WILDLIFE ECOLOGY TEAM

WILDLIFE HABITAT RELATIONSHIPS IN WASHINGTON AND OREGON FISCAL YEAR 2015.

January, 2016

STUDY

Demography of Spotted Owls on the east slope of the Cascade Range, Washington, 1989-2015

RESEARCHERS

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STATUS

This study is one of eight long-term demographic studies in the Regional Monitoring Program for the Northern Spotted Owl (Lint et al. 1999). The study was initiated in 1989.

STUDY OBJECTIVES

Determine demographic trends of Spotted Owls on the east slope of the Cascade Range in Washington, to include age-and-sex-specific survival rates, reproductive rates, and overall population trend.

POTENTIAL BENEFIT OF THE STUDY

This study was designed to collect long-term information on survival and reproductive rates of Spotted Owls on the east slope of the Cascade Mountains in Washington. This information is needed to assess the status of the owl population in this province. In combination with data from other study areas in Washington and Oregon, information from the Cle Elum Study Area is used to assess region-wide trends in the Spotted Owl population (Forsman et al. 1996, Franklin et al. 1999, Lint et al. 1999, Anthony et al., 2006, Forsman et al. 2011, Dugger et al. 2016). In addition, the long-term dataset obtained during this study has provided the baseline for a pilot study of the effect of Barred Owl removal on Spotted Owl demographics (see below).

STUDY AREA AND METHODS

The Cle Elum Study Area includes a 1,787 km^2 General Study Area (GSA), and a 204 km^2 Density Study Area (DSA) that is contained within the GSA (Figure 1). The U. S. Forest Service currently administers approximately 60% of the area within the GSA. The GSA and DSA are composed of 34 % and 88 % designated Late Successional Reserves (LSR), respectively. These LSR's were allocated by the Northwest Forest Plan to benefit species associated with late successional forest (USDA and USDI 1994).

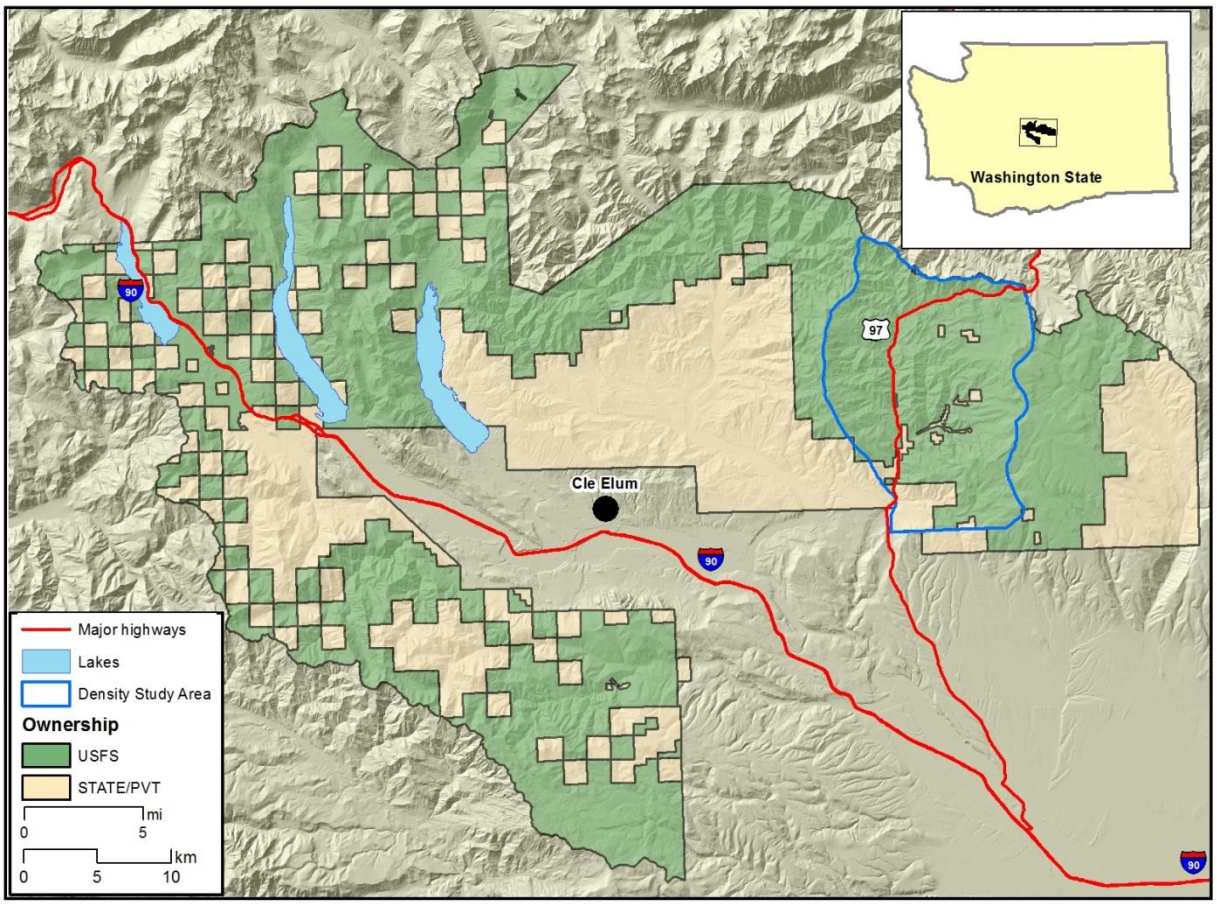

Figure 1. The Cle Elum Study Area, Washington, USA.

In October 2013, the Washington State Department of Natural Resources purchased more than 20,000 ha (~ 50,000 acres) of private land located mostly in the Teanaway River Drainage. The most recent landowner of these parcels was American Forest Holdings LLC., but the land was originally owned by Boise Cascade Corp. In October, 2014, The Nature Conservancy purchased over 19,000 ha (~ 48,000 acres) of land formerly owned by Plum Cr. Timber. These 2 purchases effectively assigned the management of nearly all private lands within the GSA to these 2 entities.

Within the GSA we survey all historic owl territories each year using standard protocols to locate and confirm previously banded owls, and to determine the number of young produced at each territory (Forsman 1983, Franklin, et al., 1996, Lint et al., 1999). Any new owls are banded with a numbered USFWS band and a uniquely colored plastic leg band (Figure 2). We attempted a complete count of Spotted Owls in the DSA each year beginning in 1991. The DSA survey involves reproducing Spotted Owl calls at each established call station on 3 occasions during the March – August field season (Forsman 1983, Lint et al. 1999, Reid et al. 1999). Call stations are positioned to achieve a 100 % auditory coverage of the entire DSA. In 2005 and 2006, we collected blood samples and oral swabs from most owls we captured to test for the presence of West Nile Virus. West Nile Virus has been identified as a potentially significant source of mortality among Spotted Owls (Courtney et al. 2004). We collected blood samples from some captured owls for future genetic study 2006-2010 (Haig et al. 2004, Funk et al. 2009).

Figure 2. Adult Spotted owl with yellow and black leg band

In January, 2014, we participated in the sixth workshop to analyze Northern Spotted Owl data. This meta-analysis, which took place in Corvallis, Oregon, included data from 8 monitoring areas funded through the Northwest Forest Plan, plus 3 additional study areas in the range of the Northern Spotted Owl. During the meta-analysis, we used mark-recapture data to estimate age-and sex-specific survival and recruitment, and population growth rate. We also included an occupancy analysis (MacKenzie et al. 2002) for the first time. The results of this workshop can be found in Dugger et al. (2016). The previous workshop occurred in 2009, and the results from that analysis were published in Forsman et al. (2011).

A study to test the response of the Spotted Owl population to the removal of Barred Owls began on the GSA this year. This study involves surveying the entire General Study Area for Barred owls by broadcasting Barred Owl calls, and removing Barred Owls from a portion of the study area while monitoring the population of Barred Owls in the remaining portion of the study area without Barred Owl removal (a Before-After-Control-Impact study design).

RESULTS

Population Trends

General Study Area

In 2015 we banded 6 juvenile owls and 2 adult owls, bringing the total number of owls banded during 1989-2015 to 865 (163 adults, 69 subadults, and 633 juveniles, Table 1). Our monitoring effort has remained relatively consistent after 1992, except for 8-10 territories we began monitoring with only 1 visit per year beginning in 2002. None of these “minimum-protocol” territories contained owls in 2015. We confirmed the bands

of 15 Spotted Owls, and detected 27 Spotted Owls on 20 territories. This compares to a high of 120 owls on 64 territories in the same area in 1992 (a decline of 77.5%, Figures 3, 4, Table 2). The high male:female ratio observed in 2008-2010 has waned somewhat in recent years, however this ratio has increased again due to the number of single males detected this year (Figure 5).

It is encouraging that the number of owls detected increased by 9 this year, however, we are likely double-counting some of the single males we detected because we were unable to confirm bands on them. We were unable to detect 2 long-term owl pairs this year. It remains to be seen whether the current population in this area is large enough to remain stable considering the inevitable stochastic processes the population will face in the future.

Key findings of the 2014 meta-analysis of Spotted Owl demography data (Dugger et al. 2016) were: 1) there was strong evidence of population declines in Spotted Owls on most study areas examined (including the Cle Elum Study Area); and 2) Barred Owl presence had a generally negative effect on demographic rates of Spotted Owls. The estimate of mean annual rate of population change (λ) for the Cle Elum Study Area was 0.916 (95% CI 0.894 – 0.938), indicating an annual population decline of 8.4% (95% CI 6.2 – 10.6%. This estimate shows a steeper decline in Spotted Owl numbers than the estimate in Forsman et al. 2011 (6.3%). This estimate of population change closely predicts the empirical estimates of population size that we collect each year (Figure 3).

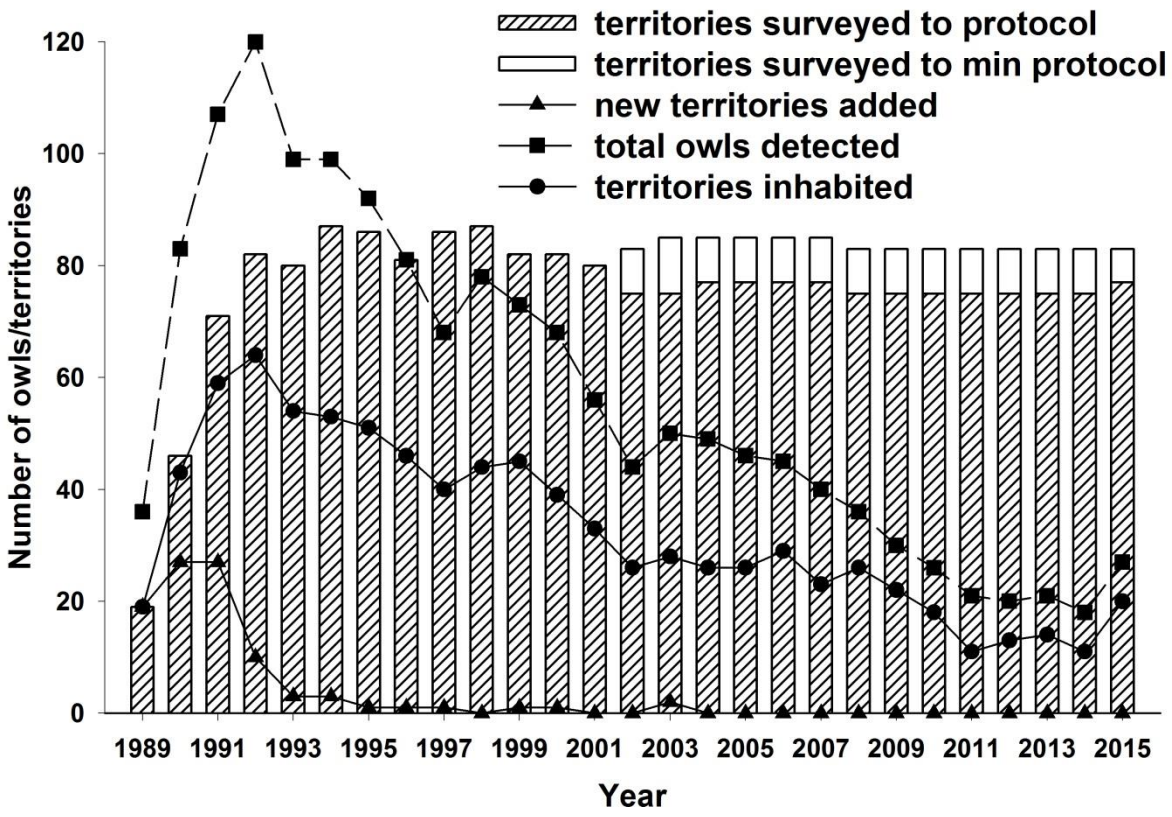

Figure 3. Number of Spotted Owls detected, number of territories in which we detected owls, number of territories surveyed, and number of new territories added by year on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015. Minimum protocol territories included 8-10 territories that we visited only once per year beginning in 2002. A territory was considered inhabited if a single owl response was detected which was not associated with a neighboring territory.

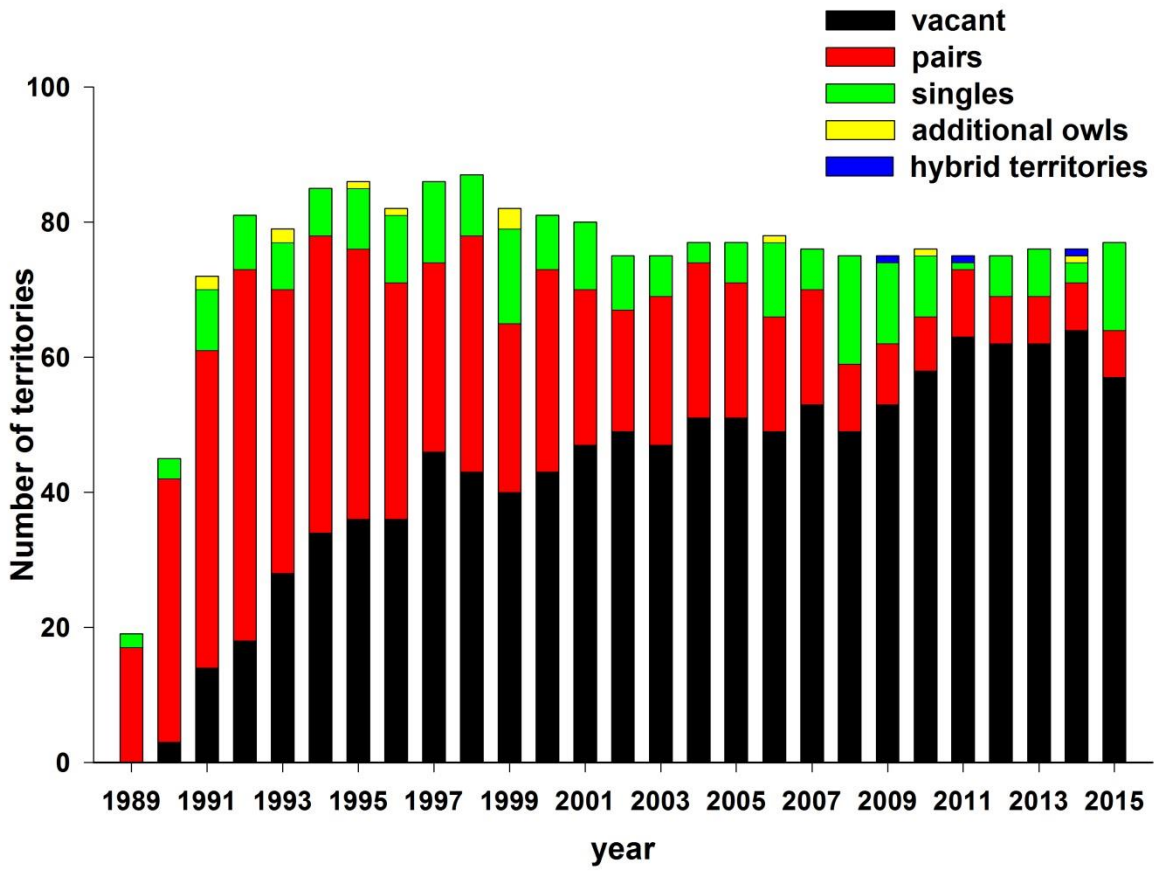

Figure 4. Number of vacant territories, hybrid territories, and number of territories inhabited by singles, pairs, and "additional owls" on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015. An "additional owl" is counted when a single owl is detected at a territory where a pair or territorial owl has already been confirmed, and the single owl response cannot be attributed to an adjacent territory. A hybrid territory is one inhabited by a Spotted owl/Barred Owl pair or a Spotted Owl x Barred Owl hybrid. Totals do not include 8-10 vacant territories where we made less than 3 complete visits in a year starting in 2002.

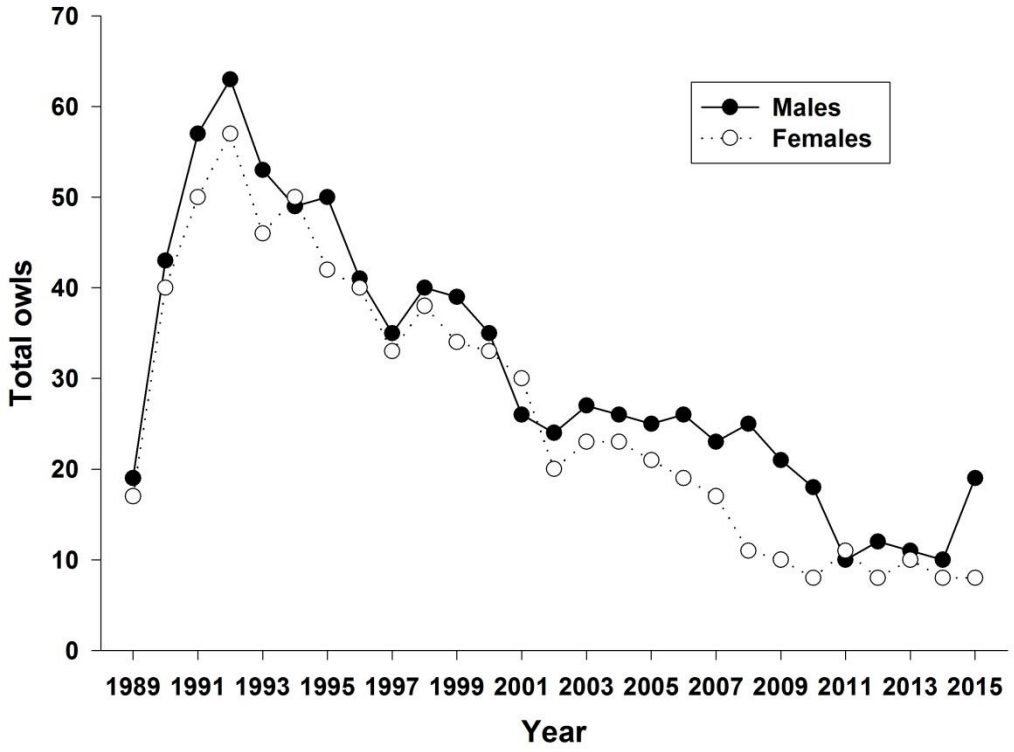

Figure 5. Number of male and female Spotted Owls detected by year on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015.

Elsewhere on the Okanogan-Wenatchee National Forest, we continued banding owls on a portion of what was the Wenatchee Demography Study Area (WEN, Figure 12). The WEN was monitored by National Council for Air and Stream Improvement from 1990-2003, in cooperation with the Wenatchee National Forest. We banded 10 new owls at 7 inhabited territories on the WEN, and changed bands or confirmed bands on 11 adult owls. We surveyed 33 territories to protocol.

Density Study Area

The DSA survey data indicate an overall decline in the number of owls detected in the DSA since 1991, however, like the GSA estimate, the number of owls detected in the DSA was higher this year than in recent years (Figure 6).

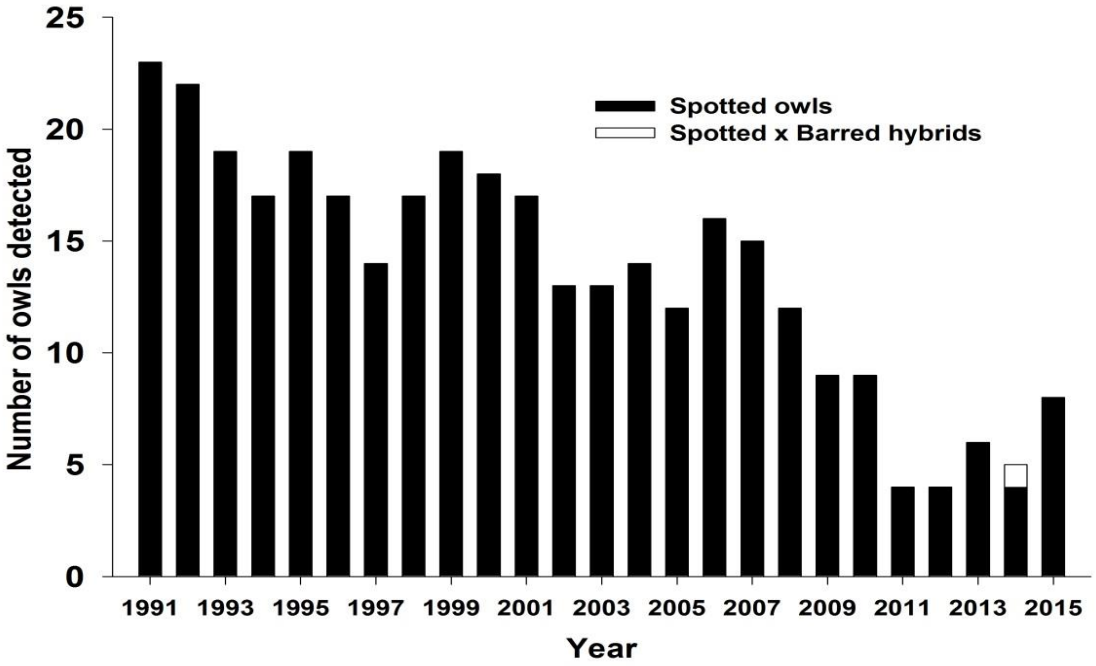

Figure 6. Number of non-juvenile owls detected on the 204 km^2 Swauk Density Study Area on the Okanogan-Wenatchee National Forest, Washington, 1991-2015. Bars represent actual counts.

West Nile Virus

None of the oral swab or blood samples from owls in 2005 or 2006 tested positive for the presence of West Nile Virus. The impact of West Nile Virus on the Spotted Owl population on the Cle Elum Study Area remains unknown. Eight mammals and 1 bird tested positive for WNV in Washington State in 2015 (WSDH 2015), but West Nile virus monitoring is not exhaustive and the virus could be more widespread than this data would indicate.

Barred Owls and Spotted Owls

The range of the Barred Owl now overlaps the range of the Northern Spotted Owl, and the potential for the Barred Owl to negatively affect the Spotted Owl population has been a concern for many years (Taylor and Forsman 1976, Courtney et al. 2006). Kelly et al. (2003) found that apparent occupancy and reproduction of Spotted Owls were lower when Barred Owls were detected nearby, and recent analyses have documented competition between Barred Owls and Spotted Owls (Dugger et al. 2011, Wiens et al. 2014). Thus, monitoring the number of inhabited Barred Owl territories is an important index to measure the effect of Barred Owls on Spotted Owl population trends (Olson et al. 2005)

Barred Owl (*Strix varia*) (photo by Steve Sleep)

General Study Area

We recorded 76 Barred Owl responses in the GSA in 2015 during our Spotted Owl surveys. Based on how these responses were situated temporally and/or geographically, we believe the responses represent 52 inhabited Barred Owl territories. Due to limited resources, we did not attempt to determine whether the responses represented nesting pairs.

Preliminary results from the Barred Owl surveys indicate there are well over 100 pairs of Barred Owls in the GSA, and many singles. This is a much greater density of Barred Owls than what we estimated from our incidental Barred Owl surveys.

The proportion of Spotted Owl territories where we detected at least 1 Barred Owl has increased through time on the Cle Elum Study Area (Figure 7), however, the increase is not as sharp as in other study areas within the range of the Spotted Owl.

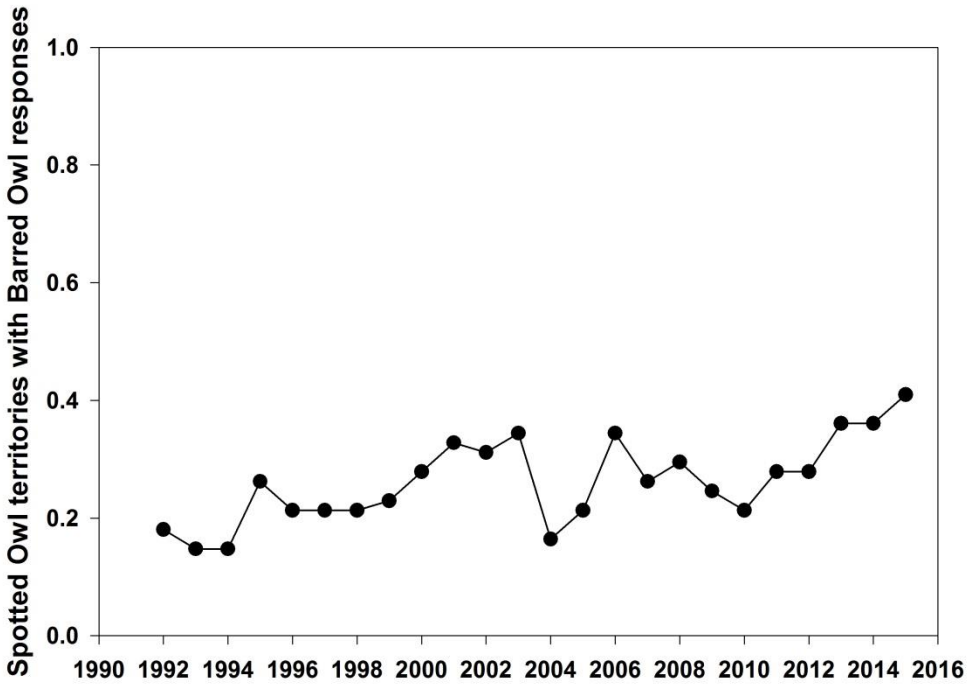

Figure 7. Proportion of 61 Spotted Owl territories with a Barred Owl response, Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1992-2015. Sample includes those territories surveyed 3 times annually since 1992. A territory was defined as the Theissen polygon generated from all Spotted Owl site centers for each territory.

Density Study Area

By completely surveying the Density Study Area each year, we were able to estimate which portions of the DSA were inhabited by Barred Owls and/or Spotted Owls. We detected Barred Owls on 38 occasions in 2015. Based on how these responses were distributed spatially and/or temporarily, we estimate there were 25 inhabited Barred Owl territories in the DSA. The apparent number of inhabited Barred Owl territories in the DSA increased in 1991-2000 (Figure 8), outnumbering inhabited Spotted Owl territories in several years. Since 2000, the number of inhabited Barred Owl territories has varied among years. This year, we found more Barred Owls than in any previous year (Figure 8).

The Barred Owl survey crew detected at least 1 Barred Owl in 33 of 52 survey areas intersecting the DSA boundary. Four of these inhabited survey areas contained more than 2 pairs of Barred Owls. The estimates of inhabited Barred Owl territories are similar for our DSA surveys and Barred Owl surveys within the DSA, however, similar to the GSA, the species-specific surveys indicated there is a greater number of Barred Owls than we had estimated from our Spotted Owl surveys.

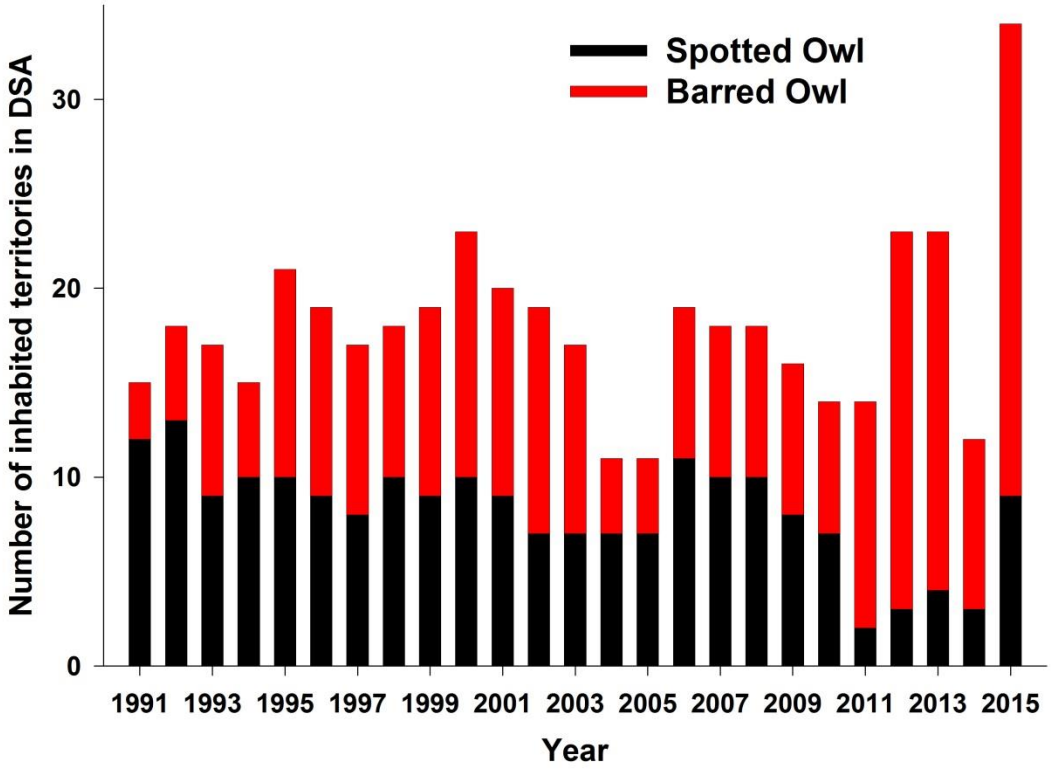

Figure 8. Number of territories in which we detected Spotted Owls and Barred Owls in the Swauk Cr. Density Study Area, Okanogan-Wenatchee National Forest, Washington, 1991-2015.Territories were considered inhabited if an owl of either sex was detected at the territory. The values for Barred Owls in 2009 include one territory inhabited by a Spotted owl/Barred Owl pair.

Spotted-Barred Owl Hybrids

"Sparred" owl (Spotted owl x Barred Owl hybrid) fledgeling, 22 July, 2009

Although we have detected Barred Owls on the General Study Area since 1989, we documented our first case of a Spotted owl/Barred Owl pair in 2009. The pair included a male Spotted owl and a female Barred Owl—the most common pair formation when Spotted Owls and Barred Owls hybridize (Haig et al. 2004, Kelly et al. 2004). The pair nested and produced 2 young. We found one of the hybrid offspring (a male) from this pair on our study area in 2011. This owl dispersed about 44 km. In 2014, we detected a hybrid Spotted x Barred male at night but were unable to determine if it was from the 2009 hybrid pair. In 2015, a hybrid was again detected at night near the 2014 location, but this owl was detected during Barred Owl surveys and thus is not represented in Figure 6 or tables indicating hybrids.

Barred Owl Removal

In September, 2013, the US Fish and Wildlife Service published its Record of Decision to begin a Barred Owl removal study (USFWS 2013). This study will evaluate the effect of Barred Owl removal on vital rates (e.g. survival, reproduction, recruitment) of the Spotted Owl. The USFWS chose the Cle Elum Study Area as 1 of 4 study areas in the range of the Spotted Owl to participate in the removal study. Barred Owl removal began on the Cle Elum Study Area in fall, 2015 and will continue until spring, 2016 at which time the project will switch back to Barred Owl surveys only.

Reproductive Rates

Five of the 8 females for which we determined nesting status in 2015 nested. Of these 5 nesting females, 3 produced young. Average number of young fledged was 2.0 (SE = 0.00, Table 3). The 2015 estimates for proportion of females nesting and number of young fledged were below the average for all years (Figure 9, Table 3).

The pronounced odd-even year pattern of nesting and number of young fledged seen in 1989-1999—a pattern that was evident in many studies throughout the range of the Spotted Owl--has waned somewhat in the last 12 years (Figure 9, Table 3).

Dugger et al. (2016) found that models that included a time trend covariate were among the competing models for number of young produced on the Cle Elum Study area. The 95% confidence intervals around the negative beta estimate (-0.004) for trend in the number of young fledged barely overlapped zero (-0.013 – 0.005, Dugger et al. 2016:82). Thus, these estimates provide suggestive evidence that reproduction has declined over time on this study area. Other covariates that seemed to influence estimates of the number of young fledged on the Cle Elum Study Area included age of the female (adult females produced more young than subadults), early nesting season temperature (higher monthly minimum temperatures were related to more young produced) , and the amount of suitable habitat present in the study area (more cover of habitat was related to more young produced).

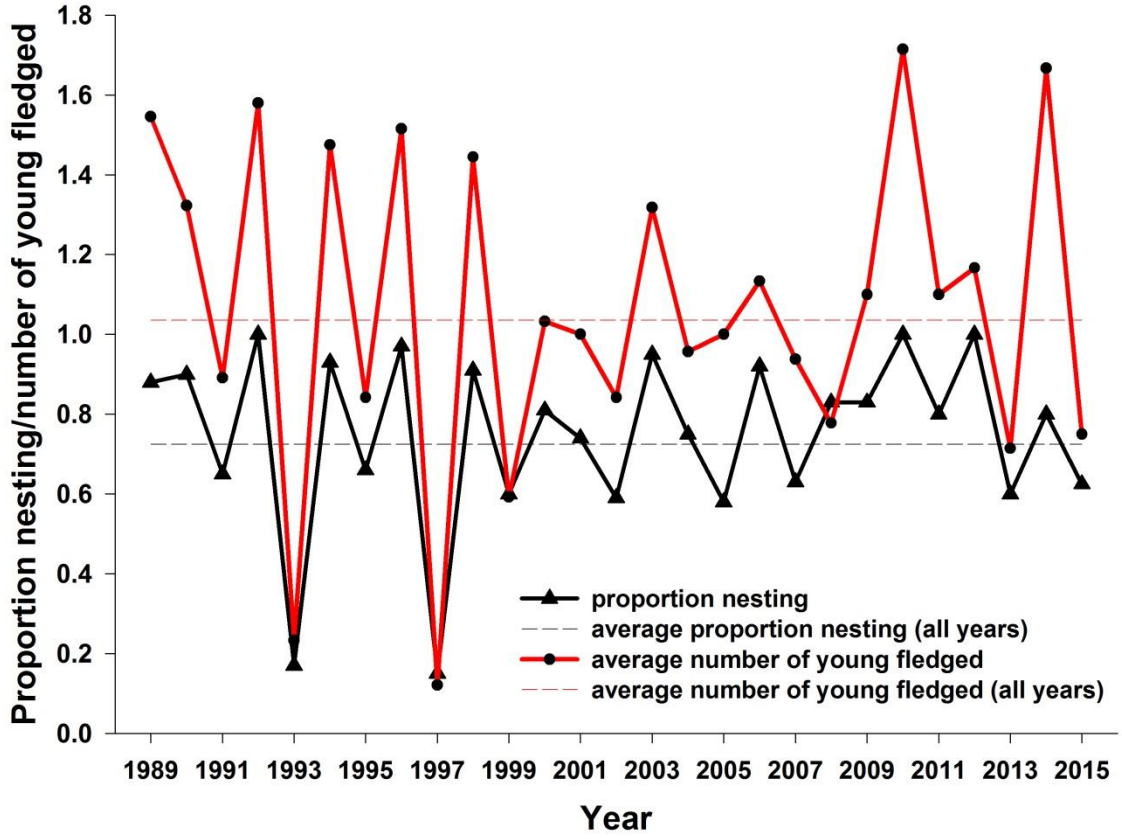

Figure 9. Reproductive indices of Northern Spotted Owls on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015. Indices shown are: *proportion of females nesting* and *number of young fledged*. The dashed lines show the average (all years 1989-2015) number of young fledged and proportion nesting.

While the reproductive rates appear to have been somewhat less variable in recent years, these reproductive indices are estimated from a declining pool of reproductive owls. Thus, the reproductive potential of the Spotted Owl population on the Cle Elum Study Area has declined over time. At the current population size, the total number of young produced in an above-average reproductive year (e.g. 2014) is only slightly greater than the worst reproductive years when the population was much larger (e.g. 1993, 1997, Figure 10). The small number of reproductive females remaining on the study area is clearly a cause for concern should this situation persist, given recent analyses that suggest there is a genetic bottleneck in this region (Funk et al. 2009). Additionally, small populations can have a depressed capacity to withstand environmental variation (Soule and Mills' 1998).

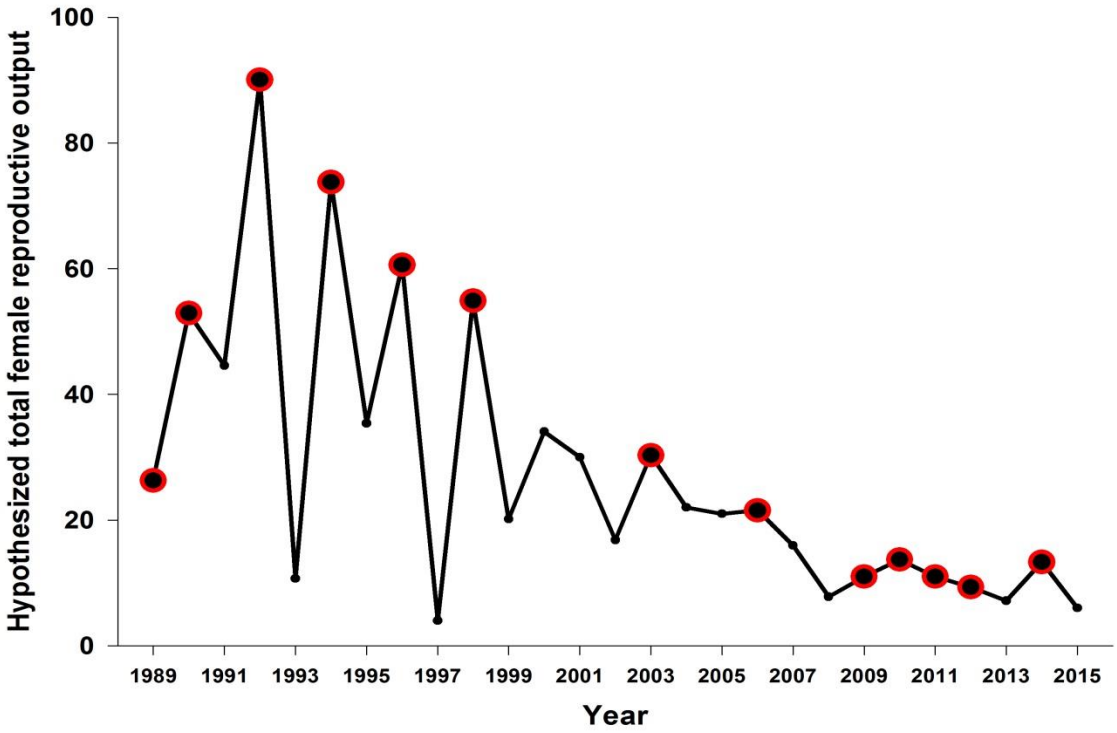

Figure 10. Hypothesized annual female reproductive output (average yearly number of young fledged * number of females detected each year), Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015. Note in the years prior to 1992 the sample of females monitored each year was increasing as we added new territories to the sample. Data points with red circles are years with above average number of young fledged.

Western Spruce Budworm

An outbreak of the western spruce budworm (*Choristoneura occidentalis)* began on the Cle Elum Study Area in 2001. Aerial detection surveys by Washington Department of Natural Resources have recorded heavy spruce budworm damage on as much as 20% of the GSA in at least 1 year in 2001-2014 (WDNR 2015). The mean percentage of owl core areas recorded with heavy budworm defoliation was 37% (SE= 2.9, range 0 - 96%). Defoliation by the budworm could reduce Spotted Owl habitat quality by decreasing canopy closure and affecting recruitment of younger trees, particularly in stands that are dominated by Douglas-fir (*Pseudotsuga menzesii*) and grand fir (*Abies grandis*). Currently, the effect of budworm defoliation on owl habitat quality is highly variable among owl core areas depending on the magnitude and duration of budworm defoliation, and the species and age composition of the stands. Yearly defoliation was less noticeable in 2013-2015, and aerial surveys in 2014 recorded less area as heavily damaged by spruce budworm compared to previous years (Figure 11). Thus, the spruce budworm outbreak may be subsiding.

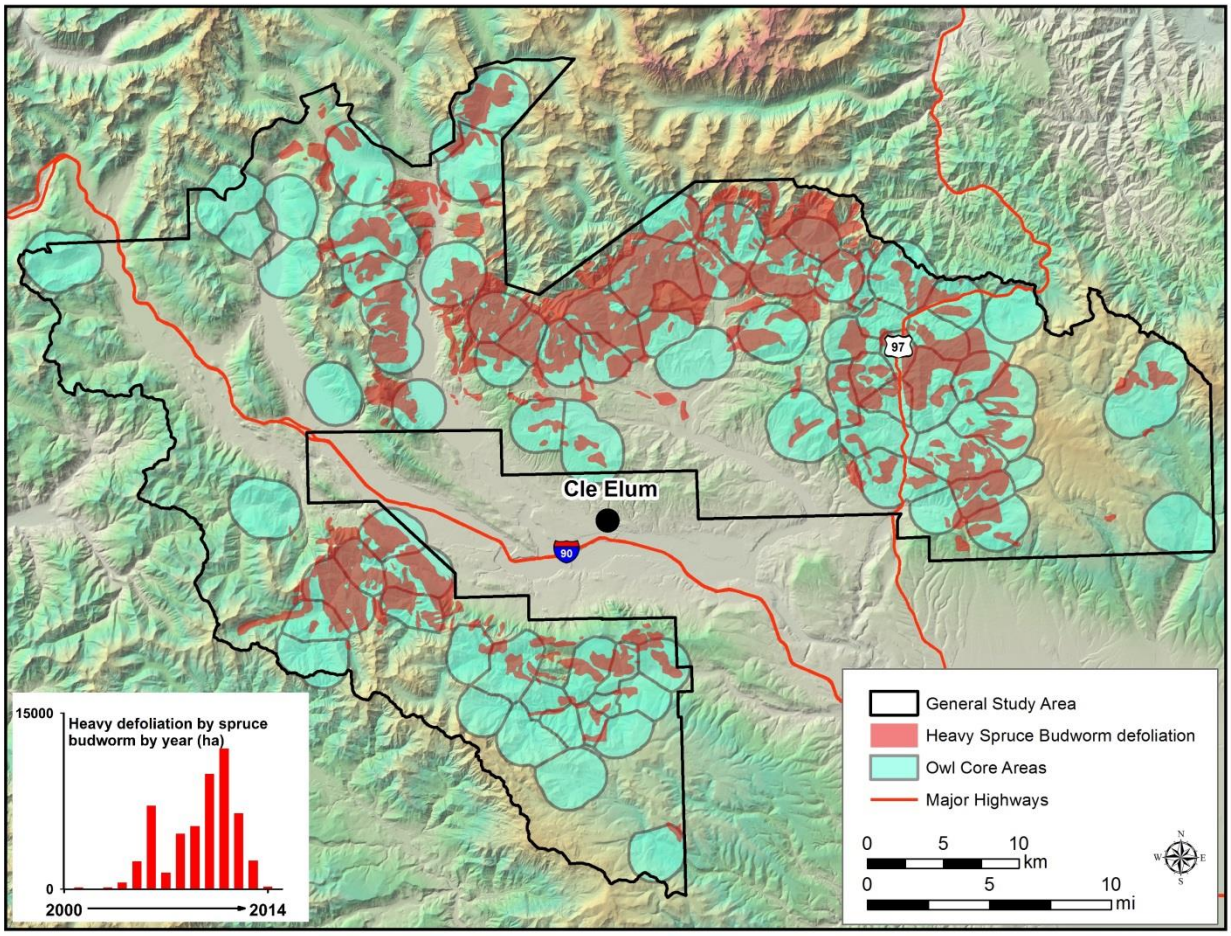

Figure 11. Areas heavily defoliated by spruce budworm in the General Study Area, Cle Elum Spotted Owl Demography Study Area, Okanogan-Wenatchee National Forest, Washington, 2000 – 2014. The area mapped in red is the total area recorded by WDNR aerial detection surveys as heavily defoliated by spruce budworm in at least 1 year. The graph at lower left shows the area (ha) recorded as heavily defoliated by budworms by year.

The 2014 Spotted Owl Demographic Workshop

January 2014 marked the sixth in a series of workshops held at 5-year intervals to analyze data from Spotted Owl demography study areas. The results from the meta-analysis were published in Dugger et al. (2016). This analysis included data from the Cle Elum Study Area 1989-2013, as well as 7 other Spotted Owl demography study areas funded under the Northwest Forest Plan (Figure 12). Three additional study areas also participated in the 2014 workshop.

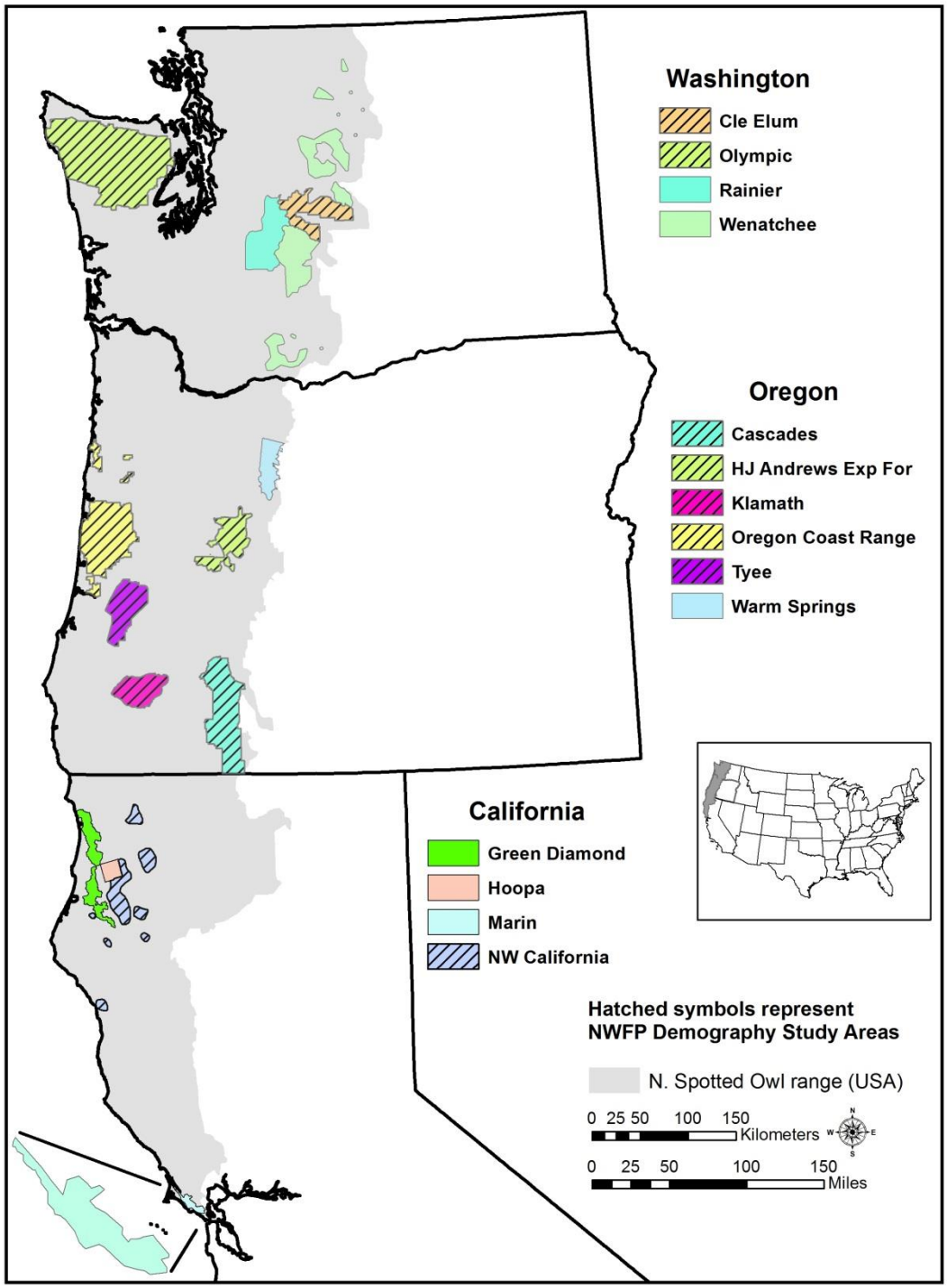

Figure 12. Northern Spotted Owl Demography Study Areas in the range of the Owl in the USA. The Marin (CA), Warm Springs (OR), and Wenatchee (WA) study areas were discontinued after the 2003 analysis.

PROBLEMS ENCOUNTERED

We were unable to survey on 6 scheduled survey days and/or nights due to inclement weather, resulting in a loss of 7.5 person-days of survey. This is a relatively small number of survey days lost compared to most years.

Reduced maintenance and decommission of Forest Service roads continues to reduce vehicle access. This often necessitates other means of travel (e.g. foot, bicycle, ATV) to our calling stations, which often increases time spent for each survey.

As Spotted Owl territories have become vacant, we have had to increase our number of nocturnal visits in order to achieve valid surveys. In addition, surveys done by cooperating organizations to monitor Spotted Owl territories in our sample have largely ceased. The combination of these 2 developments has increased the overall workload for accomplishing this study. These difficulties are not likely to change in the near future, however, this year, the Washington State Department of Wildlife surveyed several Spotted Owl territories located on land recently purchased by the Washington Department of Natural Resources.

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Sovern, S. G., E. D. Forsman, K. M. Dugger, and M. Taylor. 2015. Roosting habitat use and selection by Northern Spotted Owls during natal dispersal. Journal of Wildlife Management 79:254-262.

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"Nature of Night" program, 21 November, 2015, Central Washington University Center for Excellence in Science and Mathematics Education. A poster presentation and owl pellet examples.

The Cle Elum Ranger District staff was given weekly updates of our owl surveys and information as needed in support of District projects.

Apppendix 1

Table 1. Number of Spotted owls banded each year on the Cle Elum Study Area, Okanogan-Wenatchee National forest, Washington, 1989-2015. Total for juveniles includes 2 hybrid Spotted x Barred Owl hybrids banded in 2009.

	Density Study Area					General Study Area					
Year	Adults	(M,F)	Subadults	(M,F)	Juveniles	Adults	(M,F)	Subadults	(M,F)	Juveniles	Total
1989	12	(7,5)	3	(1,2)	10	16	(10,6)	2	(0,2)	10	53
1990	5	(3,2)	2	(1,1)	12	38	(21,17)	4	(2,2)	28	89
1991	5	(4,1)	2	(2,0)	7	20	(11,9)	12	(3,9)	34	80
1992	0	(0,0)	2	(1,1)	16	16	(7,9)	2	(0,2)	60	96
1993	1	(0,1)	1	(1,0)	2	7	(1,6)	4	(1,3)	8	23
1994	0	(0,0)	1	(1,0)	14	4	(2,2)	2	(1,1)	52	73
1995	0	(0,0)	2	(2,0)	8	4	(3,1)	2	(2,0)	23	39
1996	0	(0,0)	1	(0,1)	12	2	(0,2)	0	(0,0)	39	54
1997	0	(0,0)	0	(0,0)	0	4	(2,2)	3	(2,1)	3	10
1998	0	(0,0)	1	(0,1)	9	2	(1,1)	2	(1,1)	43	57
1999	0	(0,0)	1	(0,1)	7	1	(0,1)	1	(1,0)	8	18
2000	0	(0,0)	2	(2,0)	11	1	(1,0)	3	(0,3)	18	35
2001	1	(1,0)	0	(0,0)	9	2	(1,1)	0	(0,0)	15	27
2002	0	(0,0)	0	(0,0)	5	1	(1,0)	1	(1,0)	11	18
2003	0	(0,0)	1	(1,0)	13	5	(3,2)	1	(1,0)	16	36
2004	0	(0,0)	1	(1,0)	5	2	(0,2)	1	(0,1)	14	23
2005	0	(0,0)	0	(0,0)	7	1	(0,1)	1	(1,0)	11	20
2006	0	(0,0)	1	(1,0)	5	1	(0,1)	0	(0,0)	11	18
2007	1	(1,0)	2	(1,1)	3	3	(3,0)	2	(1,1)	11	22
2008	0	(0,0)	1	(0,1)	3	0	(0,0)	0	(0,0)	6	10
2009	0	(0,0)	0	(0,0)	4	3	(1,2)	1	(1,0)	9	17
2010	0	(0,0)	0	(0,0)	2	0	(0,0)	0	(0,0)	9	11
2011	0	(0,0)	0	(0,0)	2	0	(0,0)	1	(0,1)	7	10
2012	0	(0,0)	0	(0,0)	2	0	(0,0)	0	(0,0)	5	7
2013	0	(0,0)	0	(0,0)	2	1	(1,0)	0	(0,0)	1	4
2014	1	(1,0)	0	(0,0)	0	1	(0,1)	0	(0,0)	5	7
2015	0	(0,0)	0	(0,0)	2	2	(2,0)	0	(0,0)	4	8
Total	26	(17,9)	24	(15,9)	172	137	(71,66)	45	(18,27)	461	865

Table 2. Survey effort for the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2014.

	territories surveyed to minimum protocol [1]	territories surveyed to protocol [2]	new territories added	total owls detected	territories inhabited [3]	hybrid territories[4]
1989	0	19	19	36	19	0
1990	0	46	27	83	43	0
1991	0	71	27	109	59	0
1992	0	82	10	120	64	0
1993	0	80	3	101	54	0
1994	0	87	3	99	53	0
1995	0	86	1	93	51	0
1996	0	81	1	82	46	0
1997	0	86	1	68	40	0
1998	0	87	0	78	44	0
1999	0	82	1	76	45	0
2000	0	82	1	68	39	0
2001	0	80	0	56	33	0
2002	8	75	0	44	26	0
2003	10	75	2	50	28	0
2004	8	77	0	49	26	0
2005	8	77	0	46	26	0
2006	8	77	0	46	29	0
2007	8	77	0	40	23	0
2008	8	75	0	36	26	0
2009	8	75	0	31	22	1
2010	8	75	0	26	18	0
2011	8	75	0	21	11	1
2012	8	75	0	20	13	0
2013	8	75	0	21	14	0
2014	8	75	0	18	11	1
2015	6	77	0	27	20	0

[1] Minimum protocol consisted of one visit to the territory.
[2] Territories surveyed to protocol as outlined in Lint et al. (1999).
[3] A territory was considered inhabited if one owl was detected during the survey period, March-August.
[4] Hybrid territories are those inhabited by a pair composed of a Spotted and a Barred Owl or by a Spotted Owl/Barred Owl hybrid.

Table 3. Reproductive indices of Spotted owls on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015. Number of young fledged and mean brood size of successful nests.

	Number of young fledged			Mean brood size of successful nests		
Year	**N[1]**	**Mean**	**SE**	**N[2]**	**Mean**	**SE**
1989	11	1.55	0.25	9	1.89	0.11
1990	31	1.32	0.16	23	1.78	0.09
1991	46	0.89	0.14	24	1.71	0.11
1992	50	1.58	0.12	42	1.88	0.09
1993	43	0.23	0.09	6	1.67	0.21
1994	40	1.48	0.19	27	2.19	0.13
1995	38	0.84	0.14	20	1.60	0.11
1996	33	1.52	0.14	28	1.79	0.09
1997	33	0.12	0.07	3	1.33	0.33
1998	36	1.44	0.17	27	1.93	0.13
1999	27	0.59	0.16	10	1.60	0.16
2000	31	1.03	0.16	20	1.60	0.11
2001	26	1.00	0.18	16	1.63	0.13
2002	19	0.84	0.22	9	1.78	0.15
2003	22	1.32	0.20	16	1.81	0.14
2004	23	0.96	0.19	13	1.69	0.13
2005	20	1.00	0.22	11	1.82	0.12
2006	15	1.13	0.24	10	1.70	0.15
2007	16	0.94	0.23	9	1.67	0.17
2008	10	0.90	0.31	5	1.80	0.20
2009	10	1.10	0.31	6	1.83	0.17
2010	8	1.50	0.33	6	2.00	0.00
2011	10	1.10	0.31	6	1.83	0.17
2012	6	1.17	0.31	5	1.40	0.24
2013	7	0.71	0.36	3	1.67	0.33
2014	6	1.67	0.42	5	2.00	0.32
2015	8	0.75	0.37	3	2.00	0.00
Total	627	1.04	0.04	362	1.79	0.03

[1] Sample size (n) includes those females checked for reproductive status by August 31. Fecundity is the number of females fledged per female, assuming a 50:50 sex ratio. Values have changed from previous versions due to ignoring owls wearing tailmount transmitters.

[2] Mean brood size of nests that produced at least 1 young, and where the number of fledged young was determined by August 31. Values have changed from previous versions due to ignoring owls wearing tailmount transmiters.

Table 3 (cont). Reproductive indices of Spotted owls on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015. Proportion of females that nested.

Year	N[1]	Proportion	95% CI[4]	
1989	8	0.88	0.47	1.00
1990	21	0.86	0.64	0.97
1991	33	0.64	0.45	0.80
1992	47	1.00	0.92	1.00
1993	39	0.18	0.08	0.34
1994	34	0.91	0.76	0.98
1995	32	0.66	0.47	0.81
1996	32	0.97	0.84	1.00
1997	27	0.15	0.04	0.34
1998	34	0.91	0.76	0.98
1999	20	0.60	0.36	0.81
2000	27	0.81	0.62	0.94
2001	23	0.74	0.52	0.90
2002	17	0.59	0.33	0.82
2003	20	0.95	0.75	1.00
2004	20	0.75	0.51	0.91
2005	19	0.58	0.33	0.80
2006	13	0.92	0.64	1.00
2007	16	0.63	0.35	0.85
2008	6	0.83	0.36	1.00
2009	6	0.83	0.36	1.00
2010	5	1.00	0.48	1.00
2011	5	0.80	0.28	0.99
2012	4	1.00	0.40	1.00
2013	5	0.60	0.15	0.95
2014	5	0.80	0.28	0.99
2015	8	0.63	0.24	0.91
Total	526	0.72	0.68	0.76

[1] Sample size (n) includes females that were checked for nesting status before June 15.
[2] Sample size (n) includes nesting females that were checked for reproductive status by August 31.
[3] Sample size (n) includes all females that were checked for reproductive status by August 31. The sample size for this index is commonly larger than other indices because we often cannot make the required visits to determine nesting status before the June15 cutoff due to limited access or low response rates for non-nesting females.
[4] Exact confidence limits for the binomial proportion using the F distribution, Collett (1991).
Values are different than previous annual reports due to excluding owls with tailmount radio-transmitters in these estimates.

Table 3 (cont). Reproductive indices of Spotted owls on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015. Proportion of nesting females fledging young.

Year	N[2]	Proportion	95% CI[4]	
1989	7	1.00	0.59	1.00
1990	17	0.94	0.71	1.00
1991	21	0.81	0.58	0.95
1992	44	0.86	0.73	0.95
1993	7	0.86	0.42	1.00
1994	31	0.77	0.59	0.90
1995	21	0.90	0.70	0.99
1996	31	0.90	0.74	0.98
1997	4	0.75	0.19	0.99
1998	31	0.84	0.66	0.95
1999	12	0.75	0.43	0.95
2000	22	0.91	0.71	0.99
2001	17	0.82	0.57	0.96
2002	10	0.80	0.44	0.97
2003	18	0.78	0.52	0.94
2004	15	0.80	0.52	0.96
2005	11	0.91	0.59	1.00
2006	12	0.67	0.35	0.90
2007	10	0.90	0.55	1.00
2008	5	0.80	0.28	0.99
2009	5	1.00	0.48	1.00
2010	5	0.80	0.28	0.99
2011	4	0.75	0.19	0.99
2012	4	1.00	0.40	1.00
2013	3	0.67	0.09	0.99
2014	4	1.00	0.40	1.00
2015	5	0.60	0.15	0.95
Total	376	0.84	0.80	0.88

[1] Sample size (n) includes females that were checked for nesting status before June 15.
[2] Sample size (n) includes nesting females that were checked for reproductive status by August 31.
[3] Sample size (n) includes all females that were checked for reproductive status by August 31. The sample size for this index is commonly larger than other indices because we often cannot make the required visits to determine nesting status before the June15 cutoff due to limited access or low response rates for non-nesting females.
[4] Exact confidence limits for the binomial proportion using the F distribution, Collett (1991).
Values are different than previous annual reports due to excluding owls with tailmount radio-transmitters in these estimates.

Table 3 (cont). Reproductive indices of Spotted owls on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2015. Proportion of females fledging young.

Year	N[3]	Proportion	95% CI[4]	
1989	11	0.82	0.48	0.98
1990	31	0.74	0.55	0.88
1991	46	0.52	0.37	0.67
1992	50	0.84	0.71	0.93
1993	43	0.14	0.05	0.28
1994	40	0.68	0.51	0.81
1995	38	0.53	0.36	0.69
1996	33	0.85	0.68	0.95
1997	33	0.09	0.02	0.24
1998	36	0.75	0.58	0.88
1999	27	0.37	0.19	0.58
2000	31	0.65	0.45	0.81
2001	26	0.62	0.41	0.80
2002	19	0.47	0.24	0.71
2003	22	0.73	0.50	0.89
2004	23	0.57	0.34	0.77
2005	20	0.55	0.32	0.77
2006	15	0.67	0.38	0.88
2007	16	0.56	0.30	0.80
2008	10	0.50	0.19	0.81
2009	10	0.60	0.26	0.88
2010	8	0.75	0.35	0.97
2011	10	0.60	0.26	0.88
2012	6	0.83	0.36	1.00
2013	7	0.43	0.10	0.82
2014	6	0.83	0.36	1.00
2015	8	0.38	0.09	0.76
Total	627	0.58	0.54	0.62

[1] Sample size (n) includes females that were checked for nesting status before June 15.
[2] Sample size (n) includes nesting females that were checked for reproductive status by August 31.
[3] Sample size (n) includes all females that were checked for reproductive status by August 31. The sample size for this index is commonly larger than other indices because we often cannot make the required visits to determine nesting status before the June15 cutoff due to limited access or low response rates for non-nesting females.
[4] Exact confidence limits for the binomial proportion using the F distribution, Collett (1991).
Values are different than previous annual reports due to excluding owls with tailmount radio-transmitters in these estimates.