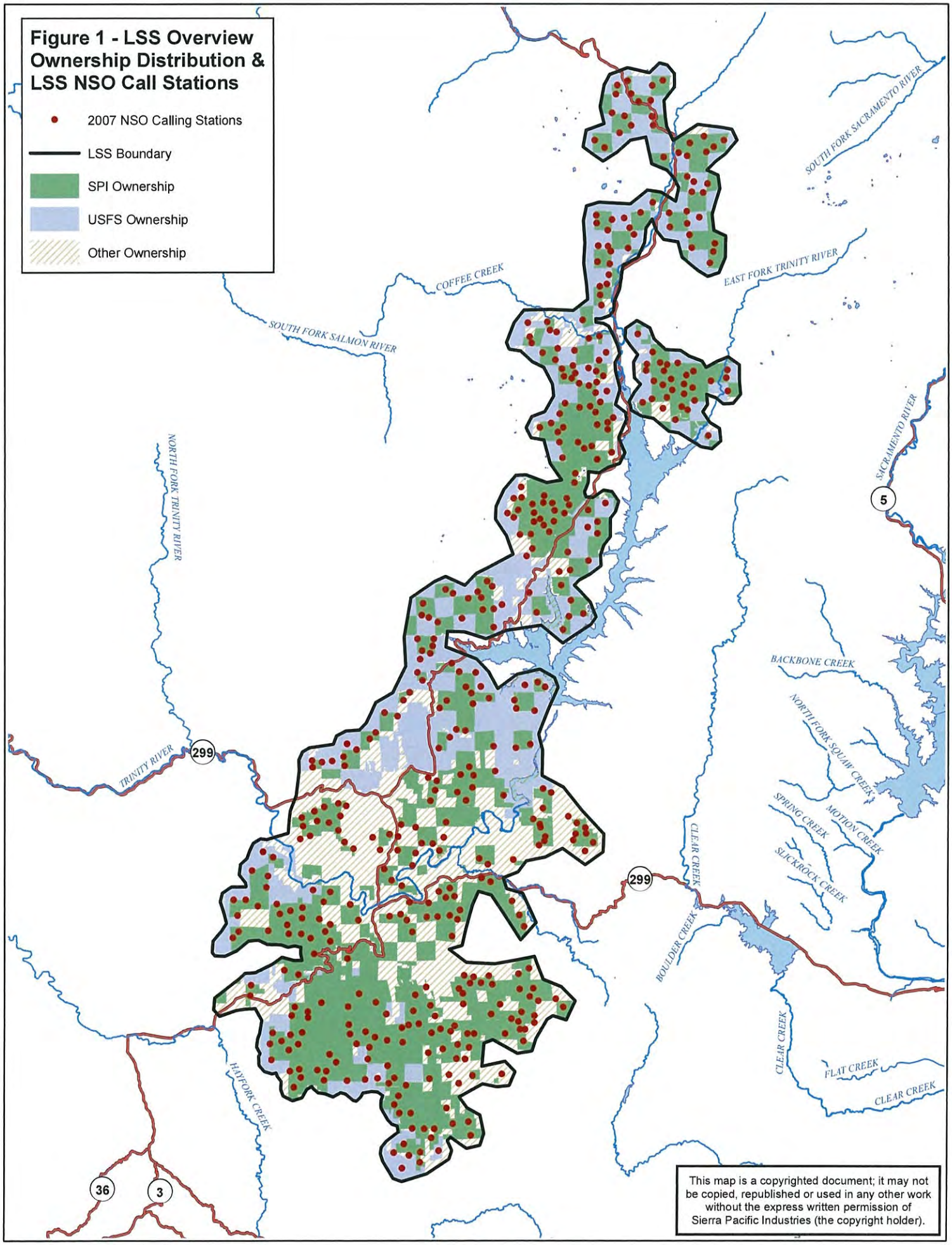
Figure 1 - LSS Overview Ownership Distribution & LSS NSO Call Stations
2007 NSO Calling Stations
LSS Boundary
SPI Ownership
USFS Ownership
Other Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
SOUTH FORK SALMON RIVER
SACRAMENTO RIVER
5
NORTH FORK TRINITY RIVER
BACKBONE CREEK
NORTH FORK SQUAW CREEK
TRINITY RIVER
299
SPRING CREEK
MOTION CREEK
SLICKROCK CREEK
CLEAR CREEK
299
BOULDER CREEK
CLEAR CREEK
FLAT CREEK
CLEAR CREEK
HAYFORK CREEK
36
3
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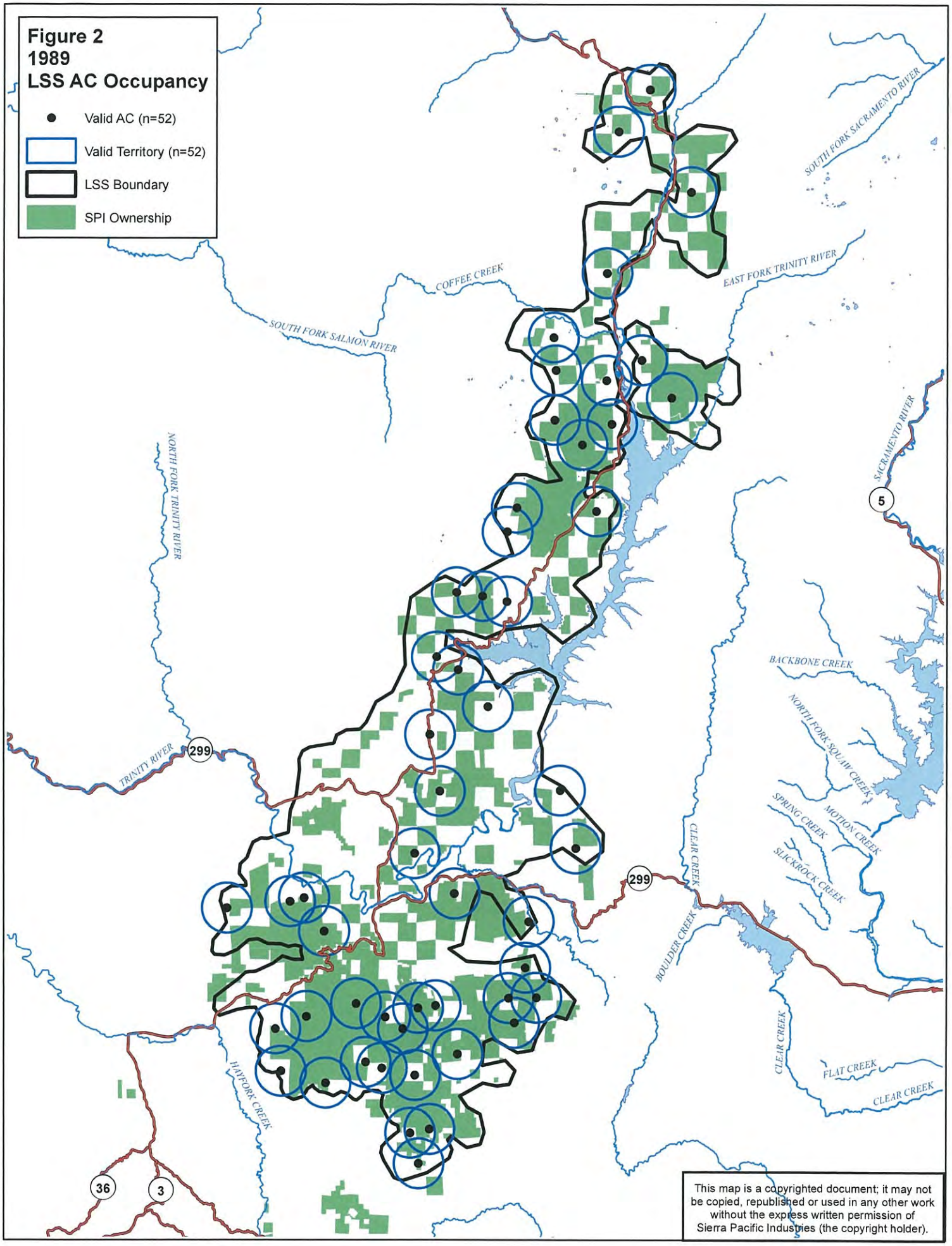
Figure 2
1989
LSS AC Occupancy
Valid AC (n=52)
Valid Territory (n=52)
LSS Boundary
SPI Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
SOUTH FORK SALMON RIVER
NORTH FORK TRINITY RIVER
SACRAMENTO RIVER
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BACKBONE CREEK
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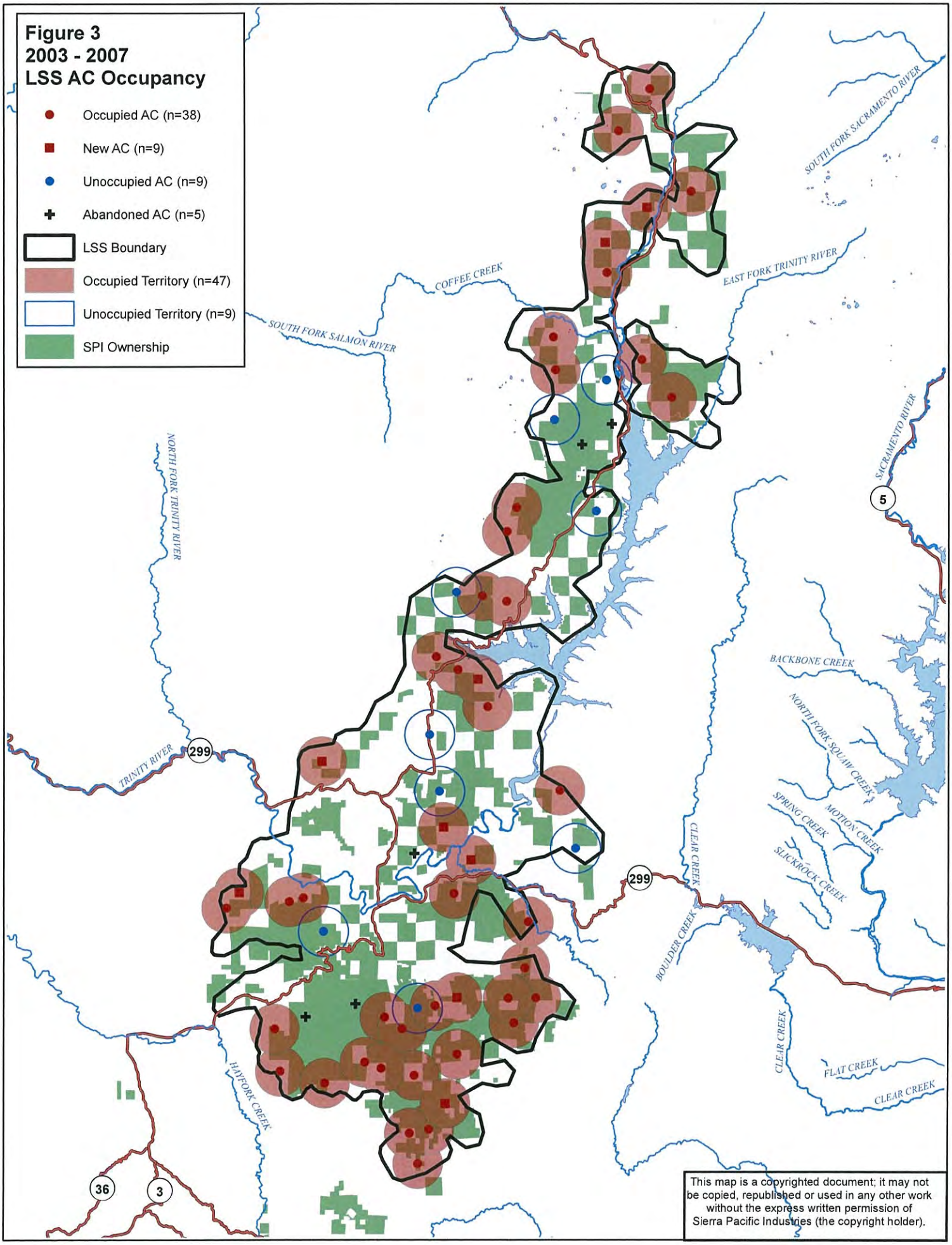
Figure 3
2003 - 2007
LSS AC Occupancy
Occupied AC (n=38)
New AC (n=9)
Unoccupied AC (n=9)
Abandoned AC (n=5)
LSS Boundary
Occupied Territory (n=47)
Unoccupied Territory (n=9)
SPI Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
SOUTH FORK SALMON RIVER
NORTH FORK TRINITY RIVER
SACRAMENTO RIVER
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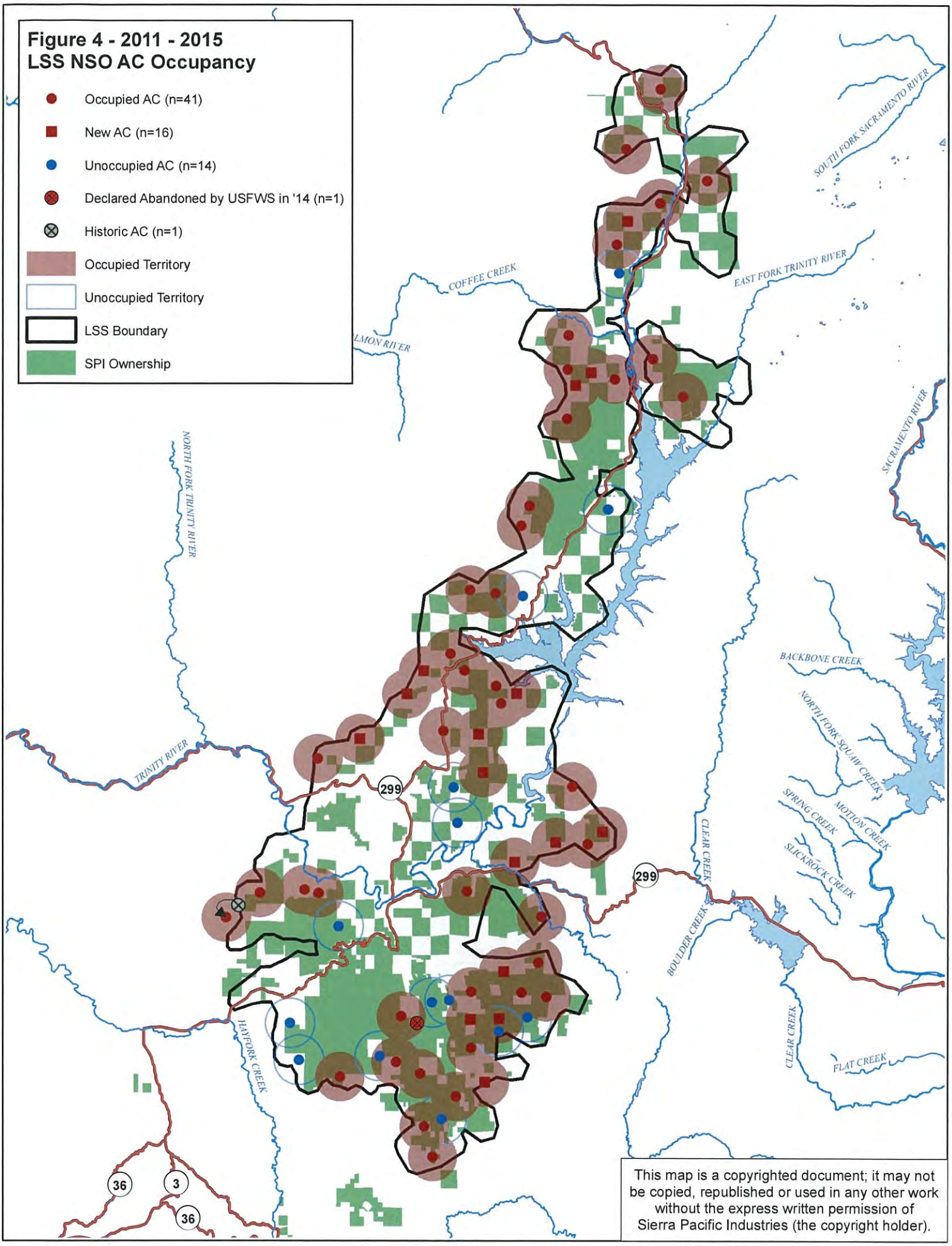
Figure 4 - 2011 - 2015
LSS NSO AC Occupancy
Occupied AC (n=41)
New AC (n=16)
Unoccupied AC (n=14)
Declared Abandoned by USFWS in '14 (n=1)
Historic AC (n=1)
Occupied Territory
Unoccupied Territory
LSS Boundary
SPI Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
LMON RIVER
NORTH FORK TRINITY RIVER
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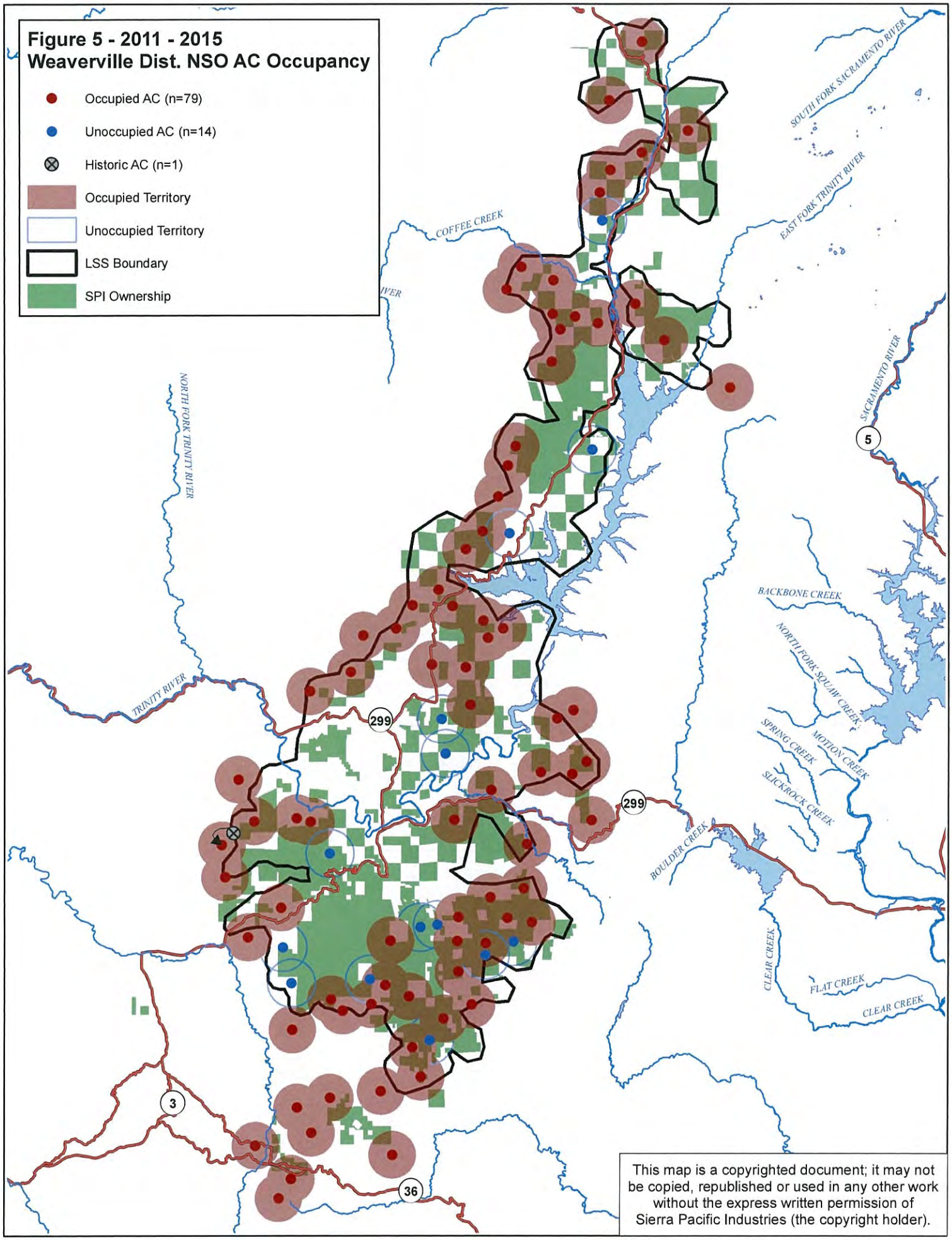

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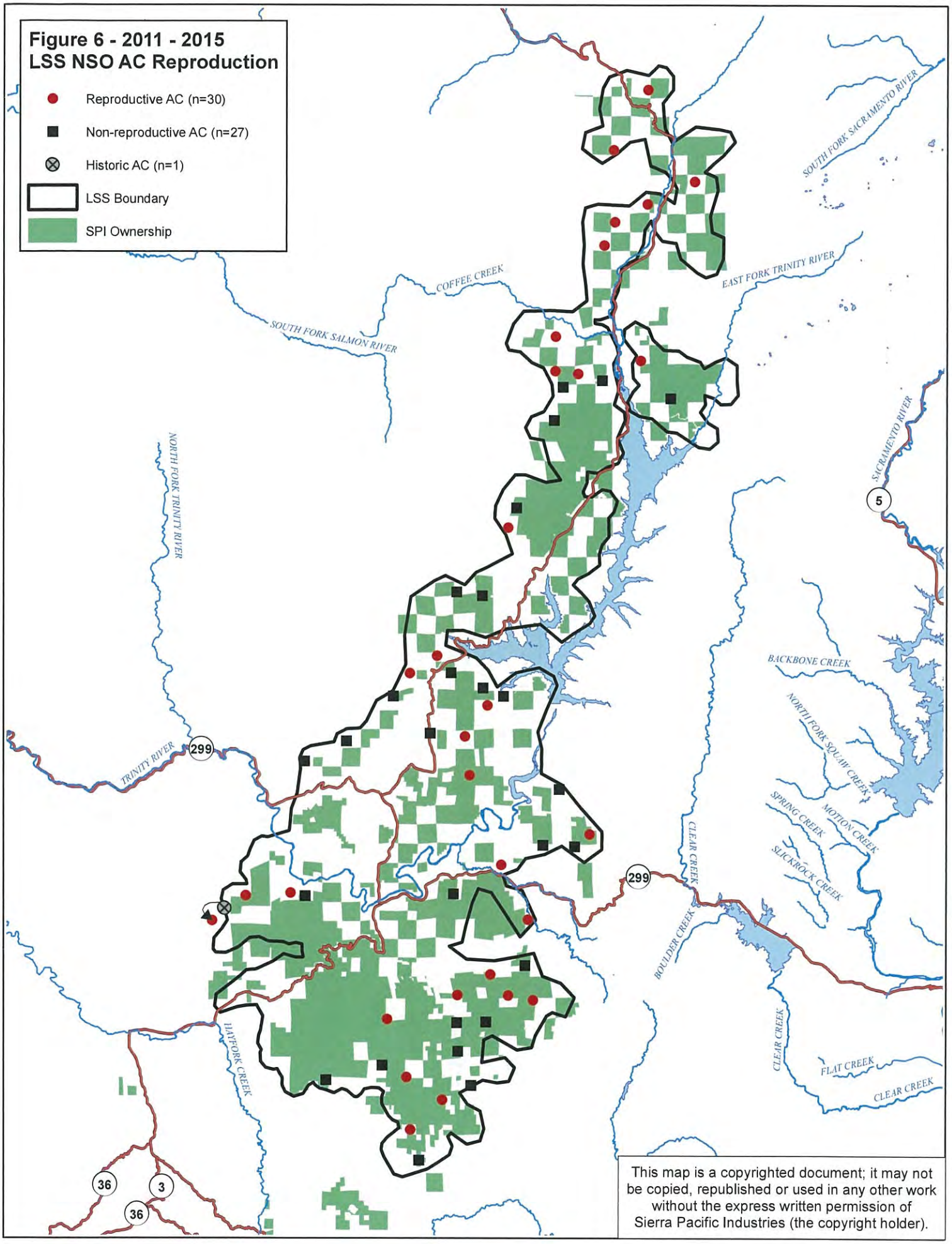

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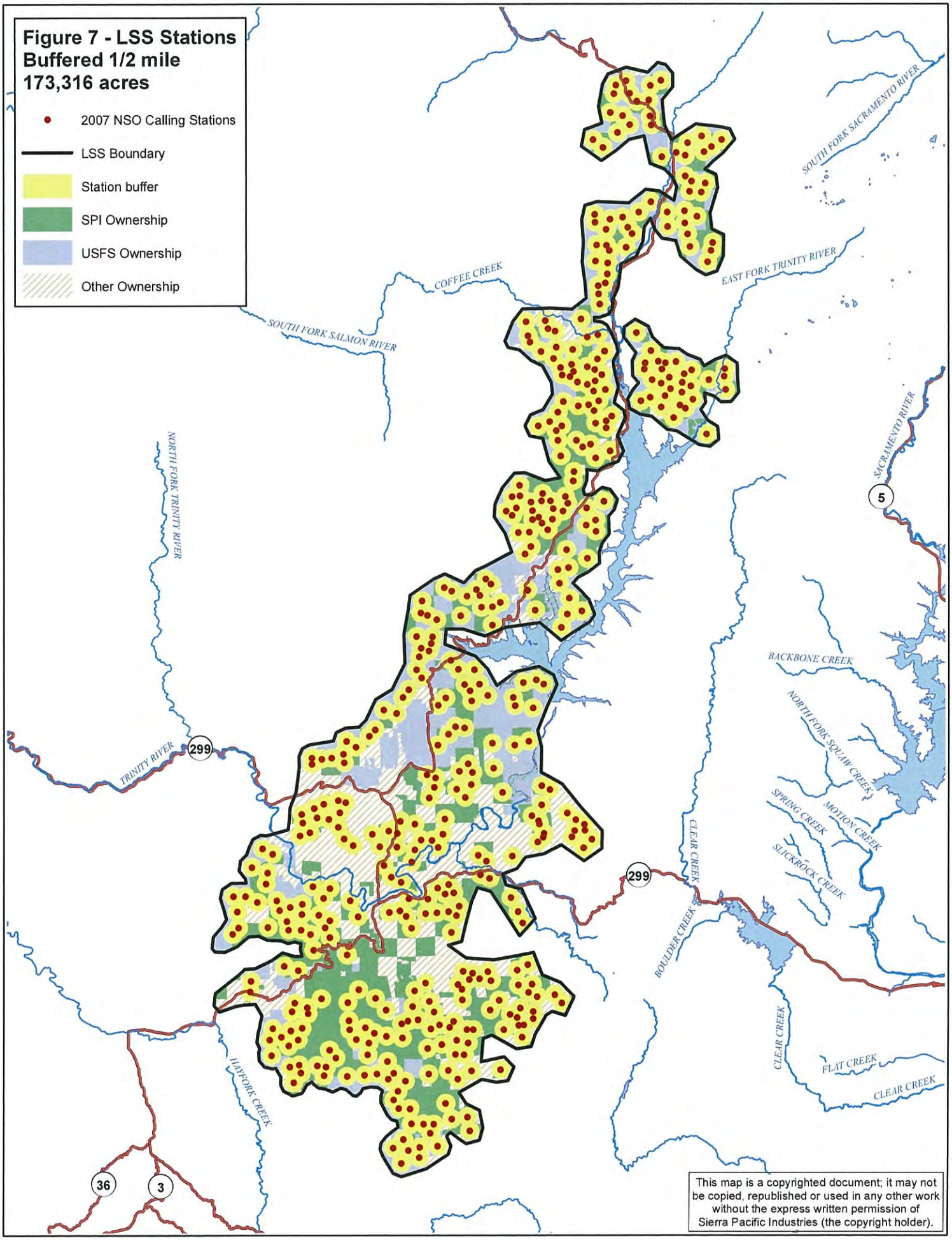
Figure 7 - LSS Stations
Buffered 1/2 mile
173,316 acres
2007 NSO Calling Stations
LSS Boundary
Station buffer
SPI Ownership
USFS Ownership
Other Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
SOUTH FORK SALMON RIVER
NORTH FORK TRINITY RIVER
SACRAMENTO RIVER
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HAYFORK CREEK
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STATE OF CALIFORNIA
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BOARD OF FORESTRY AND FIRE PROTECTION
Keith Gilless, Chair

THE NATURAL RESOURCES AGENCY
JOHN LAIRD, *Secretary*

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MEETING ANNOUNCEMENT AND AGENDA

Announcement Date: June 27, 2013

FULL BOARD:

REGULAR SESSION
July 10, 2013
Time: 8:00 a.m.

Location: **Resources Auditorium**
1416 Ninth Street
Sacramento, California

COMMITTEES:

ROAD RULES WORKSHOP
July 8, 2013
Time: 10:00 a.m. – 4:00 p.m.

Location: **Resources Auditorium**
1416 Ninth Street
Sacramento, California

FOREST PRACTICE COMMITTEE
July 9, 2013
Time: 9:00 a.m. – noon

Location: **Resources Auditorium**
1416 Ninth Street
Sacramento, California

RESOURCE PROTECTION COMMITTEE
July 9, 2013
Time: 9:00 a.m. – noon

Location: **Resources Building Room 1506-12**
1416 Ninth Street
Sacramento. California

MANAGEMENT COMMITTEE
July 9, 2013
Time: 1:00 p.m. – 3:00 p.m.

Location: **Resources Building Room 1506-12**
1416 Ninth Street
Sacramento. California

Contact information: Those requiring further information regarding this meeting notice may contact George D. Gentry, Executive Officer, State Board of Forestry and Fire Protection, P.O. Box 944246, Sacramento, CA, 94244-2460, (916) 653-8007. This meeting notice is also available in electronic format at: http://www.bof.fire.ca.gov/board_business/meeting_agendas/. Other meeting materials and sign up for WebEx are available at: http://www.bof.fire.ca.gov/.

Internet: The Full Board meeting will be simultaneously webcast by WebEx for **viewing/listening purposes only,** in addition to its regular meeting. Board members will be in attendance at the Resources Auditorium along with any members of the public that choose to attend. Members of the public may register online at the Board's web site (http://www.bof.fire.ca.gov/) in advance of the meeting. Audio and PowerPoint presentations will be available on line. ***Public participation in the public comment portion of the meeting is in person in Sacramento.***

The Board's Mission:
To lead California in developing policies and programs that serve the public interest in environmentally, economically, and socially sustainable management of forest and rangelands and a fire protection system that protects and serves the people of the state.

BOARD AGENDA

REGULAR SESSION
July 10, 2013
Time: 8:00 a.m.

Location: **Resources Auditorium**
1416 Ninth Street
Sacramento, California

1. Call to Order

2. Approval of Minutes from Previous Meetings.

MONTHLY BOARD REPORTS

3. Report of the Chairman.

4. Board discussion and Nomination for Vice Chair of the Board.

5. Report of the Director/Department.

6. Report of the Regulations Coordinator. The Board's Regulations Coordinator will report on ongoing regulatory matters. **Possible Action Items**: The Board may act in response to requests of the Regulations Coordinator on items presented in the report.

7. Report of Executive Officer. The Board's Executive Officer will report on ongoing administrative matters, proposed state or federal legislation or programs, or new items coming before the Board. **Possible Action Items:** The Board may act in response to requests of the Executive Officer on items presented in the report.

8. Report of the Standing Committees. Committee Chairpersons will report on the actionable items from Committee meetings. **Possible Action Items:** The Board may act in response to Committee recommendations. (See Committee Agendas which are incorporated as though fully set forth herein.)

   - Forest Practice, Mark Andre, Chair
   - Resource Protection, Bruce Saito, Chair
   - Management Committee, Stan Dixon, Chair

9. Report of Board's Advisory Committees

   - Forest Pest Council-
     - California Oak Mortality Task Force (COMTF) – Katie Palmieri
   - Monitoring Study Group- Pete Cafferata
   - Research and Science Committee- No report
   - Committee on Criminal Trespass- George Gentry
   - Range Management Advisory Committee- No report
   - Professional Foresters Examining Committee – Matt Dias

     The Executive Officer for Professional Foresters Registration will report on ongoing PFEC matters. **Possible Action Items**: Issuance of RPF Licenses/CRM Certifications, Withdrawals, Reinstatements, Voluntary Relinquishments, Suspensions, Revocations, or other Actions.

SPECIAL BOARD HEARINGS/REPORTS

10. Presentation and Review of the Annual State Forest Report. Helge Eng, State Forest Program Manager

11. Discussion and Review of the LaTour Management Plan Revisions. **Possible action item:** The Board may make recommendations on the plan and CEQA documents.

12. Discussion and Review of the Lumber Assessment Regulations. **Possible Action Item:** The Board may make recommendations for a 45 day notice for rulemaking.

13. **HEARING:** Amend Title 14 § 919.9, § 939.9 – Northern Spotted Owl [Coast, Northern Forest Districts] and § 919.9(g), § 939.9(g) – Northern Spotted Owl [Coast, Northern Forest Districts]. The California State Board of Forestry and Fire Protection (Board) is hearing a regulation to amend existing Forest Practice Rules pertaining to the protection of Northern Spotted Owls (NSO). The proposed amendments are in response to a petition for rulemaking brought before the Board by the Environmental Protection Information Center (EPIC) pursuant to Government Code Section 11340.6. In its petition for rulemaking, EPIC advocates for the deletion in its entirety of 14 CCR Section 919.9 [939.9] subsection (g). EPIC contends that this provision of the Forest Practice Rules has resulted in "take" of a federally listed species and must be removed from regulation to ensure the continued existence of NSO. **Possible Action Item:** The Board may adopt, modify, or reject the proposed regulation.

CONCLUSION

14. Public Forum.

    Members of the public may address the Board **on any topic within its jurisdiction not otherwise on the agenda**. Submittal of written comments is encouraged to ensure that all comments will be included in the record before the Board. Please be prepared to summarize comments to three minutes in length, or otherwise at the discretion of the chairman. **Submit your request to address the Board under this item via supplied speaker cards prior to the item being called**.

15. New and Unfinished business. Adjournment.

FOREST PRACTICE COMMITTEE
July 9, 2013
Time: 9:00 a.m. – noon

Location: **Resources Auditorium**
1416 Ninth Street
Sacramento, California

At the discretion of the committee, meeting may be continued in the afternoon.

1. Review and consideration of options to address Northern Spotted Owl protection regulations.
2. Review and consideration of draft Class II-L Forest Practice Rule amendments.
3. Discussion of Items for Next Month's Agenda, Review of 2013 Priorities.
4. New and Unfinished Business.

Note: The Forest Practice Committee may continue discussion of items included in its agenda, or the full Board agenda, if the Board recesses or adjourns.

RESOURCE PROTECTION COMMITTEE
July 9, 2013
Time: 9:00 a.m. – noon

Location: **Resources Building Room 1506-12**
1416 Ninth Street
Sacramento. California

1. Utility Vegetation Management Update. Consideration of possible regulatory changes.
2. Vegetation Treatment Program EIR Update. George Gentry and Doug Wickizer.
3. Update on Wildland Prevention Engineering. Mike Wilson, Assistant Chief, Wildland Fire Prevention.
4. Review of Fire Safe Regulation Update. George Gentry and Jana Luis.
5. Safety Element Process Update. George Gentry and Edith Hannigan.
6. Discussion of Items for Next Month's Agenda, Review of 2013 Priorities.
7. New and unfinished business.

Note: The Resource Protection Committee may continue discussion of items included in its agenda, or the full Board agenda, if the Board recesses or adjourns.

MANAGEMENT COMMITTEE
July 9, 2013
Time: 1:00 p.m. – 3:00 p.m.

Location: **Resources Building Room 1506-12**
1416 Ninth Street
Sacramento. California

1. Discussion of Management Plan Review for LaTour Demonstration State Forest.
2. Update on the Management Plan for Soquel
3. Review of the Effectiveness Monitoring Committee Charter
4. Update on Stewardship Lands for Acquisition by the Department
5. Discussion of Items for Next Month's Agenda, Review of 2013 Priorities.
6. New and Unfinished Business

Note: The Management Committee may continue discussion of items included in its agenda, or the full Board agenda, if the Board recesses or adjourns.

IMPORTANT BOARD MEETING INFORMATION

PERSONS WITH DISABILITIES

Pursuant to the Americans with Disabilities Act, individuals who, because of a disability, need special assistance to attend or participate in a State Board of Forestry and Fire Protection Meeting, may request assistance at the Board Office, 1416 Ninth Street, Room 1506-14, Sacramento, California or by calling (916) 653-8007. Requests should be made one week in advance whenever possible. These facilities are accessible to persons with disabilities.

SUBMISSION OF WRITTEN MATERIALS

The public is encouraged to comment on any item on the agenda. You may submit your comments by one of the following methods (only one is necessary): **E-mail to board.public.comments@fire.ca.gov, Fax to (916) 653-0989, or U.S. mail to Board of Forestry and Fire Protection, PO Box 944246, Sacramento, CA 94244-2460.**

SPEAKING AT THE MEETING

If you wish to speak on an agenda item, please fill out a "Speaker Card" and give it to Board staff **BEFORE** the agenda item is heard. Cards will be available near the entrance of the meeting room.

- Individuals with a shared position are encouraged to select a spokesperson for their group.
- Individuals who sign up by the deadline will have a maximum of three minutes to speak. The three minute speaking time may be changed by the Chair, depending on the number of speakers. A speaker may not cede time to another speaker. The total amount of time to be allotted to a comment period is based upon the number of those wishing to comment, and will be announced by the Chair prior to the beginning of the comment period.
- The order of speakers will generally be based on random selection, but public officials may be taken out of order.
- The Chairman retains the right to stop any speaker who raises an issue that is not under the Board's jurisdiction.
- Beverages, food, and sticks or any other type of handle are strictly prohibited. Larger signs, or signs with handles, may be left in the area between the auditorium entrance and the security screening, for retrieval after the meeting.
- Speakers may bring written copies of their own comments to a Board meeting for distribution to the Members of the Board. Copies of the written comments shall be given to the Clerk of the Board who will ensure the appropriate distribution of the comments. Please provide eleven (11) copies
- The Board retains the right to remove disruptive attendees from the Board meeting.
- The Board reserves the right to override the above rules in case of emergency or other unforeseen circumstances.

WHEN WILL MY AGENDA ITEM BE HEARD?

The Board begins each session at the time listed on the Meeting Notice and generally considers each agenda item in the sequence listed, however, The Board may take any non-hearing agenda item out of order as time permits. The Board may also act on recommendations by its committees on items listed in their respective agendas, including recommendations for notice of rulemaking.

VISUAL PRESENTATIONS/MATERIALS

PowerPoint presentations must be provided on a USB flash drive, flash memory card, DVD or CD. **All presentations are considered part of the public record**. All electronic formats must be Windows PC compatible. It is recommended that a hard copy of any electronic presentation be submitted in case of technical difficulties.

P.O. Box 944246
SACRAMENTO, CA 94244-2460
(916) 653-8007
(916) 653-0989 FAX
Website: www.bof.fire.ca.gov

BOARD OF FORESTRY AND FIRE PROTECTION

Sacramento, CA
July 10, 2013

BOARD OF FORESTRY MEMBERS PRESENT:

J. Keith Gilless, Chairman
Stan Dixon
Bruce Saito
Mark Andre
Susan Britting
Mike Miles
Richard Wade
Stuart Farber
Mary Rickert

BOARD OF FORESTRY MEMBERS ABSENT:

BOARD STAFF:

George Gentry, Executive Officer
Matthew Dias, Executive Officer, Forester's Licensing
Eric Huff, Regulations Coordinator
Linda Cano, Executive Assistant

DEPARTMENTAL STAFF:

Janet Barentson, Chief Deputy Director
Bill Snyder, Deputy Director, Resource Management
Duane Shintaku, Asst. Deputy Director, Forest Practice
Russ Henly, Asst. Deputy Director, Resource Protection
Dennis Mathisen, Communication Officer

Call to Order

Chairman Gilless called the July 10, 2013 meeting of the Board of Forestry and Fire Protection to order.

Approval of Minutes

07-13-01 Member Britting moved to approve June Minutes. Member Saito seconded the motion. The Motion passed unanimously

MONTHLY BOARD REPORTS

Report of the Chairman
The Chairman remarked on and honored the sacrifice of the 14 firefighters who lost their lives in the line of duty in Arizona.

Board discussion and Nomination for Vice Chair of the Board

07-13-02 Member Dixon nominated Member Andre for Vice Chair. Member Saito seconded the motion

Chairman Gilless called for a Roll Call vote.

Britting	**Aye**
Andre	**Abstained**
Wade	**Aye**
Saito	**Aye**
Dixon	**Aye**
Rickert	**Aye**
Farber	**Aye**
Miles	**Aye**
Gilless	**Aye**

The Motion passed with one abstention

Report of the Director/Department -Janet Barentson (Full Report available on the Board's website)

- The department is not only dealing with the deaths of the Prescott firefighters but also one of Cal Fire's own, Fire Apparatus Engineer Christopher Douglas, Riverside Unit who was killed in the line of duty July 5, 2013. Director Pimlott was traveling to meet with the firefighters, at the time of the Board meeting. Christopher was well liked at the unit; he left behind a wife, a child and one on the way. One of the Prescott firefighters Christopher Mackenzie was the son of a retired Cal Fire employee, the department is offering support to his family as well. The Director will be attending Christopher Mackenzie's funeral. Five of the Prescott firefighters had ties to California.
- Fire activity: dry conditions continue. Normally there are 200 to 300 fires per week that are caught before they become large fires. There were over 400 fires the previous week, it is indicative of the dry conditions that are very prone to fire. The state is busy with fire activity, the department is encouraging safety given the tragedy in Arizona.
- There has been an increase in the number of fires to date. The normal average is approximately 2,000 fires; there have been 3,400 fires to date. Fuel conditions are that of late August or September conditions. The department is predicting that fire activity will continue to be busy until the rain season. There were two major incidents Cal Fire was working on the Chariot Fire in San Diego County it was approximately 7,000 acres and 40% contained. 120 cabins and out buildings were destroyed. The numbers listed were at the time of the Board meeting. The

Kyburz Fire on US Forest land was the second, with approximately 600 acres burned at 40% contained. The Department made resources available to the US Forest Service.

- There were a number of arson arrests made. There were two notable arrests one in Riverside County of a repeat offender and one in Madera Mariposa Unit who was starting fires on the route into Yosemite.
- The Director along with Executive Officer Gentry and Russ Henly will attend the VTPEIR meeting with the Chaparral Institute, Endangered Habitats League and Conservation Biology Institute to provide for additional public outreach and public comment. It is hoped that it will provide a better understanding of the concerns of these groups and an opportunity to share the thoughts of the department with them.
- The department asked the Board of Equalization to begin billing for SRA fees on July 15, 2013 for the 2013 fiscal year. The stats for fiscal year 11/12, the department collected over 77 million dollars, received 90,000 petitions out of 750,000 bills that were sent, there were no statutory bases to approve 70% of those petitions. Only 2% were approved based on the data used. The department is confident in the data that determine SRA. They've made corrections to the data from last year, regarding double billing.
- The initial hearing on the Jarvis class action suit which will determine whether it should be dismissed is scheduled for July 19, 2013, in Sacramento. The Director will keep the board updated with the results.
- The Redding Pilot project is progressing through the review process. Janet Barentson hopes to have it out to the Secretaries of Natural Resources and Cal EPA to review and approve and submit to the public.
- A number of key management positions will be retiring, the department is actively working on succession planning. They are planning for exams to fill positions they will also be filling positions in the department as employees retire. Announcements will be made throughout the year of hires to key management positions.
- The Director is looking forward to the August Board meeting in Ventura.

Report of the Regulations Coordinator-Eric Huff

§1299 AB 1595 Defensible Space	**Adopted rule language correction to filed with OAL on or before 7/9/13**
§1299 "Wood Piles" Amendment, 2013	**45-day Notice pending**
Road Rules, 2012	**Remanded to Forest Practice Committee**
AB 1492-Lumber Products Assessment Emergency	**Final Readoption Approved**
AB 1492-Lumber Products Assessment Permanent Regulation	**45-day Notice pending**
NSO Protection Measures, 2013	**Initial hearing July 10, 2013**
MTHP Amendments, 2013	**45-day Notice of Rulemaking Posted.**
Section 100-§1059 Administrative Penalty Procedures	**Section 100 filed per Cal Fire request**
§895.1 Commercial Species Amendments, 2013	**45-day Notice pending**
CRM Program Guidelines, 2013	**Section 100 Pending**

Forest Practice, Mark Andre, Chair

Reviewed and consideration of draft Class II-L Forest Practice Rule amendments.

07-13-03 **Member Saito moved to put out for 45-day Notice the Class II-L Forest Practice Rule, 2013 amendments.**

Chairman Gilless called for a Roll Call vote.

Britting	**Aye**
Andre	**Aye**
Wade	**Aye**
Saito	**Aye**
Dixon	**Aye**
Rickert	**Aye**
Farber	**Aye**
Miles	**Aye**
Gilless	**Aye**

The Motion passed unanimously

Resource Protection, Bruce Saito

- Update given by George Gentry and Doug Wickizer on the Vegetation Treatment Program EIR.
- Update given by Mike Wilson on Wildland Prevention Engineering
- Reviewed Fire Safe Regulation Update. George Gentry and Jana Luis
- Update given by George Gentry and Edith Hannigan on Safety Element Process

Public Comment

Management, Stan Dixon

Discussion of Management Plan for LaTour Demonstration State Forest.

07-13-04 **Member Farber moved to certify the Negative Declaration and approve Management Plan. Member Dixon seconded the motion.**

Chairman Gilless called for a Roll Call vote.

Britting	**Aye**
Andre	**Aye**
Wade	**Aye**
Saito	**Aye**
Dixon	**Aye**
Rickert	**Aye**
Farber	**Aye**
Miles	**Aye**
Gilless	**Aye**

The Motion passed unanimously.

Report of Board's Advisory Committees

- **Forest Pest Council-**

- **California Oak Mortality Task Force (COMTF) –Katie Palmieri**

Sudden oak death (SOD) continues to be the primary cause of tree mortality in coastal California from Monterey County north to Humboldt County, according to USDA Forest Service Pacific Southwest Region aerial surveys underway this summer. Tanoak mortality is severe in the Santa Cruz Mountains as well as along the coast in Sonoma, Marin and Monterey Counties, with the worst impacted areas in Jenner/Guerneville (Sonoma County) and Big Sur and Mill Creek (Monterey County).

New *Phytophthora ramorum* confirmations near Six Rivers National Forest (SRNF) and the Trinity County line – Tanoak and California bay laurel trees were confirmed to be infected with *P. ramorum* as close as 1.1 miles from the SRNF boundary and 1.7 miles from the Trinity County line. Preliminary 2013 US Forest Service aerial surveys of the area have identified more patches of tanoak mortality consistent with SOD that are located about 1.5-2 miles from where ground sampling was done, and as close as 0.4 miles from the SRNF boundary.

First *P. ramorum* culture-positive water sample confirmed from Jackson Demonstration State Forest (JDSF) – Intensive sampling in the South Fork of the Noyo River (SFNR) watershed during this year's *P. ramorum* stream monitoring season led to the confirmation of *P. ramorum* presence in the JDSF (in April 2013). Specifically, pathogen presence in the JDSF was confirmed in the North Fork of the SFNR and Peterson Gulch drainages. However, Parlin Creek, which tested PCR positive in 2012, remained negative for the pathogen via culturing techniques during the 2013 monitoring season.

Report of Board's Advisory Committees

Monitoring Study Group- George Gentry (Full report can be found on the BOF website)

Professional Forester Examinng Committee- Matt Dias

The Office of Professional Foresters Registration notes the RECENT PASSING of George Grogan – RPF 237

The following individuals indicated a desire to <u>VOLUNTARILY RELINQUISH</u> his/her license to practice:

Scott McDonald – CRM 43
Larry Burd – RPF 2293

The following Registered Professional Foresters requested license WITHDRAWAL pursuant to 14 CCR §1608(a):

Timothy Bell – RPF 1725
Donald Berry – RPF 1889
Bard Beutler – RPF 1381
Barton Bloom – RPF 1005
Ole Buch – RPF 2731
Jerry Burke – RPF 761
David Burns – RPF 3
Mitchell Cari – RPF 1747
Christopher Click – RPF 2265
William Dean – RPF 150
Craig Ditman – RPF 1749
Bruce Emmens – RPF 2197
Michael Garcia – RPF 1859
David Goodman – RPF 575
John Gorman – RPF 265
Robert Graton – RPF 709
John Henshaw- RPF 2075
Harold Johnson- RPF 1063
Walter Levings – RPF 2367
Richard Lund – RPF 171
Dearl Mccullough – RPF 735
Jack Monschke – RPF 2405
James Mower – RPF 1757
Thomas Nelson – RPF 2201
Ronald Recker – RPF 2551
Daniel Scatena – RPF 1909
Jenny Whitaker – RPF 2786

07-13-05 **Member Miles moved to accept RPF withdrawals. Member Saito seconded the motion.**

Chairman Gilless called for a Roll Call vote

Britting	**Aye**
Andre	**Aye**
Wade	**Aye**
Saito	**Aye**
Dixon	**Aye**
Rickert	**Aye**
Farber	**Aye**
Miles	**Aye**
Gilless	**Aye**

The Motion passed unanimously.

The following individuals were presented to the Board for Registration as Successful Applicants:

Mr. Matthew Gilbert	RPF No. 2972
Mr. Aaron Smith	RPF No. 2973
Ms. Elizabeth Forwand	RPF No. 2974
Mr. Russell Dorvall	RPF No. 2975
Mr. Shane Larson	RPF No. 2976
Ms. Erica Smith	RPF No. 2977
Mr. Patrick Schafer	RPF No. 2978
Ms. Sara Jones	RPF No. 2979
Mr. Amitabha Bolton	RPF No. 2980
Mr. Drew Coe	RPF No. 2981
Mr. Matthew Lutes	RPF No. 2982
Mr. Clayton Kooperman	CRM No. M100

07-13-06 **Member Andre moved to approve registration of RPF applicants. Member Rickert seconded the motion**

Chairman Gilless called for a Roll Call vote.

Britting	**Aye**
Andre	**Aye**
Wade	**Aye**
Saito	**Aye**
Dixon	**Aye**
Rickert	**Aye**
Farber	**Aye**
Miles	**Aye**
Gilless	**Aye**

The Motion passed unanimously.

There are currently 1217 valid RPF's and 76 valid CRM's

Discussion and Review of the Lumber Assessment Regulations. Possible Action Item: The Board may make recommendations for a 45 day notice for rulemaking

George Gentry gave overview.

07-13-07 **Member Britting moved to put out for 45 day notice for rulemaking the Lumber Assessment Regulations. Member Saito seconded the motion.**

Chairman Gilless called for a Roll Call vote.

Britting	**Aye**
Andre	**Aye**
Wade	**Aye**
Saito	**Aye**
Dixon	**Aye**
Rickert	**Aye**
Farber	**Aye**
Miles	**Aye**
Gilless	**Aye**

The Motion passed unanimously.

SPECIAL BOARD HEARINGS/REPORTS

HEARING: Amend Title 14 § 919.9, § 939.9 – Northern Spotted Owl [Coast, Northern Forest Districts] and § 919.9(g), § 939.9(g) – Northern Spotted Owl [Coast, Northern Forest Districts. The proposed amendments are in response to a petition for rulemaking brought before the Board by the Environmental Protection Information Center (EPIC) pursuant to Government Code Section 11340.6.

Rob DiPerna gave a PowerPoint presentation.

Public Comment
Eric Carlson

Margo Parks, believes that option G provides flexibility to landowners, especially small landowners and provides certainties that there are flexibilities designed into option G which allow for project by project increase in protection measures. Option G gives landowners the ability to protect habitat while conducting timber harvests. They encourage the Board to reject the proposed rule and maintain the flexibilities that are currently available.

Noelle Cremers, shared the concerns of the groups on the impact of removing Option G. The rule provides regulatory certainty, having the standards in the regulation and Forest Practice Rules are helpful. She wanted to follow up on a point that Duane Shintaku made regarding the one year survey protocol on NTMP's, that it is a very important issue to their members, and suggests it would be a very important discussion for the Board. They urge the Board to keep Option G.

Luke Breit, Forests Forever, also representing Defenders of Wildlife, they strongly support the deletion of Option G, They ask that it be done quickly.

Katherine Gerwig, gave a brief history of her work experience with timber companies. She shared; to stop the protection that's given in Option G is a crime. We need to protect that little bird. Look at the original protection of the owl and let's not cut out anymore.

Jason Poborko, Forester, Sierra Pacific Industries spoke briefly on that it is important that Option G remain in the rules so they can continue to survey those grounds and have definitions to work from to develop a CEQA baseline argument to demonstrate how they will take the birds on an individual bases. The usage of the minimums of Option G are essentially antiquated in the sense of the U.S Fish and Wildlife Service concerns as expressed in their scientific document about the use of the minimums of Option G, not the use of G but the use of the minimums as a safeguard threshold. Removing Option G, in his opinion, removes options for landowners and options for small landowners.

Kevin Roberts, Senior Wildlife Biologist, Sierra Pacific Industries, gave an update on the NSO monitoring that was done regarding Option G and if it impacted NSO.

Ed Murphy, in 23 years they've never had Take enforced or otherwise, by the responsible agency. He believes the Board should reject the proposed rule change and before the Board goes into any further action, have the subcommittee hold a hearing where scientific evidence is brought to the Board to demonstrate a problem before fixing a rule system that has worked for 23 years.
Ed Struffenegger, referenced and made a few points on a letter that was submitted to the Board. Supports keeping Option G.

Kevin Conway, California Licensed Foresters Association, send it to committee and fully explore the existence of what the problem is, identify the extent of the problem and develop some clear linkage between the perceived problem and the Forest Practice Rule. Apply the rule and set a site specific criteria implementing it. He urged the Board to send it back to committee to explore the issue, he would like to see the Board solicit the best available science, from a diverse group of stakeholders and responsible investigating agencies.

Richard Gienger, the USFWS said they could no longer afford to do consultations in 2008 and it would take $250,000 per year to do consultations. Instead of paying the USFWS to use a system that had general acceptance by all parties, California choose instead to review the plans themselves.

Vern Goehring, California Native Plant Society, there to support the proposed regulatory action.

Pete Ribar, Hawthorne Timber Company, take a look at the population information look on the regulatory structure to protect NSO is extremely successful. Option G provides a way to do site specific protection the others do not the same level as Option G. It's important that RPF's and plan submitters that there is a range of options, Option G is an option. He strongly suggested that the regulation be rejected and Option G be retained, it's important to have the flexibility.

Karen Wilson, SFTURE, she has enjoyed the beautiful California forests and any reduction in clear cuts would be a benefit. She supports EPIC's proposal.

Paul Violett, Chief Forester, Soper Wheeler Co., urged the Board to reject the proposal to eliminate Option G. Option G is a valuable tool for smaller landowners in that it allows for an expert to custom design NSO survey and protection standards according to existing knowledge and conditions. Option G is the only alternative by which a small private landowner can exercise their right under CEQA to have a significance of the project analyzed in accordance with the best available information with on the ground conditions.

Gary Rynearson urged the Board to retain Option G.

07-13-08 Member Britting moved to adopt the noticed rule language with minor revisions. Member Saito seconded the motion.

Duane Shintaku, Assistant Deputy Director, Forest Practice commented

Chairman Gilless called for a Roll Call vote.

Saito	**Aye**
Britting	**Aye**
Andre	**No**
Wade	**No**
Dixon	**No**
Miles	**No**
Farber	**No**
Rickert	**No**
Gilless	**No**

The motion failed 7-2.

07-13-09 **Member Britting moved to add item 6 to section G: "the RPF and the Director shall consider current guidance provided by trustee wildlife agency(s) pertaining to appropriate take avoidance" and to notice for a 15 or 45 day notice depending on determination by Office of Administrative Law on the appropriateness of a 15 day notice. Member Saito seconded the motion.**

Continued Public Comment

Ed Murphy suggested that it be taken under advisement, to review it at the committee level and come up with a 45 day notice. He asked what the hurry was, and stated the wording should be right.

Rob DiPerna, shared his concerns that it needs to be resolved soon to avoid years of being in committee without results.

Ed Struffenegger, thanked Board members for not eliminating option G. He suggested that the issues need to be vetted and researched by appropriate agencies, and a workshop given. He shared his concern that if this issue were brought before the Board at the August Board meeting in Ventura, interested parties may not be able to attend.

Karen Wilson mentioned that she wanted to reiterate what Mr. DiPerna stated and would like to see the rule be approved as is.

Jason Poburko urged the Board to travel slowly and cautiously.

Richard Gienger stated that the Board should support funding to pay for the federal personnel who would review the plans.

Gary Rynearson suggested that the Board may want to consider is hold the hearing open and move it to the next meeting and put out a 15 day notice at that time. It would give the Board time to consider the language and vet it outside of the hearing process and bring it back in the continuation of the hearing. Another thing the Board may want to include is that the Board is a responsible agency not just a trustee. Whatever decision and action is taken that language is not created that appears to require landowners to consult with the Fish and Wildlife Service.

Pete Ribar endorsed Gary Rynearson's idea of keeping the hearing open. That would give the Board's legal counsel time to make sure that the 15 day notice is the appropriate way. He urged the Board to keep the wording close to what it is now, so that there are no additional requirements.

07-13-10 **Member Andre moved to close public comment. Member Dixon seconded the motion. Motion takes precedence over pending motion (07-13-09). The motion passed unanimously.**

07-13-11 **Member Andre moved to continue the hearing to the August Board meeting. Member Dixon seconded the motion. Motion takes precedence over pending motion (07-13-09).**

Chairman Gilless called for a Roll Call vote.

Saito	**No**
Britting	**No**
Andre	**Aye**
Wade	**No**
Dixon	**Aye**
Miles	**No**
Farber	**Aye**
Rickert	**Aye**
Gilless	**No**

The motion failed 5-4.

RETURN TO PENDING MOTION

07-13-09 **Member Britting moved to add item 6 to section G: "the RPF and the Director shall consider current guidance provided by trustee wildlife agency(s) pertaining to appropriate take avoidance" and to notice for a 15 or 45 day notice depending on determination by Office of Administrative Law on the appropriateness of a 15 day notice. Member Saito seconded the motion. Member Saito seconded the motion.**

Chairman Gilless called for a Roll Call vote.

Saito	**Aye**
Britting	**Aye**
Andre	**No**
Wade	**No**
Dixon	**No**
Miles	**No**
Farber	**No**
Rickert	**No**
Gilless	**No**

The motion failed 7-2

CONCLUSION
Public Forum

Richard Gienger, 16th Annual Coho Confab, August 9-11, 2013, Mattole River, Petrolia, CA

New and Unfinished business

None

Adjourn

Respectfully submitted,

ATTEST:

George D. Gentry
Executive Officer

Keith Gilless
Chairman

Copies of the attendance sheets can be obtained from the Board Office.

(4)

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Director's Office
1416 Ninth Street, 12th Floor
Sacramento, CA 95814
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

January 16, 2014

Ken Pimlott
Director
Department of Forestry and Fire Protection
1416 Ninth Street
PO Box 944246
Sacramento, CA 94244-2460

Dear Mr. Pimlott:

CANDIDACY OF THE NORTHERN SPOTTED OWL FOR LISTING UNDER THE CALIFORNIA ENDANGERED SPECIES ACT

During its December 11, 2013 meeting, the California Fish and Game Commission (Commission) adopted findings documenting its acceptance of a petition to list the Northern spotted owl (NSO) as a threatened or endangered species pursuant to Section 2074.2 of the Fish and Game Code. The Office of Administrative Law published these findings on December 27, 2013; therefore, a one-year "candidacy" period has begun. During this period, "take" as defined by Fish and Game Code Section 86 shall be prohibited unless authorized by the Department of Fish and Wildlife (Department) pursuant to sections 2080.1, 2091(a), or 2081(b) of the California Endangered Species Act (CESA) or Section 2835 of the Natural Community Conservation Planning Act, in conjunction with otherwise lawful activities.

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

As such, the Department, in discharging its roles and responsibilities as the public trust agency for fish and wildlife in California will, during the NSO's one-year candidacy period, rely on the process established under sections 919.10 and 939.10 to assure that timber operations conducted pursuant to approved THPs will avoid unauthorized take of NSOs. The Department's reliance on the continuing implementation by CalFire of these FPR sections will obviate the need for the Department to establish a separate NSO consultation or "approval" process for each THP pursuant to CESA.

In addition, the Department will continue its ongoing discussions with three private timberland owners for timber operations conducted pursuant to the requirements of NSO habitat conservation plans and NSO incidental take permits (ITP) issued by the U.S. Fish and Wildlife Service under Section 10(a)(1)(B) of ESA. These discussions are expected to culminate in the Department issuing NSO ITPs or consistency determinations pursuant to sections 2080.1 and 2081(b), respectively. Until the Department issues NSO take authorizations to these private timberland owners, they must avoid take under CESA notwithstanding their NSO ITPs issued pursuant to ESA. Of course, aside from these private timberland owners, any other entity may consult with the Department to seek take authorization for NSO under CESA if warranted.

Should you have questions and/or would like to discuss this matter, please feel free to contact me. Our Environmental Program Manager William Condon with the Department's Timberland Conservation Program in the Habitat Conservation Planning Branch, is also available to discuss the approach outlined in this letter or answer questions of staff and can be reached at (916) 651-3110 or by email at William.condon@wildlife.ca.gov.

Sincerely,

Charlton H. Bonham
Director

cc: J. Keith Gilless, Ph.D., Chair
California Board of Forestry and Fire Protection
P.O. Box 944246
Sacramento, CA 94244-2460

ec: California Department of Fish and Wildlife

Kevin Hunting, Chief Deputy Director
Kevin.hunting@wildlife.ca.gov

Sandra Morey, Deputy Director
Ecosystem Conservation Division
Sandra.Morey@wildlife.ca.gov

Daniel Yparraguirre, Deputy Director
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Thomas Gibson, General Counsel
Office of the General Counsel
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CLIMATE, HABITAT QUALITY, AND FITNESS IN NORTHERN SPOTTED OWL POPULATIONS IN NORTHWESTERN CALIFORNIA

ALAN B. FRANKLIN,[1,2,3] DAVID R. ANDERSON,[1] R. J. GUTIÉRREZ,[2] AND KENNETH P. BURNHAM[2]

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

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

INTRODUCTION

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

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

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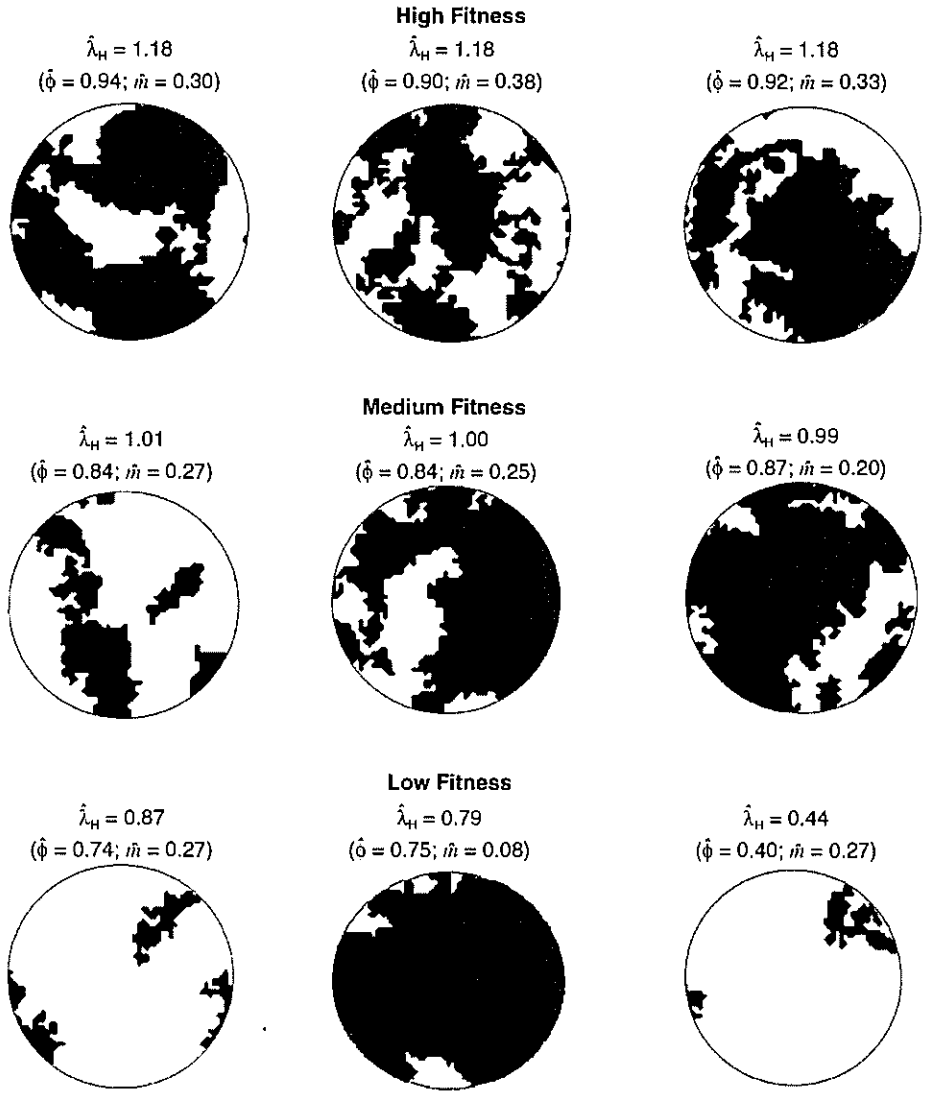

FIG. 10. Landscape habitat characteristics (within 0.71 km radius circles used to define Northern Spotted Owl territories) at three levels of habitat fitness potential in northwestern California. Dark areas are Northern Spotted Owl habitat; white areas are other vegetation types. Estimates of ϕ (apparent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

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

Relative contributions of climatic and habitat variation to population processes

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

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March 30, 2016

Via email: fgc@fgc.ca.gov

Fish and Game Commission
Eric Sklar, President
Jacque Hostler-Carmesin, Vice President
Anthony C. Williams, Member

Re: Commission Agenda Item 25 - Consider the petition, Department's evaluation report, and comments received to determine whether listing the northern spotted owl (*Strix occidentalis caurina*) as a threatened or endangered species is warranted

Dear Commissioners:

Sierra Pacific Industries (SPI) owns approximately 438,500 acres of forest land within the occupied range of the Northern Spotted Owl (NSO, *Strix occidentalis caurina*). As such, our biology and forestry staff members have been conducting surveys, managing, and protecting this species since 1989. During the course of growing, harvesting, and replanting trees as part of our business, SPI obtains state permits to cut trees. These permits are termed Timber Harvest Plans (THP), and they are carefully planned and then rigorously reviewed by California regulators before the permits are approved. A THP may not be approved if it is likely to cause take of a NSO, and SPI has gone to great lengths to ensure its employees and contractors are trained to avoid harm to these listed birds as they conduct operations authorized by a THP.

The proponents precipitating this status review and the Department's evaluation falsely represent that timber harvesting negatively impacts NSO persisting on the landscape. We believe that the record indicates that timber harvesting in NSO habitat under the California Forest Practice Rules (CFPRs) has and does promote habitat in quantities that sustain a persistent and stable NSO population.

The Commission needs to consider that during the Department's evaluation they received some of the longest running data sets with the most detailed information ever collected on a species in California. (CFA Northern Spotted Owl Science Compendium, covering 2.4 million acres) The data however was summarily dismissed by the Department, saying it wasn't peer reviewed. This data is certainly sufficient to meet the legal requirements of the ESA and CEQA. The Department's dismissal of these data as not valuable to understanding the existing condition of the NSO in California misrepresents the actual condition of a very large NSO population persisting and reproducing on and in proximity to managed industrial timberland. Owners with long running data sets of actual observed NSO and recorded surveys demonstrate that these populations are stable or increasing. It would be logical to extend this outcome to most of the other less intensively managed lands in California.

Given these facts, how can the Department conclude that somehow this species is threatened by timber harvesting and have declined by 39-49%? The range-wide scale of industrial timberland

owner NSO data cannot be overridden by the results of the two smaller scale demographic studies. It is inappropriate to use the Green Diamond Demography study since it is conducted to monitor an authorized take process in a federally approved Habitat Conservation Plan. Considering that one conclusion (i.e. that NSOs are stable and persisting) comes from actual surveyed and recorded owls over very large areas and the other comes from small studies that are "peer reviewed," the Department should have integrated the larger measured results since, taken independently, both results can't be true. As stated in the Director's transmittal memo (Feb 10, 2016), the Department's final written report is based upon the "best scientific information available". Is an actual physical inventory of NSOs not better scientific information than a small modeled area? The Department has a responsibility to analyze and reconcile these conflicting data before it can conclude that timber harvesting is a threat to NSO.

One difficulty with making inferences about changes in the NSO population by interpreting NSO occupancy from survey data is caused by how NSO Activity Center data is compiled. An Activity Center is a point location that is assigned when NSO have demonstrated a consistent pattern of use or presence at a particular location. NSO's have been shown to use more than one Activity Center over the course of several years, generally within the same drainage area. Because NSO move around from year to year, and since the NSO database rarely removes Activity Centers, the number of NSO Activity Centers generally increases over time. On any given year however the actual occupancy of NSO at a particular Activity Center is unknown until survey data confirms the site's occupancy status. The challenge for interpreting the condition of the NSO population over time is linking the number of Activity Centers to actual birds and then tracking the occupancy of Activity Centers by those birds over time. Without banding data and repeated fixed area surveys the use of Activity Centers as a population count will generally over-estimate the number of NSO on the landscape and under estimate the actual percent occupied due to inflated AC counts.

SPI has resolved this problem for its "Weaverville NSO Study Area" (WSA). Over the last 4 years SPI has banded most of its resident NSO. Using this banding data and continuous NSO survey data for the last 14 years covering a fixed area, SPI was able to refine and characterize the NSO population occurring within the WSA. The results of the WSA through 2015 are provided in the attached report (*Northern spotted owls near Weaverville and Trinity Lake in Trinity County within the Landscape Survey Strategy Area (An interim report)*). This report provides a good example of how relying only on Activity Centers without comprehensive survey data can show an apparent decline in percent occupancy, while the NSO population (the number of owls on a fixed area recounted annually) is actually stable.

The *Northern spotted owls near Weaverville and Trinity Lake in Trinity County within the Landscape Survey Strategy Area (An interim report)* demonstrates how counting all Activity Centers without regard to the NSO's behavioral trait of using alternate sites from year to year can lead to misinterpreting the trend in NSO occupancy and thus the condition of the population.

Study area results show SPI has a higher density of NSO occupied activity centers per acre of land than existed at the time the species was listed in 1990. Twenty-five years ago, protocol surveys located 52 occupied owl sites. In 2015, there were 57 occupied owl sites. SPI has harvested sustainably every year within this study area for that 25-year period. The results of this study demonstrate that there is no justification for the status review of NSO to suggest that timber

harvesting conducted in compliance with the California Forest Practice Rules is a threat to the persistence of NSO, since using our management practices we have more NSO today than 25 years ago. We are currently beginning our 27th season of surveys to locate and protect NSO in and adjacent to SPI forests.

In order to contextualize the NSO population in the WSA, consider the following worst-case scenario. If one takes the 1990 starting number of 52 occupied sites and then applies the 3.8% annual decline calculated by NSO researchers (Dugger et al., 2016), SPI should only have 18.1 occupied sites. Instead SPI has 57 occupied sites, which is remarkable considering the apparent influence of barred owls (*Strix varia*) on NSO occupancy over the past 25 years. Although only one night time vocal response within ½ mile of an established activity center is considered by protocol as an occupied Activity Center , such a response triggers maximum potential protection from timber harvest impacts. To be clear within the WSA a visual confirmation of bird presence has occurred at 51 of the 57 activity centers (89.4%). We are very confident about the certainty of our results and the existence and stability of this population. Also during just these last 5 years these 30 of these NSO AC's have produced 97 fledglings.

The most important and immediate solution for the NSO is for the Commission to address the barred owl immigration issue via their removal, on a much larger scale.

Listing proponents and regulators don't seem to account for the fact that forests grow and mature over time. In the last 25 years, although some forest stands have been harvested and replanted, the remainder of the forest has actually grown. The rate of harvest and growth is regulated by the Board of Forestry and Cal Fire and been determined to be sustainable over time. These growing trees are also subject to natural events which cause some of them to have broken tops, diseases creating cavities, insect attacks, fallen branches, and other events which create nesting and perching elements for avian species. These natural events that continually cause deformities necessary for nesting sites are also enhanced by management policies that intentionally retain high quality nesting elements from stands to be regenerated. SPI intentionally retains these nesting elements to reduce the uncertainty as to whether these features will be present in future managed forests. Therefore, SPI does not believe there will be a decline in nesting elements and habitats that contain them within its future managed stands.

The second essential item needed by NSO is an adequate prey base. SPI argues that as central point foragers, NSO establish their nests at specific locations in habitats which contain several elements: trees with nest structures, stands with shade components for thermal regulation, a water source, and a food supply. When the food supply declines near the owls' currently used central point, owls seek out another point with the necessary requisites and establish a new nest there.

SPI also believes the passive management of the vast majority of NSO habitat which is under the jurisdiction of the federal government is potentially detrimental to NSO persistence on federal landscapes – not the NSO protection measures and harvesting methods of companies who operate under the California Forest Practice Act and Rules (CFPRs). SPI believes the risk to NSO where passive management predominates is a lack of foraging opportunities.

SPI asks the Commission to direct the Department to take a fresh look at the prey producing habitat aspect of Dr. Alan Franklin's (Franklin et al. 2000) seminal study on NSO. In this monograph, Franklin et al. (2000) demonstrated that NSO demographic parameters were positively associated when the amount of habitat edge between prey producing habitat and nesting habitat increased. However, when canopy cover became too dense or extremely open, owl habitat fitness declined. There is a balance point between dense and open canopy which correlates to forested habitat edge and overall habitat fitness.

In order to help the Commission understand this interaction between dense nesting stands and more open prey producing stands we have attached National Agricultural Imagery Program (NAIP 2014) imagery of the 30 NSO Activity Centers within the WSA that have reproduced and produced a minimum known count of 97 fledglings (2011-2015). These images show the mosaic of habitats found within the 1.3-mile radius circle surrounding each reproductive NSO nest. For those Activity Centers note the diversity of tree sizes, edge habitat and open areas within each home range. Also notice the amount of overlap in the 1.3-mile circles which indicates the important use area (core area) for each owl is likely significantly less than the 1.3 miles of protection provided by the CFPRs and USFWS guidance.

This prey concept is hypothesized by recent work by SNAMP (2015) owl researchers. SNAMP is university-based research on Sierra Nevada ecosystems, and one component is the team dealing with California spotted owls (*Strix occidentalis occidentalis*), the nearest subspecies to the NSO. SNAMP researchers note,

> "Contrary to our prediction, the probability of a [California spotted owl] territory going extinct was reduced in proportion to the area harvested with high-intensity practices such as clearcutting and shelterwood harvest. In principle, harvesting prescriptions creating small gaps might promote brushy habitat suitable for prey species such as woodrats and increase prey availability for spotted owls along the edges of forested habitats (Sakai and Noon 1997). Similarly, we found that owl survival and population growth were positively associated with the amount of habitat edge between shrubs/saplings and forests dominated by trees ≥30.5 cm dbh, so the juxtaposition of owl and prey habitat could be important as suggested by Franklin et al. (2000)." (SNAMP 2015, p.26)

Since the SNAMP (2015) manuscript is in draft form and there are unstudied questions, the authors caution it is premature to accept their conclusions without further work. Nevertheless, it is important to note that researchers may now be focusing on prey bases and their importance to support owl populations.

SPI has collected regurgitated owl pellets and analyzed their contents – which indicate NSO diet. In the NSO area managed by SPI, NSO primarily eat (on a biomass basis) wood rats, northern flying squirrels, western red-backed voles, and small mice (R. Feamster, SPI Biologist, pers. comm.). SPI forest areas appear to provide a prey base for NSO (Gray 2014).

To conclude, SPI asks the Commission to recognize that adding the NSO to the State list as "threatened" would not address any of the threats below.

- The incidence of catastrophic wildfires which destroys habitat for long periods of time would not decrease.

- Disease outbreaks harming raptors, such as West Nile Virus, which are likely naturally cyclical, would not be affected.
- Barred owls, the potential largest natural threat to NSO, would continue to immigrate into NSO habitat even with current barred owl control efforts.
- Illegal forest uses which may involve the use of toxicants which harm animal species will not be affected, since existing laws are not currently being aggressively enforced (although we laud California regulators for removing the availability of some of the worst toxicants to the general public).
- The spread of non-native fungus-like pathogen responsible for Sudden Oak Death Syndrome.

Additionally, SPI believes a change in the listing status will erect additional barriers to recovery, rather than aid recovery. Private landowners who are already bearing a heavy burden of protecting NSO may see more land use restrictions with a State listing. Landowners that are burdened with additional restrictions will be even less likely to cooperate on barred owl control efforts. Public land managers would also likely have fewer tools to help recover the species.

SPI urges the Commission to not change the status of the species. Rather, SPI asks the Commission to work with agencies, private landowners, and the general public to address the largest threats to the species – regardless of the California Endangered Species Act status – dealing with the barred owl and maintaining a prey base. Most importantly, the Department's estimate of the current population is wrong, and the long term impacts of the barred owl are really unknown as to the ability of the two owls to persist in the same ecosystem. All of these facts make it very hard to claim that the continued existence of NSO is in serious danger or threatened. The Commission should therefore request the Department to further study the real population values, support the barred owl control efforts, and reject the recommendation to list the NSO under CESA.

Sincerely,

Edward C. Murphy RPF #2066
Inventory and Ecological Services Manager
Sierra Pacific Industries

Attachments: Northern spotted owls near Weaverville and Trinity Lake in Trinity County within the Landscape Survey Strategy Area (An interim report). http://www.spi-ind.com/OurForests/ResearchAndMonitoring/Northern spotted owls near Weaverville and Trinity Lake in Trinity County.pdf. 12 pages
http://www.spi-ind.com/pdf_forests/SPIResearchNSODensityStudy.pdf

NAIP Imagery (2014) (30 Pages) at each reproductive Activity Center that is discussed in *Northern spotted owls near Weaverville and Trinity Lake in Trinity County within the Landscape Survey Strategy Area (An interim report).*

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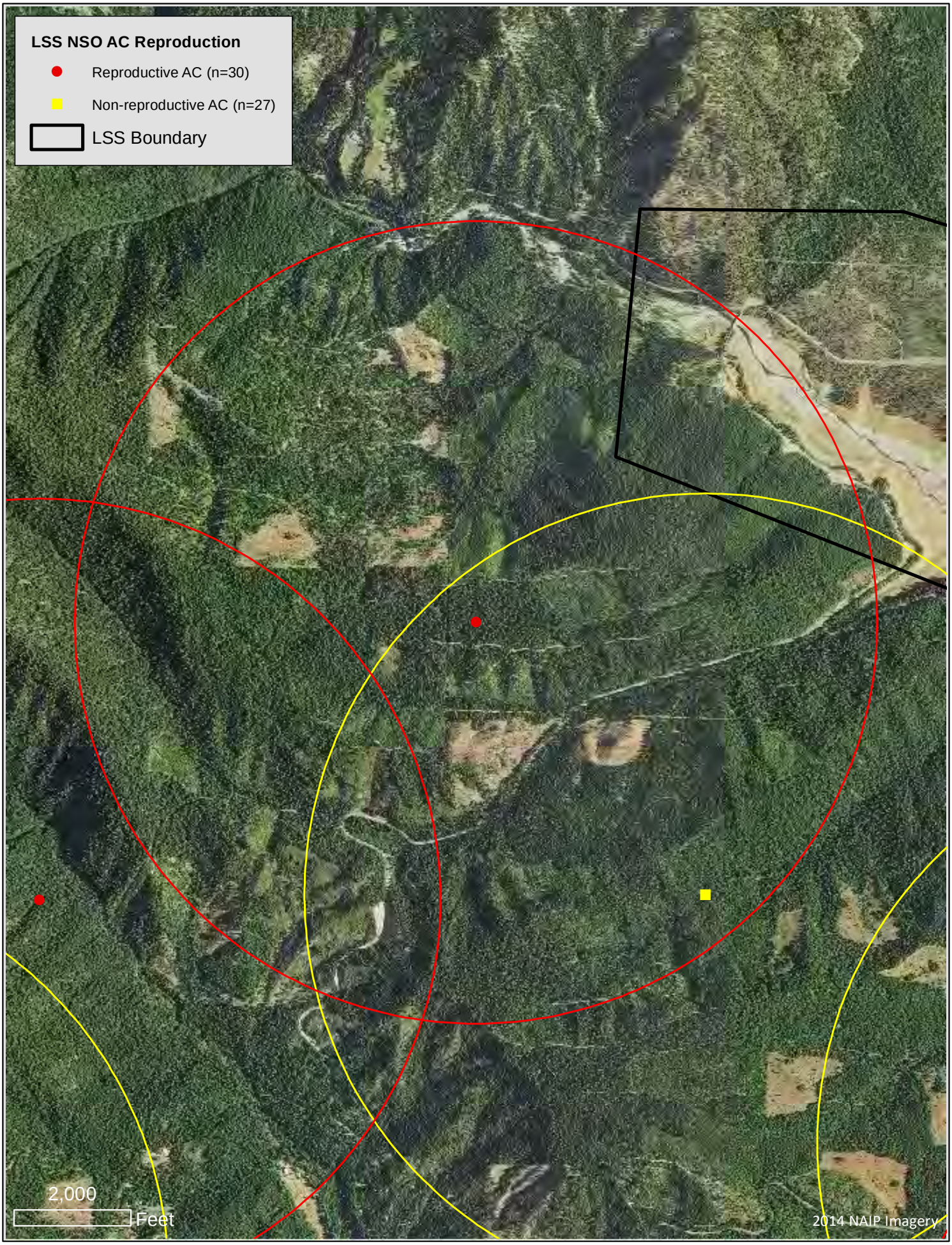
The attached 30 pages show the locations and surrounding habitats for the 30 reproductive NSO nests in the Weaverville Study Area" (WSA) outlined over the 2014 National Agriculture Imagery Program (NAIP) imagery. The red colored 1.3 mile circles are centered on the reproductive nest activity center. These 30 nests have produced a minimum of 97 known fledlgings during the 2011 to 2015 survey periods. As an explanatory note, the yellow circles are other known activity centers within the study area, demonstrating the significant amount of overlap when using a 1.3 mile radius as required by the USFWS protocol. The occasional heavy black line is the WSA density study area boundary.

If you want more information about this study it can be found at:

Northern spotted owls near Weaverville and Trinity Lake in Trinity County within the Landscape Survey Strategy Area (An interim report). http://www.spi-ind.com/OurForests/ResearchAndMonitoring/Northern spotted owls near Weaverville and Trinity Lake in Trinity County.pdf. 12 pages – or at the link below.
http://www.spi-ind.com/pdf_forests/SPIResearchNSODensityStudy.pdf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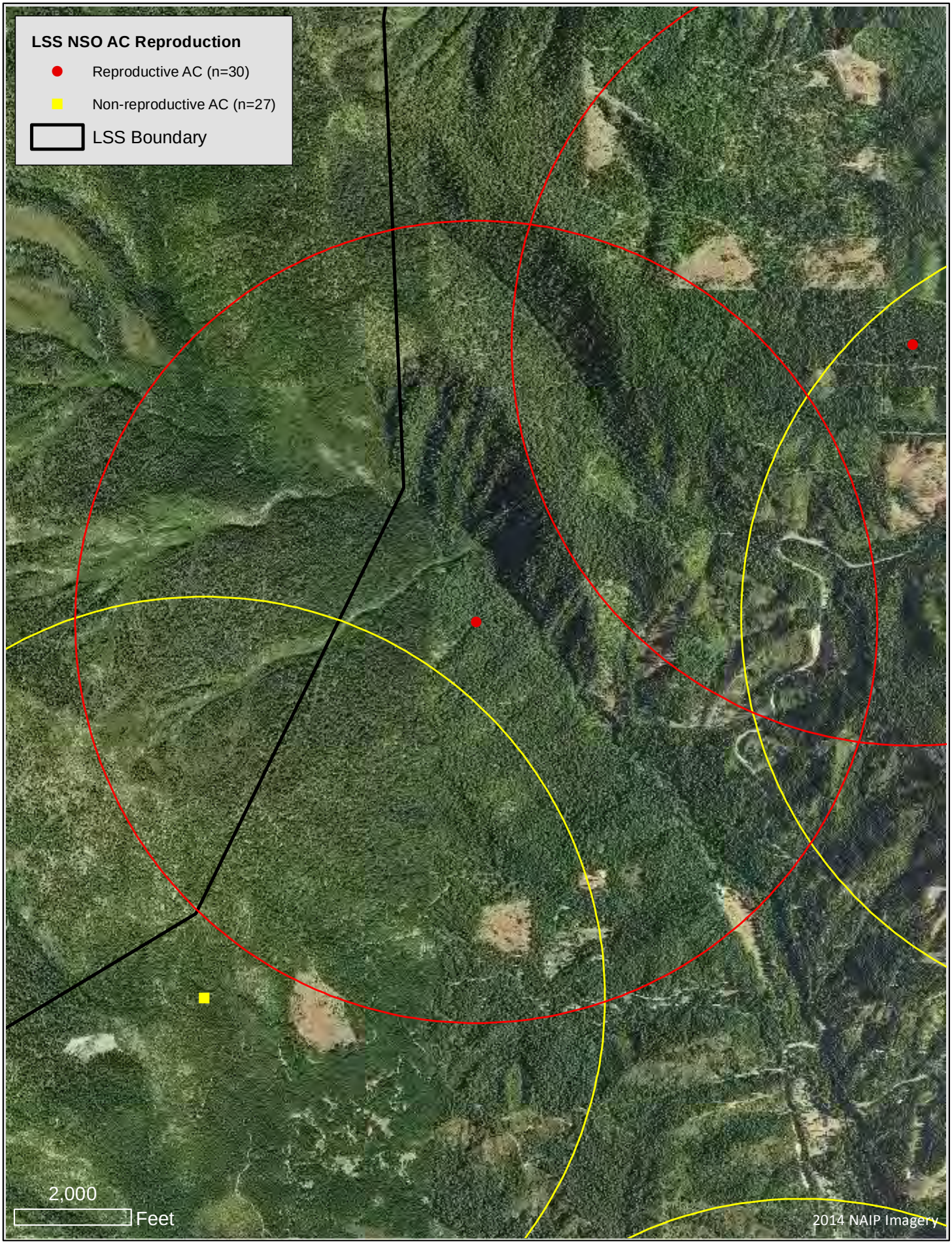
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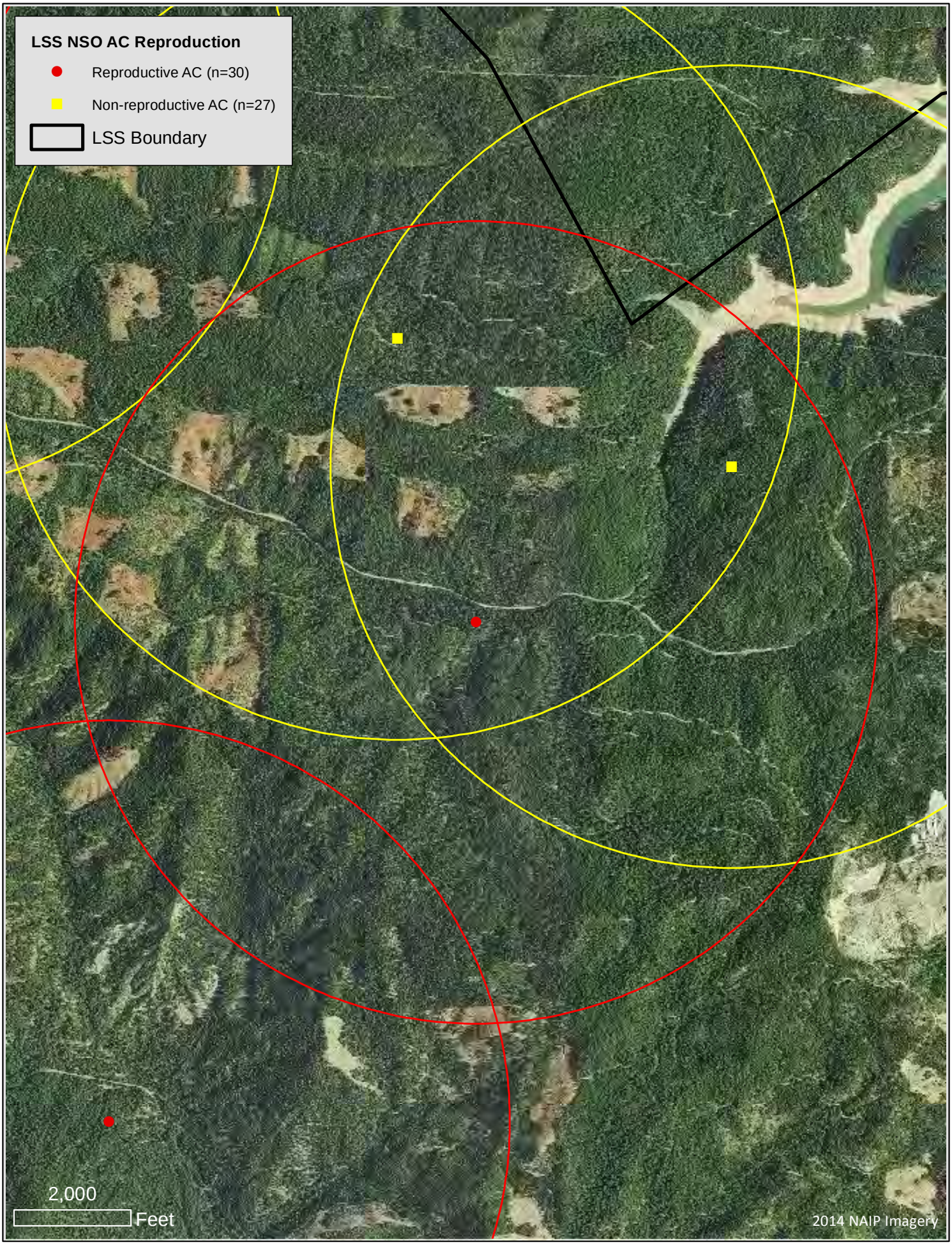
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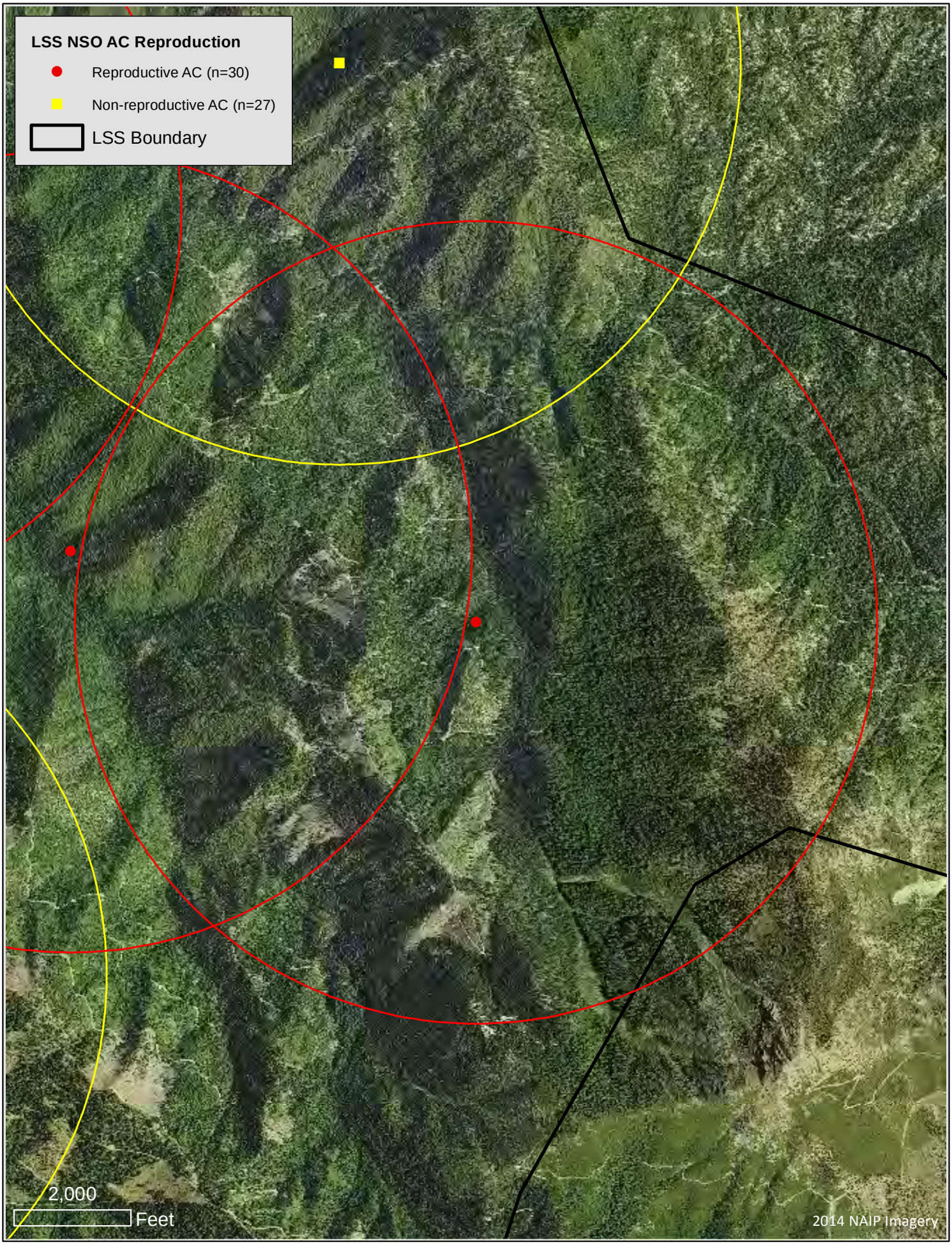
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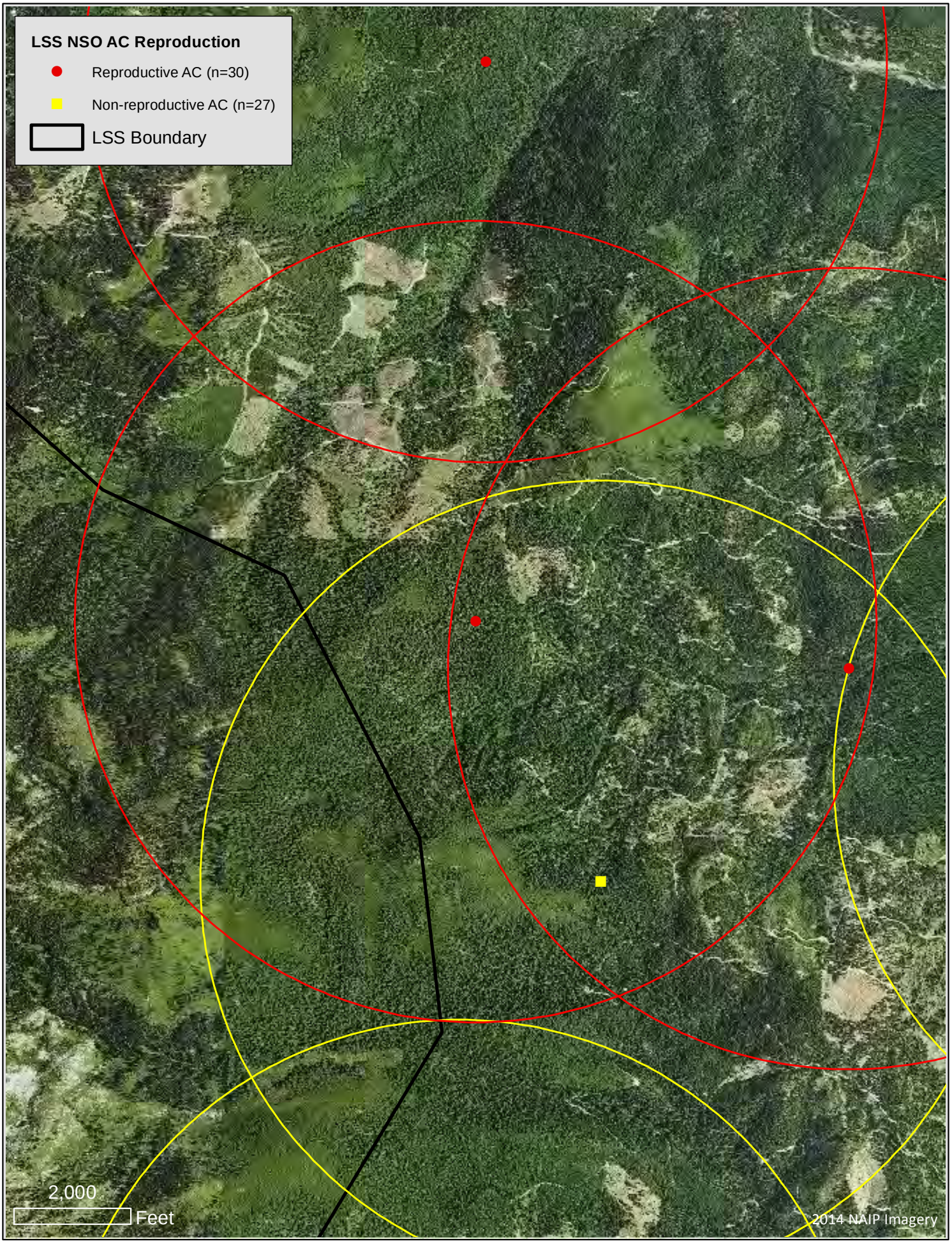
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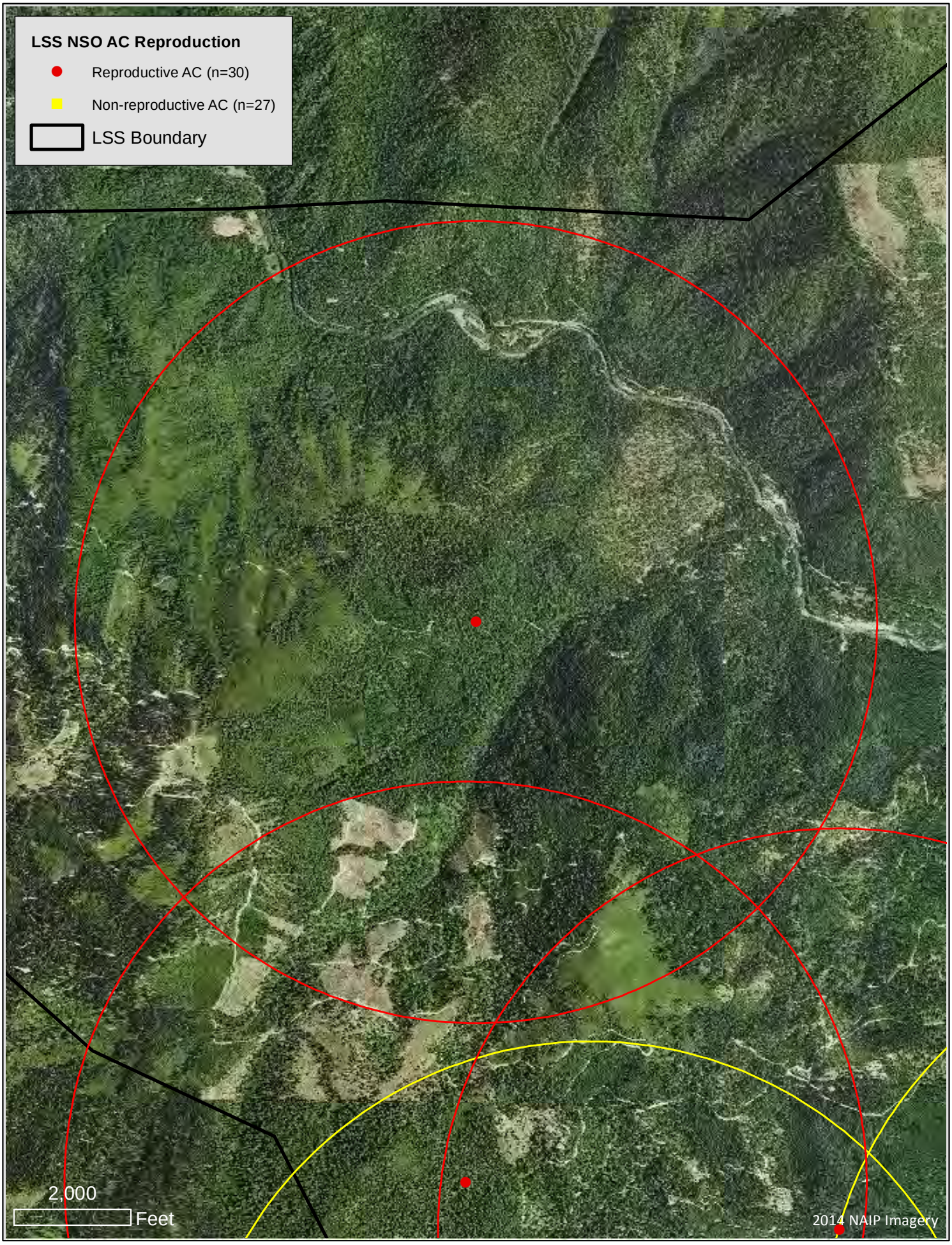
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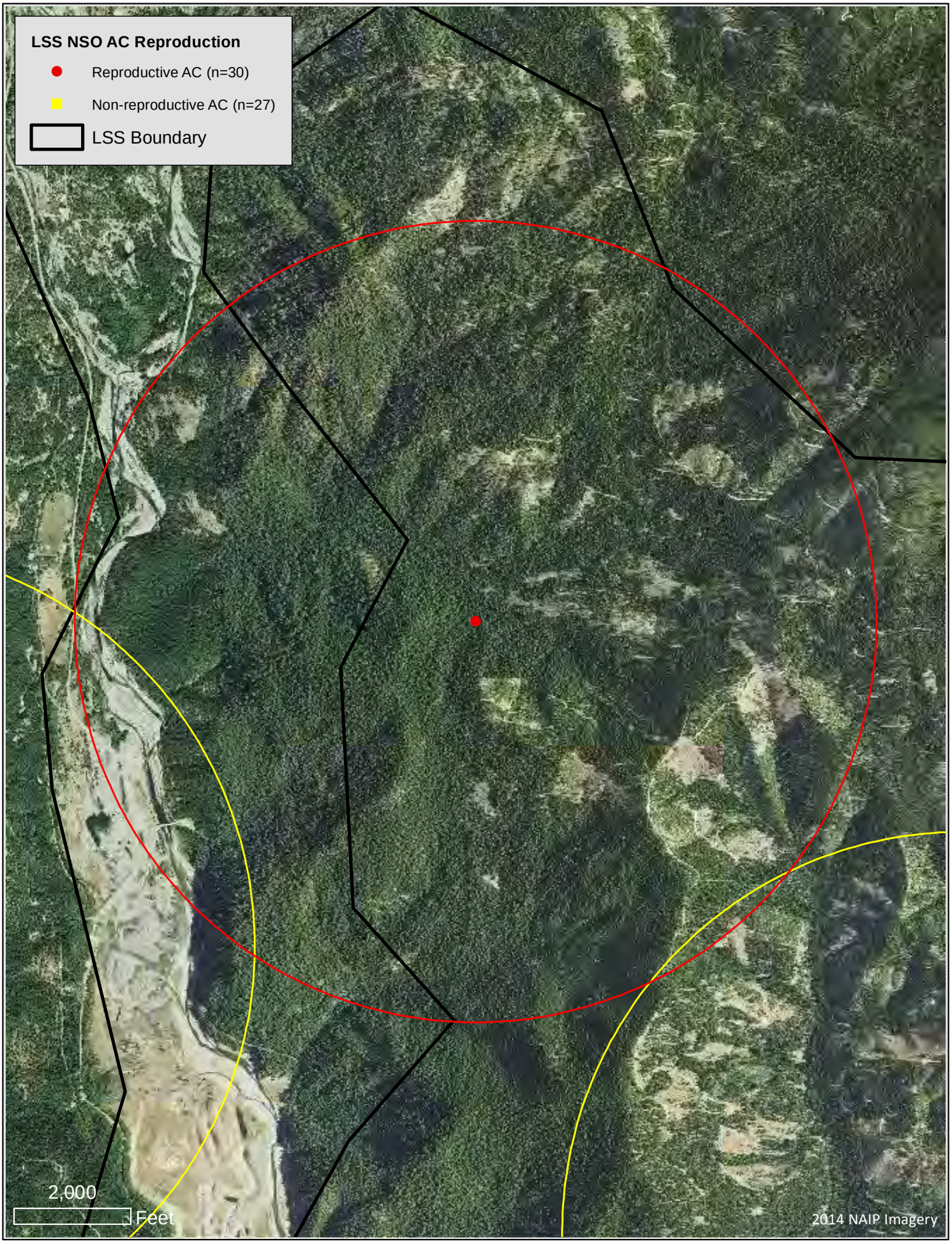
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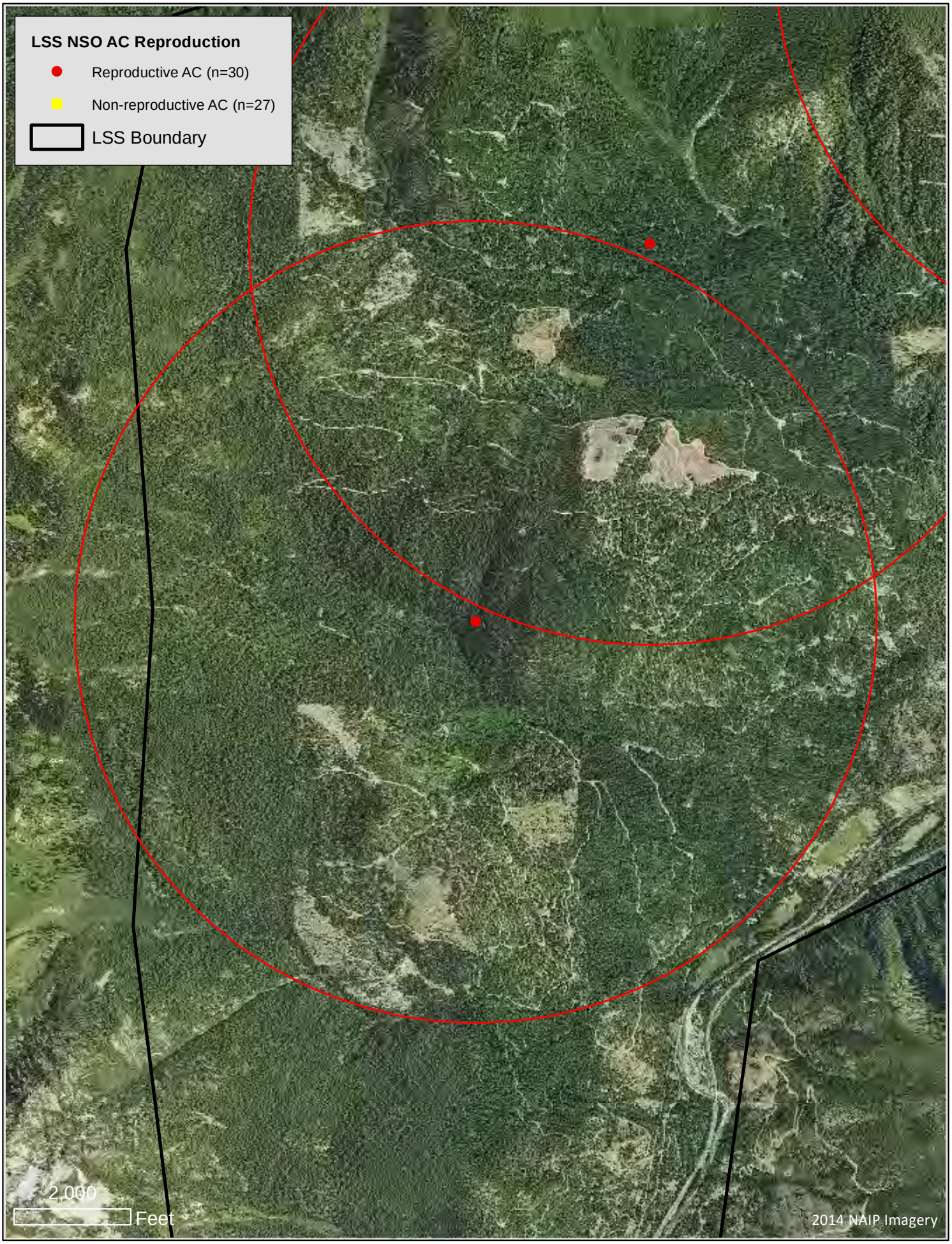
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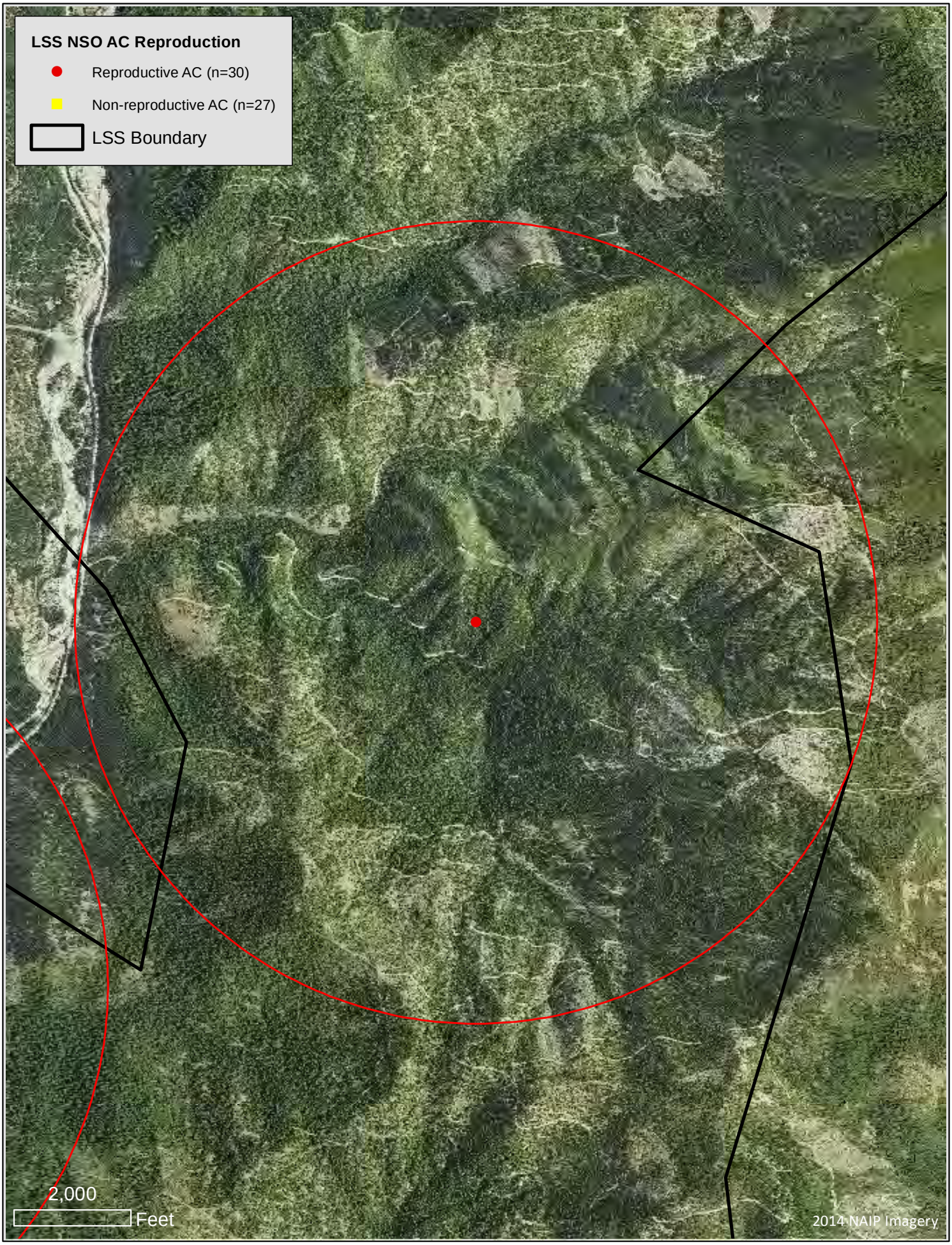
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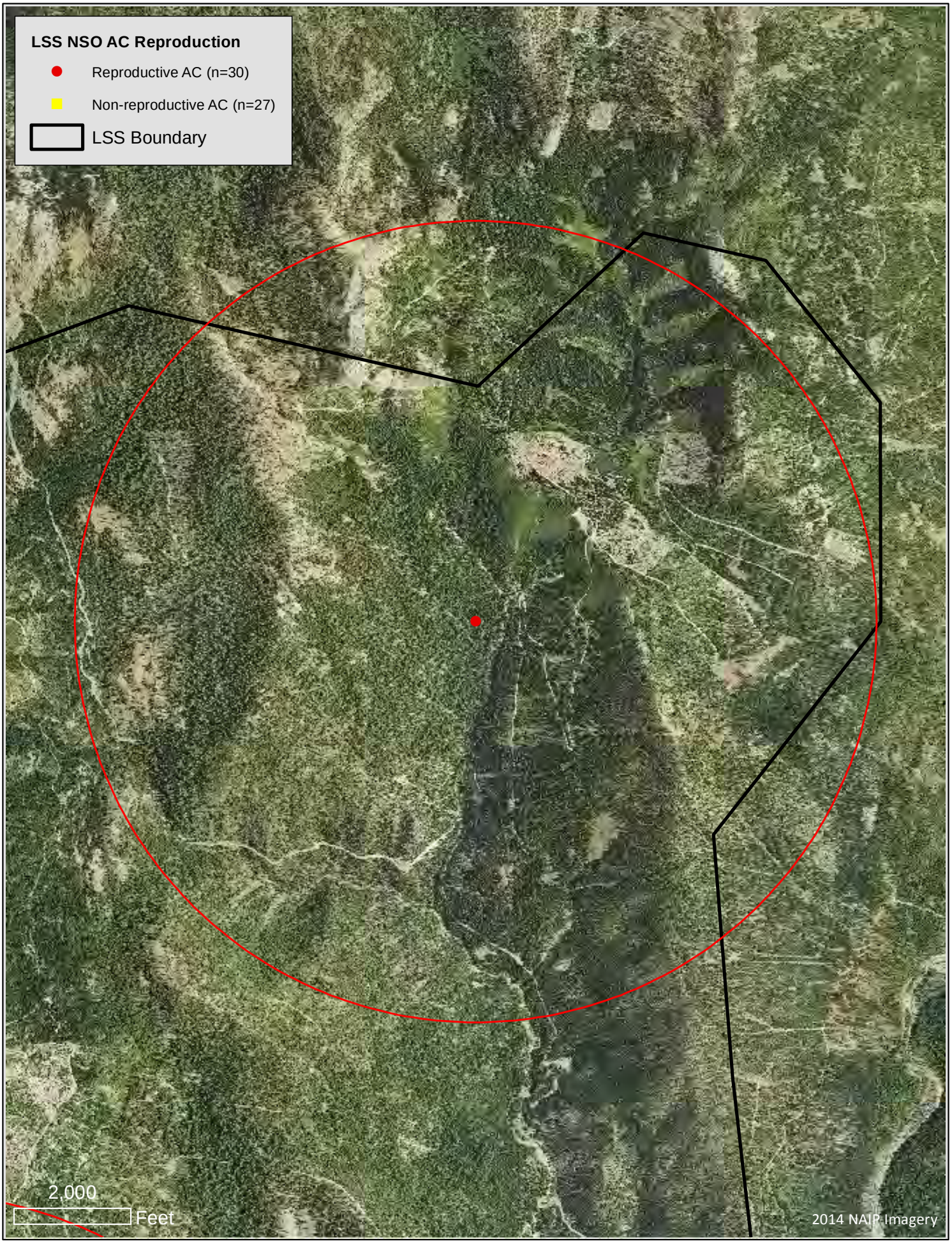
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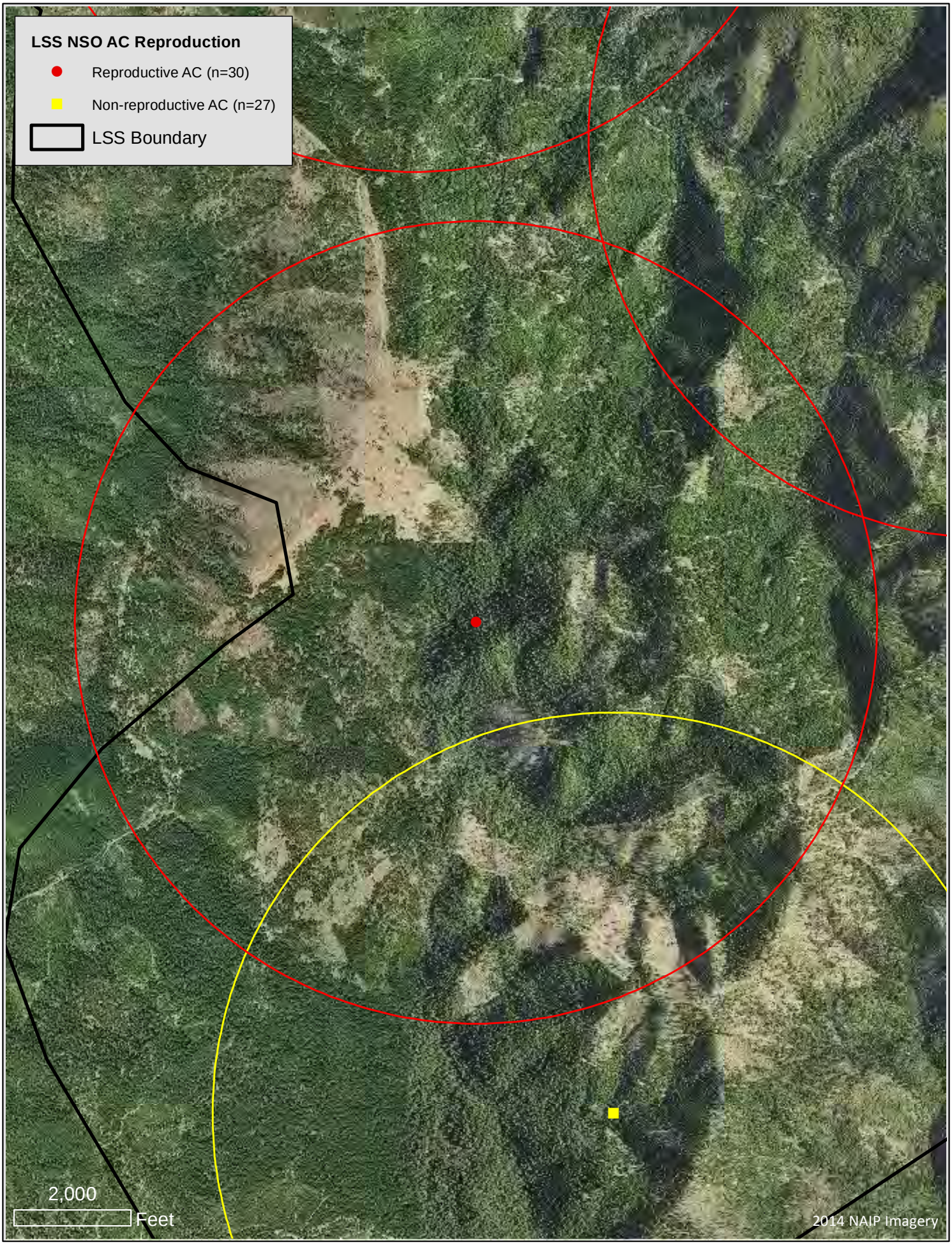
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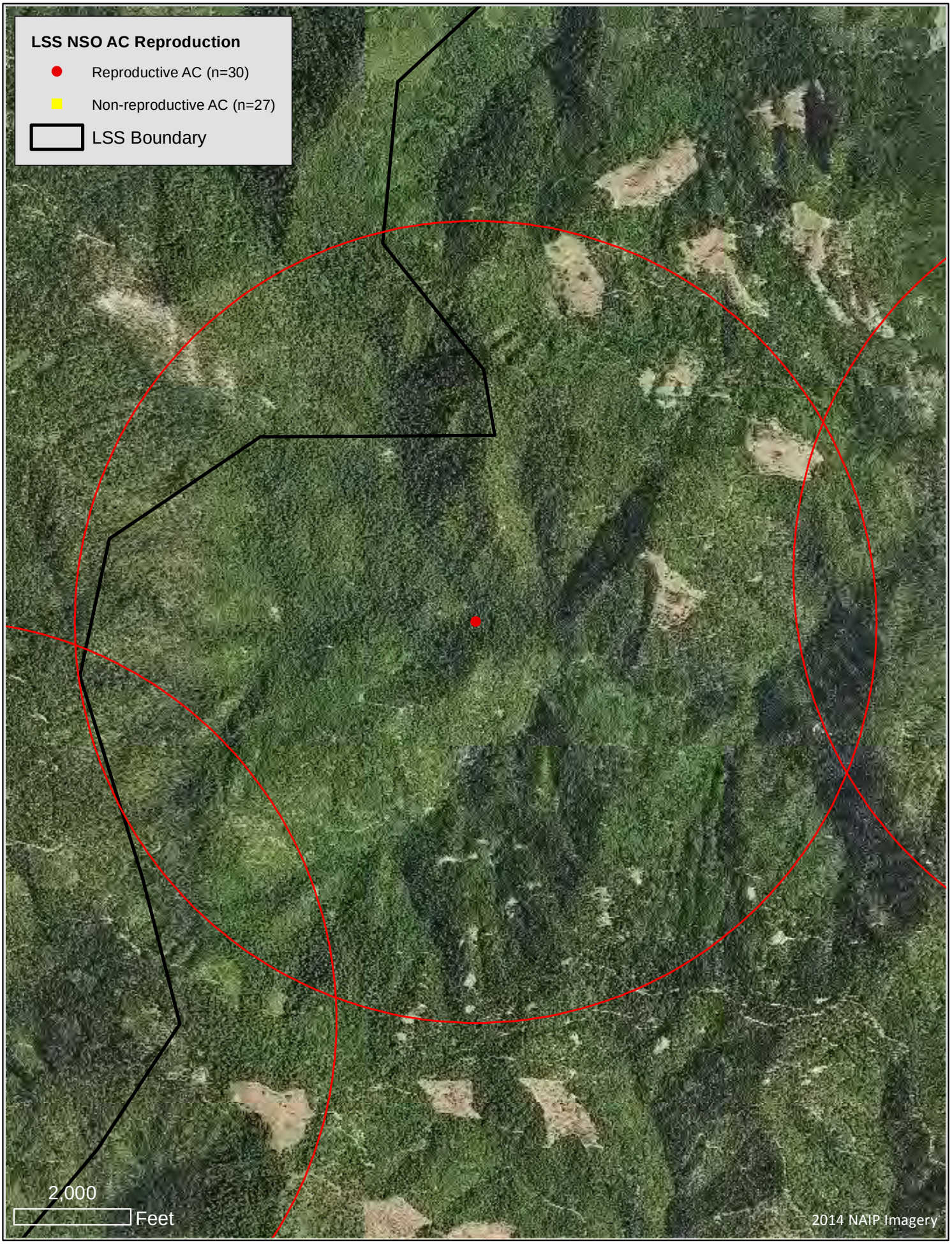
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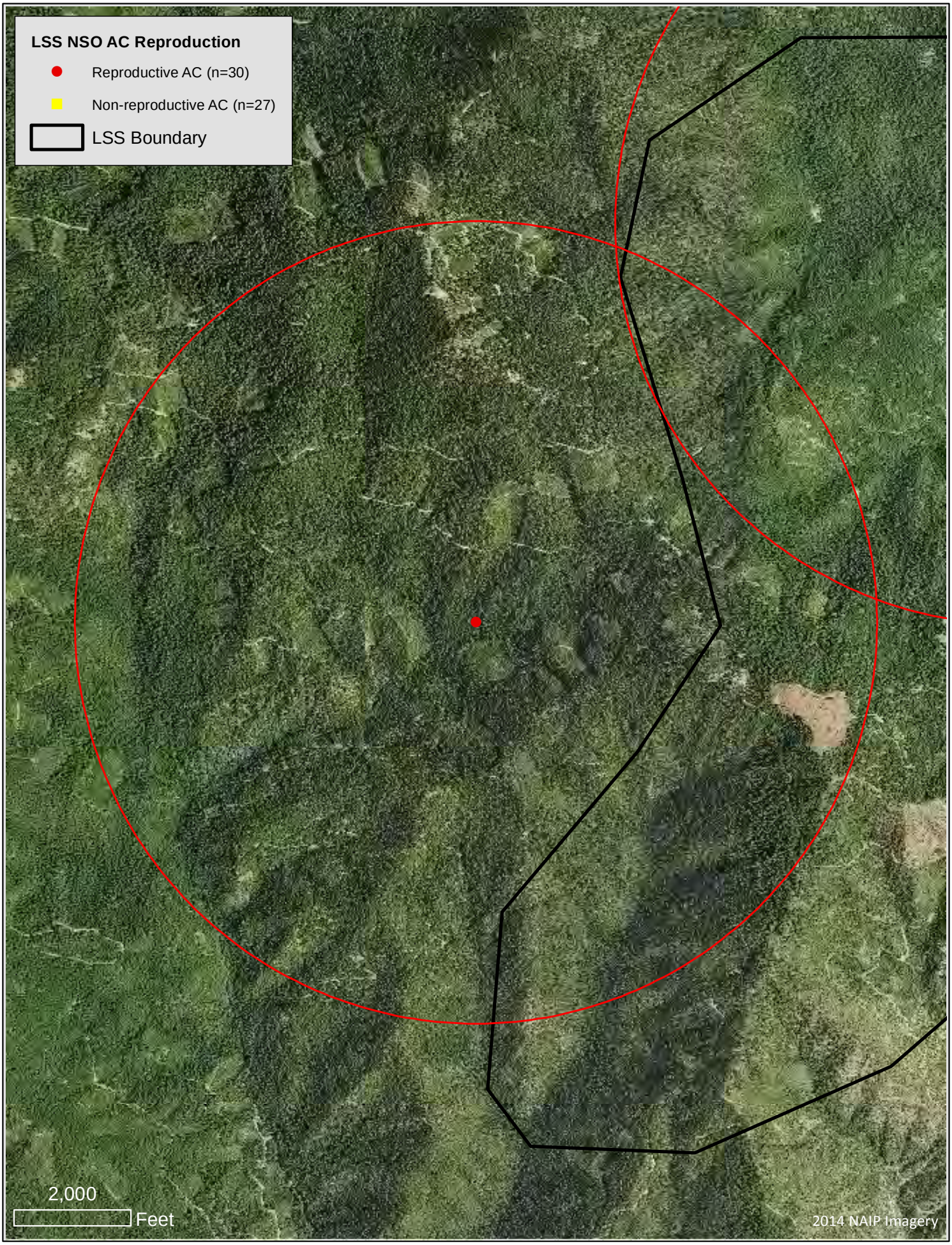
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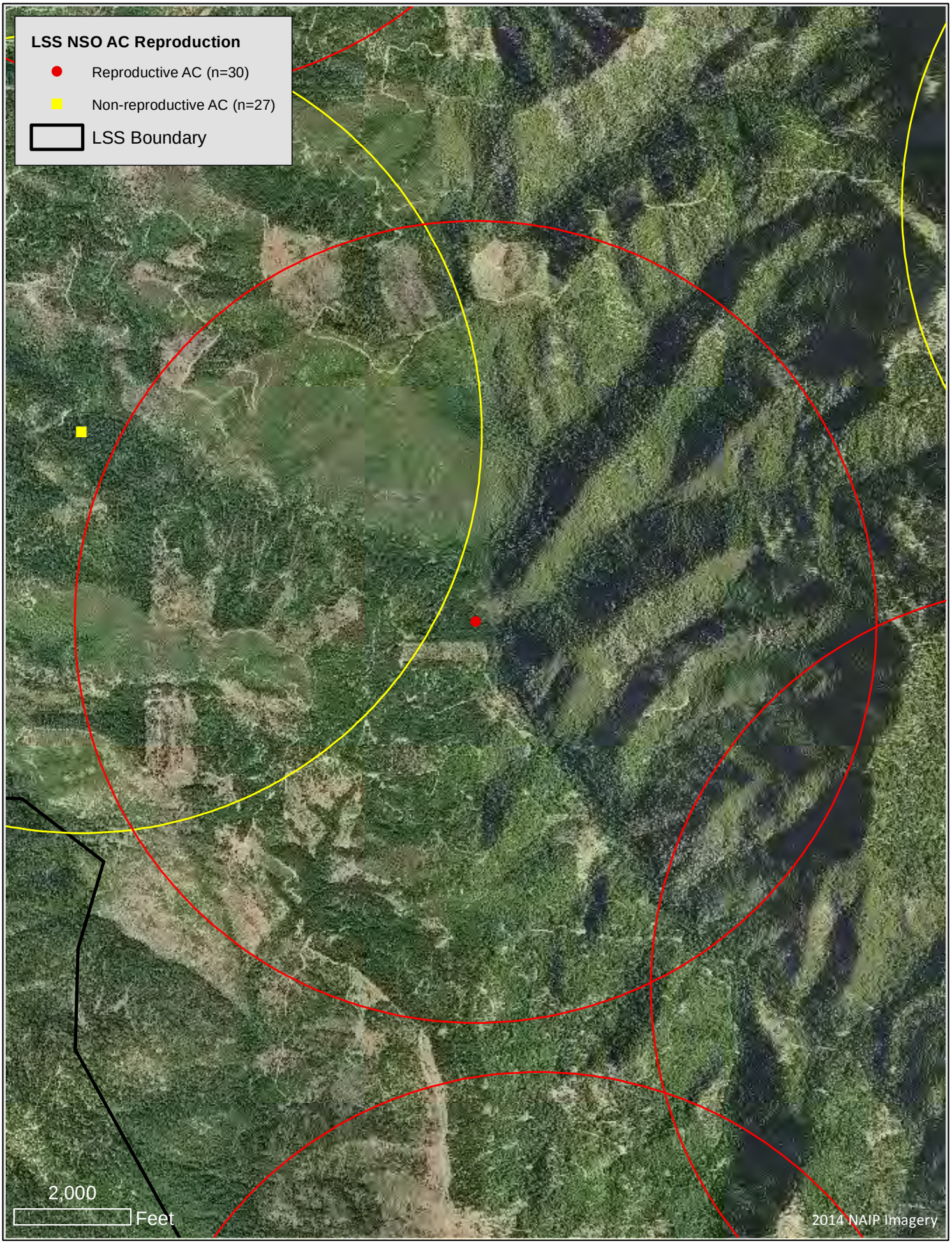
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Non-reproductive AC (n=27)
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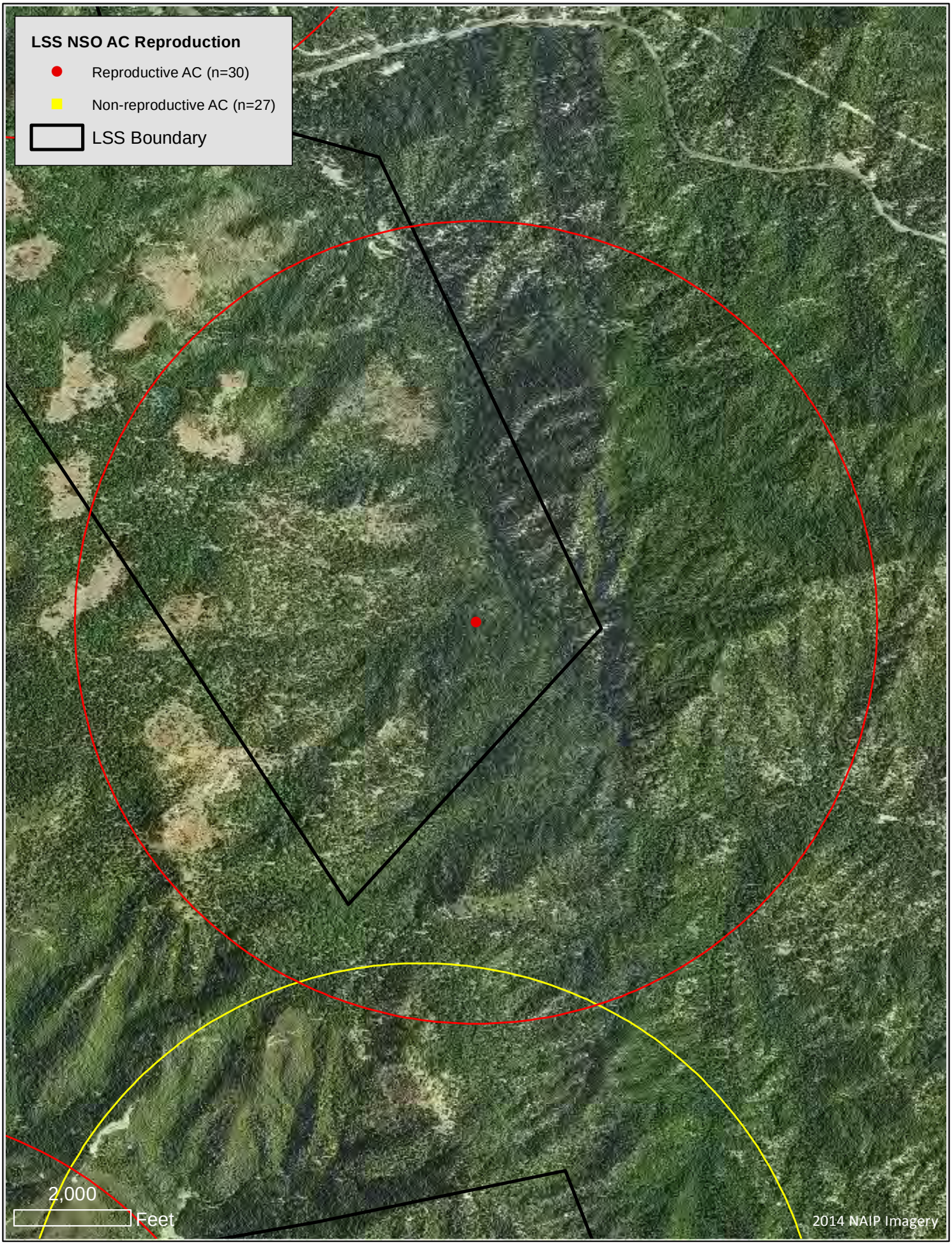
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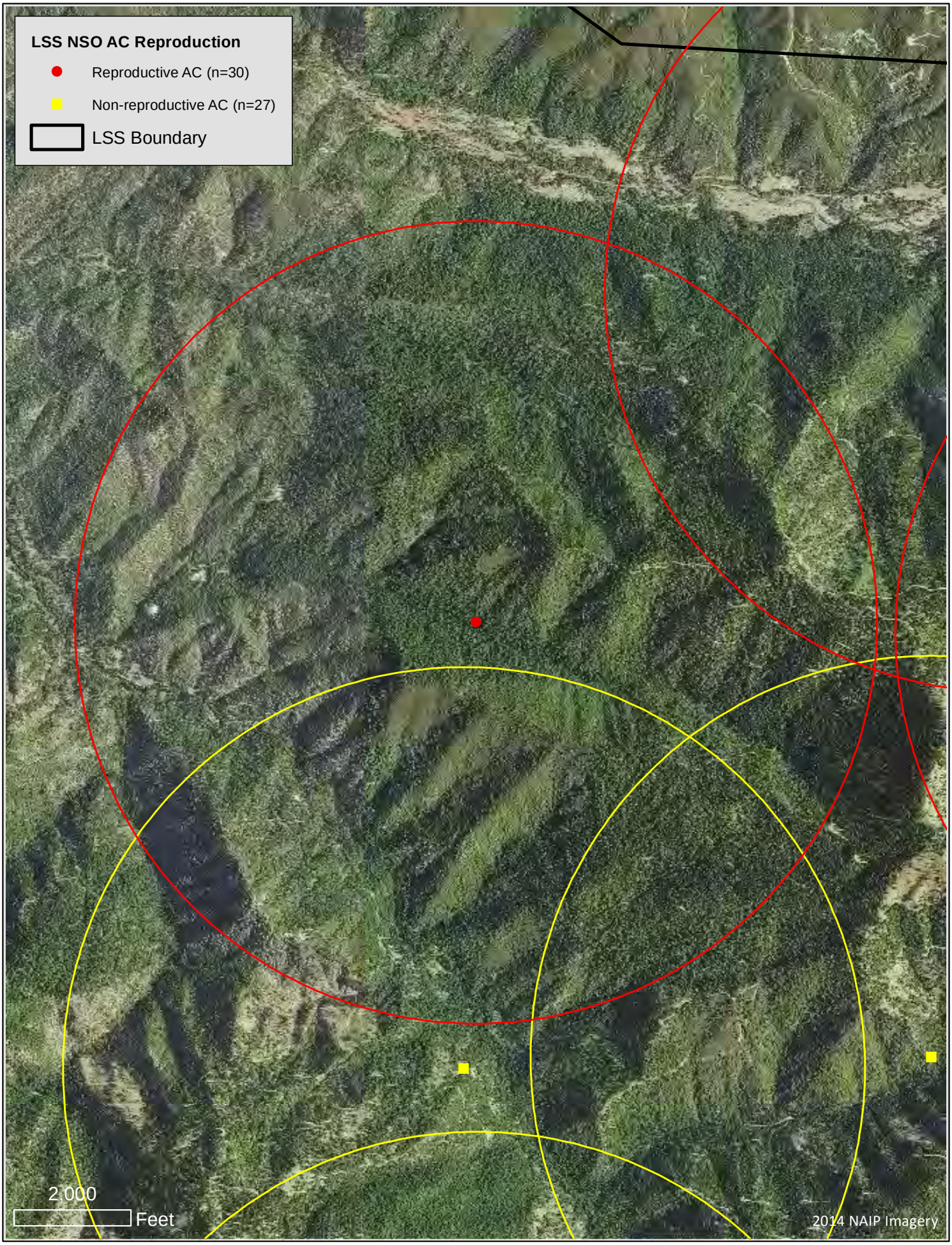
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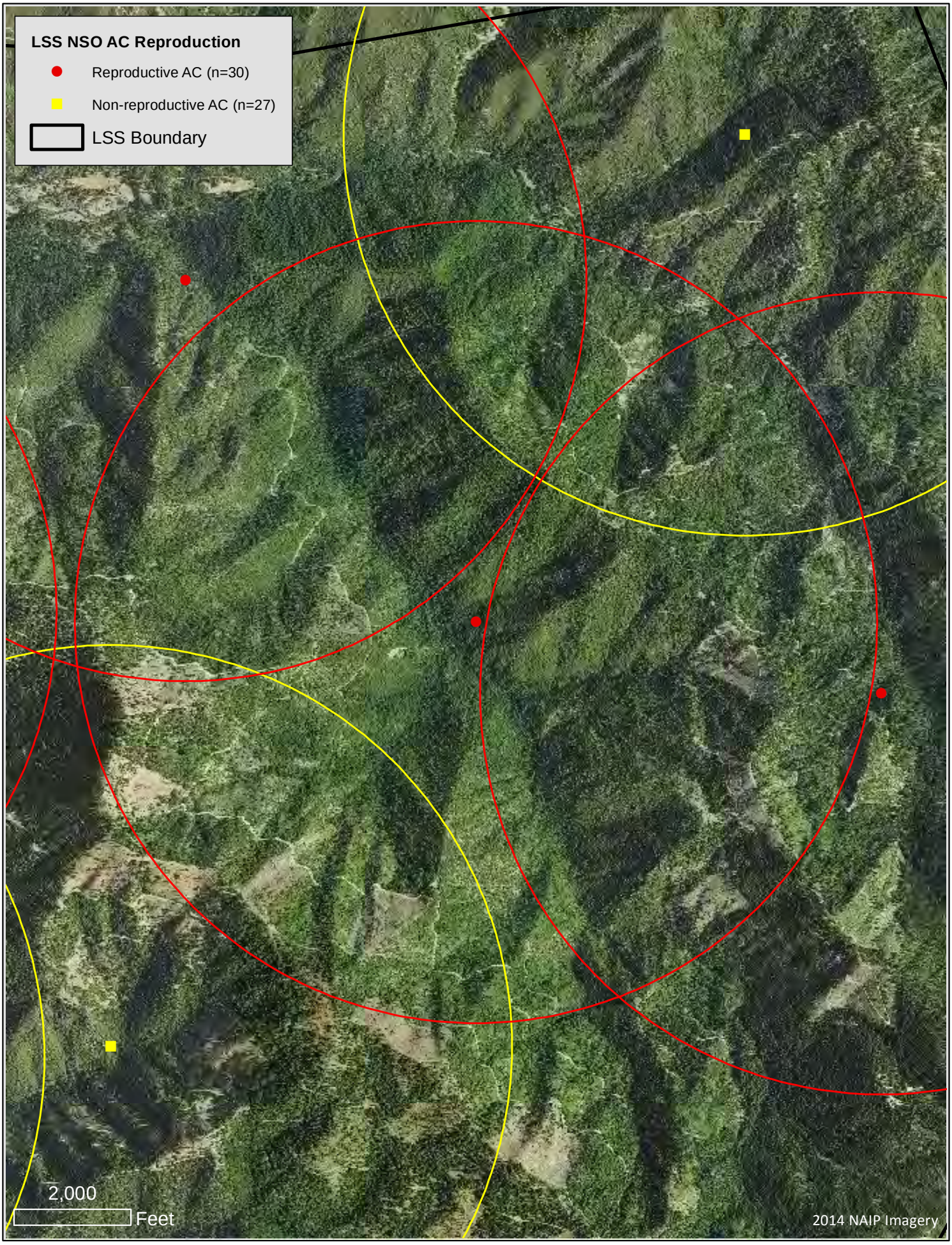
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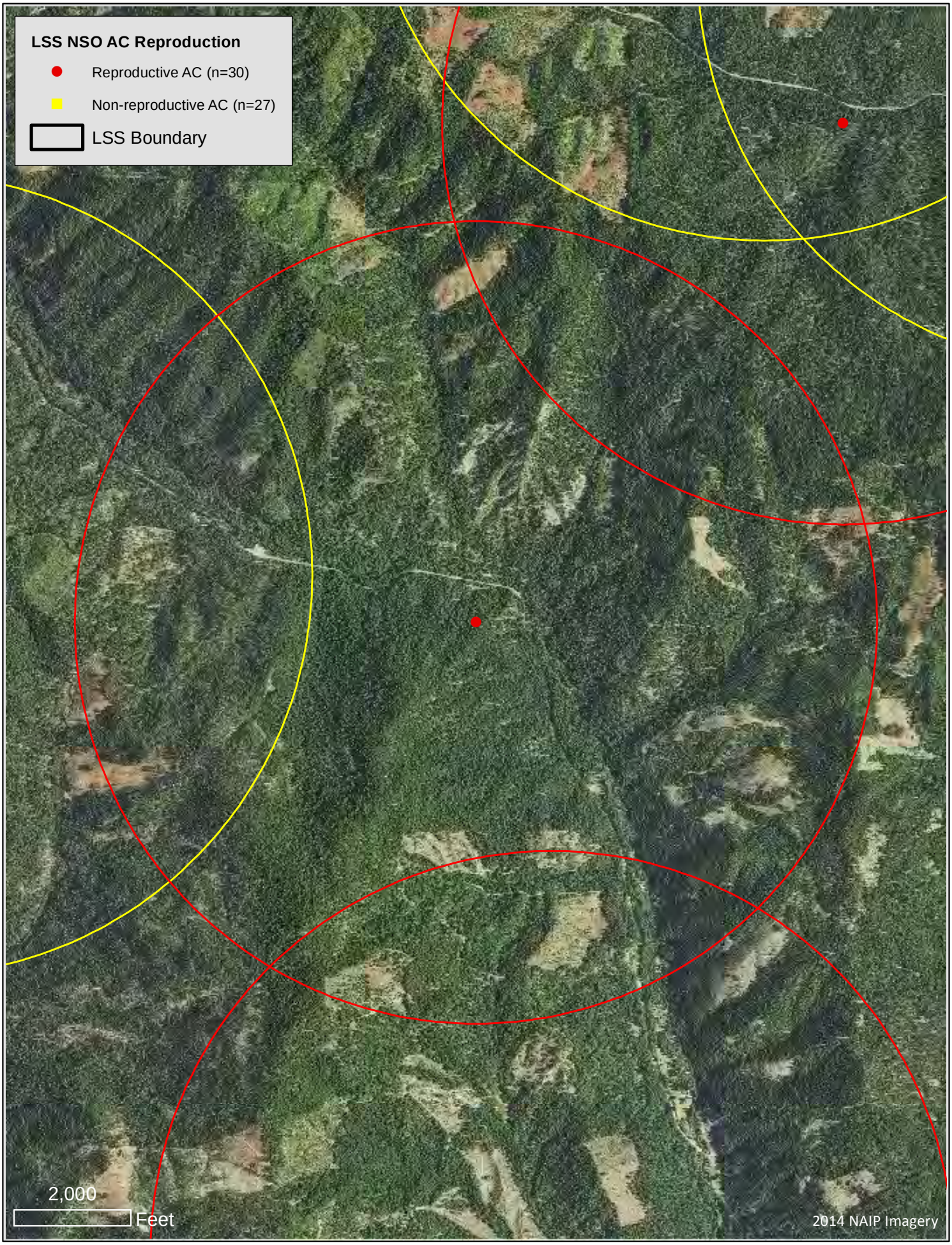
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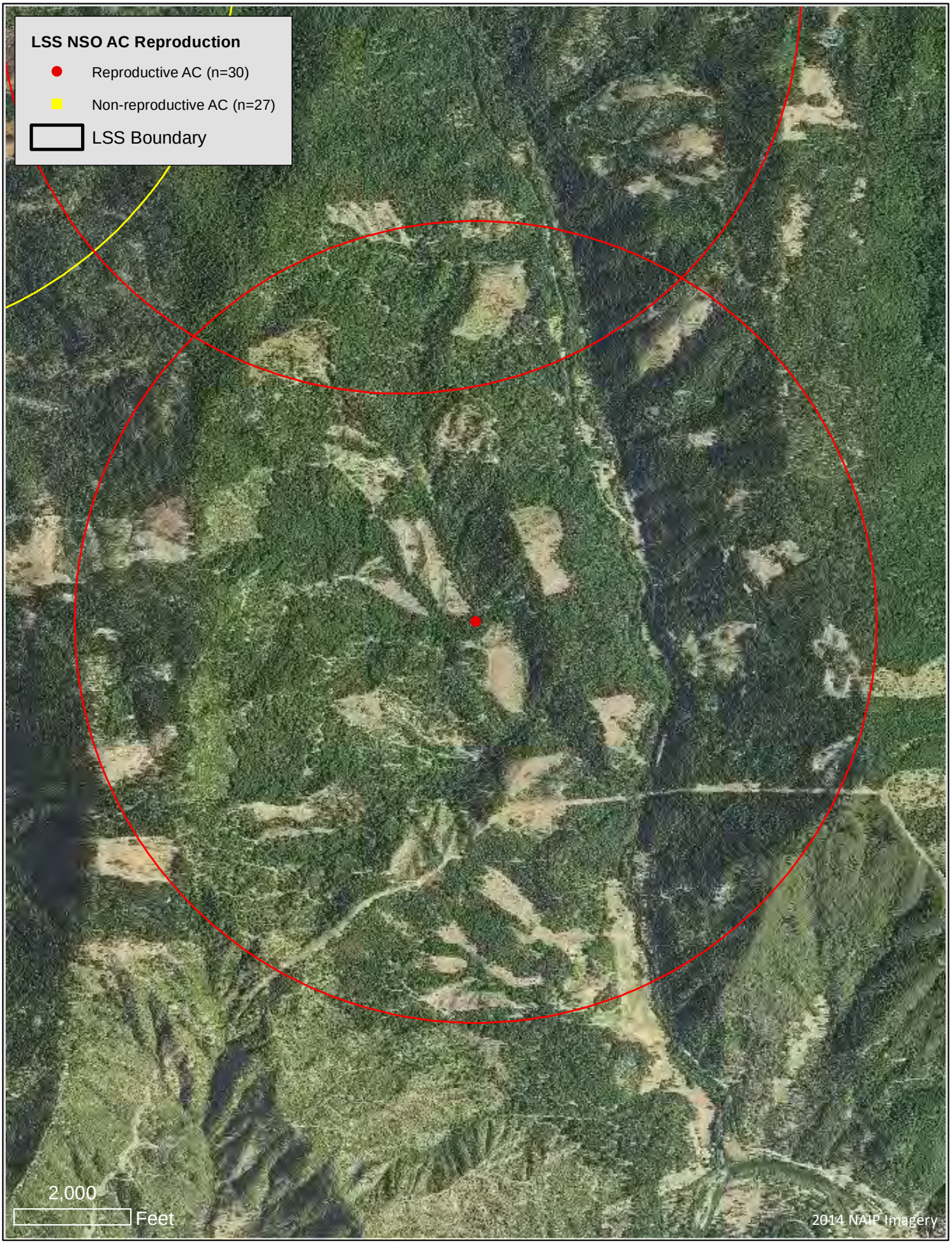
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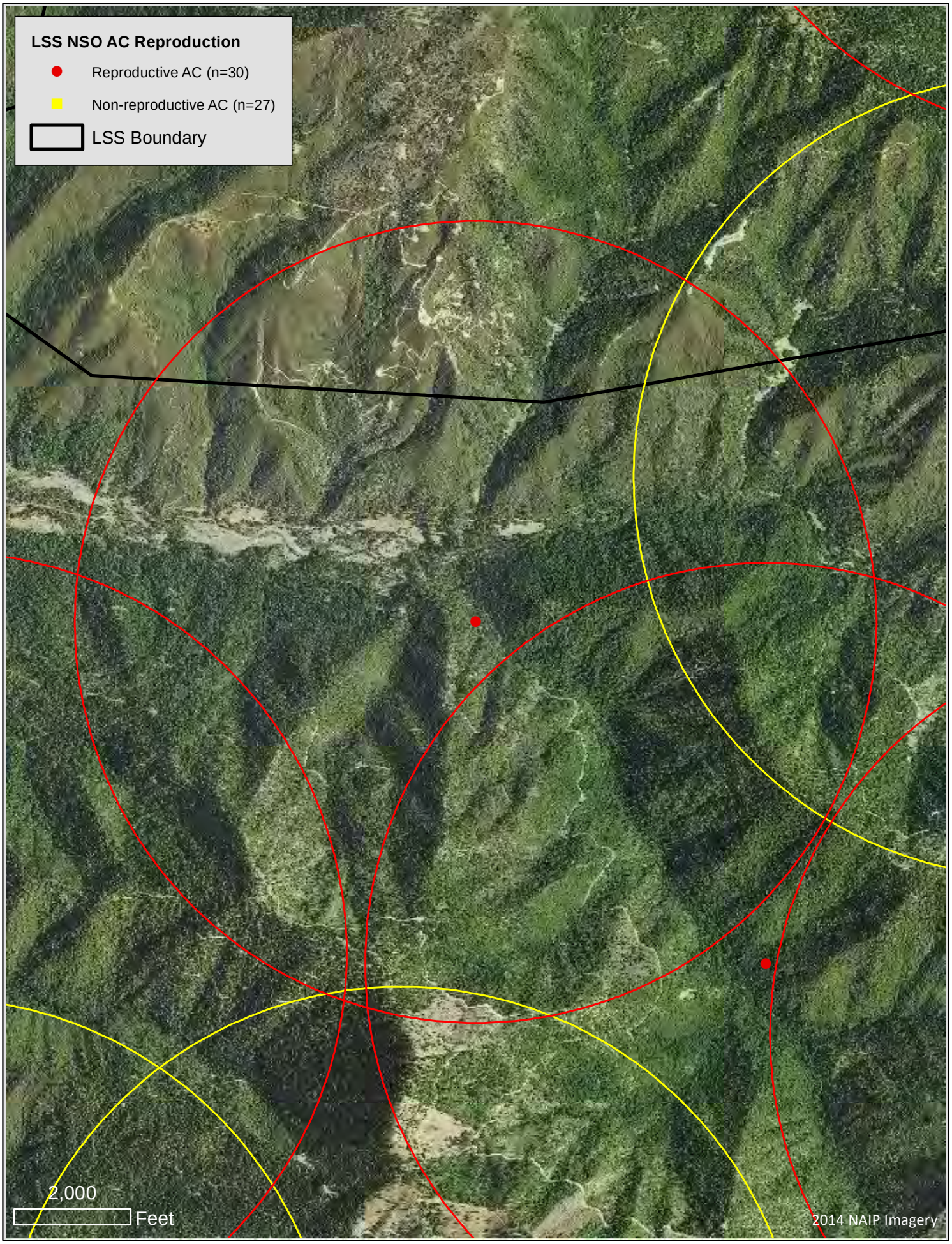
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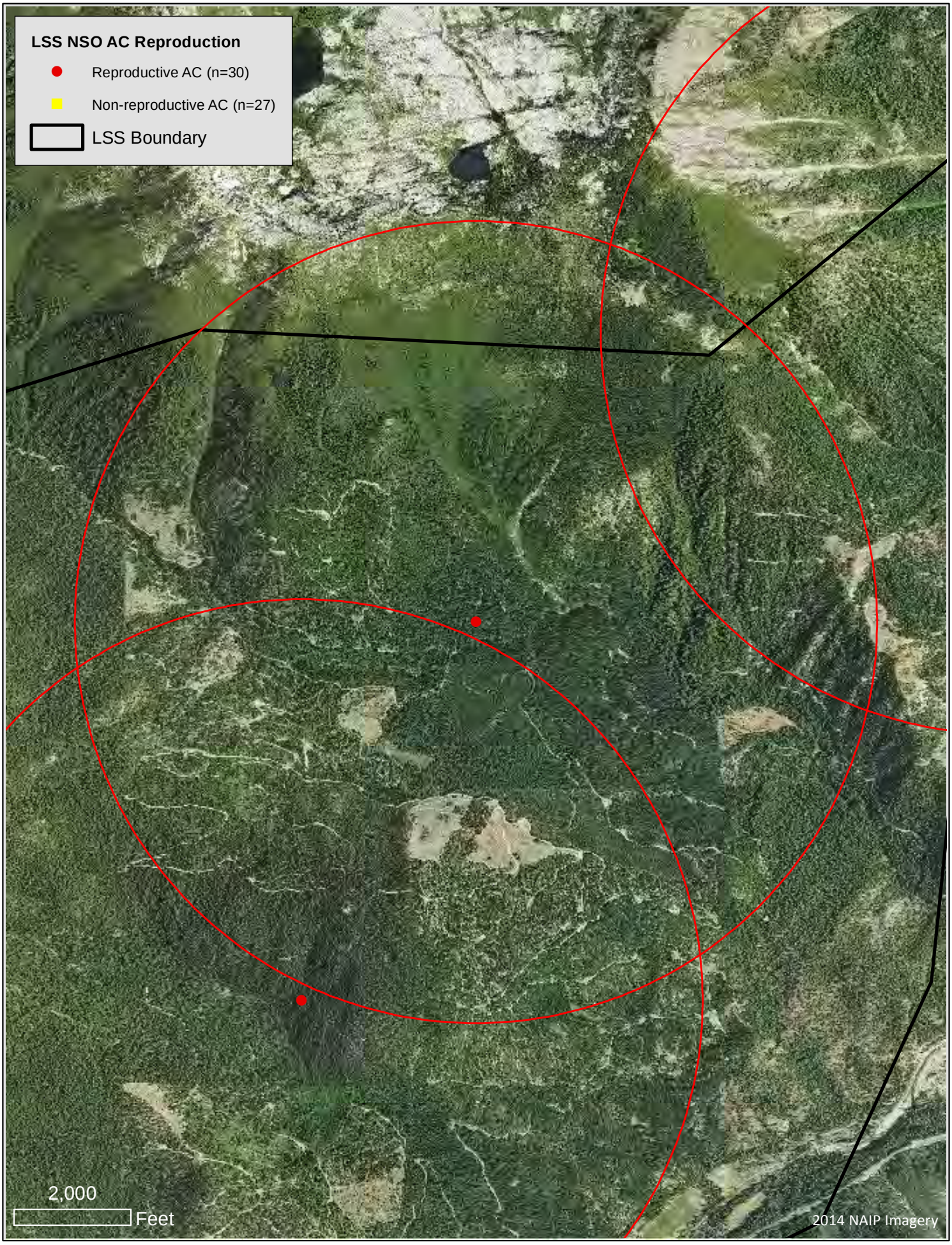
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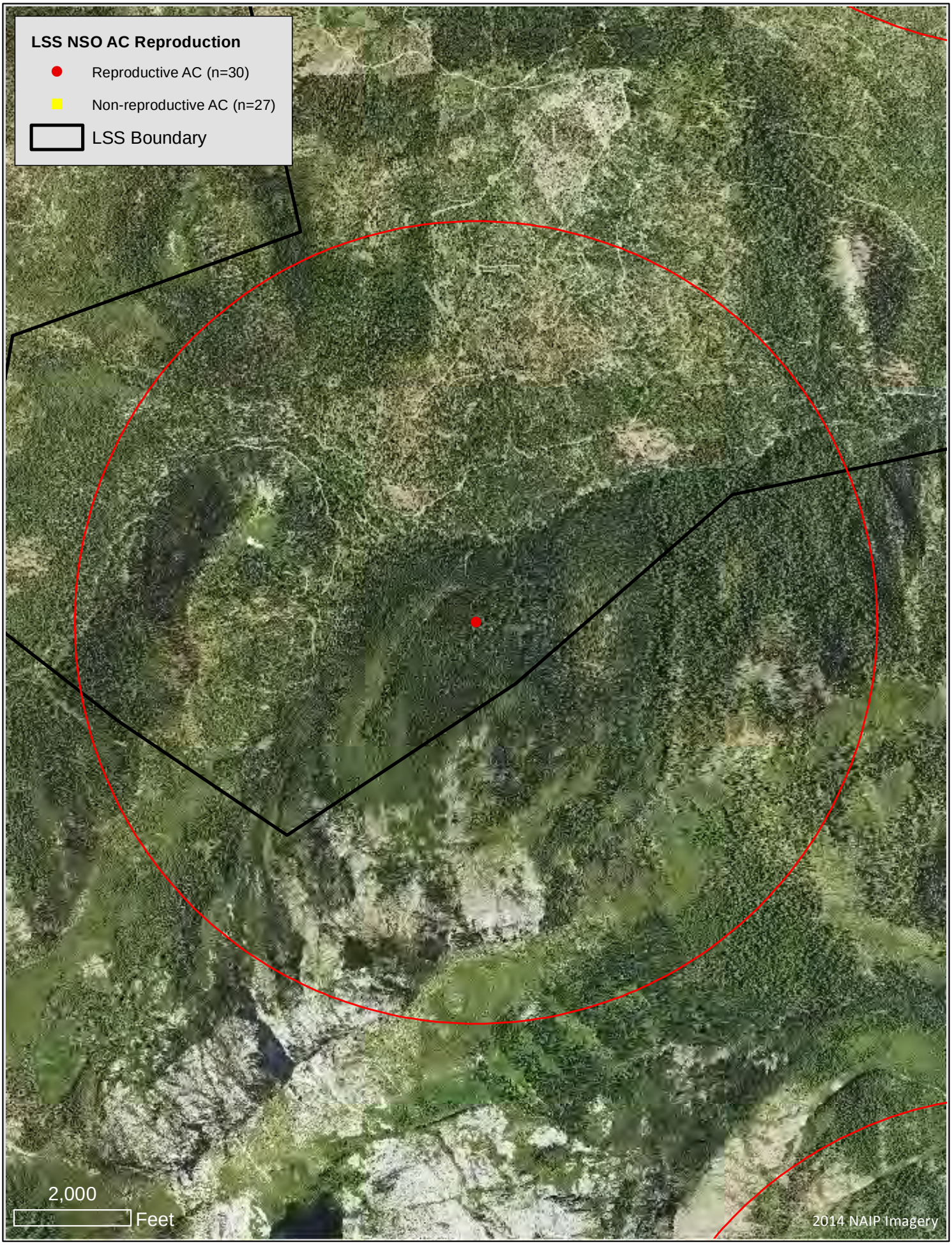
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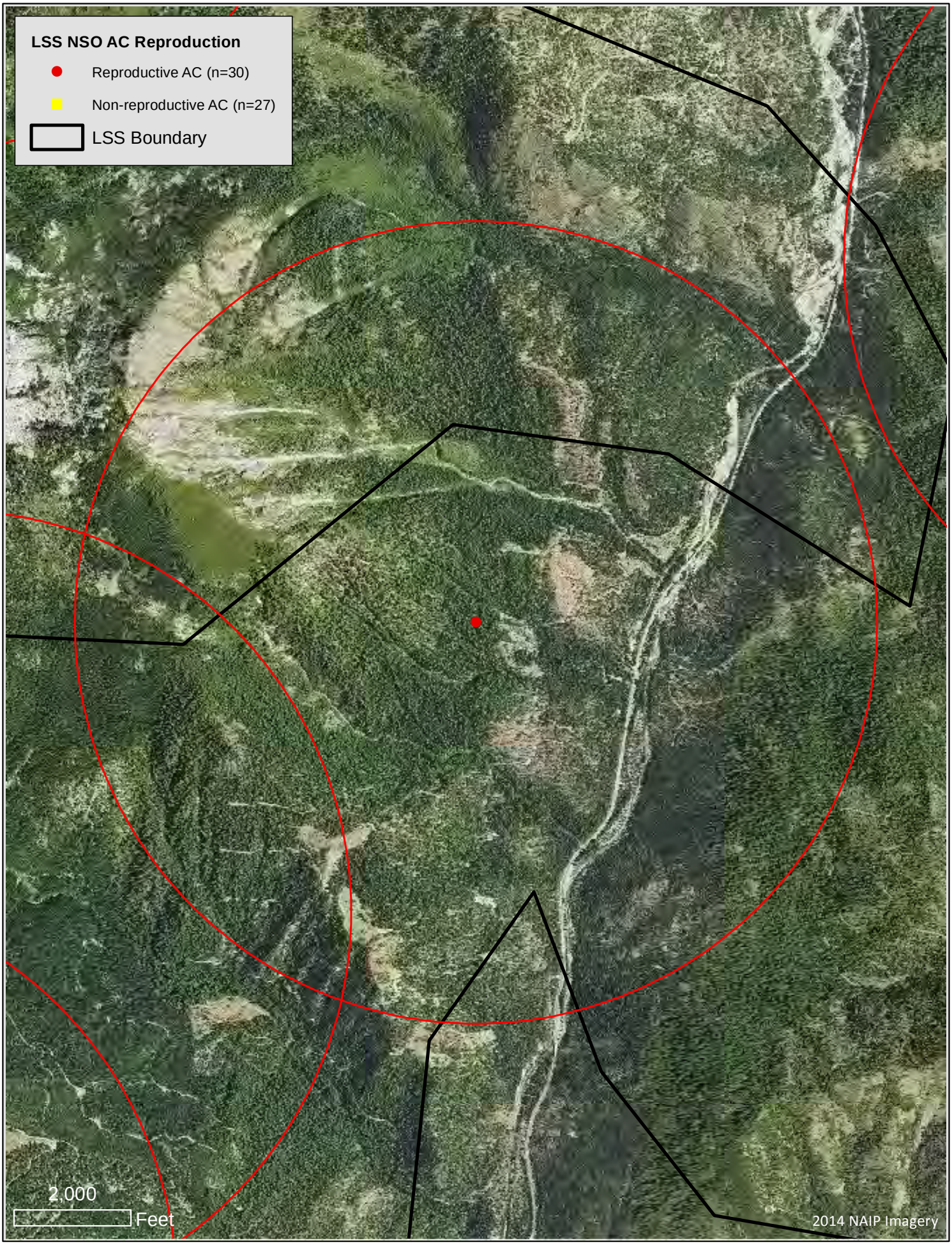
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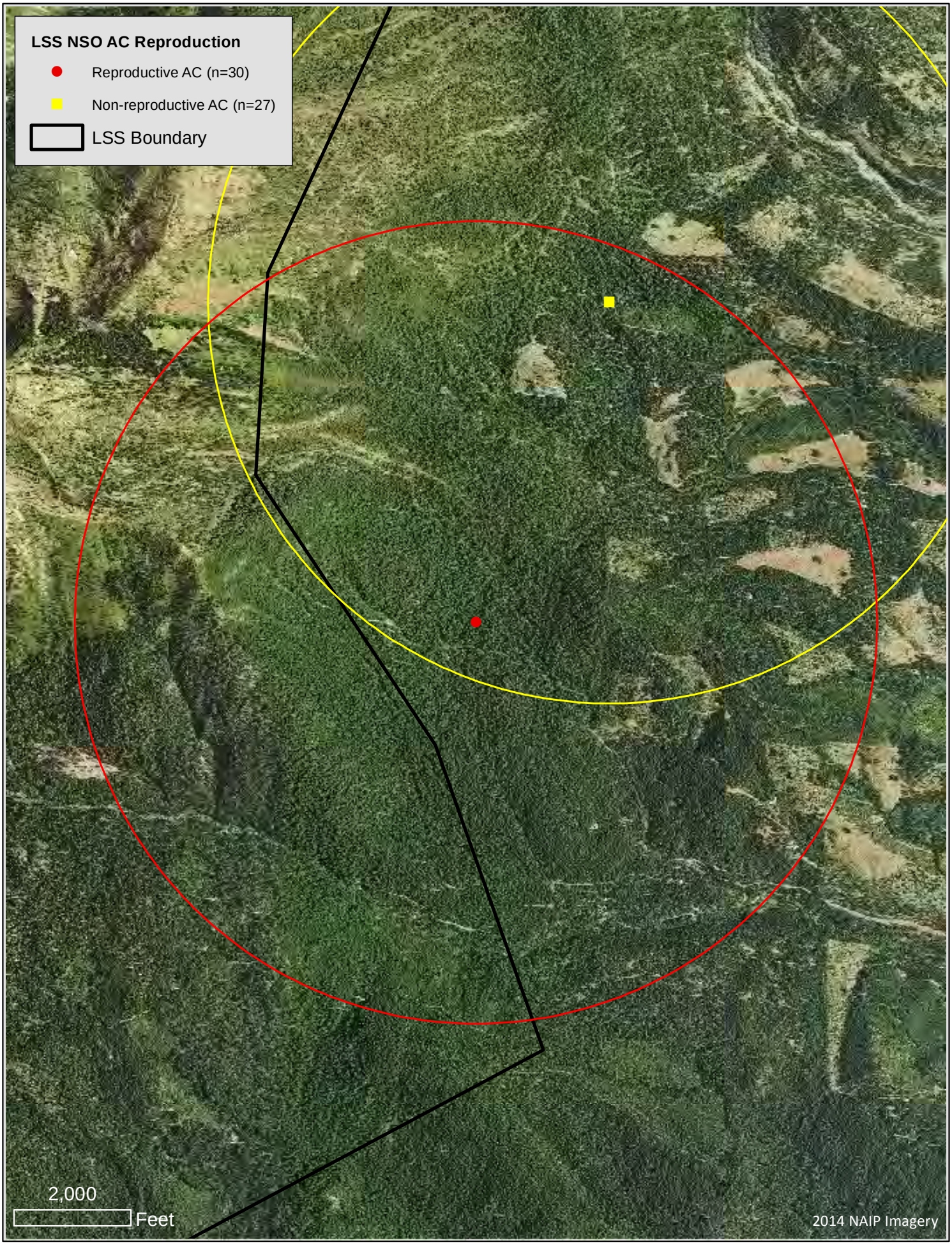
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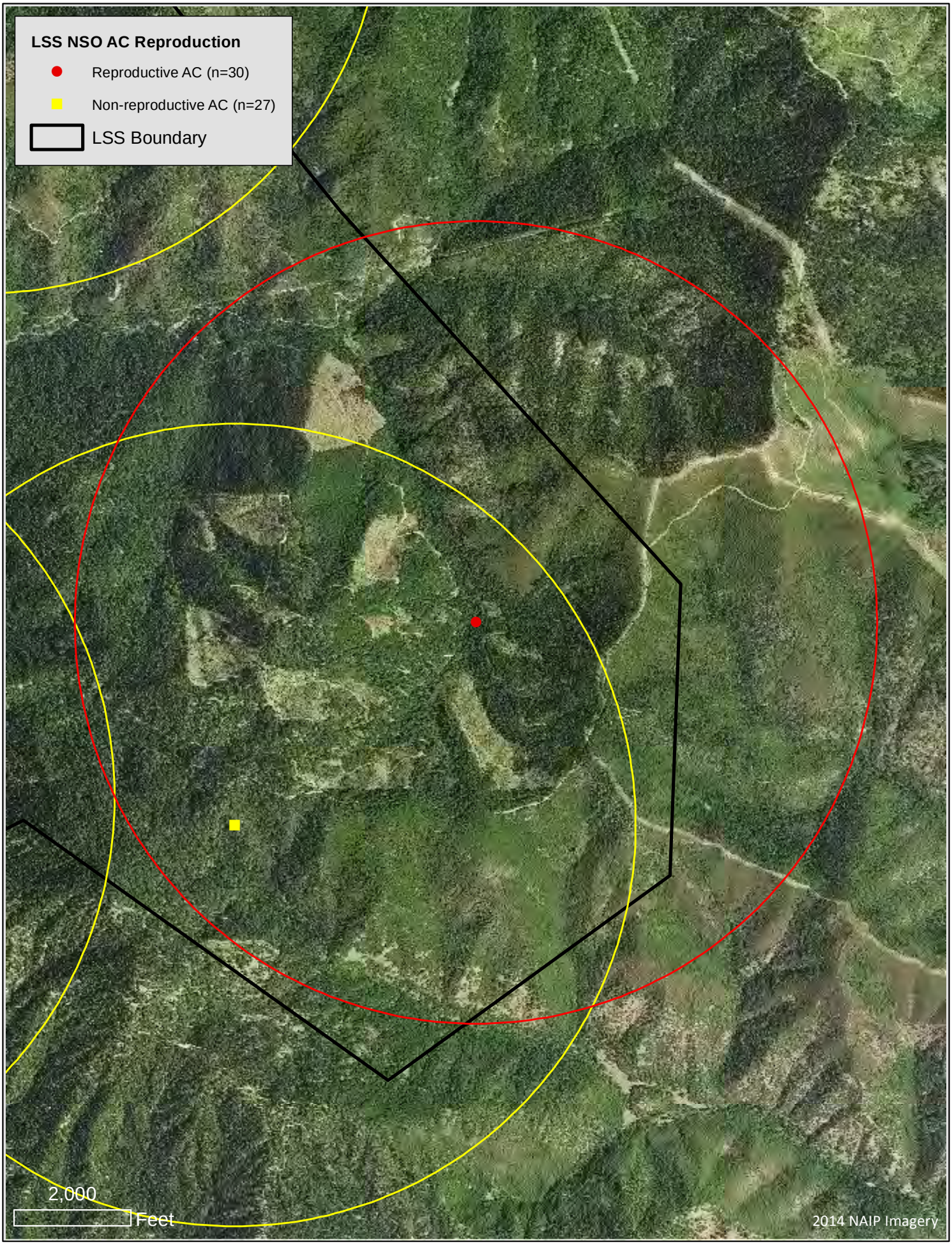
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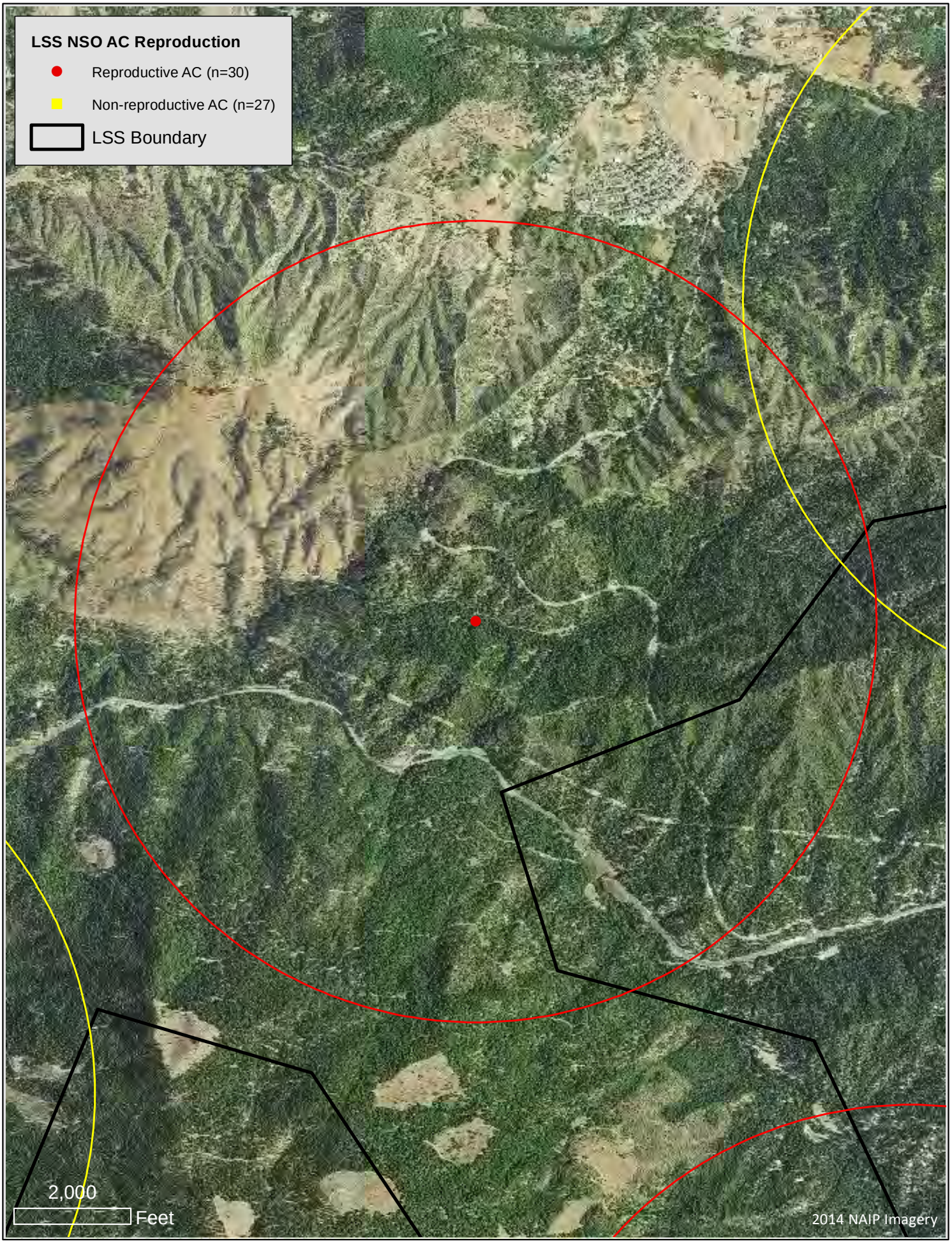
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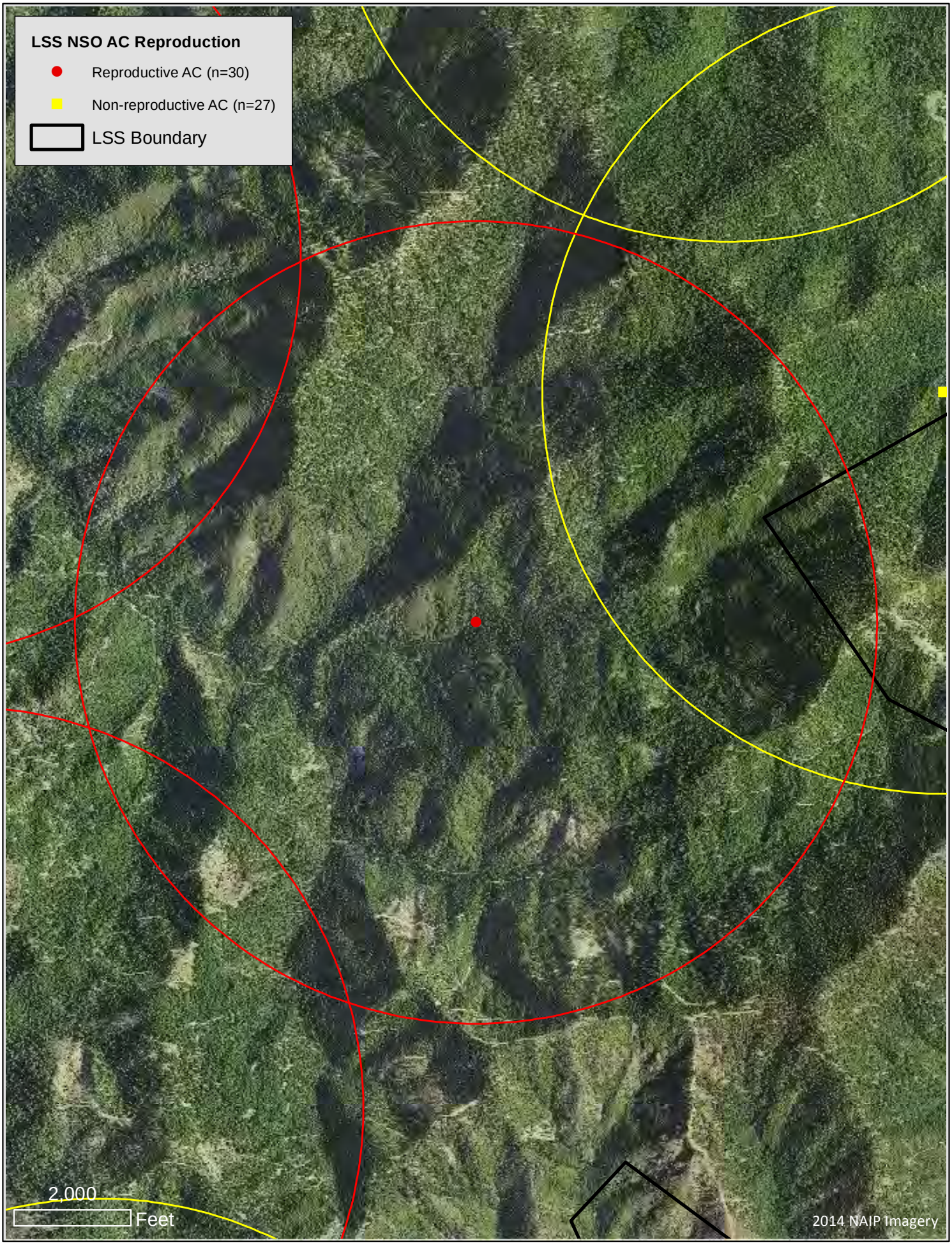
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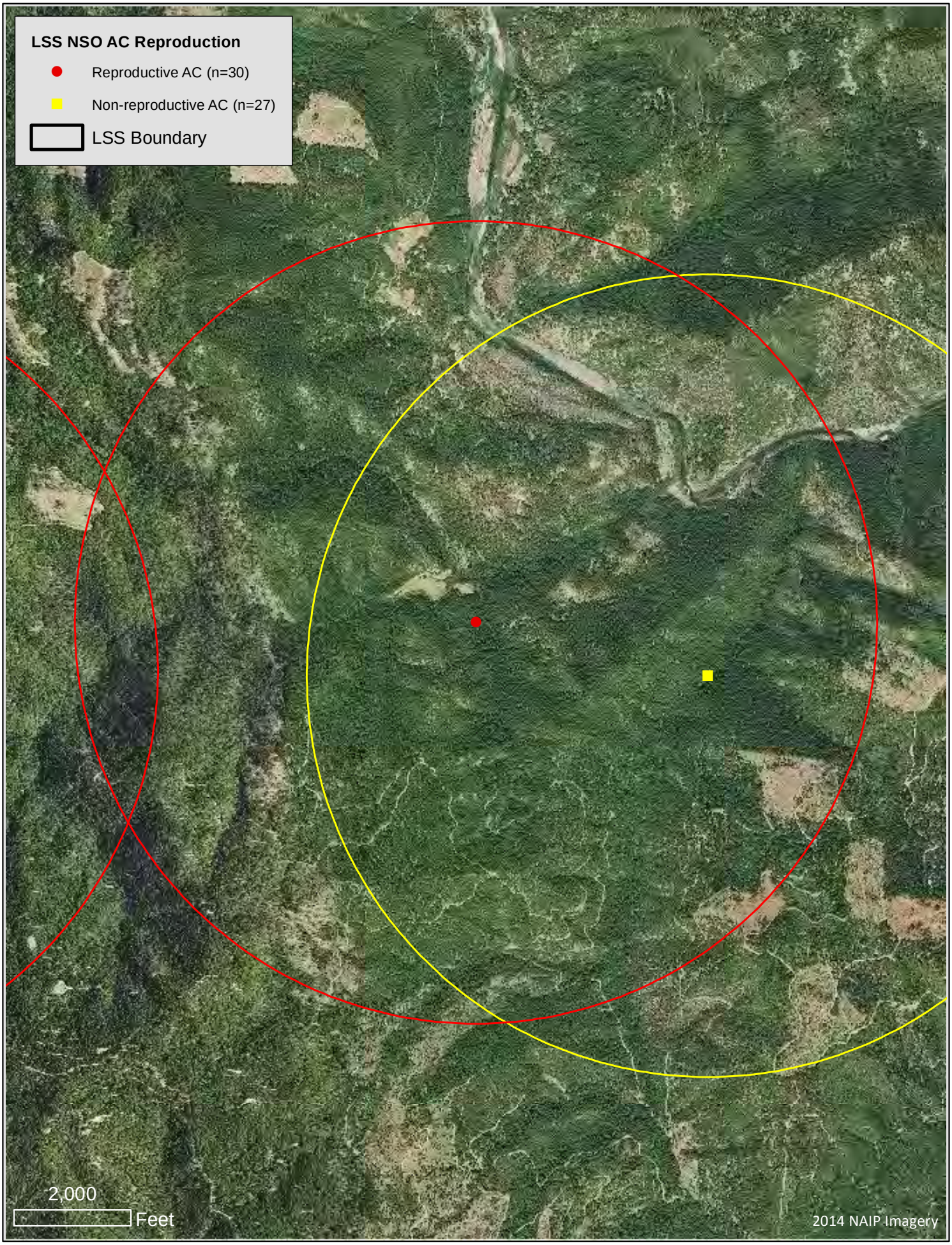
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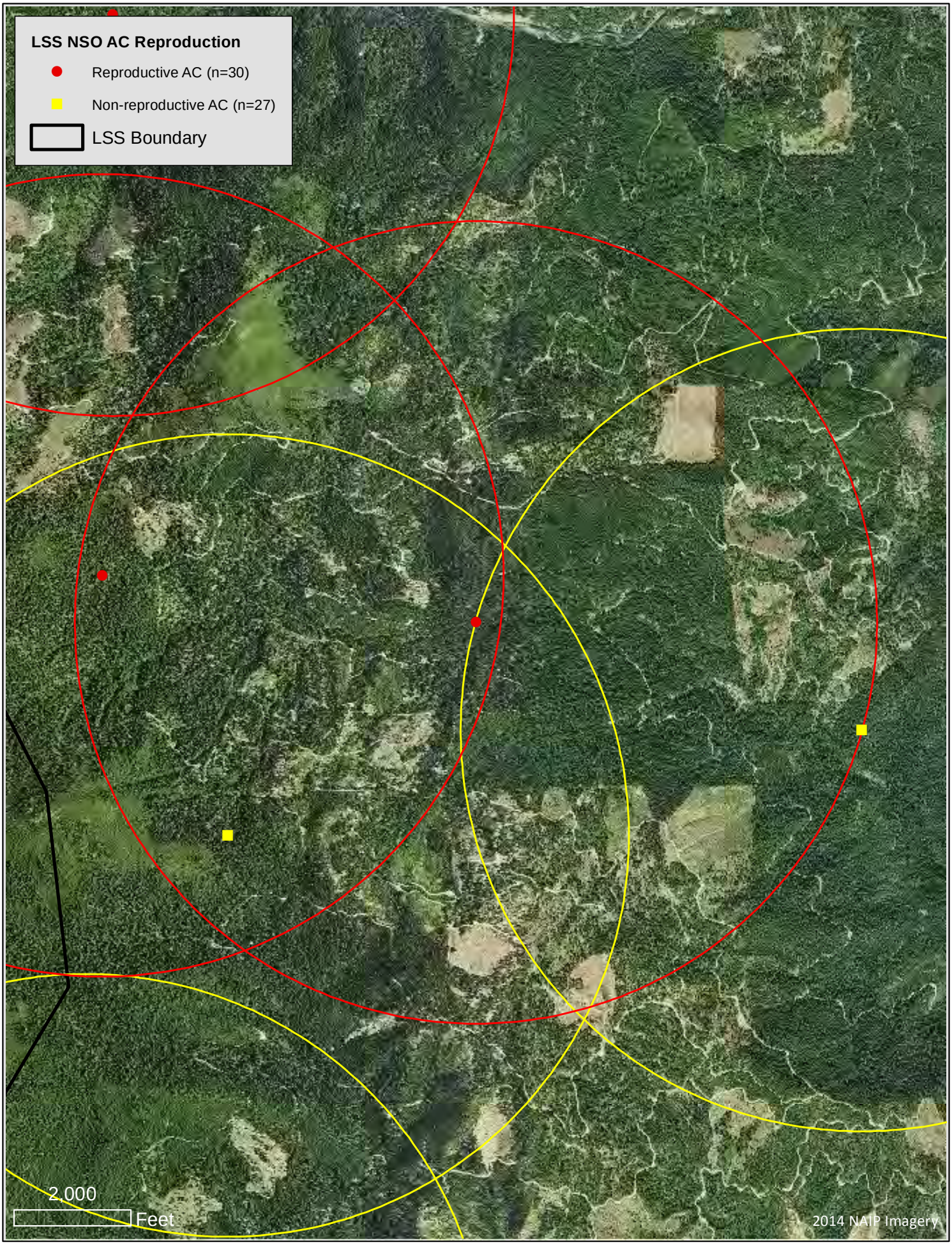
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Feet
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Northern Spotted Owls

Near Weaverville and Trinity Lake

In Trinity County

Within the Landscape Survey Strategy Area

(An Interim Report)

Sierra Pacific Industries
January 2016

Sierra Pacific Industries
Post Office Box 496014
Redding, California 96049-6014

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Sierra Pacific Research & Monitoring

Sierra Pacific Industries

Sierra Pacific Industries

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Phone (530) 378-8000 • FAX (530) 378-8139

Northern Spotted Owls near Weaverville and Trinity Lake, Trinity County
Within the Landscape Survey Strategy Area
(An Interim Report)
January 2016

Introduction

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

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

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

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

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

Results

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

In 2011, we began annual re-surveys of the LSS stations. During this five year effort, we found 57 occupied ACs within the original LSS area, 17 of which were in new locations (Figure 4). One activity center occupied during the 2003-2007 surveys was destroyed by wildfire prior to 2011. In addition, one occupied AC has continued to make minor movements throughout the resurvey period and has since been relocated outside the LSS boundary. Due to this bird originally being located within the LSS boundary and since it was included in the baseline and '03-07 analysis, it was included in the density calculations for this survey period even though it now falls just outside the LSS boundary.

Again, new ACs were usually near now unoccupied older ACs. Despite the single AC lost to wildfire, the estimated population density is stable to increasing. The raw density of 57 occupied ACs found on the 173,316 acre survey area results in 0.2105 occupied ACs per square mile. Up from 0.1736 in 2003-2007 based upon 47 occupied ACs and up from an estimated 0.1551 occupied ACs per sq. mi. in 1989 based upon an estimated 42 occupied ACs (80% of 52 known ACs). See table below:

Year	1989	80% (Recovery)	1989 - 2003	2003 - 2007	2011 - 2015
Occupied ACs	52 (max known 1974-1989)	42	47 (max)	47	57
Crude Density[1]	Not Applicable	0.1551[2]	0.1736[2]	0.1736	0.2105
Comment	Assumed 100% occupancy from CNDDB and SPI surveys since protocol surveys were not conducted.	Assume the population was a fully recovered population. (80% occupancy per 2008 NSO Recovery Plan)	Max estimate. Assumed all ACs occupied. (Removed 5 abandoned sites with USFWS concurrence)	Occupancy determined at all sites	Occupancy determined at all sites

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

In both of these survey periods, some ACs were determined to not have any responses and historically would have been declared abandoned by the USFWS. Service direction changed in this time period, and the 2012 protocol no longer included a definition for abandoning sites. Thus ACs from owls that may have moved on the landscape continue to increase in number while numbers of occupied ACs and density of owls increased.

In response to the Service's revision of the survey protocol in 2011, we switched to using electronic calling devices for these surveys, and also added over 180 new calling stations, extending geographic extent of the survey effort by about 40 percent, most of which is US Forest Service land within 1.3 miles of SPI ownership. This resulted in location of still more ACs outside the original LSS area; these sites have not been included in the summary

previously mentioned (Figure 5). Also, in 2011, we began banding all NSO on the ownership, so that in the future we will be able to ascertain whether birds in new locations are residents that have relocated, or whether they are immigrants. Since 2011, we have banded 178 NSO (118 adults/sub adults and 60 juveniles).

Reproduction

During this recent 2011- 2015 effort we were able to determine that 30 of these 57 occupied ACs were reproductive, producing at least 97 fledglings (Figure 6). This represents 60 individual successful nesting attempts as many of these AC's reproduced two to four times during this five year survey.

Summary and Conclusion

In summary, the uncertainty associated with the estimate of territories extant at the time of listing precludes precise comparison of numbers over the past 26 years. However, while we have seen some change in the location of occupied ACs, we see no indication of a population decline in the LSS area during the period between the 2003 - 2007 LSS surveys and the surveys being conducted now. While we recognize that this is a very small portion of the California population and our work is not a demographic study, it is worth noting that the LSS area apparently is not showing a similar decline as reported from the NSO demographics studies. The Willow Creek Study area (referred to as NWC) is the nearest USFS demographic study area to the LSS and they have an estimated annual decline of 3.0%. The current range wide demographic average is an estimated annual decline of 3.8% (Dugger et al, 2016).

Compared to those values our numbers of occupied ACs and density of owls appears to be increasing. If our study area NSOs were following these rates and assuming that our original 1989 AC count of 52 (minus those the service declared abandoned) we would have a 1989 starting estimate of 47 ACs. Applying the NWC demographic study estimated rate of decline our study area should have experienced a reduction to only 22.1 occupied ACs and based upon the NSO range wide estimated rate we should have only 18.1 occupied ACs today. Rather than those declines our LSS study area has had a net increase of 10 ACs from that estimated starting point.

Since the listing, over the past 26 years, all THPs have been conducted under no-take guidance in effect at the time of harvest. The increased survey effort, improved protocols, and initiation of banding should improve our understanding of the owl population in this area in the future.

In conclusion, to our knowledge, our LSS effort to determine the number of occupied ACs on a fixed area of land is the only existing dataset upon which to assess potential impacts over time of FPR - guided management on NSO density. This study shows that for the period from 2003 through 2015, despite active timber harvest, there has been only an increase in population density for this portion of the range of the NSO. While our current efforts have demonstrated movement of owls around this landscape, as described above, this has resulted in an increase in the number of ACs and a misleading percent occupied estimate. This resultant increase in overall AC count obscures the fact that actual numbers of "occupied" ACs and the density of owls have increased substantially since the listing of the owl.

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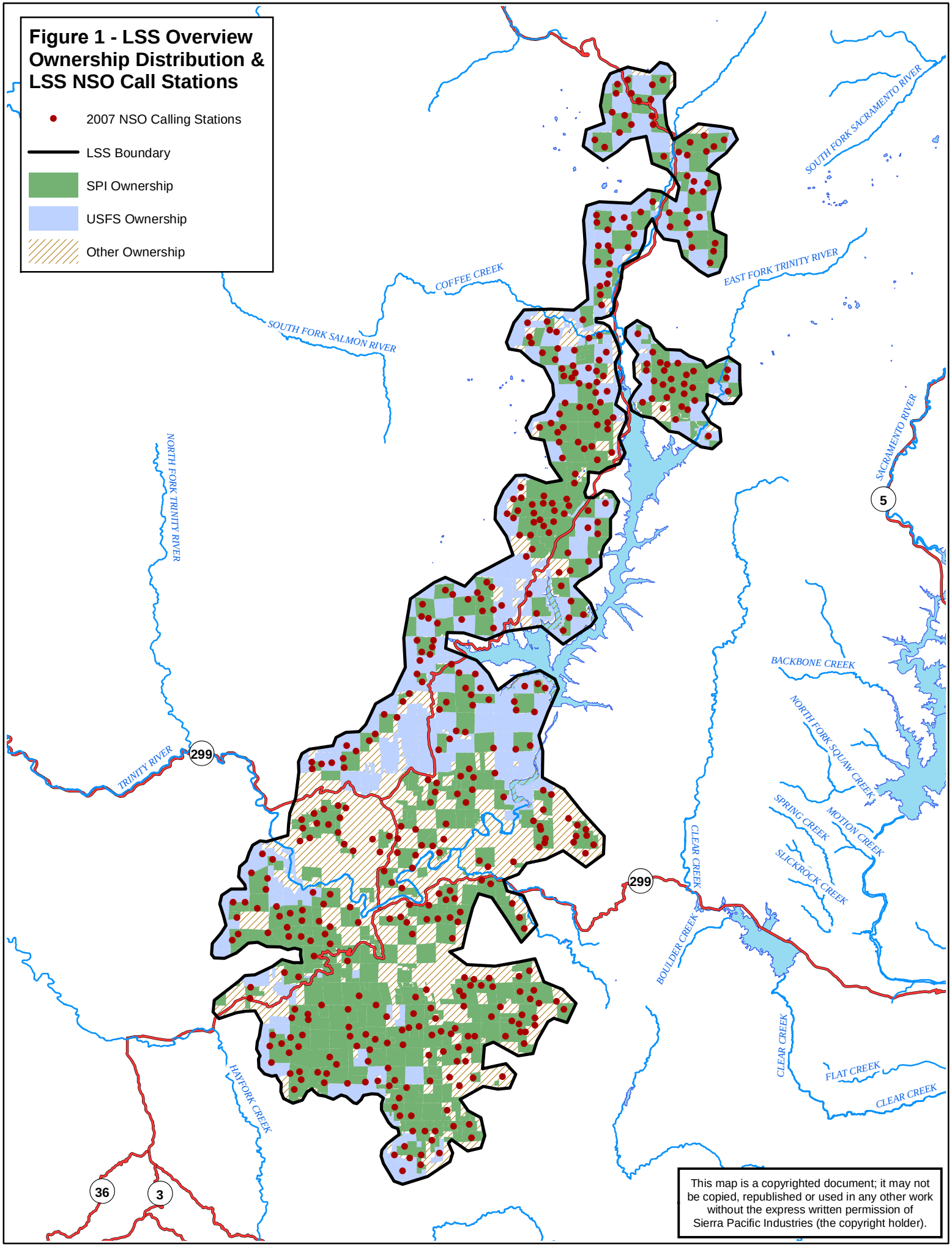

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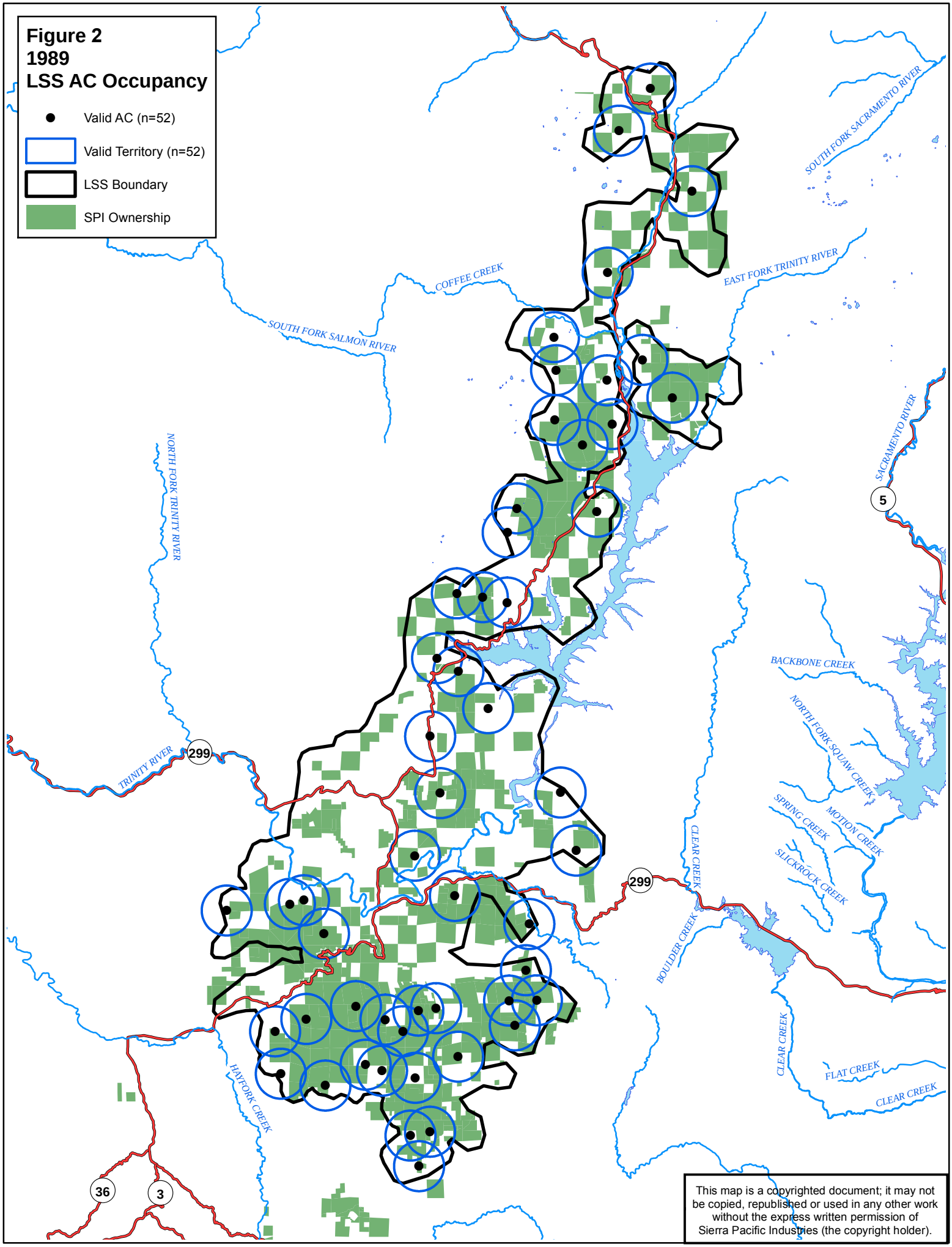

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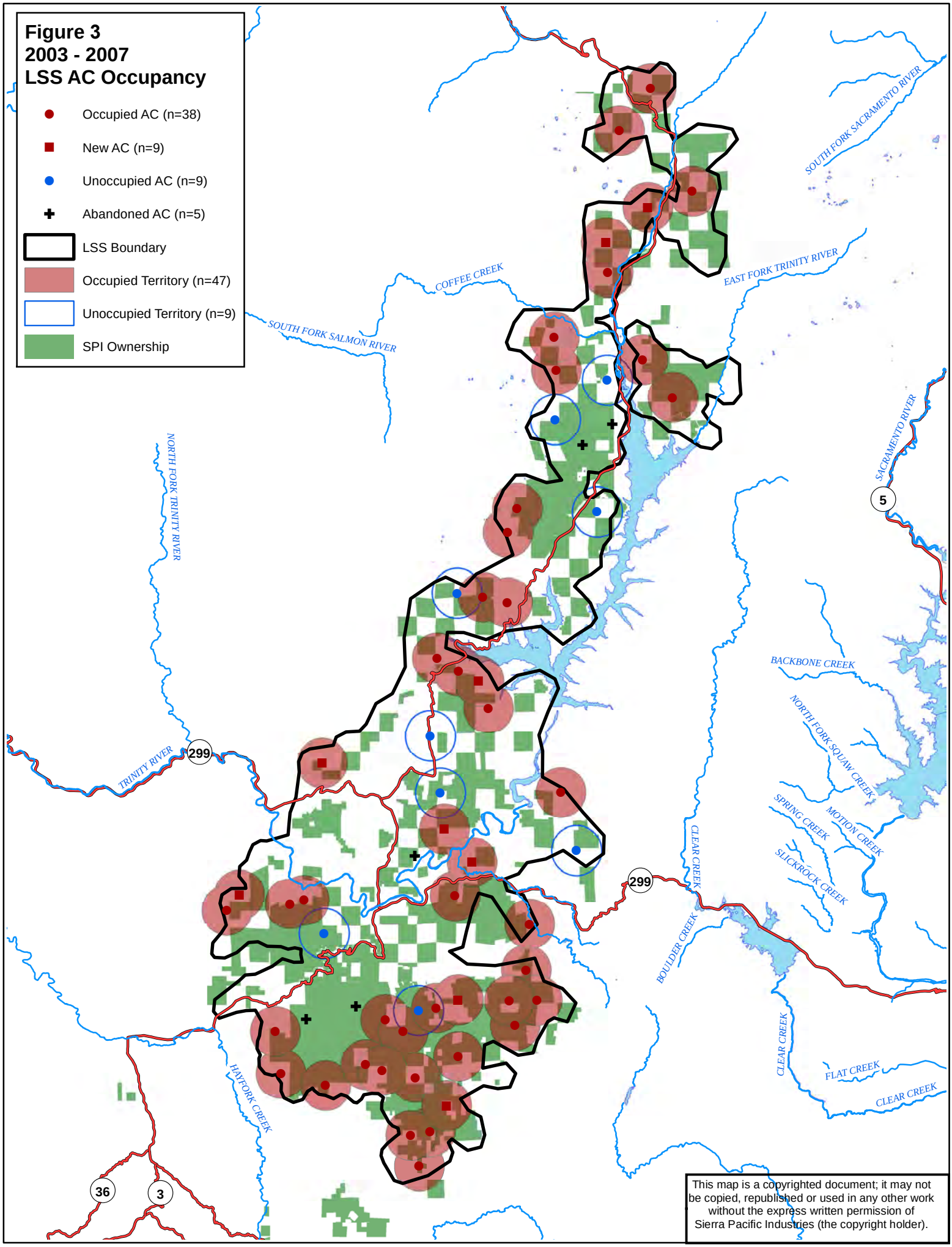
Figure 3
2003 - 2007
LSS AC Occupancy
Occupied AC (n=38)
New AC (n=9)
Unoccupied AC (n=9)
Abandoned AC (n=5)
LSS Boundary
Occupied Territory (n=47)
Unoccupied Territory (n=9)
SPI Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
SOUTH FORK SALMON RIVER
NORTH FORK TRINITY RIVER
SACRAMENTO RIVER
5
BACKBONE CREEK
NORTH FORK SQUAW CREEK
TRINITY RIVER
299
SPRING CREEK
MOTION CREEK
SLICKROCK CREEK
CLEAR CREEK
299
BOULDER CREEK
CLEAR CREEK
FLAT CREEK
CLEAR CREEK
HAYFORK CREEK
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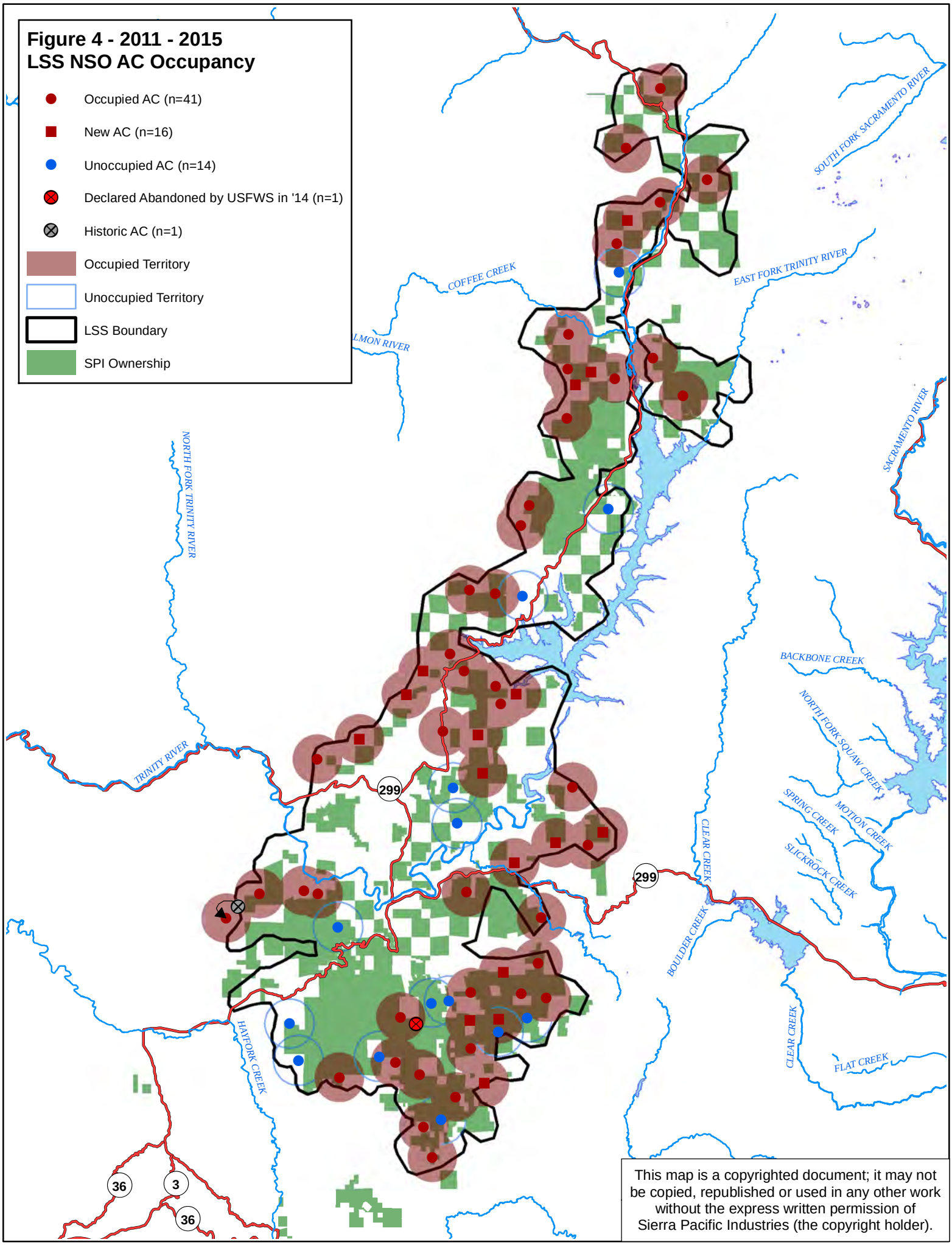
Figure 4 - 2011 - 2015
LSS NSO AC Occupancy
Occupied AC (n=41)
New AC (n=16)
Unoccupied AC (n=14)
Declared Abandoned by USFWS in '14 (n=1)
Historic AC (n=1)
Occupied Territory
Unoccupied Territory
LSS Boundary
SPI Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
LMON RIVER
NORTH FORK TRINITY RIVER
SACRAMENTO RIVER
BACKBONE CREEK
NORTH FORK SQUAW CREEK
TRINITY RIVER
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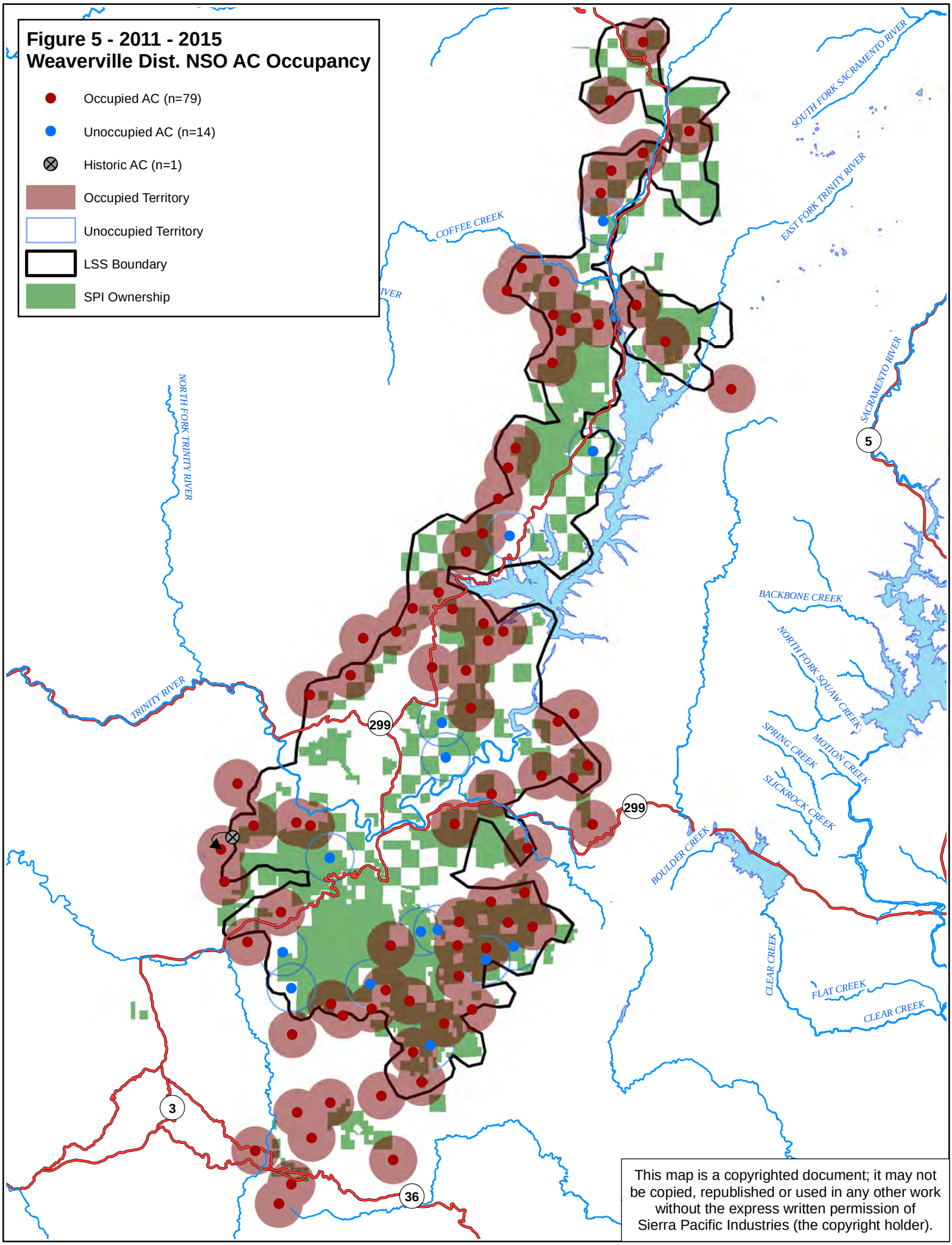

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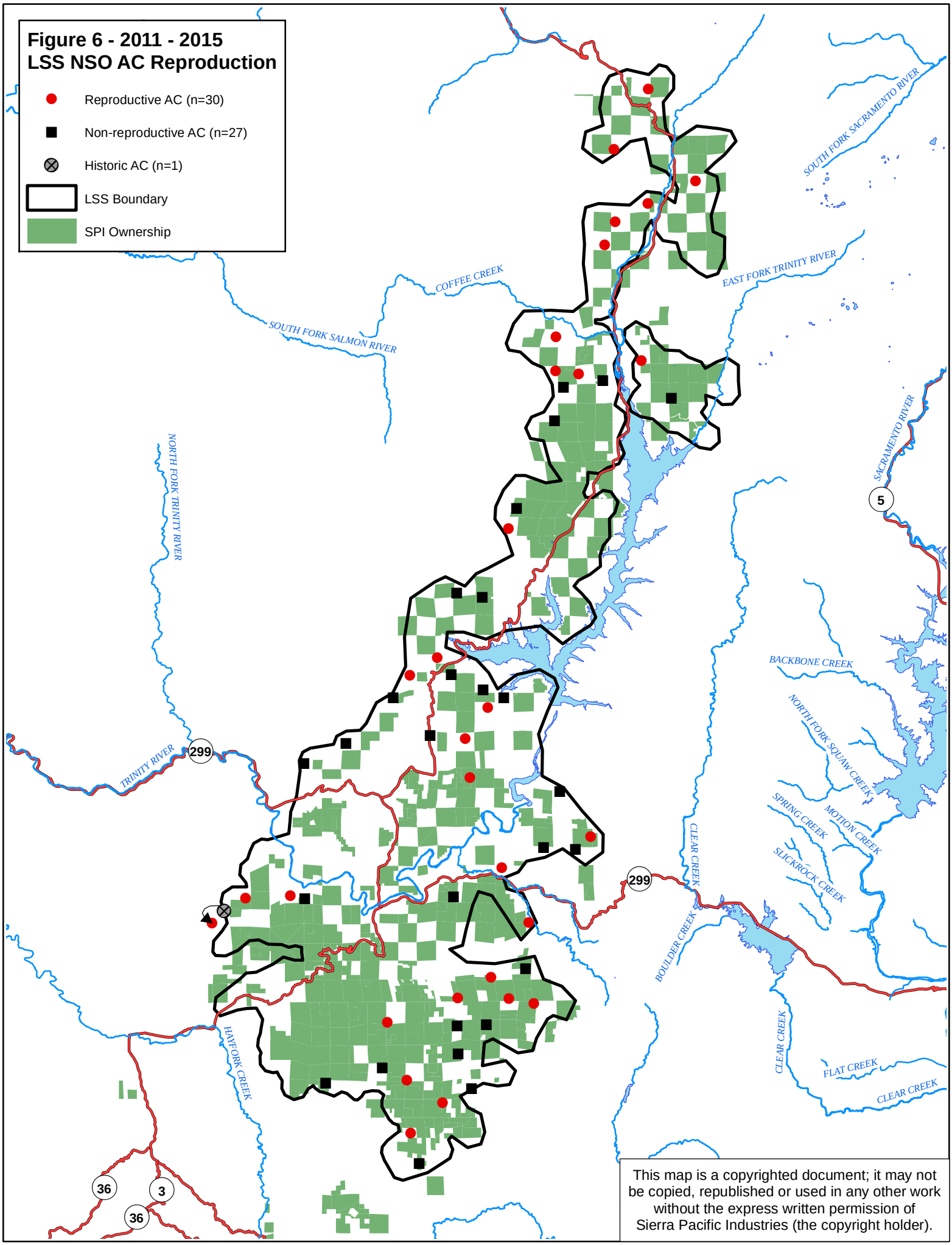

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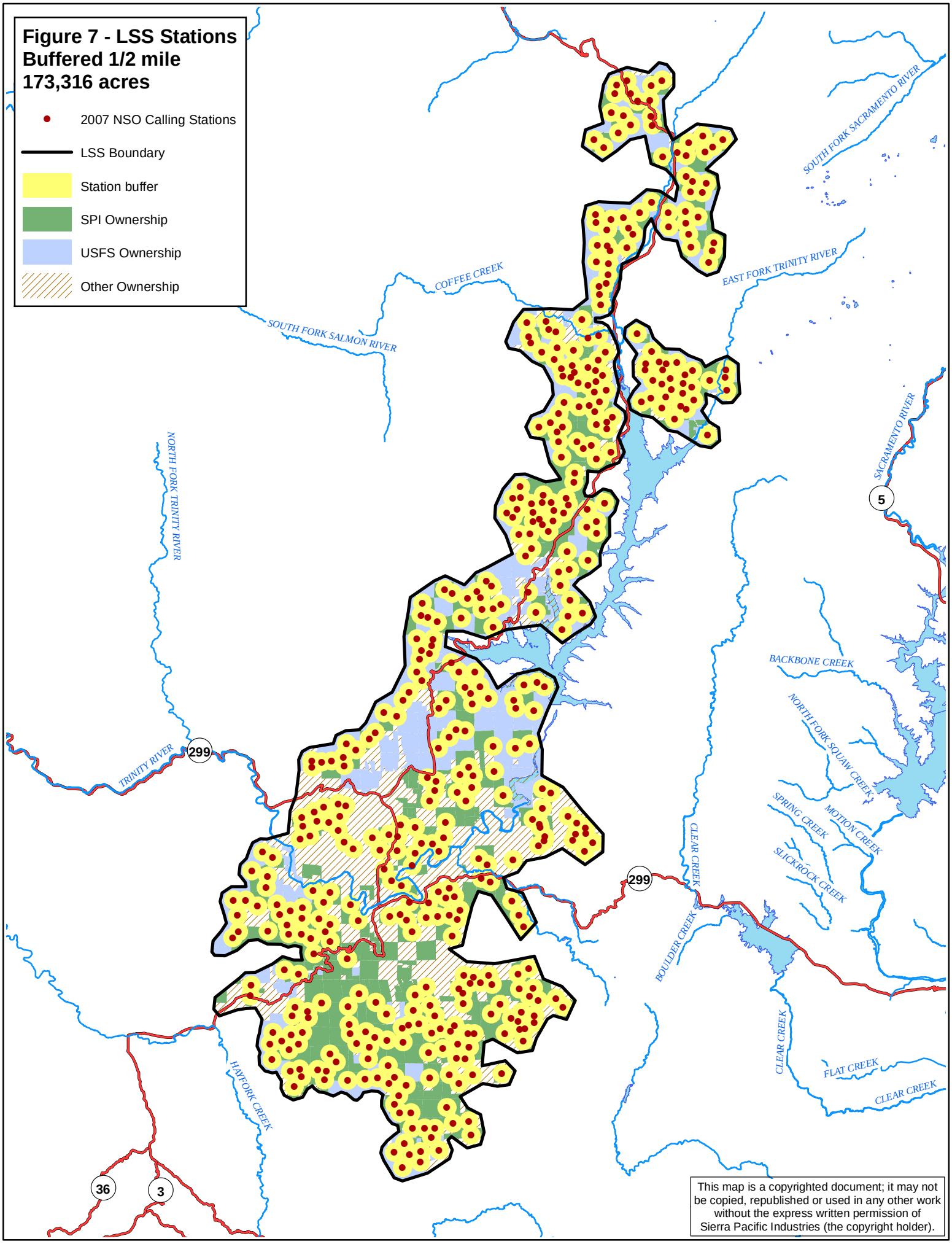
Figure 7 - LSS Stations
Buffered 1/2 mile
173,316 acres
2007 NSO Calling Stations
LSS Boundary
Station buffer
SPI Ownership
USFS Ownership
Other Ownership
SOUTH FORK SACRAMENTO RIVER
EAST FORK TRINITY RIVER
COFFEE CREEK
SOUTH FORK SALMON RIVER
NORTH FORK TRINITY RIVER
SACRAMENTO RIVER
5
BACKBONE CREEK
NORTH FORK SQUAW CREEK
TRINITY RIVER
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SLICKROCK CREEK
CLEAR CREEK
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BOULDER CREEK
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FLAT CREEK
CLEAR CREEK
HAYFORK CREEK
36
3
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Keeping Northwest California wild since 1977

Sent to: fgc@fgc.ca.gov on date shown below

March 30, 2016

Mr. Eric Sklar, President
California Fish and Game Commission
1416 Ninth Street, room 1320
Sacramento, CA 95814

Re: EPIC Comments regarding Listing Determination for Northern Spotted Owl (*Strix occidentalis caurina*)

Dear President Sklar and Commissioners:

The following comments are submitted on behalf of the Environmental Protection Information Center (EPIC) regarding agenda item #25 for the April 14, 2016 Fish and Game Commission meeting regarding the determination on EPIC's petition to list the northern spotted owl (*Strix occidentalis caurina*) as a "threatened" or "endangered" species under the California Endangered Species Act (CESA). EPIC appreciates the opportunity to provide comments at this stage of the process.

Summary

The petition to list the northern spotted owl (NSO) under CESA, and the subsequent investigatory process undertaken by the Commission, and the Department, as well as the overwhelming body of otherwise available scientific and commercial information on the status, trends, and threats to the species in California, and the well-documented need for enhanced management actions to ensure the survival and recovery of the NSO in the wild in California, all clearly point to the obvious conclusion that the listing of the NSO as an "endangered" rather than a "threatened" species "is warranted," and that the Commission should act promptly, and accordingly.

Petition and Petition Evaluation History

On September 4, 2012 EPIC submitted its petition to list the northern spotted owl as either a "threatened or "endangered" species under CESA (hereafter, "petition") to the Commission. On December 12, 2012, the Commission received and granted a request from the Department for a 30-day extension on the Department's

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(707) 822-7711
www.wildcalifornia.org

delivery of its Initial Evaluation of the petition. The Department's Initial Evaluation was not actually available for acceptance by the Commission until its March 6, 2013 meeting.

On April 17, 2013 the Commission conducted its initial hearing on the petition to determine whether or not the action requested "may be warranted." After public comment and discussion, the Commission voted to "defer" a decision on the matter until its August, 2013 meeting. At this same meeting, the Commission rejected a timber industry-lead petition requesting the adoption of emergency regulations pursuant to section 2084 of the Fish and Game Code to allow for incidental take for the NSO.

On August 7, 2013, the Commission once again considered whether the petitioned action "may be warranted." The official summary for that meeting document that the Commission decided that the petitioned action to list the NSO as either a "threatened" or "endangered" species under CESA "may be warranted," and therefore designated the NSO as a "candidate" for listing.

The Commission directed the "the Department…to promptly commence a status review for the species and report back to the Commission within one year from the date of the Commission's published findings with a recommendation as to whether the species should or should not be listed as endangered." The Commission acted to adopt findings in support of its August 7, 2013 decision to accept the petition.

At the February 2016 Commission meeting, the Department submitted its status review for the NSO, which is based on the best currently-available commercial and scientific information on the status and trends of, and threats to, the NSO, and has recommended to the Commission that listing of the NSO under CESA, "is warranted."

We revisit the petition's procedural history here, simply in an effort to point out the highly irregular and unusual delays and deferment to which our petition to list the NSO has been subjected in its long procedural history. EPIC encourages the Commission to take swift and definitive action to list the NSO under CESA at this time.

The Listing of the NSO under CESA is "Warranted"

The listing of the northern spotted owl under CESA is clearly warranted, as is evidenced by the EPIC 2012 petition, the Hansen (2015) independent status review, the CDFW February 2016 status review and associated recommendation, the latest range-wide long-term demographic study (Dugger et al. 2016), and a wealth of other readily-available commercial and scientific information clearly demonstrating that the NSO is in peril in California and throughout its range, and in alarming decline, and that the rate of decline is accelerating, including in all areas studied in California, in recent years.

EPIC's August 2012 petition to list the NSO under CESA requested that the Commission act to list as either "threatened" or "endangered." In the nearly four years that have passed since the submittal of our petition, however, the plight of the NSO has continued to become more acute, and the overwhelming body of available commercial and scientific information now leads to the conclusion that the NSO is, in fact an "endangered" species, based on the CESA definition.

According to the California Fish and Game Code, "endangered species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease. Any species determined by the commission as "endangered" on or before January 1, 1985, is an "endangered species." (F&GC section 2062).

The operative language in statute to be used as the guide-post for determining if a species is "endangered" as opposed to "threatened," is the, "*serious danger of becoming extinct throughout all or a significant portion of its range…"* In an effort to directly address the question of the danger that the NSO is at serious risk of extinction in the present, we provide the following observation from Dugger et al. (2016):

> "In the study areas where habitat was an important source of variation for Spotted Owl demographics, vital rates were generally positively associated with a greater amount of suitable owl habitat. However, Barred Owl densities may now be high enough across the range of the Northern Spotted Owl that, despite the continued management and conservation of suitable owl habitat on federal lands, the long-term prognosis for the persistence of Northern Spotted Owls may be in question without additional management intervention." (Dugger et al. 2016, abstract).

In conjunction with this grim assessment, the U.S. Fish and Wildlife Service also issued a "positive" Initial 90-Day finding on an EPIC petition to the Service requesting, "reclassification," or "uplisting" of the NSO from a "threatened" to an "endangered" species under the federal ESA, and published this in the federal register on April 10, 2015. (50 CFR 19259, April 10, 2015).

The overwhelming preponderance of the available commercial and scientific information available on the status of the NSO in California, and range-wide, suggests that the multitude of threats to the survival of the species in the wild, most notably, the ever-increasing one-two punch combination of past and ongoing habitat loss and competition from barred owls (*Strix varina*) are driving the NSO to the point where extinction is a likely and predictable outcome in the absence of greater and additive human management intervention and implementation of recovery actions.

In sum, the extinction of the NSO in California, and range-wide, is no longer a possibility that looms speculatively off somewhere in the future; indeed, information from long-term demographic study areas in other states, elsewhere in the range of the NSO, clearly shows us that extinction is a clear and present danger, and is in fact occurring before our very eyes.

This fact is also clearly spelled out in the CDFW's status report for the northern spotted owl, which states:

> "Northern Spotted Owl populations are declining throughout the range of the subspecies and annual rates of decline have been accelerating in many areas, including in California. The range-wide population of Northern Spotted Owl is estimated to have declined by 3.8% per year since 1985. On three large study areas in California, vital rates estimated from long-term datasets, including fecundity, survival, site occupancy, and rate of population change are declining, and the rates of population decline have accelerated in recent years on all three areas. The declines in vital rates and populations in California have deteriorated to levels previously restricted to more northerly portions of the subspecies' range in Washington and Oregon. Population sizes at California study areas have declined 31-55% since the 1990s and these declines are accelerating. The rates of site occupancy at known territories in these California study areas and on additional private lands in the Cascades have declined by 39-49% since 1995. The ongoing and increasing effects of Barred Owls on Northern Spotted Owl populations, coupled with other threats including habitat loss due to timber harvest and wildfire and reduced recruitment due to climate change, will lead to additional declines in Spotted Owl populations unless additional management intervention is undertaken." (CDFW 2016, at p. 2).

Despite over 25 years of federal ESA protections, and substantial and positive land management changes on federal lands in California, and elsewhere in the range of the NSO, the species continues its precipitous spiral towards oblivion, range-wide, and here in California. The status, trends, and available scientific and commercial information before the Commission clearly indicates that the NSO is now "endangered" and should be listed as such in response to the EPIC 2012 petition.

Conclusion

The listing of the NSO pursuant to EPIC's 2012 petition is plainly warranted, and the available scientific and commercial information before the Commission clearly indicates that list of the NSO as an "endangered" species is warranted, in accordance with the definition embedded in F&GC section 2062. EPIC therefore urges the Commission to act promptly to list the NSO as an "endangered" species pursuant to the process articulate in section 2075.5 (a)(2) of the Fish and Game Code.

Sincerely,

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