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A COMPARISON OF BARRED AND SPOTTED OWL NEST-SITE CHARACTERISTICS IN THE EASTERN CASCADE MOUNTAINS, WASHINGTON

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ABSTRACT.—We describe 10 nest sites of the northern Barred Owl (*Strix varia varia*) in mixed-coniferous forests of the eastern Cascades in Washington, a region where the species is sympatric with the northern Spotted Owl (*S. occidentalis caurina*). Our goal was to determine whether Barred and Spotted owls used similar habitats for nesting. In contrast to Spotted Owls, Barred Owl nest sites were situated on gentle slopes or flat ground, closer to water, and included more hardwoods and a greater richness of tree species. Barred Owl nests were usually in cavities or platforms created at the broken top of the tree bole. Only two Barred Owl nests were in abandoned hawk nests or clumps of branches infected by dwarfmistletoe (*Arceuthobium douglasii*), which were the two most common nest structures used by Spotted Owls in our study area. Barred Owls used a greater range of tree species for nesting, including three nests in black cottonwoods (*Populus trichocarpa*), a species rarely used for nesting by Spotted Owls in the Pacific Northwest. Although differences in these attributes suggest that the two species used somewhat different habitats, Barred Owls have become more abundant in our study area and the region, and further assessments of habitat use may indicate greater niche overlap.

KEY WORDS: *northern Barred Owl*; Strix varia; *northern Spotted Owl*; Strix occidentalis; *habitat*; *nest sites*; *Washington.*

UNA COMPARACIÓN LAS CARACTERÍSTICAS DEL NIDO *STRIX VARIA VARIA* Y *STRIX OCCIDENTALIS CAURINA* EN LAS MONTAÑAS DE EASTERN CASCADE, WASHINGTON

RESUMEN.—Describimos diez sitios de nido de *Strix varia* en bosques mixtos de confieras de las montañas Eastern Cascade en Washington, una región donde la especie es simpátrica con *S. occidentalis caurina.* Nuestro objetivo era el de determinar si *Strix varia varia* y *Strix occidentalis caurina,* utilizan habitats similares para anidar. En contraste a *S. occidentalis caurina* los sitios de los nidos de *S. varia varia* estaban ubicados en pendientes suaves o en pastizales planos, cerca del agua e incluían mas maderas duras y una mayor riqueza de especies de árboles. Los nidos de *S. varia varia* estaban ubicados en cavidades o en plataformas creadas por árboles quebrados en su parte superior del tronco. Tan solo dos nidos de *S. varia varia* se encontraban en nidos abandonados de gavilanes o en el follaje de ramas infectadas por *Arceuthobium douglasii,* las cuales fueron las estructuras mas comunes utilizadas por *S. occidentalis caurina* en nuestra area de estudio. *S. varia varia* utilizo un mayor rango de especies de árboles para anidar, incluyendo a *Populus trichocarpa* una especie raramente utilizada para anidar por *S. occidentalis caurina* en el Noreste Pacifico. Aunque las diferencias en estos atributos sugieren que de algún modo las dos especies utilizan diferentes habitats, *S. varia varia* se ha vuelto mas abundante en nuestra área de estudio y en la región. Una evaluación posterior del uso de hábitat puede indicarnos un mayor traslape de nicho.

[Traducción de César Márquez]

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Until recently, the range of the northern Barred Owl (*Strix varia varia*) was limited to the hardwood and mixed conifer/hardwood forests of eastern North America (Mazur and James 2000). In the last century, Barred Owls expanded their range westward across the continent to British Columbia (Grant 1966) and then south to central California (e.g., Taylor and Forsman 1976, Leder and Walters 1980, Dark et al. 1998). Barred Owls are now sympatric with northern Spotted Owls (*S. occidentalis caurina*) over nearly the entire range of the latter species (Dark et al. 1998). The continuing range expansion and increase in population density of Barred Owls in the Pacific Northwest has raised concerns because they may compete with Spotted Owls (USDI 1992, Kelly et al. 2003), and the two species hybridize (Hamer et al. 1994, Kelly 2001). The effects of competition and hybridization on the Spotted Owl, a threatened species (USDI 1990), are unknown but potentially deleterious (see Pearson and Livezey 2003).

Stand- and landscape-level habitat relationships of Barred Owls have been documented in other parts of their range (e.g., Nicholls and Warner 1972, Apfelbaum and Seelbach 1983, McGarigal and Fraser 1984, Bosakowski et al. 1987). In Washington, landscape composition of stand types or forest age classes associated with nesting Barred Owls have been described in the northwestern and southwestern Cascades (Hamer 1988, Pearson and Livezey 2003) and the central eastern Cascades (Herter and Hicks 2000), areas where both Barred Owls and Spotted Owls occur. In this paper, we describe attributes of sites used for nesting by sympatric Barred and Spotted owls in the eastern Cascade Mountains.

STUDY AREA

Our study area was the east slope of the Cascade Mountains in Washington. The 875 000-ha area extends ca. 225 km in a north-south direction, from Canada to the Oregon border, up to 45 km eastward from the Cascade crest, and includes the Wenatchee and Okanogan National Forests, portions of the Gifford Pinchot National Forest, tribal lands of the Yakama Nation, and adjacent state and private lands. The study area contains forest associations ranging from the moist Douglas-fir (*Pseudotsuga menziesii*)/western hemlock (*Tsuga heterophylla*) zone in the west to the xeric ponderosa pine (*Pinus ponderosa*)/artemesia zone in the east (Franklin and Dyrness 1973), and contains coniferous and mixed-coniferous forests (Cobb 1988). Fire suppression in the last century has changed the structure and composition of forests in parts of the region (Agee 1993).

METHODS

Between 1988 and 1994, we visited all known Barred Owl nests in our study area, except for one nest that was reported to us but located in an extremely remote area. Biologists found nests of both species during timber-sale evaluations, Spotted Owl surveys, or in the case of some Barred Owl sites, during specific searches for their nests.

At each nest, we described the nest and nest tree. This information included the species, age (based on an increment core extracted at breast height), diameter at breast height (DBH), height, canopy position, condition of the nest tree (i.e., alive or dead; top intact or broken), and the nest type (i.e., cavity, broken-top platform, abandoned hawk nest, cluster of mistletoe-infected branches), height, and orientation relative to the tree trunk.

Vegetation structure at nest sites was quantified in a single 0.10-ha circular plot (18.0-m radius) centered on the nest tree and five 0.04-ha plots (11.4-m radius). The middle 0.04-ha plot was centered on the nest tree and the others were immediately adjacent in the cardinal directions (Buchanan et al. 1995). Characteristics of snags and three dominant or codominant and three intermediate trees (tree height, canopy height, age) were assessed in the 0.10-ha plot. Snags were measured (DBH, height) and identified to species and decay class (Cline et al. 1980). In the 0.04-ha plots we identified and measured all trees $\geq$10 cm DBH, estimated the volume of coarse woody debris according to four decay classes (Sollins 1982), and counted the number of saplings <10 cm DBH. We measured canopy closure at Barred Owl nests using a spherical densiometer (Lemmon 1956). We were unable to make comparisons of canopy closure to the paired sample of Spotted Owl sites; instead, we compared our sample to a previously-documented sample of owl nests that characterized the region (Buchanan et al. 1993, 1995).

At each nest site, we described site disturbance and topographic features such as elevation, slope, topographic position, and aspect. Site disturbance was indicated by the presence of fire scars on logs or trees, or by evidence of timber harvest. Because Barred Owls often use lowland forests near water in other parts of their range (Mazur and James 2000), we estimated the distance to nearest water channels $\geq$5-m wide or ponds $\geq$2 ha and evaluated whether Barred Owl nest sites had different geophysical attributes than sites in which Spotted Owls nested. A complete description of data collection procedures is found in Buchanan et al. (1993, 1995).

We compared site and vegetation attributes at Barred Owl nests with a sample of Spotted Owl nests from a previous investigation (Buchanan et al. 1993, 1995). The forest-stand characteristics of Spotted Owl nest sites in the Eastern Cascades province vary intra-regionally (Buchanan and Irwin 1998). Much of this variation is related to the moisture gradient and concomitant changes in forest association across the region, and has been described in the context of Fire Management Analysis Zones (FMAZ), a geographic analysis and management system the U.S. Forest Service uses for fire management on the Wenatchee National Forest (Buchanan and Irwin 1998). Consequently, each Barred Owl nest was paired with a randomly-selected Spotted Owl nest from the same FMAZ, except for a nest in Klickitat County that was

paired with a Spotted Owl nest from that region. The pool of available Spotted Owl nests included 80 sites well distributed throughout the Wenatchee National Forest and vicinity (FMAZ 1 = 14 sites, FMAZ 2 = 31 sites, FMAZ 3 = 19 sites, FMAZ 4 = 13 sites, FMAZ 5 = 3 sites; Buchanan and Irwin 1998) and 31 sites in Klickitat County and vicinity (J. Buchanan unpubl. data).

We used a two-step approach to analyze our data. First, we used paired *t*-tests (Zar 1984) to determine if habitat features at Barred Owl nest sites differed from those at Spotted Owl sites. Percent-slope values were arc-sine transformed prior to analysis. The Wilcoxon test was used to compare the number of tree species present at nests of the two species. Means ±SE are presented unless otherwise indicated; df = 9 in all comparisons. We considered statistical tests significant when $\alpha \leq 0.1$.

Second, because of the possibility that some of our significant findings were the product of chance because of the large number of paired comparisons, we used logistic regression (Hosmer and Lemeshow 1989) to determine whether our significant variables would be included in multivariate models. For this analysis we included all variables with *P*-values ≤0.25 in the univariate analyses (see Mickey and Greenland 1989) and produced a set of all possible models using those variables. We evaluated the resulting models to identify variables that contributed to high rates of correct sample classification. We did not intend the models to be used as predictive tools because of our concern that habitat use by Barred Owls has likely changed, thus necessitating the development of new models (see below).

RESULTS

General Site Characteristics. We quantified habitat at 10 Barred Owl nest sites in the eastern Cascades province. These sites were 0.4–12.5 km ($\bar{x}$ = 4.8 ± 1.4 km) from known Spotted Owl nest locations. Nine sites occurred in four of the five fire management analysis zones (zone 1 = three sites, zone 2 = two sites, zone 3 = three sites, zone 5 = one site) and one site was in Klickitat County.

Barred Owl nests were generally in areas with low relief ($\bar{x}$ slope = 10.6 ± 4.1%) in bottomlands (7), on a mid-slope bench (1), a ridge-top (1), or at the base of a gradual slope (1). Spotted Owls nested on significantly steeper terrain ($\bar{x}$ slope = 41.9 ± 4.5%; $t = 5.19$, $P < 0.0001$). Because the terrain at several Barred Owl nests was level, we did not calculate site aspect. Elevation of Barred Owl sites ranged from 320–1180 m ($\bar{x}$ = 781 ± 84.6 m) and did not differ from Spotted Owl nest sites ($\bar{x}$ = 913 ± 54.8 m; $t = 1.31$, $P = 0.21$). Barred Owl nests were closer to water ($\bar{x}$ = 448 ± 183.2 m) than those of Spotted Owls ($\bar{x}$ = 1993 ± 534.1 m; $t = 2.74$, $P = 0.01$).

There was little evidence of recent fire or logging activity at Barred Owl nests, but most sites had been disturbed by these activities decades prior to known owl use. Evidence of fire (in the form of fire scars on trunks) was present at nine of 10 Barred Owl sites and six of 10 Spotted Owl sites. A slash fire burned at one Barred Owl site the year prior to nest use. Five of 10 Barred Owl sites had been lightly harvested; one site was logged several years prior to use and the others apparently several decades earlier. Four of 10 Spotted Owl sites exhibited evidence of selective timber harvest several decades prior to use.

Table 1. Mean age and size attributes of Barred Owl (N = 10) and Spotted Owl (N = 10) nest trees in the eastern Cascade Mountains, WA. Analysis results based on paired *t*-tests with df = 9.

	Barred Owl Nests		Spotted Owl Nests			
Attribute	$\bar{x}$	SE	$\bar{x}$	SE	t	P
DBH (cm)	106.0	15.4	64.9	8.1	2.36	0.03
Age (yr)	216.8	58.0	181.9	60.6	0.42	0.68
Tree height (m)	25.1	2.6	30.5	3.3	1.30	0.21
Nest height (m)	16.4	1.2	16.6	1.9	0.12	0.91

Nests and Nest Trees. There were a number of differences between the two owl species in nest tree attributes. Barred Owl nests were located in five tree species, including three in black cottonwoods (*Populus trichocarpa*), three in Douglas-firs, two in grand firs (*Abies grandis*), one in a western hemlock, and one in a western larch (*Larix occidentalis*). In contrast, nine of 10 Spotted Owl nests were in Douglas-firs. Of the 10 Barred Owl nests, two were in living and intact trees, and eight were in trees that had broken boles (six alive, two dead). In comparison, seven Spotted Owl nest trees were alive and intact, and three were either dead or had broken tops. Barred Owl nest trees were significantly larger in diameter (at breast height) than Spotted Owl nest trees, but there were no differences in tree age, tree height, or height of nest above the ground (Table 1).

The two owl species exhibited differences in the types of nests used. Eight Barred Owl nests were in cavities or on chimney-like platforms created at the point where the tree bole had broken; one was in a clump of branches infected by dwarfmistletoe (*Arceuthobium douglasii*), and one was an abandoned Northern Goshawk (*Accipiter gentilis*) nest Only two Spotted Owl nests were in cavities or on

Table 2. Mean structural and age attributes of vegetation at Barred Owl ($N = 10$) and Spotted Owl ($N = 10$) nest sites in the Eastern Cascade Mountains, WA. Analysis results based on paired t-tests with df = 9.

ATTRIBUTE	BARRED OWL NESTS		SPOTTED OWL NESTS			
	$\bar{x}$	SE	$\bar{x}$	SE	t	P
Age of dominant/codominant trees (yr)	164.4	41.0	191.9	62.1	0.37	0.71
Age of intermediate trees (yr)	88.7	18.2	108.0	17.4	0.77	0.45
Basal area of conifers (m^2/ha)	44.2	9.0	42.5	6.2	0.16	0.87
Basal area of Douglas-firs (m^2/ha)	15.1	4.1	22.8	3.5	1.43	0.17
Basal area of hardwoods (m^2/ha)	7.8	4.0	0.21	0.1	1.9	0.07
Basal area of all trees (m^2/ha)	52.1	8.1	42.7	6.1	0.93	0.37
Basal area of snags (m^2/ha)	6.3	1.8	14.6	4.1	1.84	0.08
Height (m) to base of canopy (dominants/codominants)	12.8	1.8	16.6	1.0	1.84	0.08
Height (m) to base of canopy (intermediate trees)	8.5	1.3	8.7	1.3	0.09	0.93
Height (m) of dominant/codominant trees	31.2	1.6	33.8	0.9	1.42	0.17
Height (m) of intermediate trees	20.3	1.5	21.1	1.2	0.40	0.69
Sapling abundance (0.04 ha)	20.7	3.6	13.3	2.9	1.63	0.12

broken tops. The others were in clumps of branches infected by dwarfmistletoe or abandoned goshawk nests.

Vegetation Structure. With few exceptions, there were no differences between species in the vegetation structure we measured at owl nests. Barred Owl sites had a lower height to the base of the canopy of dominant/codominant trees, a greater basal area of hardwood trees, and a lower basal area of snags (Table 2). Other measures of tree height, canopy height, basal area, or sapling abundance did not differ between the two owl species (Table 2). Canopy closure at five Barred Owl sites averaged 70.6%, which is within the range reported from the eastern Cascade Mountains (Buchanan and Irwin 1998).

We recorded 16 tree species at the Barred Owl nest sites, although seven of these were present at two sites only. At the Spotted Owl nest sites, we observed 8 tree species including three species present at ≤2 sites. Four species were present at ≥5 Barred Owl sites: Douglas-fir, grand fir, western redcedar (*Thuja plicata*), and red alder (*Alnus rubra*); and Douglas-fir and grand fir were present at ≥8 sites. The latter two species were equally prevalent at Spotted Owl sites ($N = 10$ and $N = 7$, respectively); ponderosa pine was the only other species present at ≥5 Spotted Owl sites ($N = 6$). Hardwoods were present at seven Barred Owl sites and three Spotted Owl sites. The median number of tree species present at Barred Owl nest sites ($N = 5$) was greater than at Spotted Owl nests ($N = 3$; Wilcoxon $Z = 3.53$, $P = 0.0004$).

Logistic-regression analyses identified a number of models that classified nest sites with a high degree of accuracy. Fourteen models correctly classified ≥18 of 20 nest sites, including six models that correctly classified ≥19 sites. Five of the six parameters that were significant in our paired analyses were identified in the latter six models: *percent slope* and *number of tree species* (included in four models); *distance to water* (three models), *basal area of hardwoods,* and *basal area of snags* (two models); and *height of dominant/co-dominant trees* (one model).

DISCUSSION

Many studies have documented that Barred Owls inhabit or associate with forests containing standing water or wetlands (e.g., Nicholls and Warner 1972, Devereaux and Mosher 1984, Bosakowski et al. 1987). Falk (1990) reported no association of Barred Owl nest sites in Connecticut with water, although there was significantly more water in the vicinity of nests compared to two diurnal raptors included in that study.

In the eastern Cascade Mountains of Washington, Barred Owl nests were much closer to water and were in valleys or other areas with less relief than were nests of Spotted Owls. An apparent preference for areas near water by Barred Owls may be

related to the greater diversity of small mammal (Peffer 2001) and aquatic prey species associated with riparian zones within the eastern Cascades. In addition, the prevalence of Barred Owl sites in bottomlands likely influenced the greater richness of tree species and the greater abundance of hardwoods that we observed compared to Spotted Owl nests.

We found two substantial differences between these owl species in the type of nest structures and the size of nest trees used. First, Barred Owls most often used cavities or platforms atop broken tree boles and infrequently used old goshawk nests or clusters of branches infected by mistletoe. In contrast, most Spotted Owl nests were associated with mistletoe or old goshawk nests (Buchanan et al. 1993), a use pattern that appears to be unique to the eastern Cascades and the Klamath Mountains in Oregon (Forsman et al. 1984). Barred Owls may use nest structures opportunistically; however, all six nests Yannielli (1991) found in Connecticut were in cavities. On the other hand, 18 of 38 (47%) nests reported by Bent (1938) were abandoned hawk nests. This pattern of nest use is consistent with the generalist nature of this species in western North America (Mazur and James 2000).

Second, Barred Owl nest trees were larger than those Spotted Owls used in our study area. This difference can be explained by: (1) Barred Owl use of cottonwoods, which rapidly attain large size, (2) the generally larger size of trees on gentle terrain and in bottomlands, where growing conditions are better than on the sloping terrain where Spotted Owls nested (Buchanan et al. 1995), and (3) the comparatively greater Barred Owl use of cavity and broken-top platform structures, which occur in larger trees than the goshawk or mistletoe nests that Spotted Owls used (Buchanan et al. 1993). Although Barred Owls are larger than Spotted Owls (Snyder and Wiley 1976), it is unknown if the former requires a larger cavity for nesting. The comparatively lower basal area of snags at Barred Owl nests might be explained by this species' use of varied habitats and prey.

The availability of nest sites and prey are thought to be primary factors that limit raptor populations (Newton 1979, Nelson 1983). Therefore, competition between raptor species likely involves significant mutual reliance on one or both of these resources. Hamer et al. (2001) suggested that competition between Barred and Spotted owls for prey may occur in the northern Cascades Region in western Washington.

Despite the differences we found in habitat use, a number of habitat attributes were common to the two species and suggest a certain amount of niche overlap. All Barred Owl nests were within the geographic range of the Spotted Owl and occurred within the elevation range and forest associations Spotted Owls use on the east slope of the Cascade Mountains in Washington. There were no interspecific differences in total heights of dominant or intermediate trees, or in the basal area of trees; also, there did not appear to be differences in canopy closure. In short, both species primarily nested in closed-canopy, mixed-coniferous forests at mid-elevations. Although the shared use of forests with these features placed the two species in close contact with one another, differences in geophysical position and habitat use may have minimized competition when the two species first became sympatric.

Our data indicating use of different types of nests and nest tree species by the two owls suggests the absence of significant competition for nest structures and perhaps nest sites. This perspective was based on data collected between 1988 and 1994, a period when Barred Owls appeared to be less common than at present. Indeed, Barred Owls now occur in many areas that several years previously supported only Spotted Owls (T. Fleming unpubl. data). Additionally, several Spotted Owl nests in our study area have been used by Barred Owls since 1994 (T. Fleming unpubl. data). Consequently, given the more generalist use of habitat by Barred Owls (Mazur and James 2000) compared to Spotted Owls, a future assessment of Barred Owl habitat use may indicate a different relationship between the two species.

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