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HABITAT CHARACTERISTICS OF MEXICAN SPOTTED OWLS IN SOUTHERN NEW MEXICO

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Abstract.—Nine radio-tagged Mexican Spotted Owls (*Strix occidentalis lucida*) (four pairs, one mated female) were monitored from 101 to 301 d to determine seasonal home range sizes and roost and nest characteristics. Range sizes of individuals averaged 742 ± 386 (SD) ha and of pairs 1178 ± 332 ha. During the breeding season ranges of females ($\bar{x}$ = 117 ± 93 ha) were smaller than ranges of males ($\bar{x}$ = 438 ± 206 ha), but during the non-breeding season mean ranges did not differ (male 583 ± 90; female 547 ± 450). Home ranges were dominated by mixed-conifer forest in one drainage but were mixed-conifer, ponderosa pine (*Pinus ponderosa*), pinyon pine (*P. edulis*) and alligator juniper (*Juniperus deppeana*) in another drainage. Roost trees differed in height, canopy closure and basal area between drainages. No differences were noted between the heights of roosts of males and females or between heights of roosts during breeding and non-breeding seasons. Nests were in the midsection of large trees with high canopy closure.

CARACTERÍSTICAS DEL HABITAT DE *STRIX OCCIDENTALIS LUCIDA* EN EL SUR DE NUEVO MÉXICO

Sinopsis.—Se siguieron nueve individuos de *Strix occidentalis lucida* (4 parejas, 1 hembra apareada) entre 101 y 301 días para determinar los tamaños de la extensión del hogar, y de las características de los nidos y de los dormideros. Los tamaños de la extensión del hogar promediaron 742 ± 386 ha en individuos y 1178 ± 332 ha en parejas. La extensión del hogar fue menor en las hembras ($\bar{x}$ = 117 ± 93 ha) que en los machos (438 ± 206 ha) durante la época de apareamiento, pero los tamaños de la extensión del hogar no fueron diferentes en el período no reproductivo (machos 583 ± 90 ha; hembras 547 ± 450 ha). La extensión de los hogares fueron dominados por bosques de coníferos entremezclados en

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un cauce de drenaje, pero de coníferos entremezclados junto con *Pinus ponderosa, P. edulis* y *Juniperus deppeana* en otro. Los árboles usados para dormitar difirieron en altura, abertura del dosel y área basal entre las áreas de drenaje. No se notaron diferencias entre la altura de los dormideros de machos y de hembras o entre la temporada reproductiva y la no reproductiva. Los nidos se hallaron en la porción media de árboles altos con poca abertura de dosel.

The Spotted Owl (*Strix occidentalis*) is a medium-sized owl that inhabits forested mountains and canyonlands in western North America (Forsman et al. 1984, Ganey and Balda 1989). Three subspecies are currently recognized: the California Spotted Owl (*S. o. occidentalis*), the Northern Spotted Owl (*S. o. caurina*), and the Mexican Spotted Owl (*S. o. lucida*) (American Ornithologists' Union 1983). Only the California subspecies is thought to be secure in the wild. The northern subspecies (Federal Register, 26 Jun. 1990, p. 26,114) and the Mexican subspecies (Federal Register, 16 Mar. 1993, p. 14,248) are listed as threatened because of low population numbers and decreasing habitat from timber harvesting. Many studies of home ranges and habitat of the California and Northern Spotted Owls have been conducted (Blakesley et al. 1992, Forsman et al. 1984, Sisco and Gutiérrez 1984, Solis 1983) but few researchers have investigated range and habitat characteristics of the Mexican Spotted Owl. Current guidelines for the management of the Mexican Spotted Owl that establish a 182-ha core area within which no habitat disturbance except roads is allowed (Federal Register, 11 Apr. 1991, p. 14,679) are based primarily on the results of a single radio-telemetric study of eight Mexican Spotted Owls in Arizona (Ganey 1988). Further documentation of range size and habitat use would greatly assist in determining habitat needs of this subspecies. We report on seasonal range size and roost and nest site characteristics of nine Mexican Spotted Owls in southern New Mexico.

STUDY AREA AND METHODS

We monitored radio-tagged Mexican Spotted Owls in the Rio Penasco and Sixteen Springs drainages of the Lincoln National Forest, New Mexico. The Rio Penasco drainage is characterized by moderate to steep mountain slopes with primarily mixed-conifer forest: predominantly Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*) and southwestern white pine (*Pinus strobiformis*). Gambel oak (*Quercus gambelii*) was often present in the understory. The Sixteen Springs drainage is characterized by less steep slopes with mostly ponderosa pine (*Pinis ponderosa*), although pinyon pine (*P. edulis*), alligator juniper (*Juniperus deppeana*) and small patches of mixed-conifer forest are also present.

We captured Mexican Spotted Owls with a noose pole following procedures described by Forsman (1983). Radio-transmitters of 17–19 g were attached in a backpack harness configuration. Nocturnal locations were determined by triangulation of bearings from the loudest signals (Springer 1979). Only locations with error polygons ≤ 0.7 ha were used to compute seasonal ranges. Universal Transverse Mercator coordinates for each location were placed in a computer file that was processed through Locate

II (Pacer Computer Software, Truro, Nova Scotia, Canada; use of brand names is not endorsement by the U.S. Government). This program uses the maximum likelihood estimation technique to determine the most likely location for each triangulated fix. Thus derived locations and known roost sites were used to compute minimum convex polygon (Jourich and Turner 1969) estimates of range sizes with the Microcomputer Program for Analysis of Animal Locations (Stuwe and Blohowiah 1985). Breeding and non-breeding seasonal ranges refer respectively to the total area used during 1 March–31 August and during 1 September–28 February (Ganey and Balda 1989).

Roosting and nesting radio-tagged owls with operational transmitters were located and observed at least twice each week during daylight hours. Elevation, roost tree species, roost or nest height, slope, aspect, basal area and canopy closure were recorded for each observation. Elevation was measured with an altimeter or estimated from U.S. Geological Survey maps. Aspect was measured with a compass along major slope axis. Slope, roost tree height and owl height in roost tree were measured with a clinometer. Slope was recorded as an average of uphill and downhill slope percentages. Canopy closure was estimated with a hand-held spherical densitometer as the percentage of sky obstructed by vegetation in each of the cardinal directions and averaged across directions. Basal area was measured with a prism (BAF = 10). Spearman's Rank correlation coefficients (r_s) were calculated for all variables with SAS (SAS Institute, Inc. 1989). Student's *t*-tests were used to compare seasons, sexes and elevations. Means were reported ±SD. Female roost site characteristics during the breeding season were not included in the analyses because females spend much of the breeding season on or near the nest (Forsman et al. 1984).

RESULTS

Nine Mexican Spotted Owls were radio-tagged and monitored. The Bluff Springs pair, the Greasy Canyon pair and the Willie White Canyon mated female were in the Rio Penasco drainage. The Sixteen Springs Canyon pair and the Fire Canyon pair were in the Sixteen Springs drainage. A total of 1257 locations were recorded during 101–301 d of monitoring before transmitters failed or tagged owls died. Number of locations and range size (r_s = 0.31, df = 8) and monitored days and range size (r_s = 0.32, df = 8) were not correlated ($P > 0.05$).

In ranges, elevations ranged from 2050 to 2350 m in the Sixteen Springs drainage and from 2150 to 2750 m in the Rio Penasco drainage (Table 1). Mixed-conifer forest dominated home ranges in Rio Penasco drainage, whereas home ranges in the Sixteen Springs drainage were predominantly mixed-conifer, ponderosa pine, pinyon pine and alligator juniper (Table 1)

Ranges of individual owls averaged 742 ± 386 ha (range = 269–1498 ha) and combined ranges of pairs averaged 1178 ± 332 ha (range = 834–1628 ha). The estimated mean range size of five owls in the Rio

TABLE 1. Community types (%) and range of elevations in home ranges of nine Mexican Spotted Owls (four pairs, one mated female) in the Lincoln National Forest, New Mexico, 1990–1991.

	Mixed conifer[1]	Ponderosa pine	Pinyon/juniper	Aspen	Mountain grassland	Unclassified[2]	Elevation range (m)
Willie White							2400–2750[3]
Female winter	86	0	0	5	10	0	
Bluff Springs							2400–2750
Female winter	65	0	0	0	17	18	
Male winter	73	0	0	8	10	8	
Male breeding	84	0	0	8	5	3	
Greasy							2150–2700
Female winter	79	4	0	0	2	15	
Male winter	67	5	1	0	1	27	
Male breeding	74	10	0	0	2	14	
Sixteen Springs							2050–2350
Female winter	42	35	20	0	4	0	
Male winter	40	25	32	0	0	3	
Male breeding	30	42	24	0	4	0	
Fire							2050–2300
Female winter	13	25	62	1	0	0	
Male winter	6	29	64	0	0	0	
Male breeding	6	21	73	0	0	0	

[1] Douglas-fir, white fir, white pine.
[2] Private holdings that were not classified.
[3] Elevations interpolated from U.S.G.S. topographic maps.

Penasco drainage ($\bar{x}$ = 586 ± 340 ha) was smaller ($t = -2.31$, df = 4, $P < 0.05$) than of four owls in the Sixteen Springs drainage ($\bar{x}$ = 937 ± 390 ha). Estimated breeding season ranges ($\bar{x}$ = 278 ± 226 ha) were smaller ($t = -3.59$, df = 7, $P < 0.05$) than estimated non-breeding season ranges ($\bar{x}$ = 365 ± 301 ha). In both drainages, female breeding season ranges ($\bar{x}$ = 117 ± 93 ha) were smaller ($t = -6.90$, df = 7, $P < 0.05$) than male breeding season ranges ($\bar{x}$ = 438 ± 206 ha). Yet, ranges of males ($\bar{x}$ = 583 ± 90 ha) and of females ($\bar{x}$ = 547 ± 450 ha) during the non-breeding season did not differ ($t = -0.16$, df = 4, $P > 0.05$).

Within the 60% activity contour, range size varied from 13 to 229 ha ($\bar{x}$ = 110 ± 77) and included 15 ± 10% of the total average range. Within the 80% contour, amount of used area ranged from 99 to 476 ha ($\bar{x}$ = 298 ± 179) and included 42 ± 16% of the total range.

The Bluff Springs male's range was 2.7 times as large as the female's and encompassed about 90% of the female's range during the non-breeding season. Similarly, the Greasy Canyon male's range was 1.8 times as large as his mate's and entirely encompassed his mate's range during the non-breeding season. Conversely, the Fire Canyon and Sixteen Springs

TABLE 2. Elevations of roost trees (m) and elevational band width (m) in which 50% of roost trees of nine Mexican Spotted Owls (four pairs, one mated female) occurred in two drainages in the Lincoln National Forest, New Mexico, 1990–1991.

	$\bar{x}$	(SD)	Range	50%[1]	*n*
Bluff Springs					
Male	2597	(29)	2530–2669	2577–2606	53
Female	2593	(42)	2512–2682	2573–2609	9
Willie White					
Female	2586	(37)	2526–2627	2563–2615	26
Greasy					
Male	2393	(79)	2164–2682	2370–2423	48
Female	2413	(58)	2304–2560	2393–2438	19
Fire					
Male	2156	(34)	2073–2256	2134–2181	56
Female	2172	(60)	2073–2332	2140–2198	31
Sixteen Springs					
Male	2206	(40)	2057–2286	2182–2237	58
Female	2192	(39)	2115–2256	2167–2219	28

[1] 50% of roost trees were within this elevational band width.

Canyon females' ranges were 2.2 and 1.6 times larger, respectively, than their mates' ranges during the non-breeding season. The Fire Canyon male's non-breeding territory encompassed about 85% of the female's, and there was about 50% range overlap for the Sixteen Springs Canyon pair.

We observed monitored owls on 336 (220 male, 116 female) roosts. Thirty roost trees were used more than once: 20 were used twice, three were used three times, five were used four times, one was used five times and one was used seven times. Mean elevation of roost trees of individuals ranged from 2156 to 2206 m in the Sixteen Springs drainage and from 2393 to 2597 m in the Rio Penasco drainage (Table 2). Fifty percent of roost trees were within a 58 m-wide elevational band (Table 2).

Males (65%) and females (63%) used mixed-conifer forest for most of their winter roosts, and males used mixed-conifer forest for most of their breeding season roosts (77%) (Table 3). Mixed-conifer forest (88%) was used predominantly for roost trees in the Rio Penasco drainage; Douglas-fir (65%) and ponderosa pine (38%) was used most often for roosting in the Sixteen Springs drainage (Table 3).

Roost tree height was correlated to male and female owl roost heights during winter and to male roost height in the breeding season in the Rio Penasco and Sixteen Springs drainages (Table 4). Canopy closure, basal area and slope were correlated to roost height of owls during the winter. Slope on which the roost tree stood was correlated to roosting height in the Rio Penasco drainage, but not the Sixteen Springs drainage.

The ratio of owl roost height to roost tree height ranged from 41 ±

TABLE 3. Roost trees (%) of the nine Mexican Spotted Owls (four pairs, one mated female) during the winter and breeding season in two drainages in the Lincoln National Forest, New Mexico, during 1990–1991.

	Douglas-fir	White fir	Ponderosa-pine	Other	*n*
Season					
Winter					
Female	46	17	28	10	114
Male	51	14	25	11	114
Breeding					
Male	65	11	13	12	102
Location					
Sixteen Springs	43	6	38	13	156
Rio Penasco	65	23	4	8	174

20 to 60 ± 15% during the non-breeding season. Breeding season roosts ranged from 41 ± 20 to 53 ± 19% of roost tree height. Height ratio differed between Rio Penasco ($\bar{x}$ = 0.50 ± 0.19%) and Sixteen Springs ($\bar{x}$ = 0.44 ± 0.17%) drainages (t = 2.95, df = 307.5, P = 0.003), but did not differ between sexes (t = 0.54, df = 257.1, P = 0.59) nor between seasons (t = −0.023, df = 155.7, P = 0.98).

In the Rio Penasco and Sixteen Springs drainages, roost trees differed in height (t = 7.9, df = 260.6, P = 0.0001), canopy closure (t = 5.1, df = 225.7, P = 0.0001) and basal area (t = 7.1, df = 190.9, P = 0.0001), but not in slope (t = −1.7, df = 326.8, P = 0.08) or aspect (t = −1.9, df = 303.7, P = 0.05) (Table 5). Roosting heights also differed between drainages (t = 8.5, df = 196.2, P = 0.0001).

Male and female owls differed in roost tree selection relative to slope (t = −3.46, df = 244.7, P = 0.0006), but not aspect (t = 1.85, df = 206.3, P = 0.06), tree height (t = 0.11, df = 213.1, P = 0.91), canopy closure (t = 0.35, df = 239.6, P = 0.72) or basal area (t = −1.34, df = 225.7, P = 0.18) (Table 5). Owl height in roost trees did not differ (t = 1.44, df = 204.9, P = 0.15) between males and females.

Trees selected for roosts differed seasonally in height (t = −2.05, df = 186.4, P = 0.04) and basal area (t = −2.66, df = 105.9, P = 0.009), but not in aspect (t = 1.16, df = 157.9, P = 0.25), canopy closure (t = −0.89, df = 140.8, P = 0.37) or slope (t = −1.39, df = 242.8, P = 0.17) (Table 5). Owl heights in roost trees did not differ between non-breeding and breeding season (t = −0.68, df = 167.4, P = 0.50).

Monitored pairs began roosting together in February and began nesting in March. The last clutch hatched in early July. Characteristics of five nest sites were measured (three pairs of owls nested once and one pair [Greasy Canyon] nested twice) (Table 6). All five nests were located in mixed-conifer forest. Three of the nests were located in trees on the lower third of the slope, whereas the remaining two nests were situated in trees

TABLE 4. Correlation matrices of roosting heights of nine Mexican Spotted Owls by sex, season and location with roost tree height, roost tree canopy closure, basal area of trees at roost site and slope percentage at roost site in the Lincoln National Forest, New Mexico, 1990–1991.

Roosting height	Roost tree height (m)	Canopy closure (%)	Basal area	Slope (%)
Sex				
Male	0.52[1]	0.12	0.30	−0.32
	0.0001[2]	0.1111	0.0001	0.0001
Female[3]	0.68	0.29	0.18	−0.10
	0.0001	0.0038	0.0839	0.3000
Season				
Winter	0.60	0.33	0.29	−0.23
	0.001	0.0001	0.0001	0.0004
Breeding[4]	0.55	−0.03	0.17	−0.32
	0.0001	0.8086	0.1511	0.0015
Location				
Rio Penasco	0.57	0.03	0.06	−0.34
	0.0001	0.7302	0.5080	0.0001
Sixteen Springs	0.29	0.04	0.08	−0.07
	0.0001	0.6410	0.3640	0.3505

[1] Spearman Rank Correlation coefficients.
[2] Actual probability value.
[3] Winter only.
[4] Male only.

on the middle third of the slope. Two nests were in cavities in trees and three were old stick nests. Two nests were in live Douglas-firs, one was in a dead Douglas-fir, one was in a dead white fir, and one was in a dead ponderosa pine.

DISCUSSION

In New Mexico, ranges of individual adult Mexican Spotted Owls are 14% larger and ranges of pairs are 39% larger than those reported in Arizona (Ganey and Balda 1989). Conversely, ranges of owls in New Mexico were 46 and 55% smaller than ranges of individual and paired Northern Spotted Owls (Carey et al. 1990). Our estimates of core area (60 and 80% contours) were 29 and 11% smaller than those reported by Ganey and Balda (1989). The 182-ha core area of the Forest Service, however, is similar to a 60% contour if one standard error is added (187 ha). Range differences between subspecies may reflect genetic differences. Barrowclough and Gutiérrez (1990) found the Mexican Spotted Owl distinguishable from *S. o. occidentalis* and *S. o. caurina* by a significant difference in allelic frequency at one locus. They concluded that the two taxa may represent two species based on this genetic variation and the prolonged geographic isolation it suggests.

TABLE 5. Roost site characteristics of nine Spotted Owls (four pairs, one mated female) in two drainages in the Lincoln National Forest, 1990–1991. Sample size in parentheses.

	Owl height[1] (m)	Tree height (m)	Canopy closure (%)	Basal area	Slope (%)	Aspect (deg)
Sex						
Female	9.1 ± 5.4 (113)	19.3 ± 8.7 (114)	79.4 ± 11.0 (97)	116.7 ± 51.1 (92)	19.5 ± 8.8 (115)	158.0 ± 120.5 (107)
Male	8.2 ± 4.8 (212)	19.2 ± 8.0 (215)	78.8 ± 14.1 (191)	126.5 ± 64.5 (162)	23.1 ± 9.3 (215)	131.8 ± 113.6 (199)
Season						
Winter	8.4 ± 4.8 (226)	18.6 ± 7.8 (228)	78.4 ± 11.1 (192)	115.6 ± 51.8 (179)	21.4 ± 9.9 (228)	146.3 ± 111.9 (213)
Breeding	8.8 ± 5.5 (99)	20.7 ± 8.4 (101)	80.1 ± 16.4 (96)	140.5 ± 73.8 (75)	22.8 ± 7.8 (102)	128.7 ± 103.0 (93)
Location						
Rio Penasco	10.9 ± 6.0 (153)	22.8 ± 9.0 (155)	83.3 ± 14.8 (131)	147.2 ± 68.9 (128)	20.9 ± 9.0 (156)	127.3 ± 103.0 (140)
Sixteen Springs	6.5 ± 2.4 (172)	16.1 ± 5.9 (174)	75.4 ± 10.3 (157)	98.3 ± 35.6 (126)	22.7 ± 9.5 (174)	152.5 ± 126.0 (166)

[1] Roost height of owl in roost tree.

TABLE 6. Habitat characteristics of five Mexican Spotted Owl nests in the Lincoln National Forest, New Mexico, 1990–1991.

	$\bar{x}$	(SD)	Range
Elevation (m)	2420	(143)	2210–259
Slope (%)	24.6	(2.9)	20–27
Canopy closure (%)	88.4	(5.6)	82–95
Nest height (m)	12.9	(2.9)	10.1–16.2
Basal area	204	(61)	110–280
Tree height (m)	23.2	(10.2)	12.8–38.1

We found no correlation between number of locations or length of monitoring period and range size. Thus, differences in range size estimates among individual owls were not an artifact of sample size (Ganey and Balda 1989). We caution, however, that range estimates we report may underestimate actual ranges because our estimates were not for an entire year and were based on insufficient locations and non-independent data. Ganey and Balda (1989) claimed that approximately 150 locations were needed to determine 85–90% of an owl's home range. Only three of nine birds in this study met this requirement. Furthermore, Swihart and Slade (1985) stated that non-independent data cause an underestimate of actual ranges.

From October through January, pairs were rarely located together. Owls seemed to establish individual ranges during the non-breeding season, but some range overlap was usually noted between individuals of a pair. Range overlap between pairs of northern (Forsman et al. 1984) and Mexican subspecies (Ganey and Balda 1989) was previously noted.

Individual owl ranges were larger in the Sixteen Springs drainage. Ranges in that drainage were at a lower elevation, which was reflected in the tree species mix in the home ranges. Ganey and Balda (1989) found a general tendency towards larger home ranges at higher elevations.

Forsman et al. (1984), Ganey (1988) and Carey et al. (1990) found ranges of Spotted Owls during the breeding season smaller than non-breeding season ranges, as did we. Smaller breeding season ranges in our study probably reflect three of four monitored pairs nesting, because nesting female's spend much time on or near nests and males center their activity on nest sites while providing food for mates and nestlings (Forsman et al. 1984). Range size of males and females did not differ during the non-breeding season in New Mexico, but females' ranges were smaller than males' ranges during the breeding season. Ganey and Balda (1989) found female ranges were larger overall.

We found roost site characteristics of Mexican Spotted Owls very similar in New Mexico and Arizona (Fletcher 1990, Ganey and Balda 1989). In both states, owls usually roosted in dense, uneven aged mixed-conifer or ponderosa pine forests with high canopy closure. In New Mexico, they used mixed-conifer forest for roosting 45–86% of the time. Fletcher (1990) found mixed-conifer forest provided 79% of the roosting trees on

national forest lands in Arizona and New Mexico, whereas in Arizona, Douglas-fir and ponderosa pines comprised over 70% of the roost sites (Ganey and Balda 1989). We found more use of ponderosa pine for roosting than did Fletcher (1990) who found only one of 83 day roost sites to occur in ponderosa pine.

Male and female Mexican Spotted Owls roosted in the mid-section of trees that averaged 16 m in the Sixteen Springs drainage and 23 m in the Rio Penasco drainage. Fletcher (1990) reported that Mexican Spotted Owls in Arizona and New Mexico roosted in small diameter trees of moderate height.

Male and female owls in our study roosted in the midsection of trees in both drainages, although owls roosted 6% lower in trees in the lower elevation drainage. We think roosting height reflects cover requirements by this nocturnal species. Douglas-fir and white fir, the tree species used most for roosting, are cone-shaped (Sturman 1968); branches decrease in length from the base to the tree crown. Lowest branches, however, are often shed, or at least have less foliage volume. Thus, branches in the midsection of the tree provide the most cover.

Owls that we studied roosted in shorter trees with less dense foliage during winter, but roost height was not different between seasons. McDonald et al. (1991) stated that owls perched higher during winter. They speculated that perching higher in trees exposed owls to more solar radiation. Roosting at the same height in shorter trees as owls did in this study achieves the same effect but reduces cover advantages associated with roosting in the midsection of the tree.

Nest site characteristics of Mexican Spotted Owls were also similar in New Mexico and Arizona. In both states, mixed-conifer forest was used most for nest sites (Fletcher 1990). In New Mexico, as in Arizona, nests were constructed in tree cavities or were in stick nests (Fletcher 1990). Furthermore, Fletcher (1990) found nest trees were usually on moderate to steep slopes, as we did. Nest locations previously reported and those in our study were on lower or middle third of slopes (Fletcher 1990, Ganey and Balda 1989). Nests in New Mexico were at an average height of 13 m, which was in the midsection of the nest tree. This is similar to the 12-m nest height found by Ganey (1988) in Arizona, but is less than the 30-m average nest height reported by Forsman et al. (1984) for Northern Spotted Owls in Oregon. In addition, Northern Spotted Owl nests were at about two thirds of the height of the tree. This difference in nest height selection may again reflect differences among Spotted Owl subspecies.

Nests of Spotted Owls in this study were in taller trees with greater canopy closure and on steeper slopes than were the trees used for roosting. We think nest site characteristics probably reflect behavioral preferences of the species that constructed the nest, because this species does not build its own nests (McDonald et al. 1991).

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LITERATURE CITED

AMERICAN ORNITHOLOGISTS' UNION. 1983. Check-list of North American birds. 6th edition. American Ornithologists' Union, Lawrence, Kansas.

BARROWCLOUGH, G. F., AND R. J. GUTIÉRREZ. 1990. Genetic variation and differentiation in the Spotted Owl (*Strix occidentalis*). Auk 107:737–744.

BLAKESLEY, J. A., A. B. FRANKLIN, AND R. J. GUTIÉRREZ. 1992. Spotted owl roost and nest site selection in northwestern California. J. Wildl. Manage. 56:388–392.

CAREY, A. B., S. P. HORTON, AND J. A. REID. 1990. Spotted owl home range and habitat use in southern Oregon Coast ranges. J. Wildl. Manage. 54:11–17.

FLETCHER, K. W. 1990. Habitat used, abundance and distribution of the Mexican spotted owl, *Strix occidentalis lucida,* on Forest System lands. USDA For. Serv. SW Req., New Mexico.

FORSMAN, E. D. 1983. Methods and materials for locating and studying spotted owls. USDA For. Serv. Gen. Tech. Rept. PNW-162. Pac. NW For. and Range Exp. Stn., Portland, Oregon.

———, E. C. MESLOW, AND H. M. WRIGHT. 1984. Distribution and biology of the spotted owl in Oregon. Wildl. Monogr. 87:1–64.

GANEY, J. L. 1988. Distribution and habitat ecology of Mexican spotted owls in Arizona. M.S. thesis, Northern Arizona Univ., Flagstaff, Arizona.

———, AND R. P. BALDA. 1989. Home range characteristics of spotted owls in northern Arizona. J. Wildl. Manage. 53:1159–1165.

JOURICH, R. I., AND F. B. TURNER. 1969. Measurement of non-circular home range. J. Theor. Biol. 22:227–237.

MCDONALD, C. B., J. ANDERSON, J. C. LEWIS, R. MESTA, A. RATZLOFF, T. J. TIBITTS, AND S. O. WILLIAMS, III. 1991. Mexican spotted owl (*Strix occidentals lucida*) status review. U.S. Dept. Int., Fish and Wildl. Serv. Endangered Spec. Rept. 20.

SAS INSTITUTE, INC. 1989. SAS/STAT user's guide. Vol. 1 and 2. Version 6, Fourth ed. SAS Inst., Inc., Cary, North Carolina.

SISCO, C., AND R. J. GUTIÉRREZ. 1984. Winter ecology of radio-tagged spotted owls on Six Rivers National Forest, Humbolt County, California. USDA For. Serv., Six Rivers Natl. For., Eureka, California. Final Rept.

SOLIS, D. M. 1983. Summer habitat ecology of radio-tagged spotted owls on Six Rivers National Forest, California. M.S. thesis, Humboldt State University, Arcata, California.

SPRINGER, J. T. 1979. Some sources of bias and sampling error in radio triangulation. J. Wildl. Manage. 43:926–935.

STURMAN, W. A. 1968. Description and analysis of breeding habitats of the chickadees, *Parus atricapillus* and *P. rufescens.* Ecology 49:418–431.

STUWE, M., AND C. E. BLOHOWIAH. 1985. Microcomputer programs for the analysis of animal locations (MCPAAL), Version 1.2, Conserv. and Res. Cent. Natl. Zool. Park, Smithsonian Inst., Front Royal, Virginia.

SWIHART, R. K., AND N. A. SLADE. 1985. Testing for independence of observations in animal movements. Ecology 66:1176–1184.

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