WILDLIFE HABITAT RELATIONSHIPS
IN WASHINGTON AND OREGON
FY2011

1. Title: Demographic characteristics of northern spotted owls (*Strix occidentalis*) on the Tyee Density Study Area, Roseburg, Oregon: 1985–2011.

2. Principal Investigator(s) and Organization(s): Dr. E. D. Forsman (PI), J. A. Reid (Assistant PI), U. S. Forest Service, Pacific Northwest Research Station. Biologists: S. M. Flannagan, J. S. Mowdy, A. L. Price, Department of Fisheries and Wildlife, Oregon State University.

3. Study Objectives:

a. Elucidate the population ecology of the spotted owl on the Tyee Density Study Area, northwest of Roseburg, Oregon to include estimates of population age structure, reproductive rates, survival rates, and population trends.

b. Document trends in numbers of spotted owls in a bounded study area.

c. Document social integration of juveniles into the territorial population to include age at pair formation and age at first breeding.

d. Document trends in barred owl numbers and interactions with spotted owls.

4. Potential Benefit or Utility of the Study:

The Tyee Density Study Area (DSA) on the Roseburg District of the Bureau of Land Management was designed to monitor age-specific birth and death rates of northern spotted owls, thereby allowing estimates of population trend over time. From these trends we make inferences regarding the suitability of the current habitat conditions and the effects of different landscape conditions on spotted owls. This study is one of eight long-term demographic studies that constitute the federal monitoring program for the northern spotted owl (Lint et. al., 1999, Anthony et. al., 2006, Forsman et al., 2011).

Management of forest lands by the BLM and private landowners within the boundaries of the DSA led to a reduction of suitable owl habitat during the last 40–50 years (Thomas et al. 1993). Although rates of harvest on BLM lands declined substantially since the adoption of the Northwest Forest Plan (USDA and USDI, 1994), there was an increased emphasis on thinning stands on federal lands, and harvest of old forests on non-federal lands continued. The effects of thinning within close proximity to owl sites is, as of yet, uncertain, although there was evidence that thinning in young stands in Washington and Oregon caused reductions in the density of northern flying squirrels (Wilson, 2010, Manning et al. 2011), which are an important prey of spotted owls in the Tyee Density Study Area (Forsman et al. 2004). Although habitat is still an important factor contributing to population stability of spotted owls, other factors such as climate change, increasing numbers of barred owls, and new pathogens such as West Nile Virus may also affect the numbers of spotted owls in the study area. While the data collected during this study cannot be used to predict future conditions, they can be used to assess predictive models that examine population projections under varying landscape

conditions or management regimes (Forsman et al., 2011).

We attempted to band all known fledglings produced in the study area since 1985. As a result, we know the origin and age of most individuals that were recruited into the population, and have detailed information on population age structure and internal and external recruitment in the study area.

5. Research Accomplishments:

Study Area and Methods

The Tyee Density Study Area (DSA) northwest of Roseburg, Oregon included a mixture of federal lands administered by the Bureau of Land Management (BLM) interspersed in a checkerboard pattern with intervening sections of private land (Fig. 1). Total size of the study area was approximately 1,025 km^2 (253,280 acres). We also monitor known spotted owl territories within a 6-mile buffer area outside the eastern and western boundaries of the DSA to reduce the amount of unknown emigration from the DSA (Reid et al. 1996). The study area included all or part of 4 Late-Successional Reserves (LSR's) as identified in the Northwest Forest Plan land-use allocations (USDA and USDI, 1994).

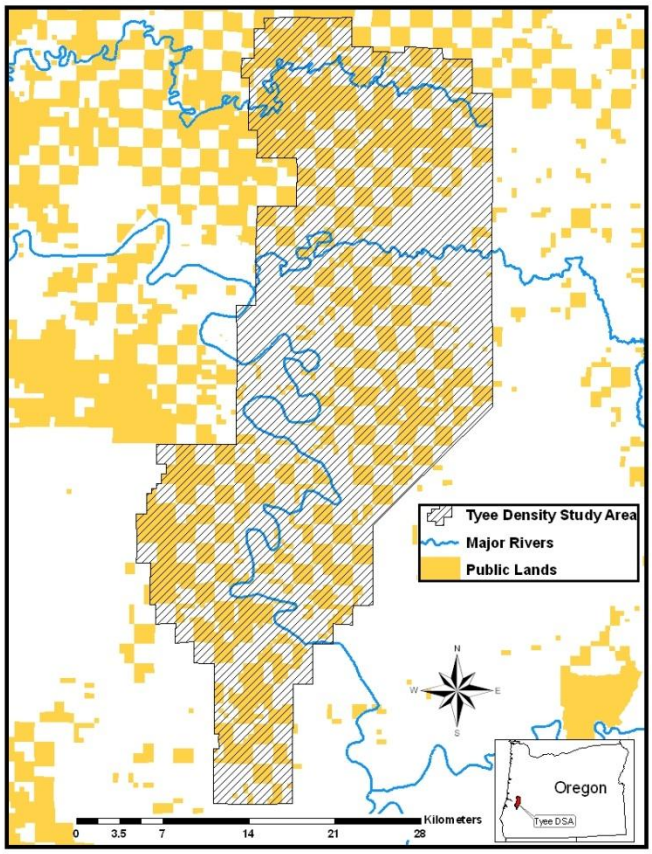


Figure 1. The hatched area represents the Tyee Density Study Area (DSA), Roseburg, Oregon.

Banding was initiated on the study area in 1983 and increased substantially in 1985. Surveys increased in 1987 to include all suitable spotted owl habitat. In 1989, the study area was expanded to include the upper third of the present area (Fig. 1). In 1990, we initiated the method in which we survey the entire study area each year (density study). Based on these surveys we estimate the actual number of territorial owls. The number of survey polygons within the DSA (160) remained relatively constant among years and was determined by the location of historical spotted owl site centers. The size of each survey polygon varied, depending on topography and land ownership, but was roughly equal to the area of a spotted owl territory. Areas between known spotted owl territories were delineated for survey depending on topography, road access, and distance from known spotted owl sites. In all surveys we document spotted owls as well as all other owls that were seen or heard.

Methods used in this study and other demographic studies of spotted owls have been described in a variety of published sources (e.g., Forsman 1983, Franklin et al. 1990, Franklin 1992, Franklin et al. 1999, Lint et al. 1999, Forsman et al. 2011). Seemingly unoccupied areas were surveyed with a minimum of 3 complete night visits spaced throughout the main survey season (1 March-31 August; Reid et. al, 1999). Resightings and recaptures of previously banded owls were used to estimate survival rates (Forsman et al. 2011).

Numbers of owls detected on the DSA

Between March 1983 and October 2011, we banded 948 spotted owls on the DSA, including 670 juveniles, 94 subadults, and 184 adults. The sex ratio of adults in the banded sample was slightly skewed towards males. By comparison, the sex ratio of subadults was skewed toward females (Appendix 1). The disproportionate number of males in the adult sample was most likely because males, especially unpaired males, were more detectable than females (Reid et al.1999).

In 2011, we documented 91 non-juvenile spotted owls in the DSA, including 32 pairs and 27 unpaired individuals (Appendix 2). This represents approximately 64% of the number of individuals that were located during the first year of the study in 1990 and was the lowest number of owls detected since inception of the study (Fig. 2).

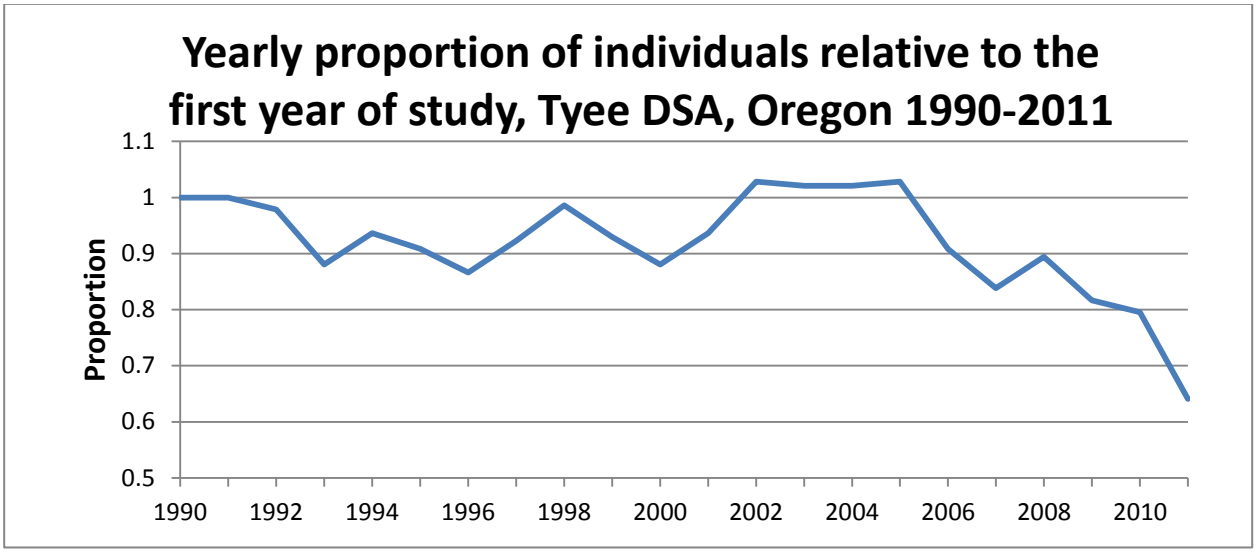


Figure 2. Yearly proportion of non-juvenile spotted owls detected relative to the first year of study, Tyee Density Study Area (DSA), Roseburg, Oregon, 1990-2011.

Within the DSA we documented 21 individuals that moved from their previous territory to another in 2011. Of the owls that moved, none were banded as juveniles and had not been previously documented in the territorial population (new recruits). Although the numbers of individuals and the annual proportion that moved within the DSA decreased, the trend was still increasing and linear (Fig. 3). We suspect that this increasing trend in the annual rate of movement among territories may be a response to competition with barred owls which were increasing on the Study Area (Fig. 4) (Yakulic, et. al. *in review*).

Number of sites with spotted owls

We defined a site as an area where a pair of spotted owls was documented in at least one year in the study and defined a pair as 2 individuals of opposite sex that clearly associated during the survey year. The number of sites with pairs declined rapidly after 2005 and had not recovered (Appendix. 2). In 2011, the number of pairs and the total number of non-juvenile spotted owls detected was below average for the 22 year survey period (Appendix 2, Fig. 2). In 2011, approximately 83% of the pairs (N=32) and all of the nesting pairs (N=3) in the DSA were located on federal land and 17% were on private land.

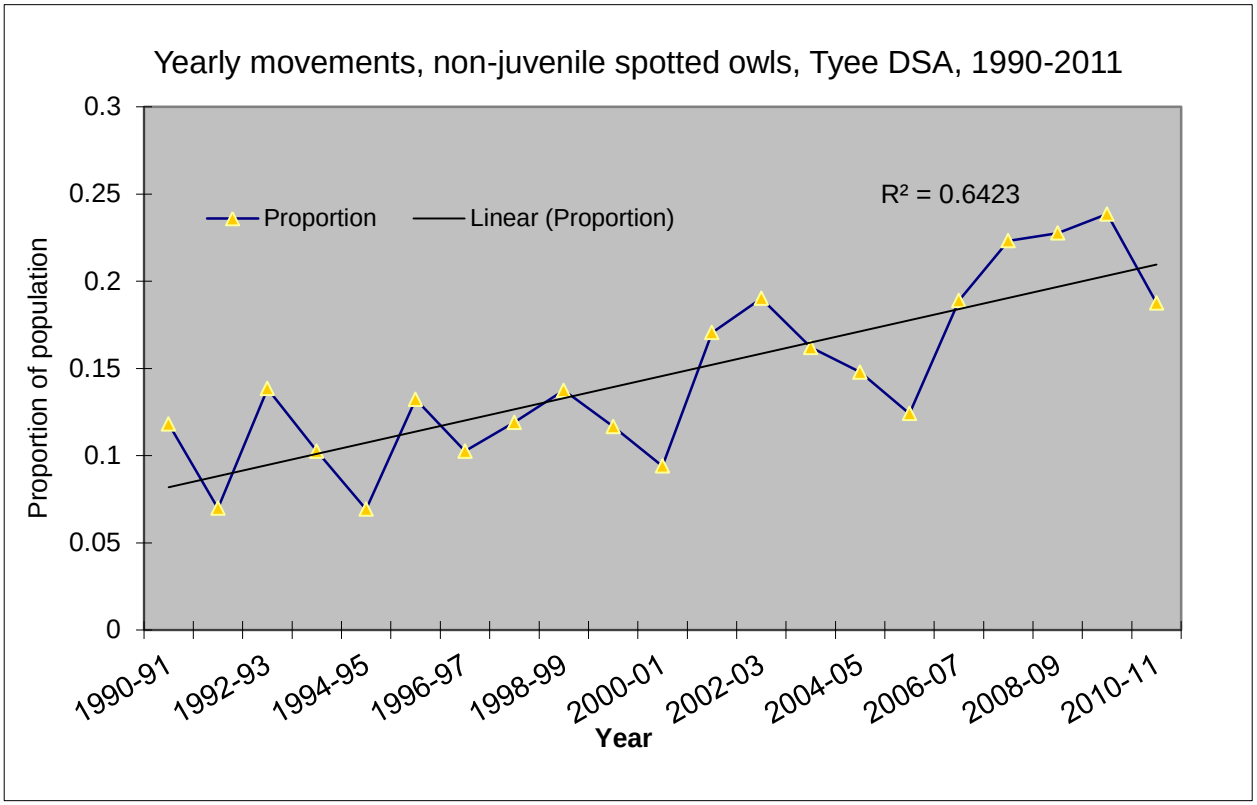


Figure 3. Yearly proportion of non-juvenile spotted owls known to have moved between territories on the Tyee Density Study Area, Roseburg, OR, 1990-2011.

Barred Owls

We documented barred owl detections since the inception of the study. Although we do not survey for barred owls, our methods for spotted owl surveys enabled us to estimate general trends in the barred owl population. The DSA was consistently surveyed in terms of area, intensity, and methods since 1990. In 2011, the number of survey areas where we detected barred owls continued to exceed the number of survey areas where we detected spotted owls (Fig. 4). The estimate of barred owls was considered conservative since we did not survey specifically for barred owls, and it was likely that some barred owls were not detected (Wiens et. al., 2011).

Although the majority of spotted owls were uniquely identified, the identity (band confirmation) of some of the spotted owls that were detected remained unknown and could have been individuals already identified during the survey season. The same circumstances applied to the barred owls, where most barred owls were unbanded and it was therefore impossible to confirm their unique identity. The number of areas where barred or spotted owls were detected consisted of any barred owl or spotted owl, regardless of identity (Fig. 3).

Movements

There appears to be no trend in the number of territories where spotted owls were detected (Fig. 4), but as the yearly number of individuals moving to different sites increased (Fig. 3), confirmations of individuals at more than one site in the same survey season also increased (Fig. 5). Causes for the linear increase in multiple observations could have included increased loss of spotted owl habitat (Kennedy et. al. 2010) leading to larger home ranges (Carey et. al., 1990), and barred owl

interactions (Dugger et. al., 2011, Van Lanen et. al., 2011, Yackulic, *in review*), but did not seem to be correlated with spotted owl reproductive output (R-squared= 0.1534)(Appendix 5).

Figure 4. Number of territories where barred owls and spotted owls were detected, Tyee Density Study Area, Roseburg, Oregon: 1990-2011.

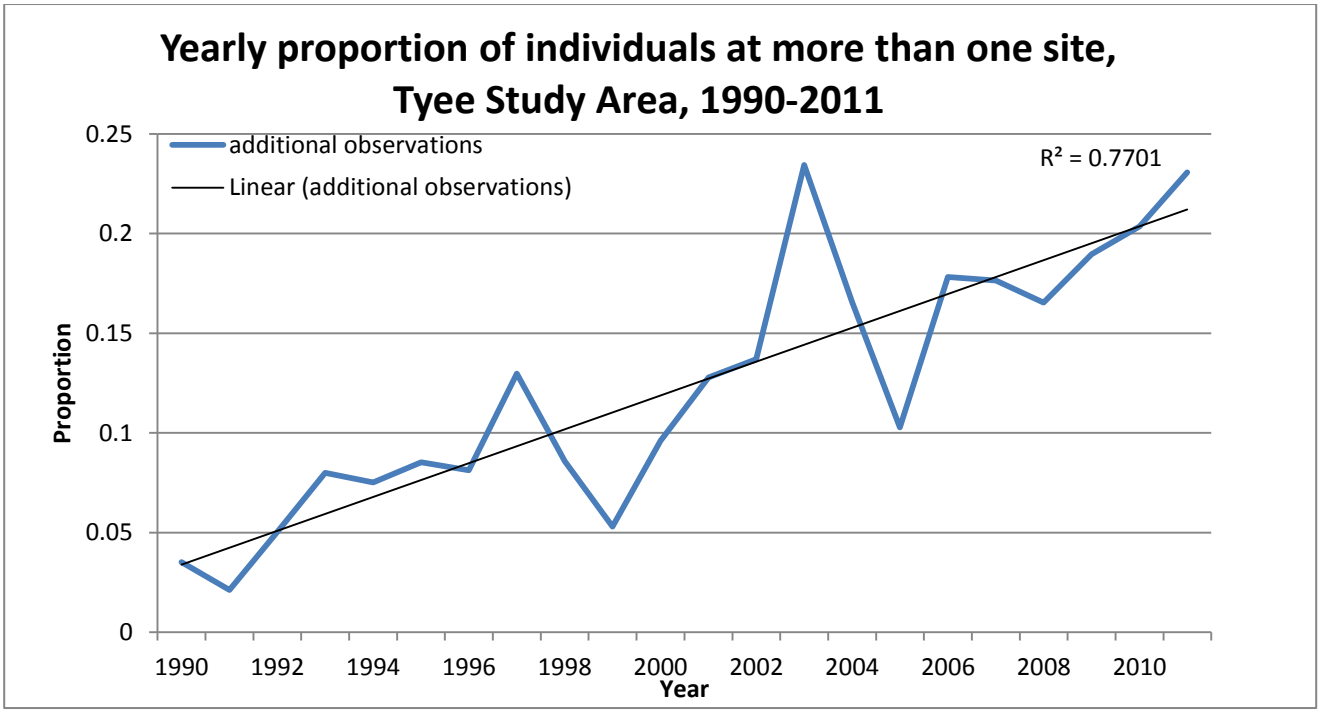


Figure 5. Proportion of spotted owls documented at more than one site during the same survey season, Tyee Density Study Area, Roseburg, Oregon: 1990-2011.

Reproduction

Nesting in 2011 was well below average, with 13% (95% CI = 0.00-0.25) of females nesting. Of the 3 females that nested, only 1 successfully produced young (Table 1). For all years combined, the percentage of females that nested averaged 52% (N= 22 years) and the percentage of nesting females that fledged young averaged 65% (Table 1).

Average female fecundity (the estimated number of female offspring produced per resident female) in 2011 was 0.027 (SE = 0.03), which was considerably lower than the average of 0.256 for all years (N=22) (Appendix 3). The data continued to indicate that most measures of reproductive performance of spotted owls were lowest for 1-yr-old owls, intermediate for 2-yr-old owls, and highest for adults (Tables 2–3). Sample size of 1-yr-old females was too small to estimate some parameters (Table 2–3).

Banding juvenile owls can give us insight into first year survival, average and maximum lifespan, genealogy, dispersal distances, and age composition of the population (e.g., see Forsman et al. 2002). It can also provide insight into the origin of new recruits as well as the individual territory productivity. We attempted to band all known fledglings in the DSA since 1985. Only 2 young were produced in the study area in 2011. Reproduction in the each of the last 6 years was below the 22 year average of 30.0 (Appendix 2) and may have been related to the exponential increase in the number of barred owls in the study area (Fig. 6).

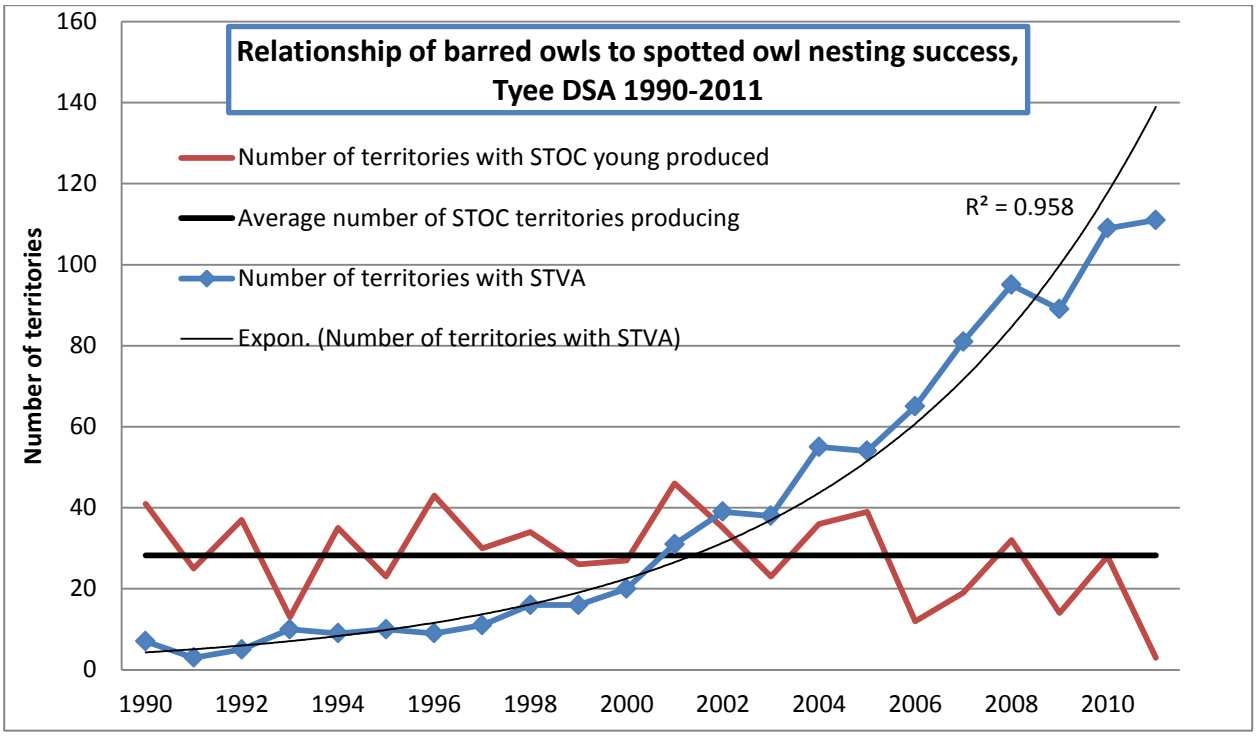


Figure 6. Yearly number of survey polygons in the Tyee DSA where barred owls were detected and where spotted owl reproduction was documented, 1990-2011. In the last 6 years, where barred owl numbers were the highest, the number of reproductively successful spotted owl sites was below the 22 year average.

Table 1. Annual reproductive statistics for female spotted owls on the Tyee Density Study Area, Roseburg, Oregon: 1990–2011.

	Proportion nesting [1]			Proportion fledging young [2]			Proportion nesting that fledged young [3]		
Year	N	Prop.	95% C.I.	N	Prop.	95% C.I.	N	Prop.	95% C.I.
1990	53	0.736	0.61–0.86	61	0.475	0.35–0.60	41	0.707	0.56–0.85
1991	56	0.446	0.31–0.58	59	0.237	0.13–0.35	25	0.560	0.35–0.77
1992	58	0.603	0.47–0.73	62	0.484	0.36–0.61	37	0.811	0.68–0.94
1993	47	0.255	0.13–0.38	54	0.130	0.04–0.22	13	0.538	0.22–0.85
1994	57	0.579	0.45–0.71	60	0.383	0.26–0.51	35	0.657	0.49–0.82
1995	53	0.415	0.28–0.55	60	0.200	0.10–0.30	23	0.522	0.30–0.74
1996	48	0.813	0.70–0.93	56	0.607	0.48–0.74	43	0.791	0.66–0.92
1997	51	0.588	0.45–0.73	55	0.327	0.20–0.46	30	0.600	0.41-0.79
1998	61	0.557	0.43–0.69	63	0.429	0.30–0.55	34	0.794	0.65–0.93
1999	45	0.556	0.40–0.71	55	0.327	0.20–0.46	26	0.692	0.51–0.88
2000	50	0.500	0.36–0.64	54	0.315	0.19–0.44	27	0.630	0.44–0.82
2001	54	0.796	0.69–0.91	61	0.639	0.52–0.76	46	0.848	0.74–0.96
2002	56	0.571	0.44–0.71	65	0.385	0.26–0.51	35	0.714	0.56–0.87
2003	58	0.379	0.25–0.51	67	0.194	0.10–0.29	23	0.565	0.35–0.78
2004	63	0.540	0.41–0.67	66	0.424	0.30–0.55	36	0.778	0.64–0.92
2005	61	0.639	0.52–0.76	66	0.439	0.32–0.56	39	0.744	0.60–0.89
2006	54	0.222	0.11-0.34	57	0.140	0.05-0.23	12	0.667	0.35-0.98
2007	44	0.432	0.28-0.58	48	0.292	0.16-0.43	19	0.737	0.52-0.95
2008	42	0.714	0.57-0.86	51	0.314	0.18-0.45	32	0.500	0.32-0.68
2009	41	0.317	0.17-0.47	45	0.178	0.06-0.29	14	0.571	0.27-0.87
2010	45	0.644	0.50-0.79	48	0.250	0.12-0.38	28	0.429	0.23-0.62
2011	31	0.129	0.00-0.25	37	0.027	0.00-0.08	3	0.333	0.00-1.00
Mean	22	**0.520**		22	**0.327**		22	**0.645**	

[1] Estimates were calculated for females whose nesting status was determined by protocol.
[2] Estimates were calculated for females whose reproductive status was determined by 31 August.
[3] Estimates were calculated for females whose reproductive status was determined to protocol and reproductive status by 31 August.

Table 2. Average age-specific reproductive parameters of female spotted owls on the Tyee Density Study Area, Roseburg, Oregon: 1990–2011.

	Proportion nesting [1]			Proportion fledging young [2]			Proportion nesting that fledged young [3]		
Age	N	Prop.	95% C.I.	N	Prop.	95% C.I.	N	Prop.	95% C.I.
1 year old	56	0.160	0.06–0.26	70	0.029	0.00–0.07	8	0.250	0.00–0.64
2 years old	84	0.440	0.33–0.55	98	0.245	0.16–0.33	39	0.615	0.46–0.78
Adults	977	0.557	0.53–0.59	1062	0.368	0.34–0.40	564	0.693	0.66–0.73
Unknown	11	0.545	0.19–0.90	20	0.250	0.04–0.46	10	0.500	0.12–0.88

[1] Estimates were calculated for females whose nesting status was determined to protocol.
[2] Estimates were calculated for females whose reproductive status was determined by 31 August.
[3] Estimates were calculated for females whose reproductive status was determined to protocol and reproductive status by 31 August.

Table 3. Average age-specific fecundity and brood size of female spotted owls on the Tyee Density Study Area, Roseburg, Oregon: 1990–2011.

		Fecundity [1]			Brood size[2]		
Age	N	Mean	SE		N	Mean	SE
1 year old	70	0.029	0.020		2	2.000	0
2 years old	9	0.204	0.038		24	1.667	0.098
Adults	1026	0.287	0.012		391	1.558	0.025
Unknown	20	0.175	0.075		5	1.400	0.245

[1] Fecundity was defined as number of female young produced per female. We assumed a 1:1 sex ratio for fledglings.
[2] Both fecundity and brood size were based on the number of young seen outside the nest tree, regardless of whether they were dead or alive.

Interesting observations and unusual events that were documented in 2011:

We documented a few interesting events and observations both inside and outside of our DSA that are worth mentioning:

Since 1990, 6 different barred owl/spotted owl hybrids were documented in our study area (3 females and 3 males). In 2011, we documented one site with a hybrid male (spotted owl/barred owl) in the DSA. Hybrids exhibit intermediate plumage characteristics of both species, and vocalizations appeared to be unique to each individual.

Barred owl interference with spotted owl demographic surveys has become evident. The affect has been on an increasing effort to locate, identify, and determine reproductive status of the spotted owl individuals in the population. All but one of the unknown age individual spotted owls in 2011, whose identity we could not confirm during the entire survey season, were in close proximity to (or directly interacted with) barred owls. In some cases, we observed aggressive physical contact

between the 2 species, indicating a lack of tolerance for the other species.

Problems encountered:
We routinely were granted permission to locate and observe spotted owls on the private property of many different landowners. In 2010, we were denied access to determine occupancy and reproductive output at two sites in the southern end of our study area. This probably did not influence our estimate of mean productivity, but could influence our ability to detect trends within the study area.

6. Summary

The number of spotted owls detected in the DSA continued to decline. When factors including habitat availability remain constant, the overall number of pairs in the study area was directly related to the previous reproductive output and can, therefore, be one of the more important metrics to assess future population levels. Low reproductive years, or years with poor first year survival, can impact the future population size. In 2011, we documented the fewest number of pairs and individuals, and the lowest reproduction since the inception of the study in 1990 (Appendices 2 and 4). Fecundity was well below the average for all years combined. Spotted owl numbers have fluctuated in the last few years but the low reproductive output in the past several years suggests that this number will not increase substantially in the near future because population increases usually occur in years following high reproductive output (Appendix 4).

In 2011, the number of nesting attempts was the lowest on record and resulted in the fewest number of young produced in all years of the study (Table 1). The low rate of nesting attempts for this year may be due in part to the unfavorable weather conditions (Franklin et. al, 2000), but the decreasing number of pairs in the study area only compounds the effects of weather on reproductive output.

The number of territories that produced young was below average for the last 5 out of 6 years (Fig. 6). At the same time, the number of territories where barred owls were detected increased and continued at an exponential rate (r^2= 0.958) (Fig. 6). Future recruitment into the spotted owl population depends on the reproductive output of previous years. If this is any indication of the trend in future population, we can expect that the numbers of spotted owls recruited into the breeding population to decrease over time.

Barred owls almost certainly compete with spotted owls for both food and space (Hamer et al. 2007, 2001). Our study area recently experienced rapid increases in barred owl detections and it appears that this may be correlated with increased social instability, lower overall reproductive output, apparent abandonment of territories, and possibly lower detection rates of spotted owls (Bailey, et. al, 2009, Yakulic, et. al. *in review*). If habitat remains the same or decreases and barred owl numbers remain the same or increase, the spotted owl population will likely continue to experience declines.

7. Publications and Presentations:

a) We provided information to the USFWS for the final Revised Recovery Plan for the Northern Spotted Owl (Section 2).

b) We provided information to Ron Gaines, Environmental Services Northwest, and biological consultant for Lone Rock Timber Company.

c) We provided survey information to Roseburg, and Coos Bay Districts of the BLM for the sites that we surveyed in their districts.

d) We provided spotted owl survey information to Oregon Department of Forestry.

e) Journalists, authors, university professors, and conservation organizations contacted us for field outings and we accommodated their requests.

f) We provided survey information to several landowners including Weyerhaeuser Company, Roseburg Resources, Seneca Jones Timber Company, and several other smaller landowners that granted us access to conduct surveys.

g) We provided feather samples for genetic analysis and datasets for pedigree analysis to the USGS genetics lab in Corvallis.

h) Forsman, E. D., Anthony, R. G., Dugger, K. M., Glenn, E. M., Franklin, A. B., White, G. C., Schwarz, C. J., Burnham, K. P., Anderson, D. R., Nichols, J. D., Hines, J. E., Lint, J. B., Davis, R. J., Ackers, S. H., Andrews, L. S., Biswell, B. L., Carlson, P. C., Diller, L. V., Gremel, S. A., Herter, D. R., Higley, J. M., Horn, R. B., Reid, J. A., Rockweit, J., Schaberl, J., Snetsinger, T. J. and Sovern. S. G. 2011. Population demography of northern spotted owls: 1985–2008. Studies in Avian Biology.

i) Glenn, E. M., R. G. Anthony, and E. D. Forsman. 2010. Population trends in northern spotted owls: associations with climate in the Pacific Northwest. Biological Conservation 143:2543-2552.

j) Glenn, E. M., R. G. Anthony, E. D. Forsman, and G. S. Olson. 2011. Local weather, regional climate, and annual survival of the northern spotted owl. Condor 113:159-176.

k) Glenn, E. M., R. G. Anthony, E. D. Forsman, and G. S. Olson. 2011. Reproduction of northern spotted owls: the role of local weather and regional climate. Journal of Wildlife Management. 75:1279-1294.

l) Yackulic, C. B., J. A. Reid, R. J. Davis, J. E. Hines, J. D. Nichols, and E. D. Forsman, Inferring Local Occupancy Dynamics during Species Expansions: the barred owl in the Oregon Coast Ranges, Ecology (*in review*).

m) We nominated a private landowner within the study area for the 2010 Oregon Chapter of the Wildlife Society's Private Landowner Stewardship Award. Allan Branscomb was presented with the award at the 2011 annual meeting for his many efforts to promote sound science and wildlife conservation.

8. Acknowledgments

This study was funded by the USDI Bureau of Land Management Oregon State Office and the USDA Forest Service, Pacific Northwest Region. The Roseburg District of the BLM provided invaluable support in all phases of the research. We would like to thank the Weyerhaeuser Company, Roseburg Resources, Lone Rock and Juniper Properties, Seneca Timber Company,

Giustina Resources, and Bear Creek Timber for allowing us access to their lands. *Westside Ecological* provided spotted owl visit information to us. Several small private landowners provided invaluable access through and to their property.

Literature Cited:

Anthony, R. G., E.D. Forsman, A.B. Franklin, D.R. Anderson, K.P. Burnham, G.C. White, C.J. Schwarz, J.D. Nichols, J.E. Hines, G.S. Olson, S.H. Ackers, L.S. Andrews, B.L. Biswell, P.C. Carlson, L.V. Diller, K.M. Dugger, K.E. Fehring, T.L. Fleming, R.P. Gerhardt, S.A. Gremel, R.J. Gutiérrez, P.J. Happe, D.R. Herter, J.M. Higley, R.B. Horn, L.L. Irwin, P.J. Loschl, J.A. Reid and S.G. Sovern, 2006. Status and trends in demography of northern spotted owls, 1985–2003. Wildlife Monographs. No.163.

Bailey, L. L., J. A. Reid, E. D. Forsman, and J. D. Nichols. 2009. Modeling co-occurrence of northern spotted and barred owls: Accounting for detection probability differences. Biological Conservation 142:2983–2989.

Carey, A. B., J. A. Reid and S. P. Horton, 1990. Spotted Owl Home Range and Habitat Use in Southern Oregon Coast Ranges. The Journal of Wildlife Management, Vol. 54, No. 1, pp. 11-17

Dugger, K. M., Anthony, R. G., and Andrews, L. S. 2011. Transient dynamics of invasive competition: Barred Owls, Spotted Owls, habitat, and the demons of competition present. Ecological Applications 21:2459–2468.

Forsman, E. D. 1983. Methods and materials for locating and studying spotted owl. USDA Forest Service General Technical Report PNW-162.

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.

Forsman, E. D., R. G. Anthony, E. C. Meslow, and C. J. Zabel. 2004. Diets and foraging behavior of northern spotted owls in Oregon. Journal of Raptor Research 38:214-230.

Forsman, E. D., Anthony, R. G., Dugger, K. M., Glenn, E. M., Franklin, A. B., White, G. C., Schwarz, C. J., Burnham, K. P., Anderson, D. R., Nichols, J. D., Hines, J. E., Lint, J. B., Davis, R. J., Ackers, S. H., Andrews, L. S., Biswell, B. L., Carlson, P. C., Diller, L. V., Gremel, S. A., Herter, D. R., Higley, J. M., Horn, R. B., Reid, J. A., Rockweit, J., Schaberl, J., Snetsinger, T. J. and Sovern.S. G. 2011. Population demography of northern spotted owls: 1985–2008. Studies in Avian Biology.

Franklin, A. B., J. P. Ward, R. J. Gutiérrez, and G. I. Gould. 1990. Density of northern spotted owls in northwest California. Journal of Wildlife Management 54:1–10.

Franklin, A. B. 1992. Population regulation in northern spotted owls: theoretical implications for management. Pages 815–827 in D. R. McCullough and R. H. Barrett, eds. Wildlife 2001: populations. Elsevier Applied Sciences, London. 1163pp.

Franklin, A. B., K. P. Burnham, G. C. White, R. G. Anthony, E. D. Forsman, C. Schwarz, J. D. Nichols, and J. Hines. 1999. Range-wide status and trends in northern spotted owl populations. Department of Wildlife and Fisheries, Colorado State University. 71 pp.

Franklin, A. B., D. R. Anderson, R. J. Gutierrez, K.P. Burnham. 2000. Climate, Habitat Quality, and Fitness in Northern Spotted Owl Populations in Northwestern California. Ecological Monograph, Vol. 70, No. 4. Pp. 539-590.

Hamer, T. E., E. D. Forsman, and E. M. Glenn. 2007. Home range and habitat selection of barred owls and spotted owls in area of sympatry. The Condor 109(4):750-768.

Hamer, T. E., D. L. Hayes, C. M. Senger, and E. D. Forsman. 2001. Diets of northern barred owls and northern spotted owls in an area of sympatry. Journal of Raptor Research 35:221-227.

Kennedy, R.E., Yang, Z., & Cohen, W.B. 2010. Detecting trends in forest disturbance and recovery using yearly Landsat time series: 1. LandTrendr - temporal segmentation algorithms. Remote Sensing of Environment, 114(12):2897-2910.

Lint, J., B. Noon, R. Anthony, E. Forsman, M. Raphael, M. Collopy, and E. Starkey. 1999. Northern spotted owl effectiveness monitoring plan for the northwest forest plan. USDA Forest Service General Technical Report PNW-GTR-440.

Reid, J. A., E. D. Forsman, and J. L. Lint. 1996. Demography of northern spotted owls on the Roseburg District of the Bureau of Land Management, Oregon. Pp. 59–66 In Forsman, E. D., S. DeStefano, M. G. Raphael, and R. J. Gutiérrez [eds.], Demography of the northern spotted owl. Studies in Avian Biology No 17.

Reid, J. A., R. B. Horn and E. D. Forsman. 1999. Detection rates of spotted owls based on acoustic-lure and live-lure surveys. Wildlife Society Bulletin. 27:986–990.

Thomas, J. W., M. G. Raphael, R. G. Anthony, E. D. Forsman, A. G. Gunderson, R. S. Holthausen, B. G. Marcot, G. H. Reeves, J. R. Sedell, and D. M. Solis. 1993. Viability assessments and management considerations for species associated with late-successional and old-growth forests of the Pacific Northwest. The report of the scientific analysis team. USDA Forest Service, Portland, OR. 530pp.

USDA and USDI. 1994. Final supplemental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. 2 volumes. U. S. Department of Agriculture - Forest Service and U.S. Department of Interior - Bureau of Land Management, Portland, Oregon, USA.

Van Lanen, N. J., A. B. Franklin, K. P. Huyvaert, R. F. Reiser II, P. C. Carlson. 2011. Who hits and hoots at whom? Potential for interference competition between barred and northern spotted owls. Biological Conservation, 144 (2011) pp. 2194–2201.

Yackulic, C. B., J. A. Reid, R. J. Davis, J. E. Hines, J. D. Nichols, and E. D. Forsman, Inferring Local Occupancy Dynamics during Species Expansions: the barred owl in the Oregon Coast Ranges, Ecology (*in review*).

Wiens, J. D., R.G. Anthony and E.D. Forsman, Barred owl occupancy surveys within the range of the northern spotted owl. Journal of Wildlife Management, 75 3 (2011), pp. 531–538.

Wilson, T. M. 2010. Limiting factors for northern flying squirrels (*Glaucomys sabrinus*) in the Pacific Northwest: a spatio-temporal analysis. PhD. Dissertation. Union Institute & University, Cincinnati, Ohio.

Appendix 1. Number of previously unbanded spotted owls banded, Tyee Density Study Area, Roseburg, Oregon: 1990–2011.

	Adults		Subadults		Fledglings
Year	Male	Female	Male	Female	
<1990[1]	66	51	12	12	58
1990	14	7	4	7	31
1991	4	5	5	3	23
1992	3	5	2	3	44
1993	1	0	2	1	11
1994	0	2	2	2	28
1995	1	1	0	0	16
1996	1	0	0	0	53
1997	2	0	0	0	26
1998	1	0	1	2	34
1999	0	2	2	1	26
2000	1	1	1	0	28
2001	2	0	0	2	68
2002	2	1	1	4	40
2003	0	1	1	2	18
2004	1	2	0	1	37
2005	0	1	0	1	45
2006	2	0	2	0	10
2007	1	0	1	2	20
2008	1	1	2	2	29
2009	3	3	0	0	11
2010	0	0	1	1	15
2011	1	0	1	1	2
Total	107	83	39	46	671

[1]Includes those owls banded 1983-1989. The analysis for the DSA focuses on 1990-2011.

Appendix 2. Number of spotted owls detected within the Tyee Density Study Area (DSA), Roseburg, Oregon: 1990–2011.

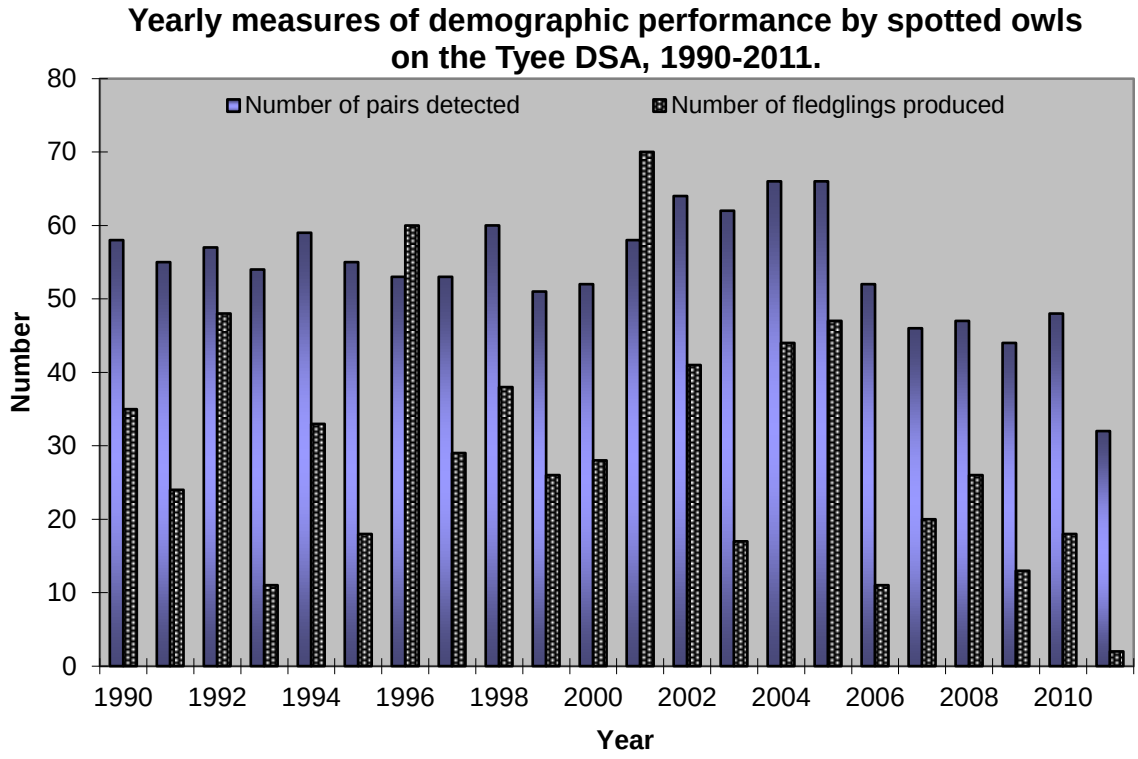
		Adults		1– 2-year-old		Age Unknown			Non-
Year	Pairs	Male	Female	Male	Female	Male	Female	Fledglings	Juveniles
1990	58	61	49	7	10	7	8	35	142
1991	55	60	51	12	6	7	6	24	142
1992	57	60	52	10	8	4	5	48	139
1993	54	56	44	8	9	4	4	11	125
1994	59	60	51	10	9	1	2	33	133
1995	55	63	54	1	3	2	6	18	129
1996	53	56	51	5	5	4	2	60	123
1997	53	57	49	14	6	4	1	29	131
1998	60	53	46	18	14	5	4	38	140
1999	51	58	50	8	4	9	3	26	132
2000	52	57	53	5	2	5	3	28	125
2001	58	61	51	9	8	1	3	70	133
2002	64	60	48	17	17	3	1	41	146
2003	62	64	46	15	17	1	2	17	145
2004	66	73	60	4	5	1	2	44	145
2005	66	71	59	8	7	1	0	47	146
2006	52	58	50	10	9	2	0	11	129
2007	46	59	42	4	7	5	2	20	119
2008	47	63	43	9	8	2	2	26	127
2009	44	56	35	9	9	3	4	13	116
2010	48	51	42	13	6	1	0	18	113
2011	32	43	35	5	2	5	1	2	91
AVG	**54.2**	**59.1**	**48.2**	**9.1**	**7.8**	**3.5**	**2.8**	**30.0**	**130.5**

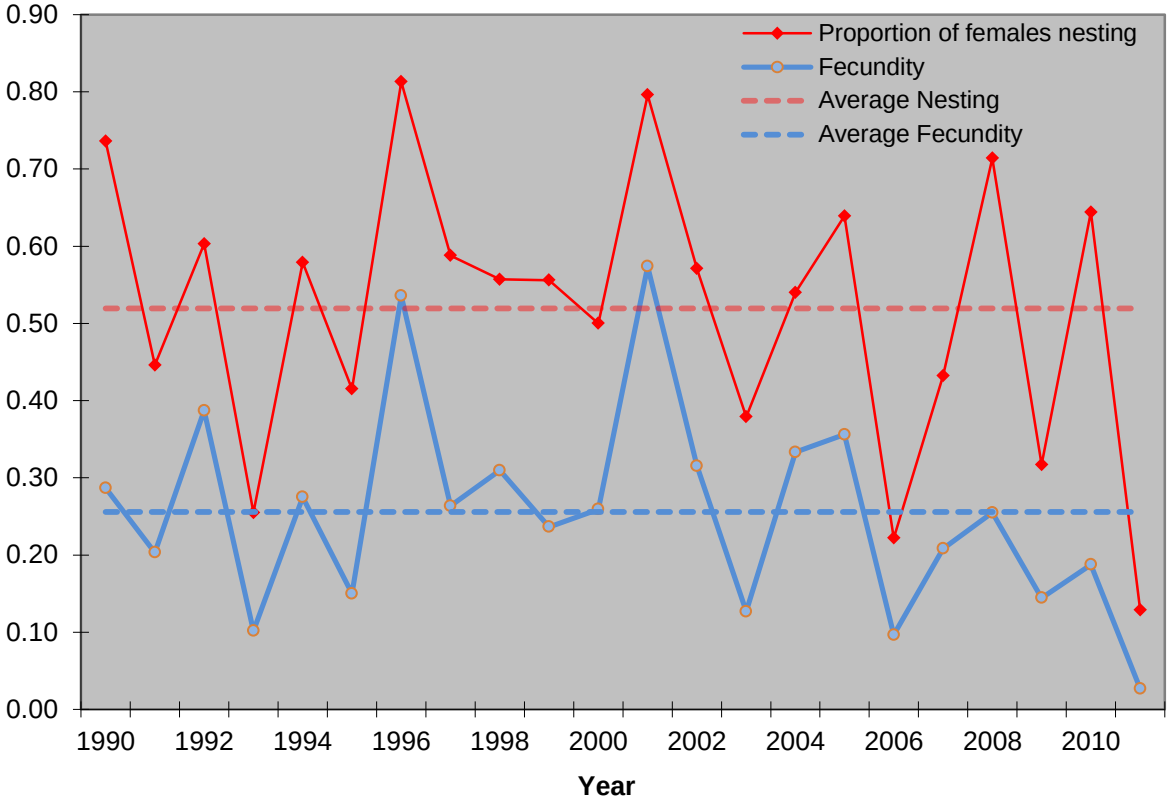
Appendix 3. Estimated fecundity and mean brood size of female spotted owls on the Tyee Density Study Area: 1990–2011. Fecundity was defined as the number of female young produced per female owl assuming a 1:1 sex ratio. Estimates were calculated for individual females for which reproductive output was documented by 31August.

	Fecundity[1]			Brood size[2]		
Year	N	Mean	SE	N	Mean	SE
1990	61	0.287	0.043	29	1.207	0.077
1991	59	0.203	0.050	14	1.714	0.125
1992	62	0.387	0.056	30	1.600	0.091
1993	54	0.102	0.038	7	1.571	0.202
1994	60	0.275	0.050	23	1.435	0.106
1995	60	0.150	0.042	12	1.500	0.151
1996	56	0.536	0.062	34	1.765	0.074
1997	55	0.264	0.055	18	1.611	0.118
1998	63	0.310	0.050	27	1.444	0.097
1999	55	0.236	0.050	18	1.444	0.121
2000	54	0.259	0.056	17	1.647	0.119
2001	61	0.574	0.061	39	1.795	0.075
2002	65	0.315	0.053	25	1.640	0.098
2003	67	0.127	0.034	13	1.308	0.133
2004	66	0.333	0.052	28	1.571	0.095
2005	66	0.356	0.054	29	1.621	0.092
2006	57	0.096	0.034	8	1.375	0.183
2007	48	0.208	0.051	14	1.429	0.137
2008	51	0.255	0.057	16	1.625	0.125
2009	45	0.144	0.049	8	1.625	0.183
2010	48	0.188	0.051	12	1.500	0.151
2011	37	0.027	0.027	1	2.000	N/A
Mean	**21**	**0.256**	0.029	**21**	**1.544**	0.032

[1] Fecundity was defined as number of female young produced per female. We assumed a 1:1 sex ratio for fledglings.
[2] Both fecundity and brood size were based on the number of young seen outside the nest tree, regardless of whether they were dead or alive.

Appendix 4. Annual estimates of selected demographic parameters for spotted owls, Tyee DSA, 1990-2011.





Appendix 5. Yearly proportion of spotted owls documented at more than one site during the survey season (x-axis) plotted against the relative trend of cumulative habitat loss, proportion of territories with barred owls, and proportion of spotted owls fledging young (respectively). Solid lines represent linear trends and their associated R-quared.