



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

## *2009 Annual Report*

Natural Resource Technical Report NPS/SFAN/NRTR—2011/432



**ON THE COVER**

Northern spotted owl (*Strix occidentalis caurina*) platform nest in Douglas-fir (*Pseudotsuga menziesii*), with the female and one nestling visible. Photograph by: Heather Jensen

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

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All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

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## Abstract

This report provides a summary of results from the 2009 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 subspecies since 1990. The Marin County population of spotted owls is of interest because of its isolation from other populations, high density and fecundity, and because only recently has this population been affected by the expansion of barred owls (*S. varia*).

The goals of our northern spotted owl monitoring program are to estimate trends in spotted owl occupancy and fecundity within the NPS legislative boundary in Marin County.

A total of 30 known spotted owl territories ("sites") were randomly selected and monitored using standardized methods during the 2009 breeding season. We used an interim sample design in 2009 while in the process of revising and formalizing our sample design for our long-term northern spotted owl monitoring protocol.

Spotted owl pair occupancy in 2009 was the second highest reported, and fecundity was above average for the program's 11 years of monitoring. Pairs of spotted owls occupied 27 of the 30 (90%) long-term monitoring sites. Of the 26 females with known reproductive status, 19 females (73%) attempted nesting. With two nest failures, the remaining 17 nests yielded a confirmed total of 27 young. A total of seven non-nesting females were confirmed at the 30 sites. In 2009, the fecundity estimate of 0.52 (SE  $\pm$ 0.09) was above the average fecundity of 0.40 (SD  $\pm$ 0.22) measured at monitoring sites from 1999 to 2009.

The percentage of pairs that attempted nesting (73%) in 2009 was above a 10-year average of 61%. A good nesting year, possibly influenced by favorable weather conditions and abundant prey, may have attributed to the high rate of pair occupancy at sites monitored in 2009. In addition, our random selection of sites for monitoring resulted in a lower percentage of sites that are impacted by barred owls than in the previous two years of monitoring. Our monitoring history has shown that in the presences of barred owls, northern spotted owls are difficult to detect and pair occupancy rate is decreased. By randomly selecting a lower percentage of sites influenced by barred owls for our 2009 monitoring, we likely increased our chances of recording northern spotted owl pairs at the sites we monitored.

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

## Acknowledgments

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

This project is possible through the assistance of numerous staff members from past years. Daniel George of NPS designed our database and additional field guidance and supervisory contributions have been made by Sarah Allen, Geoff Geupel, Daphne Hatch, Marcus Koenen, and Mia Monroe. We are grateful to Point Reyes Law Enforcement staff for accompanying staff biologists to monitoring sites with safety concerns. Thanks to Rachel Townsend and Patrick Furtado who helped with surveys at Golden Gate National Recreation Area. Last, but not least, thank you to Dan Munton, Matt Divens, and Rick Johnson for their continued assistance with surveys at Point Reyes National Seashore.

The authors thank Marcus Koenen, Alice Chung-MacCoubrey, and especially Renée Cormier for their careful review of this report and helpful edits.

## 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” (NPS 1916). To uphold this goal, the Director of the NPS approved the Natural Resource Challenge to encourage national parks to focus on the preservation of the nation’s natural heritage through science, natural resource inventories, and expanded resource monitoring (NPS 1998). Through the Challenge, 270 parks in the national park system were organized into 32 inventory and monitoring networks.

The San Francisco Bay Area Network (SFAN) Inventory and Monitoring Program includes Eugene O’Neill (EUON), John Muir (JOMU), and Fort Point (FOPO) National Historic Sites, the Presidio of San Francisco (PRES), Muir Woods (MUWO) and Pinnacles National (PINN) Monuments, Point Reyes National Seashore (PORE), and Golden Gate National Recreation (GOGA). The network has identified vital signs, indicators of ecosystem health, which represent a broad suite of ecological phenomena operating across multiple temporal and spatial scales. The intent of SFAN has been 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 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).

Although northern spotted owls were selected as a vital sign for long-term monitoring in 2005 (Adams et al. 2006), initial inventory and monitoring efforts for northern spotted owls began in the SFAN parks as early as 1993. Following intensive inventory efforts in 1997-98, the NPS began a monitoring program in coordination with PRBO Conservation Science (PRBO) in 1999 within NPS lands at PORE, GOGA, and MUWO as well as other non-NPS lands in Marin County. As required by the Inventory and Monitoring Program, the NPS began developing a formal monitoring protocol in 2003 based on the joint monitoring efforts in progress by the NPS and PRBO. In 2006, in response to initial peer review comments, the protocol was modified to focus on just NPS lands and we initiated development of a more rigorous sampling design. Monitoring years 2007-2009 were interim years while the program sought statistical support for the northern spotted owl data, developed power analyses for the data, developed a final long-term sample design, and worked towards final protocol approval. The final sample design resulting from these efforts is presented in the *San Francisco Bay Area Network Northern Spotted Owl Monitoring Protocol* (Press et al. 2010).

## Life History

The northern spotted owl has been listed as a federally threatened subspecies 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 (Golden Gate National Recreation Area, Muir Woods National Monument, Point Reyes National Seashore), and other public and private lands in Marin County.

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

Spotted owls in Marin County use a variety of tree species of differing sizes for nesting, and typically nest in platform structures, with relatively few nests in cavities. Platform nesting structures in Marin 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 NPS lands in Marin conducted in 2006 (Jensen et al. 2007). Monitoring of the Marin spotted owl population has occurred from 1999-2008 (Hatch et al. 1999; Fehring et al. 2001; Fehring et al. 2002; Fehring et al. 2003; Fehring et al. 2004; Jensen et al. 2004; Jensen et al. 2006; Jensen et al. 2008; Jensen et al. 2010). The Marin County study area supports the highest density of northern spotted owls within this subspecies' range (Blakesley et al. 2004). Based on a recent analysis, the density of spotted owl activity sites was estimated to be 0.52 owls/km<sup>2</sup>, which is slightly higher than a previous Marin County estimate due to the discovery of several additional owl sites and the use of a more limited, geographically relevant boundary for the study area (Chow 2001; Stralberg et al. 2009). As part of range-wide demographic analysis, adult survival and fecundity in Marin County were apparently stable from 1998-2003 (Anthony et al. 2006). Out of a total of 14 study sites, fecundity of adult females in Marin was the second highest and the Marin adult survival estimates were similar to most other sites (Anthony et al. 2006).

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

## Threats to the Population

In 2008, the Northern Spotted Owl Recovery Plan identified three high ranking concerns to the conservation of the spotted owl: (1) declining suitable habitat, (2) isolation of populations, and (3) decline in the population (USFWS 2008). The Recovery Plan acknowledged that protecting and managing spotted owl habitat alone is not adequate for spotted owl recovery and the U.S. Fish and Wildlife Service prioritized barred owls as a significant and complex threat (USFWS 2008). The suite of threats present in Marin County mirrors the range-wide concerns and reflects the area's close proximity to the greater San Francisco Bay area. Threats (ranked according to perceived risk level in Marin) include: (1) interspecific competition due to the continued range expansion of the barred owl, (2) loss of habitat resulting from urban development along open space boundaries and increased risk of catastrophic wildfire, (3) structural changes in forest heterogeneity due to Sudden Oak Death, (4) genetic isolation, (5) disturbance due to intense recreational pressures, and (6) West Nile virus.

The threat from barred owls is of particular concern to the spotted owl population in Marin County (Anthony et al. 2006). Barred owls have expanded their range from the eastern United States west across the Canadian Rocky Mountains and down the west coast. Barred owls exploit the same forested habitats and prey species as spotted owls. However, barred owls are slightly larger than spotted owls and can exhibit aggressive behavior toward spotted owls (Leskiw and Gutiérrez 1998). 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 in 2002, and have been documented as reproducing in 2007 and 2008. Physical confrontations and aggressive interactions between barred and spotted owls have been documented at multiple spotted owl sites within Marin County.

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 population is isolated from the spotted owl populations to the north and shows no evidence of hybridization with California spotted owls (*S. o. occidentalis*; Henke et al. 2003; Barrowclough et al. 2005). A break in forested habitat, expansive grasslands and anthropogenic development serve as dispersal barriers and has isolated the Marin population from its northern counterparts. Barrowclough et al. (2005) indicated that due to the apparent genetic isolation of Marin County's spotted owl population, the population warrants special management attention.

Currently, forests in Marin County are heavily infested by the pathogen Sudden Oak Death (*Phytophthora ramorum*). At several locations within Point Reyes National Seashore, tanoak mortality has exceeded 95% by basal area (Moritz et al. 2008). The die-off of native coast live oak and tanoak species is locally important because it results in shifts in plant species composition, changes in habitat structure, possible reduction in plant species richness, and potential impacts on forest dynamics. Specifically, the spotted owl's dominant prey item in this

area, the dusky-footed woodrat (Chow and Allen 1997; Fehring 2003), use tanoaks for cover and forage (Sakai and Noon 1993). Sudden Oak Death may also amplify fuel load accumulations and increase the potential and severity of fires.

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

### **Monitoring Objectives**

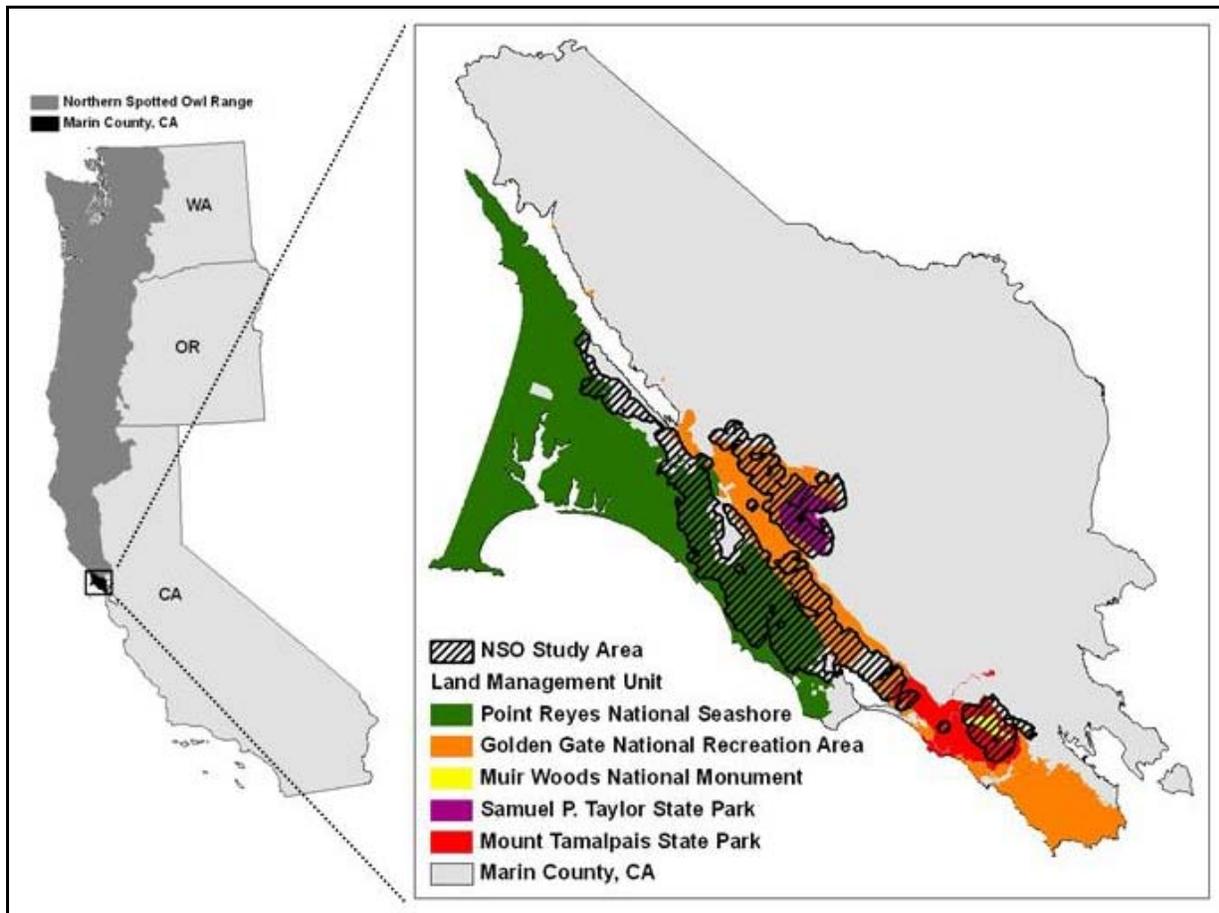
There are three current monitoring objectives for the SFAN northern spotted owl monitoring program (Press et al. 2010).

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

# Methods

## Study Area

Our study area is within a 13,889-hectare (34,320-acre) forested area of Marin County and includes suitable spotted owl habitat inside or within 400 meters (0.25 mile) of the legislative boundaries of GOGA, MUWO, and PORE (Figure 1; Press et al. 2010). California State Park (CSP) lands in Mount Tamalpais State Park and Samuel P. Taylor State Park are included in the study area, but Tomales Bay State Park is outside of the federal NPS boundary; thus, its spotted owl habitat and known territories have been excluded from the study and are not included in the acreage calculation. Also not included in the study area acreage calculation are additional management sites that occurred outside the perimeter of NPS lands on CSP, the City of Mill Valley, the Marin Municipal Water District (MMWD), and the Marin County Open Space District (MCOSED) lands.



**Figure 1.** Northern spotted owl range map (left) and Marin County study area (right). On the range map, the dark gray shows the northern spotted owl's range and the black square is centered on Marin County. On the Marin County map, land management units within and around the 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 NPS 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 (Chow and Allen 1997; Hatch et al. 1999; Chow 2001).

In partnership with PRBO Conservation Science, between 1999 and 2005, 46 Marin County sites were selected and monitored for occupancy and fecundity and to collect nest site characteristics (Hatch et al. 1999; Fehring et al. 2001; Fehring et al. 2002; Fehring et al. 2003; Fehring et al. 2004; Jensen et al. 2004; Jensen et al. 2006). The sites were chosen to represent a variety of habitat types, ongoing management concerns, accessibility, and funding availability.

Study design changes were initiated in 2006 as a result of peer review comments received to an early version of the northern spotted owl monitoring protocol in development by the SFAN Inventory and Monitoring Program (Press et al. 2010). The reviewers emphasized that the selection process for the 46 long-term monitoring territories was not done randomly. In addition several of the 46 monitoring sites were located outside of NPS boundaries, limiting the ability to make inferences to the spotted owl population on just NPS lands. The earlier sample design was rejected and we began developing a new study design to detect trends toward declines in occupancy and fecundity for NPS lands in Marin County and meet the objectives of the monitoring protocol (Press et al. 2010).

As an initial step towards developing a revised sample design, we completed a single year inventory study in 2006 to assess the spotted owl population in all suitable habitat on NPS lands (Jensen et al. 2007). This single year inventory effort utilized a model that predicted spotted owl nest-site occurrence based on habitat suitability (Stralberg et al. 2009). We applied a 400 meter buffer around the habitat model's boundary and developed a study area restricted to NPS lands and buffered lands within 400 meters of the legislative boundaries of MUWO, PORE, and GOGA. This study area excluded known spotted owl territories and suitable habitat on adjacent MMWD and MCOSD lands and was ultimately formalized in our long-term monitoring protocol (Press et al. 2010). Although PRBO Conservation Science will continue to monitor spotted owls outside of NPS boundaries in Marin County, primarily for agency management purposes, their results will not be incorporated into annual and long-term trend reports developed by the SFAN Inventory and Monitoring Program.

In 2006, we used a hybrid of the Marin Modified Protocol (Fehring et al. 2001) and the U.S. Fish and Wildlife Service's protocol (USFWS 1992) and standardized search procedures within the study area (Jensen et al. 2007). As a result, 65 areas, which included all 43 known spotted owl territories within the study area, and 22 other areas with no known established territories, were inventoried for occupancy. At a minimum, a single spotted owl was detected at 59 of the 65 areas, and pairs occupied 43 territories (Jensen et al. 2007).

During the 2007-2009 monitoring seasons, the revised study design was still being established as we finalized our monitoring protocol (Press et al. 2010). In 2007, a randomly selected subset of

25 sites from the known territories within the study area was monitored for occupancy and fecundity (Jensen et al. 2008). The same 25 sites selected in 2007 were monitored in 2008 (Jensen et al. 2010). For the 2009 breeding season reported here, we selected a new set of random sites and increased our sample size to 30 sites.

### **Field Methods**

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. In Marin County, a modified protocol has been developed collaboratively between the National Park Service and PRBO Conservation Science that reduces 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 facilitates intensive nest checks and obviates the need to use mice to monitor reproductive status. Consequently, we rely on increased search time, more frequent visits and owl behavioral observations to gather the data.

All long-term monitoring surveys (1999-2005 and 2007-2009) 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” (Fehring et al. 2001) is modeled directly from the widely used “Spotted Owl Monitoring Protocols for Demographic Studies” (Forsman 1995). Survey methods include visual surveys of previous activity centers and nest sites, playback calling and hooting both during the day and at night, mousing, visual nest checks, and counts of fledged young. Biologists attempt to sex and age all spotted owls detected during field surveys. In study areas where banding occurs, sexing and aging spotted owls is easily determined with a re-sighting of the owl’s band, but in the Marin study area only a small proportion of owls are banded. Without band identification, spotted owls are instead sexed based on vocalizations and aged by tail feather shape and coloring (Forsman 1983). Barred owls detected during surveys are noted, and reports of barred owls in or around the study area are investigated, but there are no specific methods utilized for specifically monitoring barred owls. An annual breeding status is assigned to the individual owl territories monitored and is determined using criteria in the Marin Modified Protocol.

All owl activity centers (either nest location or major roost site) are recorded in Global Positioning System (GPS) coordinates using a Garmin eTrex Legend or similar GPS unit. Roost sites or nest trees for which GPS satellite access is not available are mapped on topographic maps from compass bearings taken in the field and GPS coordinates are obtained by using ArcGIS 9.3 (ESRI 2009). Each year, at every known nest location, nest tree parameters are measured and surrounding habitat is described using a standardized methods found in our monitoring protocol (Press et al. 2010).

### **Data Management and Distribution**

All site search, owl detections, and nest record field data are compiled in a Microsoft Access database maintained at PORE (Press et al. 2010). All areas surveyed are mapped using ArcGIS 9.3 GIS software program and the data layers are made available to agencies involved in land

management and planning projects within Marin County, including the Marin County Open Space District, Marin Municipal Watershed, and California State Parks. The 1999 through 2009 spotted owl location data was submitted to the Biogeographic Information and Observation System (BIOS) database which is administered by the California Department of Fish and Game.

### **Summaries and Reporting**

In conjunction with the recent changes in sampling design, we also revised the criteria for determining which sites would be included in annual reports from 2008 and on. The new criteria were necessary to standardize the reporting process, restrict our reporting to only sites within our revised study area, and allow repeatability and robust comparisons among years.

Beginning with the 2008 report, we excluded 1997 and 1998 data from the summaries because survey purpose and level of effort were difficult to ascertain. In annual reports prior to 2008, the 1999-2005 data was reported for 46 selected long-term monitoring sites. In 2008, however, we restricted the inclusion of those 46 sites monitored in 1999-2005 to only the 36 that fell within our re-designed study area. Because the sites monitored in these years were not randomly selected, we justified including 13 additional management sites monitored in 1999-2005, which were also not randomly selected, in the data summaries if the sites were within the study area and received an adequate level of survey effort according to our field protocols. The 2006 data is excluded from the annual summaries for reproductive success and fecundity since the purpose of the single year inventory was to determine spotted owl occupancy only.

For sites monitored from 2007 to 2009, only sites randomly selected from within the study area for long-term monitoring purposes are included in our reports. In each of these years, there were sites monitored for management purposes, but these sites are not included in our occupancy and fecundity analyses because they were not randomly selected.

Any differences in results previously presented in our annual monitoring reports can be attributed to the new criteria for report inclusion that we have applied to the long-term spotted owl data.

## Results

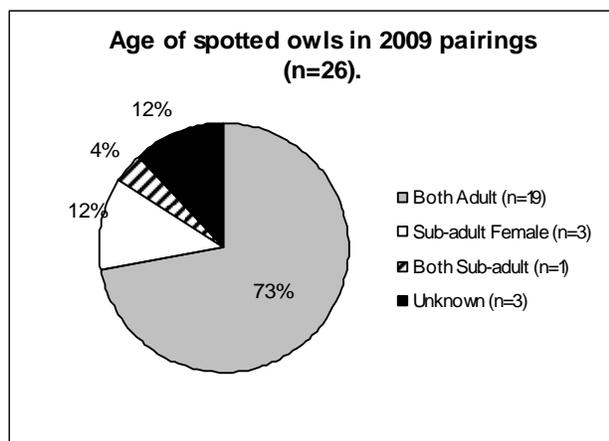
From March 10 to August 20, 2009, the survey teams made 198 visits (mean visits/site = 6.6, range 2-11) to the 30 study sites monitored for the purpose of determining occupancy and fecundity (Table 1). A summary of results are reported in Table 1. Although no statistical tests were performed on these data, we report the results of the 2009 data compared with data extending back to 1999 for observed owl sex and ages, occupancy, reproductive status, fecundity and nest trees.

**Table 1.** Summary of spotted owl monitoring results for the 2009 breeding season.

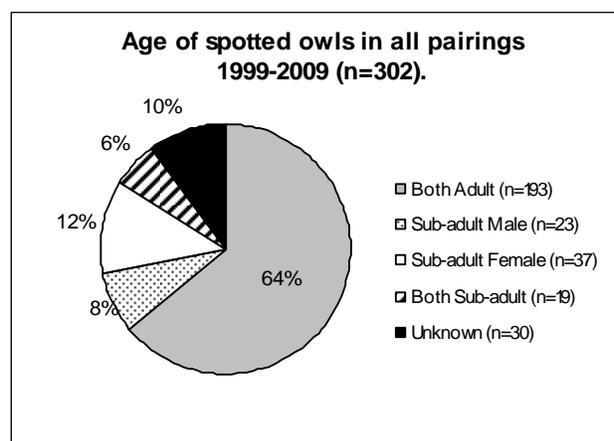
Number of sites monitored	Number of occupied territories	Number of sites occupied by pairs	Number of sites with known reproductive outcomes	Number of nests located	Number of young produced	Fecundity
30	28	27	26	17	27	0.52

### Age and Sex Determination

We positively sexed and aged 47 (23 males and 24 females) spotted owls out of the 56 total owls monitored in 2009 at 30 sites. Some owls remained silent during daylight survey hours and only vocalized at night making it impossible to assign ages to the corresponding sex. In 2009, adults constituted 89% or 42 of the 47 spotted owls whose age was identified. Four second-year sub-adults (9%) and one first-year sub-adult (2%) were located. Seventy-three percent of the 26 pairs in 2009 were composed of an adult female and male (Figure 2). In comparison, only 71% of all known age pairings from 1999-2009 were an adult pair (Figure 3). In 2009, we were unable to determine sex of at least one or both pair members at 12% our monitoring sites, which is similar to 10% of our sites from 1999-2009.



**Figure 2.** Age of spotted owls in 2009 pairings; n is the number of spotted owl pairs.



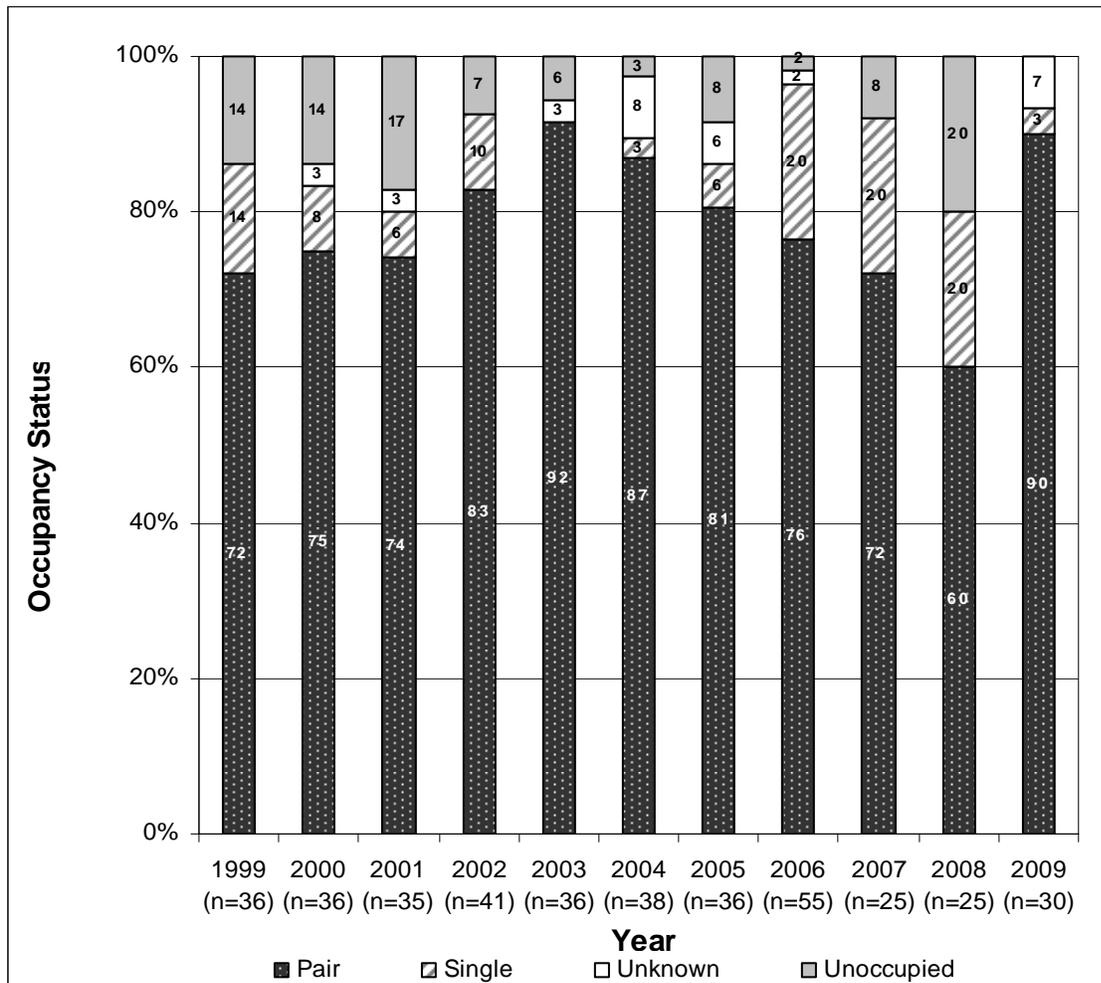
**Figure 3.** Age of spotted owls in all pairings from 1999-2009; n is the number of spotted owl pairs.

## Occupancy Status

The percentage of sites occupied by pairs or single owls remained fairly constant at roughly 90% from 1999-2007. In 2008, the total percentage of sites occupied by pairs or singles dropped to 80% (Figure 4) with pair occupancy reaching the lowest percentage (60%) in a decade of monitoring. In the 2009 breeding season, however, we observed a sharp rise in pair occupied sites to 90%, one of the highest results in our history of monitoring. Concurrently, the percentage of sites occupied by a single owl (9%) declined from the previous three years of monitoring on federal lands (Figure 4).

## Reproductive Status and Fecundity

In 2009, 27 of the 30 sites were occupied by a pair of spotted owls. Of the 26 females with known reproductive outcomes, 19 females (73%) attempted nesting (Figure 5). Seventeen females successfully nested yielding a total of 27 young. Seven non-nesting females and two nest failures were confirmed at the 26 sites with known reproductive status. Fecundity, a measure of productivity, is calculated as the average number of female young produced per territorial



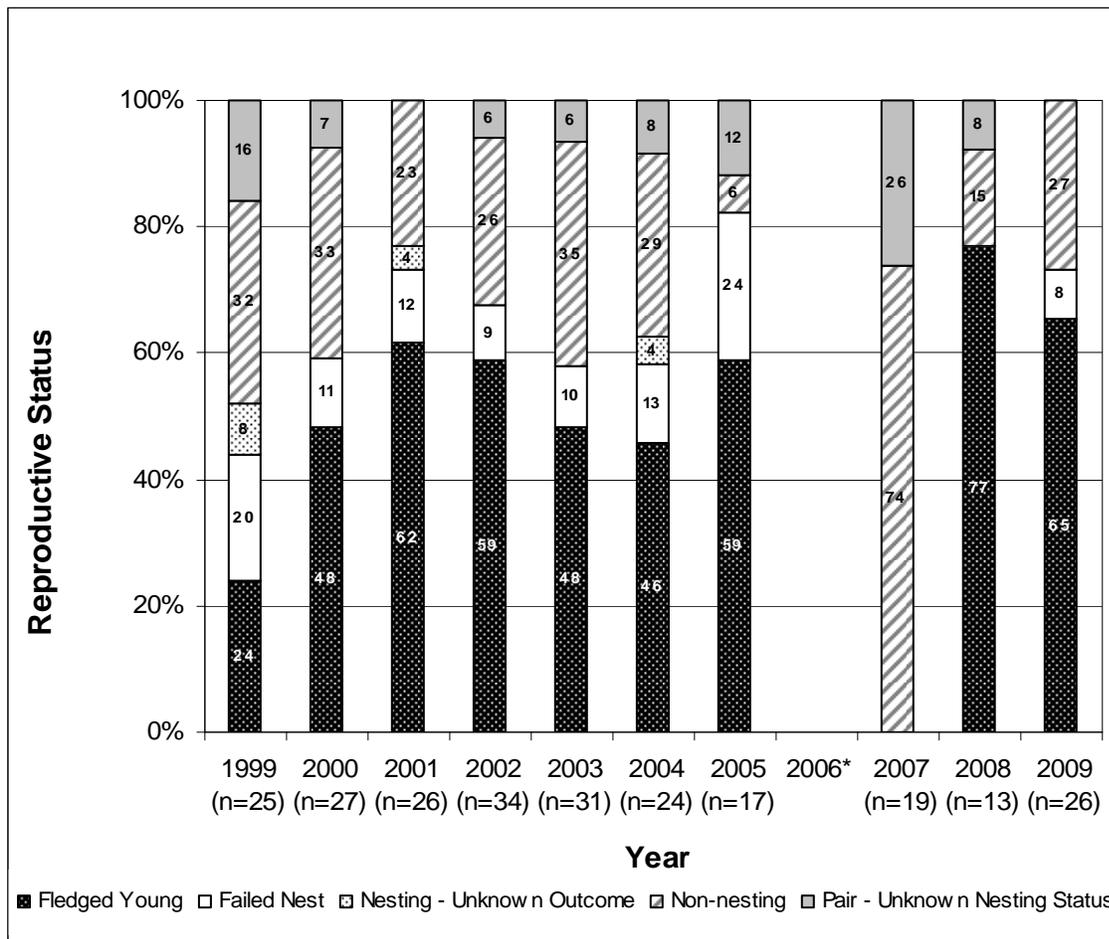
**Figure 4.** Occupancy status for all study sites (1999-2009). Numbers within the bars are the percentage for each status category and n the number of sites monitored.

female, assuming a 50:50 sex ratio of fledglings. The mean fecundity for the 2009 breeding season was 0.52 (SE ±0.09), which is above the average fecundity from 1999-2009 (0.40; SE ±0.07; Figure 6).

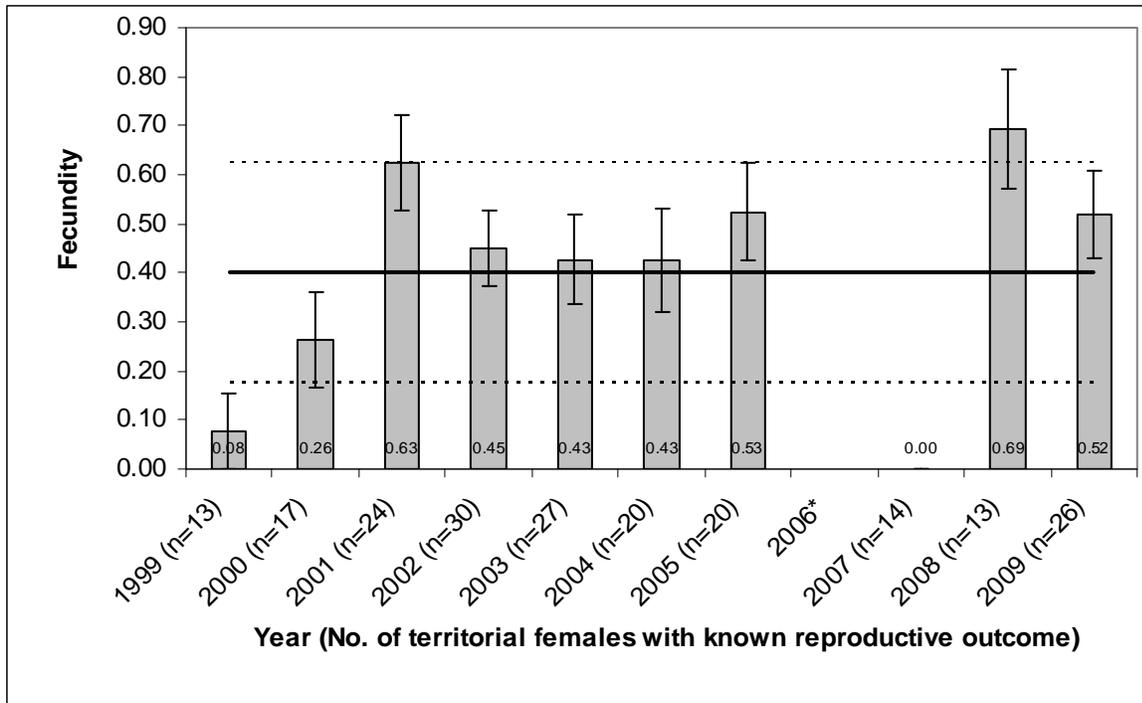
### Nest Measurements

From 1999 to 2009, spotted owl researchers have located a total of 116 spotted owl nests (Table 2). Of the 116 unique nests, 11 (10%) were in cavities and 105 (90%) were platform nests. This ratio is the opposite of owl nests in older forests where 80-90% of the nests are in cavities, but closely resembles the ratio in other parts of the range where forests are younger (Buchanan and Irwin 1993; Forsman and Griese 1997; LaHaye and Gutierrez 1999). A total of 15 platform nests and two cavity nests were located in 2009.

Over half (n=61; 53%) of the documented nests have been in Douglas-fir. The remainder of nest tree species selected include coast redwood (n=38; 33%), California bay (n=9; 8%), coast live



**Figure 5.** Reproductive status for owl pairs monitored in the NPS study area (1999-2005 and 2007-2009). Numbers within the bars are the exact percentage for each status category and n is the total number of spotted owl territories. \*2006 inventory data was excluded from this analysis.



**Figure 6.** Fecundity for 1999-2005 and 2007-2009. The solid line on the graph is mean fecundity from 1999-2009 (0.40), and the dashed lines are one standard deviation from the mean (0.22). Year error bars indicate  $\pm 1$  standard error and n is the total number of spotted owl territories. \*2006 inventory data was excluded from this analysis.

oak (n=6; 5%), tanoak (n=1; 1%), and bishop pine (n=1; 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 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 116 unique nests located within the NPS study area from 1999 to 2009.

	Platform Nests (n=105)		Cavity Nests (n=11)	
	Mean	SE	Mean	SE
DBH (cm)	100.0	$\pm 5.16$	194.0	$\pm 37.71$
Nest height (m)	19.0	$\pm 0.72$	21.4	$\pm 3.66$
Tree height (m)	34.5	$\pm 1.27$	42.3	$\pm 5.91$

### Identifications of Banded Owls

Between 1998 and 2003, 110 spotted owls were captured and color banded at 26 sites within a 9,996-hectare (24,700-acre) area surrounding Bear Valley in PORE. In 2004, the banding aspect of the project was ceased due to logistical constraints and limited sample size. We have continued to identify the presence or absence of color bands on all spotted owls encountered.

Of the 110 spotted owls banded, 50 were banded as juveniles, 23 as subadults, and 37 as adults (Fehring et al. 2004). In 2008, seven banded spotted owls were resighted (2 females and 5 males). Of the six confirmed band resights in 2009, three were adult females and three were adult males, most of which were banded in 2002 or 2003. The oldest banded owl observed in 2009 was a 12 year old male which was banded as a second year subadult in 1999.

### **Barred Owls**

The first known barred owl record for Marin County occurred in May 2002 in MUWO, and the first known successful reproduction of barred owls occurred in 2007 also at MUWO, when a barred owl pair was observed with 2 fledglings. In 2008, biologists documented the first known barred owl nest tree in Marin County and confirmed the successful fledging of two barred owls.

At the 30 randomly selected monitoring sites in 2009, there were no barred owl detections during spotted owl surveys. However, barred owls were detected separately from formal surveys, at sites monitored for management concerns, and outside of the study area.

A barred owl of unknown sex was detected at two locations in the lower Olema Valley in 2009, once during a survey for management purposes and several times from a residence housing biologists from PRBO Conservation Science. This is the sixth year that a barred owl, usually recorded as a male, has been detected on the west side of the Bolinas Ridge in the Olema Valley.

In 2009, park visitors observed a barred owl on multiple occasions along trails within and adjacent to MUWO. A barred owl was also detected once during a survey of a spotted owl site in MUWO monitored for management purposes. The barred owl pair, which as mentioned successfully nested in both 2007 and 2008, was not confirmed in MUWO in 2009.

Biologists with PRBO Conservation Science identified a sub-adult barred owl in 2009 at a spotted owl site near the edge of Mill Valley at the base of Mt. Tamalpais. This was the first detection of a barred owl at the Mill Valley site, which falls outside of the NPS study area. The MUWO barred pair nested over a ridge but only about a mile from the Mill Valley site, so the sub-adult detection may represent juvenile dispersal from MUWO.

Lastly, NPS received reports from residents of a barred owl of unknown sex calling on at least two occasions along the Inverness Ridge not too far north of Bear Valley at PORE although outside of the study area. A barred owl was first heard calling in this area in 2008.

Since barred owls in Marin County are not marked, the exact number of individuals cannot be confirmed. Based on the sex determination, frequency and repetition of barred owl detections, and distance between barred owl detections over the last several years, at least two males and a female are current residents of federal lands within the monitoring study area. Based on detections outside of the study area, there are an additional two or more unknown sex barred owls in Marin County. To date, no spotted/barred owl hybrids have been detected at any of the long term monitoring sites.

Barred owls have been observed hunting signal crayfish (*Pacifastacus leniusculus*) in the Redwood Creek drainage on numerous occasions over multiple years by park visitors and NPS

staff. On May 7, 2008, biologists watched a male barred owl hunt on the ground for 25 minutes and successfully capture a broad-footed mole (*Scapanus latimanus*). Pellet samples collected at the 2008 barred owl nest site indicate a diet composed of crayfish and small mammals. Relative to spotted owls, barred owl diet plasticity likely provides a competitive advantage over spotted owls (Livezey et al. 2008). An example of this likely competitive advantage was documented on federal lands in Marin County during the 2007 breeding season. There were no spotted owl nesting attempts, nests, or young located on federal lands in 2007; however the only known barred owl pair successfully nested and produced a maximum count of two fledglings. In contrast to spotted owls, the generalist diet and foraging strategies of barred owls may buffer the species from major fluctuations in reproductive success among years.

## Discussion

Northern spotted owl pair occupancy in 2009 (90%) was the second highest reported in the past 11 years of monitoring. Although not tested for statistical significance, the results were a sharp increase from 2008 during which only 60% of sites were pair occupied. In 2009, only a single owl was detected at one site and no owls were detected at two sites. By comparison, in 2008, five sites were determined as single status and five sites were unoccupied.

The increase in pair occupancy in 2009 may be attributed to several factors. To begin, 2009 appears to have been a good nesting year, with the percentage of pairs that attempted nesting (73%; Figure 5) above the 10-year average of 61%. Favorable weather conditions and an abundance of prey, for example, are important factors influencing reproductive rates in northern spotted owls (Franklin et al. 2000; Rosenberg et al. 2003; Courtney et al. 20004). When conditions are less favorable, spotted owls may be less likely to pair up during the breeding season, less territorial, and can be more difficult to detect (Jensen et al. 2008).

High pair occupancy also may have been influenced by our random selection of sites to monitor during the 2009 breeding season. In 2007 and 2008, the same set of 25 random sites was monitored, and at four of these sites (16%) we have documented barred owls on multiple occasions in multiple years, including 2007 and 2008. By contrast, we randomly selected a set of 30 sites to monitor in 2009, of which only 2 sites (7%) had a significant history of barred owl detections and no barred owl observations were made during formal surveys at any of the 30 sites monitored in 2009.

Our monitoring history has shown that in the presence of barred owls, northern spotted owls are difficult to detect and pair occupancy rate is decreased (Jensen et al. 2007; Jensen et al. 2008; Jensen et al. 2010, Starcevich and Steinhorst 2010). As observed in other studies (Kelly et al. 2003; Olson et al. 2005; Crozier et al. 2006), this imperfect detection of spotted owls may indicate the suppression of spotted owl vocalizations or displacement of spotted owls from their territories as a result of barred owl residency. By randomly selecting a lower percentage of sites influenced by barred owls for our 2009 monitoring, we likely increased our chances of recording northern spotted owl pairs at the sites we monitored.

Declines in spotted owl site occupancy have been seen in other areas where barred owls are present (Kelly et al. 2003; Olson et al. 2005) and are the most severe in areas where barred owls have been established the longest (Anthony et al. 2006). In reviewing barred owl and spotted owl locations in Oregon between 1974 and 1998, Kelly et al. (2003) found that when barred owls invade spotted owl territories, mean annual occupancy of spotted owls decline when compared to territories without barred owls.

Although not tested for statistical significance, the 2009 fecundity estimate of 0.52 (SE  $\pm$ 0.09) was above the average fecundity of 0.40 (SD  $\pm$ 0.22) measured at monitoring sites from 1999 to 2009. At one site in PORE, triplets successfully fledged from a nest in 2009. Although triplets have been documented in Marin County in the past, the nests have previously all been located near urban areas in east Marin. The 2009 triplets are the first known occurrence on NPS lands and in such a remote setting.

The high incidence of adult pairs at the spotted owl sites monitored may have been one factor contributing to the above average fecundity documented in 2009. Of the 26 spotted owl pairs that we monitored, 19 (73%) were adult pairings (Figure 2). In comparison, only 64% of all pairings from 1999-2009 were an adult pair (Figure 3). Anthony et al. (2006) found that the age of females was the primary factor that affected fecundity. Productivity of females increased with age and adults ( $\geq 3$  years old), a factor that contributes the most to population size (Courtney et al. 2004).

In comparison to the 2008 breeding season, spotted owl occupancy increased noticeably in 2009 (Figure 4), while fecundity declined (Figure 6). Despite a lower percentage of pair occupied sites in 2008, those sites where pairs established in 2008 had a high percentage of successful nesting. In 2009, there was a higher percentage of non-nesting pairs and nest failures and a lower percentage of successful nests compared to 2008 (Figure 5), resulting in lower fecundity in 2009.

## **Research Activities and Recommendations**

### ***Barred Owl Study***

There is a great need to study barred owl and spotted owl interactions, to determine the nature of the threat, and identify potential management options to ensure the persistence of spotted owls throughout their historic range (USFWS 2008). The NPS and other agencies are implementing studies across the northern spotted owl's range to gain a better understanding of the interspecific behavior and to learn more about management options to benefit spotted owls in the presence of barred owls. Since the barred owl has only recently invaded the southern extent of the northern spotted owl's range, Marin County offers a unique opportunity to study the early patterns of contact between barred and spotted owls. In Marin County, researchers will continue to track barred owl observations and make efforts to color band barred owls to facilitate tracking individual owls. Staff members and volunteers will continue to be made aware of the potential of hybridization and the importance of confirming the identity of both pair members. In future years, we will continue to investigate the possibility of implementing a barred owl telemetry study to track barred owl movements, predict areas likely to see barred and spotted owl interactions, and to provide insight to the overlap of diet, habitat use, and interspecific behavior.

### ***Pellet Study***

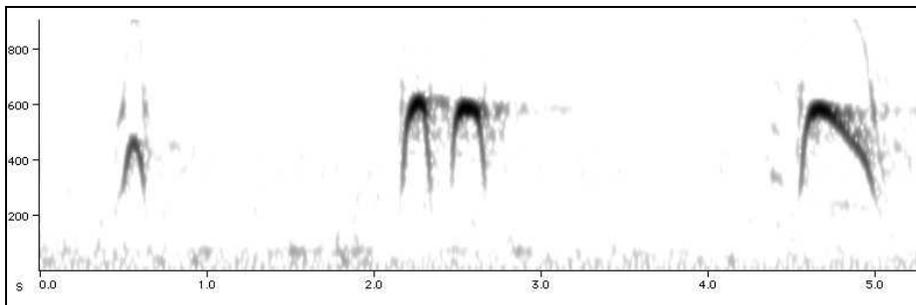
The diet of owls can be identified from the analysis of pellets (casted prey remains). Numerous studies conducted throughout the range of the northern spotted owl have reported the frequency of prey items and the relative biomass of prey items (Forsman et al. 1984). Other studies have provided evidence that prey can have an influence on reproductive success (Zabel et al. 1995; Rosenberg et al. 2003) and home range size (Zabel et al. 1995).

The SFAN spotted owl monitoring program has continued to provide Dr. James Cunningham at Dominican University with spotted owl pellets collected during the 2008 and 2009 breeding seasons for a prey analysis study. Dr. Cunningham has identified undergraduates who will dissect the pellets and identify the prey remains. Each student will develop a research idea in conjunction with Dr. Cunningham and the National Park Service.

### **Vocalization Study**

During the 2006 through 2009 breeding seasons, spotted owl staff members worked with independent researcher, Rick Johnson, to investigate the potential of identifying individual northern spotted owls through vocalization analysis. Vocal identification has been proven to be an effective tool to distinguish between individuals in the genus *Strix*, specifically the African wood owl (*Strix woodfordii*; Delport et al. 2002). The purpose of the research project was to determine if recordings of owl vocalizations, specifically four note location calls, can be used to identify individual birds. The use of vocalizations as an alternative to banding for individual identification has been proposed for the Mexican spotted owl (*S. o. lucida*; Kuntz and Stacy 1997).

During spotted owl breeding surveys, unsolicited and solicited male and female spotted owl vocalizations as well as incidental barred owl vocalizations were recorded during day and night surveys. The sounds are studied using spectrograms (Figure 7) and five parameters were selected to evaluate the spectrograms. The timing of the calls, pitch of the fourth note, and shape of the fourth note were used to distinguish individual owls. These quantitative measures are based on previous work on northern spotted owls and California spotted owls (Van Gelder 2003).



**Figure 7.** Spectrogram of a spotted owl four-note location call.

Preliminary results indicate that identification of individual spotted owls by vocalization alone is not likely to be an efficient monitoring tool for project staff to utilize in a demographic study. This technique may prove to be appropriate for the identification of a smaller population of barred owl individuals.

### **Sudden Oak Death**

Marin County is one of 14 counties in California affected by the pathogen that causes Sudden Oak Death (SOD). *P. ramorum* is a water mold that acts like a fungus, attacking the trunk of a tree and causing a canker, or wound that eventually cuts off the tree's flow of nutrients. Other secondary decay organisms such as beetles and fungi often move in after the tree is infected. Trees infected with SOD may survive for one to several years as the infection progresses. As the tree finally dies, the leaves may turn from green to brown within a few weeks, hence the appearance of sudden death (Davidson et al. 2003). Tanoaks and coast live oaks are killed by the disease; other species affected are known as "foliar hosts" 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-fire forests. Changes in forest physiognomy and shifts in forest species composition due to *P. ramorum* have the potential to affect forest ecosystem dynamics including spotted owls and their prey species. For comprehensive information regarding SOD and links to current maps visit the California Oak Mortality Task Force website at [www.suddenoakdeath.org](http://www.suddenoakdeath.org).

To date, there have been no published studies on the impacts of SOD on northern spotted owls. The most likely pathway for SOD to impact owls is via changes in owl prey species populations. The tanoak and oak species most impacted by SOD are abundant acorn producers and are an important forage species for small mammals which make up the majority of the owl prey base (Courtney et al. 2004). We strongly recommend research to help characterize of the effects of Sudden Oak Death on northern spotted owls. We suggest 1) fine-scale mapping techniques to determine if there are correlations between SOD mortality and northern spotted owl population health and 2) measures of small mammal abundance to determine whether changes in forest composition and structure due to SOD mortality are affecting owl prey species.

### **West Nile Virus**

West Nile virus (WNV) is an arbovirus that first appeared in the Western Hemisphere in New York, in the early fall of 1999. Mosquitoes and migratory birds are the main species involved in the spread of WNV. Mosquitoes are the principle vector and avian species are considered the principle host species for WNV. WNV first appeared in California in 2002. By 2004, WNV had spread to all 58 counties of California and a total of 3,232 birds tested positive for WNV. Statewide, the incidence of WNV has continued to decrease annually. On a local level, since reaching a peak in 2004 of 18 birds testing positive for WNV in Marin County, numbers have continued to steadily decline. In 2009, no dead birds tested positive for WNV in Marin County. For historical and current information that is updated weekly visit <http://westnile.ca.gov/>.

Raptors and owls have been noted to be particularly susceptible to WNV. A northern spotted owl was confirmed to have died from WNV at a captive wildlife facility in Ontario, Canada, indicating that spotted owls are susceptible to WNV. WNV has been detected within other owl species in California. Future efforts will be made to document fatalities potentially resulting from West Nile Virus. Carcasses should be tested whenever possible and the population should continue to be monitored for declines due to this new threat.

### **Management Activities and Recommendations**

Humans and their activities, including development along the wildland/urban interface, land management practices, and recreation are among the significant sources of impact in Marin County. In addition, the continued range expansion of the barred owl poses a competitive threat to spotted owls throughout their range (USFWS 2008). We recommend that owl occupancy and reproductive monitoring surveys continue, and that land managers use these data to ensure that management activities do not impact the habitat or the productivity of northern spotted owls. We

encourage continued communication between land managers and their maintenance crews in planning and executing projects in spotted owl habitat. Information on owl site locations should continue to be made available to all land managers and local city and county planning departments. The central repository for owl detection information in California is the Biogeographic Information and Observation System (BIOS) database, managed by the California Department of Fish and Game.

Given the mixed ownership patterns in Marin County, several owl home ranges contain both public and private lands. Coordination between park managers and local planners is essential. Loss of owl habitat and owl pairs due to residential land management practices (e.g., rodenticide use) and urban development is an urgent local threat. Due to the fragmented and isolated nature of the Marin County forested habitat (Stralberg et al. 2009), declines along the urban edges may impact overall population health throughout the local range.

### ***Public Outreach***

Because there is regular contact between the public and Marin County's northern spotted owl population, the NPS has developed educational resources to inform the public of their role of living and working in areas with spotted owls. Project biologists have worked with MUWO interpretative staff to develop comprehensive spotted owl information on the MUWO website. The goal of the website is to introduce Marin County residents, land owners, and agency managers to basic spotted owl biology, guidelines for protecting spotted owls and owl habitat in this county, and how to minimize potential threats to spotted owls.

In 2009, additional outreach included: 1) development and presentation of a scientific poster at the George Wright Society Biennial Conference on Parks, Protected Area, and Cultural Sites (March 2009) and 2) information on spotted owls was presented at the SFAN Natural Resources and Science Symposium (January 2009), the PORE nesting bird management workshop (February 2009), and the PORE seasonal/new staff training (May 2009). Informational materials include executive briefings and past annual reports and are made available to the public at the San Francisco Bay Area Network's Inventory and Monitoring website:

[http://science.nature.nps.gov/im/units/sfan/vital\\_signs/Spotted\\_Owl/birds.cfm](http://science.nature.nps.gov/im/units/sfan/vital_signs/Spotted_Owl/birds.cfm)



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