

**ANNUAL REPORT
FY 2015
29 December 2015**

1) Title:

The Demography of Northern Spotted Owls (*Strix occidentalis caurina*) on the Willamette National Forest, Oregon.

2) Principal Investigator and Organizations:

Principal Investigator: Dr. Katie Dugger, U.S. Geological Survey, Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR.

Biologists: Dr. Steven Ackers (Project Leader), Rita Claremont, Kelsey Crawford, Richard Leach, Kristian Skybak, and Claire Steele. Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR.

3) Study Objectives:

- a. Estimate the proportion of territories where northern spotted owls are detected, determine sex and age composition, and the reproductive success of detected owls on the Northern Spotted Owl Demography Study Area in the Willamette National Forest, including estimates by land use allocation as designated under the Northwest Forest Plan (NWFP; USDA and USDI 1994).
- b. Develop and maintain a capture history matrix of individually marked spotted owls to estimate detection rates, survivorship, recruitment, and the rate of population change using a mark-recapture modeling approach.
- c. Create and maintain databases required for participation in the periodic meta-analyses of fecundity, survivorship and annual rate of population change across the range of the northern spotted owl.
- d. Collaborate with other researchers examining northern spotted owl ecology throughout the Pacific Northwest.

4) Study Area:

The central Cascades northern spotted owl demographic study covers approximately 375,000 ac (151,763 ha) on the western slopes of the Oregon Cascades. The land is administered by the Willamette National Forest and includes the upper McKenzie River watershed, the upper Fall Creek watershed, and a portion of the South Santiam River watershed. The land west of the study area is a mixed ownership of Bureau of Land Management and private forestland. The Three Sisters and Mount Washington wilderness areas form the eastern boundary of the study area. The

remainder of the Willamette National Forest lies to the north and south of the study area. Five land use allocations defined by the Northwest Forest Plan are represented (USDA and USDI 1994): matrix lands (26%), an adaptive management area (28%), four late successional reserves (34%), and several congressionally and administratively withdrawn areas (12%). The H. J. Andrews Experimental Forest is located approximately in the center of the study area.

Elevations on the study area range from approximately 1,300 ft (400 m) to just under 5,300 ft (1,600 m). The predominant forest type is Douglas Fir (*Pseudotsuga menziesii*) – Western Hemlock (*Tsuga heterophylla*) with stands of Pacific Silver Fir (*Abies amabilis*) and Mountain Hemlock (*Tsuga mertensiana*) at high elevations. Over half of the study area is either non-forest or has been harvested (Miller *et al.* 1996). Of the remaining forested lands, approximately 51% is considered suitable habitat for spotted owls (S. Weber, Willamette National Forest, personal communication). This corresponds closely to the 51.2% of the western Oregon Cascades physiographic province classified as suitable and highly suitable habitat in the 20-year spotted owl habitat monitoring report (Davis *et al.* 2015).

5) Potential Benefit or Utility of the Study:

Studying the population demography, habitat selection, and ecology of northern spotted owls will continue to increase our understanding of the factors affecting spotted owl populations. The demographic parameters estimated by this study will continue to be an important part of the meta-analyses of northern spotted owl populations across their range, conducted every 5 years (Burnham *et al.* 1996, Franklin *et al.* 1999, Anthony *et al.* 2006, Forsman *et al.* 2011, Dugger *et al.* 2016). The most recent meta-analysis was held in January, 2014, and the results have since been published (Dugger *et al.* 2016). These analyses provide information that supports the validation and monitoring requirements of the NWFP (USDA and USDI 1994) and were an important part of the 2004 species status review and development of the Final Recovery Plan (USFWS 2011) and the designation of Critical Habitat for the species (USFWS 2012). Data from this study also have been used to study occupancy dynamics and to generate annual site occupancy rates (Olson *et al.* 2005) and predictive models that link demographic rates to vegetative characteristics in owl territories (Olson *et al.* 2004). Our data continue to be used to develop new analytical approaches to understand the effects of habitat (Ackers *et al.* 2015), climate (Glenn 2009, Glenn *et al.* 2010), and barred owl (*Strix varia*) presence (Olson *et al.* 2005, Anthony *et al.* 2006, Forsman *et al.* 2011, Dugger *et al.* 2016) on spotted owl demography.

6) Study Description and Survey Design:

The annual proportion of sites where owls were detected and reproductive success were calculated through monitoring of all known northern spotted owl territories (hereafter referred to as “sites”) within the study area during the spotted owl breeding season (April – August). Sites with a recent and consistent history of spotted owl pair detections were visited during the day to identify color-banded spotted owls and determine their nesting status and reproductive status according to established protocols (Forsman 1995). If spotted owls were not located at these sites during the initial daytime visits, then nighttime surveys of the surrounding areas were conducted. All other sites were surveyed at night to locate spotted owls before initiating daytime visits. All unbanded owls located during either day or night visits were captured and fitted with a uniquely

numbered USFWS band and a unique color band to facilitate individual identification.

The numbers of sites where pairs of spotted owls were detected and sites where at least one spotted owl detection occurred were evaluated separately. Single owls that were detected at a particular site ≥ 3 times over one or two breeding seasons were considered resident, single owls (Forsman 1995). Given that per visit detection probabilities are less than 1.0 (Olson *et al.* 2005), estimates of occupancy rates that do not account for detection rates are negatively biased (MacKenzie *et al.* 2006). Thus, here we summarize the survey data as the proportion of sites where spotted owl detections occurred. See Olson *et al.* (2005) and Dugger *et al.* (2016) for estimates of spotted owl occupancy rates on this study area.

Nesting status was determined for all pairs located by offering at least four mice to them on ≥ 2 visits prior to 1 June 2014. A pair was considered to be “nesting” if any of the four mice were delivered to a nest. If the result of the first visit indicated nesting and was conducted before 15 April, then a second visit was required to confirm nesting status because females may sit on a nest without actually laying eggs early in the Spring (Forsman 1995). Nesting also was indicated if a female owl captured for banding had a brood patch, one or more juveniles were observed with one of the adults, or if the remains of nestlings or eggs are located under a known nest tree. Non-nesting was indicated if the adults ate or cached all mice taken on two visits conducted at least 3 weeks apart before 1 June, provided that at least 4 mice were offered during each visit. If the fate of a mouse was unknown, then that mouse did not count toward the minimum of four mice. Pairs also were classified as non-nesting if a female captured for banding between 15 April and 1 June did not have a brood patch, if the female could not be relocated during at least two visits after an initial visit that indicated non-nesting, or if the female was observed roosting away from a nest for greater than 60 minutes between 15 April and 15 May. Pairs and single females that met these criteria before 1 June provided estimates of the proportion of pairs that nested (*i.e.*, nesting attempts) and the proportion of nesting pairs that hatched ≥ 1 chick (*i.e.*, nest success rate). After 1 June, it was not possible to distinguish between pairs that nested and failed and pairs that did not attempt to nest (Forsman 1995).

Visits to determine the number of young fledged were conducted between 1 June and 31 August 2014. A minimum of four mice were offered to each pair on ≥ 2 occasions to determine if any young were present. Owls previously determined to be non-nesting were considered to have produced no young, although we attempted to confirm this with at least one visit after 1 June. Owls that ate or cached all mice offered on ≥ 2 visits after 1 June also were considered to have not produced young. As with nesting status determinations, if the fate of a mouse was unknown, then that mouse did not count toward the minimum of four mice. For owls that delivered one or more mice to young, the number of young observed out of the nest tree were recorded as the number of young fledged. The highest number of fledglings observed on the two visits was the final reproductive status for that pair (Forsman 1995).

Results were summarized for the entire study area as well as separately for the three primary land use allocations on the study area: late-successional reserves (LSR), adaptive management areas (AMA), and matrix habitats as defined in the Northwest Forest Plan (USDA and USDI 1994). We were particularly interested in the productivity (number of fledglings produced per pair) and detections of northern spotted owls in the four LSRs on the study area as this land use allocation

was intended to provide the habitat base for recovery of the subspecies.

A subset of the productivity and mark-recapture data for this study area were combined with data from other northern spotted owl demographic studies during weeklong workshops in January of 1994, 1999, 2004, 2009, and 2014. During these workshops, the data from our study area was analyzed independently and combined with data from other study areas in a meta-analysis of survival, fecundity, annual rate of population change, and recruitment for spotted owl populations across their range (Burnham *et al.* 1996, Franklin *et al.* 1999, Anthony *et al.* 2006, Forsman *et al.* 2011, Dugger *et al.* 2016). The most recent meta-analysis workshop also included a two-species occupancy analysis to evaluate the effects of barred owls on spotted owl site occupancy (Dugger *et al.* 2016).

In February 2009, the master site numbering system (MSNO) and the associated locations for the site centers maintained by the Oregon Department of Fish and Wildlife (ODFW) were reviewed and compared to the site center database maintained by the Willamette National Forest (WNF). The name and master site number of 44 sites in our database were revised to match the earliest site centers in the ODFW database (Appendix 1). In most cases, this required only a change in the name or MSNO of the sites that we monitored. In five instances, this required re-assignment of survey results to better reflect the survey effort at particular ODFW site centers. The figures and summary tables in this report have been revised to reflect these changes.

We continued to monitor sites where spotted x barred owl hybrids have been located. These results were presented separately. Unless otherwise indicated, the following discussion was pertinent only to our analyses of spotted owl demography.

7) **Research Accomplishments (Demography) for FY 2015:**

Proportion of sites where owls were detected

The number of sites surveyed in 2015 was similar to the number reported in the past (170 sites; Figure 1, Table 1). Most of the non-juvenile spotted owls detections in 2015 were pairs (60%) with substantially fewer resident single owls (9%) or single owls with unknown residency status (31%; Table 1). The proportion of sites where either a pair or a single owl was detected increased by 0.3% (Table 1) and the proportion of sites where pairs were detected decreased by 3% between 2014 and 2015 (Figure 1). This is the lowest proportion of territories where we detected pairs of spotted owls to date (Figure 1). The residency status of either the male or the female was unknown for 3 (6%) of the pairs detected. The percentage of sites where resident single owls were detected decreased by 1% (Table 1) and the percentage of sites with no spotted owl detections remained nearly the same as in 2014 (Table 1).

In 2015, the highest proportion of sites where a territorial spotted owl was detected (either a single or pair) was in the AMA land allocation (50%), which was greater than in 2014 (44%; Table 2). The proportion of sites where spotted owls were detected decreased by 1% in the matrix (MAT) allocation and by 5% in the LSR allocation between 2014 and 2015 (Table 2).

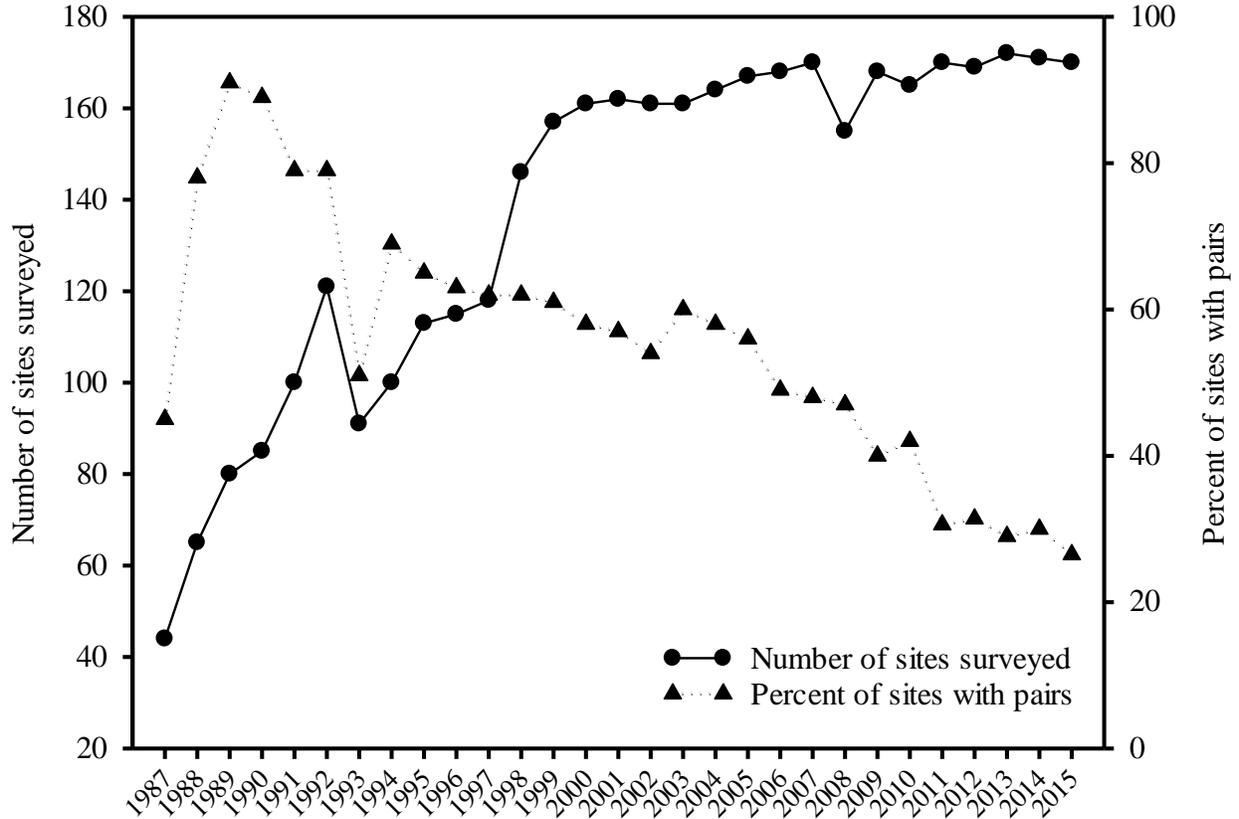


Figure 1. Number of sites surveyed for northern spotted owls and the percentage of those sites where pairs were detected in the central Cascades study area, Willamette National Forest, Oregon from 1987 – 2015.

The proportion of territories where a pair was detected decreased between 2014 and 2015 in the LSR land use allocations (5%; Figure 2). The MAT showed a decrease in pair detections (11%; Figure 2) and the AMA allocation showed a modest increase in the proportion of territories where a pair was detected (2%; Figure 2). In addition, the number of territories in the Fall Creek LSR where a pair was detected decreased by five between 2014 and 2015 (Appendix 3). Within the other LSR units, the proportion of sites where pairs were detected increased by one in the Horse Creek LSR, and remained the same in the South Santiam (3) and Hagan LSR (3 and 0 pairs, respectively; Appendix 3). Overall, fewer pairs were detected on LSR sites (18%) relative to matrix (31%) and AMA sites (35%), and the overall trend since 1997 has been a decrease in pairs detected in all three allocations (Figure 2).

Four sites were within two wildfires that occurred in 2003. The Clark fire included three sites in the Slick Creek and Bedrock Creek watersheds in the Fall Creek LSR. The Jones Creek spotted owl site (MSNO 1013) was occupied by a pair that produced two young from 2000 through 2002. Only the male was located in 2003 prior to the fire. From 2004 through 2006 this pair was

Table 1. Northern spotted owl detections and residency status ^a of northern spotted owl sites (territories) surveyed on the central Cascades study area, Willamette National Forest, Oregon, 1987 – 2015.

Year	Sites surveyed	Sites with pairs detected	Sites with resident single owls	Sites with unknown residency ^b	Sites with ≥ 1 owl detected (%)	Sites where owls were not detected ^c	Sites not surveyed to protocol ^d
1987	44	20	2	4	26 (59)	-	18
1988	65	51	2	1	54 (83)	-	11
1989	80	73	4	3	80 (100)	-	27
1990	85	76	0	3	79 (93)	6	27
1991	100	79	5	8	92 (92)	8	3
1992	121	96	4	14	114 (94)	7	28
1993	91	46	13	15	81 (89)	10	19
1994	100	69	7	22	98 (98)	2	19
1995	113	73	10	8	91 (80)	22	12
1996	115	73	11	6	90 (78)	25	5
1997	118	73	8	10	91 (77)	27	12
1998	146	90	8	14	112 (77)	34	17
1999	157	95	13	15	123 (78)	34	11
2000	161	93	8	25	126 (78)	36	0
2001	162	93	11	29	133 (82)	29	2
2002	161	87	12	28	127 (79)	34	3
2003	161	96	11	18	125 (78)	36	1
2004	164	95	6	23	124 (76)	40	3
2005	167	93	19	19	131 (78)	36	2
2006	168	83	12	23	118 (70)	50	0
2007	170	82	9	26	117 (69)	53	0
2008	155	73	5	18	96 (62)	59	15
2009	168	68	20	15	103 (61)	65	2
2010	165	70	8	19	97 (59)	68	5
2011	170	52	17	22	90 (53)	79	1
2012	169	53	5	29	87 (51)	82	2
2013	172	50	11	33	94 (55)	77	0
2014	171	51	9	15	75 (44)	96	1
2015	170	45	7	23	75 (44)	95	2

^a Residency status was determined by 1995 protocols (Forsman 1995).

^b Sites where male and/or female owls responded, but criteria for pair or resident single status were not met.

^c Sites surveyed at least three times at night with no responses or where owls from a neighboring site were detected.

^d Sites not meeting protocol for occupancy are not included in the total number of sites surveyed.

still present and produced one young. In 2007 through 2015, Jones Creek was occupied by a non-nesting pair consisting of a male spotted owl and a female spotted x barred hybrid owl. In 2013, West Slick Creek (MSNO 4549) contained two nest trees, although one was used by a spotted-barred owl pair in 2001. This site remained unoccupied by spotted owls after the fire until 2006 when a subadult female was located with the male last seen in 2003 just before the fire. This site is no longer occupied by a pair and no young have been produced since the fire. A pair was not detected at North Slick Creek (MSNO 4420) until after the fire and this pair fledged two young in 2007 which was the first documented reproduction in this site since 1996. Another pair of spotted owls originally from neighboring watersheds was located at North Slick Creek in 2012. The resident male from 2008 returned in 2013, replacing the male from 2012 and pairing with the 2012 female. This same male was a resident single at this site in 2015.

The B & B complex fire began late in the field season of 2003 and included only one site center (Lost Lake, MSNO 0815). This site contained four nest trees at elevations above 4,000 ft (1300 m) and a pair was detected there in 12 of the 14 years preceding the fire. We located the historic pair near two of the previous nest trees in both 2004 and 2005. We detected an unidentified female during one night visit in late July of 2006. This site has been unoccupied since 2006 and the male from this site was relocated east of Carmen Reservoir approximately 7.5 miles south of Lost Lake in 2007. This fire may have negatively impacted the pair, although the effect of the fire was confounded by a pair of great horned owls (*Bubo virginianus*) that were nesting approximately 200 - 300 m from the historic spotted owl nest trees in 2006.

Six additional sites were surveyed in 2015 on other land use allocations such as research natural areas and wild and scenic river corridors. Pairs were located at two of these sites, although neither pair fledged any young. A resident single male was detected at one site, and the other three sites were unoccupied.

Sex and age composition

Forty-five juvenile (i.e., young of year) and 122 non-juvenile (≥ 1 year old) spotted owls were detected during our surveys in 2015 (Table 3). The majority of the non-juvenile owls of known age were at least three years old (96%). Only one male and three female spotted owls were identified as subadults (≤ 2 years old; 4%) in 2015. Of the owls that were not identified to age class (19%), most were detected as nighttime auditory responses only and were not relocated on the daytime follow-ups. All of the owls that were resighted and identified by unique, non-juvenile color bands (87) were assigned to an age class, as were all of the non-juvenile owls that were captured for initial banding or to replace a juvenile band (10).

Based on re-observations of known age, non-juvenile owls in 2015, the median age for males on the study area was 8.5 years ($\bar{x} = 10.0$, $SE = 0.88$) and 11 years ($\bar{x} = 9.6$, $SE = 1.16$) for females. The oldest owl located in 2015 was a male, ≥ 24 -year-old originally banded off the study area as an adult in 1994. The oldest female was ≥ 19 years old as it was banded as an adult in 1999.

Table 2. Northern spotted owl detections and residency status at northern spotted owl sites by Northwest Forest Plan land-use allocation (USDA and USDI 1994) on the central Cascades study area, Willamette National Forest, Oregon, 1997 – 2015.

Land use allocation ^a	Year	Sites surveyed	Sites with pairs detected	Sites with resident single owls	Sites with unknown residency	Sites with ≥ 1 owl detected (%)	Sites where owls were not detected	Sites not surveyed to protocol
Matrix	1997	40	29	2	0	31 (78)	9	2
	1998	41	26	3	2	31 (76)	10	3
	1999	42	26	3	1	30 (71)	12	2
	2000	39	24	2	5	31 (79)	8	0
	2001	38	26	3	6	35 (92)	3	1
	2002	38	22	2	7	31 (82)	7	0
	2003	37	26	1	3	30 (81)	7	1
	2004	38	25	1	5	31 (82)	7	0
	2005	39	25	2	4	31 (79)	8	0
	2006	39	22	1	4	27 (69)	12	0
	2007	39	23	1	1	25 (64)	14	0
	2008	37	23	0	2	25 (68)	12	2
	2009	39	20	4	1	25 (64)	14	0
	2010	38	21	0	0	21 (55)	17	0
	2011	39	18	3	1	22 (56)	17	0
	2012	39	17	1	3	21 (54)	18	0
	2013	39	14	2	3	19 (49)	20	0
2014	38	16	1	1	18 (47)	20	1	
2015	39	12	2	4	18 (46)	21	0	
AMA	1997	45	31	4	1	36 (80)	9	3
	1998	44	33	1	4	38 (86)	6	1
	1999	43	30	2	4	36 (84)	7	1

Land use allocation ^a	Year	Sites surveyed	Sites with pairs detected	Sites with resident single owls	Sites with unknown residency	Sites with ≥ 1 owl detected (%)	Sites where owls were not detected	Sites not surveyed to protocol
AMA (cont.)	2000	43	30	2	1	33 (77)	10	0
	2001	44	27	4	5	36 (82)	8	0
	2002	42	27	4	5	36 (86)	6	2
	2003	43	30	2	4	36 (84)	7	0
	2004	45	26	2	4	32 (71)	13	0
	2005	45	26	9	5	40 (89)	5	0
	2006	45	24	4	7	35 (78)	10	0
	2007	47	22	4	11	37 (79)	10	0
	2008	44	21	1	4	26 (59)	18	3
	2009	44	19	5	5	29 (66)	15	1
	2010	48	22	3	6	31 (65)	17	0
	2011	48	16	4	3	23 (48)	25	0
	2012	48	12	2	10	24 (50)	24	0
	2013	48	14	4	12	30 (63)	18	0
	2014	48	16	2	3	21 (44)	27	0
2015	48	17	1	6	24 (50)	24	0	
LSR	1997	27	8	2	9	19 (70)	8	7
	1998	55	27	3	8	38 (69)	17	13
	1999	66	35	7	10	52 (79)	14	8
	2000	73	35	2	18	55 (75)	18	0
	2001	74	35	4	18	57 (77)	17	1
	2002	75	34	6	14	54 (72)	21	0
	2003	75	36	8	11	55 (73)	20	0
	2004	75	41	2	13	56 (75)	19	2

Land use allocation ^a	Year	Sites surveyed	Sites with pairs detected	Sites with resident single owls	Sites with unknown residency	Sites with ≥ 1 owl detected (%)	Sites where owls were not detected	Sites not surveyed to protocol
LSR (cont.)	2005	77	40	8	7	55 (71)	22	0
	2006	78	34	7	10	51 (65)	27	0
	2007	77	35	4	12	51 (66)	26	0
	2008	68	27	4	11	42 (62)	26	9
	2009	77	27	9	8	44 (57)	33	1
	2010	73	25	3	13	41 (56)	31	4
	2011	78	15	9	17	41 (53)	36	1
	2012	78	21	2	17	40 (51)	36	2
	2013	78	20	5	16	41 (53)	37	0
	2014	78	18	5	10	33 (42)	45	0
	2015	78	14	2	13	29 (37)	46	2

^a Sites with LUA designation of “Other”, “Private”, and “Wilderness” are not included here.

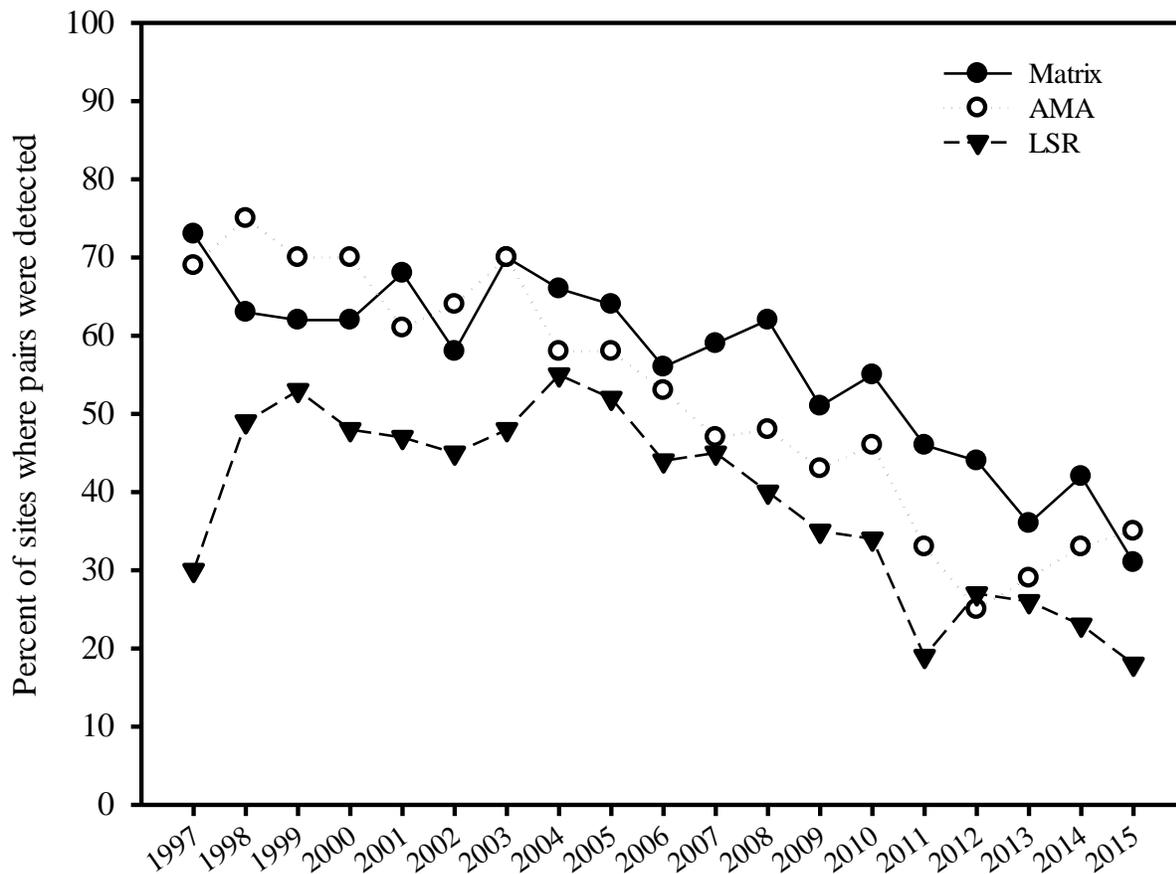


Figure 2. Percentage of sites where pairs of northern spotted owls were detected compared among land use allocations in the central Cascades study area, Willamette National Forest, Oregon from 1997 – 2015.

The ratio of subadults to adults has decreased since 1989 ($R^2 = 0.20$, p -value = 0.02, $\beta = -0.002$, 95% CI: -0.003 to -0.0004; Figure 3). Among paired owls, one male and three females were subadults in 2015. Subadults have been paired much less frequently than adults in every year of the study. The percentage of pairs with at least one subadult has varied widely from a high of 15.1% in 1988 to a low of 0.68% in 1995. There were no paired subadults in 1995, 2007, 2012, or 2013. The effect of a 2-year lag in high productivity on increased proportions of pairs with at least one two-year-old subadult was not observed ($R^2 = 0.07$, p -value = 0.19, $\beta = 2.78$, 95% CI: -1.265 to 6.818). However, there was evidence of a weak negative time trend in the proportion of subadults in the population of territorial pairs ($R^2 = 0.11$, p -value = 0.09, $\beta = -0.16$, 95% CI: -0.35 to 0.02).

Table 3. Sex and age composition of northern spotted owls detected on the Central Cascades Study Area, Willamette National Forest, Oregon, 1987 – 2015.

Year	Adults (M, F)	Subadults ^a (M, F)	Age unknown (M, F)	Non-juveniles ^b (M, F)	Juveniles ^c
1987	53 (29, 24)	7 (4, 3)	15 (14, 1)	75 (46, 28)	12
1988	98 (49, 49)	18 (11, 7)	9 (4, 5)	125 (64, 61)	40
1989	135 (72, 63)	17 (10, 7)	14 (8, 6)	166 (90, 76)	27
1990	134 (72, 62)	9 (2, 7)	28 (17, 11)	171 (91, 80)	37
1991	152 (82, 70)	14 (8, 6)	44 (25, 19)	210 (115, 95)	30
1992	170 (88, 82)	10 (4, 6)	30 (17, 13)	208 (109, 101)	116
1993	122 (72, 50)	6 (4, 2)	23 (16, 7)	151 (92, 59)	0
1994	144 (77, 67)	8 (1, 7)	14 (8, 6)	166 (86, 80)	28
1995	151 (76, 75)	2 (2, 0)	19 (13, 6)	172 (91, 81)	22
1996	140 (71, 69)	9 (5, 4)	17 (13, 4)	166 (89, 77)	68
1997	139 (71, 68)	9 (5, 4)	21 (9, 12)	169 (85, 84)	24
1998	172 (86, 86)	8 (6, 2)	40 (27, 13)	220 (119, 101)	42
1999	169 (89, 80)	2 (2, 0)	56 (36, 20)	227 (127, 100)	21
2000	169 (85, 84)	6 (5, 1)	53 (36, 17)	228 (126, 102)	60
2001	189 (98, 91)	7 (4, 3)	38 (25, 14)	234 (127, 107)	83
2002	168 (89, 79)	11 (4, 7)	46 (26, 20)	225 (119, 106)	67

Year	Adults (M, F)	Subadults ^a (M, F)	Age unknown (M, F)	Non-juveniles ^b (M, F)	Juveniles ^c
2003	172 (93, 79)	17 (7, 10)	40 (21, 19)	229 (121, 108)	25
2004	187 (99, 88)	15 (7, 8)	29 (19, 10)	231 (125, 106)	105
2005	171 (92, 79)	12 (5, 7)	54 (33, 21)	237 (130, 107)	13
2006	149 (82, 67)	11 (6, 5)	37 (23, 14)	197 (111, 86)	20
2007	178 (90, 88)	2 (1, 1)	30 (24, 6)	210 (115, 95)	48
2008	154 (82, 72)	4 (2, 1, 1 Unk.)	18 (10, 8)	176 (93, 81, 1 Unk.)	31
2009	155 (82, 73)	5 (3, 1, 1 Unk.)	27 (19, 8)	187 (104, 82, 1 Unk.)	28
2010	134 (72, 62)	10 (6, 3, 1 Unk.)	37 (17, 19, 1 Unk.)	181 (95, 84, 2 Unk.)	56
2011	122 (63, 57, 2 Unk.)	4 (2, 2)	20 (15, 5)	146 (80, 64, 2 Unk.)	2
2012	119 (66, 53)	1 (0, 0, 1 Unk.)	22 (16, 6)	142 (82, 59, 1 Unk.)	25
2013	122 (65, 57)	2 (1, 0, 1 Unk.)	34 (23, 11)	158 (89, 68, 1 Unk.)	7
2014	113 (60, 53)	2 (1, 1, 0)	18 (14, 4)	133 (75, 58)	59
2015	95 (53, 42)	4 (1, 3)	23 (21, 2)	122 (75, 47)	45

^a One- and two-year-old age classes combined.

^b Adults and subadults combined.

^c Includes the total number of young located from 1 April to 31 August, including pre- and post-fledging mortalities.

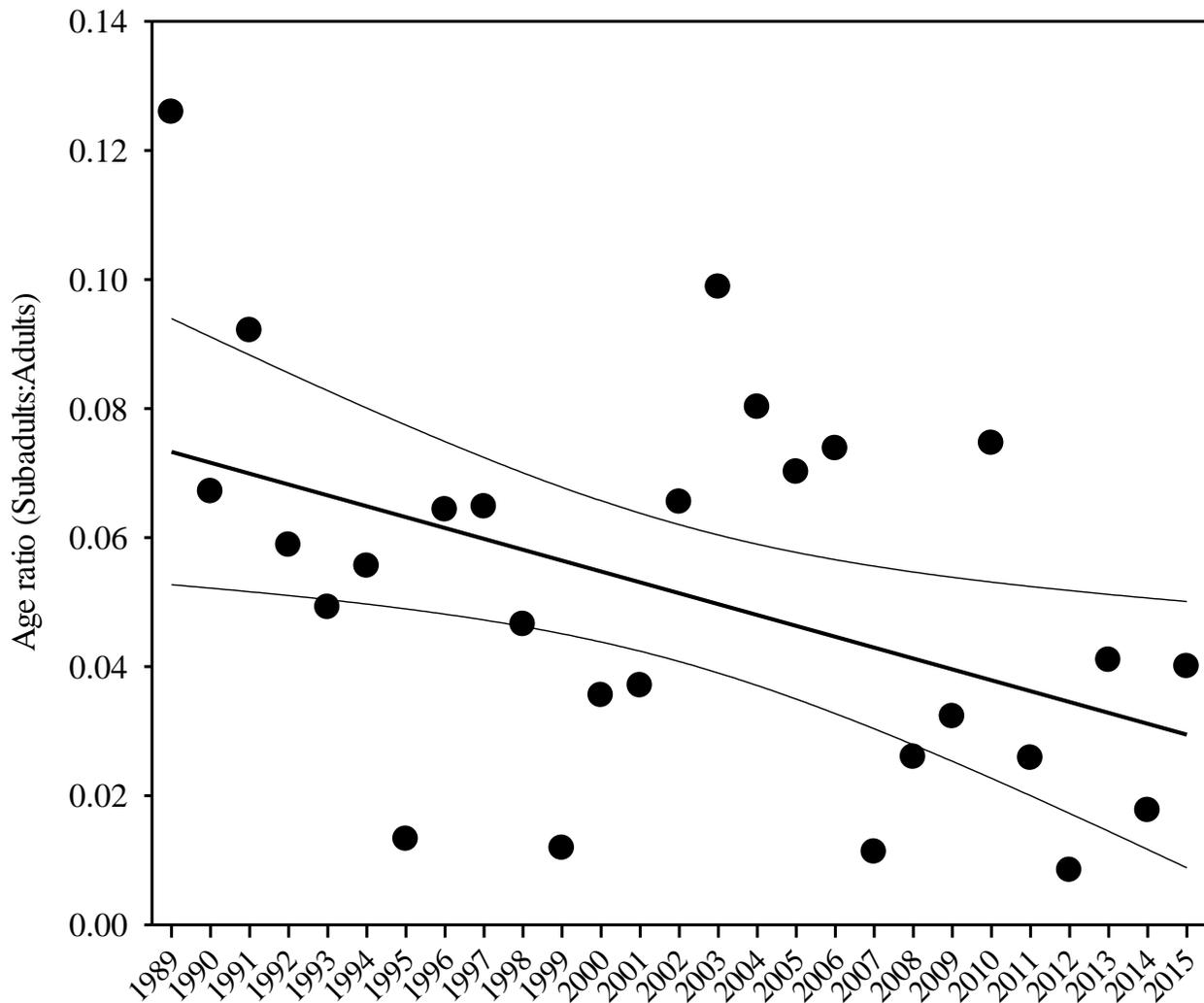


Figure 3. Ratio of subadults:adults of northern spotted owls over time in the central Cascades study area, Willamette National Forest, Oregon from 1989 – 2015.

The sex ratio among adults (≥ 3 -year-olds) identified in 2015 was similar to past estimates (males:females; 1.26:1 in 2015, 1.13:1 averaged over all previous years, $n = 28$). Among subadults, the sex ratio was more skewed toward males in most years (1.40:1 averaged over all years, $n = 28$). Small sample sizes in the subadult age class resulted in more annual variation in the sex ratios which ranged from 0:1 in 1994 to 5:1 in 2000. More subadult females than males were detected in 6 of the past 29 years (*e.g.*, 0.33:1 for 2015). The average sex ratio among non-juveniles of unknown age was even more variable and heavily skewed toward males ($\bar{x} = 2.64:1$, range: 0.75:1 - 14:1). Most of these owls of unknown age were detected only once at night and were never relocated for identification, which suggested that many of them were transients that did not hold territories.

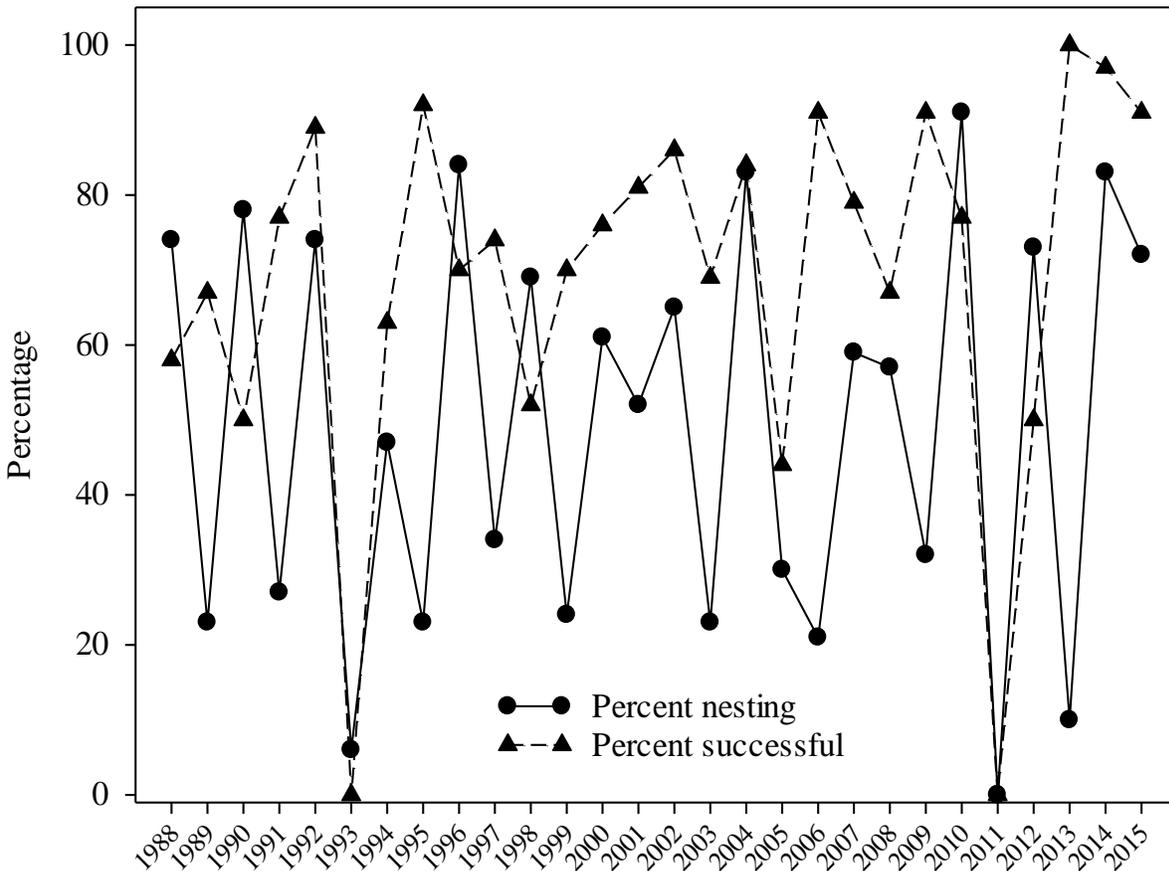


Figure 4. Percentage of pairs confirmed nesting prior to 1 June each year and the percentage of nesting pairs that fledged at least one young in the central Cascades study area, Willamette National Forest, Oregon from 1988 – 2015.

Reproductive Success

We were able to survey 32 spotted owl pairs to determine nesting status prior to 1 June 2015 (Forsman 1995). Twenty-three of these pairs (72%) initiated nesting prior to 1 June 2015; twenty-one (91%) successfully produced at least one young (Figure 4). Over all previous years, approximately half of the pairs surveyed during the nesting season attempted to nest ($\bar{x} = 48\%$, $SE = 5.3$, $n = 27$), although this long-term mean obscures the striking annual pattern in breeding propensity between consecutive years observed during most of this study (Figure 4). Of the pairs that were confirmed to be nesting in the past, most successfully fledged at least one young ($\bar{x} = 69\%$, $SE = 4.8$, $n = 26$; Figure 4). There was no correlation between nesting rates and nest success ($r = 0.30$, 95% CI: -0.08 to 0.61, p -value = 0.12; Figure 5).

Thirty-nine spotted owl pairs were surveyed for reproductive status by 31 August 2015 (Table

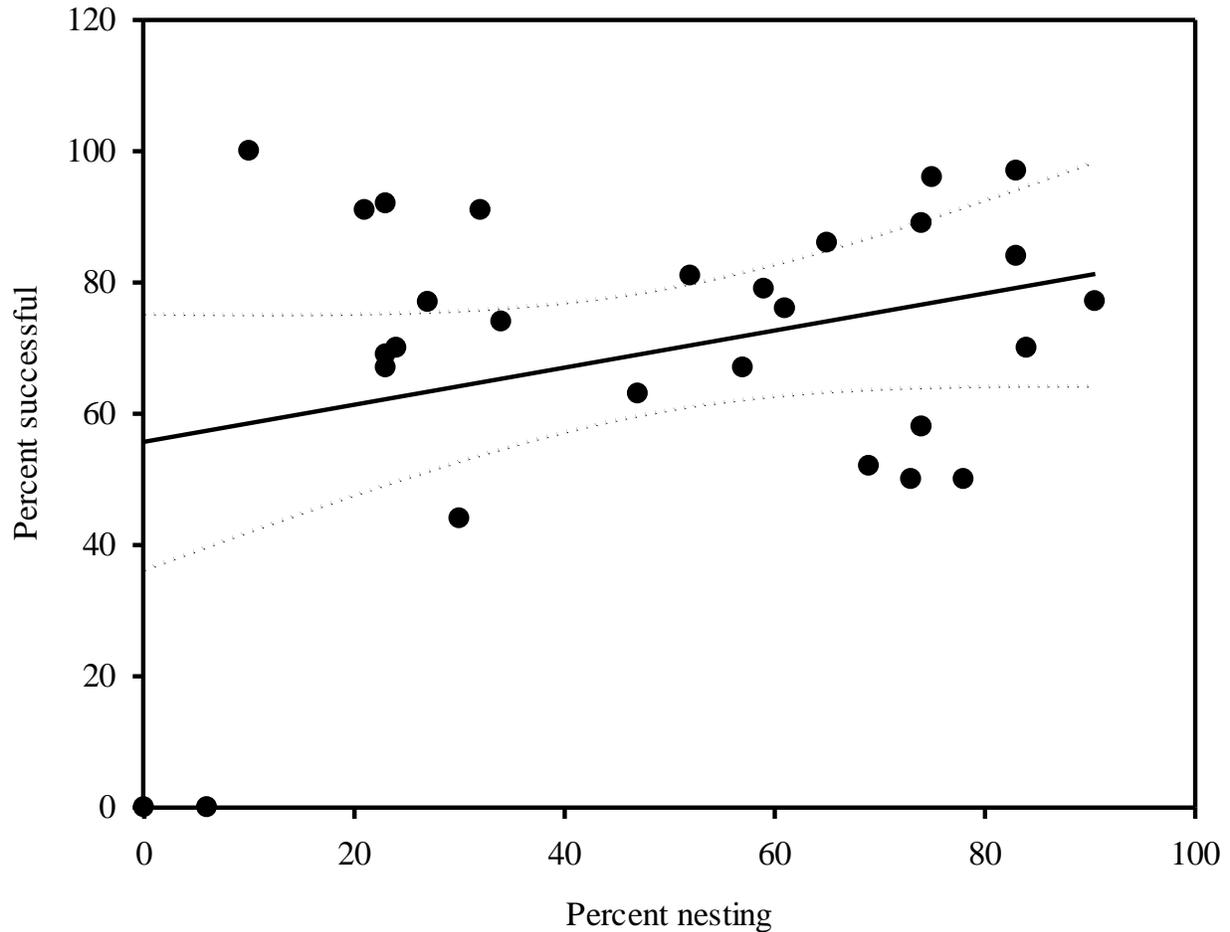


Figure 5. Relationship between the percent of pairs attempting to nest and the percentage of nesting pairs that successfully fledged ≥ 1 young in the central Cascades study area, Willamette National Forest, Oregon from 1988 – 2015.

4). This included 31 pairs that were surveyed for nesting status prior to 1 June 2015, as well as 8 additional pairs that were not located prior to 1 June. One of the pairs determined to be nesting before 1 June 2015 could not be relocated beyond that date to determine reproductive status.

For all pairs surveyed for reproductive status, the average number of young produced per pair in 2015 (1.13 young/pair) was higher than the average across all previous years ($\bar{x} = 0.59$, $SE = 0.07$, $n = 27$; Table 4). Twenty-six pairs were successful and produced an average of 1.69 young/successful pair which was similar to the average number of young produced by successful pairs over all previous years of the study ($\bar{x} = 1.62$, $SE = 0.04$, $n = 26$; Table 4). With the exception of 1993 when no young were fledged, there was little variation in the number of young produced by pairs that successfully nested.

Table 4. Summary of reproductive surveys for northern spotted owls in the Central Cascades Study Area, Willamette National Forest, Oregon from 1988 – 2015.

Year	Number of pairs checked ^a	Number (%) of pairs fledging young	Number of young fledged	Mean number of young per successful pair	Mean number of young per pair (all pairs)
1988	39	20 (51)	35	1.75	0.90
1989	49	10 (20)	17	1.70	0.35
1990	63	29 (46)	36	1.24	0.57
1991	58	16 (28)	30	1.88	0.52
1992	61	47 (77)	86	1.83	1.41
1993	50	0 (0)	0	N/A ^b	0.0
1994	63	21 (33)	28	1.33	0.44
1995	73	13 (18)	22	1.69	0.30
1996	66	42 (64)	68	1.62	1.03
1997	63	15 (24)	24	1.60	0.38
1998	81	28 (35)	41	1.46	0.51
1999	76	11 (14)	21	1.91	0.28
2000	76	37 (49)	60	1.62	0.79
2001	86	48 (56)	81	1.69	0.94
2002	76	42 (55)	62	1.48	0.82
2003	76	14 (18)	25	1.79	0.33
2004	92	62 (67)	100	1.61	1.09
2005	67	12 (18)	13	1.08	0.19
2006	66	13 (20)	20	1.54	0.30
2007	70	31 (44)	48	1.55	0.69
2008	62	22 (35)	31	1.41	0.50
2009	63	16 (25)	28	1.75	0.44
2010	47	30 (64)	47	1.57	1.00
2011	43	1 (2)	2	2.00	0.04

Year	Number of pairs checked ^a	Number (%) of pairs fledging young	Number of young fledged	Mean number of young per successful pair	Mean number of young per pair (all pairs)
2012	38	17 (45)	25	1.47	0.66
2013	48	4 (8)	7	1.75	0.15
2014	46	34 (74)	56	1.65	1.22
2015	39	26 (67)	44	1.69	1.13
Average	62	24 (38)	38	1.62	0.61

^a Includes pairs that were given at least four mice on two or more occasions prior to 31 August.

^b No pairs were successful in producing young in 1993.

Spotted owl productivity was above average in all three primary land use allocations in 2015 (matrix 2015: 1.08 young/pair, \bar{x} = 0.60 young/pair, SE = 0.09 n = 18; AMA 2015: 1.21 young/pair, \bar{x} = 0.57 young/pair, SE = 0.08, n = 18; LSR 2015: 1.17 young/pair, \bar{x} = 0.56 young/pair, SE = 0.09 n = 17; Table 5). Productivity in the Fall Creek LSR also was above average (Fall Creek 2015: 1.00 young/pair, \bar{x} = 0.61 young/pair, SE = 0.11, n = 17). Productivity in the other three LSRs remained negligible due to low numbers of pair detections (Appendix 4).

Banding/re-observation

Forty-four spotted owls were banded in the study area and at four nearby wilderness sites in 2015, including 44 fledglings, 3 subadults, and 2 adults (Table 6). Since 1987, 700 non-juvenile and 1,067 fledgling spotted owls (1,767 total) have been banded on the study area.

Movements

There were only six movements of spotted owls between site centers within the study area in 2015 (1990 – 2014 median = 17, range: 9 – 30). Three adult males and two adult females were recaptured or re-sighted at new locations within the study area. One owl originally banded as a fledgling on the study area in 2013 was recaptured and fitted with adult bands. Since initiation of the study in 1987, 141 (13%) of the fledglings banded in our study area have been recaptured on the study area and marked with adult bands. Of the marked fledglings recaptured, most (76%) were recaptured within four years after initial banding. Nineteen fledglings (13%) were recaptured as one-year-olds, 33 (23%) as two-year-olds and 89 (63%) as adults. Among those recaptured for the first time as adults, most were recaptured after 3 or 4 years. The longest period of time between initial banding and recapture on the study area was 13 years (Figure 6).

Wilderness Area surveys

Six sites located in the Three Sisters (2 sites) and Mount Washington (4 sites) Wilderness Areas within 2 km of the wilderness area boundary were surveyed on an irregular basis from 1989

Table 5. Summary of reproductive success of northern spotted owls stratified by land use allocation on the Central Cascades Study Area, Willamette National Forest, Oregon from 1997 – 2015.

Land use allocation	Year	Number of pairs ^a	Number (%) of pairs fledging young	Number of young fledged	Average number of young per successful pair	Average number of young per pair (all pairs)
Matrix	1997	25	6 (24)	10	1.67	0.40
	1998	24	12 (50)	17	1.42	0.71
	1999	23	1 (4)	2	2.00	0.09
	2000	23	10 (43)	17	1.70	0.74
	2001	26	10 (38)	17	1.70	0.65
	2002	19	11 (58)	16	1.45	0.84
	2003	22	2 (9)	3	1.50	0.14
	2004	25	19 (76)	30	1.58	1.20
	2005	21	3 (14)	3	1.00	0.14
	2006	20	6 (30)	10	1.67	0.50
	2007	20	10 (48)	15	1.50	0.75
	2008	20	6 (30)	9	1.50	0.45
	2009	20	9 (43)	17	1.89	0.85
	2010	17	12 (71)	17	1.42	1.00
	2011	16	0 (0)	0	0	0
	2012	16	9 (56)	13	1.44	0.81
	2013	14	1 (7)	2	2.00	0.14
	2014	17	14 (82)	23	1.64	1.35
2015	12	8 (67)	13	1.63	1.08	
	Ave.	20	8 (39)	12	1.51	0.62
AMA	1997	28	8 (29)	13	1.63	0.46

Land use allocation	Year	Number of pairs ^a	Number (%) of pairs fledging young	Number of young fledged	Average number of young per successful pair	Average number of young per pair (all pairs)
AMA	1998	32	7 (22)	9	1.29	0.28
	1999	29	5 (17)	9	1.80	0.31
	2000	25	12 (48)	20	1.67	0.80
	2001	24	14 (54)	24	1.71	1.00
	2002	25	10 (40)	13	1.30	0.52
	2003	23	4 (17)	8	2.00	0.35
	2004	26	19 (73)	32	1.68	1.23
	2005	19	7 (33)	8	1.14	0.42
	2006	20	5 (25)	8	1.60	0.40
	2007	16	4 (25)	6	1.50	0.38
	2008	17	10 (59)	15	1.50	0.88
	2009	17	3 (18)	5	1.67	0.29
	2010	14	11 (79)	15	1.36	1.07
	2011	14	1 (7)	2	2.00	0.14
	2012	8	3 (38)	5	1.67	0.63
	2013	13	0 (0)	0	0	0
	2014	15	9 (60)	16	1.78	1.07
2015	14	10 (71)	17	1.70	1.21	
Ave.	20	7 (38)	12	1.53	0.60	
LSR ^b	1997	5	0 (0)	0	0.00	0.00
	1998	21	7 (32)	12	1.71	0.57
	1999	20	5 (25)	10	2.00	0.50
	2000	24	14 (68)	22	1.57	0.92

Land use allocation	Year	Number of pairs ^a	Number (%) of pairs fledging young	Number of young fledged	Average number of young per successful pair	Average number of young per pair (all pairs)
LSR ^b	2001	32	22 (69)	37	1.68	1.16
	2002	28	19 (66)	31	1.63	1.11
	2003	27	5 (17)	9	1.80	0.33
	2004	38	22 (56)	34	1.55	0.89
	2005	26	2 (7)	2	1.00	0.08
	2006	24	2 (8)	2	1.00	0.08
	2007	32	15 (47)	23	1.53	0.72
	2008	23	6 (25)	7	1.17	0.30
	2009	24	4 (17)	6	1.50	0.25
	2010	16	7 (44)	15	2.14	0.94
	2011	13	0 (0)	0	0	0
	2012	14	4 (29)	6	1.50	0.43
	2013	20	3 (15)	5	1.67	0.25
	2014	14	10 (71)	15	1.50	1.07
	2015	12	8 (67)	14	1.75	1.17
Ave. ^c	23	9 (37)	14	1.48	0.60	

^a Includes only pairs that were given at least 4 mice on two or more occasions prior to 31 August.

^b The LSR estimates computed for 1998 - 2015 included the Fall Creek LSR which was not surveyed in 1997.

^c The LSR averages were computed for 1998 – 2015.

Table 6. Numbers of new spotted owls banded, re-sighted, and recaptured in the central Cascades study area and in nearby wilderness sites in the Willamette National Forest, Oregon during 2015.

Age Class	New owls banded			Owls re-sighted			Owls recaptured		
	Males	Females	Unk.	Males	Females	Unk.	Males	Females	Unk.
Adult	1	1	0	47	40	0	3	1	0
Subadult	0	3	0	0	0	0	1	0	0
Juvenile	-	-	44	-	-	-	-	-	-

through 1996. Since 1997, these sites have been surveyed annually. The data summarized here also includes a seventh site in the Three Sisters Wilderness Area where a pair was located initially in 2010 (also 2011 and 2012). The proportion of these sites where pairs were detected was initially high in the wilderness area sites (>80%) but has generally declined since 2000 (<60%; with the exception of 2005) (Table 7). Six sites were surveyed in 2015, but only one pair was detected and they produced one fledgling (Table 7).

Thirty-five sites located in the Three Sisters and Mount Washington Wilderness Areas were surveyed irregularly from 1987 through 1999. Twenty-eight owls have been banded at these sites, although only one male owl was later relocated on the primary study area. One male and one female owl banded on the study area were re-sighted in the wilderness, but survey effort at these sites was inadequate to estimate dispersal across the wilderness boundary.

Barred owl detections

Barred owls have become increasingly abundant in the study area. The overall percentage of sites with at least one barred owl increased slowly from 1988 – 1999 (Figure 7). An accelerated increase was observed until 2003, primarily in detections of single barred owls while the rate of barred owl pair detections fluctuated at a low level. From 2003 through 2008, responses by pairs of barred owls increased at nearly the same rate as single barred owl responses. The percentage of sites where at least one response from a barred owl was recorded increased by 1% between 2014 (50%) and 2015 (51%). This is the highest rate of barred owl detections since the initiation of the study.

Although barred owl pair detections decreased slightly from the high of 14% in 2008 to 10% in 2010, detections of barred owl pairs increased again to 17% in 2012 and 2013 then to 22% in 2015. Detections of single barred owls decreased from a high of 40% in 2010 to 30% in 2014. In 2015, single barred owls were detected on 29% of spotted owl sites surveyed (Figure 7), with detections on two sites with no previous history of barred owl detections. Barred owl fledglings were observed at 10 of the 40 sites where barred owl pairs were detected.

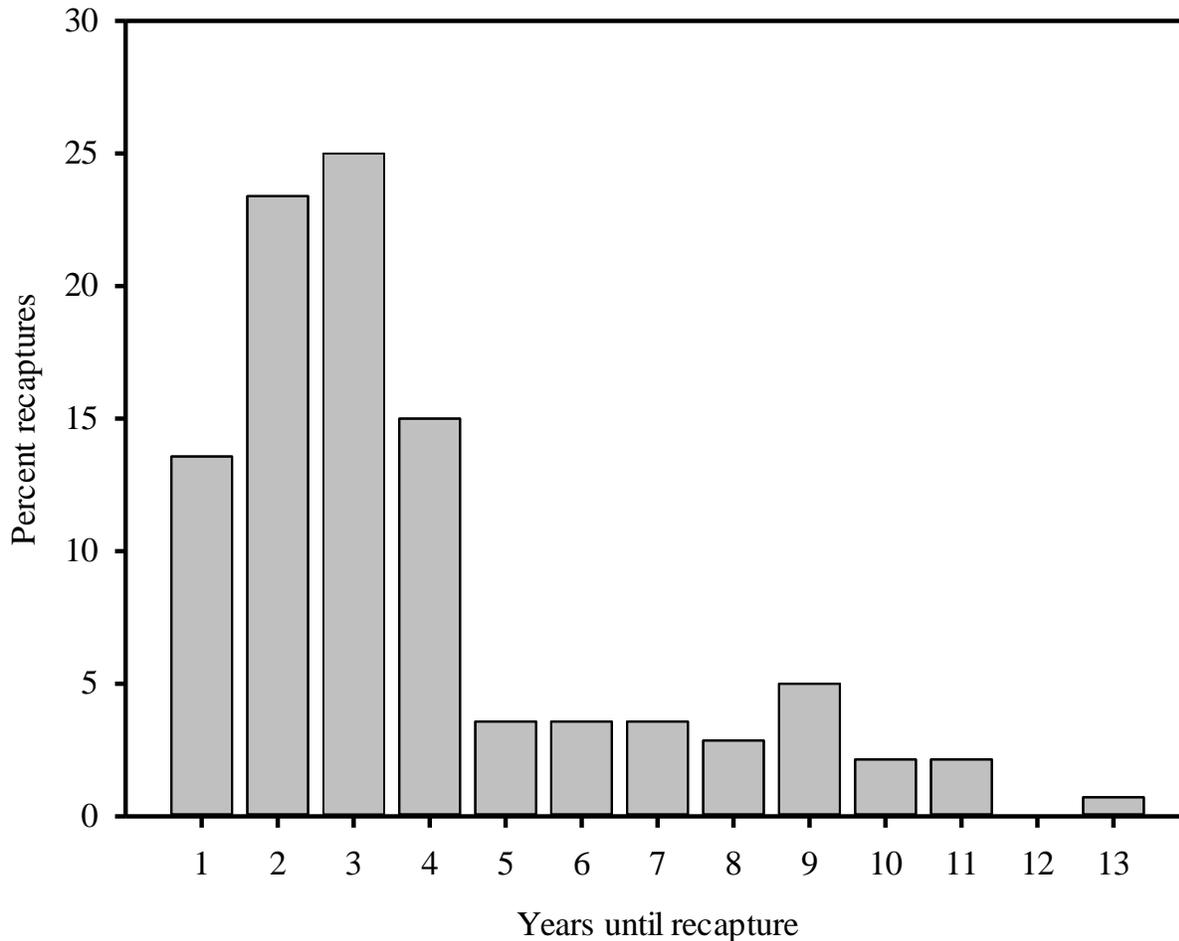


Figure 6. Years until the first recapture of 141 northern spotted owls banded as fledglings in the central Cascades study area, Willamette National Forest, Oregon from 1987 – 2015.

Hybridization with barred owls

Since 1999, we have located 12 non-juvenile spotted-barred owl F1 hybrids at 17 different sites (Appendix 5), and in 2015 we observed 1 hybrid female and 1 hybrid male on the study area. We observed eight cases involving a spotted owl paired with a hybrid or barred owl and five cases involving hybrid males paired with barred owl females. In addition, a male spotted owl was observed paired with a female barred owl (1 case) and with a female F1 hybrid owl (2 cases). A single case of a barred owl male paired with a female F1 hybrid also has been observed, although this pair did not attempt to nest.

The first F1 hybrid-barred owl pair was located west of the Fall Creek LSR in 1999. An F1 hybrid female was found near a historic spotted owl nest site within a Wild and Scenic River corridor along the McKenzie River in 2004. An F1 hybrid was detected in two neighboring

Table 7. Wilderness boundary sites surveyed concurrently with the demographic study in the central Cascades study area, Willamette National Forest, Oregon from 1997 – 2015.

Year	Sites surveyed ^a	Sites with pairs	Number of pairs producing young	Number of young fledged
1997	5	4	1	2
1998	5	5	1	1
1999	5	5	0	0
2000	5	3	0	0
2001	5	4	0	0
2002	5	2	0	0
2003	6 ^b	3	0	0
2004	6	2	0	0
2005	6	5	0	0
2006	6	3	1	2
2007	6	3	3	4
2008	5	2	0	0
2009	6	3	0	0
2010	7 ^c	3	0	0
2011	7 ^c	1	0	0
2012	7 ^c	2	0	0
2013	6	2	0	0
2014	6	2	2	3
2015	6	1	1	1

^a Includes only sites that were surveyed at least 3 times at night.

^b One site previously within an LSR has been re-assigned to the wilderness based on the 3 most recent owl locations.

^c A second pair was located from an LSR site over 1 mile into the wilderness

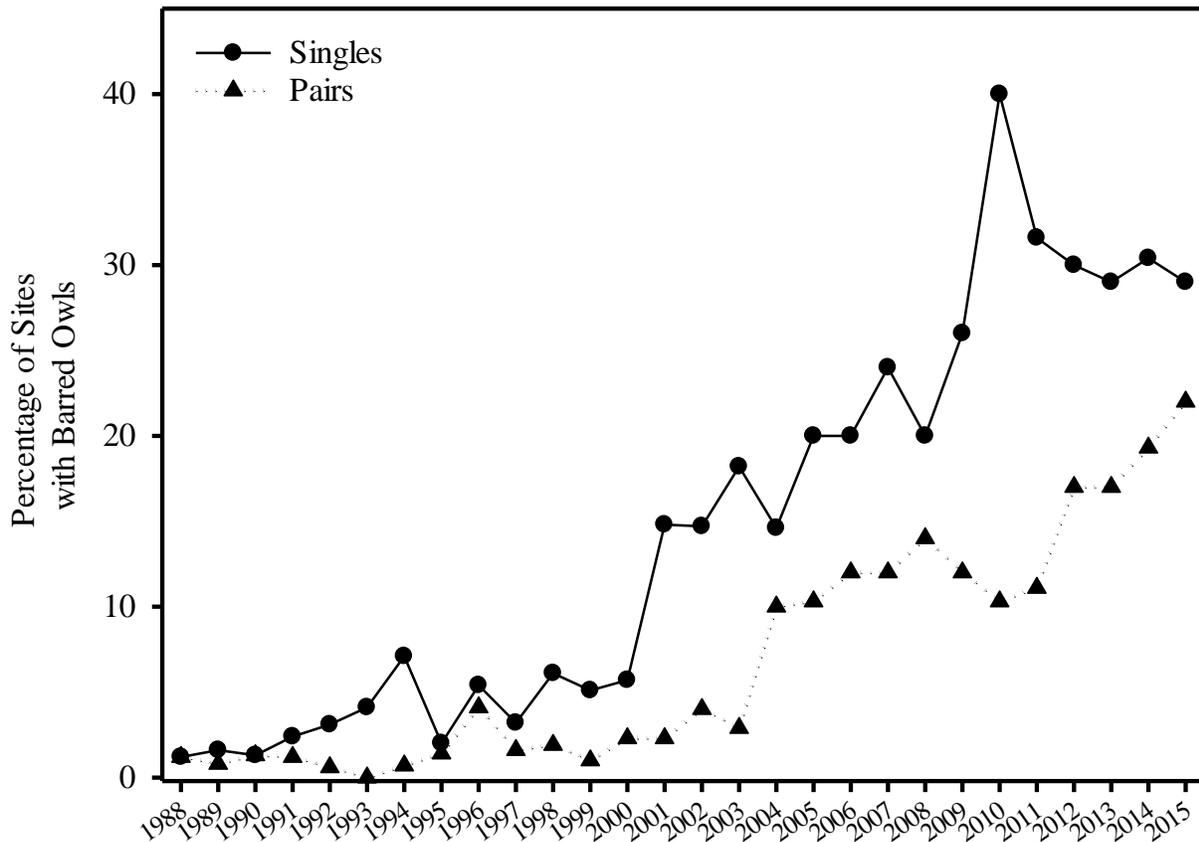


Figure 7. Percentage of sites where incidental detections of single and paired barred owls (*Strix varia*) have occurred while surveying for northern spotted owls in the central Cascades study area, Willamette National Forest, Oregon from 1988 – 2015.

matrix sites in 2006 and 2007. Most recently, an F1 hybrid originally banded in the Fall Creek LSR in 2004 was relocated in the AMA allocation in 2011. Six of the other nine F1 hybrid detections were in the Fall Creek LSR; another F1 hybrid was located in the Horse Creek LSR in 2002, and two F1 hybrid detections occurred in the South Santiam LSR in 2009 and 2010. Two of the F1 hybrids immigrated to the Fall Creek LSR from their initial banding locations in the Klamath and Roseburg study areas over 100 km away.

Reproduction was observed previously between a male F1 hybrid and a female barred owl (a total of 8 backcross young fledged by 2 different pairs from 1999 – 2006) and between a male spotted owl and a female barred owl (2 F1 hybrid young fledged in 2001). A female F1 hybrid has been paired with four different male spotted owls from 2003 to 2015, but reproduction was not documented for any pairing. To date, female spotted owls have not been observed pairing with male barred or hybrid owls in this study area (Appendix 5). This is consistent with other studies that indicated that female spotted owls rarely mate with barred or hybrid owls (Kelly 2001, Haig *et al.* 2004). This also may be a result of the male-biased spotted owl sex ratio;

unpaired male spotted owls may pair with a barred owl or hybrid if a female spotted owl is not available. We typically have not been following up on detections of single male barred owls, so it is unknown how frequently female hybrid or spotted owls are also present. We banded five of the F1 hybrids and two of the backcross young produced from 2003 – 2005. One of the previously banded F1 hybrids was relocated in 2015; a female F1 hybrid that has remained paired with four successive spotted owl males. These pairs have not produced any young. A single male F1 hybrid previously banded in 2004 was relocated in 2011 paired with a barred owl female, but this hybrid has not been relocated since. Neither of the banded backcross young from the male F1 hybrid-female barred owl pair produced in 2004 and 2005 have been relocated.

8. Discussion

Proportion of sites where owls were detected

The apparent increase in the proportion of sites where spotted owls were detected during the first three years of the study was probably related to increased survey effectiveness as site centers were located. Since 1989, the proportion of sites where a spotted owl was detected (either a single or pair) decreased an average of 2.1% per year with most of the decline occurring in 18 of the past 24 years (Table 1). These estimates included any spotted owl response at a site including auditory detections from unidentified individuals that may have been from non-territorial owls. This may be an indication that both the territorial and non-territorial segments of the spotted owl population were declining. The negative linear time trend on colonization probability and overall decline in occupancy rates (taking into account detection rates) is consistent with an accelerated decline in detections of spotted owls on territories from 1992 through 2013 (Dugger *et al.* 2016). Since 1989, the proportion of sites where pairs of spotted owls were detected has decreased an average of 2.5% per year. The proportion of sites where spotted owl pairs were detected decreased in the LSR and matrix land use allocations between 2014 and 2015. Although pair detections increased in the AMA allocation, the 2015 estimate is still consistent with an overall decreasing trend since 2004 (Table 2, Figure 2). Changes in pair detections in the LSR allocation are particularly pertinent to the effectiveness of the Northwest Forest Plan, as these areas were closely linked to the reserve designs for the recovery of the northern spotted owl. Our monitoring results suggest that not all LSRs were equally capable of supporting breeding pairs of spotted owls. The Fall Creek LSR lost 19 pairs from 2000 to 2015 and currently supports only 6 pairs of spotted owls. We have never detected more than 11, 8, and 3 pairs of spotted owls in the South Santiam, Horse Creek, and Hagan LSRs, respectively (Appendix 3) and these numbers likely reflect the highest number of pairs these LSRs can support. This is because these LSRs are relatively small and contain a large proportion of mature forest (vs. old-growth) more suitable for foraging and dispersal than for roosting or nesting. It is also important to note that the LSR design was intended to preserve late-successional forest ecosystems rather than to directly benefit any one species (USDA and USDI 1994). Not all late-successional forests can be classified as old growth or as high-quality spotted owl habitat, but they may still be important in preserving ecosystem functions at the landscape level.

The proportion of sites where spotted owls were detected should not be interpreted as an index of population size or an estimate of occupancy rate for several reasons. Detection probability was not incorporated into these estimates, and it is clear from other research, that the presence of

barred owls in the vicinity of a spotted owl territory decreases the detection rate of spotted owls even when they are present (Olson *et al.* 2005, Kroll *et al.* 2010, Dugger *et al.* 2011, Dugger *et al.* 2016); thus, declines in the proportion of sites where spotted owls were detected underestimates site occupancy and population size. Secondly, this includes detections of single owls and pairs combined, so sites where presently one owl was detected may have had a pair detected in previous years, but the loss of one of those individuals was not incorporated explicitly here. Finally, an unknown number of spotted owls may have been detected at more than one site, which would have inflated estimates of the number of individual owls detected.

Productivity

Relatively few females were confirmed to be single from 1987 through 2015 ($\bar{x} = 2.3\%$, $SE = 0.42$). Among those females that were paired and successfully fledged at least one young, there was little variation in the number of young produced ($CV = 0.13$). The percentage of pairs that attempted to nest was the most variable ($CV = 0.55$) followed by the percentage of nesting attempts that were successful ($CV = 0.35$). Environmental conditions can affect spotted owl productivity at all of these levels but it was evident that the proportion of pairs that attempted to nest every year and fledging success were the primary sources of variability in productivity of spotted owls.

A biannual pattern (*i.e.*, even/odd year variation) in nesting attempts was observed from 1988 through 2005 (Figure 4). This pattern has been broken three times: once during 2000 through 2002, when high rates of nesting attempts were recorded three years in a row, in 2005 and 2006 when low rates of nesting attempts were recorded for two consecutive years, and most recently with two consecutive years of high nesting rates between 2007 and 2008 and between 2014 and 2015. Climate has been suggested as the underlying factor driving this biannual variation through its effect on prey populations (Franklin *et al.* 2000, Glenn *et al.* 2011), but this has not yet been confirmed with long-term research on prey population dynamics. Anecdotal observations continue to suggest that pairs of spotted owls in the central Cascades of Oregon may be more likely to attempt to nest when conditions are warmer and drier than in years when late season storms occur during the early stages of nesting. Hypotheses regarding the negative effect of late nesting season rains on overall productivity and the negative effect of high precipitation and low temperature during the early nesting season on recruitment have received weak support, but the linkage between climate, the even/odd year effect and spotted owl productivity remains unclear (Glenn *et al.* 2010, Forsman *et al.* 2011.).

Fledging success has been highly variable among years, and it is not correlated with the annual number of nesting attempts (Figures 3 and 4). Given the strong territorial nature of this species, this is not a system where we would predict density dependent effects on fledging success or productivity, thus the fact that separate factors may be affecting a pair's decision to nest and their subsequent nest and fledging success is not surprising. Long-term prey cycles affecting the overall condition of breeding birds each year is likely responsible for patterns in breeding propensity (*i.e.*, proportion of pairs that attempt to breed). The demography of small mammal prey eaten by spotted owls is currently under investigation on our study area. We speculate that episodic storm events before, versus after nesting was initiated may in part explain the variation in reproductive success, independent of the decision by a pair of birds to breed. Storm events

during incubation could result in increased nest failures, whereas mild weather after nesting was initiated would allow the pairs that attempt to nest to successfully fledge young.

The number of young fledged per pair also may be affected by stochastic weather events, particularly when the fledglings are young and more vulnerable to chilling and exposure. Six post-fledging mortalities were confirmed in 2008. Five of these occurred during a week of cold temperatures and heavy rain in early June shortly after the young left the nest. A similar cluster of fledgling mortalities also was observed in 2004 when a period of unseasonably cold and wet weather occurred during the same period. In contrast, weather conditions remained mild throughout June 2009, and no post-fledging mortalities were documented. The weak negative effect of precipitation during the late nesting season (1 May – 30 June) on fecundity discussed above (Glenn *et al.* 2010, Forsman *et al.* 2011) may reflect the periodic loss of young in the nest, if weather is causing mortality of nestlings similarly to effects observed in some years on fledglings. Post-fledging mortalities did not affect our estimates of the number of young fledged or fecundity because juvenile mortalities documented during the post-fledging period are counted as having successfully fledged even if we discover that they did not survive long after fledging.

Predation may affect productivity both before and after fledging. Potential predators sighted on the study area within 1 mile (1.6 km) of active territories included great-horned owls (*Bubo virginianus*), northern goshawks (*Accipiter gentilis*), red-tailed hawks (*Buteo jamaicensis*), peregrine falcons (*Falco peregrinus*), and common ravens (*Corvus corax*). Barred owls also may directly impact productivity through predation on spotted owl nestlings or by causing nest abandonment by spotted owls. On two occasions in 2002, a dead nestling was found near a nest tree on the same day that a barred owl was observed aggressively interacting with the spotted owl pair. However, direct observations or evidence of predation have been rare (*e.g.*, Leskiw and Gutiérrez 1998) making it difficult to assess the magnitude of this effect.

Spotted owl - barred owl relationships

Although detections of barred owls in spotted owl territories have increased in a manner consistent with an expanding barred owl population (Figure 7), data collected incidentally during spotted owl surveys have limited utility (Livezey 2007). Occupancy of spotted owl sites by barred owls was underestimated because we did not use survey techniques targeted specifically to barred owls, and we rarely located barred owls during the day following nocturnal detections. While barred owl fledglings were detected at 10 spotted owl territories in 2015, these incidental observations cannot be used estimate barred owl productivity at the population level on our study areas.

Despite the limitations discussed above, a number of associations have emerged between increased barred owl detections and spotted owl detection rate, annual site occupancy, and demographic parameters. Several banded spotted owls have not been relocated following barred owl detections in their historic core areas presumably because they have either died, been excluded from suitable habitat, or were inhibited from responding to our surveys. The presence of barred owls in the Oregon Cascades has been shown to negatively influence the probability of detecting spotted owls as well as affecting the probability that a pair of spotted owls would

abandon occupied sites or recolonize an empty site (Olson *et al.* 2005, Dugger *et al.* 2011, Dugger *et al.* 2016). While mortality of displaced non-juvenile spotted owls has not been documented in this study, recent findings indicate that increased detections of barred owls throughout the study area were associated with decreased apparent survival (Forsman *et al.* 2011, Dugger *et al.* 2016.). Finally, barred owls may affect spotted owl productivity through their effect on site occupancy by pairs of spotted owls (Olson *et al.* 2005, Dugger *et al.* 2016). These effects are expected to become more pronounced as barred owl density increases (Dugger *et al.* 2011).

Early in the expansion of barred owls into the range of the northern spotted owl, there was concern over the potential for hybridization of barred and spotted owls (Hamer *et al.* 1994). Two scenarios have been proposed regarding the outcome of hybridization between spotted owls and barred owls (Hamer *et al.* 1994). If introgression of barred owl genes into spotted owl populations produces hybrids with greater fitness than spotted owls, hybrids could gradually replace spotted owls if increased barred owl abundance results in increased hybridization (Grant and Grant 1992). Alternatively, if hybridization is the result of scarcity of mates for barred owls and/or if hybrids are less fertile than spotted owls, then the frequency of hybridization may decline as barred owls become more abundant (Hamer *et al.* 1994, Randler 2006).

The first spotted owl x barred owl F1 hybrid was detected on the study area in 1999. The number of hybrids detected increased through 2004, but has since declined to only 2 or 3 detections per year since 2007 (Appendix 5). As pointed out earlier, barred owl abundance has increased to the point that they are detected at nearly half of the spotted owl territories that we monitor. These observations are consistent with the hypothesis that behavioral mechanisms usually prevent mating between spotted and barred owls unless potential barred owl mates are scarce (Randler 2006).

For barred owl genes to be introduced into spotted owl populations, backcrossing between F1 hybrids and spotted owls must occur. Most backcrossing that has been reported has been between F1 hybrids and barred owls; successful backcrossing between F1 hybrids and spotted owls has been rare even when F1 hybrids are found paired with spotted owls (Haig *et al.* 2004, Kelly and Forsman 2004, Appendix 5). From the information collected to date, it appears that little introgression of barred owl genes into spotted owl populations has occurred on our study area.

Management considerations

The first formal spotted owl reserve design recommended that 15 – 20 pairs of spotted owls would be necessary to support a stable population in a habitat reserve (Thomas *et al.* 1990). The Final 2008 Northern Spotted Owl Recovery Plan also recommended that category 1 managed owl conservation areas (MOCAs) be capable of supporting at least 20 pairs, and category 2 MOCAs should be capable of supporting 1 – 19 pairs while also providing connectivity between category 1 areas (U.S. Fish and Wildlife Service 2008). The Final Revised Recovery Plan released in 2011 (U.S. Fish and Wildlife Service 2011) has withdrawn the MOCA network and recommended that managers continue to consider the LSR land use allocation under the NWFP as the current reserve network. The Fall Creek LSR has supported as many as 25 pairs of spotted

owls, but currently supports only six. Continued loss of spotted owl pairs in that LSR may render that area ineffective as a reserve. The South Santiam, Horse Creek, and Hagan LSRs were not likely to support more than 20 pairs of spotted owls but may provide connectivity within the reserve network.

From 2000 – 2004 and in 2007, the largest numbers of young were produced in the LSR allocation (Table 5). In 2005, 2006, and 2008 through 2015, productivity in the LSRs was lower than in the matrix and AMA allocations. Most of the young produced in the LSR allocation have been from the Fall Creek LSR. Very few young have been produced in the Horse Creek and South Santiam LSRs, and young were rarely produced at all in the Hagan LSR (Appendix 4). The wide fluctuations in productivity in the Fall Creek LSR and the relatively low numbers of young produced since 2005 suggest that this area may not be a reliable source of recruits in the future. One possible reason for this has been the relatively high numbers of barred owls in the Fall Creek LSR. Since 2000, an average of 36% of all barred owl detections each year has been in the Fall Creek LSR (range: 25% – 47%). In most years, there has been nearly as many barred owls in the Fall Creek LSR as have been detected in the matrix and AMA allocations combined (an average of 40% of all barred owl detections each year). This may have been due to a greater abundance of low elevation, low slope, riparian habitats in the Fall Creek LSR relative to the rest of the study area which seems to be habitat most readily used by barred owls (reviewed in Livezey 2007). Although recent results do not support a negative effect of barred owls on fecundity in the HJA study area, declining survival in response to increasing barred owl populations obviously would impact overall population productivity through the loss of breeding spotted owls (Forsman *et al.* 2011).

Although the matrix and AMA allocations are subject to timber harvest, they still contain many productive spotted owl pairs that have made substantial contributions to population recovery. The 2012 critical habitat designation (U.S. Fish and Wildlife Service 2012) designates approximately 100,000 ha (69%) within the study area. This includes all four of the LSRs and over 50,000 ha of additional habitat, primarily in matrix and AMA allocations. Given that timber harvest may still occur in the matrix and AMA allocations (<http://www.fs.usda.gov/resources/willamette/landmanagement/resourcemanagement>), it will be critical to continue keeping management agencies informed of the most recent locations of these productive pairs as well as individuals newly recruited into the breeding population.

Current and future plans for timber harvest will provide an opportunity to evaluate the effects of different harvest strategies on spotted owl site occupancy and demography. A large-scale commercial thinning project in the Blue River watershed in the central Cascades AMA is currently underway as part of the Blue River Landscape Strategy (<http://www.fs.fed.us/nepa/fs-usda-pop.php/?project=21779>). This area contains several of the most productive pairs on the study area so it is critical that units are planned to minimize impacts on these pairs. Site- and year-specific data will be required to adequately assess the long-term effects of these actions. For this reason, we continue to inform the Forest Service biologists of the most recent locations of the spotted owls in these areas.

There has been little habitat loss due to fire on the study area and the response of the spotted owls in the affected areas has been variable. The Clark Fire in 2003 seems to have had little

effect on spotted owl detections or productivity in this area. The one site in the 2003 B&B fire remained occupied by a pair of spotted owls for two years and by a single spotted owl for an additional year following the fire. In the year that only a single spotted owl was detected, a pair of great horned owls was located during nighttime surveys of the area. Therefore, it is not possible to link habitat change due to the fire to the lack of spotted owl detections since the fire, particularly without a clear understanding of the effect of fire severity. Owls use forest stands that have burned under-stories or partially removed over-stories, but they tend to avoid areas of complete stand replacement for nesting and roosting (Clark 2007). Use of high severity burn areas for foraging has been documented for the California spotted owl (*Strix occidentalis occidentalis*) (Bond *et al.* 2009), and fire did not adversely affect spotted owl site occupancy in California (Lee *et al.* 2012), but much more research is needed to understand what appears to be a complex interaction between fire frequency and severity and owl habitat use (Clark 2007, Bond *et al.* 2009).

9. Problems encountered:

Relatively mild weather in the Spring of 2015 did not delay our access to high elevation sites as severely as in past years. Still, the Horse Creek and South Santiam LSRs include most of our high elevation sites where more snow typically remains longer into the spring, which delays the first surveys until June. As a result, the productivity of more owls remained unresolved in these LSR sites than in the matrix or AMA sites. Deeper and a more persistent snow pack also may influence the productivity of spotted owls in these LSRs.

Noise associated with high stream flows and heavy rain frequently interfered with site visits and nighttime surveys. Several surveys had to be repeated due to the effect of such noise on the detectability of spotted owls (Kissling *et al.* 2010, Lengane and Slater 2002). This forced us to allocate more effort to repeated surveys at some sites which allowed less time to complete the surveys at other sites.

The numbers of downed trees blocking Forest Service roads continued to hinder our access to many of our sites. Despite the efforts of Forest Service personnel to clear the roads, we spent several days throughout the field season clearing the roads rather than conducting site visits. In addition, although survey effort was the same for all three land use allocations, road closures that occurred in previous years made access more difficult in the LSRs. Many of the secondary roads in the LSRs are no longer maintained and several have been decommissioned which means portions of the surveys in these areas must be conducted on foot, considerably increasing the time required to access these sites.

Decreased per-visit detection rates (Olson *et al.* 2005) associated with increased barred owl detections and continued declines of spotted owl populations (Dugger *et al.* 2016) have increased the amount of time and effort required to meet protocol requirements for data collection. Many of the pairs that were previously easy to locate near their historic activity centers now require us to conduct additional night surveys to either relocate them or confirm they are indeed no longer present (Figure 8). Increased night work has fundamentally changed the survey coverage across the study area from a territory-based, site visit approach to more uniform nighttime survey

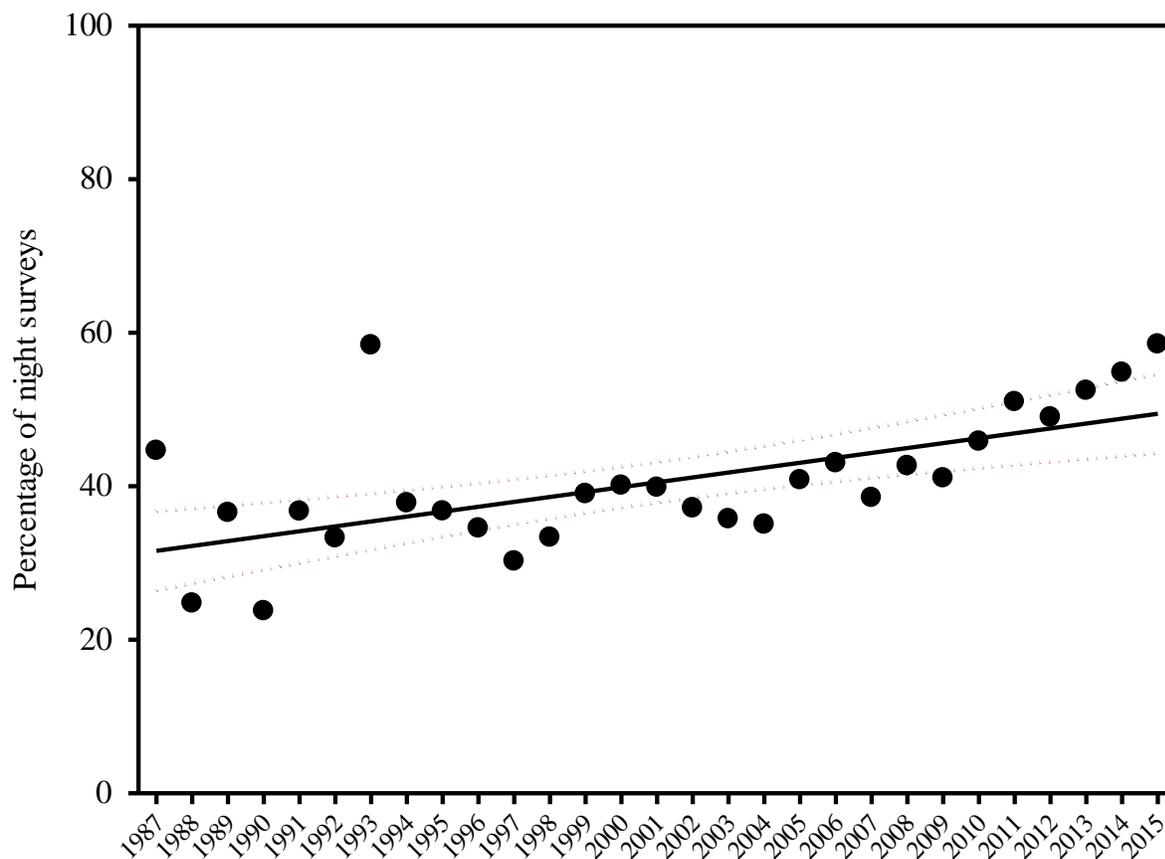


Figure 8. Percentage of night surveys conducted annually in the central Cascades study area, Willamette National Forest from 1987 through 2015.

coverage over large portions of the study area. While this improved our coverage of areas near nest sites and other activity centers, it has become more difficult to complete all site visits and nighttime surveys required by the effectiveness monitoring protocol (Forsman 1995).

10. Acknowledgments:

Several people from the Willamette National Forest contributed both information and resources that made this study possible. Forest Service biologists Joe Doerr (Willamette National Forest Supervisor’s Office), Ruby Seitz, Penny Harris, and Shane Kamrath (McKenzie River Ranger District), Tiffany Young (Sweet Home Ranger District), and Dick Davis (Lowell Ranger District) regularly consult with us regarding management activities near the owl sites and have provided valuable information regarding the history of several sites. Sonja Weber (Willamette National Forest Supervisor’s Office) and Janice Reid (Roseburg BLM) provided valuable assistance in revising master site numbers and site names to reconcile our database with the ODFW master site list. Shari Johnson (Pacific Northwest Forestry Sciences Laboratory), Mark

Schulze (Oregon State University) and the staff of the H. J. Andrews Experimental Forest provided housing and office facilities. Financial support was provided by the USDA Forest Service and USDI Bureau of Land Management via a Cost Reimbursable Research Agreement with Oregon State University.

11. Research plans for FY 2016:

- a) Continue collecting data on occupancy, survival and reproductive success of the northern spotted owl population on the Willamette National Forest Northern Spotted Demography Study Area in the central Cascades of Oregon.
- b) Continue summarizing monitoring data of spotted owls among the matrix, AMA, and LR land use allocations.
- c) Continue the analysis of spotted owl diet composition and update the prey database to be compatible with other studies.
- d) Cooperate with the staff of the Middle Fork Ranger District in developing priorities for proposed management in the Fall Creek LSR.
- e) Cooperate with the staff of the McKenzie River Ranger District in planning pre-commercial and commercial thinning operations in the Blue River watershed.

12. Publications and technology transfer completed in FY 2015:

Presentations

- a) S. Ackers presented an overview of spotted owl ecology and recent research to the Eugene Rotary Club (January, 2015).
- b) S. Ackers presented habitat suitability modeling results using lidar data at the Salem BLM office (April, 2015).
- c) S. Ackers attended a field trip with Willamette National Forest personnel (June, 2015).
- d) S. Ackers attended a field trip with personnel from the Pacific Northwest Forestry Sciences Laboratory to examine the effectiveness of lidar in identifying RA32 spotted owl habitat (July, 2015).
- e) S. Ackers presented habitat suitability modeling results using lidar data at the Grant's Pass BLM office (November, 2015).
- f) K. Dugger participated in the Public Forum for "Sharing Key Findings of the Northwest Forest Plan 20-Year Monitoring Reports" and made a presentation. The forum was sponsored by the Interagency Regional Monitoring Program, and

included stakeholders from a variety of state and federal agencies, NGO's, the media, and the general public, Vancouver, WA, (June , 2015).

- g) K. Dugger gave an invited lecture for FW507, OSU Department of Fisheries and Wildlife Seminar series entitled *The effects of habitat, climate and barred owls on long-term demographics of northern spotted owls*. Corvallis, OR, October 21, 2015.

Publications

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, Matthew 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, 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.

Technology transfer.

- a) Project personnel coordinated spotted owl surveys with the district biologists of the Willamette National Forest and continued to provide information on spotted owl locations and demographics for their management needs.
- b) S. Ackers provided data on occupancy and productivity of sites within 1.6 km of BLM and private land to the Eugene BLM, Westside Ecological (under contract with the Oregon Department of Forestry) and Weyerhaeuser Inc.
- c) S. Ackers attended monthly H.J. Andrews staff meetings at the H. J. Andrews Experimental Forest.

13. Duration of the study:

This study was initiated in FY 1987 and is part of the long-term monitoring plan for the northern spotted owl under the Northwest Forest Plan (Lint *et al.* 1999).

14. Literature cited:

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Appendix 1. Master site number (MSNO) and site name revisions as of 26 October 2009.

District	ODFW MSNO	ODFW Site Name	Previous MSNO	Previous Site Name
McKenzie River	0032	Upper McRae Creek	0033	Middle McRae Creek
	0033	Lower McRae Creek	3025	
	0085	Lamb Butte		Lowder Mountain
	0111	NF Quartz Creek		N Fk Quartz Creek
	0113	East Fork McKenzie	5043	E Fk McKenzie River
	0119	Middle Horse Creek	0982	
	0750	Pasture Creek	0850	
	0818	Horsepasture Mount		Horsepasture Mtn
	0821	Great Spring		Great Spg-Clear Lake
	0836	Lost Creek	2442	White Branch Creek
	0850	Upper Horse Creek	2824	
	0851	Lower Roney Creek	2835	
	0857	Lowder Mountain		Upper East Fork
	0869	EF Augusta Creek		E Fk Augusta Creek
	0871	Wolf Rock	2844	Mann Creek
	2465	Hagan Block	5071	
	2477	Gate Creek	5070	
	2826	Indian Fork	1414	Indian Creek
	2827	Lost Branch	0836	Lost Creek
	2831	Castle Creek	1737	
4085	Upper Cook Creek	3962		
Middle Fork	1015	Slick Creek	4549	West Slick Creek
	1017	Tiller Ninemile		Tiller-Ninemile Cr
	1020	West Delp Creek	4421	Upper Delp
	1028	Logan Creek	2858	Logan Creek
	1031	Briem Creek	4476	
	1032	Upper Pernot Creek	2888	
	1063	Delp Creek Tributary	1020	West Delp Creek
	2899	Upper Marine Creek	1028	Lower Logan Creek
	2463	Saturn Creek	1031	Saturn-Briem Creek
	2861	Little Fall Creek 2		Little Fall Creek Trib
	2867	South Puma Creek	4082	Pumarine

District	ODFW MSNO	ODFW Site Name	Previous MSNO	Previous Site Name
Middle Fork	4549	West Slick Creek	1015	Slick Creek
Sweet Home	0007	Burnside Creek	2956	Indian Tombstone
	0012	Indian Creek	4093	Indian Creek (Sweet)
	0013	Echo Creek		Echo Creek-Lost Prairie
	0064	Boulder Cr (Sweet)	0641	
	0668	Parks Creek	0664	
	0689	Upper Two Girls	5052	
	0694	Squaw Mountain	4098	
	1156	Gordon Meadows	0646	
	1322	Gordon Meadows West	5058	
	2964	East Wildcat Mount		East Wildcat Mountain
	4405	Squaw Headwaters		Squaw Creek Headwaters

Appendix 2. Occupancy^a and reproductive^b status of northern spotted owls in the four late-successional reserves (LSR) in the Central Cascades Study Area, Willamette National Forest, Oregon from 2008 – 2015. Data from prior years are available upon request.

LSR	MSNO ^c	2010		2011		2012		2013		2014		2015	
		Occ.	Repro.										
Fall Creek (LSR-219)	0124	P	0	A	0	P	0	P	0	RM	-	P	2
	1011	SU	0	P	0	SU	-	SU	-	Unoccupied		Unoccupied	
	1012	Not surveyed		SU	-	SU	-	Unoccupied		Unoccupied		Unoccupied	
	1013	P ^d	0										
	1015	Unoccupied		SU	-	Unoccupied		SU	-	Unoccupied		SU	-
	1016	Unoccupied		SU	-								
	1017	Unoccupied											
	1018	P	1	RM	-	P	0	P	0	P	2	P	0
	1019	SU	-	Unoccupied									
	1020	P	2	P	0	P	2	P	0	P	2	SU	-
	1021	P	0	A	0	A	0	P	0	P	1	P	2
	1022 ^g	P	Unk.	RM	-	P	Unk.	P	0	P	1	Unoccupied	
	1022 ^g	SU	-	SU	-	NR	-	Unoccupied		Unoccupied		Unoccupied	
	1028^e	NR	-	Unoccupied									
	1029	RM	-	P	Unk.	P	0	SU	-	Unoccupied		Unoccupied	
	1031	SD	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied		SU	-
	1032	P	2	SU	-	P	Unk.	SU	-	RM	-	P	0
	1043	Unoccupied											
	1063	P	2	P	0	P	Unk.	P	0	P	1	Unoccupied	
	1101	Unoccupied		Unoccupied		Unoccupied		Unoccupied		SU	-	Unoccupied	
1102	P	1	P	0	P	0	P	0	P	1	P	0	

LSR	MSNO ^c	2010		2011		2012		2013		2014		2015	
		Occ.	Repro.	Occ.	Repro.								
Fall Creek (LSR-219)	2444	SU	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2462	Unoccupied		Unoccupied		SU	-	PU	0	P	1	Unoccupied	
	2463	SU	-	Unoccupied		Unoccupied		SU	-	Unoccupied		SU	-
	2807	P	0	RF	0	P	Unk.	P	0	Unoccupied		Unoccupied	
	2808	P	0	SU	-	SU	-	Unoccupied		Unoccupied		Unoccupied	
	2817	P	Unk.	Unoccupied		PU	Unk.	RF	0	P	Unk.	P	2
	2826	P	F	SU	-	PU	Unk.	P	2	P	2	Unoccupied	
	2861	Unoccupied		Unoccupied		Unoccupied		RM	0	Unoccupied		SU	-
	2863	SU	-	SU	-	SU	-	SU	-	Unoccupied		Unoccupied	
	2864	Unoccupied		SU	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2865	Unoccupied		Unoccupied		Unoccupied		SU	-	Unoccupied		Unoccupied	
	2867	SU	-	Unoccupied		Unoccupied		SU	-	P	0	RM	-
	2889	P	3	A	0	P	1	P	0	PU	Unk.	SU	-
	2891	Unoccupied		Unoccupied									
	2895	SU	-	SU	-	P	0	P	0	SU	-	Unoccupied	
	2897	Unoccupied		Unoccupied		NR	-	Unoccupied		Unoccupied		Unoccupied	
	2899	Unoccupied		PU	Unk.								
	2900	Unoccupied		SU	-	Unoccupied		SU	-	SU	-	Unoccupied	
	2949	SD	-	Unoccupied		SU	-	Unoccupied		Unoccupied		Unoccupied	
	3550	P	2	P	0	SU	-	Unoccupied		Unoccupied		SU	-
4105	Not surveyed		Not surveyed		Not surveyed		Not surveyed		Not surveyed		Not surveyed		
4392	Unoccupied		SU	-	Unoccupied		SU	-	RM	-	NR	-	
4420	Unoccupied		Unoccupied		P	2	P	0	SU	-	RM	-	

LSR	MSNO ^c	2010		2011		2012		2013		2014		2015	
		Occ.	Repro.										
Fall Creek (LSR-219)	4549	Unoccupied											
	4585	SU	-	PU	Unk.	P	Unk.	P	0	P	Unk.	Unoccupied	
Hagan (LSR-215)	0112	Unoccupied		Unoccupied		SU	-	Unoccupied		Unoccupied		SU	-
	2465	Unoccupied		SU	-	SU	-	Unoccupied		Unoccupied		Unoccupied	
	2477	Unoccupied											
	3401	RF	Unk.	RF	Unk.	Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	4503	Unoccupied		Unoccupied		SU	-	Unoccupied		Unoccupied		Unoccupied	
Horse Creek (LSR-218)	0085	Unoccupied											
	0113	SU	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied		SU	-
	0119	Unoccupied											
	0750	P	Unk.	RM	-	PU	Unk.	SU	-	SU	-	SU	-
	0818	Unoccupied		P	0	P	0	A	0	P	1	P	1
	0834	Unoccupied		NR	-								
	0857	P	3	P	0	P	0	P	1	P	0	P	2
	1736	SU	-	NR	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2428	P	2	SU	-	P	0	RM	-	Unoccupied		PU	Unk.
	2446 ^d	Unoccupied											
	2828	SU	-	RF	0	Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2830	Unoccupied		SU	-	SU	-	RM	-	P	Unk.	P	Unk.
	2831	A	Unk.	RF	0	SU	-	P	0	P	0	P	1
	3023	P	0	P	0	SU	-	SU	-	SU	-	Unoccupied	
S. Santiam (LSR-217)	0007	P	Unk.	P	0	P	1	P	0	RM	-	Unoccupied	
	0011	Unoccupied		Unoccupied		SU	-	P	0	P	0	P	2

LSR	MSNO ^c	2010		2011		2012		2013		2014		2015	
		Occ.	Repro.	Occ.	Repro.	Occ.	Repro.	Occ.	Repro.	Occ.	Repro.	Occ.	Repro.
S. Santiam (LSR-217)	0014	Unoccupied		Unoccupied		Unoccupied		SU	-	Unoccupied		Unoccupied	
	0064	NR	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	0619	RF	0	Unoccupied		P	0	P	2	P	2	P	2
	0689	P	0	Unoccupied		Unoccupied		Unoccupied		Unoccupied		SU	-
	0694	P	0	Unoccupied		Unoccupied		SU	0	Unoccupied		Unoccupied	
	1156	SU	-	SU	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	1322	P	1	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2460	Unoccupied		Unoccupied		Unoccupied		SU	-	Unoccupied		Unoccupied	
	2846	P	Unk.	P	0	SU	-	Unoccupied		Unoccupied		Unoccupied	
	2959	P	0	RM	Unk.	Unoccupied		Unoccupied		Unoccupied		SU	-
	2962	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	4196	Unoccupied		Unoccupied		Unoccupied		Unoccupied ^d		Unoccupied		Unoccupied	
	4405	P	0	P	0	RM	-	P	0	P	2	P	2
	4488	Unoccupied		SU	-	SU	-	Unoccupied		SU	-	Unoccupied	

^a Occupancy status: P = pair; A = pair plus one or more additional adults or subadults; RM = resident single male; RF = resident single female; PU = pair detected, only one meets residency criteria; SU = one or more owls detected but not meeting the above criteria and survey effort ≥ 3 night visits; SD = one or more owls detected but not meeting the above criteria and survey effort < 3 visits; NR = no responses in < 3 night visits.

^b Reproductive status: 0, 1, 2, 3 = number of young produced; N = non-nesting; F = nest failure; Unk. = undetermined.

^c Master Site Numbers in bold are new or corrected numbers. Please see Appendix 1 for the master site number revisions.

^d Spotted/barred owl hybrid(s) identified at this site (see Appendix 5).

^e The Logan (2858) and L. Logan (2899) sites have been surveyed as a single site since 2000 and are now designated Logan Creek (1028) (see Appendix 1).

^f A spotted owl x barred owl pair produced two hybrid fledglings at this site in 2006.

^g Two pairs of spotted owls were located at two different historic site centers at this site.

Appendix 3. Summary of survey effort and spotted owl detections in the four late-successional reserves (LSR) in the Central Cascades Study Area, Willamette National Forest, Oregon from 1997 – 2015.

LSR	Year	Sites surveyed	Sites with ≥ 1 owl detected (%)	Sites with pairs detected (%)
Fall Creek (LSR-219)	1997	0	-	-
	1998	23	17 (74)	13 (57)
	1999	36	30 (83)	23 (64)
	2000	40	33 (83)	25 (63)
	2001	40	34 (85)	24 (60)
	2002	41	36 (88)	25 (61)
	2003	41	35 (85)	21 (51)
	2004	40	31 (78)	24 (60)
	2005	42	30 (71)	24 (57)
	2006	42	30 (71)	20 (48)
	2007	42	30 (71)	20 (48)
	2008	36	25 (69)	16 (44)
	2009	41	23 (56)	14 (34)
	2010	38	23 (61)	15 (39)
	2011	43	25 (58)	9 (21)
	2012	42	24 (57)	15 (36)
	2013	43	28 (65)	13 (30)
2014	43	19 (44)	11 (26)	
2015	43	17 (40)	6 (14)	
Hagan (LSR-215)	1997	3	2 (67)	1 (33)
	1998	4	3 (75)	2 (50)
	1999	5	3 (60)	0
	2000	5	3 (60)	1 (20)
	2001	5	5 (100)	2 (40)

LSR	Year	Sites surveyed	Sites with ≥ 1 owl detected (%)	Sites with pairs detected (%)
	2002	5	2 (40)	1 (20)
	2003	5	3 (60)	2 (40)
	2004	5	3 (60)	2 (40)
	2005	5	4 (80)	1 (20)
	2006	5	3 (60)	3 (60)
	2007	5	3 (60)	1 (20)
	2008	4	1 (25)	1 (25)
	2009	5	2 (40)	2 (40)
	2010	5	1 (20)	0
	2011	5	2 (40)	0
	2012	5	3 (60)	0
	2013	5	0	0
	2014	5	0	0
	2015	5	1 (20)	0
Horse Creek (LSR-218)	1997	12	8 (67)	3 (25)
	1998	14	9 (64)	7 (50)
	1999	13	9 (69)	7 (54)
	2000	13	8 (62)	7 (54)
	2001	13	9 (69)	4 (31)
	2002	14	8 (57)	3 (21)
	2003	14	10 (71)	7 (50)
	2004	14	11 (79)	8 (57)
	2005	14	10 (71)	4 (29)
	2006	14	8 (57)	5 (36)
	2007	14	9 (64)	6 (43)
	2008	13	8 (62)	6 (46)

LSR	Year	Sites surveyed	Sites with ≥ 1 owl detected (%)	Sites with pairs detected (%)
	2009	14	11 (79)	6 (43)
	2010	14	8 (57)	5 (36)
	2011	14	8 (57)	3 (21)
	2012	14	7 (50)	4 (29)
	2013	14	7 (50)	3 (21)
	2014	14	8 (57)	4 (29)
	2015	14	7 (50)	5 (36)
S. Santiam (LSR-217)	1997	12	9 (75)	4 (33)
	1998	14	9 (64)	5 (36)
	1999	12	10 (83)	5 (42)
	2000	15	11 (73)	2 (13)
	2001	15	8 (53)	4 (27)
	2002	15	8 (53)	5 (33)
	2003	15	8 (53)	6 (40)
	2004	15	10 (67)	6 (40)
	2005	16	11 (69)	11 (69)
	2006	16	9 (56)	5 (31)
	2007	16	9 (56)	8 (50)
	2008	15	8 (53)	4 (27)
	2009	16	8 (50)	5 (31)
	2010	15	9 (60)	7 (47)
	2011	16	6 (38)	3 (19)
	2012	16	6 (38)	2 (13)
	2013	16	7 (44)	4 (25)
2014	16	5 (31)	3 (19)	
2015	16	5 (31)	3 (19)	

Appendix 4. Summary reproductive statistics in the four late-successional reserves (LSR) in the Central Cascades Study Area, Willamette National Forest, Oregon from 1997 – 2015.

LSR	Year	Nesting surveys ^a	Pairs nesting	Reproductive surveys ^b	Pairs fledging young (%)	Young fledged	Young per successful pair	Young per all pairs
Fall Creek	1997	Fall Creek not surveyed by OCFWRU staff in 1997.						
(LSR-219)	1998	9	7	10	4 (40)	8	2.00	0.80
	1999	8	2	12	4 (33)	8	2.00	0.67
	2000	11	9	19	12 (67)	20	1.67	1.05
	2001	13	6	23	15 (65)	24	1.60	1.04
	2002	17	14	22	15 (71)	27	1.80	1.23
	2003	14	2	18	2 (11)	4	2.00	0.22
	2004	19	12	23	13 (59)	22	1.69	0.96
	2005	14	6	17	0	0	0	0
	2006	15	0	16	0	0	0	0
	2007	14	9	20	11 (58)	16	1.45	0.80
	2008	8	4	18	5 (29)	6	1.20	0.33
	2009	8	2	13	5 (38)	4	1.33	0.31
	2010	9	8	9	4 (44)	9	2.25	1.00
	2011	3	0	9	0	0	0	0
	2012	10	7	9	3 (33)	5	1.67	0.55
	2013	7	0	14	1 (7)	2	2.00	0.14
	2014	5	5	8	7 (88)	10	1.43	1.25
	2015	5	3	6	3 (50)	6	2.00	1.00
Hagan	1997	1	1	0	0	0	0	0
(LSR-215)	1998	1	1	1	0	0	0	0
	1999	0	-	0	-	-	-	-
	2000	0	-	0	-	-	-	-
	2001	1	1	2	2 (100)	3	1.50	1.50
	2002	1	0	1	0	0	0	0
	2003	1	1	1	0	0	0	0
	2004	2	1	2	0	0	0	0
	2005	0	-	0	-	-	-	-
	2006	1	0	1	0	0	0	0

LSR	Year	Nesting surveys ^a	Pairs nesting	Reproductive surveys ^b	Pairs fledging young (%)	Young fledged	Young per successful pair	Young per all pairs
	2007	1	0	1	0	0	0	0
	2008	1	0	1	0	0	0	0
	2009	1	1	2	0	0	0	0
	2010	0	-	0	-	-	-	-
	2011	0	-	0	-	-	-	-
	2012	0	-	0	-	-	-	-
	2013	0	-	0	-	-	-	-
	2014	0	-	0	-	-	-	-
	2015	0	-	0	-	-	-	-
Horse Cr. (LSR-218)	1997	2	0	3	0	0	0	0
	1998	2	0	6	2 (40)	2	1.00	0.33
	1999	4	2	4	1 (20)	2	2.00	0.50
	2000	3	2	3	1 (33)	1	1.00	0.33
	2001	2	1	4	3 (60)	6	2.00	1.50
	2002	2	1	3	1 (33)	1	1.00	0.33
	2003	3	1	5	2 (50)	3	1.50	0.60
	2004	2	2	8	5 (63)	7	1.40	0.88
	2005	3	0	4	1 (25)	1	1.00	0.25
	2006	2	1	2	1 (50)	1	1.00	0.50
	2007	3	1	6	2 (40)	4	2.00	0.67
	2008	1	0	2	0	0	0	0
	2009	1	1	5	1 (20)	2	2.00	0.40
	2010	3	3	3	2 (67)	5	2.50	1.67
	2011	1	0	5	0	0	0	0
	2012	1	0	3	0	0	0	0
	2013	1	1	3	1 (33)	1	1.00	0.33
	2014	1	0	3	1 (33)	1	1.00	0.33
	2015	2	2	3	3 (100)	4	1.33	1.33
S.Santiam (LSR-217)	1997	4	2	5	0	0	0.00	0.00
	1998	4	2	5	1 (25)	2	2.00	0.40
	1999	1	0	4	0	0	0.00	0.00

LSR	Year	Nesting surveys ^a	Pairs nesting	Reproductive surveys ^b	Pairs fledging young (%)	Young fledged	Young per successful pair	Young per all pairs
	2000	1	1	2	1 (50)	1	1.00	0.50
	2001	2	2	3	2 (67)	4	2.00	1.33
	2002	2	2	3	3 (100)	3	1.00	1.00
	2003	3	1	6	1 (17)	2	2.00	0.33
	2004	4	4	6	4 (67)	5	1.25	0.83
	2005	4	1	7	1 (14)	1	1.00	0.14
	2006	4	1	5	1 (20)	1	1.00	0.20
	2007	3	1	7	2 (29)	3	1.50	0.43
	2008	4	2	4	1 (25)	1	1.00	0.25
	2009	2	0	5	0	0	0	0
	2010	1	1	6	1 (17)	1	1.00	0.17
	2011	0	-	3	0	0	0	0
	2012	0	-	2	1 (50)	1	1.00	0.5
	2013	4	1	5	1 (20)	2	2.00	0.4
	2014	2	2	3	2 (67)	4	2.00	1.33
	2015	2	1	3	2 (67)	4	2.00	1.33

^a Includes pairs and females given at least four mice on at least two occasions by 31 May and all females examined for a brood patch while in hand by 30 June.

^b Includes all pairs and females given at least four mice on at least two occasions by 31 August.

Appendix 5. Summary of spotted x barred hybrid owl activity in the Central Cascades Study Area, Willamette National Forest, Oregon from 1999 – 2015.

Year	MSNO	Male species ^a	Female species	Number of young fledged	Additional STOC observations
1999	4549	STXX	STVA	1	Pair, reproduction unknown
2000	4549	STXX	STVA	Unknown	None
2001	1015	STOC	STVA	2	None
	4549	STXX	--	--	Female, 1 auditory detection
2002	2446	STVA	STXX	Unknown	Male, 1 auditory detection
	4549	STXX ^b	STVA	2	None
2003	1013	--	STXX ^c	Unknown	Resident male
	1031	STXX	--	--	Male, 1 auditory detection
	4549	STXX	--	--	None
2004	1015	STXX	--	--	None
	1031	STXX ^d	STVA	2 ^e	None
	2444	STOC	STXX ^c	Non-nesting	None
	2447	--	STXX	Unknown	Pair, 1 auditory detection
	2861	STXX	STVA	Unknown	Male, visual identification
	2897	--	STXX ^f	Unknown	Male, 1 auditory detection
	4392	STXX ^g	STVA	Unknown	Pair, 1 auditory detection
	4549	STXX	STVA	Unknown	Male, 1 auditory detection
2005	1031	STXX ^{d, h}	STVA	1 ⁱ	None
	2861	STXX	--	Unknown	Unk. sex, 1 auditory detection
	4392	STXX	--	Unknown	Pair, failed nesting attempt
	4549	STXX	STVA	Unknown	Unk. sex, 1 auditory detection
2006	1012	STXX ^g	--	Unknown	Male, visual, not identified
	4549	STXX	STVA	Unknown	Female, 2 auditory detections
	1016	STXX	--	Unknown	Male, visual identification
	1031	STXX ^d	STVA	2 ^e	None
	2410	--	STXX	Unknown	Pair, no young produced

Year	MSNO	Male species ^a	Female species	Number of young fledged	Additional STOC observations
	2444	STOC	STXX ^c	Non-nesting	None
2007	1013	STOC	STXX ^c	0	None
	2413	--	STXX	Unknown	Pair, non-nesting
	4392	STXX ^g	--	Unknown	None
2008	1013	STOC	STXX ^c	0	Male, 1 auditory detection
	4392	STXX ^g	--	Unknown	Male, 3 auditory detections
2009	1013	STOC	STXX ^c	0	Male, 2 auditory detections
	4196	STXX	--	Unknown	None
2010	1013	STOC	STXX ^c	0	None
	4196	STXX	--	Unknown	None
2011	1013	STOC	STXX ^c	0	None
	2427	STVA	STXX ^f	Unknown	Pair, no young produced
2012	1013	STOC	STXX ^c	0	None
2013	1013	STOC	STXX ^c	0	None
	4196	STXX	STVA	Unknown	None
2014	1013	STOC	STXX ^c	Unknown	None
	2427	STVA	STXX ^f	Unknown	Pair, 2 young fledged
2015	0007	STXX	--	Unknown	None
	1013	STOC	STXX ^c	Unknown	None

^a STOC = northern spotted owl, STVA = barred owl, STXX = spotted x barred owl hybrid.

^b Banded as an adult on 9 June 2002; orange/yellow tab, left leg.

^c Banded 141 km SSW of the study area as a fledgling on 21 June 2001, color band replaced 30 April 2003: pink/white dots/orange tab, left leg. This owl was also re-sighted at site 1032 on 13 August 2003.

^d Banded as an adult on 17 May 2004; green/white triangles, right leg.

^e One backcross fledgling banded on 21 June 2004; white/red triangles, left leg.

^f Banded as an adult on 26 May 2004; black/white dots/white tab, left leg.

^g Banded 103 km SW of the study area as a 2-year-old on 11 March 2003, re-sighted on the study area on 19 May 2004; green/white diagonals/orange tab, left leg.

^h Lost original color band. New band attached on 20 June 2005; pink/white dots/black tab, right leg.

ⁱ Single backcross fledgling banded on 20 June 2005; red/white stripe, left leg.