

SPOTTED OWL HOME RANGE AND HABITAT USE IN SOUTHERN OREGON COAST RANGES

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Abstract. We radiotracked 9 adult spotted owls (*Strix occidentalis*) in the southern Oregon Coast Ranges for 6-12 months. Owls selected home ranges that emphasized old growth within the landscape. Minimum convex polygon home ranges of 4 pairs were 1,153-3,945 ha and contained 726-1,062 ha of old growth. The percentages of the home ranges in old growth were 25-73%. Home-range size expanded significantly ($P < 0.05$) with decreasing proportions of old growth ($r = -0.83$). The amount of old growth in the pair home ranges was less variable than was home-range size. Old growth was selected by the owls for foraging and roosting ($P < 0.05$); clearcuts and other nonforested areas were not used. Early to middle stages of forest development were used either less than or in proportion to their availability within the home ranges, even where old growth was scarce.

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Spotted owl management in the Pacific Northwest is controversial because it involves a mix of biological, economic, political, and social issues (Heinrichs 1983, Strong 1987). Spotted owls are associated with commercially valuable old-growth, coniferous forests (Carey 1985). Habitat management rests primarily on 3 telemetry studies of habitat use and home-range sizes (Forsman et al. 1984, Gutierrez et al. 1984, Forsman and Meslow 1985) and various unpublished reports (see Marcot and Holthausen 1987). Only 1 study (Forsman et al. 1984 as supplemented by Forsman and Meslow 1985) is reported in detail. Dawson et al. (1987) conclude that precise information on the owl's habitat needs will be necessary to resolve the controversy over the preservation of the species.

Forsman et al. (1984) and Forsman and Meslow (1985) report habitat use, home-range sizes, and the composition of home ranges of 8 adult owls radiotracked for 9-12 months in the central Oregon Cascade Range and 6 adult owls tracked for 4 months in the central Oregon Coast Ranges. Gutierrez et al. (1984) tracked 8 owls for up to 1 year in the North Coast Range of California; they provide only an overview of their study.

Our objectives were to determine the home-range sizes, home-range composition, habitat use, and response to forest fragmentation of spotted owls across a large landscape, the southern Oregon Coast Ranges. We wanted to assess if the results reported by Forsman and Meslow (1985) could be generalized and to determine possible geographic differences in

the habitat of spotted owls in the Western Hemlock Zone of Oregon, as described by Franklin and Dyrness (1973).

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STUDY AREAS

We chose 4 study areas in the Western Hemlock Zone of the southern Oregon Coast Ranges. All 4 included forest that had been logged within the last 3 years. One pair of owls was in the Cherry Creek Research Natural area (T27S, R10W), which typified old-growth (350 yr old) Douglas-fir /western hemlock (*Pseudotsuga menziesii* / *Tsuga heterophylla*) forests on the wet, west slope of the Coast Ranges (Franklin et al. 1972). This 239-ha block of old growth was surrounded by a mixture of clearcut, sapling, pole, and old-growth stands. We do not know the landscape composition outside of the

these owls. A second pair of owls was near Miner Creek (T24S, R8W). The western half of this township (46 km²) was 43% old growth. The area around Miner Creek was dominated by 300-year-old old-growth mixed with clearcut, pole, and sapling stands. Miner Creek was typical of east slope Douglas-fir/western hemlock stands in the southern Coast Ranges and has been occupied by spotted owls for at least 10 years. The third study area, Riverview (T25S, R7 and R8W), lay at the juncture of the Western Hemlock Zone and the Interior (Umpqua River) Valley Zone and supported 1 pair of owls. The 2 quarter-townships containing Riverview were 30% Douglas-fir/incense cedar (*Calocedrus decurrens*) old growth (275 yr old) mixed with nonforested land (grasslands and pastures), riparian hardwood forests, and all ages of coniferous forest. Two pairs of owls were radiomarked in the fourth study area, Peterson Point-Lookout Mountain (T21S, R6W), which differed from the other areas in its history of recent fires (1868, 1939, 1951, 1966) and consequently had larger amounts of young (35-70 yr old), mature (80-120 yr old), and mixed-age forests (Juday 1977). This township was 18% old-growth Douglas-fir / western hemlock.

METHODS

Telemetry

We located, captured, and placed radio transmitters on spotted owls (Forsman 1983). We initially decided to obtain at least 2 precise (<2 ha) triangulations per owl per sample night (one before midnight and one after midnight) and one the next day because owls usually forage at night and roost during the day (Forsman et al. 1984). We assumed night locations were foraging locations and day locations were roost locations. When time permitted, we located owls throughout the night. After discovering that the owls generally stayed within a stand during a night, we got 1 precise triangulation per owl per sample night, and we located ≥ 2 owls per night (Carey et al. 1989). We located each bird every 3-7 nights and avoided locating individuals at the same time each sample night.

We subjectively evaluated signal strength and directionality of each bearing taken. Poorly directional signals were not used in triangulations. Bearings were taken from different locations until 3 or 4 strong, directional bearings were obtained; these were plotted on aerial photographs. We retained locations only if the triangulation polygon was <8 ha; 95% of the retained locations had triangulation polygons ≤ 2 ha. After daytime triangulations, owls were located visually to assess the accuracy of triangulation data and to identify those areas where radio signals were misleading. Daytime locations ($n = 108$) averaged 119 ± 10 (SE) m from the actual location of the bird. Additional discussion of sampling methods may be found in

Carey et al. (1989).

Home Range Calculations

The minimum convex polygon (MCP) method (Hayne 1949) was used to delineate the home ranges of individuals and pairs. We report the MCP home-range sizes and MCP home-range composition to be comparable to Forsman et al. (1984), Gutierrez et al. (1984), and Forsman and Meslow (1985).

In any set of home-range data, outlying locations reflect occasional forays outside the normal range of the animal. Although these locations are not within the home range, they might reflect spatial and social orientation, natural tendencies for exploration, preparation for invasion of depopulated areas, or extension of the species' range (Stickel 1954). In keeping with the definition of home range (Burt 1943) and subsequent practice (Carey et al. 1989), we removed the outermost 5% of locations from each of 2 subsets of the data (breeding 1 Feb-31 Aug and nonbreeding 1 Sep-31 Jan) and repeated the minimum convex polygon analysis (MCP95%). In addition, we used the modified minimum convex polygon method (MMCP) (Harvey and Barbour 1965) to examine the influence of outlying locations on MCP estimates of home-range size.

Analysis of Habitat Selection

Only 1 location per night with a triangulation polygon <2 ha was used in the analysis of habitat selection because locations within a night were not independent (Carey et al. 1989). The geometric center of each polygon was recorded as a point and as being within a particular type of plant community or in the edge between 2 plant communities. Fewer than 3% of the locations were in edges. Edges were sharply defined, reflecting forest management. We delineated plant communities (stands) in and around MCP ranges by tracing their boundaries from 1:12,000 aerial photographs onto Mylar. We recognized 9 types of stands that were ≥ 4 ha. We combined all nonforest communities into 1 type and classified forest communities into hardwood-riparian communities and 7 stages of coniferous, Douglas-fir dominated forest: (1) clearcut (grass, forb, and shrub stages), (2) sapling (average tree dbh = 2-10 cm), (3) pole (dbh = 11-20 cm), (4) young (dbh = 21-50 cm), (5) mature (dbh = 51-100 cm and even-aged), (6) mixed-age (generally old growth with inclusions of young or mature stands <4 ha), and (7) old growth (dominant tree dbh > 100 cm, multilayered canopy, large decaying fallen trees, and large standing dead trees). We used Bureau of Land Management inventories, aerial photographs, and field reconnaissance to classify the stands.

Areas in each stand type were summed for home ranges of individuals and pairs. We calculated the

proportion of each home range in each stand type and the proportion of total locations of each owl in each stand type. We tested for habitat selection by comparing use in proportion to availability (Neu et al. 1974, Byers et al. 1984) within the MCP ranges because restricting the analysis to areas that were actually used (MMCP ranges) could prove trivial, and expanding consideration to areas that were not within the home range (not immediately available for use) could be misleading (Johnson 1980). For the 3 study areas where we had recent aerial photographs, we calculated landscape composition and the composition of systematically located circles of the approximate size of the home range of a pair. We used 6 1,000-ha circles for Miner Creek and Riverview and 5 2,000-ha circles for Peterson Point-Lookout Mountain. We could not obtain recent aerial photographs for the landscape around the Cherry Creek pair. We compared home-range composition to the landscape composition and to the composition of the home-range-sized circles for each pair of owls using paired *t*-tests.

We calculated indexes to mean stand size by drawing 2-km transects to scale on aerial photographs. The nests of the pairs (the breeding season center of activity for the nonnesting Miner Creek pair) served as the origin for the transects. The azimuth of the first transect was random; 3 additional transects were drawn at 90, 180, and 270 degrees from the random transect. Mean stand width as intersected by the transects was used as an index to mean stand size and, thus, fragmentation. We also tallied stands by size class: 0-10, 11-20, 21-40, 41-60, 61-80, 81-100, and ≥ 100 ha.

We used all-possible-subsets regression (Frane 1985) to examine the relation among MCP area and sex of the owl, proportion of home range in old growth (with an arc sine transformation), an index to fragmentation (mean stand width), and sample size information, i.e., the length of the tracking period in days, the total number of locations used to estimate home-range size, and the number of independent locations obtained (the number of nights and days the owl was located). All-possible-subsets regression identifies the best subset of predictor variables through extensive analyses of residuals and the requirement of highly significant *t*-statistics for coefficients. The best subset was defined as the one that minimized Mallows' C_p , the quotient of the residual sum of squares and residual mean square contrasted with the difference between the number of cases and twice the number of variables in the subset. This procedure is designed to preclude redundant variables and irrelevant variables from being returned in the regression, avoiding spuriously high R^2 values. Pearson product-moment correlations were calculated to examine the relationships between the fragmentation index, proportion of the home ranges in old growth, and home-range size.

RESULTS

Transmitters were placed on 10 adult owls (5 pairs) between 16 April and 7 August 1986. We tracked 1 owl for 14 days (14 locations; not included in analyses), 3 owls for 6-8 months (87-136 locations), and 6 owls for 9-12 months (138-187 locations). The pairs inhabiting Cherry Creek and Riverview each produced 2 young during 1986. The Cherry Creek male died in December 1986. One of the Riverview young, possibly the other, and probably the female were killed by a great horned owl (*Bubo virginianus*) in June 1986. The Miner Creek pair did not nest in 1986. The male died in February 1987. The Peterson Point pair and the Lookout Mountain pair nested in 1986 but produced no young. The Lookout Mountain female left the area in December and moved 30 km north, and her transmitter failed. She returned to the study area the next year.

Home-Range Sizes

The MCP home ranges of individual owls averaged $1,580 \pm 285$ ha (Table 1). Lengths of the major axes of the ranges were 3.8-10.9 km and averaged 6.1 ± 0.75 km. Breeding season ranges averaged 606 ± 88 ha and uniformly were smaller (43%, on average) than nonbreeding season ranges ($1,420 \pm 302$ ha). Because of the death of the Riverview female, only 4 pairs of owls could be analyzed—Cherry, Lookout, Miner, and Peterson. MCP home ranges of pairs averaged $2,121 \pm 641$ ha (Table 2). Overlap in ranges between members of a pair was 74-97% during the breeding season, 64-91% during the nonbreeding season, and 72-92% over the course of the year. Because the pairs were separated geographically, there was no potential for overlap among the pairs.

Based on the regression analysis, the proportion of the home range in old growth explained 64% of the variance in MCP home-range size ($P = 0.001$). Adding the number of independent locations explained an additional 21% of the variance in home-range size (adjusted $R^2 = 0.85$, $F = 24.12$, $P < 0.001$). Other variables did not contribute significantly to the regression. The MMCP home ranges were 33-86% ($O = 68\%$) of MCP ranges and excluded much of the apparently unused areas on the peripheries of MCP home ranges. The MCP95% estimates were 31-92% ($O = 72\%$) of MCP estimates but often excluded areas actually used as well as unused areas.

Differential Use of Stand Types

Old-growth Douglas-fir forest was the dominant

Table 1. Home-range areas of 9 spotted owls studied for 6–12 months, April 1986–August 1987, in the Oregon Coast Ranges, as calculated by the minimum convex polygon (MCP) method, the modified MCP (MMCP) method, and the MCP method with removal of the outermost 5% of locations (MCP95%).

Owl, location, and sex	Locations ^a n	Home-range area (ha)		
		MCP	MMCP	MCP95%
Cherry F	153	1,121	960	861
Cherry M	130	818	620	604
Lookout F	85	1,769	589	1,338
Lookout M	152	3,635	1,654	1,115
Miner F	177	1,228	930	993
Miner M	147	777	672	644
Peterson F	86	1,599	990	1,470
Peterson M	141	1,536	882	978
Riverview M	266	1,737	1,502	1,297

^a Only locations with triangulation polygons <8 ha were used.

feature of the owls' home ranges. Individual MCP home ranges were 27–75% old growth (Table 3), and pair ranges were 25–73% old growth (Table 2). In all cases, the owls foraged in old growth significantly ($P < 0.05$) more than expected based on availability. Similarly, the owls selected old growth for roosting (Table 3) ($P < 0.05$). Old growth was the only stand type that owls selected out of proportion to its occurrence for foraging or roosting. Where old growth was the scarcest (at Lookout Mountain, 27–31% of the ranges), it received the most disproportionate use: 79–83% of the foraging locations and 75–86% of the roosting locations. The nest groves of the 4 nesting pairs and the joint center of breeding season activity of the nonnesting Miner Creek pair were in old growth.

Riparian areas and mixed-age stands constituted small proportions of some home ranges (Table 3). A small proportion of the foraging and roosting locations were recorded in these areas. In 2 areas, Peterson and Riverview, mature stands constituted a significant portion of the owls' home ranges. Use of these areas for foraging and roosting was in proportion to their availability. Young stands constituted a significant portion of the Peterson and Lookout home ranges, where old growth was scarce, but the owls avoided the young stands ($P < 0.05$). Non-forested areas were not used, and the owls avoided sapling and pole stands.

The amount of old growth in individual home ranges differed twofold (538–955 ha), whereas home-range sizes differed fivefold (777–3,635 ha). The amount of old growth in the pair home ranges (726–1,062 ha) was also less variable than was home-range size (1,153–3,945 ha). Home-range size was negatively correlated ($r = -0.83$) with the proportion of the range in old growth. The

Table 2. Minimum convex polygon (MCP) home ranges, amounts of old growth within the ranges, and proportional use of old growth for 4 pairs of spotted owls in the Oregon Coast Ranges, 1986–87.

Name	MCP range (ha)	Old growth (ha)	% Old growth		
			Owl use	Range Circle ^a	Land- scape
Cherry	1,153	726	93	63	^b
Lookout	3,945	968	80	25	20
Miner	1,304	955	94	73	49
Peterson	2,082	1,062	73	51	20
Riverview ^c			72	53	29
Average	2,121	928	82	53	30

^a Average of systematically placed, home-range-sized circles.

^b Landscape data not available.

^c Male only, not included in calculations of pair range areas.

proportion of old growth was negatively correlated ($r = -0.73$) with the fragmentation index and was more highly correlated ($r = 0.83$) with home-range size than was degree of fragmentation ($r = 0.52$). The pairs with the smallest home ranges and least amount of old growth (Miner and Cherry) concentrated their foraging in the old growth, which constituted a high proportion of their home ranges. Their home ranges were less fragmented and were composed of fewer stands (36 and 37 stands with 16% of stands > 100 ha) than the Lookout, Peterson, and Riverview areas, which contained 116, 68, and 55 stands, respectively, with only 10% of the stands > 100 ha.

Comparison of Home Ranges and Landscapes

Landscapes around the owl home ranges contained 20–49% old-growth stands (Table 2). Home-range-sized circles systematically placed throughout the landscapes averaged $49 \pm 5\%$ old growth for Miner Creek, $28 \pm 6\%$ for Riverview, $20 \pm 4\%$ for Lookout, and $20 \pm 4\%$ for Peterson. The average percentage of old growth in the circles did not differ significantly ($P = 0.22$) from the percentage of the landscape in old growth. In all cases the amount of old growth in pair and individual home ranges was greater than that observed in the local landscape as measured by the systematic overlaying of “dummy” home ranges ($P < 0.05$). This indicates a universal selection for areas with higher amounts of old growth and a greater selection of this habitat type for foraging and roosting.

DISCUSSION

Sampling Intensity.—We sampled less intensively than is usually the case in telemetry studies (Dunn and Gipson 1977). Our analyses of statistical independence on

Table 3. Percent home-range composition, use for foraging, and use for roosting (composition/foraging/roosting) for 9 spotted owls in the southern Oregon Coast Ranges, 1986–87.

Owl, location, and sex	Coniferous forest ^a					Hardwood riparian (all ages)	Nonforest ^b
	Old growth	Mixed age	Mature 100 yr	Young 50 yr	Sapling & pole		
Cherry F	64/90/97*	0/0/0	<1/<1/0	2/0/0*	25/6/3*	5/4/0‡	4/0/0*
Cherry M	63/97/100*	0/0/0	<1/0/0	3/0/0*	25/0/0*	4/3/0‡	4/0/0*
Lookout F	31/83/85*	4/3/8	5/0/0†	26/7/8*	19/7/0*	2/0/0*	13/0/0*
Lookout M	27/79/90*	8/3/3	6/1/0†	26/10/7*	18/6/0*	4/0/0*	11/0/0*
Miner F	74/96/97*	1/0/0*	2/3/0‡	0/0/0	14/1/3*	<1/0/0	9/0/0*
Miner M	75/98/97*	1/0/0*	1/0/3†	0/0/0	13/2/0*	<1/0/0	10/0/0*
Peterson F	50/75/80*	3/8/12	8/8/4	21/0/0*	12/8/4†	3/0/0*	2/0/0*
Peterson M	57/82/94*	2/0/6†	10/8/0‡	17/0/0*	10/4/0*	4/5/0‡	<1/0/0
Riverview M	53/72/88*	0/0/0	14/8/8	5/11/2	9/1/0*	5/6/2	14/1/0*

^a Dominant tree dbh's were >100 cm in old growth, 51–100 cm in mature, 21–50 cm in young, and <20 cm in sapling-pole stands. Mixed-age stands generally were old growth mixed with younger forests.

^b Nonforest includes grass, forb, and shrub stages of forest development.

* Significant ($P < 0.05$) preference or avoidance for foraging and roosting.

† Significant ($P < 0.05$) preference or avoidance for foraging.

‡ Significant ($P < 0.05$) preference or avoidance for roosting.

our telemetry data (Carey et al. 1989) showed that more frequent sampling would have resulted in redundant data. Our regression analysis indicated that neither sampling period nor number of independent locations could account for a major part of the variance in home-range size. Forsman et al. (1984) sampled much more frequently than we did. Also they found that 6 months of observation could identify almost all of an owl's range. Gutierrez et al. (1984) did not report sample sizes or discuss adequacy of sampling. Sampling not including October, November, or December would probably underestimate home-range size (Carey et al. 1989).

Home-Range Selection.—We view the MCP home range as a measure of the response of the owl to the landscape, akin to second-order selection (Johnson 1980). The owls selected home ranges within the general landscape such that they contained much more old growth than would be expected based on random placement. Home-range selection probably is not just a function of landscape composition. The population of spotted owls must partition the landscape, and intraspecific interactions probably play an important role in determining home-range boundaries. The ultimate examination of habitat selection must be at the population level, not at the level of pairs of owls.

Home-Range Size.—Home ranges of spotted owls are large compared to other birds (Schoener 1968). Only the snowy owl (*Nyctea scandiaca*), the prairie prairie falcon (*Falco mexicanus*), and the common raven (*Corvus corax*) maintain breeding-season home ranges of the same magnitude (Schoener 1968) as the spotted owl. The closely related and slightly larger barred owl (*S. varia*) has home ranges of 84–498 ha

in Minnesota (Nicholls and Warner 1972, Fuller 1979). The tawny owl (*S. aluco*), which is slightly smaller than the spotted owl, has a much smaller home range—12–20 ha in England and 27–182 ha in other parts of Europe (Southern 1970). Great horned owls, which are considerably larger than spotted owls, have ranges of 71–560 ha (Fuller 1979).

Home-Range Composition.—Home ranges were 20–54% old growth in the central Coast Ranges and 33–66% old growth in the central Cascade Range (Forsman et al. 1984) compared to 27–75% old growth in the southern Coast Ranges (Table 3). Among the 3 areas, mean home-range size reflects the percentages of the areas in old growth: central Coast Ranges, 28% (2,917 ha); central Cascades, 49% (2,436 ha); and southern Coast Ranges, 53% (2,121 ha).

Studies of spotted owls in Oregon document a relationship between old growth and homerange size. We found the amount of old growth in an individual's or pair's home range to be much less variable than home-range size. The same relative lack of variability is apparent in Forsman and Meslow's (1985) data.

Selection of Stands for Foraging and Roosting.—Strong selection of old growth for roosting and foraging is a consistent finding in studies of spotted owl habitat (Table 3) (Forsman et al. 1984, Gutierrez et al. 1984). Neutrality towards mature conifer patches and disproportionately low use of young seral stages and nonforested areas were also consistent, even where old growth was scarce.

Spotted Owls and Old Growth.—Surveys in western Washington (Postovit 1979) and western Oregon (Forsman et al. 1977, 1984; Forsman 1988)

show that spotted owls are rare in areas devoid of old growth. Forsman et al. (1984) report that 98% of the 595 known nest sites in Oregon are in old growth. Our results show that spotted owls select areas of concentrated old growth in the landscape for their home ranges. Within their ranges, owls strongly select old growth for foraging and roosting (Forsman et al. 1984, Gutierrez et al. 1984, our study). Range lengths and avoidance of all but old-growth stands show that spotted owls travel long distances to use old growth, bypassing young and mature forests. These results provide strong evidence that spotted owls depend on old growth in the Western Hemlock Zone in Oregon. Spotted owls maintain home ranges of 800-1,000 ha of old growth, and they will traverse unusually large areas to do so, even when other closed-canopy coniferous and deciduous forest stands are present.

The major prey of the spotted owl in the Western Hemlock Zone are the northern flying squirrel (*Glaucomys sabrinus*) and the red tree vole (*Phenacomys longicaudus*) (Forsman et al. 1984), both of which are associated with old-growth forests (Carey 1989). These species are not abundant in the Western Hemlock Zone (Carey et al., in press), and the red tree vole seems patchily distributed (Carey 1989). A high density for the northern flying squirrel in old growth would be 2-3/ha (Carey et al., in press). The spotted owl is a specialist on medium-sized (100-200 g) prey (Forsman et al. 1984, Barrows 1985), and we hypothesize that the low densities of prey are responsible for large owl home ranges.

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