SPOTTED OWL ROOST AND NEST SITE SELECTION IN NORTHWESTERN CALIFORNIA

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Abstract: We directly observed roost and nest site selection in a population of northern spotted owls *(Strix occidentalis caurina)* in northwestern California during 1985-89. Because of potential biases caused by use of radio telemetry in previous studies, we examined habitat use relative to habitat availability at a level not previously reported for spotted owls. Spotted owls selected coniferous forest characterized by trees >53.3 cm in diameter more often ($P < 0.05$) than it was available. Hardwood stands and coniferous forest dominated by smaller trees were used less than ($P < 0.05$), or in proportion to, their availability. The owls selected forests at 300-900 m elevations for roosting ($P < 0.05$), selected the lower third of slopes within a specific drainage ($P < 0.05$) and avoided the upper third for both roosting and nesting ($P < 0.05$). These observations support the findings of earlier workers who used radio telemetry to assess habitat selection in the northern spotted owl.

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Johnson (1980) described habitat selection by an organism in terms of 4 hierarchical classifications: first-order selection of the geographical distribution of a species; second-order selection of home ranges, or sites, within the geographical distribution; third-order selection of habitat components within home ranges; and fourth-order selection of, for example, food items within a feeding site. Studies of the northern spotted owl have documented first-order selection of major coniferous forest types in the Pacific Northwest (Forsman 1976, Forsman et al. 1984, Gould 1977, Garcia 1979); third-order selection for mature and old-growth forests within home ranges (Forsman et al. 1984, Carey et al 1990, Solis and Gutierrez 1990); and fourth-order selection for patches of high dusky-footed woodrat *(Neotoma fuscipes)* abundance (Ward 1990). However, no researchers have examined second-order selection of spotted owl sites across landscapes. Although Forsman et al. (1977, 1987), Forsman (1988), and Marcot and Gardetto (1980) examined distributions of spotted owl sites across the landscape, these studies were not designed to examine habitat use relative to habitat availability, and, therefore, did not evaluate second-order selection.

Researchers studying third-order selection in northern spotted owls (Forsman et al. 1984, Carey et al. 1990, Solis and Gutiérrez 1990) documented a strong selection by individuals for old-growth coniferous forest. This habitat selection pattern has led to a major controversy because of its potential impact on the timber industry in the Pacific Northwest (Dixon and Juelson 1987, Simberloff 1987). However, comparisons of habitat use and availability within home ranges may be misleading when viewed from outside the context of second-order selection. All home range studies of northern spotted owls used radio-telemetry to document owl movements from which to infer habitat selection patterns. Potential sources of bias in owl radio-telemetry studies mav have included: (1) the home ranges in which owls were marked may have consisted primarily of old-growth (Forsman et al. 1987), and (2) radio-tagged owls may have been atypical of the population in general because the radio-marked owls represented a small segment of the study populations. In this study, we examined second-order selection by observing roosting and nesting habitat selection within a contiguous population of northern spotted owls in northwestern California.

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METHODS

We observed 421 spotted owl locations, including 79 nest sites, during the breeding season (Apr-Aug) from 1985 through 1989 during a demography study on the 292.4-km^2 Willow Creek Study Area (WCSA) in northwestern California. The location of the study area and its vegetation types were described by Franklin et al. (1990). Roost sites and nests were located during daytime walk-in surveys, which consisted of visually locating owls that responded to our imitated calls (Forsman 1983, Franklin et al. 1990). Roosts and nests represented sites used by the entire known population of territorial owls within the WCSA (Franklin et al. 1990).

We recognized 6 major cover types because they represent the spectrum of habitat types and vegetation seral stages on the study area. These included non-vegetated (NVG), hardwood (HDW), and 4 size-classes of conifer forest (CF). Size-classes were defined by the diameter at breast height (dbh) of the dominant trees as follows: CF1-seedlings and saplings, < 12.7 cm (<5.0 in.) dbh; CF2—pole timber, 12.7-27.8 cm (5.0-11.0 in.) dbh; CF3—small timber, 27.9-53.2 cm (11.1-21.0 in.) dbh; and CF4—mature and old-growth, >53.2 cm (>21 in.) dbh (U.S. For. Serv. 1976). These size categories represent tree diameter distributions associated with each seral stage. Although mature and old-growth forests vary greatly in their tree sizes, once trees achieve diameters of >53 cm under natural conditions in our study area, they structurally resemble old-growth forests (Solis and Gutiérrez 1990). The oldest stands that had been harvested previously on the study area were approximately 35 years old (H. Ludke, Six Rivers Natl. For., pers. commun.). Some stands of small timber and mature and old-growth may have been thinned, but none represented managed second-growth forest. Stands of small timber were the result of natural (fire) succession or edaphic responses (Solis and Gutiérrez 1990).

We plotted locations of nest and roost sites on 1:12,000 U.S. Forest Service timber stratum maps. From these stratum maps, we measured total area for each cover type within the WCSA (using a digital planimeter) and identified the cover types of stands where roost and nest sites were located. Owls often used the same roost and nest sites (Forsman et al. 1984); therefore, we did not use multiple roost and nest site locations that occurred within the same 100-m^2 block. Habitat selection was evaluated following Neu et al. (1974). We herein use the term "selection" to mean that owls' use of habitat was a non-random choice of available habitats (Peek 1986:82). Logging altered less than 2.5% of the WCSA during 1985-89; therefore, we used the proportions of each cover type, averaged over the 5-year period, for habitat availability values. We used the proportion of roost and nest observations in each cover type for habitat use values.

For each owl location, we also measured elevation using an altimeter. Aspect, percent slope (steepness), and position on the slope (i.e., lower, upper, or middle third) were measured from maps using the plotted locations. We also measured these same variables at 200 random points stratified among cover types according to the amount of each cover type in the WCSA. Elevations were grouped into 4 300-m classes, aspects into 8 45-degree classes, and percent slope into 6 15% classes. Analyses of physiographic variables followed Marcum and Loftsgaarden (1980). Null hypotheses of no difference between use and availability were rejected at $P < 0.05$ for Chi-squared tests and $P = 0.05$ for family confidence intervals.

RESULTS

Spotted owl roost sites did not occur in proportion to cover-type availability ($\chi^2 = 328.88$, 5 df, $P < 0.001$; Table 1). Spotted owls selected mature and old-growth (used mature and old-growth more than in proportion to its availability); whereas pole timber and hardwood stands were avoided by the owls (used less than expected relative to their availability). Small timber was used in proportion to its availability. Owl roost sites were not found in seedling-sapling stands nor in non-vegetated areas. Spotted owl nest sites occurred in mature and old-growth more than in proportion to its availability; whereas nest sites were found in small timber in proportion to its availability ($\chi^2 = 68.8$, 5 df, $P < 0.001$; Table 1). No nests were found in the other cover types.

When only small timber and mature and old-

Table 1. Expected (p_io) and observed (p_i) proportions of roost and nest locations of northern spotted owls in relation to cover types, Willow Creek Study Area, northwestern California, 1985–89.

		Roost locations			Nest locations		
Cover type[a]	p_io[b]	p_i	n	95% CI[c]	p_i	n	95% CI[c]
CF1	0.204	0.000	0		0.000	0	
CF2	0.099	0.002	1	0.000–0.008	0.000	0	
CF3	0.213	0.235	99	0.180–0.290	0.266	21	0.135–0.397
CF4	0.354	0.732	308	0.675–0.789	0.734	58	0.603–0.865
HDW	0.111	0.031	13	0.009–0.053	0.000	0	
NVG	0.020	0.000	0		0.000	0	

[a] CF = coniferous forest; CF1 = 0–12.6 cm dbh, CF2 = 12.7–27.8 cm dbh, CF3 = 27.9–53.2 cm dbh, CF4 = ≥53.3 cm dbh; HDW = hardwood forest; NVG = non-vegetated area.
[b] Expected proportions based on areas measured from 1:12,000 U.S. Forest Service timber strata maps and averaged over the 5-year study period for the 292.4-km^2 study area.
[c] Expected values which fall outside of confidence intervals on the proportion of observed values indicate a selection for (expected value less than confidence interval) or avoidance of (expected value greater than confidence interval) individual cover types.

growth cover types were analyzed, mature and old-growth were selected more than expected and small timber was selected less than expected for all roost sites (χ^2 = 30.42, 1 df, P < 0.001). In addition, use of small timber and mature and old-growth only was not in proportion to availability for nest sites (χ^2 = 4.063, 1 df, P = 0.044); although 95% family confidence intervals on proportion of each type used overlapped the proportion available by 0.001.

Spotted owls did not roost (χ^2 = 83.56, 3 df, P < 0.001) or nest (χ^2 = 7.815, 3 df, P < 0.001)

Table 2. Proportions of 200 random points (p_{1i}) and 421 roost (p_{2i}) and 79 nest locations (p_{3i}) of northern spotted owls within categories (i) of physiographic variables, Willow Creek Study Area, northwestern California, 1985–89.

		Roost locations		Nest locations	
	p_{1i}	p_{2i}	95% CI, $p_{1i} - p_{2i}$[a]	p_{3i}	95% CI, $p_{1i} - p_{3i}$[a]
Elevation (m)					
<300	0.195	0.019	−0.248–−0.104	0.013	−0.259–−0.105
300–600	0.250	0.356	0.010– 0.202	0.342	−0.062– 0.246
600–900	0.370	0.549	0.074– 0.283	0.532	−0.003– 0.326
>900	0.185	0.076	−0.185–−0.033	0.114	−0.184– 0.042
Aspect					
North	0.115	0.140		0.177	
Northeast	0.225	0.173		0.203	
East	0.240	0.219		0.241	
Southeast	0.115	0.105		0.063	
South	0.085	0.126		0.139	
Southwest	0.090	0.076		0.051	
West	0.045	0.074		0.025	
Northwest	0.085	0.088		0.101	
Slope (%)					
0–14	0.025	0.017	−0.042– 0.025	0.038	
15–29	0.255	0.147	−0.201–−0.014	0.139	
30–44	0.205	0.257	−0.042– 0.145	0.304	
45–59	0.330	0.380	−0.058– 0.158	0.354	
60–74	0.145	0.169	−0.058– 0.105	0.139	
75+	0.040	0.031	−0.052– 0.034	0.025	
Position (⅓ slope)					
Lower	0.340	0.475	0.036– 0.234	0.570	0.074– 0.384
Middle	0.355	0.385	−0.069– 0.129	0.354	−0.153– 0.152
Upper	0.305	0.140	−0.253–−0.077	0.076	−0.335–−0.123

[a] Ninety-five percent family confidence intervals indicate selection, avoidance, or use in proportion to availability for each variable category where χ^2 tests were significant (P < 0.05). Absence of confidence intervals indicates non-significant χ^2 tests. If a confidence interval overlaps zero, category i is used in proportion to its availability. If an entire confidence interval is negative, category i is avoided. If an entire confidence interval is positive, category i is selected.

within each elevation category relative to its availability (Table 2). Spotted owls used elevations from 0 to 300 m for roosting and nesting less than expected, selected elevations of 300-600 and 600-900 m for roosting, and used elevations of >900 m less than expected for roosting. Spotted owls also selected the lower third of slopes, used the middle third of slopes in proportion to their availability, and used the upper third of slopes less than expected for roosting (χ^2 = 25.12, 2 df, $P < 0.001$) and nesting (χ^2 = 19.74, 2 df, $P < 0.001$; Table 2).

Spotted owls used aspects in proportion to their availability for roosting (χ^2 = 7.04, 7 df, P = 0.424) and nesting (χ^2 = 6.79, 7 df, P = 0.451; Table 2), although aspects were not equally available within the WCSA (χ^2 = 58.95, 7 df, $P < 0.001$). In addition, spotted owls selected gentle (15-30%) slopes less than expected and used other slope categories in proportion to their availability for roosting (χ^2 = 12.38, 5 df, P = 0.030; Table 2). All slope categories were used in proportion to availability for nesting (χ^2 = 6.57, 5 df, P = 0.254).

DISCUSSION

Our observations of spotted owl habitat selection were consistent with the radio-telemetry studies which assessed owl habitat selection on different spatial scales. Previous studies of spotted owl habitat use were facilitated by radio-telemetry (Forsman et al. 1984, Carey et al. 1990, Sisco 1990, Solis and Gutiérrez 1990). Habitat selection in these studies was assessed by comparing habitats selected by radio-marked spotted owls with habitats available within each individual owl's home range. In contrast, we evaluated habitat selection of a population of spotted owls during the breeding season by comparing daytime habitat selection of owls lacking radio-tags with all habitats available within the boundaries of the population. Although stands of small timber were used in proportion to their availability for roost and nest sites, the small timber on our study area resulted from natural conditions and processes. Therefore, these results may not apply to small timber regenerated after timber harvesting because natural stands of small timber have diverse species composition and complex structure (Solis and Gutierrez 1990).

Spotted owls in our study used physiographic features similar to those used by radio-marked birds within the same area (Solis and Gutierrez 1990). However, the association of the owls with specific physiographic features probably is correlated with other environmental features (e.g., streams) rather than with physiography per se (Solis and Gutiérrez 1990).

MANAGEMENT IMPLICATIONS

The spotted owl is one of the most controversial threatened species because of the high economic value of its forest habitat (Simberloff 1987). This controversy has precipitated a scrutiny of spotted owl studies unprecedented in wildlife studies (e.g., Boyce 1987, Green 1991, Reich 1991, Sheriff 1991). Two of the most recent critiques specifically criticized the use of radio-telemetry for evaluating habitat selection in owls because telemetry emphasizes individual animal ecologies (i.e., first- and third-order selection) rather than population ecology (i.e., second-order habitat selection) (Green 1991:3, Sheriff 1991:3), and because telemetry may influence habitat selection in these birds (Sheriff 1991:3). Our study of second-order habitat selection addressed this concern because we sampled a population of owls within a large discrete area. This area also contained the mixture of habitats typical of public lands in the region. Thus, owls in our population had access to a variety of habitat types within their home ranges. While the influence of radio transmitters on behavior is a general concern of wildlife ecologists (Gilmer et al. 1974, Hooge 1991), our study of a population without radio transmitters demonstrated a strong consistency in habitat selection between owls carrying transmitters and those without transmitters.

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