Characteristics of California Spotted Owl Nest Sites in Foothill Riparian and Oak Woodlands of the Southern Sierra Nevada, California[1]

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Abstract: *Forty-one California spotted owl (*Strix occidentalis occidentalis*) nest sites were examined in foothill riparian and oak woodlands at 1,140 to 4,200 feet in elevation in the Sierra National Forest and Sequoia National Park, California. Nest sites were generally located on the lower 1/3 of the slope where dense canopy cover (averaging 86 percent) and multiple layers of vegetation were present. Aspects at nest sites were either west, north, or east; southern aspects were not used. Slopes ranged from nearly flat to more than 100 percent, but preference for a particular range of slopes was not detected. We found 24 platform nests, 13 side cavity nests and four top cavity nests. Nests were located in California sycamore (*Platanus racemosa*), ponderosa pine (*Pinus ponderosa*), and five species of oaks (*Quercus *spp.). Nest trees averaged 24 inches in diameter (range 7 to 54 inches) with a mean tree height of 62 feet and nest height of 39 feet. Nest tree diameters were smaller, basal area of live trees lower, and the percent of platform nests greater than results reported for nests in Sierra Nevada conifer forests.*

California spotted owls (*Strix occidentalis occidentalis*) in the Sierra Nevada nest in a variety of tree species in different habitats. Historically, research has concentrated on nest sites in conifer habitats above 3,000 feet in elevation. Characteristics such as dense canopy and large decadent trees with cavities appear to be critical to successful nesting in conifer habitat (Verner and others 1992). Conifers with oak understory in southern California and stands dominated by canyon live oak (*Q. chrysolepis*) along the southern coast of California have been identified as habitats used by California spotted owls (Gould 1977, Gutiérrez and Pritchard 1990). Migrating spotted owls use oak woodlands along the Sierra Nevada as wintering areas (Laymon 1988, Verner and others 1991), and owls in the southern Sierra Nevada can be found in oak habitats throughout the year, including the breeding season (Steger and others 1993, Verner and others 1991). Despite these observations, little is known about nest site characteristics of Sierra Nevada oak woodland areas where breeding is known to occur. This paper describes the characteristics of nest trees, nest structures, associated vegetation, and physical attributes at spotted owl nest sites in the southern Sierra Nevada oak woodlands. Comparisons of nest sites on National Forest lands to those on National Park lands are also reported.

Study Area

This study was conducted in the southern Sierra Nevada in the Sierra National Forest (SNF) and Sequoia National Park (SNP), California (*fig. 1*). The SNF study area covered 61 mi^2, and the SNP study area covered 32 mi^2. The study areas ranged in elevation from 1,140 to 4,200 feet within blue oak-gray pine, montane hardwood, and valley-foothill riparian wildlife habitats as defined by Mayer and Laudenslayer (1988).

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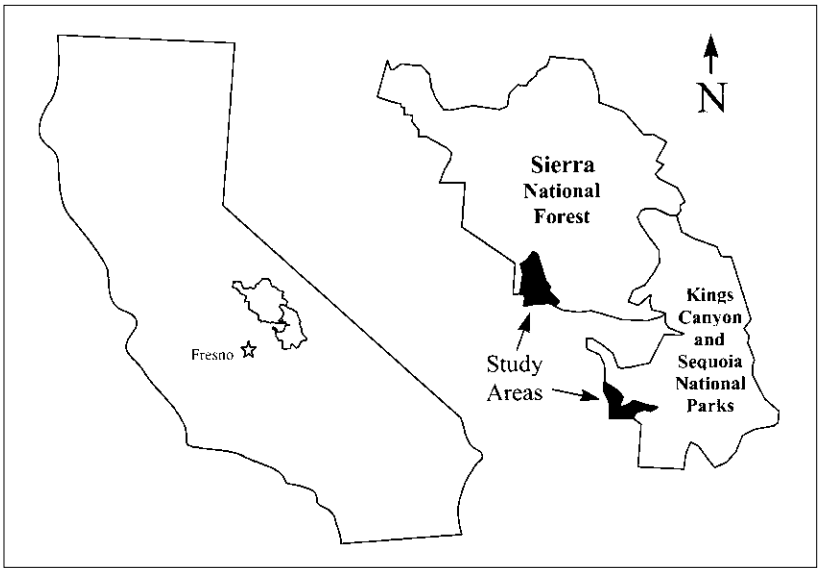

Figure 1—Locations of study areas in the Sierra National Forest (SNF) and Sequoia National Park (SNP), California.

Methods

California spotted owl nest trees were located from 1990 through 1995 using methods described by Forsman (1983). Data were collected at all known nest sites regardless of the owls' reproductive success. Nest trees were identified to species, and condition as a live tree or snag was recorded. The diameter of each nest tree was measured at breast height (DBH) (4.5 feet) with a diameter tape. Height of the nest tree and nest were measured with a Relaskop. Nests were described as platform (raptor nests or mistletoe), top cavity, or side cavity. Topographical information (aspect, slope, position on slope, elevation, type and distance to nearest water, and distance to and type of nearest road) was recorded at each nest site. Vegetation measurements around each nest were taken on a 0.3-acre plot that consisted of four 0.07-acre (33 feet × 98 feet) strip plots each starting 16 feet from the nest tree and radiating outward in each cardinal direction. Canopy cover was measured at 16, 33, and 82 feet from the nest tree along each strip plot using a spherical densiometer, and means of these measurements were calculated to determine the canopy cover for the plot. All live woody vegetation greater than 6 feet tall was considered trees, and all dead trees >5 inches DBH and >6 feet tall were considered snags. Those trees or snags with half or more of the bole rooted inside the plot were identified to species and measured for DBH and height. Large woody debris, greater than 10 inches in diameter, within the plot, was measured for small-end and large-end diameters and length. Live woody vegetation less that 6 feet tall was considered shrub cover and grouped by type: conifer, hardwood, shrub (evergreen and deciduous), and fern. Ground cover was classified as rock, soil, large litter (2 to 10 inches), small litter (<2 inches), herb, grass, moss, and lichen. Shrub cover and ground cover were measured along a line intercept through the middle of the 0.07-acre strip plots.

A two-sample *t*-test was used to evaluate differences between the vegetative measurements around nest sites on the SNF and SNP. Basal areas in square feet per acre and stems per acre for live trees and snags were calculated by vegetative category (oaks, conifers, and other species) and 10-inch stem diameter classes using the data from the 0.3-acre plots. The heights of live trees were categorized by the stem diameter classes, and means were calculated. Downed woody debris larger than 10 inches in diameter was used to calculate cubic feet and tons of debris per acre. Line intercept measurements (shrub cover and ground cover) were reported as the proportion of the line dominated by each of the categories. Means and standard deviations were calculated.

Results

Forty-one spotted owl nests in foothill riparian and oak woodland habitats were examined—26 in SNF and 15 in SNP. Thirty-six nests (88 percent) were found in oaks, two in California sycamores, two in ponderosa pines and one on a rock cliff. Interior live oak (*Q. wislizenii*), black oak (*Q. kelloggii*), and canyon live oak were the most commonly used for nests (*table 1*). All nest trees were live except for one black oak snag. Average DBH for all nest trees was 24 inches (± 12.6). Interior live oak had the smallest average DBH at 14.7 inches (± 6.0; range = 7–27 inches), and a single valley oak (*Q. lobata*) was the largest at 41 inches (*table 2*). Mean diameters of nest trees were consistently larger than the mean diameter of those same species from around the nest sites. Only 5 percent of the trees from around the nest sites had a DBH larger than the mean nest tree diameter. Height of nest trees and nests averaged 62 feet (± 22.8) and 39 feet (± 15.7), respectively. Canopy cover did not differ between the 16- and 33-foot samples ($t = 0.295$, df = 80, $P = 0.768$), the 16- and 82-foot samples ($t = 0.03$, df = 80, $P = 0.975$), or the 33- and 82-foot samples ($t = -0.296$, df = 80, $P = 0.767$). Combined canopy cover at all nest sites averaged 87 percent (± 14; range = 25-99 percent) (*table 1*) and did not differ between study areas ($t = 0.672$, df = 39, $P = 0.505$).

We found 24 (58.5 percent) platform, 13 (31.5 percent) side cavity, and 4 (10 percent) top cavity nests. All platform nests were associated with interior live oak or canyon live oak trees, except for one on a rock cliff and another in a ponderosa pine. Mean DBH of platform nest trees (17 inches ± 8.5) was significantly smaller ($t = 5.53$, df = 38, $P < 0.01$) than the mean DBH of trees that supported cavity nests (34 inches ± 10.7). The platform nest site found on the rock cliff in the SNF was a stick structure on a small ledge 32 feet up on a 40-foot cliff. Elevation at the nest site was 4,100 feet, and the canopy around the nest site was open (25 percent canopy cover).

Table 1—Structural attributes of California spotted owl nest sites in the Sierra National Forest (SNF) and Sequoia National Park (SNP) study areas, southern Sierra Nevada, California

Study area Tree species and rock	No. snags	No. live trees	Mean tree height		Mean nest height		Nest platform	Nest cavities	Mean canopy cover	
Sierra National Forest			*ft*	*SD*	*ft*	*SD*	*no.*	*no.*	*pct*	*SD*
Quercus chrysolepis	0	1	52	±0.0	46	±0.0	1	0	98.3	±0.3
Quercus kelloggii	0	3	50	±26.5	36	±10.0	0	3	89.9	±6.4
Quercus wislizenii	0	14	54	±12.8	39	±7.7	14	0	87.0	±9.7
Quercus douglasii	0	4	70	±31.3	36	±11.4	0	4	86.0	±14.5
Quercus lobata	0	1	66	±0.0	30	±0.0	0	1	88.6	±5.4
Platanus racemosa	0	2	82	±9.3	26	±4.5	0	2	86.2	±6.9
Pinus ponderosa	0	1	138	±0.0	92	±0.0	1	0	95.3	±2.9
Sequoia National Park										
Quercus chrysolepis	0	7	58	±13.0	49	±12.6	7	0	96.8	±3.5
Quercus kelloggii	1	5	60	±23.4	33	±10.5	0	6	79.7	±17.2
Pinus ponderosa	0	1	102	±0.0	82	±0.0	0	1	92.4	±3.2
Rock	-	-	-	-	-	-	1	-	25.4	±29.6

Table 2—Diameter of nest trees of California spotted owls and samples of diameters of similar tree species from around the nest trees in the Sierra National Forest (SNF) and Sequoia National Park (SNP) study areas, southern Sierra Nevada, California.

Study area / Tree species	Nest tree			Sampled trees			No. of trees larger than mean nest tree
	No.	Mean diameter		No.	Mean diameter		
		in.	*SD*		*in.*	*SD*	
Sierra National Forest							
Quercus chrysolepis	1	15.7	±0.0	33	10.5	±8.3	3
Quercus kelloggii	3	41.6	±17.1	29	12.8	±7.3	0
Quercus wislizenii	14	14.7	±6.0	466	9.1	±3.7	38
Quercus douglasii	4	35.5	±13.0	88	9.8	±6.9	2
Quercus lobata	1	40.9	±0.0	16	12.9	±6.0	0
Platanus racemosa	2	26.9	±0.3	70	13.0	±3.7	0
Pinus ponderosa	1	29.1	±0.0	20	16.3	±6.8	0
Sequoia National Park							
Quercus chrysolepis	7	21.0	±11.5	277	10.2	±4.4	9
Quercus kelloggii	5	30.1	±8.0	70	13.9	±5.2	0
Pinus ponderosa	1	36.6	±0.0	10	10.9	±7.6	0

Nest sites of California spotted owls were on slopes ranging from 0 to 105 percent (mean = 43.5 percent ± 24.5). No preference for a particular range of slopes was detected. Slopes at nest sites in the SNF (mean = 32.4 percent ± 18.8, range = 0-60 percent) were significantly different ($t = 4.7$, df = 39, $P = 0.0001$) from those in the SNP (mean = 62.7 percent ± 21.6, range = 28-105 percent). Nest sites tended to be located on the lower third of the slope, but distance to permanent water was usually greater than 330 feet in both study areas (*table 3*). Owls nested on all aspects except those ranging between 135 to 225 degrees (*fig. 2*). Owl nests tended to be greater than 330 feet from the nearest road in both study areas, although two nests were located within 33 feet of improved roads in the SNF study area (*table 3*).

Structural attributes of the vegetation around nests in the foothill riparian and oak woodlands were variable among sites and between study areas (*tables 4* and *5*). Total number of live trees at nest sites in both study areas averaged 874 stems per acre (± 622), with no significant difference between study areas ($t = 0.99$, df = 39, $P = 0.33$). We did find that approximately 85 percent of the total stems per acre were under 5 inches in DBH and there were more small oaks under 5 inches DBH on the SNP (411 ± 337) compared to the SNF (163 ± 112). Total basal area of live trees was greater on the SNP (130 sq. ft/acre) than on the SNF (105 sq. ft/acre) but did not differ significantly ($t = 1.50$, df = 39, $P = 0.15$). Oak trees with diameters ranging from <5 to 30 inches accounted for 86 and 68 percent of the basal area in the SNP and SNF, respectively. The SNP study area tended to have higher basal area and more hardwood stems with diameters between <5 to 30 inches, while the SNF had greater basal area and stems of larger (31- to 60-inch) hardwoods.

Plant species over 6 feet tall, other than oaks and conifers, accounted for approximately half of the live stems on both study areas, but represented only 15 percent of the total basal area (*table 4*). The majority of these other species were <5 inches DBH, had high variability in stem densities between plots, and were similar in number of stems and basal area on both study areas. Other species 5 to 60 inches in DBH were significantly greater in basal area ($t = 3.72$, df = 39,

Table 3—Physiographic attributes of California spotted owl nest sites in the Sierra National Forest (SNF) and Sequoia National Park (SNP) study areas, southern Sierra Nevada, California.

Physiographic attribute	SNF	SNP
Mean elevation *(ft)*	2045.0	3715.0
Mean slope *(pct)*	32.4	62.7
No. of nests by:		
Topographical position		
Upper 1/3	8	2
Middle 1/3	4	5
Lower 1/3	13	8
Distance to water *(ft)*		
<33	6	3
33-98	3	1
99-330	1	2
>330	16	8
Distance to road *(ft)*		
<33	2	0
33-98	0	0
99-330	3	0
>330	21	15

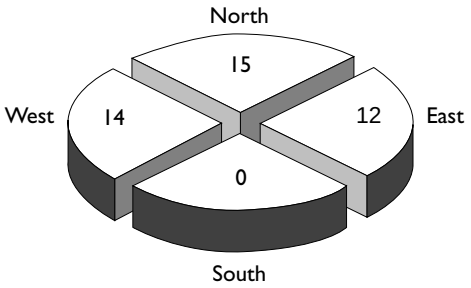

Figure 2—Frequency distribution of nest sites by aspect at 41 California spotted owl nests on the Sierra National Forest and Sequoia National Park, southern Sierra Nevada, California.

$P = 0.001$) and stem density ($t = 3.18$, df = 39, $P = 0.003$) on the SNF than on the SNP. Basal area of conifers, which were present at only 13 nest sites, accounted for only 4.5 (± 11.0) ft²/acre and 7 stems/acre, 4 of which were <5 inches DBH.

Canopy structure for both study areas was composed of a dense understory (743 stems/acre) of trees <5 inches DBH averaging 13 feet in height, a dominant canopy structure made up of a moderately dense (129 stems/acre) layer of 5- to 30-inch DBH trees from 31- to 60- feet in height, and a sparse layer (<1 stem/acre) of 31- to 60-inch DBH trees from 68- to 102- feet in height (*table 4*).

An average of 14 (± 11.0) snags per acre were at nest sites in oak woodlands, with the majority (12 ± 8.9) being small (5- to 20-inch DBH) hardwoods (*table 5*). Basal area of snags was greater in the SNP (12.2 ± 13.0 ft²/acre) than in the SNF (5.7 ± 5.6 ft²/acre) but did not differ significantly ($t = 1.72$, df = 39, $P = 0.11$). Downed woody debris differed significantly ($P = 0.05$) between study sites (*table 5*). The SNP nest sites averaged 331 (±260) ft³ (4 tons) per acre of woody debris, whereas those in the SNF contained only 156 (± 156) ft³ (2 tons) per acre.

The vegetative cover on the forest floor at owl nest sites was similar in both study areas (*table 5*). Generally, we found about 20 percent cover of small shrubs and ferns, whereas the majority of ground cover was small litter (60 ± 25 percent) and grass (21 ± 24 percent). Two shrub cover attributes (evergreen shrub and fern) and one ground cover attribute (large ground litter) differed significantly ($P = 0.03$) between the study areas, but the overall quantities of these attributes were low (*table 5*).

Table 4—Live tree characteristics at California spotted owl nest sites in the Sierra National Forest (**n = 26**) *and the Sequoia National Park* (**n = 15**) *study areas in the southern Sierra Nevada, California*

Attributes	Diameter at breast height by size class	Sierra Mean	Sierra SD	Sequoia Mean	Sequoia SD	*t*-test	*P*
Live trees basal area		---------- *ft² per acre* ----------					
Oaks	<5 in.	14.3	±8.7	25.5	±29.2	1.45	0.17
	5-10 in.	21.1	±11.8	25.2	±19.9	0.73	0.47
	11-20 in.	28.8	±15.2	41.7	±25.5	1.79	0.09
	21-30 in.	7.3	±8.5	18.8	±20.9	2.04	0.06
	31-40 in.	4.4	±9.2	1.2	±4.5	1.49	0.14
	41-50 in.	1.2	±5.9	0.0	0.0	1.00	0.32
	51-60 in.	2.0	±10.2	0.0	0.0	1.00	0.32
Subtotal	5-60 in.	64.7	±26.8	89.9	±43.8	1.78	0.08
Conifers	<5 in.	0.4	±1.2	0.3	±1.4	0.15	0.88
	5-60 in.	4.7	±12.0	3.1	±6.7	0.55	0.58
Other species	<5 in.	12.6	±10.4	12.3	±11.4	0.07	0.93
	5-60 in.	7.8	±5.2	1.8	±4.8	3.72	0.001
Total basal area		**104.5**	**±34.2**	**130.0**	**±60.3**	**1.50**	**0.15**
Live trees, number		---------- *stems per acre* ----------					
Oaks	<5 in.	163.6	±111.6	410.9	±337.2	2.76	0.01
	5-10 in.	69.0	±41.0	80.9	±57.9	0.70	0.49
	11-20 in.	28.0	±12.9	34.6	±22.2	1.05	0.30
	21-30 in.	2.5	±2.8	5.8	±6.7	1.87	0.08
	31-40 in.	0.7	±1.4	0.2	±0.9	1.22	0.23
	41-50 in.	0.1	±0.7	0.0	0.0	1.00	0.32
	51-60 in.	0.1	±0.7	0.0	0.0	1.00	0.32
Subtotal	5-60 in.	100.4	±41.3	121.6	±68.9	1.08	0.28
Conifers	<5 in.	5.2	±14.4	1.3	±4.4	0.26	0.79
	5-60 in.	2.9	±6.4	2.9	±9.5	0.02	0.98
Other species	<5 in.	501.8	±593.3	456.6	±482.3	0.27	0.79
	5-60 in.	26.3	±18.8	7.0	±18.7	3.18	0.003
Total live trees		**800.0**	**±616.7**	**1000.5**	**±632.3**	**0.99**	**0.33**
Height		---------- *feet* ----------					
All live trees	<5 in.	13.0	±3.2	12.4	±3.5	0.18	0.86
	5-10 in.	32.0	±5.0	31.0	±7.9	0.47	0.64
	11-20 in.	48.0	±8.5	53.3	±20.6	0.32	0.75
	21-30 in.	57.8	±33.6	60.0	±34.2	0.47	0.73
	31-40 in.	68.9	—	—	—	—	—
	41-50 in.	98.4	—	—	—	—	—
	51-60 in.	101.7	—	—	—	—	—

Discussion

The presence of California spotted owls in the foothill riparian and oak woodlands of the Sierra Nevada is not widely documented. Grinnell and Miller (1944) described the life zones occupied by the California spotted owl as the Upper Sonoran and Transition, with the altitude of occurrence mostly between 2,500 and 6,000 feet. Gould (1977) described the spotted owl in the southern Sierra Nevada as being found almost exclusively in the mixed-conifer zone, although their use of oaks along the south coast of California was identified. Since 1977, as interest in the California spotted owl increased because of concerns over logging in the coniferous habitats, incidental sightings of spotted owls in oak habitats have become more common. Laymon (1988) identified oak woodlands as wintering areas for migrating spotted owls in the central Sierra Nevada. Steger and others (1993) and Verner and others (1992) reported year-round use with breeding in the oak woodlands of the southern Sierra Nevada. Steger and others (1993) described the crude density of spotted owls in oak

Table 5—*Snags, down logs, shrubs, and ground cover characteristics of California spotted owl nest sites in the Sierra National Forest* (n = 26) *and the Sequoia National Park* (n = 15) *study areas in the southern Sierra Nevada, California*

Attributes	Diameter at breast height by size class	Sierra Mean	Sierra SD	Sequoia Mean	Sequoia SD	*t*-test	*P*
Snags basal area				*ft² per acre*			
Oaks	5-10 in.	2.8	±2.6	2.0	±1.9	1.12	0.26
	11-20 in.	2.1	±3.9	3.1	±3.9	0.84	0.41
	21-30 in.	0.5	±2.6	1.5	±4.2	0.95	0.34
	31-40 in.	0.0	0.0	1.6	±6.5	1.00	0.33
	41-50 in.	0.0	0.0	2.1	±8.0	1.00	0.33
	51-60 in.	0.0	0.0	0.0	0.0	-	-
Subtotal	5-60 in.	5.4	±5.5	10.4	±12.3	1.49	0.15
Conifers	(All)	0.1	±0.3	1.8	±6.8	0.99	0.33
Other species	(All)	0.3	±0.7	0.1	±0.1	2.15	0.04
Total Snag basal area		**5.7**	**±5.6**	**12.2**	**±13.0**	**1.72**	**0.11**
Snags, number				*stems per acre*			
Oaks	5-10 in.	10.4	±8.5	8.1	±7.8	0.86	0.39
	11-20 in.	1.9	±3.3	2.7	±3.2	0.71	0.48
	21-30 in.	0.1	±0.7	0.4	±1.2	0.96	0.35
	31-40 in.	0.0	0.0	0.2	±0.9	1.00	0.33
	41-50 in.	0.0	0.0	0.2	±0.9	1.00	0.33
	51-60 in.	0.0	0.0	0.0	0.0	-	-
Subtotal	5-60 in.	12.5	±9.1	11.7	±8.5	0.26	0.79
Conifers	(All)	0.1	±0.7	2.6	±9.6	1.04	0.31
Other species	(All)	1.2	±2.1	0.2	±0.9	1.99	0.06
Total snags		**13.8**	**±10.4**	**14.6**	**±13.1**	**0.22**	**0.83**
Woody debris				*tons per acre*[1]			
All logs >10 in.		2.0	±2.0	4.3	±3.3	2.08	0.05
Woody debris				*ft³ per acre*			
All logs >10 in.		155.8	±155.7	330.9	±260.1	2.08	0.05
Shrub cover				*percent*			
Conifer		0.3	±0.1	0.0	0.0	-	-
Hardwood		1.2	±1.1	2.0	±3.0	1.01	0.33
Evergreen		0.3	±0.8	2.8	±3.0	2.44	0.03
Deciduous		13.3	±12.9	11.5	±12.2	0.45	0.65
Fern		0.9	±1.9	5.4	±5.3	3.16	0.01
Total shrub cover		**15.8**	**±13.7**	**21.7**	**±14.1**	**1.19**	**0.24**
Ground cover				*percent*			
Rock		4.4	±5.9	7.2	±12.3	0.82	0.42
soil		4.2	±6.4	1.5	±1.8	2.01	0.06
Large litter		1.5	±1.0	2.8	±1.9	2.36	0.03
Small litter		57.0	±23.3	66.7	±26.0	1.18	0.24
Herbaceous		4.1	±7.8	3.2	±5.7	0.45	0.65
Grass		23.7	±23.5	15.2	±24.5	1.08	0.28
Moss		4.5	±5.7	2.9	±4.1	1.03	0.31
Lichen		0.3	±1.1	0.4	±1.6	0.20	0.85

[1] Assumes a specific gravity of 0.4 for downed woody debris.

woodlands of Sequoia National Park at 0.376 owls/mi², which is slightly lower than the density (0.529 owls/mi²) in the mixed-conifer type. Further investigation of the distribution, population size, and reproductive potential of California spotted owls in the oak woodlands of the Sierra Nevada is needed.

California spotted owls do not build their own nest. They rely on naturally occurring sites such as large cavities, trees and snags with broken tops, or, to a lesser extent, platforms associated with abandoned raptor nests, squirrel nests, mistletoe brooms, or debris accumulations (Verner and others 1992). In the southern Sierra Nevada foothill riparian and oak woodland habitats, 59 percent of the spotted owl nests were on platforms. These platform structures were most likely stick nests abandoned by raptors, squirrels, or ravens. Platform nest trees

in our study areas were significantly smaller in diameter than cavity nest trees. High incidences of platform nest utilization have been reported for the Mexican spotted owl (*S. o. lucida*) (Seamans and Gutiérrez 1995) and northern spotted owl (*S. o. caurina*) (Buchanan and others 1993) in mixed-conifer and conifer/hardwood forests. In both of these studies the average nest tree diameters were smaller than those commonly reported for nest trees in conifer forests where cavity nesting is more common. In our study area, the presence of large platform structures, used by California spotted owls to nest, may allow reproduction in foothill riparian and oak woodlands where tree diameters are not large enough to provide cavities of suitable size for nesting.

California spotted owls in foothill riparian and oak woodlands selected nest structures in seven species of trees, with interior live oaks the most frequently used (34 percent). Nest trees in foothill riparian and oak woodlands had a mean diameter of 23 inches and a mean height of 59 feet and were smaller in diameter and shorter in height than those typically reported for conifer forests. For example, Gutiérrez and others (1992) reported that nest trees in conifer habitats were typically large, averaging 90 feet tall and 41 inches DBH, with more than 75 percent of the nest trees more than 30 inches DBH. Regardless of the size difference between nest trees in coniferous habitats and those reported here for the foothill riparian and oak woodlands, trees with larger diameters seem to support the nest structures selected by spotted owls, especially cavity nest sites.

One platform nest was located on a rock ledge in the SNP study area in 1992. Nest sites on rock ledges have been reported before for California spotted owls (Peyton 1910), but no recent observations of this nesting behavior have been made (Gutiérrez and others 1992). Mexican spotted owls have been observed nesting on cliff ledges and in potholes on cliffs (Ganey 1988, Seamans and Gutiérrez 1995).

Canopy cover at nest sites in oak woodlands averaged 86 percent. This is consistent with the average 75.4 percent canopy cover reported for nest sites in Sierra Nevada conifer forests (Gutiérrez and others 1992) and generally reflects canopy densities at nest sites for all three subspecies of spotted owls (Ganey 1988, Thomas and others 1990, Verner and others 1992).

In our study areas, most owls used the lower third of the slope and northern aspects for nesting. Aspect, slope, and position of nest sites in the lower third of drainage bottoms in foothill riparian and oak woodlands are probably related to the location of adequate canopy cover. Dense stands of oaks and sycamore are usually found near the bottom or on the north-facing aspects of drainages. Nesting on the lower third of the slope and use of primarily northern aspects have been reported for all spotted owl subspecies, although this type of activity is not consistent across all studies (Blakesley and others 1992, Buchanan and others 1993, Gutiérrez and others 1992, LaHaye 1988, Seamans and Gutiérrez 1995). Use of dense canopy, steep slopes, and northern aspects may also play a role in thermoregulation (Barrows and Barrows 1978). Distance to water from nest sites on our study areas was usually greater than 330 feet, the maximum distance measured. Thus water did not seem to be a limiting factor for nest location at our scale of measurement.

Vegetative structure associated with California spotted owl nests in foothill riparian and oak woodlands varied considerably between sites. The total basal area of live trees in the SNF (104.5 ft^2/ac) and SNP (130.0 ft^2/ac) represents a medium stand density class (71–155 ft^2/ac) for native hardwood species in California's central coast (Pillsbury 1979). Basal area was highest in the 11- to 20-inch tree diameter class in both SNF and SNP. In contrast, the highest basal areas for conifer nest sites of the California spotted owl were from the large tree component (>25 inches) (Gutiérrez and others 1992). Total basal areas for the oak woodland nest sites were roughly half those found at conifer nest sites. In the

foothill riparian and oak woodlands of the southern Sierra Nevada, we found that approximately 100 oaks per acre in the 5- to 30-inch size class and 31- to 60-foot heights provided suitable nesting cover for California spotted owls. The presence of a few pairs of owls nesting in a relatively open site, as low as 25 percent canopy closure, is unusual, but the short-term need for an adequate nest structure may be compelling enough to pull birds from denser canopy-covered areas.

Concerns for the California spotted owl in foothill riparian and oak woodlands of the southern Sierra Nevada involve potential impacts from habitat disturbance. Fire, human occupation and residential development, logging, firewood cutting, and livestock grazing affect these habitats (Gould 1977, Verner and others 1992). In our study area, the SNP was found to have a significantly higher hardwood basal area and nearly three times as many stems per acre of oaks <5 inches DBH than the SNF. Possible reasons contributing to the differences between study areas may have been fire frequency and livestock grazing. Further investigation is need to determine whether these disturbances affect spotted owls.

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