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DENSITY AND ROOST SITE CHARACTERISTICS OF SPOTTED OWLS IN THE SIERRA MADRE OCCIDENTAL, CHIHUAHUA, MEXICO[1]

KENDAL E. YOUNG AND RAUL VALDEZ
Department of Fishery and Wildlife Sciences, New Mexico State University, Las Cruces, NM 88003, e-mail: kyoung@leopold.nmsu.edu

PHILIP J. ZWANK
New Mexico Cooperative Fish and Wildlife Research Unit, U.S. Geological Survey, Biological Resources Division, New Mexico State University, Las Cruces, NM 88003

WILLIAM R. GOULD
University Statistics Center, New Mexico State University, Las Cruces, NM 88003

Abstract. We estimated density and characterized roosting habitat of Mexican Spotted Owls (*Strix occidentalis lucida*) in the Sierra Madre Occidental in southwestern Chihuahua, Mexico. Mean Spotted Owl density in Chihuahua (0.089 owls km^{-2}) was approximately half that reported for Arizona and New Mexico. Owls were primarily (70%) roosting in medium-sized trees, which likely resulted from a paucity of mature and old-growth forest on our study area. Spotted Owl roosts had steeper slopes, more canopy layers, greater canopy closure, and greater live tree basal area than random sites. Management objectives should promote increasing canopy closure and understory diversity to improve habitats for Mexican Spotted Owls in northern Mexico.

Key words: density, habitat, Mexican Spotted Owl, Mexico, Strix occidentalis lucida.

Mexican Spotted Owls (*Strix occidentalis lucida*) currently range from the Rocky Mountains of southern Utah and Colorado south through the Sierra Madre Occidental of Mexico. This subspecies of Spotted Owl was listed as threatened in the United States in 1993 (U.S. Department of Interior 1993) and in Mexico in 1994 (Anonymous 1994), primarily due to historical alteration of its habitat. Most historical records of Spotted Owls in Mexico are from the Sierra Madre Occidental in Chihuahua and Sonora (Williams and Skaggs 1993, Ward et al. 1995). Highest densities of Mexican Spotted Owls in the United States are estimated to be in the Upper Gila Mountains of Arizona and New Mexico (Ward et al. 1995). No density estimates were available for Mexico.

Although they use a variety of habitats, Mexican Spotted Owls are considered habitat specialists (Ganey and Dick 1995, Seamans and Gutiérrez 1995) that inhabit mature mixed-conifer communities (Ganey and Balda 1994, Seamans and Gutiérrez 1995). These communities are structurally diverse and are characterized by uneven-aged, multistoried forests with high canopy closure (U.S. Fish and Wildlife Service 1995). These habitat-use characterizations are based primarily upon research conducted in the southwestern United States (Ganey and Balda 1994, Zwank et al. 1994, Seamans and Gutiérrez 1995, Rinkevich and Gutiérrez 1996). Habitat use information in Mexico is limited to Tarango et al. (1997) who found Mexican Spotted Owl roosts in southwestern Chihuahua in isolated forest patches in steep canyons that had moderate canopy closure. Tarango et al.'s study did not sample all available habitat, so additional owls were probably missed. We further characterize roosting habitat and provide density estimates for Mexican Spotted Owls in the Sierra Madre Occidental of Chihuahua, Mexico.

METHODS

STUDY AREA

The study was conducted in five randomly selected 70 km^2 quadrats located in Conservation and Forest Development Unit 5 (27°52′–28°17′N, 108°09′–107°34′W) in the Sierra Madre Occidental of southwestern Chihuahua, Mexico (Fig. 1). Quadrats were established following guidelines in May et al. (1996), except that quadrats encompassed multiple vegetation strata in our study. Based upon visual estimates from stations where Spotted Owl responses were elicited, forest habitats were primarily pine-oak (71%), dominated by Durango pine (*Pinus durangensis*), Mexican white pine (*P. ayachuite*), and Arizona pine (*P. arizonica*). Dominant oak species included netleaf oak (*Quercus rugosa*) and Arizona white oak (*Q. arizonica*). Pure pine and mixed-conifer represented 17% and 12%, respectively, of forested habitats (Young 1996). Less frequent tree species included Douglas-fir (*Pseudotsuga menziesii*), junipers (*Juniperus* spp.), Arizona cypress (*Cypressus arizonica*), Chihuahuan spruce (*Picea chihuahuana*), madrones (*Arbutus* spp.), and black cherry (*Prunus* sp.). Elevation of the study area ranged from 980–2,980 m.

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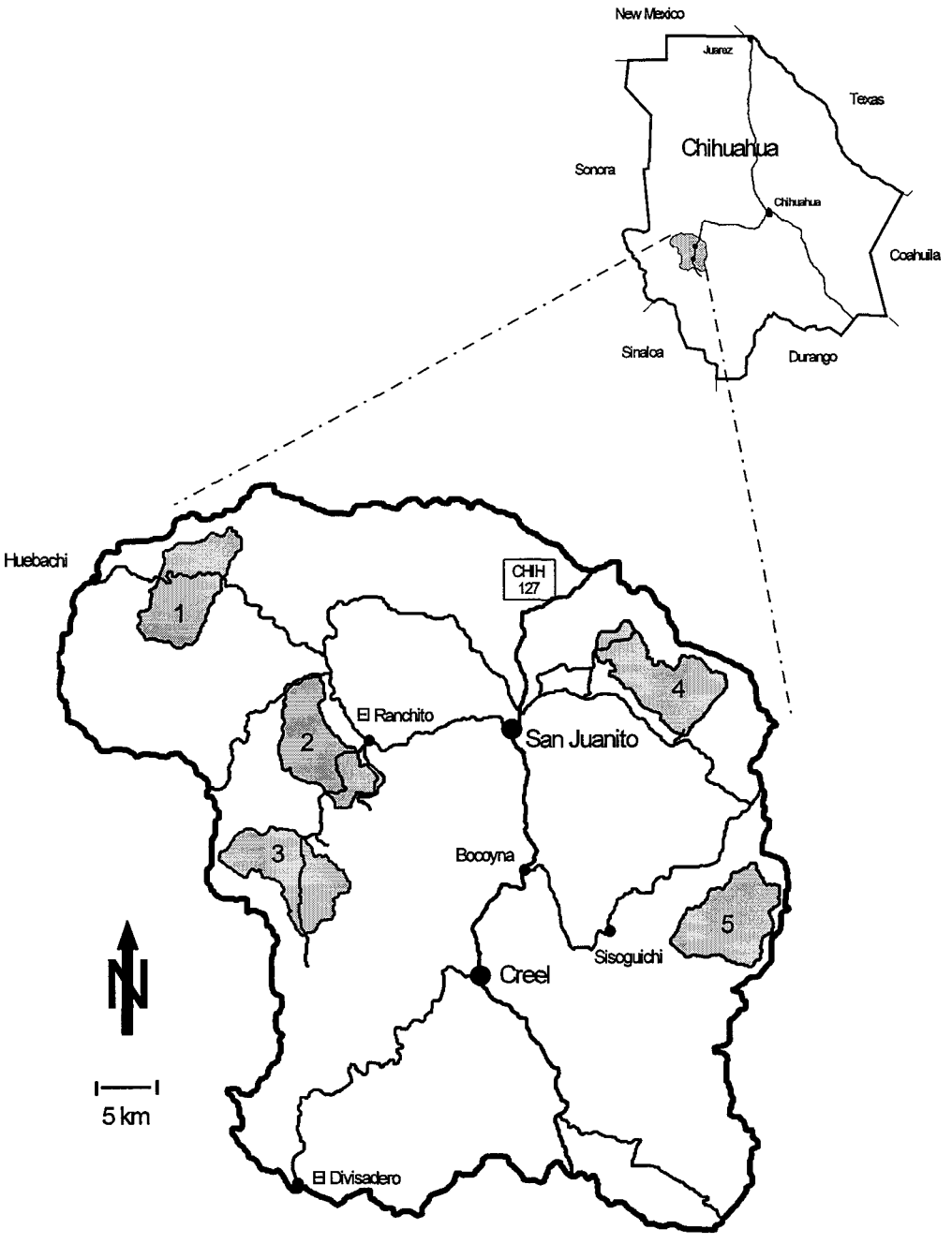

FIGURE 1. Study area and quadrats (shaded area) with principal towns and roads in the Sierra Madre Occidental, southwestern Chihuahua, Mexico.

DENSITY

Densities were estimated from data collected during four complete systematic surveys of each quadrat conducted between April–September 1994. A total of 441 call stations were placed between 0.3–0.8 km along forest roads or among ridgetops in nonroaded areas. Spotted Owl responses were elicited from nocturnal call stations by vocal imitation or playback of recorded owl responses (Forsman 1983, Franklin et al. 1990). Roost sites were located during the daytime, and co-

ordinates were recorded using altimeter, topographic characteristics, and a Global Positioning System. We attempted to locate and capture all Spotted Owls within each quadrat. We estimated Spotted Owl crude density as the number of territorial owls identified per unit area of each quadrat (Franklin et al. 1990). Territorial owls were defined as individually observed marked birds or nocturnally detected owls that were > 2.4 km from other Mexican Spotted Owls (Gutiérrez and Pritchard 1990).

ROOSTING HABITAT

We characterized microhabitat at owl roosts and random sites based upon 12 measured variables. If more than one roost occurred within the same 100-m^2 area, the roost most frequented was used for analysis (Blakesley et al. 1992). Roost plots were centered directly below the observed roost location and five random plots were centered on the nearest tree located at a random direction and distance between 150–800 m from a roost within each Spotted Owl territory to determine correlates of microhabitat use. Our random plots were not randomly placed within quadrats or home ranges because home range estimates for Spotted Owls in Mexico were unknown. The placing of random plots between 150–800 m from a roost insured that plots were available for use, yet maintained some level of independence between roost and random plots, and provided an estimate of local habitat selection.

Due to inaccessibility, we were unable to measure all habitat variables at cave roosts, therefore, only slope position and aspect is presented for cave roost sites. Elevation of roosts was determined with an altimeter. Slope position was described in categories of upper, middle, or lower third of the slope (Blakesley et al. 1992) and was estimated from topographic maps. Aspect was measured with a compass along major slope axis and grouped in cardinal heading intervals. Percentage of slope was estimated using the average of one downhill and one uphill clinometer measurement (Ganey and Balda 1989). The number of canopy layers was estimated visually. Canopy height was estimated by averaging the height of the three nearest overstory trees (Ganey 1988). Tree height was measured with a clinometer. Percent canopy closure was estimated at 5- and 10-m intervals in two cardinal directions using a 37-mm diameter tube divided in eight equal parts. The four estimates were averaged. Tree species composition was recorded within a 0.04-ha circular plot (Solis 1983) centered at the roost tree. Tree sizes were classified, using diameter at breast height (dbh), into five categories: old-growth (≥ 90 cm), mature (52.5–89.9 cm), medium (27.5–52.4 cm), pole (12.5–27.4 cm), and saplings (≤ 12.4 cm) (Bias and Gutiérrez 1992, Blakesley et al. 1992). Basal area (m^2 ha^{-1}) of all live trees and snags were estimated in a variable radius plot (Mueller-Dombois and Ellenberg 1974) using a 5-BAF prism. A 23.0-m line intercept transect was used to estimate percentage of ground cover (Call et al. 1992). Ground cover was classified as litter, rock, bare ground, herbaceous, grass, woody debris, or shrub. Small sample sizes precluded statistical analyses of data; therefore, we present means accompanied by SE of microhabitat characteristics at roosts and from random plots.

TABLE 1. Mean ± SE of habitat characteristics measured at 10 Spotted Owl tree roosts and 40 random plots in southwestern Chihuahua, Mexico, during April–September 1994.

Microhabitat characteristic	Roost	Random
Slope (%)	63.2 ± 7.3	40.5 ± 3.1
Canopy layers (*n*)	2.6 ± 0.2	1.8 ± 0.1
Canopy height (m)	18.6 ± 1.8	15.0 ± 0.8
Canopy closure (%)	72.6 ± 31.7	39.7 ± 2.9
Live basal area (m^2ha^{-1})	20.8 ± 4.7	7.4 ± 0.8
Snag basal area (m^2ha^{-1})	1.1 ± 0.6	<0.1 ± 0.1
Ground cover (%)		
litter	55.2 ± 6.9	71.1 ± 4.0
rock	22.9 ± 6.6	15.2 ± 3.5
bare ground	0.0 ± 0.0	6.6 ± 2.4
herbaceous	16.0 ± 5.0	1.3 ± 0.7
grass	3.0 ± 2.1	0.8 ± 0.3
woody debris	2.8 ± 1.9	1.5 ± 0.4
shrub	0.0 ± 0.0	1.8 ± 0.9

RESULTS

DENSITY

Thirty-five owls (14 pairs, 3 single males, 1 single female, and 3 juveniles) were found within the five quadrats. Within the 357.8 km^2 surveyed, crude densities of territorial owls averaged 0.089 ± 0.025 owls km^{-2}, but ranged from 0.055–0.111 owls km^{-2} in the quadrats. Mean nearest neighbor distances were 5.12 ± 0.57 km (n = 17 territories). The minimum known distance between two active territories was 2.64 km and the maximum nearest neighbor distance was 9.64 km.

ROOSTING HABITAT

Habitat variables at 12 roosts and 55 random sites were measured from 11 owl territories. Owls roosted at elevations between 2,072 m and 2,600 m ($\bar{x}$ = 2,368 ± 46 m). Ten roosts were located in trees, whereas two were in caves. Owls roosted in oaks (n = 4), pines (n = 4), Douglas-fir (n = 1), and black cherry (n = 1). Tree species composition within roost stands was pines (49%), oaks (36%), Douglas-fir (7%), and other species (8%). Pine composition was Durango pine (66%), Mexican white pine (23%), and Arizona pine (11%). Seven of 10 roost plots were classified as medium-sized trees, with mean stand dbh ranging between 29.3 ± 2.8 cm and 46.4 ± 6.5 cm. One owl pair roosted in mature-sized trees (59.2 ± 5.8 cm dbh) and two owl pairs roosted in pole-sized trees (19.7 ± 1.1 cm and 20.0 ± 1.0 cm dbh, respectively).

Roost sites were generally on the middle to upper third of the slope (91%) with a north to west aspect (84%). Roost sites tended to have steeper slopes, more canopy layers, higher canopy height, greater canopy closure, and greater live tree and snag basal area than random sites (Table 1). Ground cover at roost sites was

comprised of less litter and more rock, herbaceous vegetation, grass, and woody debris than random sites. Shrubs were absent at all roost sites and were infrequent at random sites.

DISCUSSION

We found Mexican Spotted Owls in the Sierra Madre Occidental of southwestern Chihuahua to be sparsely distributed. Mean nearest neighbor distance of Mexican Spotted Owls in Chihuahua (5.1 km) was substantially greater than those reported in Arizona (3.5–3.8 km) (Ganey and Balda 1989). Furthermore, crude density in Chihuahua (0.089 owls km^{-2}) appears to be approximately half of that reported for Spotted Owls in Arizona (0.148 owls km^{-2}) and New Mexico (0.180 owls km^{-2}) (Gutiérrez et al. 1994). However, our density estimate is approximately three times higher than that reported for Zion National Park, Utah (0.030 owls km^{-2}) (Rinkevich and Gutiérrez 1996). Sampling duration, geographic variation, or differences in habitat may contribute to these differences.

Mexican Spotted Owl roosts in Chihuahua were primarily in pine-oak forests, on steep canyon slopes with higher live basal areas and canopy closure than random plots. Although our study was conducted in the same area of Chihuahua as Tarango et al.'s (1997) study, our results varied slightly from theirs. Roost sites in our study exhibited greater canopy closures (72 vs. 68%), taller trees (19 vs. 13 m), larger tree roost stands (medium vs. pole size), and higher slope positions (upper two thirds vs. lower two thirds) than those reported in Tarango et al. (1997). These observed differences probably reflect owl survey methodology and sample size considerations. Our findings support those of Verner et al. (1992), Ganey and Dick (1995), and Gutiérrez (1996) who previously noted that Spotted Owls tended to be found in forest habitats that contained high canopy closures and basal areas.

Ganey and Dick (1995), Rinkevich and Gutiérrez (1996), and Tarango et al. (1997) noted that in canyon regions, Mexican Spotted Owls roost on cliff ledges in steep-walled canyons. Sixteen percent of Mexican Spotted Owl roosts we located in Chihuahua were in caves, all with a high timber component surrounding the cave. In addition, we found three forested roost sites located adjacent to cliffs. The combination of caves/cliffs and forests may provide more lateral and overhead protection from predation than either alone. This combination of habitat features also may foster suitable microclimates for Spotted Owls, as this species is thought to be heat intolerant and to seek microhabitats that aid in thermoregulation (Barrows 1981, Forsman et al. 1984, Ganey et al. 1993). Egested pellet remains from previous years were found at these roost sites, suggesting these roosts are frequently used.

Although they did not stratify tree stands into age classes, Tarango et al. (1997) reported a mean tree dbh at roost stands of 25.1 cm. We found owls roosting in slightly older tree stands (80% roosting in < 27.4 cm mean stand tree dbh). However, we located only one owl pair roosting in mature-sized trees; the remaining owl roosts were located in either medium or pole class trees. Mexican Spotted Owls predominantly inhabit mature to old-growth forests for roosts in the southwestern United States (Ganey and Balda 1989, Seamans and Gutiérrez 1995). This difference likely reflects habitat availability, as very little mature or old-growth forest existed on our study area; that which did exist was limited to isolated patches, mainly in steep canyons. Scarcity of old-growth forests in southwestern Chihuahua probably reflects timber harvest practices as well as natural conditions.

We found roost sites characterized by less litter and more herbaceous vegetation ground cover. However, at both roost and random plots, over half of the soil surface cover consisted of litter. Our estimates of ground cover by litter are inversely related to other ground cover features. Thus, as the percentage of ground cover of litter increases, the percentage of ground cover by woody debris, shrubs, grass, and herbaceous vegetation decreases. The relative scarcity of woody debris, shrubs, grass, and herbaceous vegetation at roosts and random plots in Chihuahua, likely results from a combination of frequent fires, firewood collection, and livestock grazing. The importance of ground cover in roost selection by Mexican Spotted Owls is unknown. However, a diverse understory structure would provide a more diverse prey base for Spotted Owls (Ward and Block 1995, Young et al. 1997).

The Mexican Forest Service (Conservation and Forest Development Unit 5) has developed a comprehensive management plan for their area. Currently, they are trying to protect 40 ha of forest surrounding each Spotted Owl activity center. Depressed economic conditions have led to a high unregulated timber harvest. Because the Mexican Forest Service has no forest protection authority, this illegal harvest has hampered their management activities. Forest management objectives in the Sierra Madre Occidental should promote increasing canopy closure, basal area, and understory diversity to improve habitats for Mexican Spotted Owls.

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