



# Spotted Owl Monitoring in Olympic National Park

## *1992-2016*

Natural Resource Report NPS/OLYM/NRR— 2017/1530





**ON THIS PAGE**

Adult spotted owl, Elwha River valley, Olympic National Park  
Photograph courtesy of Patrick Loafman, National Park Service

**ON THE COVER**

Juvenile spotted owl, fledged from the only nest found this year in Olympic National Park  
Photograph courtesy of Patrick Loafman, National Park Service

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# **Spotted Owl Monitoring in Olympic National Park**

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## Executive Summary

This report summarizes progress on the northern spotted owl (*Strix occidentalis caurina*) monitoring program in Olympic National Park in 2016. Monitored spotted owl territories in the national park, together with those visited by the U.S. Forest Service Pacific Northwest Research Station in the surrounding Olympic National Forest, make up the Olympic demographic study area. This is one of eight study areas called for in the Northwest Forest Plan to estimate spotted owl population trends and monitor the effectiveness of the plan. Spotted owl territories in the NPS portion of the study have now been monitored for an average of over 24 years.

In 2016, National Park Service personnel monitored a sample of 52 spotted owl territories (hereafter “sites”) to estimate rates of occupancy, survival and reproduction. Crews made 202 field visits, detecting spotted owl pairs at five sites and single spotted owls at three sites. At the eight sites where spotted owls responded, they were found on an average of 48% of monitoring visits. Crews banded two spotted owls, and observed ten previously banded spotted owls. One nest attempt was documented, where the pair fledged a single juvenile

Data collected on eleven northern spotted owl demography studies 1985-2013 were analyzed at a workshop in Corvallis, Oregon in January of 2014. This analysis estimated a range-wide rate of population decline of 3.8% a year, and a 3.9% annual decline for the Olympic Peninsula. Rates of spotted owl territory occupancy on the Olympic Peninsula declined from 81% in 1995 to 21% in 2013.

Barred owls (*Strix varia*) were first documented on the Olympic Peninsula in 1985, and have now been detected at 94% of the monitored spotted owl sites in Olympic National Park. Displacement by barred owls is now the primary threat to the conservation of spotted owls in protected areas. The presence of barred owls has had a negative effect on spotted owl territory colonization rates and a positive effect on spotted owl territory extinction rates. Spotted owls that persisted on territories following detections of barred owls both moved a greater distance from their initial locations and higher in elevation relative to sites where barred owls were absent. Spotted owls initially showed some ability to move within their territories to avoid barred owl competition, but barred owls have continued to occupy new portions of spotted owl sites each year. Models suggest that barred owls are less likely to occupy spotted owl sites on the steepest, driest slopes, and the movement of the remaining spotted owls to the steepest portions of their territories is making access and complete survey of the remaining activity centers more difficult.

## **Acknowledgments**

The project is only possible due to the hard work, skill and dedication of the field crew. Declining spotted owl numbers require an increasing number of daylong no response searches in roadless wilderness and often difficult weather conditions. E.R. Burke, M.D Calloway, E.H. Graham, C.R. Grattan, S.A. Gremel, A.R. Hokit, A.M. Hotopp, T.J. Kay, P.M. Loafman, and L.M. Platt performed the fieldwork in 2016. Patti Happe, ONP Wildlife Branch Chief, provided overall project supervision and administration, T.J. Kay assisted with coordination and supervision of the field work, and R.A. Hoffman and K.F. Beirne provided GIS support. Liz Kelly of the USFWS generously provided the program used to map barred owl locations relative to spotted owl sites. T. Parker and J. Ransom reviewed an earlier version of this document, M. Huff reviewed the report as the Peer Review Manager, and L. Grace oversaw final edits and formatting. All funding was provided by the NPS through the Regional Ecosystem Office of the Northwest Forest Plan. Funding for spotted owl monitoring was provided at the level of \$155,626 in FY 2016.



## Introduction and Methods

Olympic National Park (ONP) is located on the Olympic Peninsula in northwest Washington State. The park consists of 922,653 acres, of which roughly 756,000 acres are forested valleys naturally fragmented by high elevation peaks and ridges. Due to the lack of historic timber harvest or recent stand-replacing natural disturbance, most of the forested landscape is dominated by stands older than 100 years. There is a steep precipitation gradient from rainforest valleys in the southwest to rainshadow areas in the northeast, resulting in two very different habitat strata. Drier, east-side forests tend to be younger than west-side forests and are dominated by Douglas-fir (*Pseudotsuga menziesii*). Because precipitation is substantially higher on the west-side, forests have a lower frequency of fire and contain more shade-tolerant species such as western red-cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), and Pacific silver fir (*Abies amabilis*), with varying amounts of Douglas-fir.

The Olympic is one of eight studies where demographic rates are monitored to assess the effectiveness of the Northwest Forest Plan in preventing a further decline in spotted owl populations (USDA 1994; Lint et al. 1999). This area consists of 52 northern spotted owl (hereafter spotted owl) sites monitored by National Park Service crews in ONP and 45 sites monitored by U.S. Forest Service Pacific Northwest Research Station (PNW) crews in the surrounding Olympic National Forest. Except where specifically noted, the results in this report include only the 52 sites monitored in ONP. This study area, including both Park and Forest Service managed lands, is generally representative of habitat conditions on federal lands on the Olympic Peninsula, although the proportion of suitable habitat in the study area is somewhat higher than outside, owing to the higher proportion of National Park land (Appendix F, Anthony et al. 2006). It is not representative of state, private and tribal lands on the Olympic Peninsula, where there is little suitable habitat and few or no remaining spotted owls.

Each “site” is roughly equivalent to a spotted owl territory, and can have multiple activity centers occupied by spotted owls in different years. Site boundaries are determined by topography or the past occurrence of adjacent spotted owls, but are generally no more than two kilometers from the earliest known activity center. Site selection for the ONP portion of the study was not strictly random. Initially, all known sites were monitored. As additional sites were located in the course of surveying randomly located inventory plots, these were added to the sample if they were within a one day hike of a site already being monitored. Forty percent of the current sites were monitored by 1990 and none were added or dropped after 1996 regardless of their occupancy status. The 52 spotted owl sites monitored in 2016 represent 23% of the 229 spotted owl territories estimated to occur in ONP as of 1995 (Seaman et al. 1996).

Details of the field methods used on this and other cooperating studies are described in Franklin et al. (1996). In general, crews visit historically occupied spotted owl territories calling for spotted owls. Due to the wilderness character of Olympic and the distance between sites, most visits are made during daylight and a single site is surveyed each day. All captured owls are fitted with a unique U.S. Fish and Wildlife Service number band and a color band. Mark-recapture methods are used to

calculate survival rates and population trends based on resighting histories of banded owls. In 2016 we captured and banded under ONP master station banding permit 22633 and U.S. Fish and Wildlife Service 10(a)(1)(a) “take” permit TE842449-5. Behavior of the owls when they are offered live mice allows the determination of nesting and reproductive status. Spotted owl productivity (fecundity) is calculated as the number of female young produced per territorial female, assuming a 50:50 sex ratio of offspring.

The first documented occurrence of barred owls on the Olympic Peninsula was on the west side of ONP in 1985 (Sharpe 1989). This species now occurs across the entire range of the northern spotted owl and is considered to be the greatest threat to spotted owl conservation within protected reserves. Barred owls are dominant in competitive interactions with spotted owls and evidence from many areas suggests that barred owls displace spotted owls from otherwise suitable habitat (Dark et al. 1998, Kelly 2001, Gremel 2005, Wiens 2012). At ONP, rates of pair occupancy declined at spotted owl sites following the first barred owl detection there. At sites where spotted owls remained after barred owls were detected, they both moved farther from their original location and shifted to higher elevations, relative to spotted owl sites without barred owls (Gremel 2005). While we record all encounters with barred owls in the course of spotted owl monitoring activities, we do not specifically target barred owls for surveys or spend extensive time establishing whether a pair or single owl is present when they respond. Data from ONP indicate that the probability of detecting barred owls on spotted owl surveys when they are present at a site is low, ranging from 7-25% on an annual basis (NPS, unpublished data). When analyzing the presence of barred owls at spotted owl sites, we define a spotted owl site as the area within 800m of all activity centers occupied between 1990 and 2016.

This report summarizes the accomplishments, cooperative efforts and administration of the National Park Service’s portion of the Olympic study for the 2016 field season, as well as cumulative results from all years of the study, including data from this season. Reports from the Forest Service administered portion of the study through 2015 are available at:

<https://re0.gov/monitoring/reports/northern-spotted-owl-reports-publications.shtml>

The specific objectives of this monitoring are to:

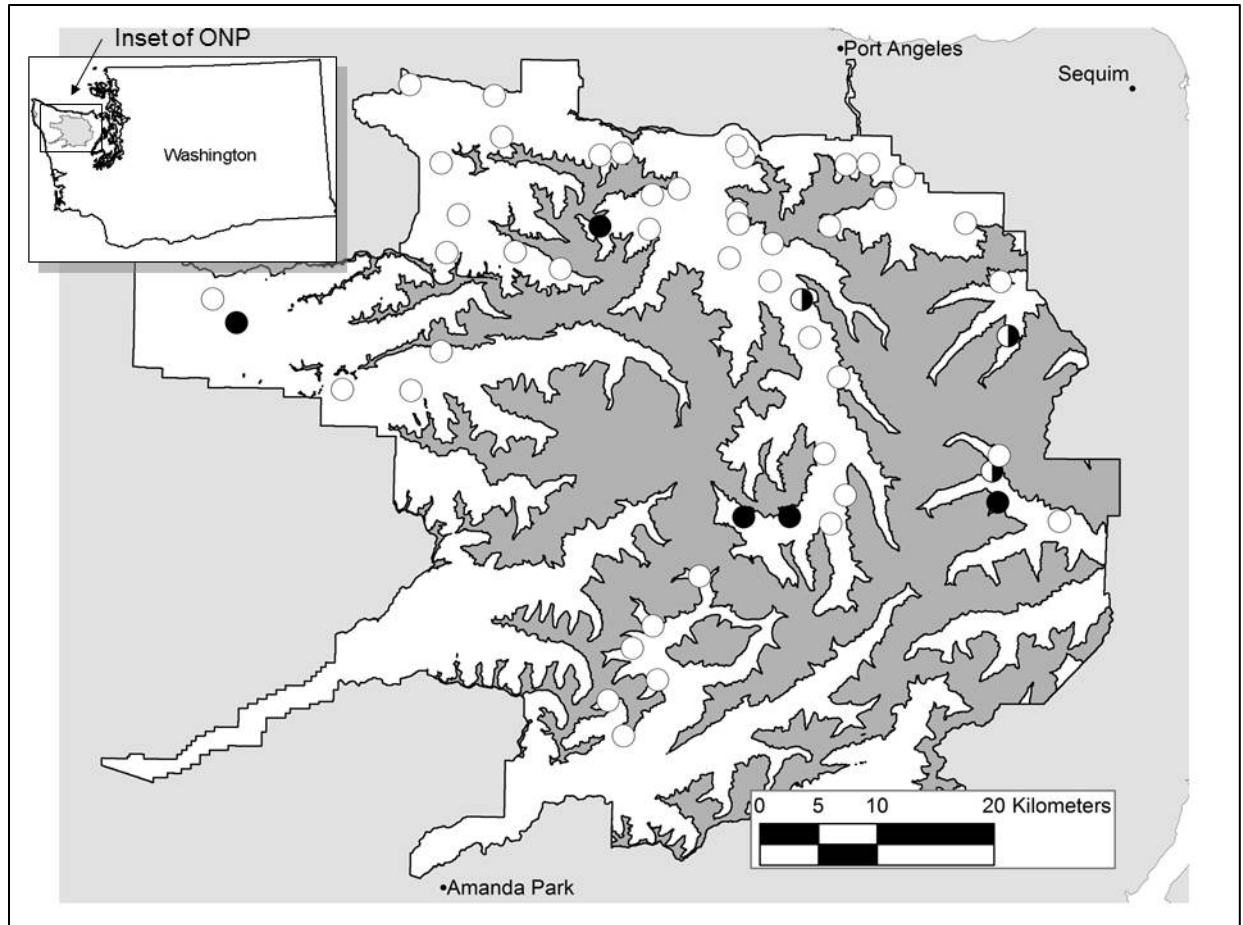
- 1) Contribute to a range-wide assessment of spotted owl population trends, as required by the effectiveness monitoring component of the Northwest Forest Plan.
- 2) Monitor the effects of barred owls on spotted owl demographics and occupancy rates.

# Results

## General Monitoring and Site Status

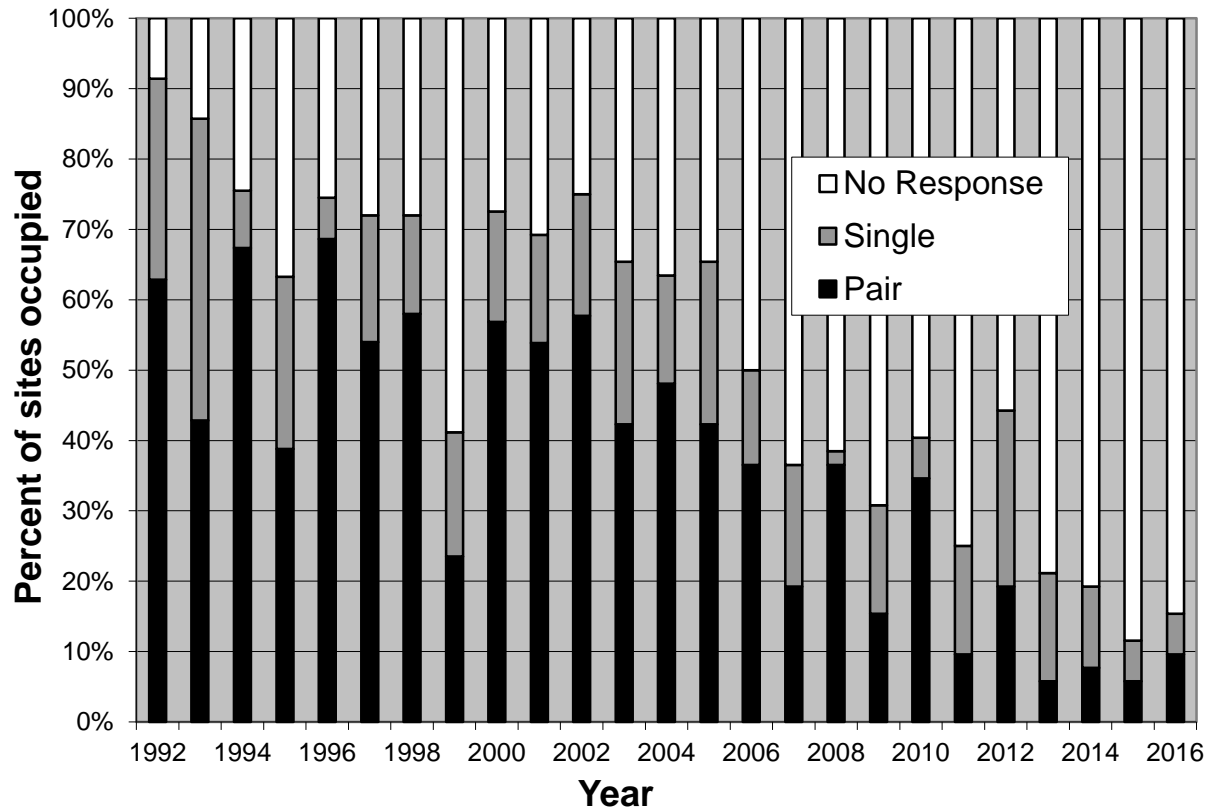
The project employed nine full or part-time biological aids and technicians, and the project lead. ONP crews made 202 visits to 52 monitored spotted owl sites (site locations and occupancy status, Figure 1) and the mean number of visits per site was 3.9 (range 3-7). The mean length of record is now 24.4 years (range 21-25), not including years prior to 1992 when monitoring to current protocols began at most sites. ONP crews also made five visits to two sites near the park boundary that are monitored by PNW, and six visits to a site in ONP that is not part of the monitoring program. Ninety-one percent of the visits were daytime searches where crews focused their efforts on recently occupied activity centers, covering suitable habitat within 2 km of all past activity centers as time permitted. The remaining visits were night or twilight surveys from roads or trails. The full field crew (4 one or two-person teams) visited owl sites between March 21 and July 5 and one additional visit was completed after this date.

The April 1 snow water equivalent in the Olympic Mountains was measured at 108% of average (USDA NRCA). Temperatures were above average over the late winter and April and May during the field season, leading to an earlier than normal snow melt (NWS). Winter precipitation was near or above average, but April and May were markedly drier, averaging under 40% of normal (NWS). Although snowpack as measured at higher elevation sites was near average, there was unusually little snow at the elevation of most spotted owl sites. As a result, crews completed at least one visit to 49 of 52 monitored sites by May 15. Precipitation was recorded on 20% of site visits in the form of snow or hail (1%) and rain or drizzle (19%).



**Figure 1.** Location and occupancy status of 52 monitored spotted owl territories in Olympic National Park, 2016. Black circles are spotted owl pairs, half-filled circles are single owls and white circles are monitored sites with no response. Shaded area within the park boundary is high elevation non-habitat.

Field crews detected 13 adult or subadult spotted owls: five pairs and three single males (Figure 1). Of the 12 spotted owls identified to age class, all were adults three years of age or older. Over the five year period from 2012-2016 there has been no occupancy by spotted owl pairs or resident singles at 36 of the sites monitored. At sites where spotted owls were found in 2016, the per visit detection rate was 48%, below the 24 year average of 61%.



**Figure 2.** Percent of monitored spotted owl sites with 0, 1, or 2 adult owls detected, Olympic National Park, 1992-2016.

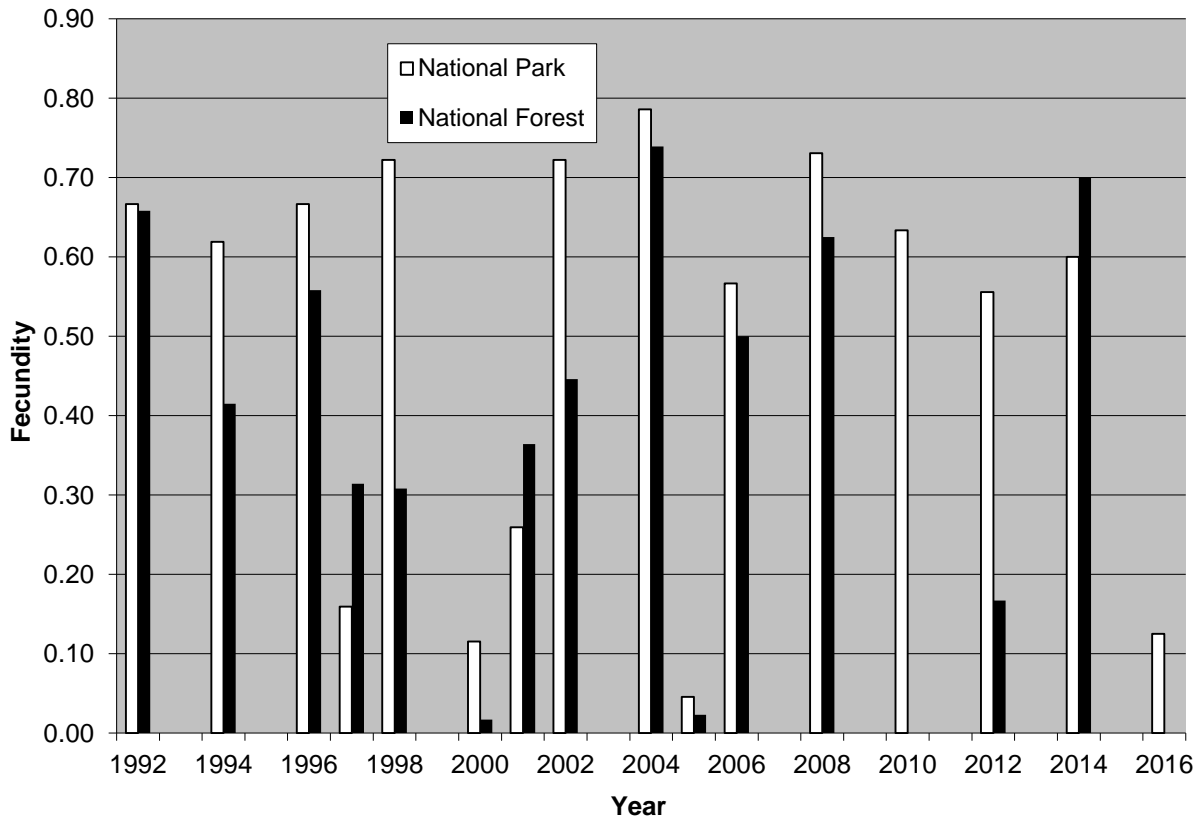
The percentage of sites where spotted owl pairs or individuals were detected has steadily declined over the course of this study (Figure 2). Since 1994, the mean elevation of occupied spotted owl activity centers has increased by 560' to 2686', and mean slope has increased from 24° to 30° ( $N = 49$  sites monitored continuously 1994-2016). These changes can result from both declining occupancy at sites that are lower in elevation and less steep, or the movement of spotted owls to the steeper and higher elevation areas within monitored sites.

### Nest and Reproductive Monitoring

The average fecundity rate at monitored sites was 0.13 female offspring per female. One pair fledged a single juvenile and there was no evidence of reproduction by the remaining four females we located. Three females were confirmed to be non-nesting according to protocols, and the fourth was found too late to confirm nest status, but was not with young on a single visit in early June.

Spotted owl fecundity in the Olympics has been highly variable, with years of high productivity often followed by a year with few or no nesting attempts (Figure 3). We documented no successful reproduction in nine of the last 24 years, most recently including 2015. The mean annual fecundity rate for adult female spotted owls in ONP ( $N = 25$  years) was 0.32 (SE 0.064). It is important to note that this estimate is the rate per adult female spotted owl, and is derived from a decreasing number of individuals (Appendix 1). The actual number of juveniles produced in the study area in 2016 (one) is

much lower than it was 1994-2004 when 30-40 juveniles fledged from monitored sites in average nesting seasons.



**Figure 3.** Olympic Peninsula adult spotted owl fecundity (mean # of female offspring/ territorial female), 1992-2016. Includes both National Park (white bars) and National Forest (black bars). Data were not available for National Forest sites in 2016. The nine years with no data between 1993 and 2015 represent years with no reproduction.

### Banding and Capture

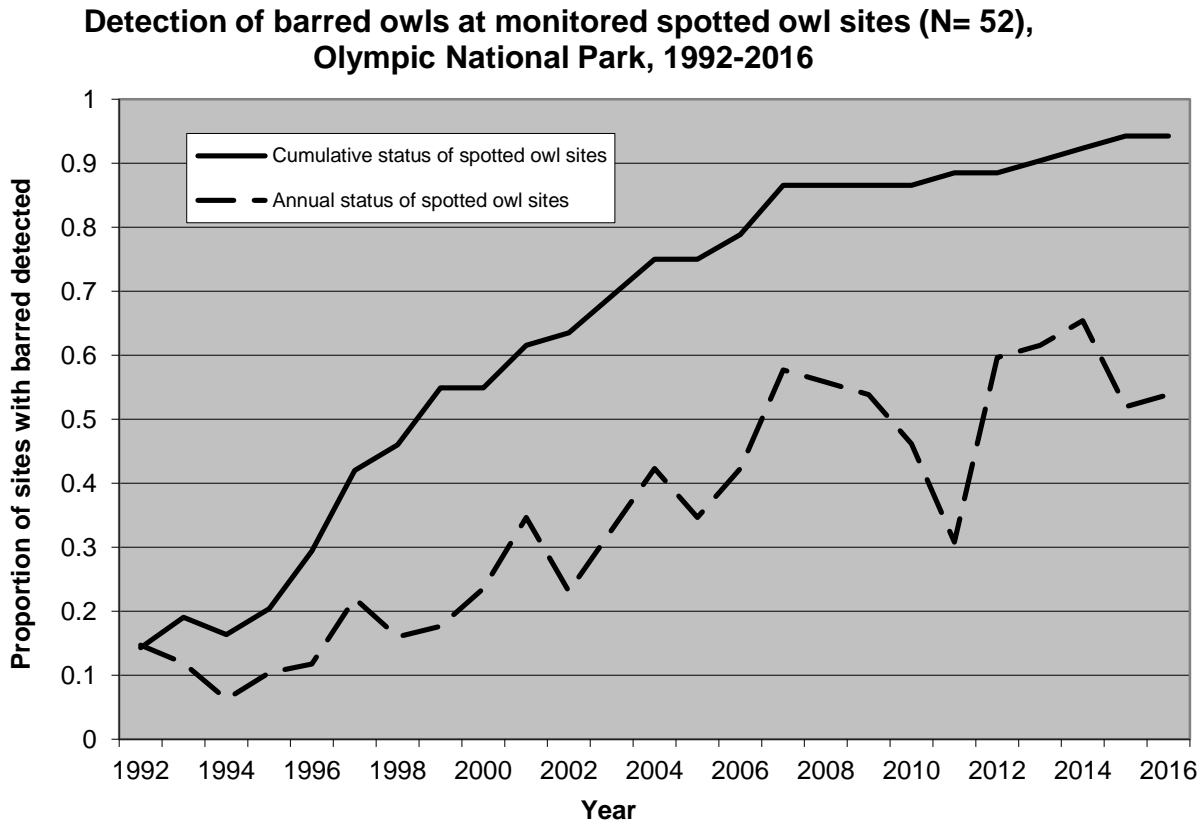
ONP crews captured and banded two adult male spotted owls in 2016. Of 13 non-juvenile owls detected at monitored sites in 2016, two were newly banded, 10 were “recaptures” based on sightings of marked owls from previous seasons, and one was an unknown owl that was heard but never sighted. Since 1988, ONP crews have performed 553 captures and banded 403 spotted owls.

### Juvenile Dispersal

No owls originally banded as juveniles were recaptured this season. Twenty of the 171 spotted owls banded as juveniles by ONP crews prior to 2016 have been recaptured as adults or sub-adults on the Olympic Peninsula. Five dispersed to Olympic National Forest, the others were found within ONP. The median dispersal distance was 15.8 km (mean 18.9 km, SD 9.59, range 5.3- 41.8 km) and the mean age at recapture was 3.5 years. We have documented no dispersal of spotted owls between the Olympic Peninsula and any of the study areas in the Washington Cascades.

## Barred Owls

We detected barred owls at 28 of the 52 spotted owl sites monitored in 2016 (Figure 4). Barred owls have now been detected at 49 spotted owl sites (94%) in at least one year of the study, and 47 spotted owl sites (90%) at least once in the last three years.



**Figure 4.** Proportion of monitored spotted owl sites (N=52) with barred owls detected, Olympic National Park, 1992-2016. The solid line is the cumulative proportion of sites where barred owls have ever been detected, and the broken line is the proportion of sites where barred owls were detected in each year during spotted owl monitoring visits.

Excluding data from barred owl surveys and field recorders, barred owls responded on 46 separate occasions representing an estimated 33 barred owl territories. We confirmed pairs at 13 of these territories, either by direct observation or the presence of juveniles. Single barred owls were observed at 20 sites and a total of four juveniles were observed at three sites. Barred owls were detected at four additional sites resulting from barred owl surveys or from field recorders.

Of the eight activity centers where spotted owls were detected, two were located within 250 meters of a barred owl detected this year. In both cases, the spotted owls were not relocated after the barred owls were detected. Five spotted owl activity centers were found between 400 and 800 meters of barred owls detected on a single occasion in previous years, and the remaining spotted owl pair was greater than 800 meters from any previous barred owl detection.

No hybrids between barred and spotted owls were observed in 2016.

### **Other Species**

In addition to barred and spotted owls, we record incidental responses by northern goshawks (*Accipiter gentilis*) and great-horned owls (*Bubo virginianus*). The number of occupied goshawk sites encountered during owl monitoring has ranged from 0-6 per year. This year field crews encountered goshawks at four sites, all single birds. No great-horned owls were detected at spotted owl sites.



## Discussion

Since the beginning of the monitoring program in the early 1990's, the proportion of sites with detections of spotted owls has declined steadily. As recently as 2012 crews located at least one spotted owl at 44% of the sites visited, however barred owls were occupying the historic activity centers at most of these sites, and the spotted owls were often found away from the core areas that they had used in the past. By 2015, there were no spotted owls detected at the majority of these sites. This year crews detected spotted owls at only one site that was not known to be occupied in 2012. This suggests a pattern of more consistent detections at a small and decreasing number of occupied sites and the long-term absence of birds at unoccupied sites. This decline in the area where spotted owls occur continues as barred owls are found in new parts of some territories each year.

Evidence indicates that barred owls are displacing spotted owls from sites where they occurred when the study began. Although annual estimates of barred owl presence are incomplete, once barred owls are detected at a spotted owl activity center, the spotted owls rarely persist in that area. While spotted owls may continue to occupy a territory after barred owls are first detected, it is usually by shifting their activity center away from the barred owls. At most territories, there is now little or no suitable habitat that is not already occupied by barred owls.

For the first time since the spring of 2000, most spotted owls did not attempt to nest in 2016 following a non-nesting year. Unlike the winter of 1999-2000, the winter of 2015-2016 was not unusually severe. Instead, the lack of breeding could be a function of the lack of stable pairs in high quality habitat. Only one of the five pairs we found this year was both at a historic breeding site and composed of the same owls found at the site last year. This pair was also the only one greater than 800 meters from any previous barred owl detections, and fledged the only juvenile on the study.

The high year-to-year variation in female fecundity has been driven by the proportion of the population attempting to nest, and to a lesser extent the productivity of those nests, rather than the rate of nest success which has averaged 91% (Appendix 1). The mean annual fecundity rate for adult female spotted owls in ONP (N = 25 years) was 0.32 (SE 0.064), and the estimate over the range of the northern spotted owl was 0.31 (SE 0.027) (Dugger et al. 2016).

While there is clearly a relationship between elevation and the likelihood that a spotted owl site has remained occupied, models indicate that slope and topographic moisture explain more of the variance in occupancy than elevation alone (Gremel 2005). It is likely that these topographic variables are simply correlates for barred owl occupancy. Regardless of the factors responsible, spotted owl distribution in the Olympics has changed dramatically over the course of this study. This has implications for both conservation efforts and our ability to monitor spotted owl sites safely and effectively.

Besides the obvious conservation concerns, the occurrence of spotted owls at so few locations should lead to a re-evaluation of whether the current monitoring strategy is appropriate. With no evidence of occupancy this year at 85% of monitored sites, the goal of the majority of site visits is now to confirm the absence of spotted owls, or the presence of barred owls, rather than to resight and band

owls for the demography study. Over 30% of the spotted owl sites have not yielded a detection in over ten years or more than 40 site visits. In the short-term, one option would be to reduce the number of visits to these unoccupied sites while continuing to test the effectiveness of alternate monitoring methods, including the use of field recorders and occupancy analyses that would not require annual visits to every site. However, if current trends continue, there will be a need to evaluate the goals of the monitoring program as the spotted owl approaches extirpation in the Olympics.

## **Cooperative Efforts**

### **2009/2014 Spotted Owl Demography Workshops**

We participated in a meta-analysis workshop held January 5-11, 2014 in Corvallis, OR. This was the fifth such analysis to examine data from the spotted owl demography studies being conducted across the range of the species, and it included five additional years of data (2009-2013) collected since the last workshop. Data from federal lands on the Olympic Peninsula (ONP and Olympic National Forest combined) were analyzed, along with those from 10 other demographic studies to estimate age-specific rates of fecundity, apparent survival and population trends across the range of the northern spotted owl for the years 1985-2013. For the first time an occupancy analysis was also conducted, providing an alternate measure of population trends for both barred and spotted owls, as well as rates of territory extinction and colonization.

Results from the workshop were published in 2016 (Dugger et al. 2016). Range-wide the number of territorial northern spotted owls was estimated to be declining 3.8% a year. Point estimates for all studies indicated declining populations, although estimates were not precise enough to provide strong evidence for declines in three areas. The rate of decline on the Olympic demographic study was 3.9% annually. Overall, it appeared that spotted owl populations in Washington were among those with the greatest declines.

There was no trend over time in rates of spotted owl fecundity or survival on the Olympic study. Both varied by year and fecundity was best explained by the tendency of spotted owls to reproduce in alternate years (even/odd year effect). Spotted owl territory occupancy rates were found to be declining on all studies. On the Olympic study area, occupancy rates declined from 81% in 1995 to 21% in 2013. There was strong evidence that barred owls were having a negative effect on spotted owl territory colonization rates and a positive effect on spotted owl territory extinction rates.

### **Northern Spotted Owl Presence/Absence Monitoring**

Beginning in 2005, spotted owl surveys were implemented as part of a long-term landbird monitoring program in the three large national parks in Washington State: Olympic, North Cascades and Mount Rainier. Crews from The Institute for Bird Populations survey randomly located 1.8 km-long transects, using protocols developed for a spotted owl inventory conducted at ONP in the early 1990s. After conducting point counts for landbirds at stations along these transects, surveyors call for spotted owls at five stations located 400 meters apart. Stations are called for 10 minutes and all stations in forested habitat are called, regardless of elevation. These surveys are providing an inexpensive test of the feasibility and statistical power of implementing a larger scale presence/absence survey, either to complement or replace the current demographic monitoring program.

Overall detections of spotted owls have been quite low (Appendix 2). Though data from 2016 are not yet available, surveys between 2005 and 2015 in the three parks resulted in 7 detections of spotted owls and 41 detections of barred owls on 608 transects.

## Other Data Sharing

- All field visit data were provided to the Washington Department of Fish and Wildlife for a state-wide spotted owl database.
- An analysis of the effects of barred owls on spotted owl population trends was included as part of a natural resource conservation assessment being conducted at ONP. Data from the monitoring program were used to examine trends in territory occupancy rates, including colonization and extinction dynamics, of spotted owls and barred owls on the Olympic Peninsula. This analysis also compared these rates between sites monitored in ONP and those monitored by PNW crews on Olympic National Forest ownership.
- Information from spotted owl surveys was routinely used in project planning at ONP to ensure compliance with regulations related to spotted owls and their habitat.

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## Appendix 1. Nest Success

**Table A-1.** Nesting status and success rate of female spotted owls of all age classes, at monitored sites in Olympic National Park, 1992-2016.

Year	Non-nesting	Nesting	Unknown nest status	Total females	Proportion nest status known	Proportion females nesting	Nest success <sup>1</sup>
1992	1	15	7	23	0.70	0.94	0.93
1993	16		5	21	0.76	0	*
1994	3	24	7	34	0.79	0.89	0.92
1995	15		6	21	0.71	0	*
1996	5	28	3	36	0.92	0.85	0.92
1997	15	8	6	29	0.79	0.35	0.75
1998	1	24	5	30	0.83	0.96	0.91
1999	9		5	14	0.64	0	*
2000	17	10	4	31	0.87	0.37	0.56
2001	16	8	4	28	0.86	0.33	1.00
2002	3	27		30	1.00	0.90	0.92
2003	23		2	25	0.92	0	*
2004	2	21	4	27	0.85	0.91	0.95
2005	20	1	3	24	0.88	0.05	1.00
2006	1	16	2	19	0.89	0.94	0.94
2007	13		1	14	0.93	0	*
2008	1	16	2	19	0.89	0.94	0.94
2009	8		1	9	0.89	0	*
2010	4	14		18	1.00	0.78	0.93
2011	5		1	6	0.83	0	*
2012	2	7	2	11	0.82	0.78	1.00
2013	3		1	4	0.75	0	*
2014	1	4		5	1.00	0.80	1.00
2015	2		1	3	0.67	0	*
2016	3	1	1	5	0.80	0.25	1.00
<b>Total<sup>2</sup></b>	<b>189</b>	<b>224</b>	<b>73</b>	<b>486</b>	<b>0.84</b>	<b>0.44</b>	<b>0.92</b>

<sup>1</sup> Proportion of nest attempts that result in at least one fledgling, calculated on nests with known outcomes. Asterisks indicate years with no nesting.

<sup>2</sup> Where totals are calculated on proportions, they are the unweighted averages of the annual means.

## Appendix 2. IBP Owl Survey Results

**Table B-1.** Results of presence/absence owl surveys performed by The Institute for Bird Populations' landbird monitoring crews, 2005-2015. This includes barred and spotted owls detected at or associated with owl calling stations, as well as incidental detections outside of formal survey or while conducting point counts. Multiple owls at a point are recorded as a single detection.

Year	National Park	Transects Called	Stations Called	Barred Owl Detections			Spotted Owl Detections		
				At Stations	Between Stations	Incidental	At Stations	Between Stations	Incidental
2005	Mt. Rainier	9	40	0	1	0	0	0	0
	N. Cascades	11	53	0	0	0	0	0	0
	Olympic	8	34	0	0	0	0	0	1
2006	N. Cascades	12	57	1	1	0	1	0	0
	Olympic	10	44	3	0	0	1	0	0
2007	Mt. Rainier	19	114	0	1	1	0	0	0
	N. Cascades	22	104	2	1	2	0	0	0
	Olympic	21	95	0	0	0	0	0	0
2008	Mt. Rainier	20	94	1	1	0	0	0	0
	N. Cascades	20	96	3	0	0	0	0	0
	Olympic	21	95	0	0	3	1	1	0
2009	Mt. Rainier	16	69	1	0	0	0	0	0
	N. Cascades	23	97	0	0	0	0	0	0
	Olympic	22	91	2	0	2	1	0	1
2010	Mt. Rainier	17	74	1	0	0	0	0	0
	N. Cascades	19	80	1	0	0	0	0	0
	Olympic	22	95	0	0	1	1	0	0
2011	Mt. Rainier	12	50	1	1	1	0	0	0
	N. Cascades	21	101	2	0	1	0	0	0
	Olympic	20	93	0	0	4	0	0	0
2012	Mt. Rainier	20	99	1	0	0	0	0	0
	N. Cascades	24	114	4	0	3	0	0	0
	Olympic	24	114	0	0	2	0	0	0
2013	Mt. Rainier	19	85	1	0	0	0	0	0
	N. Cascades	23	104	0	0	6	0	0	0
	Olympic	24	116	1	0	0	1	0	0
2014	Mt. Rainier	19	87	1	1	2	0	0	0
	N. Cascades	23	114	0	0	1	0	0	0
	Olympic	23	108	3	0	2	0	0	0
2015	Mt. Rainier	18	86	0	0	2	0	0	0
	N. Cascades	23	97	2	0	3	0	0	0
	Olympic	23	105	2	1	4	0	0	1
<b>Totals</b>		<b>608</b>	<b>2805</b>	<b>33</b>	<b>8</b>	<b>40</b>	<b>6</b>	<b>1</b>	<b>3</b>



### **Appendix 3. Acoustic Monitoring**

Since 2010 we have investigated the use of acoustic field recorders to augment the occupancy data derived from the demographic monitoring program. In 2010-2012 we tested these recorders at sites with known occupancy by barred and spotted owls to get initial estimates of detection probabilities and develop sampling protocols. Between 2013 and 2015 we implemented the protocols at sites still known to be occupied by spotted owls in 2012. The goals of this acoustic monitoring were to: 1) estimate the probability of detecting spotted owls with field recorders at sites known to be occupied; and 2) track occupancy of both barred and spotted owls with multiple methods (demography site visits and acoustic monitoring) at sites that have recently been occupied by spotted owls. The sample unit was a four hour recording beginning either 10 minutes before sunset or ending ten minutes after sunrise, recorded in one channel at a sample rate of 16 khz. Length of time recorders were left out was based on the logistics of installing and removing the units during our demographic monitoring visits, but was generally a week or more. We visually browsed recordings in the program Raven with 8 minute page intervals, noting the presence of all owl species and marbled murrelets.

In 2016 acoustic monitoring was done at 18 sites occupied by pairs or a resident single spotted owl in 2012. The total number of four-hour samples collected at 17 of these sites was 386 (mean 22.7 samples/deployment, range 16-34). One unit failed to record and parts of several deployments were corrupted, apparently due to moisture in the recorders or microphones. We detected spotted owls at four sites, and barred owls at six. All spotted owls that were detected on recorders were also found on demography visits.

We also collected 270 four-hour recordings from nine other sites that had recent detections of spotted owls. These included both sites in ONP and sites monitored by U.S. Forest Service Pacific Northwest Research Station crews on Olympic National Forest. These recordings are still being analyzed.



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