WILDLIFE HABITAT RELATIONSHIPS
IN WASHINGTON AND OREGON
FY2010

1. Title: Demographic characteristics of northern spotted owls (*Strix occidentalis*) on the Tyee Density Study Area, Roseburg, Oregon: 1985–2010.

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: 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 (Lint et. al., 1999, Anthony et. al., 2006).

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 caused reductions in the density of northern flying squirrels (Wilson, 2010), 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. *in press*).

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 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).

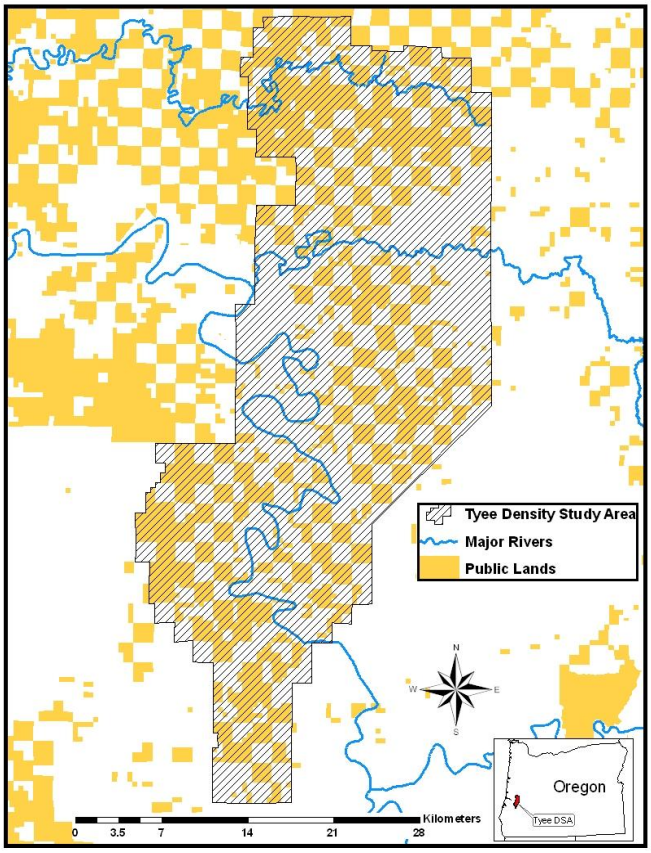

Figure 1. The hatched area represents the Tyee Density Study Area (DSA), Roseburg, Oregon.

Banding was initiated on the study area in 1983 and increased substantially in 1985. Surveys increased in 1987 to include all suitable spotted owl habitat. 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 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 varies, depending on topography and land ownership, but was 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 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. *in press*, Anthony et al. 2006).

Numbers of owls detected on the DSA

Between March 1983 and October 2010, we banded 1007 spotted owls on the DSA, including 691 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, are more detectable than females (Reid et al.1999).

In 2010, we documented 113 non-juvenile spotted owls in the DSA, including 48 pairs and 17 unpaired individuals (Appendix 2). This represents approximately 80% 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).

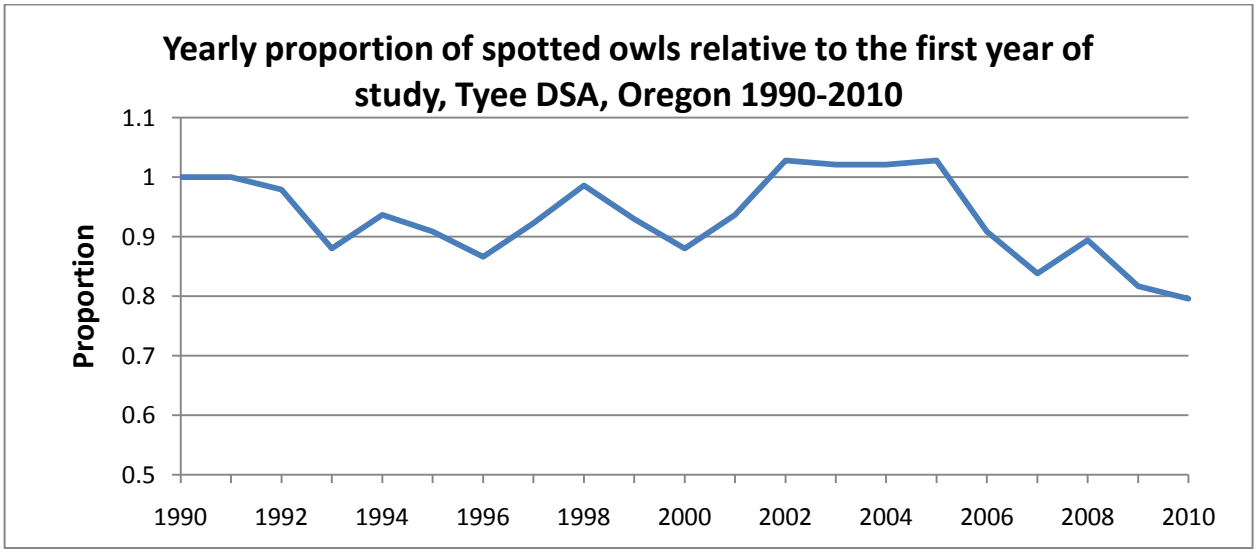

Figure 2. Yearly proportion of non-juvenile spotted owls detected relative to the first year of study, Tyee Density Study Area (DSA), Roseburg, Oregon, 1990-2010.

During 2009-2010, we documented 26 movements of individuals from one territory to another within the DSA. Of the owls that moved, 5 were banded as juveniles and had not

been previously documented in the territorial population (new recruits). Although the numbers of individuals that moved within the DSA decreased, the population estimate decreased as well, such that the annual proportion of individuals that moved was 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).

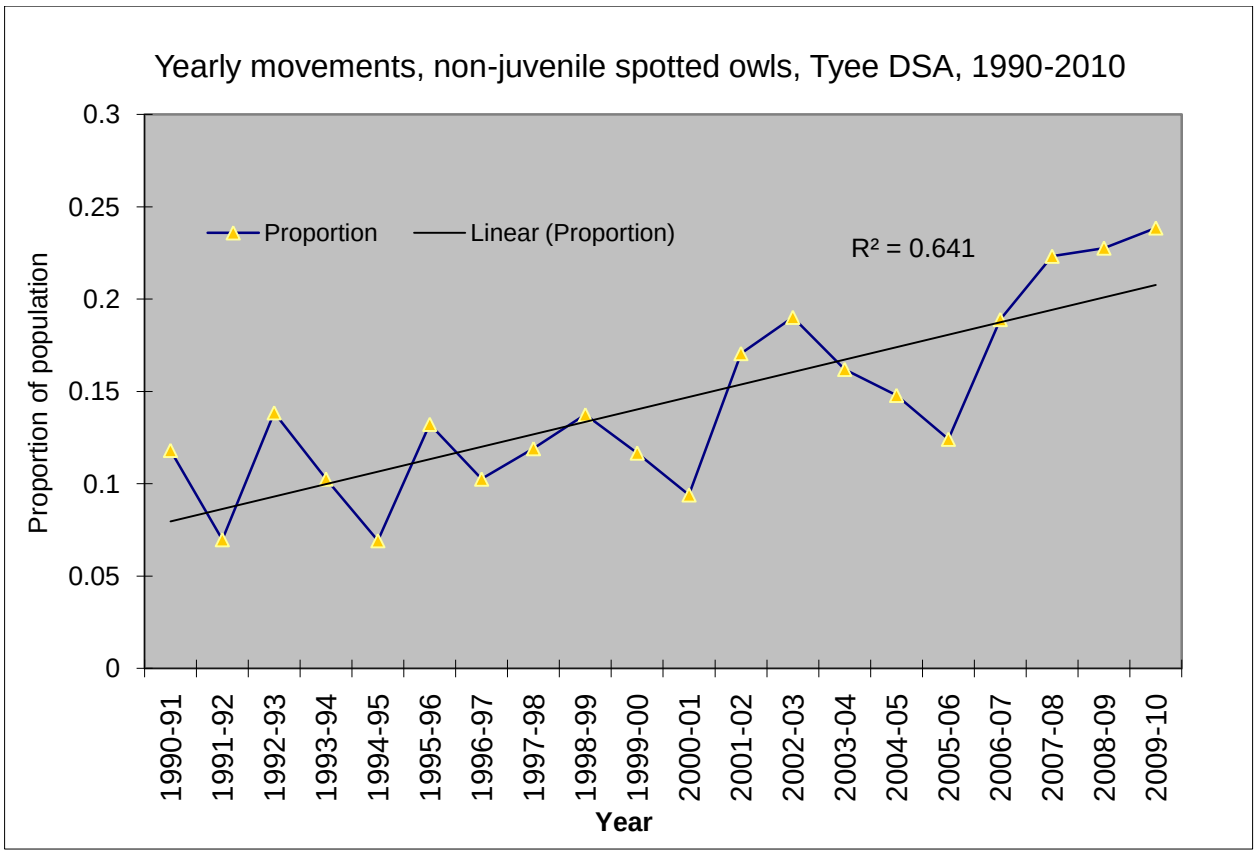

Figure 3. Yearly proportion of non-juvenile spotted owls known to have moved between territories on the Tyee Density Study Area, Roseburg, OR, 1990-2010.

Number of sites with 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 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 completely since then (Fig. 2). In 2010, the number of pairs and the total number of non-juvenile spotted owls detected are below average for the 21 year survey period (Fig. 2, Appendix 2).

In 2010, approximately 83% of the pairs in the DSA were located on federal land and 17% were on private land. Most (93%) of the nesting pairs in 2010 were located on federal lands. Due to the decrease in the number of occupied spotted owl sites (Appendix

2) and the apparent affects of barred owls on spotted owl detection rates (Bailey et. al. 2009), survey effort conducted at night (in minutes) increased from 24% in 1990 to over 42% in 2010.

Reproduction

Nesting in 2010 was above average, with 64% (95% CI = 0.50-0.79) of females nesting. However, only 43% (95% CI = 0.24-0.62) of the nesting females successfully produced young (Table 1). For all years combined, the percentage of females that nested averaged 54% (N= 21 years) and the percentage of nesting females that fledged young averaged 66% (Table 1).

Average female fecundity (the estimated number of female offspring produced per resident female) in 2010 was 0.188 (SE = 0.51), which was up slightly from 2009 but still below the average of 0.267 for all years (N=21) (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 did 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 collected genetic material that was used to assess and analyze potential problems with gene flow and bottlenecks (Funk, et. al., 2009). We attempted to band all known fledglings in the DSA since 1985.

Table 1. Annual reproductive statistics for female spotted owls on the Tyee Density Study Area, Roseburg, Oregon: 1990–2010.

	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	0.36–0.76
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	0.25–0.83
1994	57	0.579	0.45–0.71		60	0.383	0.26–0.51		35	0.657	0.49–0.84
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	0.67–0.92
1997	51	0.588	0.45–0.73		55	0.327	0.20–0.45		30	0.600	0.42-0.78
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	0.41–0.71		55	0.327	0.20–0.45		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	0.44–0.70		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	0.38-0.95
2007	44	0.432	0.28-0.58		48	0.292	0.16-0.42		19	0.737	0.53-0.94
2008	42	0.714	0.57-0.86		51	0.314	0.18-0.44		32	0.500	0.32-0.68
2009	41	0.317	0.17-0.46		45	0.178	0.06-0.29		14	0.571	0.30-0.85
2010	45	0.644	0.50-0.79		49	0.245	0.12-0.37		28	0.429	0.24-0.62
Mean	**21**	**0.538**			**21**	**0.341**			**21**	**0.660**	

[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: 1990–2010.

	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	55	0.145	0.05–0.24	70	0.029	0.00–0.07	8	0.463	0.00–0.58
2 years old	83	0.446	0.34–0.56	97	0.247	0.16–0.34	39	0.493	0.46–0.77
Adults	948	0.571	0.54–0.60	1027	0.380	0.35–0.41	561	0.461	0.66–0.73
Unknown	11	0.545	0.23–0.86	20	0.250	0.05–0.45	10	0.527	0.17–0.83

[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: 1990–2010.

	Fecundity [1]			Brood size[2]		
Age	N	Mean	SE	N	Mean	SE
1 year old	70	0.029	0.020	2	2.000	0.000
2 years old	97	0.206	0.039	24	1.667	0.098
Adults	1026	0.296	0.013	390	1.556	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.

Barred Owls

We 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 enabled us to estimate trends in the barred owl population as well. The DSA was 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 2010, for the first time since the beginning of the study, the number of survey areas where we detected barred owls surpassed 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 is likely that some barred owls are not detected.

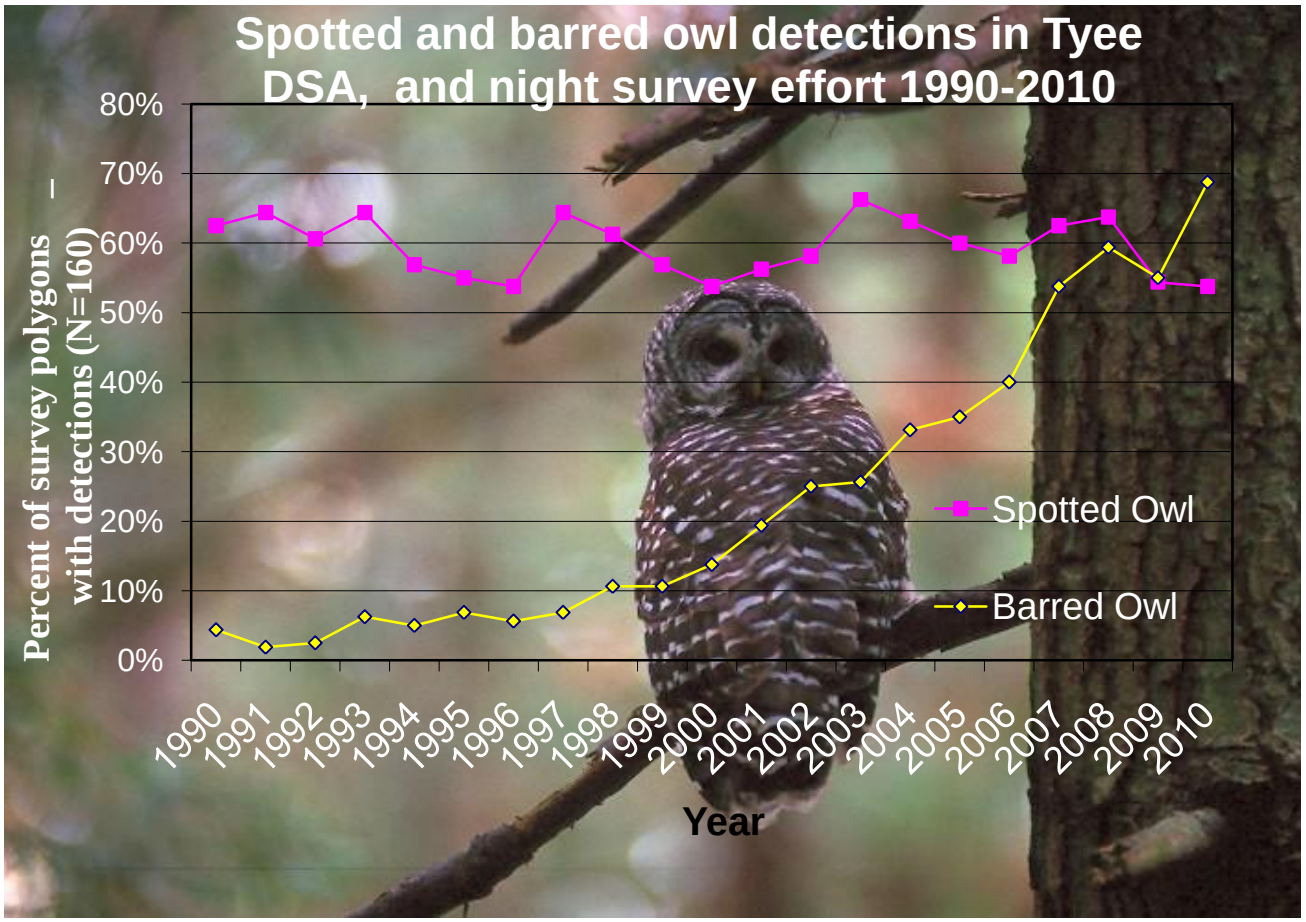

Figure 4. Number of territories where barred owls and spotted owls were detected, Tyee Density Study Area, Roseburg, Oregon: 1990-2010.

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 spotted owls 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).

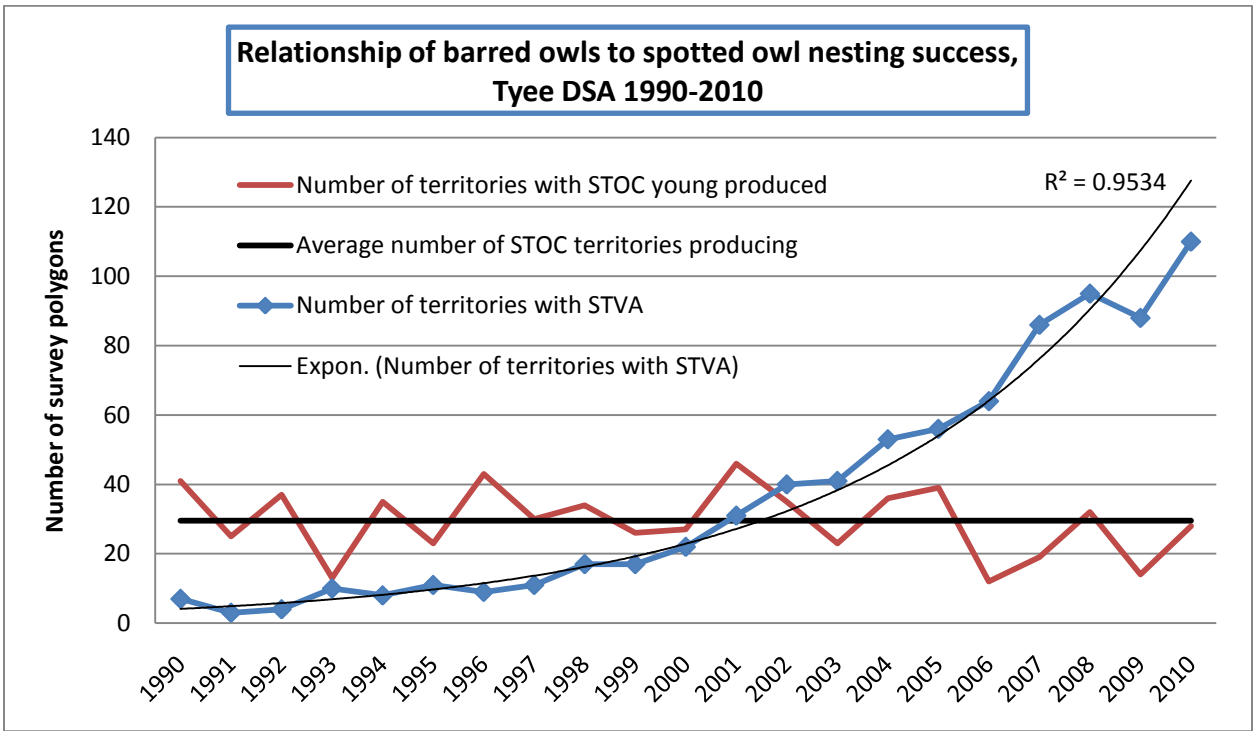

Figure 5. Yearly number of survey polygons in the Tyee DSA where barred owls were detected and where spotted owl reproduction was documented, 1990-2010. In the last 5 years, where barred owl numbers are the highest, the number of reproductively successful spotted owl sites had fallen below the 21 year average.

Habitat

A recently available map product (Kennedy et. al, 2010) provided estimates of the relative annual change (or loss) of spotted owl habitat (nesting, roosting, and/or foraging) due to harvest, heavy thinning, or fire for all ownership types. Figure 6 shows relative changes (loss of habitat) in and around the DSA. These maps depict the amount of change and are not designed to reflect the amount of various age classes. The loss of habitat during the first 10 years of the study (~5 %) was approximately half of the estimated loss of habitat for the second 10 years of the study (~14%). Habitat loss apparently accelerated in the last 10 years of the study. Figure 7 shows the annual loss of habitat for 1990-2008. The best fit for the amount of habitat loss was highly correlated with an exponential trend ($r^2 = 0.97$). Nearly all of the loss of habitat was due to clearcut (regeneration) harvest; no significant fires occurred during the survey period and heavy thinning occurred in only small amounts as of 2008. The mapping product was unable to distinguish between these types of losses and it can be surmised from observational information, both on the ground and overlaying the mapping product onto an aerial photo, that the amount of habitat loss to other than clearcut harvest is minimal.

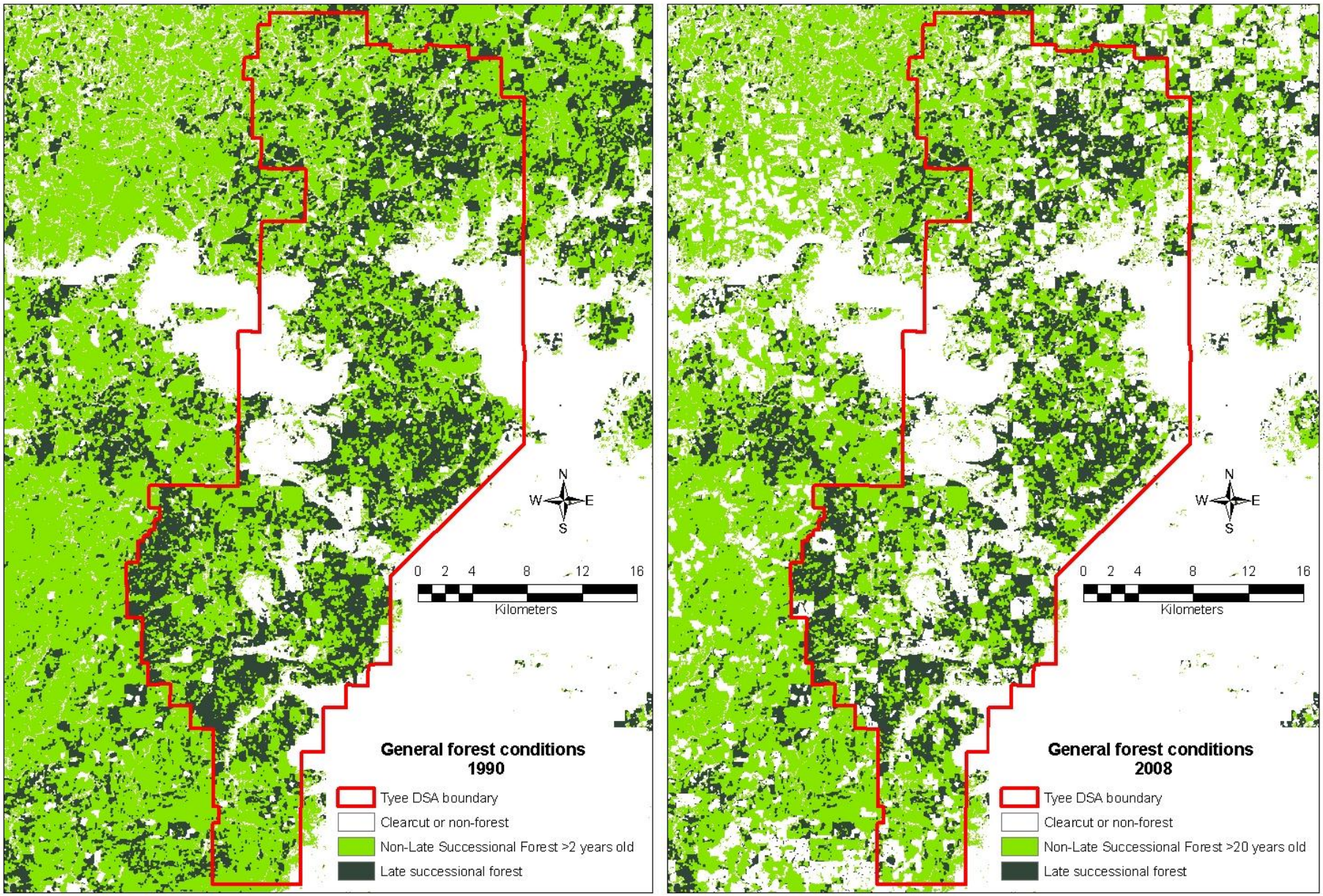

Figure 6. Relative change in forest conditions between 1990 and 2008, Tyee Density Study Area, Note: These maps depict the **change** (loss) of nesting, roosting, and/or foraging habitat of the spotted owl between the 2 time periods and does not depict the **quantity** of nesting, roosting and/or foraging habitat of the spotted owl. The remaining Non-Late Successional Forest may not all be suitable spotted owl habitat.

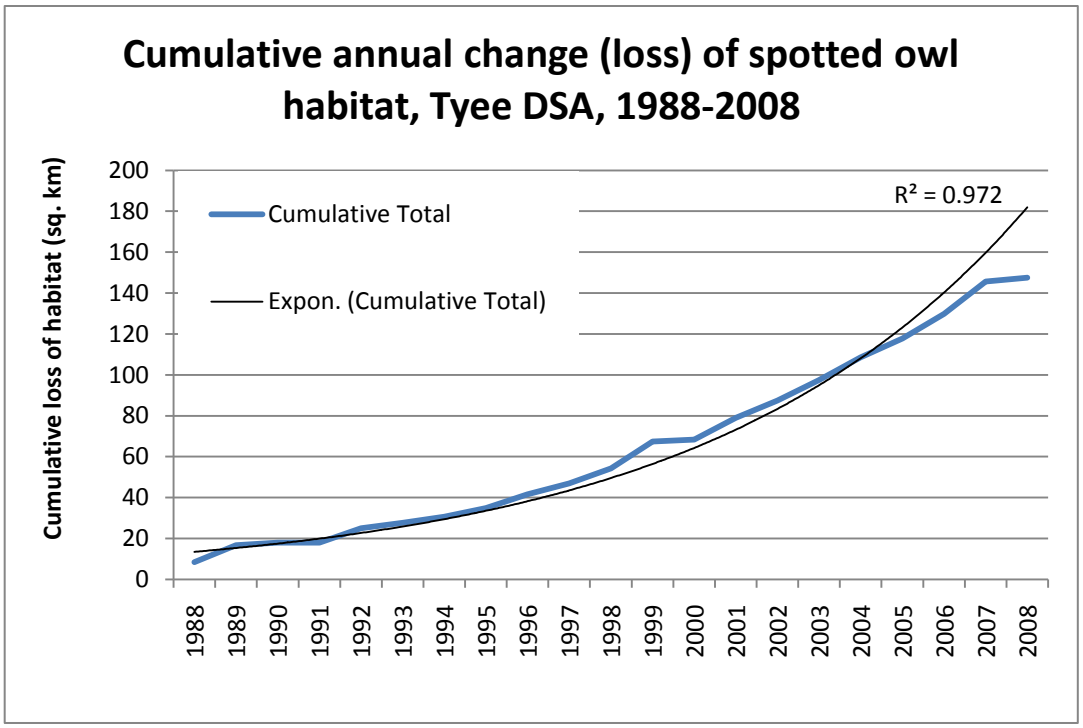

Figure 7. Cumulative loss of nesting, roosting, and/or foraging habitat (sq. km.) since inception of the 1025 sq. km. Tyee DSA, 1988-2008.

Interesting observations and unusual events that were documented in 2010:

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

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 was 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. In 2010, both of these foster juveniles nested and the foster juvenile from 2005 produced one young. It is important to note that these successful cases of captive breeding and release were only accomplished by fostering juveniles into the nests of wild spotted owls. There have been no successful cases in which captive bred juveniles have been raised in captivity and then released.

Since 1990, 6 different barred owl/spotted owl hybrids were documented in our study area (3 females and 3 males). In 2010, we had one site with a hybrid male (spotted owl/barred owl) in the DSA. The hybrids exhibit plumage characteristics that are intermediate between both species, and vocalizations appear to be unique to each individual. The hybrid male was paired with a barred owl female.

Through the use of a genealogy program, we were able to identify two 9-yr-old siblings from the same 2001 nest that were paired and nesting on a territory that was 40 km from their natal site. The pair produced at least one young, but that young was found dead shortly after fledging.

Problems encountered:
We routinely are granted permission to locate and observe spotted owls on private property of

many different landowners. In 2010, we were denied access to determine reproductive output at one nest site 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 continues to decline. In 2010, we documented the fewest number of pairs in the study area since the inception of the study in 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 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 2010, the number of nesting attempts was nearly twice the level of 2009, but the number of unsuccessful nests resulted in one of the lowest reproductive years of the entire study (Table 1). The high rate of nest failure may be due in part to the unfavorable weather conditions that occurred in the critical late nesting period when the study area received unusually high levels of cold and wet precipitation.

The number of territories that produced young was at or below average for the last 5 consecutive years (Fig. 5). At the same time, the number of territories where barred owls were detected increased exponentially (r^2= 0.9534) (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.

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). 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 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 districts.

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

d) 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.

e) We provided survey information for the purposes of analysis and inclusion into an updated US Fish and Wildlife Service protocol (2010). (Dugger, K., R.G. Anthony, and E.D. Forsman. 2009. Estimation of northern spotted owl detection probabilities. Updating the USFWS Northern Spotted Owl Survey Protocol. Unpublished Report. Department of Fisheries and Wildlife, Oregon State University, Corvallis, OR 97331)

f) We provided feather samples for genetic analysis to the USGS genetics lab in Corvallis.

g) Forsman, E. D., et al. (*in press*). Population demography of northern spotted owls: 1985–2008. Studies in Avian Biology

h) 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 Volume 143, Issue 11, Pages 2543-2552

i) We provided survey information to the USFWS for modeling presence and absence of spotted owls at the landscape level. These data were used for habitat modeling workshops or presentations in FY 2010: US Forest Service Region 5 (CA), Klamath Province Biologists; Redding, California – August 31, 2010. Environmental groups/modeling professionals from S. Oregon/N. California; Ashland, Oregon – September 16, 2010

8. Acknowledgments

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Appendix 1. Number of previously unbanded spotted owls banded, Tyee Density Study Area, Roseburg, Oregon: 1990–2010.

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
2010	0	0	1	1	15
Total	106	83	39	46	671

[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: 1990–2010.

		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

Appendix 3. Estimated fecundity and mean brood size of female spotted owls on the Tyee Density Study Area: 1990–2010. 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
Mean	21	0.267	**0.027**	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, 1990-2010.