



Monitoring Northern Spotted Owls on Federal Lands in Marin County, California

2017 Report

Natural Resource Report NPS/SFAN/NRR—2018/1677



ON THE COVER

Female northern spotted owl on a platform nest.

Photograph by Taylor Ellis

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Abstract

This report provides a summary of results from the 2017 field season of the National Park Service's (NPS) northern spotted owl (*Strix occidentalis caurina*) monitoring program in Marin County, California. The northern spotted owl has been listed as a federally threatened species since 1990. The Marin County population of spotted owls is of interest because of its isolation from other populations, high density and fecundity, and because they have been minimally impacted by barred owl (*Strix varia*) range expansion. The goals of our northern spotted owl monitoring program are to estimate trends in spotted owl occupancy and fecundity within the NPS legislative boundaries in Marin County.

A total of 37 known spotted owl sites were randomly selected and monitored using standardized methods during the 2017 breeding season. Pairs of spotted owls occupied 25 of these 37 (68%) long-term monitoring sites. Of the 25 territorial females in 2017, 22 females (88%) attempted nesting. Twenty of the nests were successful and yielded a confirmed total of 34 fledged young. A total of 3 non-nesting females were confirmed at the 37 sites. In 2017, the fecundity estimate of 0.74 (SE ± 0.08) was well above the average fecundity of 0.38 (SE ± 0.08) measured at monitoring sites from 1999 to 2017.

We recommend continued annual monitoring of the spotted owl population, and continuing to share information and work with land managers and county officials to reduce potential adverse impacts of projects on spotted owls. Research focused specifically on barred owls and their impacts on spotted owls in Marin County should be continued. In addition, studies investigating the effects of Sudden Oak Death on spotted owls also are needed. The NPS should continue to provide outreach materials related to spotted owl awareness and recovery.

Acknowledgments

This project has been made possible by funding from the following agencies and organizations: San Francisco Bay Area Network Inventory and Monitoring Program, Point Reyes National Seashore, Golden Gate National Recreation Area, Muir Woods National Monument, Golden Gate National Parks Conservancy, and Point Reyes National Seashore Association. The NPS monitors spotted owls in cooperation with Point Blue Conservation Science, Marin Municipal Water District, Marin County Open Space District, and California State Parks.

This project has benefited from the assistance of numerous staff members from past years. Sarah Allen, Daphne Hatch, Mia Monroe, and Geoffrey Geupel pioneered northern spotted owl monitoring in Marin County and successfully directed land management agencies towards the importance of spotted owl management in Marin County. Daniel George of NPS designed the monitoring program database, which was upgraded in 2016 by Lizzy Edson and Sarah Wakamiya. Our annual report is modeled after a template that was refined over several years by Dawn Adams, Heather Jensen, Dave Press, and Bill Merkle. Dave Press and Bill Merkle currently provide supervisory oversight of the monitoring program. Lastly, we are grateful for the numerous field biologists and interns that have worked thousands of hours monitoring northern spotted owls in Marin County since 1998.

Introduction

The mission of the National Park Service (NPS) is “to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations” (16 U.S.C. 1). To uphold this goal, Congress approved the Natural Resource Challenge in 1998 to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (PL 105-391). The NPS Inventory and Monitoring Program organized 270 parks in the national park system into 32 inventory and monitoring networks. The networks use common methodologies for data comparability, to reduce the level of effort, and to share resources. The San Francisco Bay Area Network (SFAN) includes Eugene O’Neill, John Muir, and Fort Point National Historic Sites, the Presidio of San Francisco, Muir Woods National Monument (MUWO), Pinnacles National Park, Point Reyes National Seashore (PORE), and Golden Gate National Recreation Area (GOGA). SFAN has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent is to monitor a balanced and integrated “package” of vital signs that meets the needs of current park management, but will also be able to accommodate unanticipated environmental conditions in the future. Northern spotted owls (*Strix occidentalis caurina*) represent a vital sign for SFAN due to their federally threatened status, ecological significance, and high interest to the public (Adams et al. 2006, Press et al. 2010).

Life History

The northern spotted owl has been listed as a federally threatened species under the Endangered Species Act since 1990. Northern spotted owls inhabit forested regions from southern British Columbia through Washington, Oregon, and northwestern California. They reach the southern limit of their range in Marin County, California, north of San Francisco, where they occur on NPS lands (GOGA, MUWO, PORE), and other public and private lands in Marin County.

In the majority of their range, northern spotted owls are typically found in mature coniferous forests (Forsman et al. 1984). In Marin County, they inhabit second growth and old growth Douglas fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), mixed conifer-hardwood, and evergreen hardwood forests. All forest types and ages contain a significant hardwood component. A nest site occurrence model developed in cooperation with Point Blue Conservation Science indicated that forest connectivity, areas with more forest cover, less forest edge and urban development, and topographic conditions such as locations lower in the watershed, closer to streams, and more south-facing aspects, were the strongest predictors of spotted owl presence (Stralberg et al. 2009).

Spotted owls in Marin County use a variety of tree species of differing sizes for nesting, and typically nest in platform structures, with relatively few nests in cavities. Platform nesting structures in Marin County have included tree forks, large limbs, broken top trees with lateral branches, old raptor, corvid, squirrel, and woodrat nests, debris piles, poison oak tangles (*Toxicodendron diversilobum*)

and dwarf mistletoe infestations (*Arceuthobium* spp.). Cavity nests included both side entry and top entry cavities. Spotted owl nests have been documented in tree species including coast redwood, Douglas fir, bishop pine, California bay (*Umbellularia californica*), tanoak (*Lithocarpus densiflorus*) and coast live oak (*Quercus agrifolia*).

An inventory of most of the forested habitat in Marin County was conducted in 1997 and 1998 (Chow and Allen 1997, Chow 2001), with a second inventory focusing on federal lands in Marin conducted in 2006 (Jensen et al. 2007). Monitoring of the Marin County spotted owl population has occurred from 1999 to 2017 (see Appendix A for monitoring program bibliography). The Marin County study area supports one of the highest known densities of northern spotted owls within its range (Chow 2001, Blakesley et al. 2004, Stralberg et al. 2009). As estimated in a 2006 range-wide, demographic analysis, adult survival and fecundity in Marin County were apparently stable from 1998 to 2003 (Anthony et al. 2006). Out of a total of 14 study sites, fecundity of adult females in Marin County was the second highest and the Marin County adult survival estimates were similar to most other sites (Anthony et al. 2006).

Spotted owls in Marin County forage primarily on dusky-footed woodrats (*Neotoma fuscipes*), which make up over 75% of their diet by weight (Chow and Allen 1997, Fehring 2003). Zabel et al. (1995) found that in areas where the dusky-footed woodrat is their primary prey species, spotted owls tend to have smaller home ranges and higher reproductive rates. This may explain the high density and fecundity estimates of the spotted owl population in Marin County (Chow 2001, Anthony et al. 2006, Jensen et al. 2007), however additional research is needed to confirm high densities of dusky-footed woodrats in Marin County. Other prey species taken by spotted owls in Marin County include small mammals such as deer mice (*Peromyscus maniculatus*), California meadow vole (*Microtus californicus*), and brush rabbit (*Sylvilagus bachmani*) as well as a variety of forest-dwelling birds (Chow and Allen 1997, Fehring 2003).

Threats to the Population

In the 2011 Northern Spotted Owl Revised Recovery Plan, the US Fish and Wildlife Service (USFWS) identified past and current habitat loss as threats to the spotted owl, despite significant reductions in timber harvest on federal lands over the last two decades (USFWS 2011). The recovery plan acknowledged, however, that protecting and managing spotted owl habitat alone is not adequate for spotted owl recovery and the USFWS prioritized barred owls (*S. varia*) as a “significant and complex threat” (USFWS 2011). The suite of threats present in Marin County mirrors the range-wide concerns and reflects the area’s close proximity to the greater San Francisco Bay Area. Threats (ranked according to perceived risk level in Marin County) include: (1) interspecific competition due to the continued range expansion of the barred owl, (2) loss of habitat resulting from urban development along open space boundaries and increased risk of catastrophic wildfire, (3) structural changes in forest heterogeneity due to Sudden Oak Death (SOD), (4) genetic isolation, (5) disturbance due to intense recreational pressures, and (6) West Nile virus (Press et al. 2010).

The threat from barred owls is of particular concern to the spotted owl population in Marin County (Anthony et al. 2006, Jennings et al. 2011). Barred owls have expanded their range from the eastern United States west across the Canadian Rocky Mountains and down the west coast. Barred owls

exploit the same forested habitats and prey species as spotted owls (Wiens 2012). However, barred owls are slightly larger than spotted owls and can exhibit aggressive behavior toward spotted owls. Temporary and permanent displacement of spotted owl pairs from their historic sites as a result of the spread of barred owls into the spotted owl's range has been documented by biologists in the Pacific Northwest (Gremel 2000) and the sharpest declines in the spotted owl population have occurred in the northern portion of the spotted owl's range where barred owls have been present the longest (Anthony et al. 2006). Evidence of negative effects of barred owls on spotted owls include territorial exclusion (Hamer 1988, Hamer et al. 2007) and declines in site occupancy (Kelly et al. 2003, Olson et al. 2005), reproduction (Olson et al. 2004), and apparent survival (Anthony et al. 2006). Barred owls were first detected in Marin County in 2002, and have been documented as reproducing in 2007, 2008, 2011, 2012, 2013, and 2014. Confrontations and aggressive interactions between barred and spotted owls have been documented at multiple spotted owl sites within Marin County (Jennings et al. 2011).

Small populations at the edges of a species' range have a much higher risk of local extinction, due to environmental and demographic stochasticity (Gilpin and Soulé 1986). The Marin County population is isolated from the spotted owl populations to the north and shows no evidence of hybridization with California spotted owls (*S. o. occidentalis*; Henke et al. 2003, Barrowclough et al. 2005). A break in forested habitat, expansive grasslands and anthropogenic development serve as dispersal barriers and have isolated the Marin County population from its northern counterparts. Barrowclough et al. (2005) indicated that due to the apparent genetic isolation of Marin County's spotted owl population, the population warrants special management attention.

Currently, forests in Marin County are heavily infested by the pathogen (*Phytophthora ramorum*) that causes SOD. At several locations within PORE, tanoak mortality due to SOD has exceeded 95% by basal area (Moritz et al. 2008). The die-off of native coast live oak and tanoak species is locally important because it results in shifts in plant species composition, possible reduction in plant species richness, and potential impacts on forest dynamics. Specifically the dusky-footed woodrat, the spotted owl's dominant prey item in this area, uses tanoaks for cover and forage (Sakai and Noon 1993). Oak mortality from SOD has been shown to negatively affect woodrat abundance in Marin County forests (Swei et al. 2011). The effects of SOD may also amplify fuel load accumulations and increase the potential and severity of fires (Forrestel et al. 2015).

NPS lands in Marin County are situated within the immediate San Francisco Bay Area and receive several million human visitors each year. Spotted owl nest sites in Marin County are generally close to roads and trails. This is likely the result of the high density of trails and fire roads located within potential spotted owl habitat including riparian drainages where owls often nest. As a result, spotted owls in the region have a high potential for interaction with humans. Furthermore, spotted owl territories located on a matrix of public and private lands or near the wildland-urban interface face an increased risk of injury and death due to effects of human related activities including poisoning, domestic animal interactions, nest site disturbance, and collisions with vehicles.

Monitoring Objectives

The three current monitoring objectives for the SFAN northern spotted owl monitoring program (Press et al. 2010) are:

- 1) Monitor long-term trends in northern spotted owl site occupancy rates of territories within the legislated NPS boundaries of Marin County, California.
- 2) Monitor long-term trends in northern spotted owl fecundity (number of female young per territorial female) within northern spotted owl territories within the legislated NPS boundaries of Marin County, California.
- 3) Determine long-term trends in northern spotted owl nest site characteristics including nest tree metrics and abiotic and biotic habitat characteristics to evaluate changes in nesting habitat associations within the legislated NPS boundaries of Marin County, California.

Methods

Study Area

Our study area is within a 36,098 acre forested area of Marin County and includes suitable spotted owl habitat inside or within 400 meters (0.25 mile) of the legislative boundaries of GOGA, MUWO, and PORE (Figure 1; Press et al. 2010). California State Park (CSP) lands in Mount Tamalpais State Park, Samuel P. Taylor State Park, and Tomales Bay State Park are included in the study area. Not included in the study area acreage calculation are additional management sites that occur outside the perimeter of federal lands on CSP, the City of Mill Valley, the Marin Municipal Water District (MMWD), and the Marin County Open Space District (MCOSD) lands. These sites are monitored by Point Blue using similar methods.

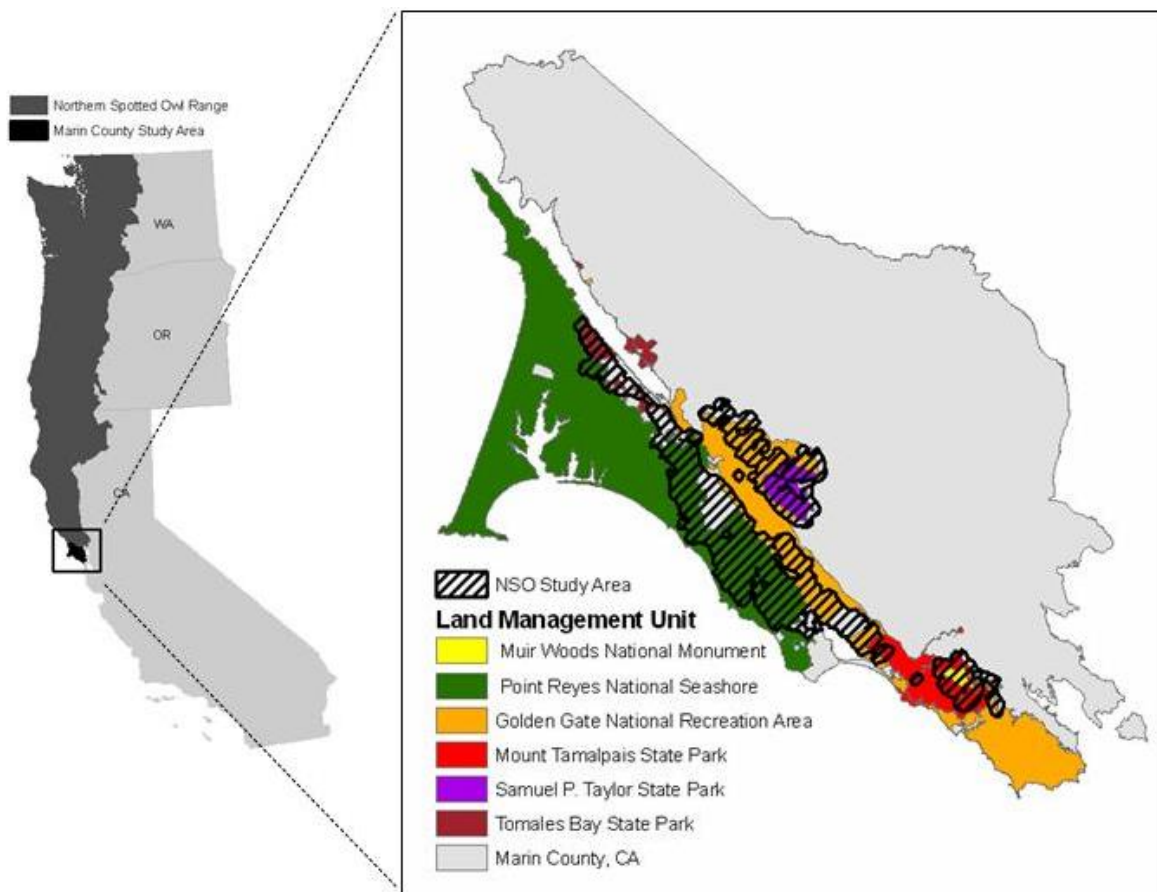


Figure 1. Northern spotted owl range map and Marin County study area. On the left, the dark gray shows the northern spotted owl's range and the black square is centered on Marin County. On the right, land management units included in the Marin County study area are color coded. The study area itself is shaded in black, diagonal lines.

Monitoring History and Study Design

In a 1997–1998 spotted owl inventory study, all evergreen forest habitat located on federal lands within Marin County was thoroughly and systematically surveyed for spotted owl presence using the

USFWS protocol (USFWS 1992). Additional surveys on MMWD and MCOSD lands were completed in 1999 (Hatch et al. 1999). A total of 83 spotted owl sites, including 53 pairs, were identified on public lands in Marin County (Hatch et al. 1999, Chow 2001).

Between 1999 and 2005, 46 sites were monitored annually for occupancy and fecundity and nest site characteristics were collected. The sites were chosen to represent a variety of habitat types, ongoing management concerns, accessibility, and funding availability. Due to the non-random monitoring site selection process, the study design limited the ability to make valid inference across federal lands in Marin County. As a result, we developed a revised study design that allows us to make inferences to all federal lands in Marin County (see Press et al. 2010).

To create a within-subject study design to detect trends toward declines in occupancy and fecundity for all federal lands in Marin County, we first completed a single-year inventory study in 2006 to assess the spotted owl population for all suitable habitat. This single-year inventory effort utilized a model that predicted spotted owl nest-site occurrence based on habitat suitability (Stralberg et al. 2009). We applied a 400-meter buffer around the habitat model's boundary and included lands within 400 meters of the legislative boundaries of MUWO, PORE, and GOGA, thus developing a 33,842 acre study area. The study area encompassed 43 known spotted owl territories and 22 other suitable areas with no known established territories. All 65 areas were inventoried for occupancy in 2006.

In 2007, a randomly-selected subset of 25 sites was obtained from 47 spotted owl sites that had known pair occupancy in at least one year from 1997–2006. The same 25 sites established in 2007 were monitored in 2008. For the 2009–2011 breeding seasons, we increased our sample size to 30 sites and selected a random set of sites for each year.

Beginning with the 2013 season the annual sample size was increased to 40 sites in accordance with our peer-reviewed protocol (Press et al. 2010). One of those sites was dropped during the 2013 season because we were not able to access it through private land, leaving a total of 39 sites sampled per year. Twenty-nine of those are monitored every year. An additional 40 sites have been grouped into four panels of ten monitoring sites each. One panel is monitored each year in conjunction with the 29 annual sites. The panels are rotated every year so that the sites within them are monitored every four years. Sites monitored by NPS staff strictly for management purposes are not included in our analyses because they are not randomly selected.

Field Methods

All long-term monitoring surveys (1999–2005 and 2007–2017) for occupancy and reproductive information follow the Marin Modified Protocol developed for use in areas with high potential owl/human interaction (Fehring et al. 2001, Press et al. 2010). The “Modified Protocol for Spotted Owl Monitoring and Demographic Studies in Marin County California” (Marin Modified Protocol; Fehring et al. 2001) is modeled directly from the widely used “Spotted Owl Monitoring Protocols for Demographic Studies” (Forsman 1995) and the “Protocol for Surveying Proposed Management Activities that may Impact Northern Spotted Owls” (USFWS 2011). Survey methods include visual surveys of previous activity centers and nest sites, playback calling and hooting both during the day and at night, mousing, visual nest checks, and counts of fledged young.

Standard spotted owl survey protocols may lead to changes in owl behavior due to repeated calling and the feeding of live mice (*Mus domesticus*) to owls (known as “mousing”). Owls habituated to people may be more vulnerable to disturbance and manipulation by park operations and visitors. The Marin Modified Protocol was developed collaboratively between the NPS and Point Blue Conservation Science to reduce the number of mice used to obtain the relevant nest site and reproductive information (Fehring et al. 2001, Press et al. 2010). The ease of access to nest sites and high visibility of nesting structures in Marin County facilitate intensive nest checks and often obviate the need to use mice to monitor reproductive status. Consequently, we rely on increased search time, more frequent visits, and owl behavioral observations to gather the data.

Spotted owls are sexed based on vocalizations and aged by tail feather shape and coloring (Forsman 1983). Barred owl detections are noted, and reports of barred owls in or around the study area are investigated, but there are no specific methods utilized for monitoring barred owls in our study. An annual breeding status is assigned to the individual spotted owl territories monitored and is determined using criteria in the Marin Modified Protocol.

All owl activity centers (either nest location or major roost site) are recorded in Global Positioning System (GPS) coordinates using a Garmin eTrex Legend or similar GPS unit. Roost sites or nest trees for which GPS satellite access is not available are mapped on topographic maps from compass bearings taken in the field and GPS coordinates are obtained by using ArcGIS 10.2 (ESRI 2013). Each year, at every known nest location, nest tree parameters are measured and surrounding habitat is described using standardized methods found in the monitoring protocol (Press et al. 2010).

Data Management and Distribution

All site searches, owl detections, and nest record field data are compiled in a Microsoft Access database maintained at PORE (Press et al. 2010). All areas surveyed are mapped using ArcGIS 10.2 GIS software and the data layers are made available to agencies involved in land management and planning projects within Marin County, including MCOSSD, MMWD, and CSP managers. Spotted owl location data is also submitted to the Biogeographic Information and Observation System (BIOS) database which is administered by the California Department of Fish and Game.

Summaries and Reporting

In annual reports prior to 2008, data from 1999 to 2005 was reported for 46 long-term monitoring sites. Starting in 2008, we restricted the inclusion of results to only data from the 36 sites that fell within our re-designed study area (see Monitoring History and Study Design). Although non-randomly selected, we justified including 12 management sites (number of management sites varied annually) and 14 inventory areas in the analyses if the sites or areas received an adequate level of survey effort for the years 1999–2006. Starting in 2013, we folded Tomales Bay State Park into our study area, and are therefore including historical data from Tomales Bay State Park collected from 1999 to 2005. The 2006 data is excluded from the annual summaries for reproductive success and fecundity since the primary purpose of the single year inventory surveys was to determine presence/absence. Data from 1997 and 1998 are also excluded from annual reports due to the differences in survey purpose and effort level in those years.

Each year additional sites may be monitored to ensure that park operations and other activities, such as road repairs or trail maintenance, do not impact nesting northern spotted owls. Additional sites monitored in 2007 to 2017 for purposes other than demography (i.e., management sites) were not included in the summaries. Any discrepancies from previously reported results can be attributed to the application of the new criteria now applied to how we summarize data in our annual spotted owl reports.

Results

In 2017, 39 sites were initially selected for monitoring. Two of the sites were dropped because they were found to be partly occupied by owls from adjacent territories. From March 1 to July 20, the survey teams made 214 visits (mean visits/site = 5.8, range 2–10) to these 37 study sites for the purpose of determining occupancy and fecundity (Table 1). Of the 37 sites monitored, 30 sites were determined to be occupied (25 by pairs) and 25 of those sites had known reproductive outcomes. Of the 25 sites occupied by pairs, 22 of those were nesting pairs; 34 spotted owl fledglings were confirmed in 2017 for an annual fecundity value of 0.74 (Table 1).

Table 1. Summary of the spotted owl monitoring results for the 2017 breeding season.

Year	Number of sites monitored	Number of occupied territories	Number of sites occupied by pairs	Number of sites with known reproductive outcomes	Number of nesting pairs	Number of fledglings produced	Fecundity
2017	37	30	25	25	22	34	0.74

Age and Sex Determination

In other study areas where banding occurs, sexing and aging of spotted owls is easily determined with a re-sighting of the owl's band, but in the Marin County area banded owls are rarely encountered. On numerous occasions when a single owl or pair was located, but without band identification, biologists relied on sexing the owl in view based on vocalizations and aging the owl based on tail feather wear (Forsman 1983). Some owls remained silent during daylight survey hours and only vocalized at night, making it impossible to assign ages to the corresponding sex.

In 2017, we positively sexed and aged a total of 49 (27 males and 22 females) spotted owls. Adults constituted 47 of the 49 (96%) spotted owls for which age was identified. Two sub-adults (4%) were located. At 22 spotted owl territories, we were able to age both pair members and 91% of those pairs were composed of an adult female and male (Figure 2), more than the fourteen year average (Figure 3). One pair included a subadult female, and one pair included a subadult male.

Occupancy Status

In 2017, the total percentage of sites occupied by pairs or singles was 82%. Pairs occupied 25 (68%) of the sites, and single owls occupied five (14%) sites (Figure 4). The 19-year average for pair occupancy (1999-2017) was 80%, while the average for occupancy by single owls was 11%

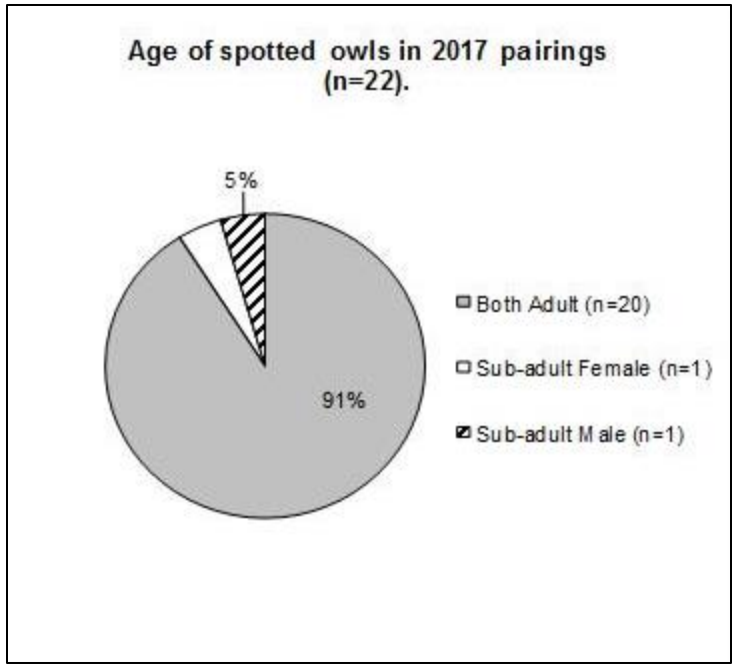


Figure 2. Age of spotted owls in 2017 pairings; n is the number of spotted owl pairs.

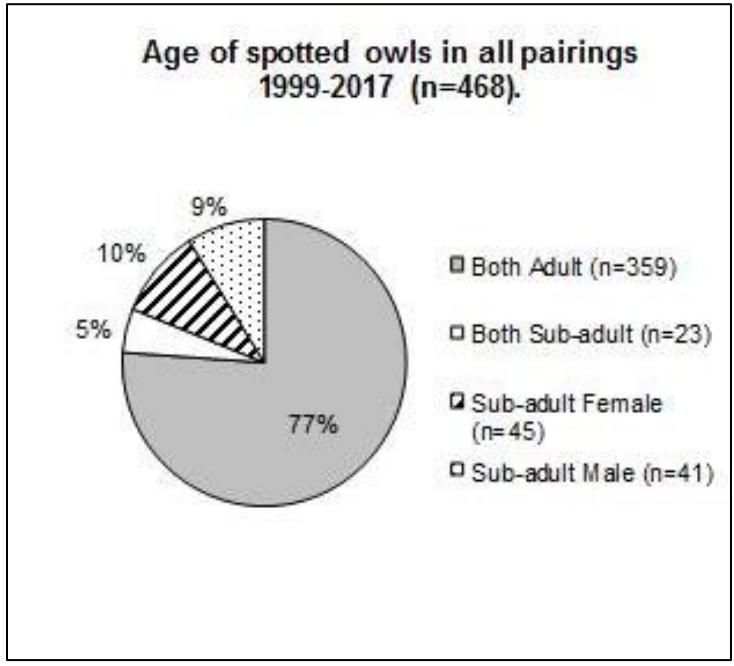


Figure 3. Age of spotted owls in all pairings 1999-2017; n is the number of spotted owl pairs.

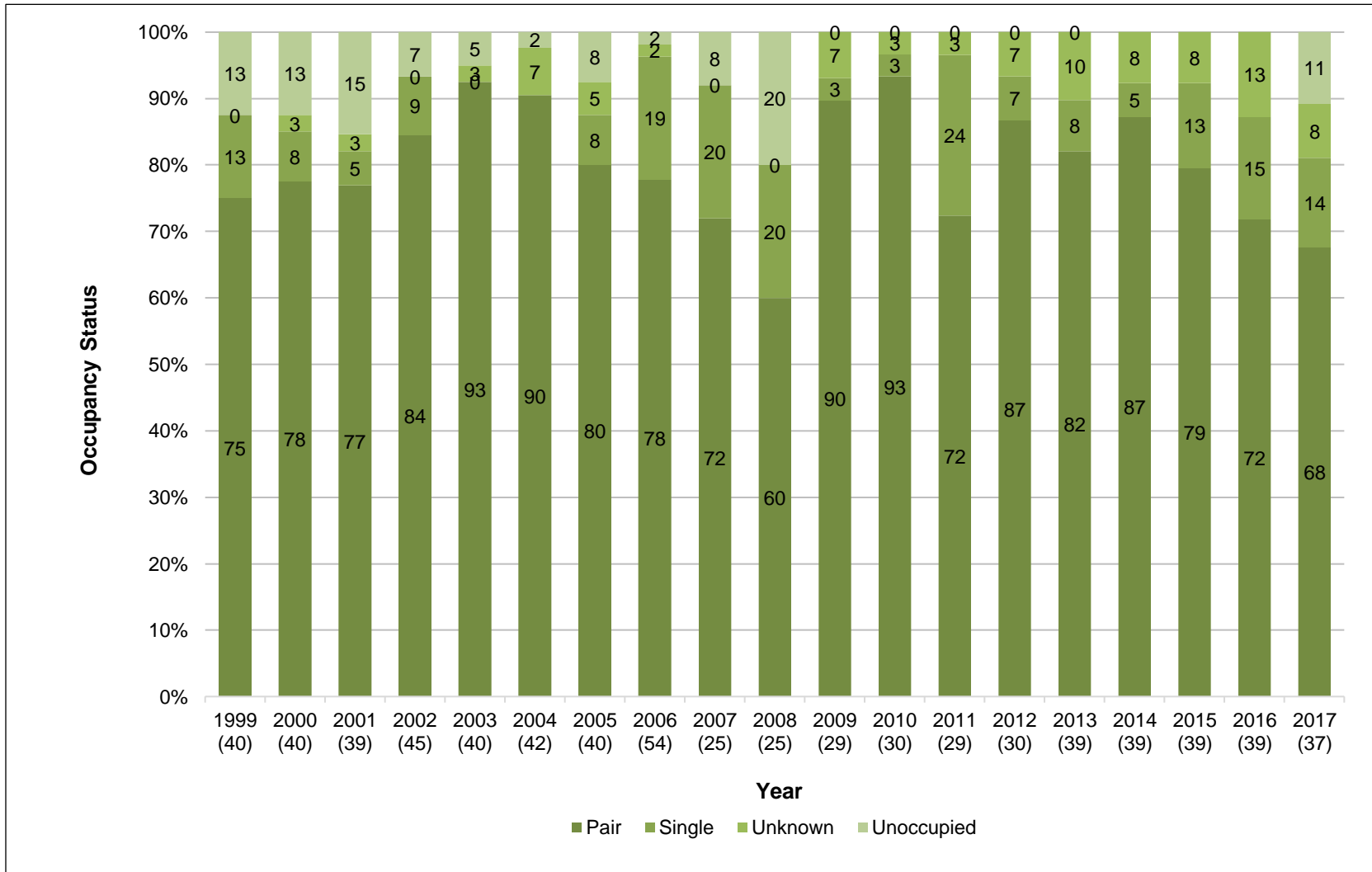


Figure 4. Occupancy status for all study sites (1999–2017). Numbers within the bars are the percentage for each status category. Numbers in parentheses are the total number of spotted owl territories monitored per year.

Reproductive Status and Fecundity

In 2017, of the 25 territorial females with known reproductive outcomes, 22 (88%) attempted nesting (Figure 5). Twenty females successfully nested yielding a total of 34 fledglings. Three non-nesting females and one nest failure was confirmed at the 25 sites, and one additional nest likely failed as well but was unconfirmed. Fecundity, a measure of productivity, is calculated as the average number of female young produced per territorial female, assuming a 50:50 sex ratio of fledglings (Anthony et al. 2006). The mean fecundity for the 2017 breeding season was 0.74 (SE \pm 0.08), the highest fecundity yet observed in this study and well above the average fecundity from 1999 to 2017 (0.37, SE \pm 0.08; Figure 6).

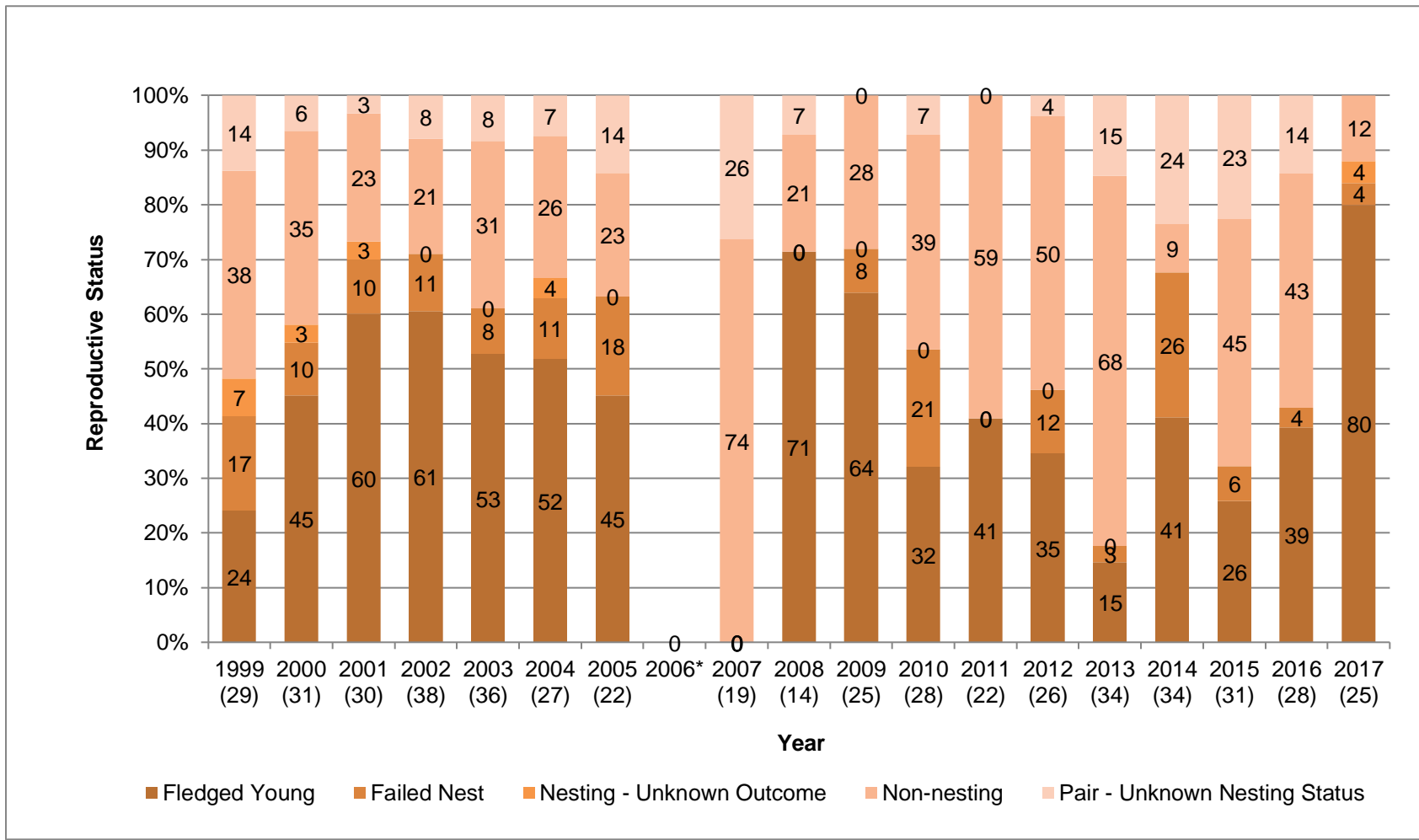


Figure 5. Reproductive status for territorial female spotted owls monitored in the NPS study area (1999–2005 and 2007–2017). Numbers within the bars are the exact percentage for each status category. Numbers in parentheses are the total number of territorial females per year. *2006 inventory data was excluded from this analysis.

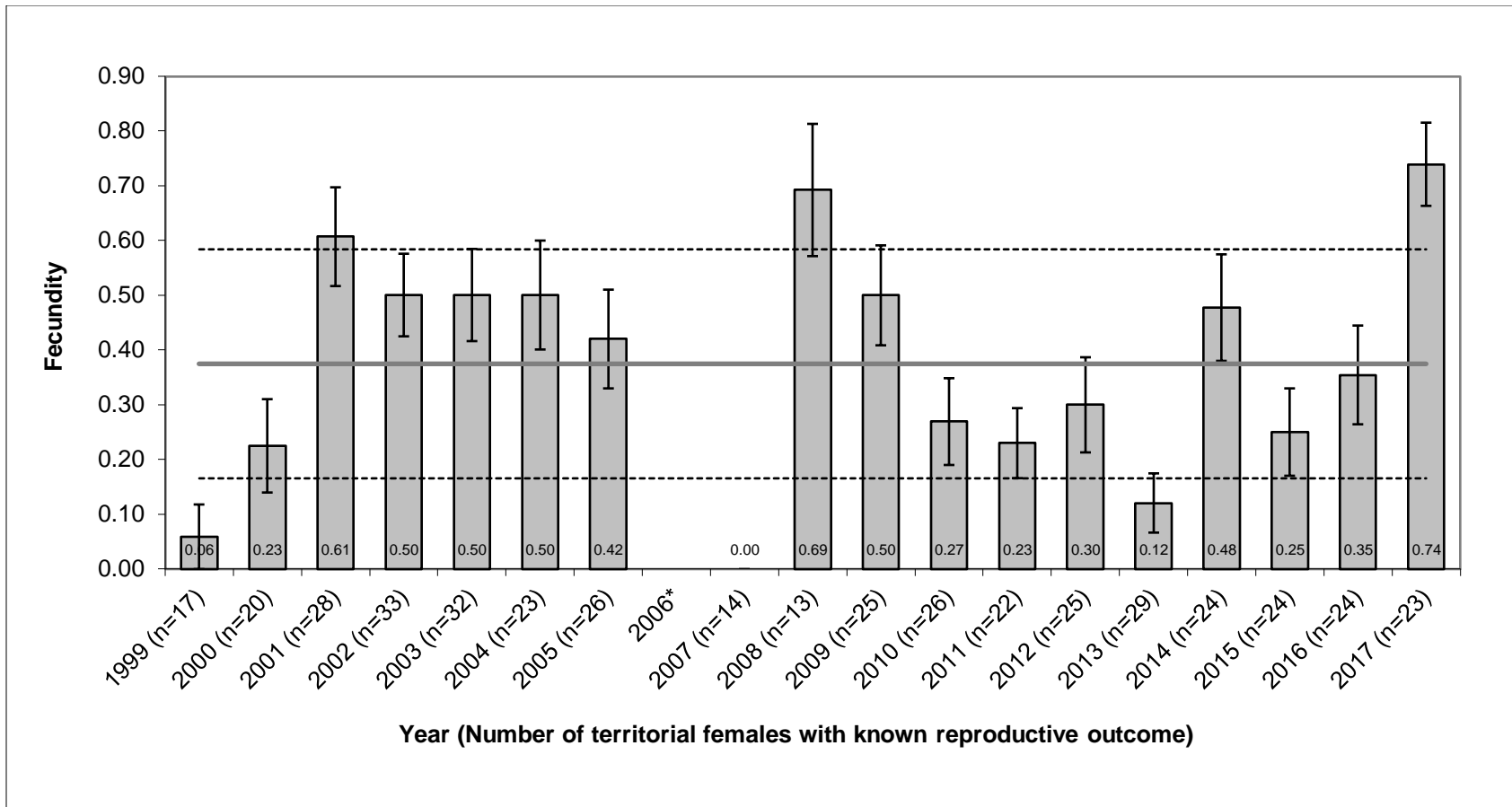


Figure 6. Fecundity for 1999–2005 and 2007–2017. The solid line on the graph is mean fecundity from 1999 to 2017 (0.36), and the dashed lines are one standard deviation from the mean (0.20). Year error bars indicate ± 1 standard error and n is the total number of spotted owl territories with females with known reproductive outcomes. *2006 inventory data was excluded from this analysis.

Nest Measurements

During surveys from 1999 to 2017, spotted owl researchers have located a total of 220 spotted owl nest trees in monitoring sites (Table 2). Of the 220 unique nests, 16 (8%) were in cavities and 203 (92%) were platform nests. One nest was of unknown type because it was obscured by poison oak. This ratio is the opposite of owl nests in older forests where 80–90% of the nests are in cavities, but closely resembles the ratio in other parts of the range where forests are younger (Buchanan and Irwin 1993, Forsman and Griese 1997, LaHaye and Gutierrez 1999). In 2017, 18 new platform nests were documented.

Half (52%) of the documented nests have been in Douglas fir (n=114). The remainder of nest tree species selected include coast redwood (n=66), California bay (n=17), bishop pine (n=14, coast live oak (n=7), and tanoak (n=1). The broad range of species and size of trees selected as nest trees indicate a broader use of forest types and ages in the Marin County study area relative to the northern regions of the spotted owl's range. Although the sample size for cavity nests is small, it appears that cavity nests tend to occur in larger trees (Table 2).

Table 2. Average nest measurements for 219 unique northern spotted owl nests located within the NPS study area from 1999 to 2017.

Measurement	Platform Nests (n=202)		Cavity Nests (n=16)	
	Mean	SE	Mean	SE
dbh (cm)	101.2	±4.0	188.8	±26.52
Nest height (m)	18.9	±0.5	20.1	±2.60
Tree height (m)	33.2	±0.94	41.2	±4.08

Identifications of Banded Owls

Between 1998 and 2003, 110 spotted owls were captured and color banded at 26 sites within a 9,996-hectare (24,700-acre) area surrounding Bear Valley in PORE. Of the 110 spotted owls banded, 50 were banded as juveniles, 23 as subadults, and 37 as adults (Fehring et al. 2004). In 2004, the banding aspect of the project was ceased due to logistical constraints and limited sample size. We attempt to determine the presence or absence of color bands on all spotted owls encountered, but have not observed any banded owls since 2014.

Barred Owls

The first barred owl record for Marin County occurred in May 2002 in Muir Woods, and the first known successful reproduction of barred owls occurred in 2007, also at MUWO. In 2008, biologists documented the first known barred owl nest tree in Marin County and confirmed the successful fledging of two barred owls (Jennings et al. 2011). Although MUWO was home to two territorial pairs of spotted owls when monitoring began in 1999, spotted owls have not established an activity

center within the boundaries of MUWO since 2010, though they likely still use MUWO as part of their territories.

Barred owls have been observed hunting signal crayfish (*Pacifastacus leniusculus*) in the Redwood Creek drainage on numerous occasions over multiple years by park visitors and NPS staff (Jennings et al. 2011). In May 2008, biologists watched a male barred owl hunt on the ground for 25 minutes during the day and successfully capture a broad-footed mole (*Scapanus latimanus*). Pellet samples collected at the 2008 and 2012 barred owl nest sites indicate a diet composed of crayfish and small mammals. Relative to spotted owls, barred owl diet plasticity likely provides a competitive advantage over spotted owls (Livezey et al. 2008). An example of this likely competitive advantage was documented on federal lands in Marin County during the 2007 breeding season. There were no spotted owl nesting attempts, nests, or young located on federal lands in 2007; however the only known barred owl pair successfully nested and produced at least two fledglings (Jennings et al. 2011). In contrast to spotted owls, the generalist diet and foraging strategies of barred owls may buffer the species from major fluctuations in reproductive success among years.

In 2016, for the first time since 2003, no barred owls were detected within the study area during the spotted owl survey season. During the 2017 season, a barred owl was detected within two adjacent spotted owl territories in Olema Valley. Studies have shown reduced pair occupancy in spotted owl territories after barred owls move in (Kelly et al. 2003, Olson et al. 2005). To date, no spotted/barrred owl hybrids have been detected at any of the long term monitoring sites.

Discussion

The percentage of sites occupied by pairs or single owls has remained high, averaging 91% from 1999 to 2017. The 18-year average for pair occupancy from 1999 to 2017 was 80%, while the average for occupancy by single owls was 11%. Northern spotted owl pair occupancy in 2017 was below average at 68%. Single owls were detected at five sites (14%), four sites were unoccupied (11%), and three sites had unknown occupancy (8%). Pair occupancy has declined each year since 2014, when occupancy was 87%.

2017 was a banner year for spotted owl reproduction in Marin County, and followed a period of below-average reproductive success. With the exception of 2014, spotted owl reproduction from 2010-2016 hovered at or below the 18 year average. A preliminary review of the data collected in Marin County, including sites within the study area monitored for other purposes and sites outside of the study area monitored by Point Blue Conservation Science, indicates that a pattern of reduced productivity was documented at all spotted owl sites monitored in Marin County during that time. The causes underlying this apparent decline in productivity are unknown, and because northern spotted owls are long-lived, we may only now be seeing a population-level effect, as indicated by declining occupancy rates within the study area since 2014 (Figure 4). One factor that may have impacted productivity is the drought or near-drought conditions that persisted in the years 2012-2015.

At the end of 2017, we knew of two confirmed barred owls in the study area. One was detected in Olema Valley during the spotted owl survey season. In November, after the survey season, a barred owl was photographed in MUWO, and in December a dead barred owl, possibly the same one, was found in MUWO. Low density of barred owls within our study area has likely helped to sustain high spotted owl pair occupancy levels compared to other areas within the spotted owl's range. Declines in spotted owl site occupancy have been seen in other areas where barred owls are present in high numbers (Kelly et al. 2003, Olson et al. 2005) and are the most severe in areas where barred owls have been established the longest (Anthony et al. 2006). In reviewing barred owl and spotted owl locations in Oregon between 1974 and 1998, Kelly et al. (2003) found that when barred owls invade spotted owl territories, mean annual occupancy of spotted owls declines when compared to territories without barred owls. Later work by Wiens (2012) in western Oregon confirmed the competitive interactions of barred owls against spotted owls by documenting high densities of barred owl territories in areas once occupied by spotted owls, smaller home range sizes of barred owls, a high degree of overlap in habitat use between the two species, a more varied diet in barred owls, higher annual survivorship in barred owls, and more young produced each year by barred owls than by spotted owls. Removal of barred owls from private timberlands in northern California increased spotted owl survival and population growth compared to untreated areas, but northern spotted owls are otherwise in decline across most of their range in the absence of barred owl management (Dugger et al. 2016).

Barred owl expansion into Marin County is probably limited by suitable dispersal corridors from adjacent Napa and Sonoma counties to the north. The Mendocino Redwood Company, which

manages 229,000 acres of forest in coastal Sonoma and Mendocino counties, documented an exponentially increasing number of barred owl detections during spotted owl surveys from 2005-2013 (Mendocino Redwood Company 2016), while barred owl numbers in Marin county have remained low. Vast agricultural lands coupled with urban development, especially along Highway 101, has likely slowed the influx of barred owls into our study area, but we suspect that over time, more barred owls will occur within PORE and GOGA managed lands. Where barred owls do occur here, we have documented spotted owl displacement and declines in spotted owl occupancy similar to what has been observed in other studies (Jennings et al. 2011, Diller et al. 2016, Dugger et al. 2016). Over time, if barred owl numbers increase, we expect that barred owl effects on Marin County's distinct northern spotted owl population will become more pronounced.

Research Activities and Recommendations

Barred Owl Study

There is a great need to study barred owl and spotted owl interactions, to determine the nature of the threat, and identify potential management options to ensure the persistence of spotted owls throughout their historic range (USFWS 2011). The NPS and other agencies are implementing studies across the northern spotted owl's range to gain a better understanding of the interspecific behavior and to learn more about management options to benefit spotted owls in the presence of barred owls. Since the barred owl has only recently invaded the southern extent of the northern spotted owl's range, Marin County offers a unique opportunity to study the early patterns of contact between barred and spotted owls (Jennings et al. 2011). Efforts within our study have included following up on incidental barred owl detections made during spotted owl surveys and determining the annual nesting status and success of the barred owl pair in MUWO. In 2012, we furthered our barred owl efforts by establishing and surveying call routes specific to detecting barred owls. These surveys did not detect any barred owls that were not known from spotted owl survey efforts, and ceased after 2015 due to staffing constraints. Future detections of barred owls are likely based on that species' pattern of range expansion, and we will attempt to determine the status of any known barred owls each year. We hope that our efforts will allow us to better understand the nature and extent of the threat posed by barred owls to spotted owls in Marin County and identify possible management solutions that will allow us to sustain our unique spotted owl population.

Sudden Oak Death

Marin County is one of 14 counties in California affected by the pathogen that causes Sudden Oak Death (SOD). *Phytophthora ramorum* is a water mold that acts like a fungus, attacking the trunk of a tree and causing a canker, or wound, that eventually cuts off the tree's flow of nutrients. Other secondary decay organisms such as beetles and fungi often move in after the tree is infected. Trees infected with SOD may survive for one to several years as the infection progresses. As the tree finally dies, the leaves may turn from green to brown within a few weeks, hence the appearance of sudden death (Davidson et al. 2003). Tanoaks and coast live oaks are killed by the disease; other species affected, such as California bay laurel, are known as "foliar hosts" because their leaves and twigs may be infected. These foliar hosts can spread the disease, but are only occasionally killed.

The diversity of host species affected by *P. ramorum* indicates potential long-term landscape modifications through changes in the forest canopy, understory, and ground layer (Rizzo and Garbelotto 2003). Moritz et al. (2008) found that nearly every stand of tanoak within PORE is already impacted by SOD and at several locations tanoak mortality was greater than 95% by basal area. Tanoak is currently the most common subcanopy species in coniferous forests within the study area and Moritz et al. (2008) suggest that tanoak will be replaced by redwood in redwood forest and California bay in Douglas fir forests. For comprehensive information regarding SOD and links to current maps visit the California Oak Mortality Task Force website at www.suddenoakdeath.org.

To date, there have been no published studies on the impacts of SOD on northern spotted owls. Research is needed to understand potential impacts to food webs and habitat structure. There are many pathways through which SOD could affect spotted owl populations. There could be direct impacts due to the loss of structural complexity of forested owl habitat. Northern spotted owls might also be affected indirectly by SOD through changes in prey species populations. The tanoak and oak species most impacted by *P. ramorum* are abundant acorn producers and are an important forage species for small mammals (Tappeiner et al. 1990), such as dusky-footed woodrats, which make up the majority of the spotted owl diet in Marin County (Chow and Allen 1997, Courtney et al. 2004). Another potential indirect effect of SOD on northern spotted owls is through increased potential for uncharacteristically severe wildfire in diseased forests. Because these owls require mature forest habitat, they could be adversely affected by large, high severity wildfires (Forsman et al. 1984, Gaines et al. 1997, USFWS 2011).

Management Activities and Recommendations

Humans and their activities, including development along the wildland/urban interface, land management practices, and recreation are among the significant likely sources of impact to spotted owl population viability in Marin County. We recommend that owl occupancy and reproductive monitoring surveys continue, and that land managers use these data to ensure that management activities do not impact the habitat or the productivity of northern spotted owls. We encourage continued communication between land managers and maintenance crews in planning and executing road, trail, and other maintenance and construction projects in spotted owl habitat. Information on owl site locations should continue to be made available to all land managers and local city and county planning departments. The central repository for owl detection information in California is the BIOS database, managed by the California Department of Fish and Game.

Given the mixed ownership patterns in Marin County, several owl home ranges contain both public and private lands. Coordination between park managers and local planners is essential. Loss of owl habitat and owl pairs due to residential land management practices (e.g., rodenticide use) and urban development is a local concern. Due to the fragmented and isolated nature of the Marin County forested habitat, declines along the urban edges may impact overall population health throughout the local range.

Public Outreach

Due to the consistent public interaction with Marin County's northern spotted owl population, the NPS has developed educational resources to inform the public of their role of living and working in

areas with spotted owls. Project biologists have worked with MUWO interpretative staff to develop comprehensive spotted owl information on the MUWO website. The goal of the website is to provide Marin County residents, land owners, and agency managers easily accessible information on basic spotted owl biology, guidelines for protecting spotted owls and owl habitat in this county, and how to minimize potential threats to spotted owls.

Informational materials including executive briefings and past annual reports are made available to the public at the SFAN Inventory and Monitoring website:

<https://www.nps.gov/im/sfan/spotted-owls.htm>

Literature Cited

- Adams, D., S. Allen, J. Bjork, M. Coopriider, A. Fesnock, M. Koenen, T. Leatherman, S. O'Neil, D. Press, D. Schirokauer, and others. 2006. San Francisco Bay Area Network vital signs monitoring plan. Natural Resource Report. NPS/SFAN/NRR— 2006/017. National Park Service, Fort Collins, Colorado.
- Anthony, R. G., E. D. Forsman, A. B. Franklin, D. R. Anderson, K. P. Burnham, G. C. White, C. J. Schwarz, J. Nichols, J. Hines, G. S. Olson, and others. 2006. Status and trends in demography of northern spotted owls, 1985–2003. *Wildlife Monographs* 163:1–48.
- Barrowclough, G. F., J. G. Groth, L. A. Mertz, and R. J. Gutierrez. 2005. Genetic structure, introgression, and a narrow hybrid zone between northern and California spotted owls (*Strix occidentalis*). *Molecular Ecology* 14:1109–1120.
- Blakesley, J. A., W. La Haye, J. M. Marzluff, B. R. Noon, and S. Courtney. 2004. Demography. Pages 8-1–8-46 in S. P. Courtney, J. A. Blakesley, R. E. Bigley, M. L. Cody, J. P. Dumbacher, R. C. Fleischer, A. B. Franklin, J. F. Franklin, R. J. Gutiérrez, J. M. Marzluff, and L. Sztukowski. Scientific evaluation of the status of the northern spotted owl. Sustainable Ecosystems Institute, Portland, Oregon.
- Buchanan, J. B., and L. L. Irwin. 1993. Characteristics of spotted owl nest trees in the Wenatchee National Forest. *Journal of Raptor Research* 27:1–7.
- Chow, N., and S. Allen. 1997. Assessment of northern spotted owl after the Vision Fire wildfire 1996. Unpublished report. Point Reyes National Seashore, Point Reyes, California.
- Chow, N. 2001. Distribution and Habitat Associations of northern spotted owls in Marin County, California. M.S. Thesis. Humboldt State University, Arcata, California.
- Courtney, S. P., J. A. Blakesley, R. E. Bigley, M. L. Cody, J. P. Dumbacher, R. C. Fleischer, A. B. Franklin, J. F. Franklin, R. J. Gutiérrez, J. M. Marzluff, and L. Sztukowski. 2004. Scientific evaluation of the status of the northern spotted owl. Sustainable Ecosystems Institute, Portland, Oregon.
- Davidson, J. M., S. Werres, M. Garbelotto, E. M. Hansen, and D. M. Rizzo. 2003. Sudden Oak Death and associated diseases caused by *Phytophthora ramorum*. *Plant Health Progress*, DOI:10.1094/PHP-2003-0707-01-DG.
- Diller, L. V., K. A. Hamm, D. A. Early, D. W. Lamphear, K. M. Dugger, C. B. Yackulic, C. J. Schwarz, P. C. Carlson, and T. L. McDonald. 2016. Demographic response of northern spotted owls to barred owl removal. *Journal of Wildlife Management* 80(4):691-707.
- ESRI (Environmental Science Research Institute, Inc.) 2010. ArcGIS 10.0. ESRI, Redlands, California.

- Dugger, K. M., E. D. Forsman, A. B. Franklin, R. J. Davis, G. C. White, C. J. Schwarz, K. P. Burnham, J. D. Nichols, J. E. Hines, C. B. Yackulic, P. F. Doherty, Jr., L. Bailey, D. A. Clark, S. H. Ackers, L. S. Andrews, B. Augustine, B. L. Biswell, J. Blakesley, P. C. Carlson, M. J. Clement, L. V. Diller, E. M. Glenn, A. Green, S. A. Gremel, D. R. Herter, J. M. Higley, J. Hobson, R. B. Horn, K. P. Huyvaert, C. McCafferty, T. McDonald, K. McDonnell, G. S. Olson, J. A. Reid, J. Rockweit, V. Ruiz, J. Saenz, and S. G. Sovern. 2016. The effects of habitat, climate, and Barred Owls on long-term demography of Northern Spotted Owls. *The Condor: Ornithological Applications* 118:57-116.
- Fehring, K., D. Adams, D. Hatch, and S. Allen. 2001. Modified protocols for spotted owl monitoring and demographic studies in Marin County, California - July 2001. Unpublished protocol. U.S. Department of the Interior, National Park Service, Point Reyes, California.
- Fehring, K. E. 2003. Dusky-footed woodrat monitoring in Point Reyes National Seashore Final Report. Unpublished report, Point Reyes Bird Observatory, Stinson Beach, California.
- Fehring, K. E., D. B. Adams, and D. Hatch. 2004. Northern spotted owls in Marin County, California: 2003 annual report. Unpublished report. National Park Service.
- Forrestel, A. B., B. S. Ramage, T. Moody, M. A. Moritz, and S. L. Stephens. Disease, fuels and potential fire behavior: Impacts of Sudden Oak Death in two coastal California forest types. *Forest Ecology and Management* 348:22-30.
- Forsman, E. D. 1983. Methods and materials for locating and studying spotted owls. USDA Forest Service General Technical Report PNW-162. Pacific Northwest Research Station. Portland. Oregon.
- Forsman, E. D., E. C. Meslow, and H. M. Wright. 1984. Distribution and biology of the spotted owl in Oregon. *Wildlife Monograph* 87:1-64.
- Forsman, E. D. 1995. Spotted Owl monitoring protocols for demographic studies, 29 March 1995. USDA Forest Service, Corvallis Forestry Sciences Lab, Oregon. 12 pp.
- Forsman, E. D., and A. R. Griese. 1997. Nests of northern spotted owls on the Olympic Peninsula, Washington. *Wilson Bulletin* 109(1):28-41.
- Gaines, W., R. Strand, and S. Piper. 1997. Effects of the Hatchery complex fires on Northern spotted owls in the Eastern Washington Cascades. Pages 123-129 *in* J. Greenlee, editor. *Fire Effects on Rare and Endangered Species and Habitats Conference*, International Association of Wildfire and Forestry, Coeur D'Alene, Idaho.
- Gilpin, M. E., and M. E. Soule. 1986. Minimum viable populations: processes of species extinction. Pages 19-34 *in* M. Soule, editor. *Conservation biology: the science of scarcity and diversity*. Sinauer Associates, Inc., Sunderland, Massachusetts.

- Gremel, S. 2000. Barred owl displaces northern spotted owl at Olympic. Natural Resource Year in Review - 2000. National Park Service, U.S. Department of the Interior (publication D-1459).
- Hamer, T. E. 1988. Home range size of the northern barred owl and northern spotted owl in Western Washington. M.S. thesis. Western Washington University, Bellingham, Washington.
- Hamer, T. E., E. D. Forsman, and E. M. Glenn. 2007. Home range attributes and habitat selection of barred owls and spotted owls in an area of sympatry. *Condor* 109:750–768.
- Hatch, D., S. Allen, G. Geupel, and M. Semenov-Irving. 1999. Northern spotted owl demographic study Marin County, California: 1999 annual report. Unpublished report. National Park Service.
- Henke, A. L., T. Chi, C. Brinegar, and J. Smith. 2003. Preliminary microsatellite analysis of two populations of northern spotted owls (*Strix occidentalis caurina*). Unpublished report. Conservation Genetics Laboratory, Department of Biological Sciences, San Jose State University, San Jose, California.
- Jennings, S., R. L. Cormier, T. G. Gardali, D. T. Press, and W. W. Merkle. 2011. *Status and distribution of the barred owl in Marin County, California*. *Western Birds* 42:103–110.
- Jensen, H. J., D. B. Adams, and W. W. Merkle. 2007. Northern spotted owl inventory on federal lands in Marin County, 2006 annual report. NPS/PWR/SFAN/NRR—2007/004. San Francisco Bay Area Network, Golden Gate National Recreation Area, Fort Cronkhite, Sausalito, California.
- Kelly, E. G., E. D. Forsman, and R. G. Anthony. 2003. Are barred owls displacing spotted owls? *Condor* 105:45–53.
- LaHaye, W. S., and R. J. Gutierrez. 1999. Nest sites and nesting habitat of the northern spotted owl in Northwestern California. *Condor* 101:324–330.
- Livezey, K. B., M. F. Elderkin, P. A. Cott, J. Hobbs, and J. P. Hudson. 2008. Barred owls eating worms and slugs: the advantage of not being picky eaters. *Northwestern Naturalist* 89:185–190.
- Mendocino Redwood Company. 2016. Northern spotted owl conservation and management on Mendocino Redwood Company forestlands (unpublished report). Ukiah, CA.
- Moritz, M., T. Moody, B. Ramage, and A. Forrestel. 2008. Spatial distribution and impacts of *Phytophthora ramorum* and Sudden Oak Death in Point Reyes National Seashore. Final report to the National Park Service. California Cooperative Ecosystems Study Unit Task Agreement No.J8C07050015.
- National Park Service Organic Act, 16 U.S.C. 1 et seq. (1988), Aug. 25, 1916, Ch. 408, 39 Stat. 535.
- National Park Service Omnibus Management Act, Pub. L. No. 105–391, Nov. 13, 1998, 112 Stat. 3498.

- Olson G. S., E. M. Glenn, R. G. Anthony, E. D. Forsman, J. A. Reid, P. J. Loschl, and W. J. Ripple. 2004. Modeling demographic performance of northern spotted owls relative to forest habitat in Oregon. *Journal of Wildlife Management* 68:1039–1053.
- Olson, G. S., R. G. Anthony, E. D. Forsman, S. H. Ackers, P. J. Loschl, J. A. Reid, K. M. Dugger, E. M. Glenn, and W. J. Ripple. 2005. Modeling site occupancy dynamics for northern spotted owls, with emphasis on the effects of barred owls. *Journal of Wildlife Management* 69:918–932.
- Press, D., D. Adams, H. Jensen, K. Fehring, W. Merkle, M. Koenen, and L. A. Starcevich. 2010. San Francisco Bay Area Network northern spotted owl monitoring protocol. Natural Resource Report NPS/SFAN/NRR—2010/245. National Park Service, Fort Collins, Colorado.
- Rizzo, D. M., and M. Garbelotto. 2003. Sudden Oak Death: Endangering California and Oregon forest ecosystems. *Frontiers in Ecology and the Environment* 1(5):197–204.
- Rosenberg, D. K., K. A. Swindle, and R. G. Anthony. 2003. Influence of prey abundance on northern spotted owl reproductive success in western Oregon. *Canadian Journal of Zoology* 18:1715–1725.
- Sakai, H. F., and B. R. Noon. 1993. Dusky-footed woodrat abundance in different-aged forests in northwestern California. *Journal of Wildlife Management* 57(2):373–382.
- Stralberg, D., K. E. Fehring, N. Nur, L. Y. Pomara, D. B. Adams, D. Hatch, G. R. Geupel, and S. Allen. 2009. Modeling nest-site occurrence for the Northern Spotted Owl at its southern range limit in central California. *Landscape and Urban Planning* 90:76–85.
- Swei, A., R. S. Ostfeld, R. S. Lane, and C. J. Briggs. 2011. Effects of an invasive forest pathogen on abundance of ticks and their vertebrate hosts in a California Lyme disease focus. *Oecologia* 166:91–100.
- Tappeiner, J., P. McDonald, and D. F. Roy. 1990. Tanoak. Pages 417–425 *in* R. M. Burns and B. H. Honkala, editors. *Silvics of North America: Volume 2. Hardwoods*. USDA Forest Service, Washington, DC.
- U.S. Fish and Wildlife Service (USFWS). 2011. Protocol for surveying proposed management activities that may impact Northern Spotted Owls. February 2, 2011. Endorsed by U.S. Fish and Wildlife Service.
- U.S. Fish and Wildlife Service (USFWS). 2011. Revised recovery plan for the northern spotted owl, *Strix occidentalis caurina*. U.S. Fish and Wildlife Service, Portland, Oregon. xvi + 258pp.
- Wiens, J. D., R. G. Anthony, and E. D. Forsman. 2011. Barred owl occupancy surveys within the range of the northern spotted owl. *Journal of Wildlife Management* 75(3):531–538.

Wiens, J. D. 2012. Competitive interactions and resource partitioning between northern spotted owls and barred owls in western Oregon. Ph.D. Dissertation, Oregon State University, Corvallis, Oregon.

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

Appendix A: SFAN northern spotted owl monitoring program bibliography

- Chow, N., and S. Allen. 1997. Assessment of northern spotted owl after the Vision Fire wildfire 1996. Unpublished report. Point Reyes National Seashore, Point Reyes, California.
- Chow, N. 2001. Distribution and Habitat Associations of northern spotted owls in Marin County, California. M.S. Thesis. Humboldt State University, Arcata, California.
- Ellis, T., E. Schultz, and D. Press. 2013. Monitoring northern spotted owls on federal lands in Marin County, California: 2012 report. Natural Resource Technical Report NPS/SFAN/NRTR—2013/829. National Park Service, Fort Collins, Colorado.
- Ellis, T, and K. Harrigan. 2016. Monitoring northern spotted owls on federal lands in Marin County, California: 2013 report. Natural Resource Report NPS/SFAN/NRR—2016/1180. National Park Service, Fort Collins, Colorado.
- Fehring, K., D. Adams, D. Hatch, and S. Allen. 2001. Modified protocols for spotted owl monitoring and demographic studies in Marin County, California - July 2001. Unpublished protocol. U.S. Department of the Interior, National Park Service, Point Reyes, California.
- Fehring, K. E., D. B. Adams, and D. Hatch. 2001. Northern spotted owls in Marin County, California: 2000 annual report. Unpublished report. National Park Service.
- Fehring, K. E., D. B. Adams, and D. Hatch. 2002. Northern spotted owls in Marin County, California: 2001 annual report. Unpublished report. National Park Service.
- Fehring, K. E. 2003. Dusky-footed woodrat monitoring in Point Reyes National Seashore Final Report. Unpublished report, Point Reyes Bird Observatory, Stinson Beach, California.
- Fehring, K. E., D. B. Adams, and D. Hatch. 2003. Northern spotted owls in Marin County, California: 2002 annual report. Unpublished report. National Park Service.
- Fehring, K. E., D. B. Adams, and D. Hatch. 2004. Northern spotted owls in Marin County, California: 2003 annual report. Unpublished report. National Park Service.
- Forsman, E. D., and A. R. Griese. 1997. Nests of northern spotted owls on the Olympic Peninsula, Washington. *Wilson Bulletin* 109(1):28–41.
- Hatch, D., S. Allen, G. Geupel, and M. Semenov-Irving. 1999. Northern spotted owl demographic study Marin County, California: 1999 annual report. Unpublished report. National Park Service.
- Jennings, S., R. L. Cormier, T. G. Gardali, D. T. Press, and W. W. Merkle. 2011. *Status and distribution of the barred owl in Marin County, California*. *Western Birds* 42:103–110.

- Jensen H. J., D. B. Adams, W. W. Merkle, and K. E. Fehring. 2004. Monitoring northern spotted owls in Marin County, California: 2004 annual report. Unpublished report. National Park Service.
- Jensen H. J., D. B. Adams, and W. W. Merkle. 2006. Monitoring northern spotted owls in Marin County, California: 2005 annual report. Unpublished report. National Park Service.
- Jensen, H. J., D. B. Adams, and W. W. Merkle. 2007. Northern spotted owl inventory on federal lands in Marin County, 2006 annual report. NPS/PWR/SFAN/NRR—2007/004. San Francisco Bay Area Network, Golden Gate National Recreation Area, Fort Cronkhite, Sausalito, California.
- Jensen, H., D. Adams, W. Merkle, and D. Press. 2008. Northern spotted owls on federal lands in Marin County, California, 2007 annual report. NPS/SFAN/NRTR—2008/089. National Park Service, Fort Collins, Colorado.
- Jensen, H. J., W. W. Merkle, and D. Press. 2010. Monitoring northern spotted owls on federal lands in Marin County, California: 2008 annual report. Natural Resources Technical Report NPS/SFAN/NRTR—2010/312. National Park Service, Fort Collins, Colorado.
- Press, D., D. Adams, H. Jensen, K. Fehring, W. Merkle, M. Koenen, and L. A. Starcevich. 2010. San Francisco Bay Area Network northern spotted owl monitoring protocol. Natural Resource Report NPS/SFAN/NRR—2010/245. National Park Service, Fort Collins, Colorado.
- Press, D., W. W. Merkle, and H. J. Jensen. 2011. Monitoring northern spotted owls on federal lands in Marin County, California: 2009 annual report. Natural Resources Technical Report NPS/SFAN/NRTR—2011/423. National Park Service, Fort Collins, Colorado.
- Press, D., W. W. Merkle, H. Jensen, T. Ellis, and F. Taroc. 2012. Monitoring northern spotted owls on federal lands in Marin County, California: 2010–2011 report. Natural Resources Technical Report NPS/SFAN/NRTR—2012/606. National Park Service, Fort Collins, Colorado.
- Stralberg, D., K. E. Fehring, N. Nur, L. Y. Pomara, D. B. Adams, D. Hatch, G. R. Geupel, and S. Allen. 2009. Modeling nest-site occurrence for the Northern Spotted Owl at its southern range limit in central California. *Landscape and Urban Planning* 90:76–85.

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