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Study

Demography of spotted owls on the east slope of the Cascade Range, Washington, 1989-2002

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 and will continue at least until 2004.

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.

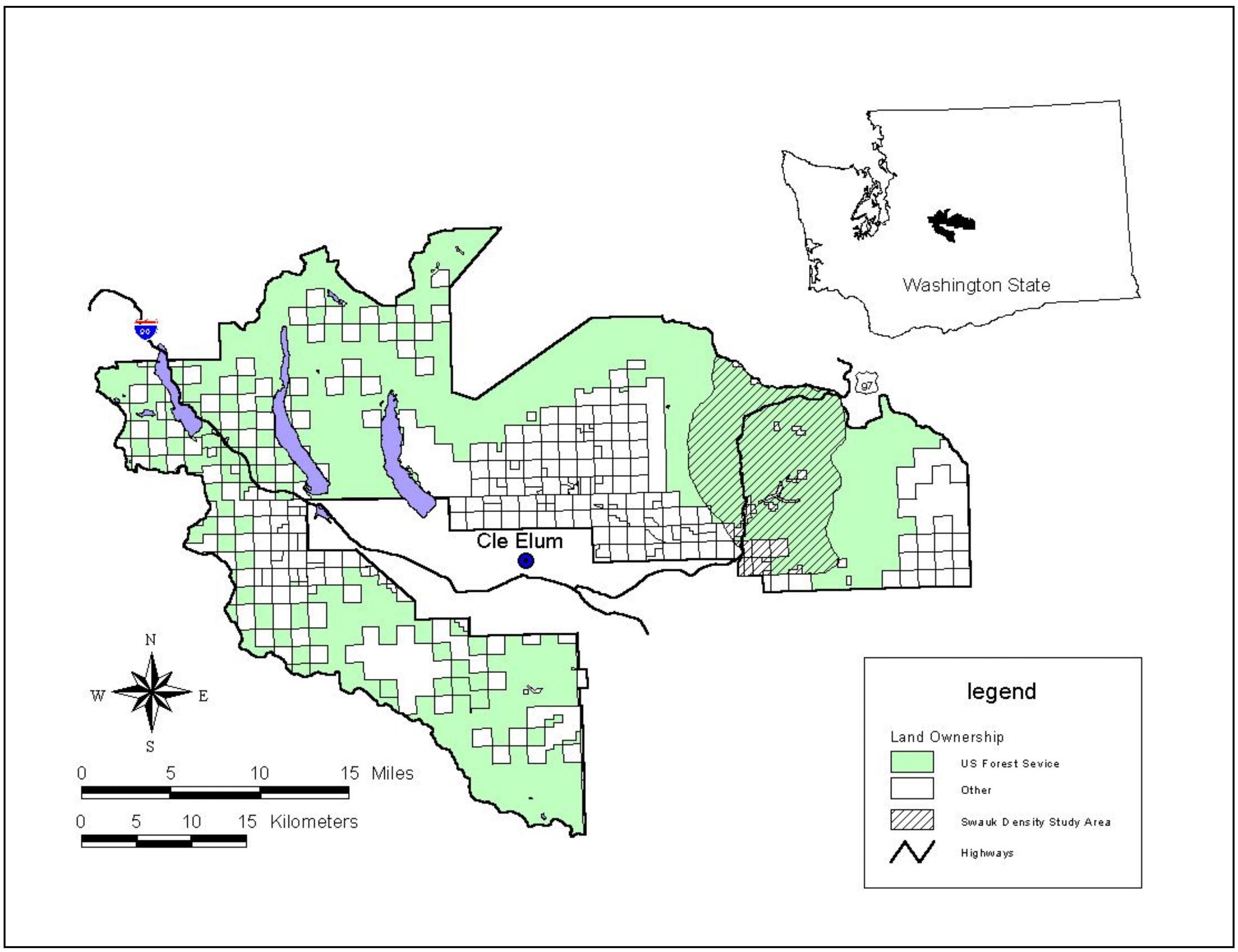
Potential benefit of the study

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 (Franklin et al. 1999).

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). Approximately 60% of the area within the GSA is administered by the U. S. Forest Service. Within the GSA we survey all historic owl territories each year to locate and confirm previously banded owls, determine the number of young produced at each territory, and band new owls. We conduct a complete survey of the DSA each year in order to estimate the number of resident owls within the area. On both areas we use standard protocols to confirm bands of owls that are relocated and we band all new owls with numbered USFWS bands and unique colored leg bands.

Figure 1. Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington.



We used Poisson log-linear regression to model the number of owls detected in the GSA in 1992-2002, using year and $year^2$ as explanatory variables. We used 1992 as the starting point for this analysis because the number of owl territories surveyed within the GSA peaked in 1992 and remained relatively constant thereafter (Figure. 2) . The least significant explanatory variables (P > 0.05) were eliminated in a stepwise process until only significant variables remained in the model. For this analysis we used log(number of territories surveyed) as an offset variable to compensate for small differences in the number of territories surveyed each year.

We used logistic regression to test the relative influence of age, sex and year on reproduction. The three response variables used in these models were: (1) *proportion of females nesting*, (2) *proportion of females fledging young*, and *(3) proportion of nesting females that successfully fledged young.* The year-effect was modeled as an even-odd year effect. We used a forward stepwise process to eliminate non-significant ($P > 0.05$) variables.

RESULTS

Population Trends

General Study Area

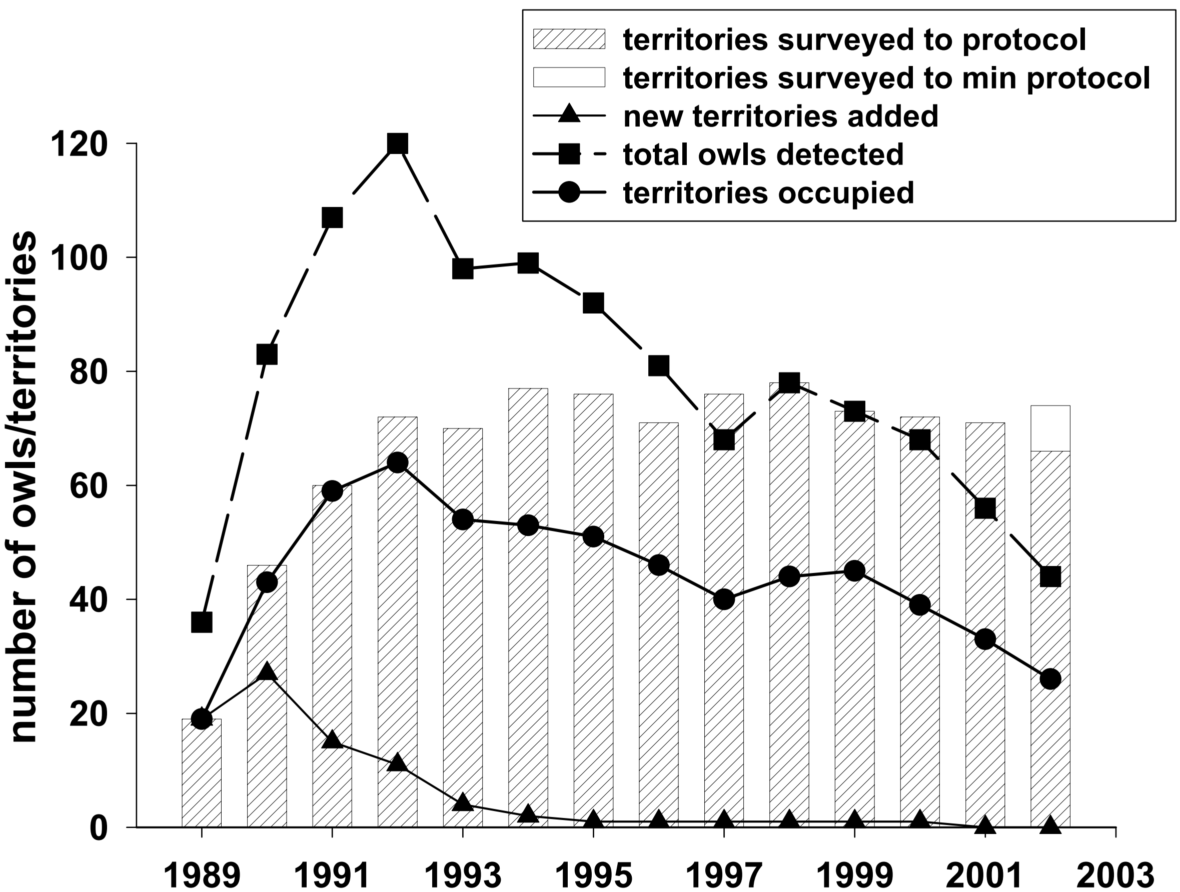
In 2002 we banded 18 new owls and confirmed bands on 44 owls on 26 territories in the General Study Area. This compares to a high of 120 owls on 64 territories in the same area in 1992 (Figure 2). Due to staffing constraints we surveyed 8 territories with only 1 visit in 2002. These territories had been vacant for 2-9 years, and none were occupied in 2002. The number of owls and territories detected in 2002 indicates a continuation of the decline observed since 1992 (Figure 2). The final model for the number of owls detected in the GSA in 1992-2002 was:

$$\log(\text{number of owls detected}) = 0.0470 - 0.0802 * \text{year} \qquad (1)$$

(Complete output of final models can be found in Appendix 2, listed by number). This model indicated a decline in the number of owls detected on the GSA of approximately 7.7% per year in 1992-2002 (95% C.I. = 5-9%). Franklin et al. (1999:39) estimated that the population of non-juvenile females on the Cle Elum study area declined by about 6% per year in 1989-1998.

We heard 62 responses from barred owls on the study area in 2002. Based on the distribution of these responses we believe they represented 31 different barred owl territories. This suggests that barred owls now outnumber spotted owls on our study area. Although we did not do follow-up surveys to determine the nesting status of barred owls, we did document one barred owl nest.

Figure 2. Number of Spotted Owls detected, number of territories occupied, number of territories surveyed, and number of new territories added by year, Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2002. Minimum protocol territories include 8 territories we visited only once, and were vacant for 2-9 years prior to 2002. A territory was considered occupied if a single owl response was detected which was not associated with a neighboring territory.



Density Study Area

The regression model that best fit the population data from the DSA was:

$$\text{Number of owls detected} = 18.00 - 0.55*yr \quad (2)$$

This model explained about 50% of the variation in number of owls detected in the DSA ($R^2 = 0.50$). and indicated a population decline of about 3% per year within the DSA in 1991-2002 (Figure 3). Addition of the polynomial terms $year^2$ and $year^3$ yielded the model:

$$\text{Number of owls detected} = 17.90 + 0.28*yr + 0.055*yr^2 - 0.039*yr^3 \quad (3)$$

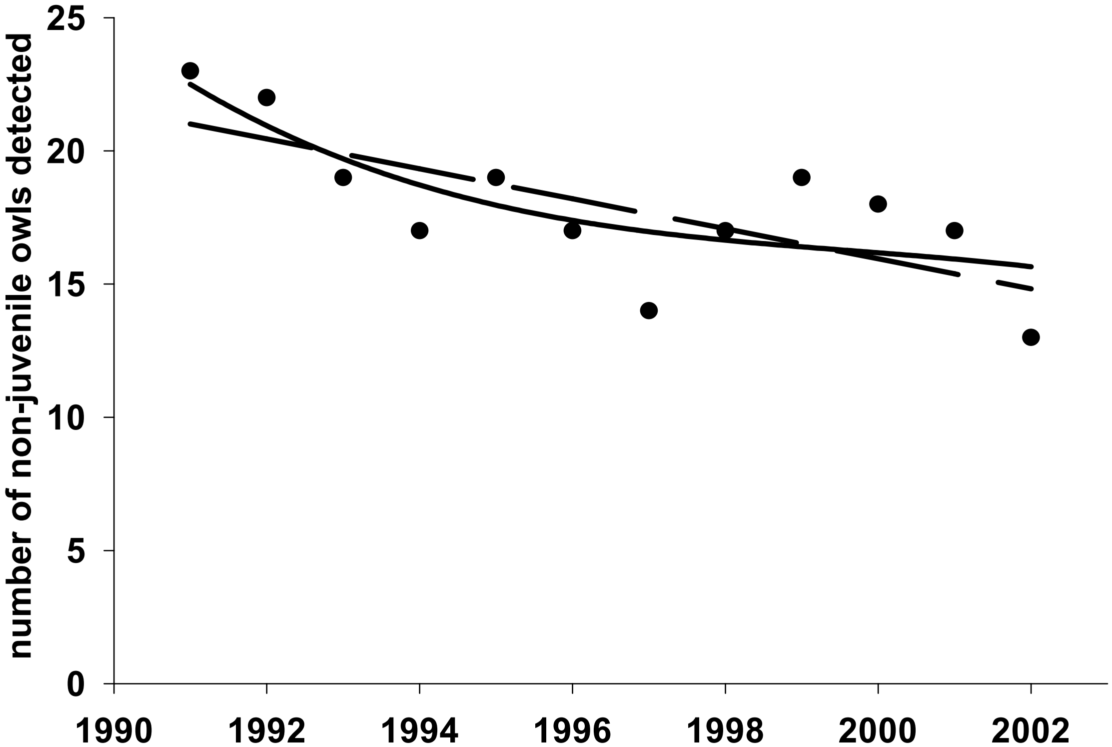
This model explained 75% of the variation in number of owls detected within the DSA ($R^2 = 0.75$). While the addition of the polynomial terms improved the fit of the model to the data, this model should be considered specific to this data set. The reduced model (i.e. without the polynomial terms) is more likely to be applicable to future analyses as more data become available.

Figure 3. Number of non-juvenile owls detected on the 204 km^2 Cle Elum Density Study Area, Okanogan-Wenatchee National Forest, Washington, 1991-2002. Points represent actual counts. The dashed line represents the model :

Number of owls detected = 18.00 - 0.55*yr

The solid line represents the model:

Number of owls detected = 17.90+0.28*yr +0.055*yr^2- 0.039*yr^3.



Reproductive Rates

Of the 17 non-juvenile females detected on the study area in 2002, 10 (59%) attempted to nest. We were able to determine that 9 (47%) of 19 females on the study area produced young. Average fecundity (# female young produced per female owl) was 0.368. Compared to previous years, the proportion of females nesting in 2002 was slightly below average (Figure 5, Appendix 1), as was average fecundity (Figure 5, Appendix 1). The odd-even year pattern, with even-numbered years being high reproductive years, has been less apparent in the last 3 years (Figure 5), but the pattern still has a strong effect on modeling output. The selected logistic model for nesting vs not nesting indicated that the relative odds of a female nesting was dependent on all the variables tested, as follows:

$$\text{Relative odds of nesting} = 575.67 + 1.73^{*}\text{female age} + 2.14^{*}\text{male age} - 0.29^{*}\text{yr} - 668.20^{*}\text{odd yr} + 0.333^{*}\text{year}^{*}\text{even year} \quad (4)$$

This model indicated that, all other things being equal, (1)adult females paired with adult males had the highest odds of nesting, (2) the odds of nesting was higher in even-numbered years, and (3) the odds of nesting declined by a factor of 0.75 per year.

The selected model for the relative odds of a female fledging young vs not fledging young in a particular year was:

$$\text{Relative odds of female fledging young vs not fledging young} = 94.29 + 0.93^{*}\text{adult female} - 0.048^{*}\text{yr} \quad (5)$$

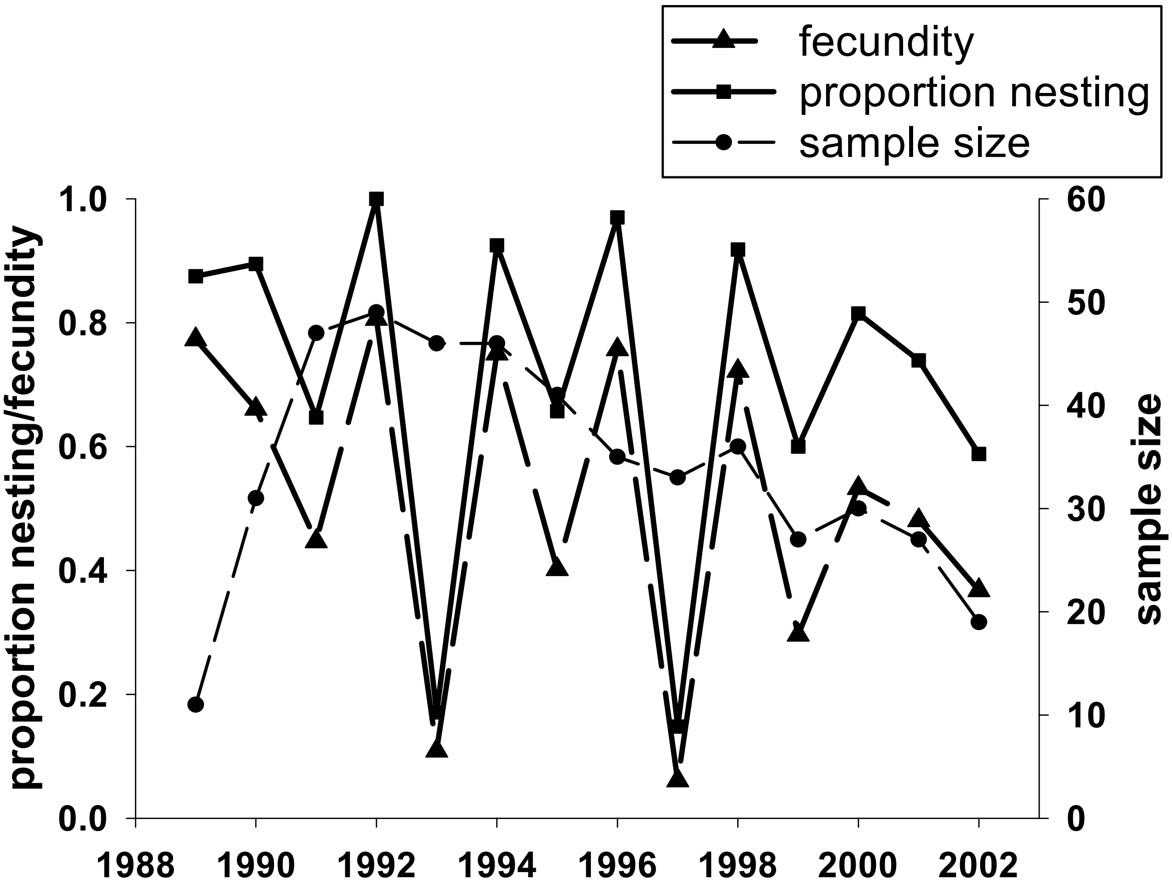
The P-value for the year term in this model was 0.079 (Appendix 2), but we left the year term in the model because we felt it might be biologically significant. This model suggested that the odds of a female fledging young declined by a factor of 0.95 during the study period.

The selected model for the odds of nest success vs nest failure in a given year was a simple model that included no year or sex-effects, as follows:

$$\text{Relative odds of nest success} = 1.83 \quad (6)$$

This model indicated that, once they started to nest, spotted owls successfully produced young approximately 86% of the time, regardless of year or the age of the male and female.

Figure 5. Reproductive indices of Northern Spotted Owls, Cle Elum Study Area, Okanogan- Wenatchee National Forest, Washington, 1989-2002. Indices shown are: *proportion of females nesting* and *fecundity*. Sample size of females used for fecundity analysis for each year is shown plotted on axis Y2. Fecundity is the number of females produced per female owl, assuming a 50:50 sex ratio.



Two aspects of the reproductive trends on the Cle Elum Study Area are disturbing should they continue: 1) the number of sites where we have reproductive pairs of owls has declined since 1992; 2) the negative trends in the odds of females nesting and the odds of a female fledging young suggest the territories now occupied have a lower reproductive potential than those territories we were monitoring 10 years ago.

The decline in the number of owls detected on the GSA is also disturbing. One of the assumptions in The Northwest Forest Plan was that spotted owl populations would initially decline, and then begin to stabilize as conservation measures adopted in the plan began to have a beneficial effect. However, the Cle Elum population is showing no signs of stabilizing despite what appears to be a decline of approximately 60 % in the total number of occupied territories on the study area since 1992. Whether this decline is due to harvest of non-federal lands within the study area, the invasion of the area by barred owls, short-term weather patterns, or all of the above, is unknown. What we do know is that there has been little harvest of forests on federal lands within the study area since 1989, so there is no reason to believe that continued harvest of federal forests is exacerbating the decline.

Literature cited

Franklin, A. B., Burnham, K. P., White, G. C., Anthony, R. G., Forsman, E. D., Schwartz, C., Nichols, J. D., and Hines, J. 1999. *Range-wide status and trends in northern spotted owl populations*. Unpublished report. 71 pp.

Lint, J., Noon, B., Anthony, R., Forsman, E., Raphael, M., Collopy, M., and Starkey, E. 1999. Northern spotted owl effectiveness monitoring plan for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-440. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 43p.

Publications and presentations

Forsman, E.D., Otto, I.O., Sovern, S.G., Taylor, M., Hays, D.W., Allen, H., Roberts, S.L., and Seaman, D.E. 2001. Spatial and temporal variation in diets of spotted owls in Washington. Journal of Raptor Research 35: 141-150.

Forsman, E. D., R. G. Anthony, J. A. Reid, P. J. Loschl, S. G. Sovern, M. Taylor, B. L. Biswell, A. Ellingson, E. C. Meslow, G. S. Miller, K. A. Swindle, J. A. Thrailkill, F. F. Wagner, and D. E. Seaman. 2002. Natal and breeding dispersal of northern spotted owls. Wildlife Monographs No. 149.

For further reading, a thorough discussion of Spotted Owl demography in the Northwest can be found in the following journal articles:

Forsman, E. D., DeStefano, S., Raphael, M. G., and Gutiérrez, R. J., Eds. 1996. *Demographics of the northern spotted owl*. Studies in Avian Biology 17. 122 pp.

Franklin, A. B., Burnham, K. P., White, G. C., Anthony, R. G., Forsman, E. D., Schwartz, C., Nichols, J. D., and Hines, J. 1999. *Range-wide status and trends in northern spotted owl populations*. Unpublished report. 71 pp.

Appendix 1.

Table 1. Number of owls detected in the 204 km^2 Density Study Area (DSA) on the Cle Elum Ranger District Study Area, Okanogan-Wenatchee National Forest, Washington, 1991-2002.

Year	Adults (M/F)	Subadults (M/F)	Age Unk (M/F)	Fledglings	Total non-juveniles	Numberof Ad/Subad per km^2
1991	20 (11/9)	2 (2/0)	1 (1/0)	7	23	0.113
1992	16 (9,7)	3 (2,1)	3 (2,1)	17	22	0.108
1993	16 (8,8)	3 (2,1)	0	2	19	0.093
1994	14 (7,7)	2 (1,1)	1 (1,0)	14	17	0.083
1995	14 (7,7)	4 (3,1)	1 (1,0)	8	19	0.093
1996	12 (10,7)	3 (1,2)	2 (2,0)	12	17	0.083
1997	12 (7,5)	2 (1,1)	0	0	14	0.069
1998	13 (7,6)	3 (2,1)	2 (1,1)	9	18	0.088
1999	14 (9,5)	3 (1,2)	2 (1,1)	7	19	0.093
2000	14 (7,7)	4 (3,1)	0	11	18	0.088
2001	15 (7,8)	1 (1,0)	1 (0,1)	10	17	0.083
2002	13 (7,6)	0	1	5	13	0.064

Table 2. Number of pairs and single spotted owls detected in the 204 km^2 Density Study Area (DSA) on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1991-2002.

Year	Pairs	Singles[a]	Total adult/subadult
1991[b]	9	5	23
1992	9	4	22
1993[c]	9	1	19
1994	7	3	17
1995	8	3	19
1996	7	3	17
1997	6	2	14
1998	8	2	18
1999	8	3	19
2000[d]	8	2	18
2001	8	1	17
2002	6	1	13

[a] Includes two instances where single owls were detected at a territory where a pair of owls (both different owls than the single) was later verified.

[b] In 1991, there were two territories where different males were detected in the presence of the same female; only one of these territories was counted as a pair.

[c] In 1993, a new subadult male was found with the historic female at one territory, and later in the season, the historic male was verified roosting with the same female.

[d] In 2000, an adult female from a territory approximately 15 km away was found with a male in the DSA. This territory was listed as a single bird, because the female was recorded at her territory earlier in the year.

Table 3. Number of owls detected on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2002. Numbers reflect totals from the General Study Area and Density Study Area combined.

Year	Male (A,S,U)	Female (A,S,U)	Total (A,S,U)
1989	19 (16,2,1)	17 (11,4,2)	36 (27,6,3)
1990	43 (38,4,1)	40 (29,4,7)	83 (67,8,8)
1991	57 (49,6,2)	50 (35,11,4)	107 (84,17,6)
1992	63 (51,8,4)	57 (40,10,7)	120 (91,18,11)
1993	52 (44,5,3)	46 (40,5,1)	98 (84,10,4)
1994	49 (43,4,2)	50 (41,3,6)	99 (84,7,8)
1995	50 (40,7,3)	42 (36,4,2)	92 (76,11,5)
1996	41 (34,4,3)	40 (34,3,3)	81 (68,7,6)
1997	35 (29,5,1)	33 (31,2,0)	68 (60,7,1)
1998	40 (35,4,1)	38 (32,3,3)	78 (67,7,4)
1999	39 (30,5,4)	34 (24,5,5)	73 (54,10,9)
2000	35 (28,5,2)	33 (25,7,1)	68 (53,12,3)
2001	26 (24,1,1)	30 (25,3,2)	56 (49,4,3)
2002	24 (18,3,3)	20 (18,1,1)	44 (36,4,4)

Table 4. Number of territories surveyed, number of new territories added in a given year, and number of owls detected on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2002. Territories were considered surveyed if 3 visits were made to the territory in a given year.

Year	# territories surveyed	#number territories added	# owls detected	# territories occupied
1989	19	19	36	19
1990	46	27	83	43
1991	60	15	107	59
1992	72	11	120	64
1993	70	4	98	54
1994	77	2	99	53
1995	76	1	92	51
1996	71	1	81	46
1997	76	1	68	40
1998	78	1	78	44
1999	73	1	73	45
2000	72	0	68	39
2001	71	0	56	33
2002	74*	0	44	26

* Includes 8 territories where our survey included only 1 visit

Table 5. Proportion of female spotted owls that nested on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2002.

Year	No. females checked (A,S,U)	Proportion of females nesting[a]			
		Adult	Subadult	Unknown	Combined
1989	8 (6,1,1)	1.000 (0.48-1.00)	0.000	1.000 (0.00-1.00)	0.875 (0.37-0.99)
1990	20 (16,1,3)	0.938 (0.62-0.99)	0.000	1.000 (0.21-1.00)	0.900 (0.62-0.99)
1991	34 (24,9,1)	0.792 (0.53-0.93)	0.222 (0.01-0.62)	1.000 (0.00-1.00)	0.647 (0.43-0.81)
1992	47 (35,8,4)	1.000 (0.88-1.00)	1.000 (0.58-1.00)	1.000 (0.32-1.00)	1.000 (0.91-1.00)
1993	41 (37,4,0)	0.189 (0.06-0.37)	0.000	--	0.171 (0.06-0.34)
1994	40 (36,2,2)	0.944 (0.77-0.99)	0.500 (0.00-0.99)	1.000 (0.07-1.00)	0.925 (0.76-0.99)
1995	35 (31,3,1)	0.677 (0.45-0.84)	0.333 (0.00-0.92)	1.000 (0.00-1.00)	0.657 (0.44-0.82)
1996	34 (31,3,0)	1.000 (0.87-1.00)	0.667 (0.02-0.99)	--	0.971 (0.80-0.99)
1997	27 (26,1,0)	0.154 (0.03-0.37)	0.000	--	0.148 (0.03-0.36)
1998	34 (30,3,1)	0.933 (0.73-0.99)	0.667 (0.02-0.99)	1.000 (0.00-1.00)	0.912 (0.72-0.98)
1999	20 (18,2,0)	0.611 (0.31-0.84)	0.500 (0.00-0.99)	--	0.600 (0.31-0.82)
2000	27 (22,5,0,)	0.909 (0.65-0.99)	0.400 (0.01-0.87)	–	0..814 (0.57-0.94)
2001	23 (21,2,0)	0.810 (0.53-0.95)	0.000	--	0.739 (0.47-0.90)
2002	17 (16,1,0)	0.625 (0.31-0.86)	0.000	--	0.588 (0.28-0.83)

[a] Includes only data on females from sites where nesting was determined by 15 June. Sample does not include pairs where either males or females were wearing backpack radio transmitters in a given year. 95% confidence intervals around proportions from are in parentheses (Bailey, B. J. R. 1980. Large sample simultaneous confidence intervals for the multinomial probability base on transformation of the cell frequencies. Technometrics 22:583-589).

Table 6. Proportion of female spotted owls that fledged young on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2002.

Year	No. females checked (A,S,U)	Proportion of females fledging young[a]			
		Adult	Subadult	Unknown	Combined
1989	11 (7,2,2)	1.000 (0.53-1.00)	0.000	1.000 (0.07-1.00)	0.818 (0.40-0.98)
1990	31 (24,3,4)	0.833 (0.58-0.96)	0.000	0.750 (0.09-0.99)	0.742 (0.51-0.89)
1991	47 (33,11,3)	0.636 (0.42-0.81)	0.273 (0.03-0.63)	0.333 (0.00-0.92)	0.532 (0.35-0.69)
1992[b]	49 (36,10,3)	0.861 (0.67-0.96)	0.900 (0.46-0.99)	0.667 (0.02-0.99)	0.857 (0.70-0.94)
1993	46 (40,5,1)	0.150 (0.04-0.31)	0.000	0.000	0.130 (0.04-0.28)
1994	46 (39,3,4)	0.744 (0.54-0.88)	0.667 (0.02-0.99)	0.250 (0.00-0.83)	0.696 (0.51-0.83)
1995	41 (36,4,1)	0.528 (0.32-0.71)	0.250 (0.00-0.83)	1.000 (0.00-1.00)	0.512 (0.32-0.68)
1996	35 (32,3,0)	0.875 (0.67-0.97)	0.667 (0.02-0.99)	--	0.857 (0.66-0.96)
1997	33 (31,2,0)	0.097 (0.01-0.27)	0.000	--	0.091 (0.01-0.26)
1998	36 (32,3,1)	0.781 (0.56-0.91)	0.667 (0.02-0.99)	0.000	0.750 (0.54-0.89)
1999	27 (24,2,1)	0.375 (0.16-0.61)	0.500 (0.00-0.99)	0.000	0.370 (0.17-0.59)
2000	31 (25,6,0)	0.720 (0.46-0.89)	0.333 (0.01-0.80)	--	0.645 (0.42-0.82)
2001	27 (24,3,0)	0.667 (0.40-0.85)	0.000	–	0.593 (0.35-0.79)
2002	19 (18,1,0)	0.500 (0.22-0.76)	0.000	--	0.474 (0.20-0.73)

[a] Includes females at sites where number of young fledged was determined by 31 August. Sample does not include sites where either males or females were wearing backpack radio transmitters in a given year. 95% confidence intervals around proportions are in parentheses (Bailey, B. J. R. 1980. Large sample simultaneuos confidence intervals for the multinomial probability based on transformation of the cell frequencies. Technometrics 22:583-589).

[b] A female that nested and failed but re-nested after 26 April is counted in this sample as producing 2 young.

Table 7. Proportion of nesting female spotted owls that fledged young on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2002.

Year	No. nesting (A,S,U)	Proportion fledging young[a] Adult	Subadult	Unknown	Combined
1989	7 (6,0,1)	1.000 (0.48-1.00)	--	1.000 (0.00-1.00)	1.000 (0.53-1.00)
1990	17 (15,0,2)	0.933 (0.60-0.99)	--	1.000 (0.07-1.00)	0.941 (0.64-0.99)
1991	22 (19,2,1)	0.790 (0.49-0.94)	1.000 (0.07-1.00)	1.000 (0.00-1.00)	0.818 (0.54-0.95)
1992[b]	43 (33,8,2)	0.879 (0.68-0.97)	0.875 (0.37-0.99)	1.000 (0.07-1.00)	0.884 (0.72-0.96)
1993	7 (7,0,0)	0.857 (0.31-0.99)	--	--	0.857 (0.31-0.99)
1994	37 (34,1,2)	0.824 (0.62-0.94)	1.000 (0.00-1.00)	0.000	0.784 (0.58-0.91)
1995	23 (21,1,1)	0.857 (0.58-0.97)	1.00 (0.00-1.00)	1.000 (0.00-1.00)	0.870 (0.61-0.97)
1996	33 (31,2,0)	0.903 (0.70-0.98)	1.000 (0.07-1.00)	--	0.909 (0.71-0.98)
1997	4 (4,0,0)	0.750 (0.09-0.99)	--	--	0.750 (0.09-0.99)
1998	31 (28,2,1)	0.857 (0.63-0.96)	1.000 (0.07-1.00)	0.000	0.839 (0.62-0.95)
1999	12 (11,1,0)	0.727 (0.32-0.95)	1.000 (0.00-1.00)	--	0.750 (0.35-0.95)
2000	22 (20,2,0)	0.900 (0.62-0.99)	1.000 (0.07-1.00)	--	0.910 (0.65-0.99)
2001	17 (17,0,0)	0.824 (0.50-0.97)	--	--	0.824 (0.50-0.97)
2002	10 (10,0,0)	0.800 (0.36-0.98)	–	--	0.800 (0.36-0.98)

[a] Includes females at sites where nesting was determined by 15 June, and number of young fledged was determined by 31 August. Sample does not include sites where males or females were wearing backpack radio transmitters in a given year. 95% confidence intervals around proportions are in parentheses (Bailey, B. J. R. 1980. Large sample simultaneous confidence intervals for the multinomial probability based on transformation of the cell frequencies. Technometrics 22:583-589.).

Table 8. Mean brood size[a] of female spotted owls on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2002.

Year	No. females checked (A,S,U)	Mean brood size[b]			
		Adult	Subadult	Unknown	Combined
1989	9 (7,0,2)	2.000 (0.000)	--	1.500 (0.500)	1.889 (0.111)
1990	23 (20,0,3)	1.750 (0.099)	--	2.000 (0.000)	1.783 (0.088)
1991	25 (21,3,1)	1.714 (0.122)	1.333 (0.333)	2.000 --	1.680 (0.111)
1992	42 (31,9,2)	1.903 (0.107)	1.890 (0.200)	1.500 (0.500)	1.881 (0.091)
1993	6 (6,0,0)	1.667 (0.211)	--	--	1.667 (0.211)
1994	32 (29,2,1)	2.207 (0.115)	2.000 (0.000)	1.000 --	2.156 (0.111)
1995	21 (19,1,1)	1.579 (0.116)	2.000 --	1.000 --	1.571 (0.111)
1996	30 (28,2,0)	1.786 (0.094)	1.500 (0.500)	--	1.767 (0.092)
1997	3 (3,0,0)	1.333 (0.333)	--	--	1.333 (0.333)
1998	27 (25,2,0)	1.960 (0.135)	1.500 (0.500)	--	1.926 (0.130)
1999	10 (9,1,0)	1.556 (0.176)	2.000 --	--	1.600 (0.163)
2000	20 (18,2,0)	1.667 (0.114)	1.000 (0.000)	--	1.600 (0.112)
2001	16 (16,0,0)	1.625 (0.125)	--	--	1.625 (0.125)
2002	9 (9,0,0)	1.778 (0.147)	–	--	1.778 (0.147)

[a] Mean brood size was defined as the number of young fledged per female that successfully fledged young.

[b] Includes females at sites where the number of young fledged was determined by 31 August. Sample does not include those sites where either males or females were wearing backpack radio transmitters in a given year. Dead owlets or fledglings found beneath nests were counted as fledglings. Standard errors are in parentheses.

Table 9. Fecundity of female spotted owls on the Cle Elum Study Area, Okanogan-Wenatchee National Forest, Washington, 1989-2002.[a]

Year	No. females checked (A,S,U)	Fecundity[b]			
		Adult	Subadult	Unknown	Combined
1989	11 (7,2,2)	1.000 (0.000)	0.000 (0.000)	0.750 (0.250)	0.773 (0.124)
1990	31 (24,3,4)	0.729 (0.080)	0.000 (0.000)	0.750 (0.250)	0.661 (0.078)
1991	47 (33,11,3)	0.545 (0.082)	0.182 (0.102)	0.333 (0.333)	0.447 (0.068)
1992	49 (36,10,3)	0.819 (0.072)	0.850 (0.130)	0.500 (0.289)	0.806 (0.062)
1993	46 (40,5,1)	0.125 (0.050)	0.000 (0.000)	0.000 --	0.109 (0.044)
1994	46 (39,3,4)	0.821 (0.089)	0.667 (0.333)	0.125 (0.125)	0.750 (0.083)
1995	41 (36,4,1)	0.417 (0.073)	0.250 (0.250)	0.500 --	0.402 (0.068)
1996	35 (32,3,0)	0.781 (0.067)	0.500 (0.289)	--	0.757 (0.066)
1997	33 (31,2,0)	0.065 (0.038)	0.000 (0.000)	--	0.061 (0.036)
1998	36 (32,3,1)	0.766 (0.090)	0.500 (0.289)	0.000 --	0.722 (0.086)
1999	27 (24,2,1)	0.292 (0.085)	0.500 (0.500)	0.000 --	0.296 (0.081)
2000	31 (25,6,0)	0.600 (0.087)	0.167 (0.105)	--	0.516 (0.079)
2001	27 (24,3,0)	0.542 (0.090)	0.000 (0.000)	–	0.481 (0.086)
2002	19 (18,1,0)	0.389 (0.111)	0.000 –	--	0.368 (0.107)

[a] Includes females at sites where number of young fledged was determined by 31 August. Sample does not include sites where either males or females were wearing backpack radio transmitters in a given year.

[b] Fecundity was defined as the number of female offspring produced per female owl, assuming a 50:50 sex ratio among offspring. Dead owlets or fledglings found beneath nests were counted as fledglings Standard errors are in parentheses.

Appendix 2.

SAS output from final models described in text

Model (1)

```
      Poisson regression of owls detected on the General Study Area,
                Cle Elum Study Area, Washington, 1992-2002
       log(number of sites surveyed)=offset,survyear = survyear-1997

                          The GENMOD Procedure

                           Model Information

                Data Set                    WORK.COUNTS
                Distribution                    Poisson
                Link Function                       Log
                Dependent Variable                total
                Offset Variable                lognsurv
                Observations Used                    11


              Criteria For Assessing Goodness Of Fit

       Criterion                DF           Value        Value/DF

       Deviance                  9          5.8409          0.6490
       Scaled Deviance           9          5.8409          0.6490
       Pearson Chi-Square        9          5.7708          0.6412
       Scaled Pearson X2         9          5.7708          0.6412
       Log Likelihood                    2989.5811


   Algorithm converged.


                      Analysis Of Parameter Estimates

                              Standard   Wald 95% Confidence      Chi-
 Parameter   DF   Estimate      Error          Limits            Square   Pr > ChiSq

 Intercept    1     0.0470     0.0348    -0.0213     0.1152        1.82       0.1773
 survyear     1    -0.0802     0.0110    -0.1017    -0.0588       53.59       <.0001
 Scale        0     1.0000     0.0000     1.0000     1.0000

NOTE: The scale parameter was held fixed.
```

Model (2)

Regression of number of owls detected vs. year for Swauk DSA 1991-2002
yr standardized as year-1996.5
Reduced model
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	43.64336	43.64336	9.84	0.0106
Error	10	44.35664	4.43566		
Corrected Total	11	88.00000			

Root MSE	2.10610	R-Square	0.4959
Dependent Mean	18.00000	Adj R-Sq	0.4455
Coeff Var	11.70056		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	18.00000	0.60798	29.61	<.0001
yr	1	-0.55245	0.17612	-3.14	0.0106

Durbin-Watson D	1.315
Number of Observations	12
1st Order Autocorrelation	0.256

Model (3)

Regression of number of owls detected vs. year for Swauk DSA 1991-2002
yr standardized as year-1996.5
Rich model
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	65.69808	21.89936	7.86	0.0091
Error	8	22.30192	2.78774		
Corrected Total	11	88.00000			

Root MSE	1.66965	R-Square	0.7466
Dependent Mean	18.00000	Adj R-Sq	0.6515
Coeff Var	9.27585		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	18.00000	0.48199	37.35	<.0001
yr	1	0.28412	0.35801	0.79	0.4503
yr2	1	0.05544	0.04570	1.21	0.2597
yr3	1	-0.03937	0.01551	-2.54	0.0348

Durbin-Watson D	2.069
Number of Observations	12
1st Order Autocorrelation	-0.081

Model (4)

proc genmod output of logistic regression of prop. of females nesting,
Cle Elum Study Area, 1989-2002

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	575.6719	179.6578	223.5491	927.7946	10.27	0.0014
AGEF	A	1	1.7289	0.4594	0.8285	2.6294	14.16	0.0002
AGEF	S	0	0.0000	0.0000	0.0000	0.0000	.	.
AGEM	A	1	2.1431	0.4932	1.1764	3.1099	18.88	<.0001
AGEM	S	0	0.0000	0.0000	0.0000	0.0000	.	.
YEAR		1	-0.2887	0.0900	-0.4650	-0.1123	10.29	0.0013
even	0	1	-668.198	203.5064	-1067.06	-269.333	10.78	0.0010
even	1	0	0.0000	0.0000	0.0000	0.0000	.	.
YEAR*even	0	1	0.3333	0.1019	0.1336	0.5330	10.70	0.0011
YEAR*even	1	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	1.0000	0.0000	1.0000	1.0000		

NOTE: The scale parameter was held fixed.

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
AGEF	1	15.62	<.0001
AGEM	1	22.11	<.0001
YEAR	1	6.24	0.0125
even	0	0.00	.
YEAR*even	1	12.04	0.0005

Model (5)

proc genmod output of logistic regression of prop. of females fledging young
Cle Elum Study Area, 1989-2002

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	94.2877	53.8433	-11.2433	199.8187	3.07	0.0799
AGEF	A	1	0.9327	0.2939	0.3566	1.5087	10.07	0.0015
AGEF	S	0	0.0000	0.0000	0.0000	0.0000	.	.
YEAR		1	-0.0475	0.0270	-0.1004	0.0054	3.10	0.0785
Scale		0	1.0000	0.0000	1.0000	1.0000		

NOTE: The scale parameter was held fixed.

LR Statistics For Type 3 Analysis

Source	DF	Chi-Square	Pr > ChiSq
AGEF	1	10.42	0.0012
YEAR	1	3.12	0.0775

Model (6)

proc genmod output of logistic regression of prop. of nesting females fledging young, Cle Elum Study Area, 1989-2002

The GENMOD Procedure

Analysis Of Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	1.8305	0.1747	1.4880	2.1730	109.73	<.0001
Scale	0	1.0000	0.0000	1.0000	1.0000		

NOTE: The scale parameter was held fixed.