WILDLIFE HABITAT RELATIONSHIPS
IN WASHINGTON AND OREGON
FY2009

1. Title: Demographic characteristics of northern spotted owls (*Strix occidentalis*) on the Tyee Density Study Area, Roseburg, Oregon: 1985–2009.

2. Principal Investigator(s) and Organization(s): Dr. E. D. Forsman (PI), Lead Biologist: J. A. Reid, U. S. Forest Service, Pacific Northwest Research Station. Biologists: J. D. Baldwin, 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.

Management of forest lands by the BLM and private landowners within the boundaries of the DSA has 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 has declined substantially since the adoption of the Northwest Forest Plan (USDA and USDI, 1994), there is an increased emphasis on thinning stands on federal lands, and harvest of old forests on non-federal lands has continued. The effects of thinning within close proximity to owl sites is, as of yet, uncertain, although there is evidence that thinning in young stands in Washington caused reductions in the density of northern flying squirrels (Wilson 2010), which are a primary 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 barred owl numbers, 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. *in review*).

We have 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 are 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, includes 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 is 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 includes all or part of 4 Late-Successional Reserves (LSR's) as identified in the Northwest Forest Plan land-use allocations (USDA and USDI, 1994).

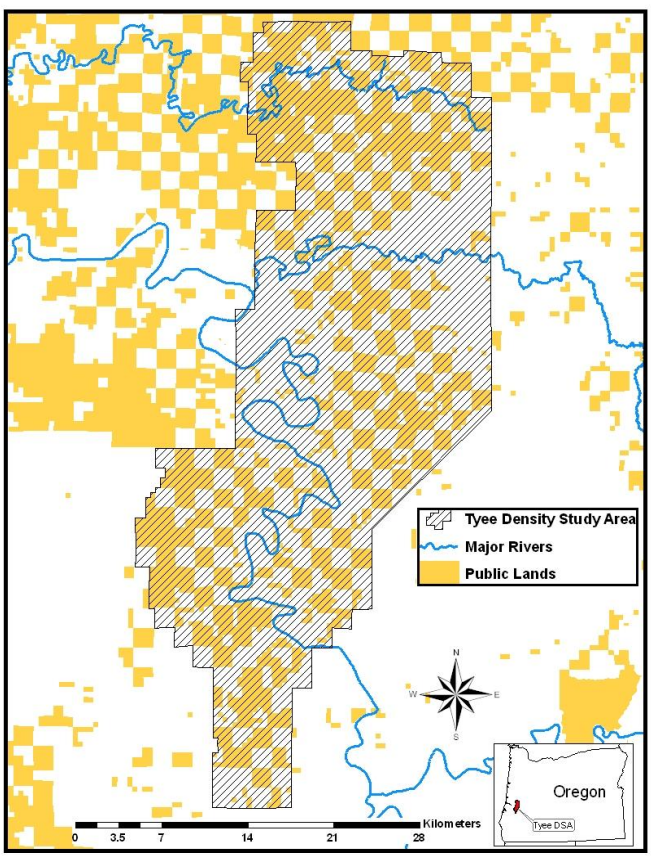

Figure 1. The hatched area represents the Tyee Density Study Area (DSA), Roseburg, Oregon.

Banding was initiated on the study area in 1983 and increased substantially in 1985. Surveys increased in the study area to include suitable spotted owl habitat in 1987. In 1989, the study area was expanded to include the upper third portion of the present area (Fig. 1). In 1990, we initiated the density study area method in which we survey the entire study area each year. Based on these surveys we estimate the actual number of territorial birds. The number of survey polygons within the DSA (160) has remained relatively constant among years and was determined by the location of historical spotted owl site centers. The size of each survey polygon varies, depending on topography and land ownership, but is roughly equal to the area of a spotted owl

territory. Areas between known spotted owl territories are 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 are 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). Seemingly unoccupied areas were surveyed with 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. *in review*, Anthony et al. 2006).

Numbers of owls on the DSA

Between March 1983 and October 2009, we banded 990 spotted owls on the DSA, including 676 juveniles, 92 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, are more detectable than females (Reid et al.1999).

In 2009, we documented 116 non-juvenile owls in the DSA, including 44 pairs and 28 unpaired owls. Subadults comprised 16% of the population in the DSA in 2009, up from 13% in 2008 (Fig. 2, Appendix 2).

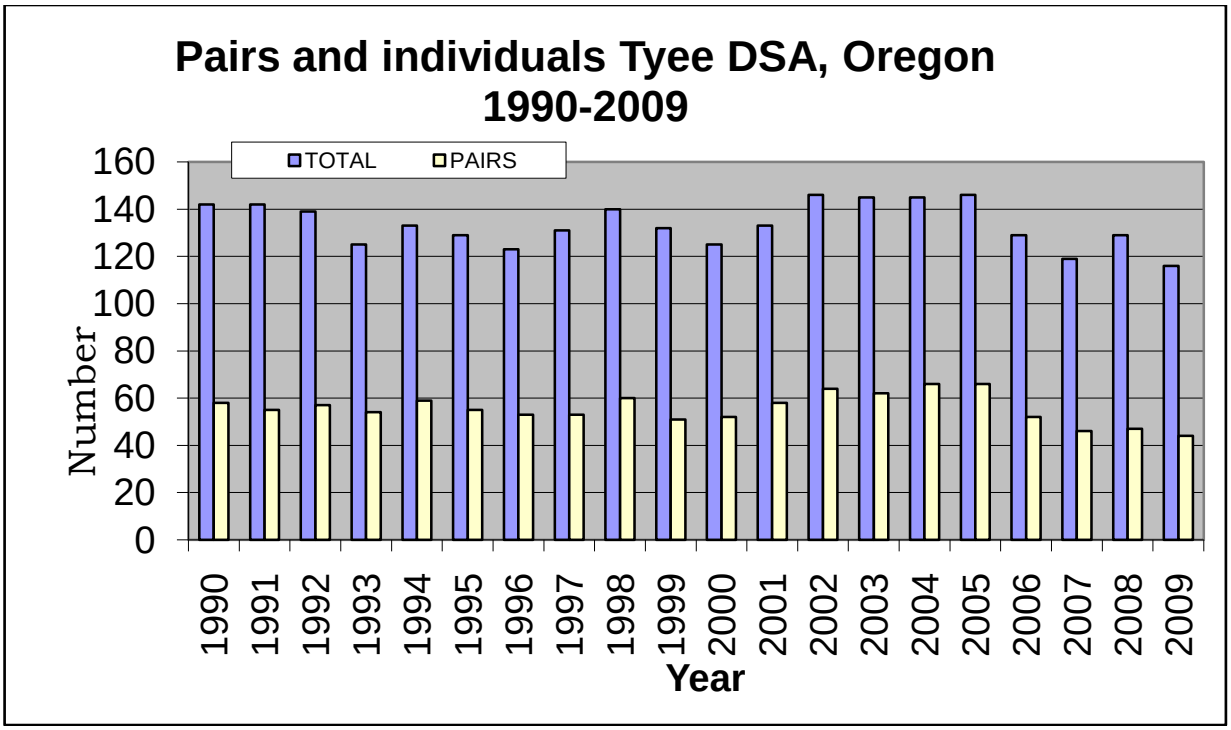

Figure 2. Numbers of non-juvenile spotted owls and territorial pairs in the Tyee Density Study Area (DSA), Roseburg, Oregon, 1990-2009.

Between 2008 and 2009, we documented 30 movements of individuals from one territory to another within the DSA. Of the owls that moved, 7 were banded as juveniles and had not been previously documented in the territorial population (new recruits). Although the numbers of individuals that move within the DSA has decreased, the population estimate has decreased as well, such that the annual proportion of individuals that move is actually increasing (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 are increasing on the Study Area (Fig. 4).

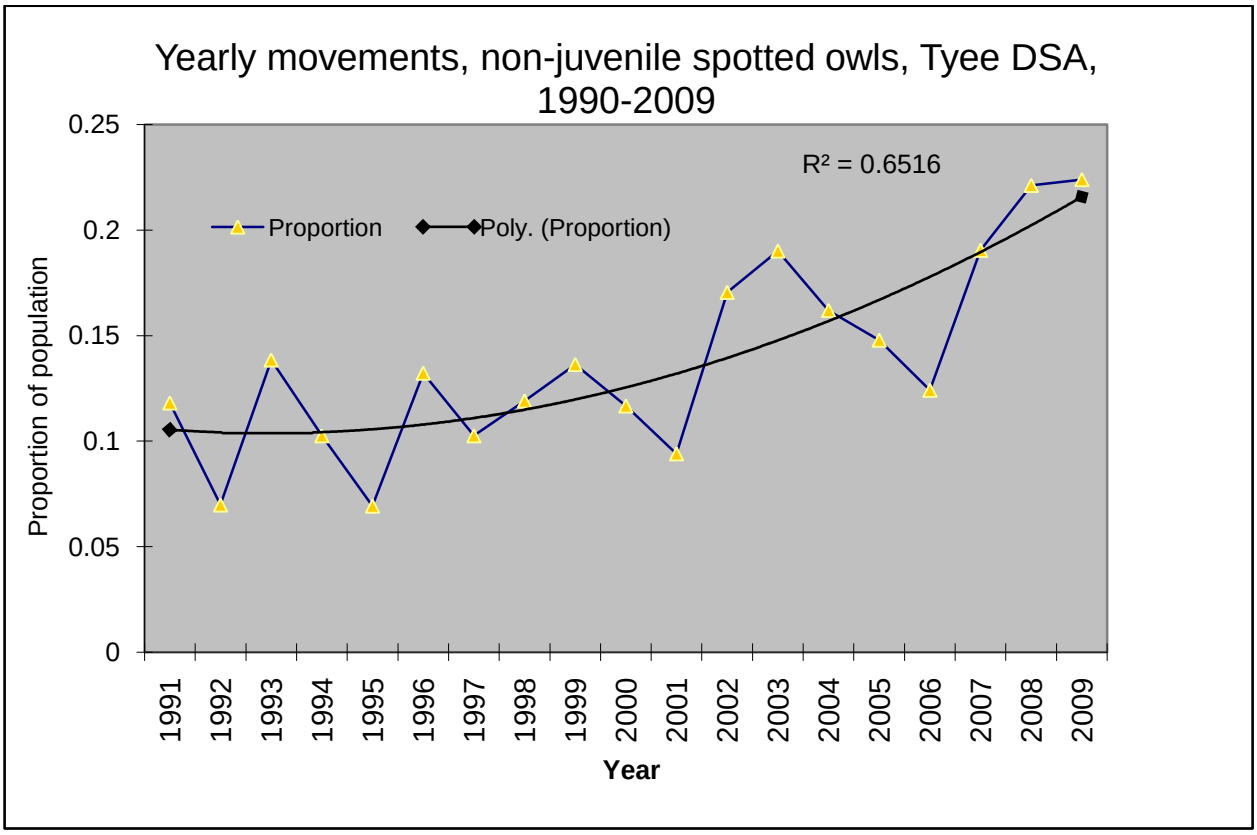

Figure 3. Polynomial trend line (2 change points) fitted to the actual proportion of non-juvenile spotted owls that were known to have moved between territories each year within the Tyee Density Study Area, Roseburg, OR, 1990-2009.

Site occupancy

We defined a site as an area where a pair of spotted owls was documented in at least one year in the survey history. We 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 has not recovered (Fig. 2). In 2009, the number of pairs and the total number of non-juvenile spotted owls detected were the lowest on record (Fig. 2, Appendix 2).

In the Smith River watershed in the northern third of our study area we documented 7 pairs in 2005, 3 pairs in 2006 and 2007 and 2 pairs in 2008 and 2009. In 2009, approximately 72 % of the pairs in the DSA were located completely on federal land,

14% were located in areas with a mixture of federal and private lands and 14 % were completely on private land. Most (87%) of the nesting pairs in 2009 were located on federal lands. Commensurate with a decline in territories with spotted owl pairs, the proportion of survey effort conducted at night (in minutes) has changed from 24% in 1990 to almost 42% in 2009. This change is due to the fact that we have gradually had to increase the amount of time spent surveying for spotted owls at night because of the increasing number of sites where no spotted owls are detected on the initial diurnal survey.

Reproduction

Nesting in 2009 was considerably below average, with only 34% (CI = 0.19-0.49) of females nesting, and only 53% (CI = 0.25-0.82) of nesting females successfully producing young (Table 1). For all years combined, the percentage of females that nested averaged 53% (N= 20 years) and the percentage of nesting females that fledged young averaged 67% (Table 1).

Average female fecundity (the estimated number of female offspring produced per resident female) in 2009 was 0.148 (SE = 0.50), which was one of the lowest estimates for the DSA, and approximately half of the 20-yr average for 1990-2009 (0.271, Appendix 3). The data continue to indicate that most measures of reproductive performance of spotted owls are 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). In contrast to some other study areas (Anthony et al., 2006), the pattern for reproductive performance has not consistently followed an even-odd year pattern (Table 1, Appendix 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. In the process of banding, we have collected genetic material that has been used to assess and analyze potential problems with gene flow and bottlenecks (Funk, et. al., 2009). We have attempted to band all known fledglings in the DSA since 1985. Those that we could not band were always due to the inability to locate them after repeated visits.

Table 1. Annual reproductive statistics for female spotted owls on the Tyee Density Study Area, Roseburg, Oregon: 1990–2009.

	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	.736	0.61–0.86		61	.475	0.35–0.60		41	.707	0.56–0.85
1991	56	.446	0.31–0.58		59	.237	0.13–0.35		25	.560	0.35–0.77
1992	58	.603	0.47–0.73		62	.484	0.36–0.61		37	.811	0.68–0.94
1993	48	.2710	0.14–0.40		54	.130	0.04–0.22		15	.467	0.18–0.75
1994	58	.569	0.44–0.70		60	.383	0.26–0.51		35	.657	0.49–0.82
1995	53	.415	0.28–0.55		60	.200	0.10–0.30		23	.522	0.30–0.74
1996	48	.813	0.70–0.93		56	.607	0.48–0.74		43	.791	0.66–0.92
1997	51	.588	0.45–0.73		55	.327	0.20–0.46		30	.600	0.41-0.79
1998	61	.557	0.43–0.69		63	.429	0.30–0.55		34	.794	0.65–0.94
1999	45	.556	0.40–0.71		55	.327	0.20–0.46		26	.692	0.50–0.88
2000	50	.500	0.36–0.64		54	.315	0.19–0.44		27	.630	0.43–0.82
2001	54	.796	0.69–0.91		61	.639	0.52–0.76		46	.848	0.74–0.96
2002	56	.571	0.44–0.71		56	.385	0.26–0.51		35	.714	0.56–0.87
2003	58	.379	0.25–0.51		67	.194	0.10–0.29		23	.565	0.35–0.78
2004	63	.540	0.41–0.67		66	.424	0.30–0.55		36	.778	0.64–0.92
2005	61	.639	0.52–0.76		66	.439	0.32–0.56		39	.744	0.60–0.89
2006	54	.222	0.11-0.34		57	.140	0.05-0.23		12	.667	0.35-0.98
2007	44	.432	0.28-0.58		48	.292	0.16-0.43		19	.737	0.52-0.95
2008	42	.714	0.57-0.86		51	.314	0.18-0.45		32	.500	0.32-0.68
2009	41	.341	0.19-0.49		44	.182	.006-0.30		15	.533	0.25-0.82
Mean	20	**0.534**			20	**0.346**			20	**0.666**	

[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: 1990–2009.

	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	54	0.167	0.06–0.27	68	0.044	0.00–0.09	9	.333	0.00–0.72
2 years old	81	0.395	0.29–0.50	92	0.217	0.13–0.30	36	.556	0.39–0.73
Adults	908	0.570	0.54–0.60	985	0.387	0.36–0.42	538	.708	0.67–0.75
Unknown	11	0.545	0.19–0.90	19	0.263	0.05–0.48	10	.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: 1990–2009.

	Fecundity [1]			Brood size		
Age	N	Mean	SE	N	Mean	SE
1 year old	68	0.044	0.025	3	2.000	0.000
2 years old	92	0.179	0.038	20	1.650	0.109
Adults	985	0.302	0.013	381	1.559	0.026
Unknown	19	0.184	0.078	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.

Barred Owls

We have documented barred owl detections since the inception of the study. Although we do not actively survey for barred owls, our methods for spotted owl surveys have enabled us to estimate trends in the barred owl population as well. The DSA has been consistently surveyed in terms of area, intensity, and methods since 1990, except for an increase in the relative amounts of nocturnal versus diurnal surveys, as noted earlier. In 2008 the number of survey areas where we detected barred owls reached a peak and then dipped slightly in 2009 (Fig. 4). The estimate of barred owls was considered conservative since we did not survey specifically for barred owls.

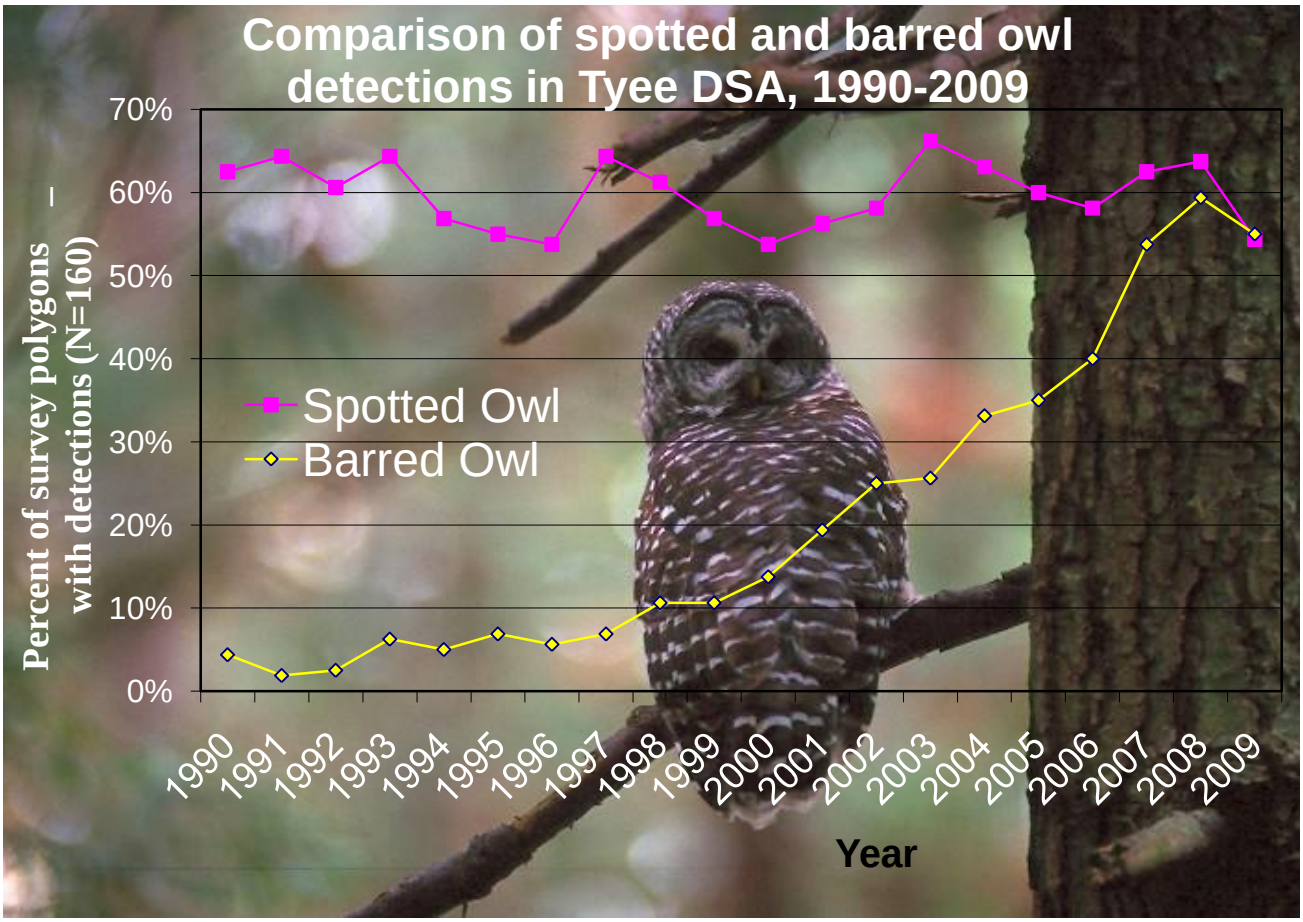

Figure 4. Number of territories where barred owls and spotted owls were detected, Tyee Density Study Area, Roseburg, Oregon: 1990-2009.

There appears to be no trend in the number of territories where spotted owls were detected (Fig. 4). However, the identity of some of the individuals detected was not known, and as the number of movements of non-juvenile spotted owls has increased over time, some of these individuals may be counted more than once as they move through the landscape, respond to our survey technique, but remain unidentified (Fig. 3).

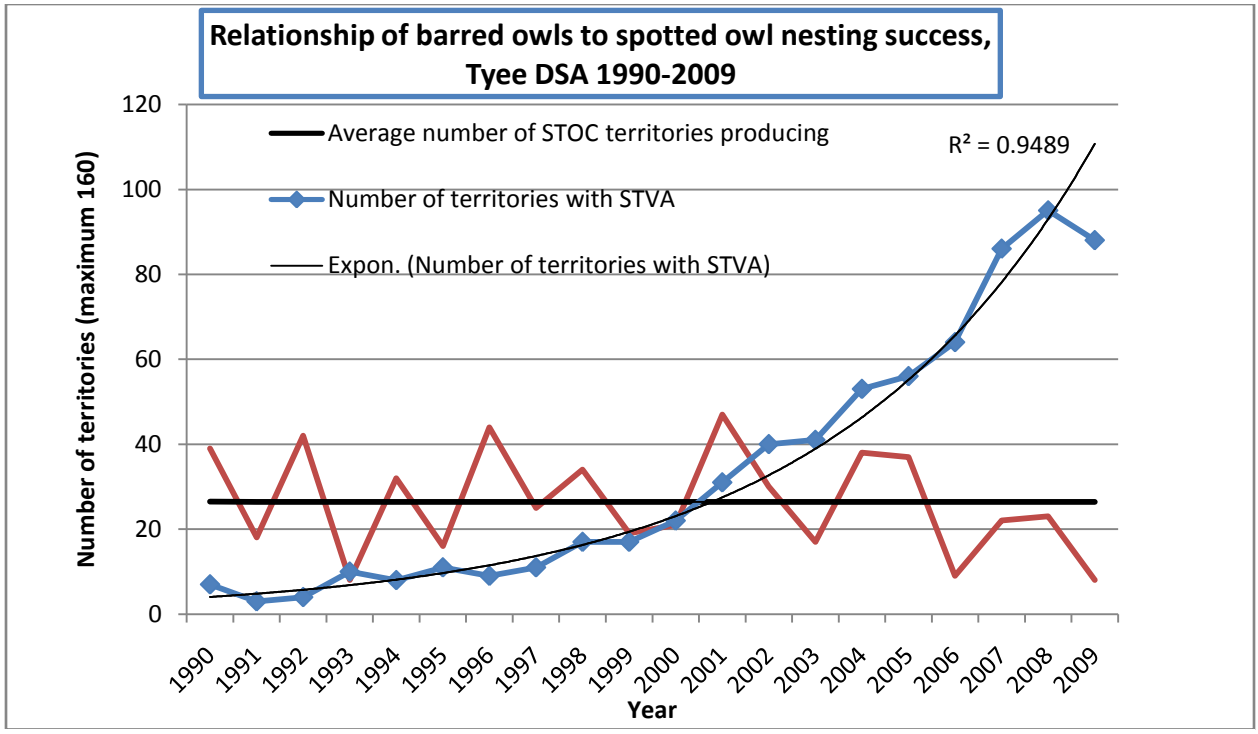

Figure 5. Yearly number of territories in the Tyee DSA where barred owls were detected and where spotted owl reproduction was documented, 1990-2009. In the last 4 years, where barred owl numbers are the highest, the number of reproductively successful spotted owl territories has fallen below the 20 year average.

In January 2009, we and our cooperators from other demographic study areas conducted a week-long workshop in which we used all of our respective data sets to assess the status and trends of the northern spotted owl. Data were assembled for all of the long term spotted owl studies and analyzed in a meta-analysis. The report from that workshop is currently undergoing peer review and will be presented in a separate publication (Forsman et al., *in review*).

Interesting observations and unusual events that were documented in 2009:

In 2009, we documented a pair of spotted owls that nested in a hole in the side of a small sandstone cliff that was surrounded by forest. This is the second instance of cliff-nesting by spotted owls in the DSA. The previous instance was in 2002, at the same territory, and involved the same pair of owls (Hane et al. 2007).

In 2009, we surveyed a territory where Great Gray Owls were documented in the previous 3 years. The territory had been heavily impacted by harvest over the past winter and our surveys resulted in no detections.

For the past 2 field seasons we have been using plastic push-in rivets to attach color bands to assess whether they result in less band loss than the aluminum pop-rivets that we have used in all prior years. The impetus for this change was the occurrence of broken and missing color bands. In 2009, we estimated that 17% of the plastic color bands on non-juvenile spotted owls were either missing or showed some sign of damage.

In 2003 and 2005, juvenile spotted owls that were hatched in captivity at the Oregon High Desert Museum were fostered into nests of spotted owls on the DSA. One of the 2 juveniles fostered in 2003 has been paired inside the DSA since 2005. One of the two juveniles fostered in 2005 was re-observed in 2009 outside of our study area and was paired. No reproduction was documented from either of these females.

In 2007, a barred owl/spotted owl interaction study was initiated to the north of the DSA (Wiens, 2009). Sites immediately outside the DSA were included in the interaction study, and individual radio-marked spotted owls from the interaction study were infrequently located within the DSA during our demographic surveys. Specifically, a female spotted owl that was radio-marked as part of the interaction study was located in the breeding season in 2008 and nested unsuccessfully. One other female was repeatedly located in 2 successive non-breeding periods immediately adjacent to our DSA, and a radio-marked male was found on multiple occasions within the DSA. In 2009, we again found this male within the DSA, and we removed his non-functioning radio.

Between 1990 and 2008, we documented 9 cases where territories were occupied by 3 individuals (a pair plus an additional spotted owl). The extra individuals included 4 males and 5 females). In all 9 cases, the resident spotted owl pairs were aware of the additional individual. In 2009 we documented 3 cases of the same behavior. We also documented the same individual male spotted owl at several apparently unoccupied survey areas (territories). Locations of this male were as much as 6.4 km (4 miles) apart during the survey season. In addition, we documented 6 cases where 2 or more males were present at the same territory.

In 2009, we documented 2 hybrid males (spotted owl/barred owl) in the DSA. Hybrids exhibit plumage characteristics that are intermediate between both species, and vocalizations appear to be unique to each individual.

Although not inside of our DSA, we documented a few interesting events and observations outside of our DSA that are worth mentioning:

We discovered a blind fledgling spotted owl that we removed from the wild and euthanized at the Oregon State University Veterinary Diagnostics Lab. There was no trauma to the eyes or evidence of bacterial infection, so the exact cause of blindness was undetermined. However, the necropsy results revealed that Leucocytozoan parasites were present in the eyes and may have been responsible for the blindness.

Through the use of a genealogy program, we were able to identify two 8-yr-old siblings that were paired and not nesting on a territory that was 40 km from their natal site.

6. Summary

The number of spotted owls detected in the DSA continues to decline. In 2009, we documented the lowest number of pairs in the study area since 1990 and one of the lowest reproductive years as well (Appendices 2 and 4). Many of the traditional measures of reproductive performance are provided in this report. 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). When factors including habitat availability remain constant, the overall number of pairs in the study area is 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.

We were unsure if the high rate of spotted owl nesting failure in 2009 was directly linked to harassment by barred owls, but that certainly seems possible (Table 1, Fig. 5). In 2009, we suspected that barred owls were interfering with at least 2 nesting pairs of spotted owls which subsequently produced no young. In 2008, both pairs of nesting spotted owls that we reported as being directly negatively influenced by barred owls moved to other territories in 2009. Direct observation of such events is difficult to document as an observer must be present when the confrontation occurs.

The number of territories that produced spotted owl young has been below average for the last 4 consecutive years (Fig. 5). At the same time, the number of territories where barred owls have been detected has exponentially increased (R^2= 0.9489) (Fig. 5). 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. Figure 6 shows the decadal shift of the spotted owl pairs and their reproductive status in relation to the detections of barred owls. The representation is meant to show the trends rather that the complete inventory of barred owls in our study area as we do not conduct barred owl specific surveys.

Barred owls almost certainly compete with spotted owls for both food and space (Hamer et al. 2007, 2001). Our study area has 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 by spotted owls, possibly lower detection rates of spotted owls (Bailey, et. al, 2009). 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.

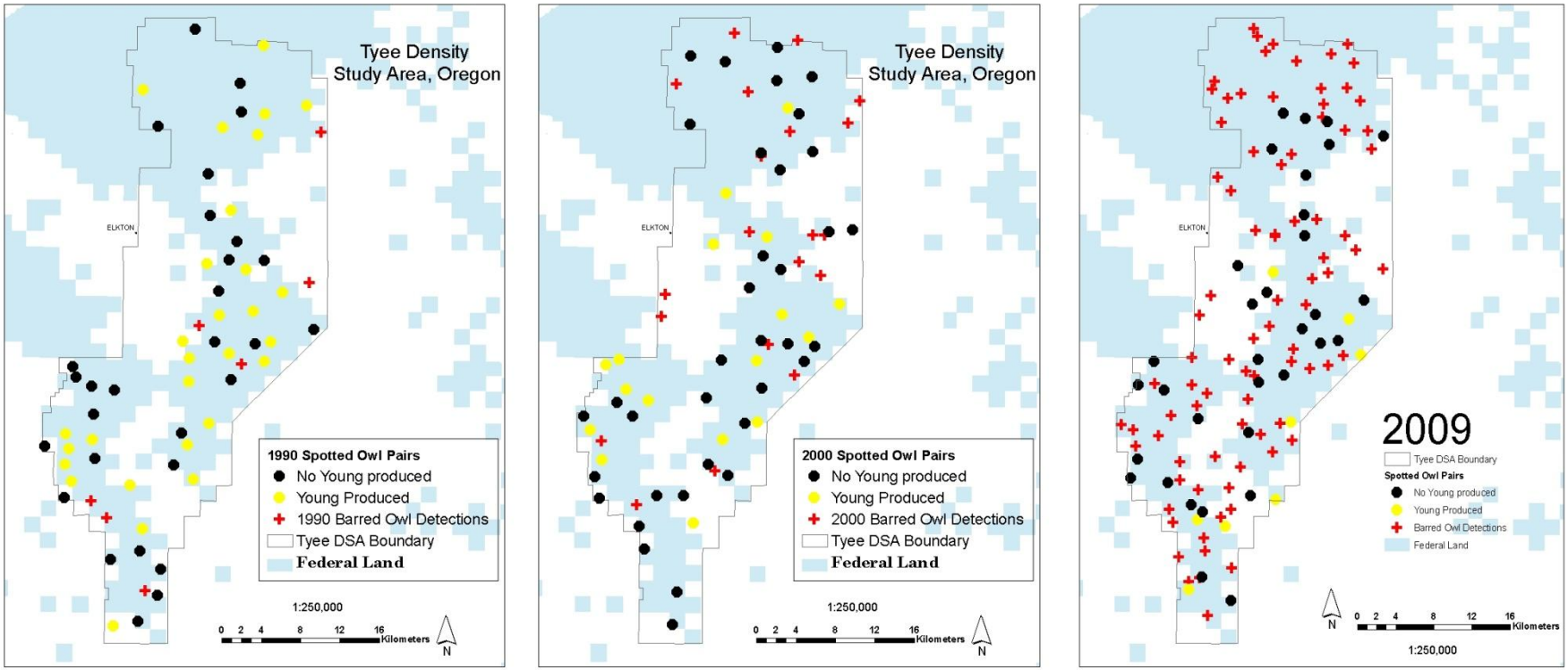

Figure 6. Location of barred owl detections (✚) and spotted owl pairs. Reproductive output of spotted owls is also displayed (no young produced ●, young produced ●), Tyee Density Study Area, Roseburg, Oregon: 1990 (left), 2000 (center) and 2009 (right).

7. Publications and Presentations:

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

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

c) We provided historical data on spotted owl and barred owl locations to David J. Wiens of Oregon State University for his PhD on spotted owl and barred owl interactions. We gathered radio-telemetry locations for 2 successive non-breeding seasons.

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

e) 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 our surveys.

f) Raphael, M.G. 2009. The depth and breadth of the fish and wildlife research program. Keynote address, SPA review panel, Forest Service Research and Development, SPA review. Washington, DC.

g) Oregon Public Broadcasting aired an issue of Oregon Field Guide that was filmed on the DSA and featured the Barred Owl and Spotted Owl competitive interaction issue.

h) We provided survey information for the purposes of analysis and inclusion into an updated US Fish and Wildlife Service protocol (in prep.).

i) We provided feather samples for genetic analysis to Sue Haig at the USGS genetics lab in Corvallis.

j) The Oregonian newspaper conducted an interview with Eric Forsman on the genetic findings in spotted owl research.

k) Raphael, M.G. 2009. Large-scale influences of habitat and barred owls on demographics of the northern spotted owl. Northern Spotted Owl Demography Workshop, Jan. 9-18, 2009: LaSells Stewart Center, Oregon State University.

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

m) We and our fellow researchers on 10 other spotted owl demographic study areas received the 2009 Wings Across the Americas Research and Partnership award from the USDA Forest Service in Washington, D.C. This award recognizes scientists whose work emphasizes a strong partnership between research and management to improve the status of a bird species or community of bird species.

n) Glenn, E. M., Anthony, R. G., Forsman, E.D., and Olson, G. S. Effects of climate on demographic performance of northern spotted owls in the Pacific Northwest, 2009 Annual Meeting of the Oregon Chapter of The Wildlife Society, Gleneden Beach, OR

o) Funk, W., Forsman, E.D., Johnson, J.M., Mullins, T.D., Haig, S.M., 2009, Evidence for recent population bottlenecks in northern spotted owls (*Strix occidentalis caurina*): Conservation Genetics.

p) Glenn, E. M., R. G. Anthony, E.D. Forsman, and G. S. Olson. *In review*. Associations between climate and reproduction of northern spotted owls. Journal of Wildlife Management.

q) Glenn, E. M., R. G. Anthony, and E. D. Forsman. *In review*. Population trends in northern spotted owls: associations with climate in the Pacific Northwest. Journal of Wildlife Management.

r) Glenn, E. M. Local weather, regional climate, and population dynamics of northern spotted owls in Washington and Oregon. Ph.D., Oregon State University, March 2009.

s) Funk, W. C., E. D. Forsman, T. D. Mullins, and S. M. Haig. 2008. Introgression and long-distance dispersal among spotted owl (*Strix occidentalis*) subspecies. Evolutionary Applications ISSN 1752-4563.

8. Acknowledgments

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Appendix 1. Number of previously unbanded spotted owls banded, Tyee Density Study Area, Roseburg, Oregon: 1990–2009.

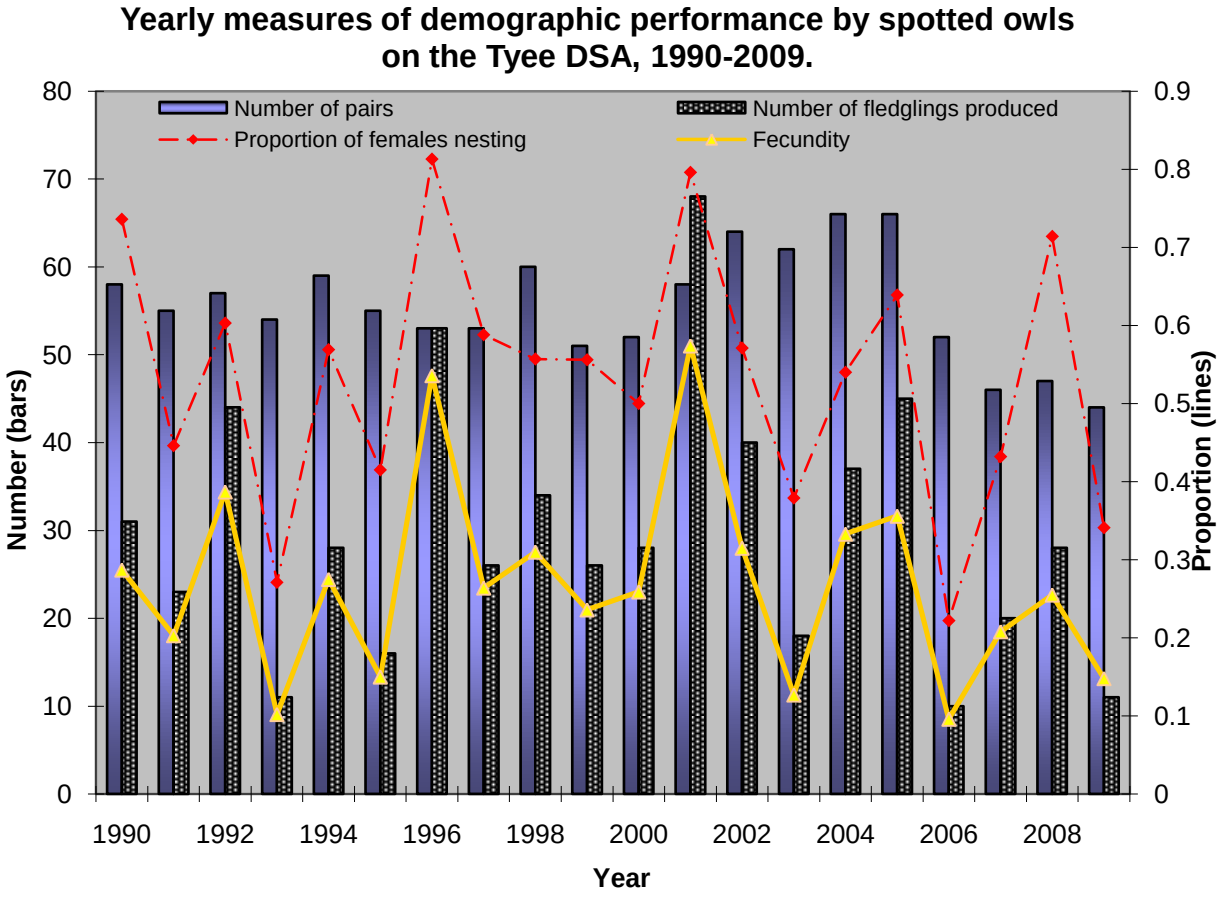
Year	Adults		Subadults		Fledglings
	Male	Female	Male	Female	
<1986[1]	15	14		1	5
1986	13	9			19
1987	7	5	2	4	6
1988	14	15	7	5	6
1989	17	8	3	2	22
1990	14	7	4	7	31
1991	4	5	5	3	23
1992	3	5	2	3	44
1993	1	0	2	1	11
1994	0	2	2	2	28
1995	1	1	0	0	16
1996	1	0	0	0	53
1997	2	0	0	0	26
1998	1	0	1	2	34
1999	0	2	2	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
Total	**104**	**80**	**39**	**47**	**665**

[1]Includes those owls banded 1983-1985. The analysis for the DSA focuses on 1990-2009 data.

Appendix 2. Number of spotted owls detected within the Tyee Density Study Area (DSA), Roseburg, Oregon: 1990–2009.

		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	34	142
1991	55	60	51	12	6	7	6	26	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	29	132
2000	52	57	53	5	2	5	3	28	125
2001	58	61	51	9	8	1	3	67	135
2002	64	60	48	17	17	3	1	67	146
2003	62	64	46	15	17	1	2	16	145
2004	66	73	60	4	5	1	2	40	145
2005	66	71	59	8	7	1	0	43	146
2006	52	58	50	10	9	2	0	10	129
2007	46	59	42	4	7	5	2	20	119
2008	47	63	43	9	8	2	2	28	128
2009	44	56	35	9	9	3	4	13	116

Appendix 3. Estimated fecundity and mean brood size of female spotted owls on the Tyee Density Study Area: 1990–2009. 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			Mean brood size		
Year	N	Mean	SE	N	Mean	SE
1990	61	.287	0.043	29	1.207	0.077
1991	59	.203	0.050	14	1.714	0.125
1992	62	.387	0.056	30	1.600	0.091
1993	54	.102	0.038	7	1.571	0.202
1994	60	.275	0.050	23	1.435	0.106
1995	60	.150	0.042	12	1.500	0.151
1996	56	.536	0.062	34	1.765	0.074
1997	55	.264	0.055	18	1.611	0.118
1998	63	.310	0.050	27	1.444	0.097
1999	55	.236	0.050	18	1.444	0.121
2000	54	.259	0.056	17	1.647	0.119
2001	61	.574	0.061	39	1.795	0.075
2002	65	.315	0.053	25	1.640	0.098
2003	67	.127	0.034	13	1.308	0.133
2004	66	.333	0.052	28	1.571	0.095
2005	66	.356	0.054	29	1.621	0.092
2006	57	.096	0.034	8	1.375	0.183
2007	48	.208	0.051	14	1.429	0.137
2008	51	.255	0.057	16	1.625	0.125
2009	44	.148	0.50	8	1.625	0.183
Mean	**20**	**0.271**		**20**	**1.546**	

Appendix 4. Annual estimates of selected demographic parameters for spotted owls, Tyee DSA, 1990-2009.