ANNUAL REPORT
FY 2012
3 December 2012

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 (Demography-RWU 4203), 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, Elizabeth Hurkes, Richard Leach, Kristian Skybak, Alexis Smoluk, and Jason Winiarski. Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR.

3) **Study Objectives**:

a. Estimate proportion of territories within the study area where owls are detected, and determine sex and age composition, and reproductive success of the northern spotted owl population on the Willamette National Forest.

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. Obtain the data and parameter estimates required for periodic meta-analyses of fecundity, survivorship and annual rate of population change across the range of the northern spotted owl.

d. Examine the relationships between the above demographic parameters and land use allocations designated under the Northwest Forest Plan (NWFP) (USDA and USDI 1994).

e. 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 15-year spotted owl monitoring report (Davis *et al*. 2011).

5) <u>Potential Benefit or Utility of the Study</u>:

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 conducted every 5 years, across their range (Burnham *et al*. 1996, Franklin *et al*. 1999, Anthony *et al*. 2006, Forsman *et al*. 2011). Results from these analyses support the validation and monitoring requirements of the NWFP (USDA and USDI 1994) and were an important part of the 2004 status review and development of the Final Recovery Plan and its recent revision (USFWS 2008, 2011). 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, climate (Glenn 2009, Glenn *et al*. 2010), and barred owl (*Strix varia*) presence (Olson *et al*. 2005, Forsman *et al*. 2011) on spotted owl demography.

6) <u>Study Description and Survey Design</u>:

The proportion of sites where owls were detected and reproductive success were calculated through annual monitoring of all known northern spotted owl territories (hereafter referred to as “sites”) within the study area. 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 site 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 three or more 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), ecological and logistic factors that influence detection probability confound estimates of site occupancy based solely on the proportion of sites where spotted owls were detected. Per-visit detection probability was not estimated, so estimates of the proportion of sites where detections occurred were calculated rather than estimates of true occupancy.

Nesting status was determined for all located pairs by offering at least four mice to an adult owl prior to 1 June 2012. 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 2012. A minimum of four mice were offered to each pair and single female on at least two 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 at least two 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 or single female (Forsman 1995). Our primary measure of productivity was fecundity, which was estimated as the average number of female young produced by all territorial (adult and subadult) female owls. This was calculated as one-half the estimate of the number of young produced for both paired and single females based on a 1:1 sex ratio of hatchlings (Forsman 1995, Fleming *et al*. 1996).

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 survivorship 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.

Survivorship and fecundity (number of female fledglings produced per adult female owl) for this study area were calculated at five-year intervals within a mark-recapture framework during a weeklong workshop each January in 1994, 1999, 2004, and 2009. During this same workshop, these data were combined with data from other study areas in a meta-analysis of survival, fecundity and annual rate of population change for spotted owl populations across their range (Burnham *et al*. 1996, Franklin *et al*. 1999, Anthony *et al*. 2006, Forsman *et al*. 2011).

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 2012:

Proportion of sites where owls were detected

The number of sites surveyed in 2012 was similar to the level reported in past years (169 sites; Figure 1). Two sites did not meet the minimum number of night surveys because we discontinued surveys after detecting nesting pairs at nearby sites (Table 1). This was to avoid additional disturbance to these pairs and because these two sites apparently were within their territories.

Most of the spotted owls detected in 2012 were members of a pair (76%) with substantially fewer resident single owls (4%) or single owls with unknown residency status (21%; Table 1). The proportion of total sites where either a pair or a single owl was detected decreased by 2%, and the number of sites where pairs were detected increased by 0.8% between 2011 and 2012 (Figure 1). This is the lowest proportion of territories where we detected any spotted owls to date, and the second lowest proportion of territories where pairs were detected (Figure 1, Table 1). The residency status of either the male and/or the female was unknown for 4 (8%) of the pairs detected. The percentage of sites where resident single owls were detected decreased by 7% (Table 1) whereas the percentage of sites with no spotted owl detections was the highest since the initiation of the study (49%; Table 1).

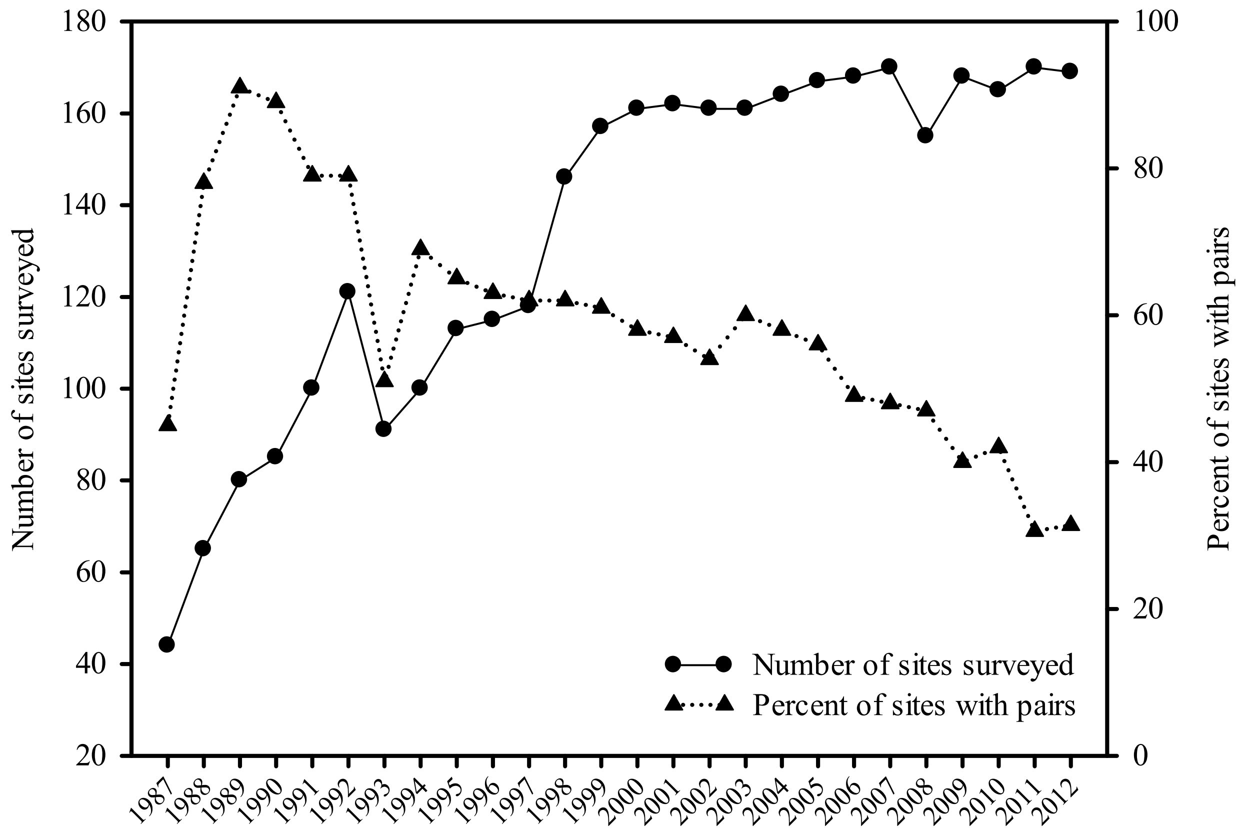

Figure 1. Number of sites surveyed for northern spotted owls and the percentage of those sites where pairs were detected in the central Cascades study area, Willamette National Forest, Oregon from 1987 – 2012.

In 2012, the highest proportion of sites where a territorial spotted owl was detected (either a single or pair) was in the matrix land allocation (54%), which was less than in 2011 (56%) (Table 2). Similarly, the proportion of sites where spotted owls were detected in the LSR allocation decreased by 2% in 2012. However, these small changes still represent a decrease from pre-2008 rates. The proportion of territories where any owl (single or pair) was detected increased by 2% in the AMA allocation between 2011 and 2012 after a 17% decrease between 2010 and 2011 (Table 2).

The proportion of territories where pairs were detected decreased between 2011 and 2012 in the matrix and AMA land use allocations (2% and 8%, respectively; Figure 2). The LSR allocation showed an increase in the proportion of territories where pairs were detected (8%; Figure 2). In addition, the number of territories in the Fall Creek LSR where a pair was detected increased by six (15%) between 2011 and 2012 to the same number as in 2010 (Appendix 3). Within the other LSR units, the proportion of sites where pairs were detected increased the Horse Creek LSR (8%), decreased in the South Santiam LSR (6%), and remained at zero in the Hagan LSR (Appendix 3). Overall, fewer pairs were detected on AMA sites (25%) relative to matrix (44%)

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 – 2012.

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

[a] Residency status was determined by 1995 protocols (Forsman 1995).
[b] Residency status was undetermined at sites where responses were obtained from male and/or female owls but criteria for pair or resident single status were not met.
[c] Unoccupied sites were 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.

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 – 2012.

Land use allocation [a]	Year	Sites surveye d	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
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
	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

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.*)	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
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
	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

Land use allocation [a]	Year	Sites surveye d	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	2011	78	15	9	17	41 (53)	36	1
	2012	78	21	2	17	40 (51)	36	2

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

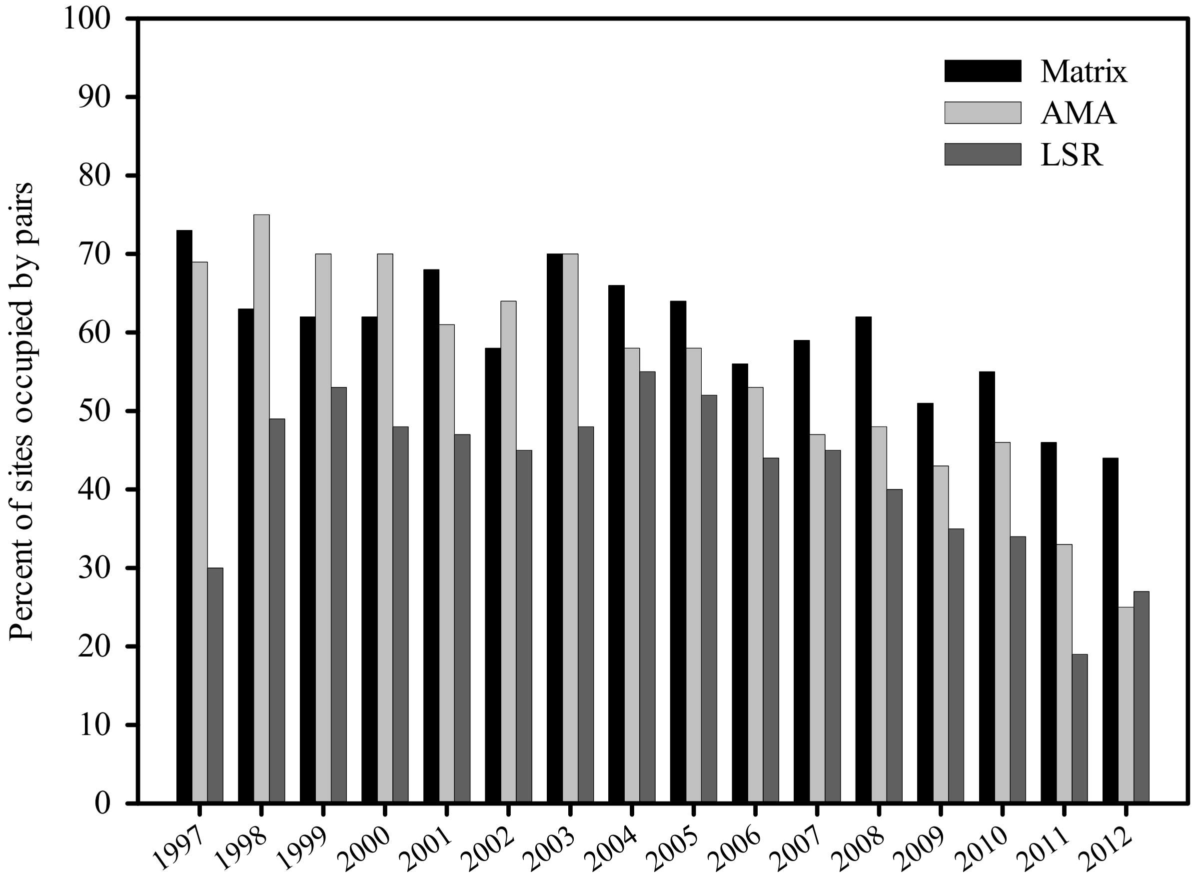

Figure 2. Percentage of sites occupied by pairs of northern spotted owls compared among land use allocations in the central Cascades study area, Willamette National Forest, Oregon from 1997 – 2012.

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and LSR sites (27%), and the overall trend since 1997 has been a decrease in pairs detected in all three allocations (Figure 2).

Four sites were affected by 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 still present and produced one young. In 2007 through 2012, Jones Creek was occupied by a non-nesting pair consisting of a male spotted owl and a female spotted x barred hybrid owl. 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 were located at North Slick Creek and they produced two young in 2012.

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 13 of 15 years. 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 other land use allocations such as research natural areas and wild and scenic river corridors. Pairs were detected at two of these sites; one of the pairs fledged one young, but reproductive status was unknown for the other pair. The other four sites were unoccupied, but an owl from a neighboring site was detected at two of these sites.

Sex and age composition

Twenty-five juvenile and 142 non-juvenile spotted owls were detected during our surveys in 2012 (Table 3). The majority of the non-juvenile owls of known age were at least three years old (99%). Only one spotted owl of unknown sex was identified as a subadult. Of the owls that were not identified to age class (16%), 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 (98) were assigned to an age class as were all of the non-juvenile owls that were captured for banding or to replace a juvenile band (21).

The sex ratio among adults (≥ 3-year-olds) identified in 2012 was skewed more toward males than past estimates (males:females; 1.25:1 in 2012, 1.12:1 averaged over all previous years). Among subadults, the sex ratio was more skewed toward males in most years (1.45:1 averaged over all years). 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 only 5 of the past 25 years (e.g., 0.64:1 for 2003). The average sex ratio among non-juveniles of unknown age was even more variable and heavily skewed toward males ($\bar{x}$ = 2.29:1, 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.

Among paired owls, none were subadults in 2012. 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. A lag effect of high productivity on increased proportions of pairs with at least one subadult after a two-year time lag was not observed ($r^2 = 0.02$, $\beta = 1.03$, 95% CI: -1.87 – 3.932). There also was no evidence of a time trend in the proportion of subadults in the population of territorial pairs ($r^2 = 0.14$, $\beta = -0.17$, 95% CI: -0.34 – 0.01).

Table 3. Sex and age composition of northern spotted owls detected on the Central Cascades Study Area, Willamette National Forest, Oregon, 1987 – 2012.

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

[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.

Reproductive Success

We were able to survey 30 spotted owl pairs to determine nesting status prior to 1 June 2012 (Forsman 1995). Twenty-two pairs (73%) initiated nesting prior to 1 June 2012. Of these, 11 (50%) successfully produced at least one young (Figure 3). Over all previous years, approximately half of the pairs surveyed during the nesting season attempted to nest ($\bar{x}$ = 47%, SE = 5.4), although this long-term mean obscures the striking annual pattern in breeding propensity between consecutive years observed during most of this study (Figure 3). Of the pairs that were confirmed to be nesting in the past, most successfully fledged at least one young ($\bar{x}$ = 67%, SE = 5.0; Figure 3). There was no correlation between nesting rates and nest success (r = 0.34, 95% CI:-0.06 – 0.65; Figure 4).

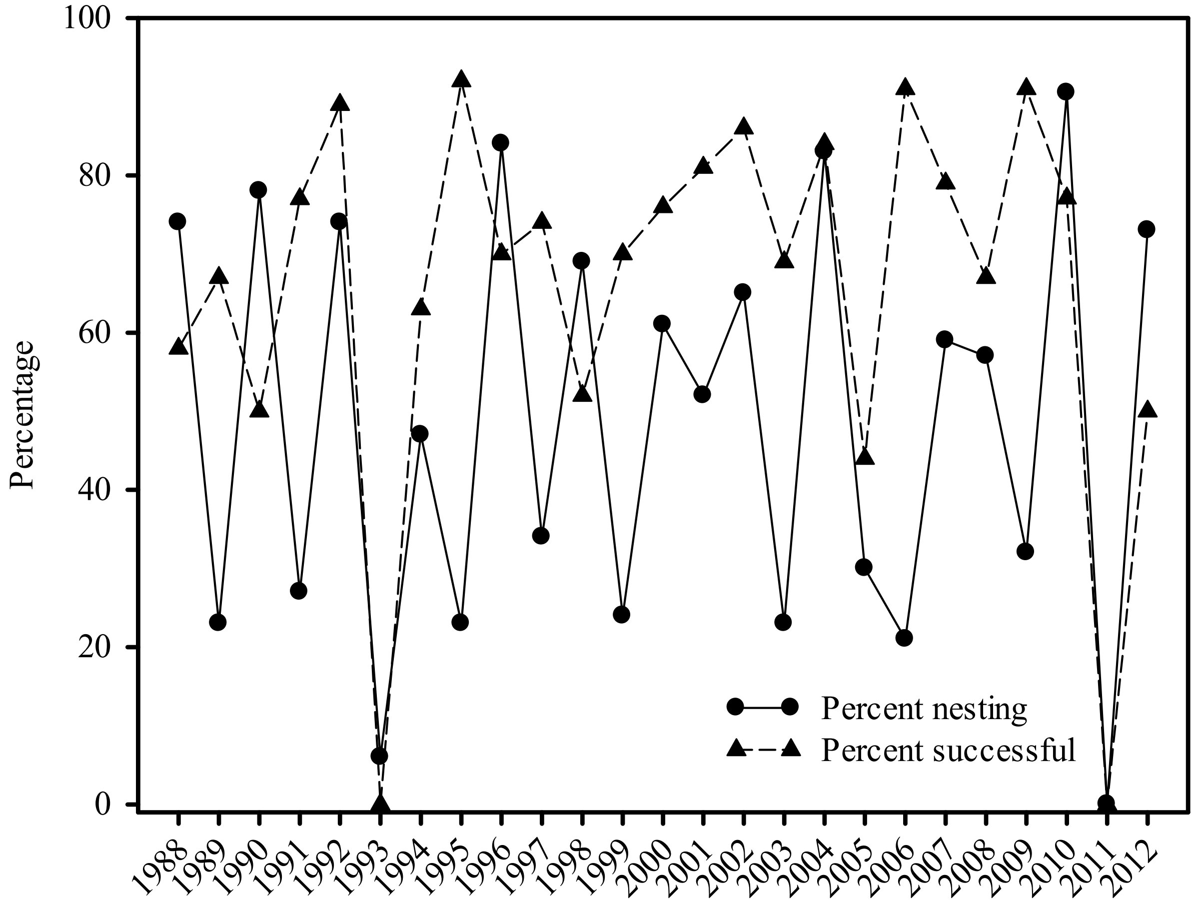

Figure 3. Percentage of pairs confirmed nesting prior to 1 June 2012 and the percentage of nesting pairs that fledged at least one young in the central Cascades study area, Willamette National Forest, Oregon from 1988 – 2012.

Thirty-eight spotted owl pairs were surveyed for reproductive status by 31 August 2012 (Table 4, Figure 5). No resident single females were located. This included 27 of the pairs that were surveyed for nesting status prior to 1 June 2012, as well as 11 additional pairs that were not located prior to 1 June or were located at high elevation sites that were not accessible before that date.

For all pairs surveyed for reproductive status, the average number of young produced per pair in 2012 (0.66 young/pair) was higher than the combined average for previous years ($\bar{x}$ = 0.58, SE = 0.07; Table 4, Figure 5). Seventeen pairs were successful and produced an average of 1.47 young/successful pair which was greater than the average number of young produced by successful pairs over all previous years of the study ($\bar{x}$ = 1.61, SE = 0.05; 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. The fecundity estimate for 2012 was 0.32 female

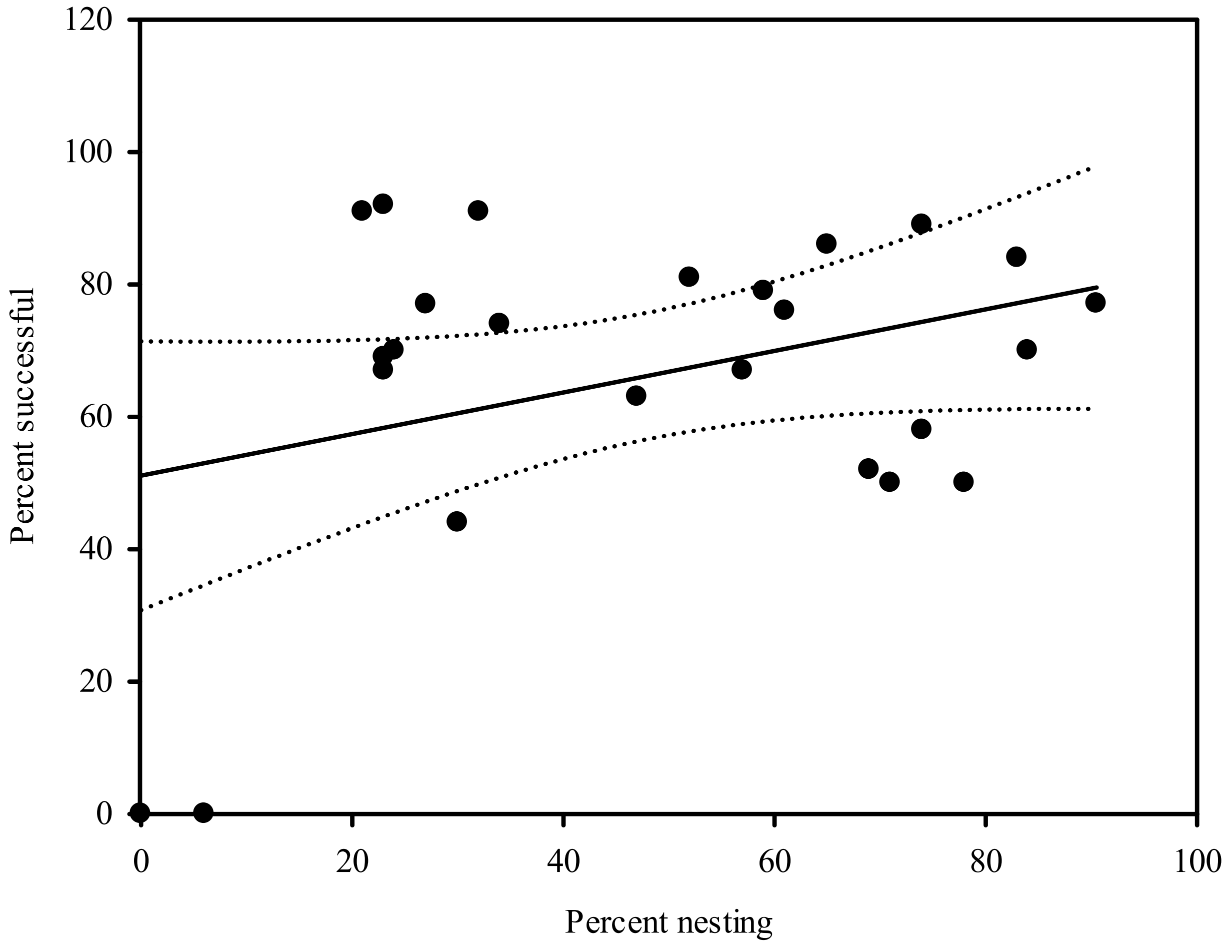

Figure 4. Relationship between the percent of pairs attempting to nest and the percentage of nesting pairs that successfully fledged ≥1 young in the central Cascades study area, Willamette National Forest, Oregon from 1988 – 2012.

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young/adult female (SE = 0.06, Figure 5), which was above average compared to previous years ($\bar{x}$ = 0.28, SE = 0.03).

Spotted owl productivity increased in all three primary land use allocations between 2011 and 2012 (Table 5). Above average productivity occurred in the matrix and AMA allocations (matrix 2012: 0.81 young/pair, $\bar{x}$ = 0.56 young/pair, SE = 0.09; AMA 2012: 0.63 young/pair, $\bar{x}$ = 0.57 young/pair, SE = 0.09). Fewer young were produced in the LSR allocation (0.43 young/pair) than the average over previous years ($\bar{x}$ = 0.56 young/pair, SE = 0.11). Productivity in the Fall Creek LSR returned to near average (Fall Creek 2012: 0.55 young/pair, $\bar{x}$ = 0.62 young/pair, SE = 0.12). Productivity in the other three LSRs remained negligible due to low numbers of pair detections (Appendix 4).

Table 4. Summary of reproductive surveys for northern spotted owls in the Central Cascades Study Area, Willamette National Forest, Oregon from 1988 – 2012.

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
2012	38	17 (45)	25	1.47	0.66

[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.

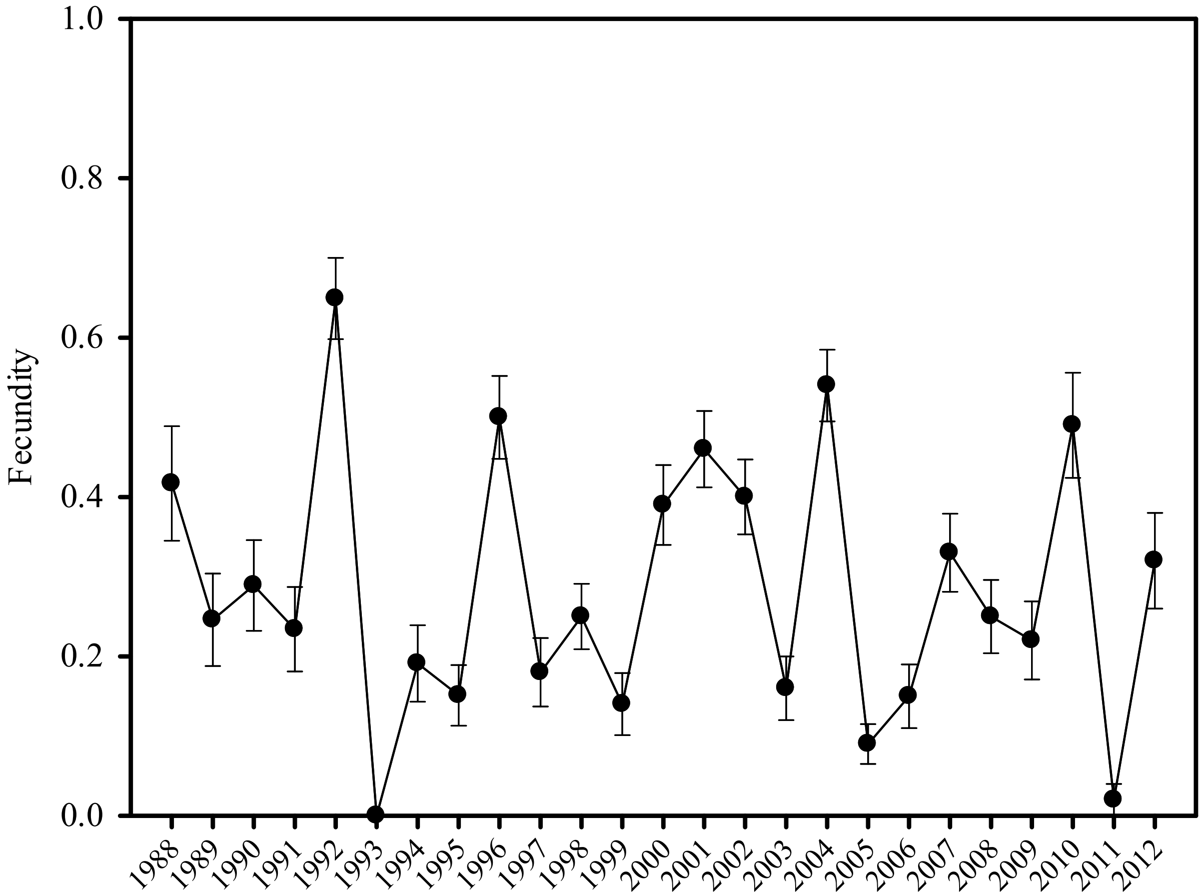

Figure 5. Annual fecundity estimates for the central Cascades study area, Willamette National Forest, Oregon from 1988 – 2011. Sample sizes indicate the numbers of paired and resident single female northern spotted owls checked for reproductive status before 31 August of each year.

Banding/re-observation

Thirty spotted owls were banded in the study area and at four nearby wilderness sites in 2012, including 21 fledglings and 9 adults (Table 6). Since 1987, 679 non-juvenile and 959 fledgling spotted owls (1,638 total) have been banded on the study area. Based on re-observations of banded non-juvenile owls in 2012, the minimum average age for males on the study area was 9.7 years (SE = 0.66) and 9.4 years (SE = 0.59) for females. The oldest owl located in 2012 was a 23-year-old male originally banded as a 2-year-old in 1991. The oldest female was 21 years old and was originally banded in 1991 as a fledgling.

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 – 2012.

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)	Mean fecundity (number of females)
Matrix	1997	25	6 (24)	10	1.67	0.40	0.19 (26)
	1998	24	12 (50)	17	1.42	0.71	0.34 (25)
	1999	23	1 (4)	2	2.00	0.09	0.04 (23)
	2000	23	10 (43)	17	1.70	0.74	0.35 (24)
	2001	26	10 (38)	17	1.70	0.65	0.31 (27)
	2002	19	11 (58)	16	1.45	0.84	0.42 (19)
	2003	22	2 (9)	3	1.50	0.14	0.07 (22)
	2004	25	19 (76)	30	1.58	1.20	0.60 (25)
	2005	21	3 (14)	3	1.00	0.14	0.07 (21)
	2006	20	6 (30)	10	1.67	0.50	0.25 (20)
	2007	20	10 (48)	15	1.50	0.75	0.36 (21)
	2008	20	6 (30)	9	1.50	0.45	0.23 (20)
	2009	20	9 (43)	17	1.89	0.85	0.40 (21)
	2010	17	12 (71)	17	1.42	1.00	0.50 (17)
	2011	16	0 (0)	0	0	0	0 (17)
	2012	16	9 (56)	13	1.44	0.81	0.41 (16)
AMA	1997	28	8 (29)	13	1.63	0.46	0.23 (28)
	1998	32	7 (22)	9	1.29	0.28	0.14 (32)
	1999	29	5 (17)	9	1.80	0.31	0.15 (30)
	2000	25	12 (48)	20	1.67	0.80	0.40 (25)

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)	Mean fecundity (number of females)
AMA	2001	24	14 (54)	24	1.71	1.00	0.46 (26)
	2002	25	10 (40)	13	1.30	0.52	0.25 (26)
	2003	23	4 (17)	8	2.00	0.35	0.17 (23)
	2004	26	19 (73)	32	1.68	1.23	0.62 (26)
	2005	19	7 (33)	8	1.14	0.42	0.19 (21)
	2006	20	5 (25)	8	1.60	0.40	0.20 (20)
	2007	16	4 (25)	6	1.50	0.38	0.19 (16)
	2008	17	10 (59)	15	1.50	0.88	0.44 (17)
	2009	17	3 (18)	5	1.67	0.29	0.15 (17)
	2010	14	11 (79)	15	1.36	1.07	0.54 (14)
	2011	14	1 (7)	2	2.00	0.14	0.07 (14)
	2012	8	3 (0.38)	5	1.67	0.63	0.31 (8)
LSR [b]	1997	5	0 (0)	0	0.00	0.00	0.00 (8)
	1998	21	7 (32)	12	1.71	0.57	0.27 (22)
	1999	20	5 (25)	10	2.00	0.50	0.25 (20)
	2000	24	14 (68)	22	1.57	0.92	0.46 (24)
	2001	32	22 (69)	37	1.68	1.16	0.58 (32)
	2002	28	19 (66)	31	1.63	1.11	0.53 (29)
	2003	27	5 (17)	9	1.80	0.33	0.15 (30)
	2004	38	22 (56)	34	1.55	0.89	0.45 (38)
	2005	26	2 (7)	2	1.00	0.08	0.04 (28)
	2006	24	2 (8)	2	1.00	0.08	0.04 (24)

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)	Mean fecundity (number of females)
LSR [b]	2007	32	15 (47)	23	1.53	0.72	0.35 (33)
	2008	23	6 (25)	7	1.17	0.30	0.15 (24)
	2009	24	4 (17)	6	1.50	0.25	0.13 (24)
	2010	16	7 (44)	15	2.14	0.94	0.44 (17)
	2011	13	0 (0)	0	0	0	0 (16)
	2012	14	4 (29)	6	1.50	0.43	0.21 (14)

[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 - 2012 include the Fall Creek LSR which was not surveyed in 1997.

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 2012.

	New owls banded			Owls re-sighted			Owls recaptured		
Age Class	Males	Females	Unk.	Males	Females	Unk.	Males	Females	Unk.
Adult	5	4 [a]	0	53	45	0	7	4	0
Subadult	0	0	0	0	0	0	0	0	1
Juvenile	-	-	21	-	-	-	-	-	-

[a] One female had extremely worn tail feathers when banded. The observer could not determine her age.

Movements

There were 21 movements of spotted owls between site centers within the study area in 2012 (1990 – 2011 median = 17, range: 8 – 28). Seventeen adult owls were recaptured or re-sighted at new locations within the study area. An adult female originally banded as a fledgling on the study area in 2000 was recaptured and fitted with an adult band 44 miles north of the banding location. Four owls originally banded as fledglings on the study area were recaptured and fitted with adult bands; one was originally banded in 2001, one in 2003, one in 2008, and one in 2010. Since initiation of the study in 1987, 131 (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 (79%) were recaptured within four years after initial banding. Nineteen fledglings (15%) were recaptured as one-year-olds, 32 (24%) as two-year-olds and 80 (61%) 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 11 years (Figure 6). One fledgling banded on the study area in 2000 was recaptured this year in the Tyee study area.

Meta-analysis of spotted owl demography

A subset of the productivity and mark-recapture data summarized in this report were combined with data from 10 other studies in a meta-analysis of the range-wide trends in spotted owl populations (Forsman *et al*. 2011). This subset of the data did not include 30 observations from 27 sites that were monitored during the early years of this study because more restrictive criteria were used in deciding which data could be included in the meta-analysis than had been applied for inclusion in the annual report prior to the publication of the current protocol (Forsman 1995).

The data were analyzed for each study area individually and in two meta-analyses, one which pooled the data from all 11 studies, and a second meta-analysis of the data from the 8 monitoring areas described in the Effectiveness Monitoring Plan (Lint *et al*. 1999). Here, we focus on the results for this study area.

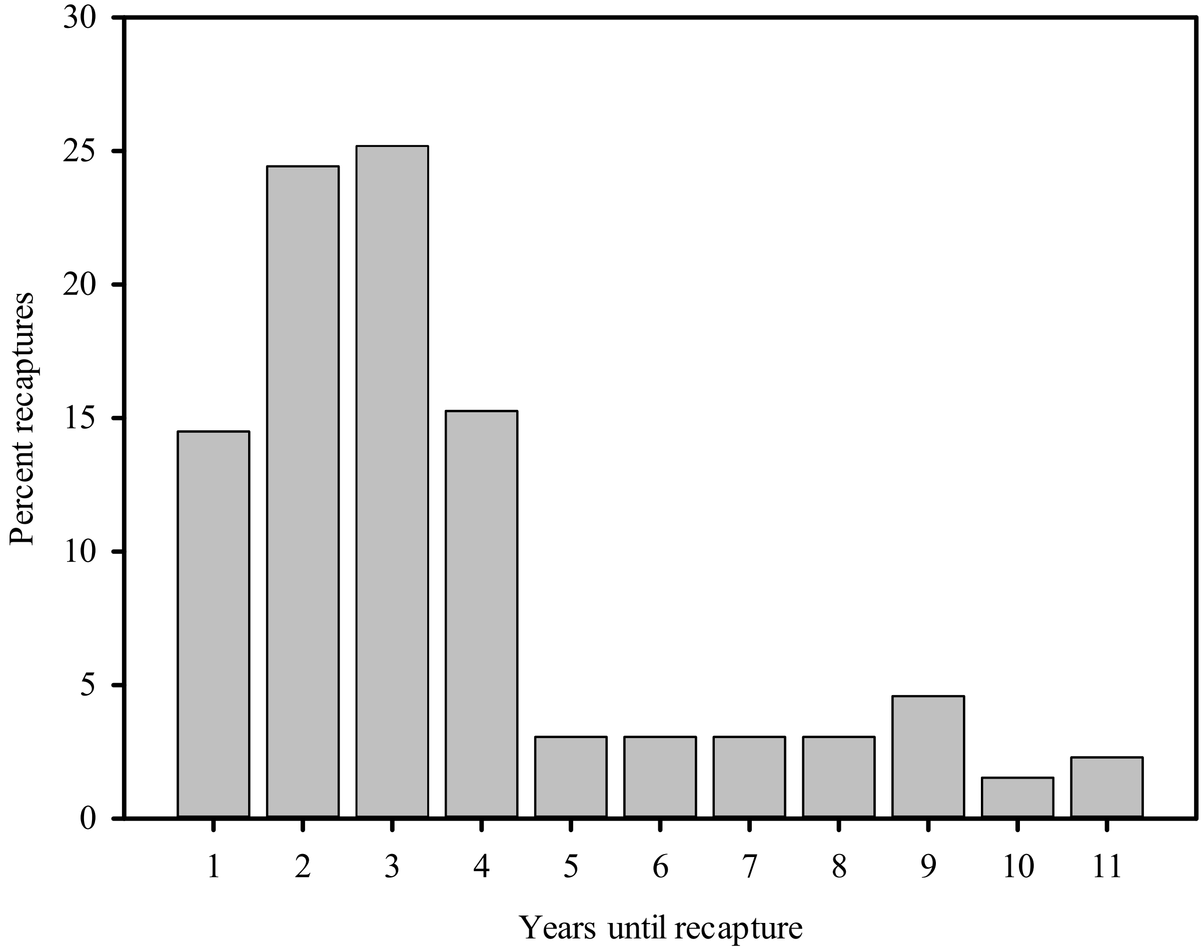

Figure 6. Years until the first recapture of 124 northern spotted owls banded as fledglings in the central Cascades study area, Willamette National Forest, Oregon from 1987 – 2012.

Fecundity, apparent survival, and annual rates of change were estimated and several *a priori* models were evaluated to determine sources of variation in each parameter using techniques employed in previous analyses (Franklin *et al*. 1999, Anthony *et al*. 2006). Covariates that quantified variation in barred owl detections, climate, and habitat were included in models to evaluate the potential causes for any observed trends in fecundity. The individual study area analyses of apparent survival and the annual rate of population change (λ) included covariates for barred owl detections and climate. In addition to climate and the barred owl influence, the meta-analyses of all three parameters (apparent survival, fecundity, and the annual rate of population change) included models with a covariate that quantified the amount of suitable habitat at scales of 2.4 km and 23 km around spotted owl territories (for details see Forsman *et al*. 2011).

The best fecundity models from the analysis of this study area included effects of age, even/odd year variation, habitat, barred owls, late nesting season precipitation, and a linear time trend (Table 7). Age-specific fecundity estimates were lower for subadults compared to adult owls (1-

Table 7. Model selection results from the analysis of productivity (number of fledglings/pair) in the central Cascades study area, Willamette National Forest, Oregon conducted during the 2009 meta-analysis (from Forsman et al. 2011). Only competing models with $\Delta AIC_c < 2.00$ are listed.

Model [a]	ΔAIC_c	AIC_c weights	Number of parameters
A + EO + HAB1	0.00	0.17	6
A + EO + BO + HAB1	0.10	0.16	7
A + EO + T + HAB1	1.20	0.09	7
A + EO + LNP + HAB1	1.40	0.08	7

[a] Covariates used in the models: A = age class, EO = even/odd year effect, HAB1 = change in the percent suitable owl habitat within 2.4 km of site centers, BO = barred owl effect, T = linear time trend, LNP = precipitation during the late nesting season (1 May – 30 June).

year-olds: $\bar{x} = 0.083$, SE = 0.083; 2-year-olds: $\bar{x} = 0.110$, SE = 0.043; adults: $\bar{x} = 0.323$, SE = 0.041). The even/odd year variation in fecundity continued to be an important effect despite the breaks in this pattern that occurred between 2000 – 2002 and 2007 – 2008 (Figure 5). A positive effect of the amount of suitable habitat within 2.4 km of site centers was evident in all of the top models ($\beta = 11.313$, 95% CI: 5.787 – 16.475). Other models also provided weak evidence of a positive barred owl effect ($\Delta AIC_c = 0.10$, $\beta = 0.551$, 95% CI: -0.059 – 1.160), a positive linear time trend ($\Delta AIC_c = 1.20$, $\beta = 0.010$, 95% CI: -0.006 – 0.027), and a negative effect of precipitation during the late nesting season ($\Delta AIC_c = 1.40$, $\beta = 0.004$, 95% CI: -0.011 – 0.003) on fecundity (Forsman *et al*. 2011).

Several models for apparent survival were competitive with the best model, and all included effects of sex and annual variation on re-sighting probabilities with age and general time effects the most important sources of variation on apparent survival (Table 8). The age effect on survival indicated lower survival in the subadult age classes compared to adults (1-year-olds: $\varphi = 0.717$, SE = 0.084; 2-year-olds: $\varphi = 0.830$, SE = 0.042; adults: $\varphi = 0.864$, SE = 0.010). A competitive model included a cut-point effect on survival suggesting that apparent survival before 2004 differed from that after 2004 ($\Delta QAIC_c = 0.679$). The coefficient for this effect suggested that apparent survival had increased after 2004, although the confidence interval included zero (β = 0.021, 95% CI: -0.009 – 0.015), so this was not a strong effect. The model that included a barred owl effect on survival was marginally competitive ($\Delta QAIC_c = 2.238$), and a negative effect was indicated by the regression coefficient and 95% confidence interval ($\beta = -0.753$, 95% CI: -1.352 to -0.153). There was little evidence of an effect of reproduction or climate on apparent survival in our study area.

The annual rate of population change for this study area ($\lambda_{RJS} = 0.977$, 95% CI: 0.957 – 0.996) indicated an average annual population decline of 2.3% per year. Confidence limits on this point estimate are below 1.0, providing strong evidence that this population is declining (Forsman *et*

Table 8. Model selection results from the analysis of apparent survival in the central Cascades study area during the 2009 meta-analysis (from Forsman et al. 2011). Only competing models with $\Delta QAIC_c < 2.00$ are listed.

Model [a]	$QAIC_c$	$\Delta QAIC_c$	$QAIC_c$ weights	Number of parameters
φ[S1+(S2=A)]+t, *p*(s+t)	4659.00	0	0.08589	41
φ [S1+S2+A]+t, *p*(s+t)}	4659.22	0.2174	0.07705	42
φ (S1+(S2=A)]+CP, *p*(s+t)	4659.68	0.6792	0.06116	25
φ [S1+(S2=A)]+TT, *p*(s+t)	4659.80	0.8008	0.05755	25
φ (S1+S2+A]+CP, *p*(s+t)	4659.90	0.9028	0.05469	26
φ [(S1=S2)+A+CP, *p*(s+t)	4659.93	0.9344	0.05383	25
φ [(S1=S2)+A]+TT, *p*(s+t)	4660.12	1.1253	0.04893	25
φ [S1+S2+A]+TT, *p*(s+t)	4660.18	1.1819	0.04757	26

[a] Codes for model structure: φ = apparent survival probability, *p* = resighting probability, S1 = one-year-olds, S2 = two-year-olds, A = adults, s = sex, t = variable time effect, T = linear time trend, TT = quadratic time trend, CP = cut point time trend.

al. 2011). The best model for λ included a quadratic time trend on annual estimates with most of the decline occurring from 1992 – 93 and 2004 – 06 (Figure 7). The estimates for the realized population change indicated that the population on our study area declined between 20% – 30% since 1991 (Forsman *et al.* 2011).

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 have been surveyed on an irregular basis from 1989 through 1996. Since 1997, these sites have been surveyed annually and the data summarized here includes a seventh pair located in the Three Sisters Wilderness Area in 2010.

The proportion of these sites where pairs were detected was initially high in the wilderness area sites but declined between 2000 and 2004. In 2005, pairs were detected on 5 of the 6 sites but no young were produced. Fewer pairs were detected in 2006, and only one pair produced young. Pairs were detected at three sites in 2007, and all three pairs successfully fledged at least one offspring. Two pairs were detected in 2008 and 2012, three in 2009 and 2010, and only one pair in 2011. No young have been produced in these sites for the past four years (Table 9).

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

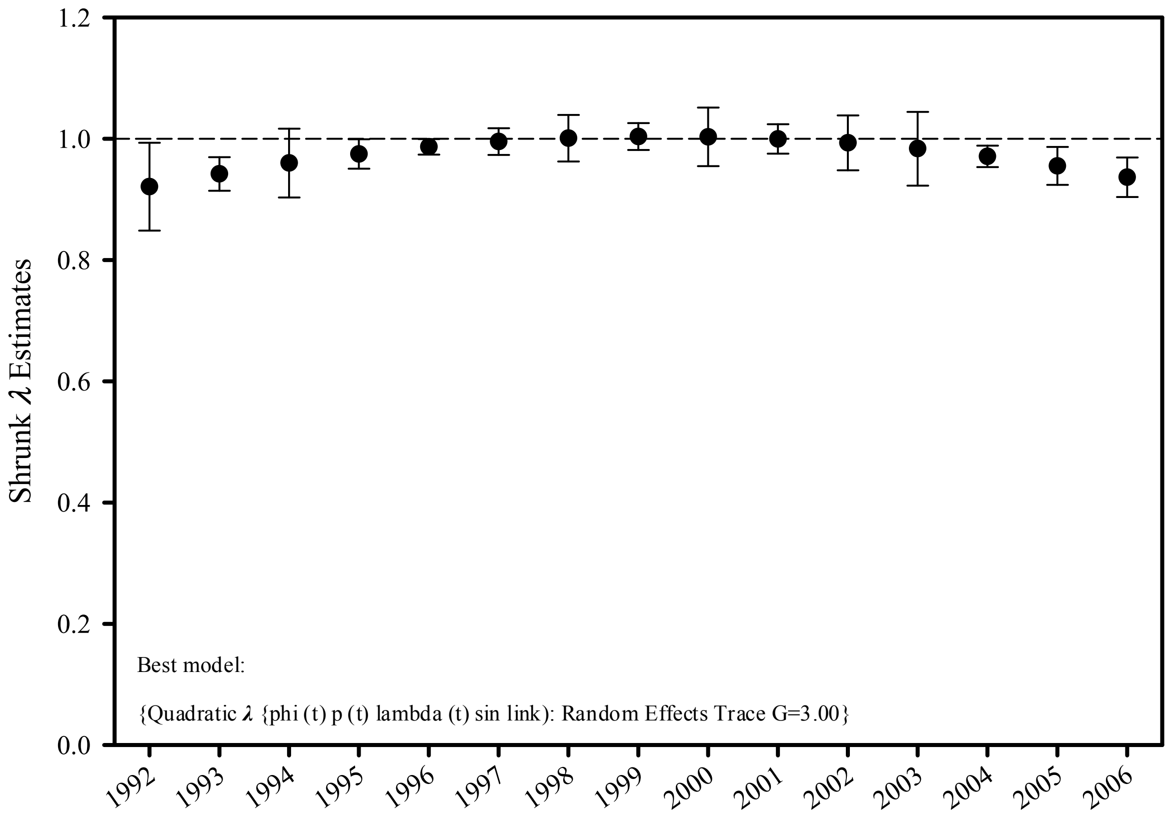

Figure 7. Estimates of the annual rate of population change (λ) under the best model ($QAIC_c$ weight = 0.50968) from the 2009 meta-analysis.

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sites, although only one male owl was later relocated on the 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 8). 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 from 2011 (43%) to 2012 (47%). 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. Detections of single barred owls decreased from a high of 40% in 2010 to 30% in 2012 (Figure 8). Barred owl fledglings

Table 9. Wilderness boundary sites surveyed concurrently with the demographic study in the central Cascades study area, Willamette National Forest, Oregon from 1997 – 2012.

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

[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 allocation.

were observed at 14 of the 29 sites where barred owl pairs were detected. Barred owls were detected at 3 sites with no previous history of barred owl detections.

Hybridization with barred owls

Since 1999, we have located 12 non-juvenile spotted-barred owl F1 hybrids at 16 different sites (Appendix 5). We observed eight cases involving a spotted owl paired with a hybrid or barred

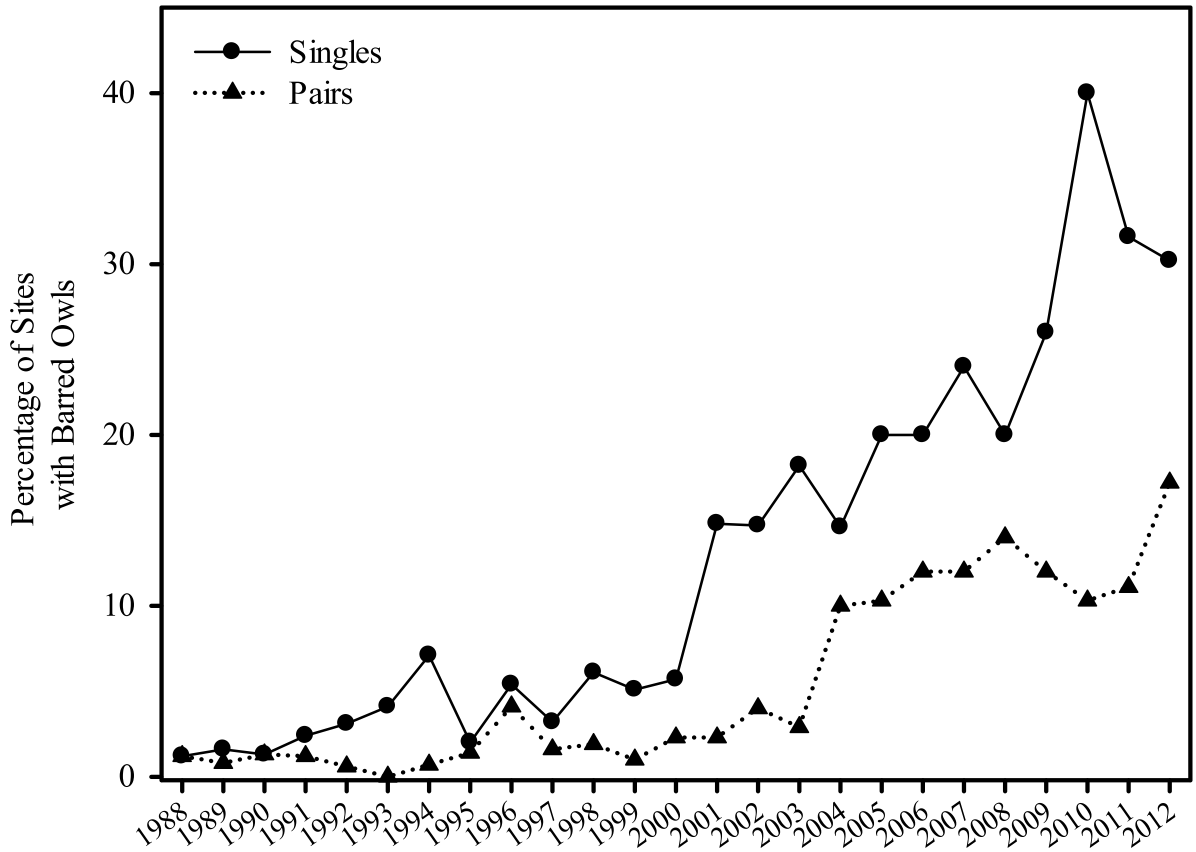

Figure 8. Percentage of sites where incidental detections of single and paired barred owls (*Strix varia*) have occurred while surveying for northern spotted owls in the central Cascades study area, Willamette National Forest, Oregon from 1988 – 2012.

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owl and four of these involved 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.

Only four of the F1 hybrids located since 1999 were found outside of an LSR. 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 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 9 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 two different male spotted owls from 2003 to 2012, but reproduction was not documented for either 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). 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 also are 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 2012; a female F1 hybrid that has remained paired with two spotted owl males for 3 and 5 years, respectively. This pair has 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 was not relocated in 2012. 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 17 of the past 22 years (Table 1). These estimates included any spotted owl response at a site including auditory detections from unidentified individuals that may have been from territorial or non-territorial owls. This may be an indication that both the territorial and non-territorial segments of the spotted owl population were declining, although this parameter should not be interpreted as an index of population size for several reasons. As discussed above, 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 (Olson *et al.* 2005, Kroll *et al.* 2010, Dugger *et al.* 2011); thus, declines in the proportion of sites where spotted owls were detected cannot necessarily be equated to declines in site occupancy or 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 owls may have been counted at more than one site, which would have inflated estimates of the number of individual owls detected.

Since 1989, the proportion of sites where pairs of spotted owls were detected has decreased an average of 2.6% per year which was higher than the average annual population decline of 2.2% per year indicated by the λ_{RJS} estimate for this study area from the meta-analysis (λ_{RJS} = 0.978; Forsman et al. 2011). As discussed above, pair detection probability was not estimated, particularly in relation to associated barred owl detections, so the proportion of sites where pairs were detected would be expected to underestimate true pair occupancy, and thus, does not accurately estimate population size.

The proportion of sites where spotted owl pairs were detected continued to decrease in the AMA and matrix land use allocations between 2011 and 2012. Although pair detections increased in the LSR allocation, the 2012 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 efforts suggest that not all LSRs were equally capable of supporting breeding pairs of spotted owls. The Fall Creek LSR lost 10 pairs from 2000 to 2012 and currently supports only 15 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.

Productivity

Relatively few females were confirmed to be single from 1987 through 2012 ($\bar{x}$ = 2.2%, SE = 0.45). 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 = 0.56) followed by the percentage of nesting attempts that were successful (CV = 0.36). Environmental conditions can affect spotted owl productivity at all of these levels but it was evident that the proportion of pairs that breed every year and fledging success were the primary factors that affected productivity in spotted owls.

A biannual pattern (i.e., even/odd year variation) in nesting attempts was observed from 1988 through 2005 (Figure 3). 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, again 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 in 2007 and 2008. 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. Predictions regarding the negative effect of late nesting season rains on overall productivity and the negative effect of high precipitation 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 (Figure 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 are not surprising. Long-term prey cycles affecting the overall condition of breeding birds each year is likely responsible for breeding propensity patterns (i.e., proportion of pairs that attempt to breed). 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 recent 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 also 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 8), 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 14 spotted owl territories in 2012, these incidental observations also cannot be used estimate barred owl productivity, without studies designed specifically to monitor barred owl productivity.

Despite the limitations discussed above, a number of associations between increased barred owl detections and spotted owl detection rate, annual site occupancy, and demographic parameters have emerged. 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 the probability that a pair of spotted owls would re-colonize an abandoned site (Olson *et al*. 2005, Dugger *et al*. 2011). 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). Finally, barred owls may affect spotted owl productivity through their effect on site occupancy by pairs of spotted owls (Olson *et al*. 2005). 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 great 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 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; 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.

2009 meta-analysis

The parameter estimates calculated at the January 2009 meta-analysis workshop support several of the occupancy and productivity estimates presented in our annual reports. The sharp decrease in the number of territories where pairs were detected from 1992-93 (28%) and 2004-06 (9%

over both intervals) is consistent with the quadratic time trend in λ in that significant population declines occurred during these intervals (Forsman *et al*. 2011). The proportion of territories where pairs were detected decreased at a lower rate from 1994-2003 (1.1% per year), consistent with the λ_{RJS} point estimates during this time period which averaged 0.99. The confidence intervals of all these estimates included 1.0, suggesting the population was stable from 1994 through 2003 (Figures 1 and 7; Forsman *et al.* 2011).

The average fecundity estimate calculated during the meta-analysis weighted by age class was greater than the average annual fecundity estimate for 1988 – 2012 from our annual reports, although the confidence intervals overlapped considerably (meta-analysis: weighted $\bar{x}$ = 0.312, 95% CI: 0.223 – 0.343; annual report: $\bar{x}$ = 0.283, 95% CI: 0.218 – 0.347). The difference in point estimates is because a subset of the overall data set was used for the meta-analysis as discussed above. This mostly affected pairs and single females that did not produce young; several of these observations were not included in the meta-analysis because insufficient data were recorded on at least one of the visits to determine reproductive status.

The even/odd year effect included in the best fecundity models from the analysis of this study area reflects the biannual pattern in the number of pairs breeding each year (Forsman *et al*. 2011). As discussed above, variation in the number of pairs that attempt to breed each year appears to be a more important component of the even/odd year effect than the number of young produced per breeding pair. This may reflect a "bet-hedging" strategy related to the effect of climate on prey populations (Franklin *et al*. 2000). Although it seems plausible that owls may choose to nest when weather conditions are favorable, or when favorable spring weather increased prey populations, climate during the late winter and early nesting season were not included in the top fecundity models for this study area. If the even/odd year effect is due to climate variation, then one or more of the climate covariates should better explain variation in fecundity. It is likely that climate and as yet little-known factors such as prey abundance interact in complex ways to influence nesting behaviors.

During the meta-analysis, a weak positive effect of barred owls on fecundity was also noted for our study area (Forsman *et al*. 2011), which is contrary to expectations. It is possible that this was an artifact of the influence of barred owls on the detectability of spotted owls. If non-nesting spotted owls were less detectable in the presence of barred owls, then pairs and females that do not produce young would be under-represented in the fecundity data. This would produce a positive bias in fecundity estimates which potentially could get more severe as the frequency of barred owl detections increased on the study area. A year- and territory-specific barred owl covariate may ameliorate this bias by incorporating individual detection probabilities into the estimates.

The amount of suitable spotted owl habitat within 2.4 km of cumulative site center buffers on our study area by year had a strong positive effect on fecundity (Forsman *et al*. 2011). Thus, habitat loss would result in decreased fecundity. Decreased habitat availability also may increase the likelihood of competitive interactions with barred owls; indirectly increasing the negative effect of barred owls on survival and occupancy.

In the HJA study area, barred owls exerted a strong negative effect on survival (Forsman *et al.*

2011). Given the importance of high survival rates to population stability (Noon and Biles 1990), the steady increase in incidental detections of barred owls (Figure 8) may explain the population declines observed since 2004 (Figure 7). Although the cut-point effect indicated increased survival after 2004, this effect was small ($\beta = 0.021$) and the confidence interval included zero (95% CI: -0.009 – 0.015). The barred owl effect was much stronger ($\beta = -0.753$, 95% CI: -1.352 – -0.153) and influenced the spotted owl population in our study area more than the cut-point effect.

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). As of this writing, the 2008 Final Recovery Plan has been revised and the MOCA network had been withdrawn (U.S. Fish and Wildlife Service 2011). The final Critical Habitat designation for northern spotted owls is expected before the end of 2012, but it was unclear from the draft report whether the complete LSR network as outlined under the Northwest Forest Plan will be included in the final ruling (U.S. Fish and Wildlife Service 2012). The Fall Creek LSR has supported as many as 25 pairs of spotted owls, but currently supports only 15. 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 have never supported more than 11, 8, and 3 pairs, respectively. These 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 2012, 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 strong association between the amount of habitat and productivity reported above underscores the importance of monitoring and protecting pairs of spotted owls outside of existing reserves. The 2012 proposed critical habitat revision (U.S. Fish and Wildlife Service 2012) designates 105,033 ha (69%) within the study area. This includes all four of the LSRs and an additional 53,211 ha of 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/Internet/FSE_DOCUMENTS/stelprdb5212148.pdf), 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 B&B fire, also in 2003, 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**:

Late season storms and exceptionally high precipitation and low temperatures delayed our access to several sites which are usually accessible well before 31 May. Because more snow remained longer into the spring, many of our first surveys were delayed until June when many spotted owls may have already attempted to nest and failed. These nest attempts would not have been included in our estimate of the proportion of nesting pairs that were unsuccessful. This problem was exacerbated at high elevation sites. The Horse Creek and South Santiam LSRs include most of our high elevation sites where more snow 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). Most pairs were difficult to locate and the male and female often were found separately and at considerable distances from their historic core areas. This forced us to allocate more effort to repeated surveys at some sites which allowed less time to complete the surveys at other sites. In addition, visits to determine nest status were conducted later in the spring and at much shorter intervals between successive visits. As discussed above, early nest attempts that failed before our initial visits may have been missed.

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. The reallocation of time away from daytime site visits contributed to the lower numbers of pairs checked for reproductive status in 2010 through 2012 (Table 4). 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. Additional road closures occurred in 2011 with more expected in 2012.

In addition, decreased per-visit detection rates (Olson *et al*. 2005) associated with increased barred owl detections and continued declines of spotted owl populations (Forsman *et al*. 2011) 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 9). Increased night work fundamentally changed the survey coverage across the study area from a territory-based, site visit approach to more uniform nighttime survey coverage over larger 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

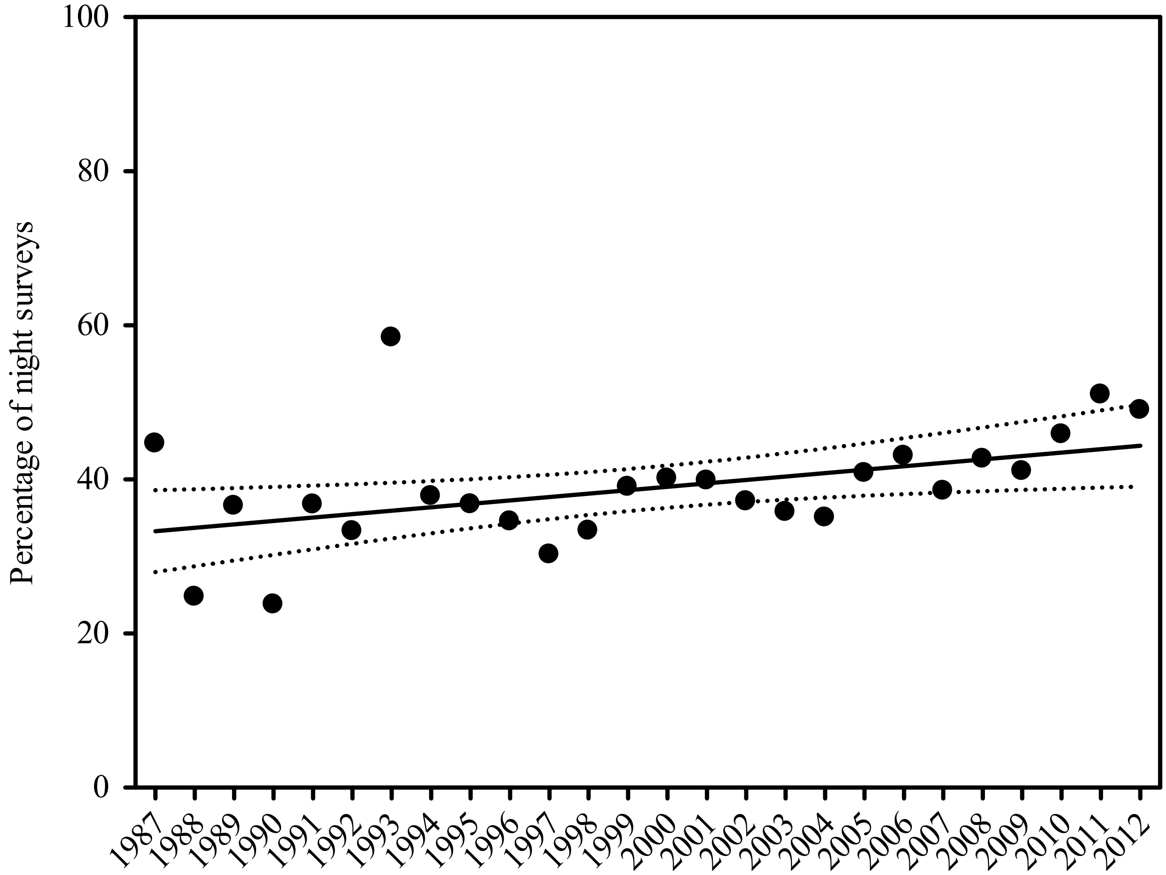

Figure 9. Percentage of night surveys conducted annually in the central Cascades study area, Willamette National Forest from 1987 through 2012.

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 U. S. Forest Service and the Portland Field Office of the U. S. Fish and Wildlife Service.

11. Research plans for FY 2013:

a) Continue the demographic study of the northern spotted owl population in the central Cascades of Oregon.

b) Continue comparing the demography of spotted owls among the matrix, AMA, and LSR land use allocations.

c) Publish an analysis of spotted owl habitat characteristics using LIDAR data recently acquired for the Blue River Watershed.

d) Continue the analysis of spotted owl diet composition and update the prey database to be compatible with other studies.

e) Cooperate with the staff of the Middle Fork Ranger District in developing priorities for proposed management in the Fall Creek LSR.

f) 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 2012:

Presentations

a) S. Ackers led a field trip for a film crew from the Environmental Education Media Project (http://eempc.org/) and discussed recent study results and current management issues (May, 2012).

b) S. Ackers led a field trip for Arch McCallum of Applied Bioacoustics to record spotted owl vocalizations (June, 2012).

c) S. Ackers gave a presentation to an international group of forester ecologists and remote sensing experts about spotted owl habitat modeling using LiDAR and GNN data as part of the 2012 Forest SAT conference (September, 2012).

Publications

Ackers, S.H., R.J. Davis, and K.M. Dugger. 2012. Evaluation of northern spotted owl (*Strix occidentalis caurina*) habitat models using LiDAR-based vegetation measurements and GNN-imputed forest stand characteristics (*in prep.*).

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.

12. **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.

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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	Lower 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		East Wildcat Mountain

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 2006 – 2012. Data from prior years are available upon request.

LSR	MSNO [c]	2007 Occ.	2007 Repro.	2008 Occ.	2008 Repro.	2009 Occ.	2009 Repro.	2010 Occ.	2010 Repro.	2011 Occ.	2011 Repro.	2012 Occ.	2012 Repro.
Fall Creek (LSR-219)	0124	P	1	P	0	P	2	P	0	A	0	P	0
	1011	-	-	-	-	-	-	SU	0	P	0	SU	-
	1012	RM	-	SD	-	Unoccupied		Not surveyed		SU	-	SU	-
	1013	P [d]	0	P [d]	0	P [d]	N	P [d]	0	P [d]	0	P [d]	0
	1015	SU	-	Unoccupied		Unoccupied		Unoccupied		SU	-	Unoccupied	
	1016	PU	Unk.	Unoccupied		SU	-	Unoccupied		Unoccupied		Unoccupied	
	1017	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	1018	P	0	RF	0	A	N	P	1	RM	-	P	0
	1019	SU	-	NR	-	Unoccupied		SU	-	SU	-	SU	-
	1020	P	1	P	1	P	N	P	2	P	0	P	2
	1021	P	0	P	0	P	N	P	0	A	0	A	0
	1022 [g]	P	0	P	0	A	0	P	Unk.	RM	-	P	Unk.
	1022 [g]	-	-	P	1	Unoccupied		SU	-	SU	-	NR	-
	1028 [e]	Unoccupied		Unoccupied		Unoccupied		NR	-	Unoccupied		Unoccupied	
	1029	P	2	P	0	P	0	RM	-	P	Unk.	P	0
	1031	Unoccupied [d]		NR	-	RF	0	SD	-	Unoccupied		Unoccupied	
	1032	P	0	P	0	P	N	P	2	SU	-	P	Unk.
	1043	SU	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	1063	P	1	P	0	P	1	P	2	P	0	P	Unk.
	1101	Unoccupied		NR	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	1102	P	2	P	1	P	N	P	1	P	0	P	0

		2007		2008		2009		2010		2011		2012	
LSR	MSNO[c]	Occ.	Repro.	Occ.	Repro.	Occ.	Repro.	Occ.	Repro.	Occ.	Repro.	Occ.	Repro.
Fall Creek (LSR-219)	2444	P	0	SU	-	RM	-	SU	-	Unoccupied		Unoccupied	
	2462	P	1	P	0	P	N	Unoccupied		Unoccupied		SU	-
	2463	SU	-	P	0	RF	0	SU	-	Unoccupied		Unoccupied	
	2807	P	1	P	0	P	1	P	0	RF	0	P	Unk.
	2808	P	2	P	1	P	N	P	0	SU	-	SU	-
	2817	P	1	P	2	Unoccupied		P	Unk.	Unoccupied		PU	Unk.
	2826	P	0	SU	-	SU	-	P	F	SU	-	PU	Unk.
	2861	SU	-	SU	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2863	Unoccupied		NR	-	Unoccupied		SU	-	SU	-	SU	-
	2864	Unoccupied		Unoccupied		Unoccupied		Unoccupied		SU	-	Unoccupied	
	2865	Unoccupied		Unoccupied		RM	-	Unoccupied		Unoccupied		Unoccupied	
	2867	Unoccupied		Unoccupied		Unoccupied		SU	-	Unoccupied		Unoccupied	
	2889	P	2	P	0	P	N	P	3	A	0	P	1
	2891	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2895	P	Unk.	Unoccupied		Unoccupied		SU	-	SU	-	P	0
	2897	Unoccupied		SU	-	SU	-	Unoccupied		Unoccupied		NR	-
	2899	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2900	Unoccupied		SU	-	RM	-	Unoccupied		SU	-	Unoccupied	
	2949	SU	-	SU	-	RM	-	SD	-	Unoccupied		SU	-
	3550	A	0	P	0	P	N	P	2	P	0	SU	-
	4105	Not surveyed		Not surveyed		NR	-	Not surveyed		Not surveyed		Not surveyed	
	4392	SU[d]	-	SU[d]	-	RM	-	Unoccupied		SU	-	Unoccupied	
	4420	P	2	RM	-	Unoccupied		Unoccupied		Unoccupied		P	2

LSR	MSNO[c]	2007 Occ.	2007 Repro.	2008 Occ.	2008 Repro.	2009 Occ.	2009 Repro.	2010 Occ.	2010 Repro.	2011 Occ.	2011 Repro.	2012 Occ.	2012 Repro.
Fall Creek (LSR-219)	**4549**	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	4585	SU	-	SU	-	Unoccupied		SU	-	PU	Unk.	P	Unk.
Hagan (LSR-215)	0112	Unoccupied		NR	-	Unoccupied		Unoccupied		Unoccupied		SU	-
	2465	Unoccupied		Unoccupied		Unoccupied		Unoccupied		SU	-	SU	-
	2477	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	3401	RM	-	Unoccupied		P	0	RF	Unk.	RF	Unk.	Unoccupied	
	4503	P	0	P	0	P	0	Unoccupied		Unoccupied		SU	-
Horse Creek (LSR-218)	**0085**	A	2	NR	-	SU	-	Unoccupied		Unoccupied		Unoccupied	
	0113	SU	-	Unoccupied		SU	-	SU	-	Unoccupied		Unoccupied	
	0119	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	0750	P	0	P	0	RM	-	P	Unk.	RM	-	PU	Unk.
	0818	RM	-	RM	-	A	0	Unoccupied		P	0	P	0
	0834	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	0857	Unoccupied		P	Unk.	P	0	P	3	P	0	P	0
	1736	A	Unk.	PU	Unk.	SU	-	SU	-	NR	-	Unoccupied	
	2428	P	0	P	0	P	2	P	2	SU	-	P	0
	2446[d]	Unoccupied		Unoccupied		SU	-	Unoccupied		Unoccupied		Unoccupied	
	2828	Unoccupied		SU	-	Unoccupied		SU	-	RF	0	Unoccupied	
	2830	SU	N	P	Unk.	A	0	Unoccupied		SU	-	SU	-
	2831	P	0	P	Unk.	P	0	A	Unk.	RF	0	SU	-
	3023	P	2	Unoccupied		P	0	P	0	P	0	SU	-
S. Santiam (LSR-217)	**0007**	P	2	P	0	P	0	P	Unk.	P	0	P	1
	0011	PU	Unk.	Unoccupied		RM	-	Unoccupied		Unoccupied		SU	-

LSR	MSNO[c]	2007 Occ.	2007 Repro.	2008 Occ.	2008 Repro.	2009 Occ.	2009 Repro.	2010 Occ.	2010 Repro.	2011 Occ.	2011 Repro.	2012 Occ.	2012 Repro.
S. Santiam (LSR-217)	0014	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	0064	Unoccupied		Unoccupied		Unoccupied		NR	-	Unoccupied		Unoccupied	
	0619	P	0	P	0	P	0	RF	0	Unoccupied		P	0
	0689	P	0	P	0	Unoccupied		P	0	Unoccupied		Unoccupied	
	0694	P	0	RM	-	P	0	P	0	Unoccupied		Unoccupied	
	1156	Unoccupied		Unoccupied		Unoccupied		SU	-	SU	-	Unoccupied	
	1322	Unoccupied		Unoccupied		SU	-	P	1	Unoccupied		Unoccupied	
	2460	Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	2846	P	0	SU	-	RM	-	P	Unk.	P	0	SU	-
	2959	P	0	P	1	P	0	P	0	RM	Unk.	Unoccupied	
	2962	Unoccupied		NR	-	Unoccupied		Unoccupied		Unoccupied		Unoccupied	
	4196	SU	-	SU	-	Unoccupied[d]		Unoccupied		Unoccupied		Unoccupied	
	4405	P	1	SU	-	P	0	P	0	P	0	RM	-
	4488	Unoccupied		Unoccupied		Unoccupied		Unoccupied		SU	-	SU	-

[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 owls detections in the four late-successional reserves (LSR) in the Central Cascades Study Area, Willamette National Forest, Oregon from 1997 – 2012.

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)
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)
	2002	5	2 (40)	1 (20)
	2003	5	3 (60)	2 (40)
	2004	5	3 (60)	2 (40)

LSR	Year	Sites surveyed	Sites with ≥1 owl detected (%)	Sites with pairs detected (%)
Hagan (LSR-215)	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
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)
	2009	14	11 (79)	6 (43)
	2010	14	8 (57)	5 (36)
	2011	14	8 (57)	3 (21)
	2012	14	7 (50)	4 (29)
S. Santiam (LSR-217)	1997	12	9 (75)	4 (33)
	1998	14	9 (64)	5 (36)
	1999	12	10 (83)	5 (42)

LSR	Year	Sites surveyed	Sites with ≥1 owl detected (%)	Sites with pairs detected (%)
S. Santiam (LSR-217)	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)

Appendix 4. Summary reproductive statistics in the four late-successional reserves (LSR) in the Central Cascades Study Area, Willamette National Forest, Oregon from 1997 – 2012.

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 (LSR-219)	1997	Fall Creek not surveyed by OCFWRU staff in 1997.						
	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
Hagan (LSR-215)	1997	1	1	0	0	0	0	0
	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
	2007	1	0	1	0	0	0	0
	2008	1	0	1	0	0	0	0
	2009	1	1	2	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
Hagan (LSR-215)	2010	0	-	0	-	-	-	-
	2011	0	-	0	-	-	-	-
	2012	0	-	0	-	-	-	-
Horse Creek (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
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
	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

LSR	Year	Nesting surveys [a]	Pairs nesting	Reproductive surveys [b]	Pairs fledging young (%)	Young fledged	Young per successful pair	Young per all pairs
S. Santiam (LSR-217)	2009	2	0	5	0	0	0	0
	2010	1	1	6	1	1	1.00	0.17
	2011	0	-	3	0	0	0	0
	2012	0	-	2	1	1	1.00	0.5

[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 – 2012.

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

Year	MSNO	Male species [a]	Female species	Number of young fledged	Additional STOC observations
2006	2410	--	STXX	Unknown	Pair, no young produced
	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

[a] STOC = northern spotted owl, STVA = barred owl, STXX = spotted x barred owl F1 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.