

## Chapter 1

# Assessment of the Current Status of the California Spotted Owl, with Recommendations for Management

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Release of a proposed conservation strategy for the northern spotted owl in April of 1990 (Thomas et al. 1990) raised concern in Region 5 (R5) of the U.S. Department of Agriculture, Forest Service (FS) about the adequacy of their regional guides for managing the California spotted owl (Barker and Jay pers. comm.). This concern was amplified by a decision formally announced on 26 June 1990 by the U. S. Department of Interior, Fish and Wildlife Service (1990) to confer "threatened" status on the northern spotted owl throughout its range. Negotiations began shortly thereafter to undertake an assessment of the current status of the California subspecies. This process led to the formation of the California Spotted Owl Assessment Team Steering Committee, with members representing several State of California (Resources Agency, Board of Forestry, Department of Fish and Game, and Department of Forestry and Fire Protection) and Federal entities (U.S. Department of Agriculture, Forest Service; and U.S. Department of Interior-Bureau of Land Management, Fish and Wildlife Service, and National Park Service). Observers represented the California Farm Bureau, California State Association of Counties, California Forestry Association, National Audubon Society, Nature Conservancy, private timber companies, Sacramento Chamber of Commerce, and the Wilderness Society. The Steering Committee held its first meeting on 11 May 1991, in Sacramento, CA, and established two teams to implement the assessment--a Technical Assessment Team to be designated by the FS and a Policy-Implementation Team to be designated by State entities. The charter for the Technical Assessment Team specified submission to the Steering Committee of a report on the current status of the California spotted owl (the "CASPO Report"), following "accepted scientific standards and practices." The report would:

1. Present, analyze, and interpret relevant information currently available on the biology of the owl--its distribution, abundance, density, movements, breeding biology, diet, demography, habitat associations, and so on.
2. To the extent possible, characterize the attributes of various habitats used for foraging, roosting, and nesting by the owl throughout its range in California.
3. Evaluate current land-management practices throughout the range of the owl, recognizing that more detailed information may be available for some ownerships than for others.
4. Evaluate a range of options to achieve an amount and configuration of suitable habitat to provide for the long-term maintenance of the owl throughout its range.

5. Identify research, monitoring, and inventory programs needed to answer existing critical questions and to provide for adaptive management of the owl in the future.

The Technical Assessment Team consisted of a Core Group of six members (see Appendix A), consultants from the State and Federal entities represented on the Steering Committee, observers from the timber industry and the environmental community, and staff. This volume is the CASPO Report to the Steering Committee; this chapter synthesizes the Team's findings and presents its recommendations.

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## Producing the Technical Assessment

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We established an agenda, schedule, objectives, and operating procedures (see chronology of Team activities in Appendix A). We spent 19 days on field trips throughout the range of the owl in the Sierra Nevada and southern California, including 5 days on private industrial timberlands. Arrangements were made for a professional photographer to accompany the Team on all field trips and to search archives for historical photos of locations that might be rephotographed now. Workshops were held to exchange information and explore concepts with agency biologists from throughout the State of California, with leading authorities in silviculture, and with some of the Nation's leading conservation biologists. Numerous other informational meetings were held with smaller groups and with more focused objectives. An extensive reference library, including most published literature and unpublished reports (from many very recent field studies of California spotted owls), was assembled and made available to the Team in its offices in Sacramento. We acquired all other relevant information currently available on the owl, its habitats, and its biology; reviewed the current-management situation; and identified the major factors leading to concern for the well-being of the California spotted owl throughout its range. The Team and staff analyzed and synthesized all information obtained from the variety of sources mentioned above. Various Team members and other specialists prepared the supporting chapters contained in this report.

# Background and the Current Management Situation

As done for the northern spotted owl (Thomas et al. 1990, p. 12), we have subdivided the range of the California spotted owl into two major physiographic provinces, based on a variety of factors. These are the Sierra Nevada Province and the Southern California Province, with Tehachapi Pass as the dividing line between provinces. These regions are clearly distinct geographically; owl populations in the two provinces probably seldom exchange individuals; most owls in the Sierra Nevada Province prey mainly on northern flying squirrels, but all owls in the Southern California Province prey almost exclusively on dusky-footed woodrats (table 4A); the predominant threats to owl populations differ markedly between provinces; and feasible options for dealing with those threats also differ markedly between provinces.

The administrative history of the California spotted owl is closely tied to that of the northern spotted owl. Detailed research began in 1969, with studies on the northern subspecies, and early surveys for both subspecies of spotted owls in California were done in 1973 and 1974. Those surveys located owls at 159 sites (Chapter 3), primarily by visiting selected late-successional forests and areas with known historical sightings. Region 5 (R5) of the FS designated the spotted owl as a "Sensitive Species" on National Forests (NFs) throughout California in the late 1970s. In spite of this and increasing concern over the status of the northern spotted owl, FS surveys in the range of the California spotted owl did not begin in earnest until 1981.

Primary concern for the status of the California spotted owl has been in regard to timber management on the seven westside Sierran NFs and on private industrial timberlands. The Sierra Nevada owl population is contiguous and fairly evenly distributed throughout its 400-mile length (figs. 4A and 4B) but is probably poorly linked to the southern California population. Connectivity may exist through the Tehachapi Mountains and the Liebre/Sawmill area east of Interstate Highway 5 (fig. 9A). The California spotted owl connects to the northern spotted owl in Shasta County (fig. 4A).

Standard survey and monitoring protocols have been established by the FS to locate owl sites; these protocols have been used by most other entities involved in owl inventories. An owl site is an area of unspecified dimensions where a single owl or a pair of owls has been located, usually repeatedly. In demographic and radio-tracking study areas, where efforts to locate all owls are more intense than elsewhere, most owl sites with single owls have eventually been found to have a pair. All owl sites have been mapped and given unique spatial references, so they can be tallied. Designation of an owl site makes no assumption about home-range or territory boundaries of the owls, although usually a center of activity can be identified by the location of a nest or a primary roosting area. The terms "owl site" and "site" are general and often used generically to refer to home ranges, territories, or to sites designated by agencies for special owl management (see glossary in Appendix B).

Surveys, inventories, and other field efforts produced an estimated 1,250 spotted owl sites in the Sierra Nevada during the period 1987-1991, 92 percent on public lands (table 1A). Pairs were confirmed at 697 of those sites (table 3B). Only 162 of the sites were in reserved lands [National Parks (NPs) and Wilderness Areas in NFs]. Biologists have estimated an additional 305

**Table 1A-Known California spotted owl sites (1987-1991 surveys) and estimated acreages of suitable habitat, by ownership and physiographic province (see tables 3B and 3J).**

Ownership	California spotted owl sites						Estimated acres of potential suitable habitat <sup>1</sup>	
	Sierra Nevada Province		Southern California Province		Statewide		Sierra Nevada	Southern California
	Known	Additional estimated	Known	Additional estimated	Known	Additional estimated		
Federal ownerships								
Forest Service	1,028	250	294	190	1,322	440	3,500,000	540,000
National Park Service	120	55	0	0	120	55	461,000	0
Bureau of Land Management	1	?	1	?	2	?	68,500	7,600
Subtotal of Federal	1,149	305+	295	190+	1,444	495+	4,029,500	547,600
State of California	3	?	7 <sup>2</sup>	14 <sup>2</sup>	10	14+	26,000	25,000 <sup>2</sup>
Private ownerships	98	?	37	?	135	?	2,408,000 <sup>3</sup>	? <sup>4</sup>
Native American Nations	0	?	4	?	4	?	? <sup>4</sup>	? <sup>4</sup>
Grand total	1,250	305+	343	204+	1,593	509+	6,463,500	572,600

<sup>1</sup> Acreages are based on forested land currently known to be suitable habitat (dominant tree size  $\geq 12$ -14 inches in diameter at breast height, with  $\geq 40$  percent canopy cover) or land that is currently not suitable but has high timber-producing capability, providing for a relatively rapid return to suitable habitat.

<sup>2</sup> Includes some local governmental ownerships.

<sup>3</sup> Figure is only for known forested lands in private ownership in the Sierra Nevada; an unknown amount of that is unsuitable.

<sup>4</sup> The quantity of suitable habitat on private ownerships in southern California and on Native American Nations' lands has not been determined.

sites, based on unsurveyed areas in habitats considered to be suitable (tables 1A and 3B). We have assigned owl sites in the Sierra Nevada Province to one of five general habitat types, based primarily on tree-species composition:

1. *Foothill riparian/ hardwood forest*-This type generally occurs at low elevations in the Sierran foothills. It includes denser stands of hardwoods immediately adjacent to streams, as well as denser stands of hardwood forests on the adjoining slopes. Tree species along streams include cottonwood, California sycamore, interior live oak, California buckeye, Oregon ash, and occasionally white alder. Tree species on the adjoining slopes include blue oak, interior live oak, and digger pine.
2. *Ponderosa pine/ hardwood forest* (montane hardwood)-- This habitat blends with the upper elevations of riparian/ hardwood forests. In the southern Sierra Nevada, ponderosa pine at its lowest elevation generally occurs with interior live oak, canyon live oak, and black oak, with incense-cedar and white fir coming into stands at slightly higher elevations. In the northern Sierra Nevada, tanoak and Pacific madrone commonly contribute to the hardwood component of this type.
3. *Mixed-conifer forest*-This type is the predominant timber-producing forest of the Sierra Nevada, consisting of various mixtures of white fir, ponderosa pine (at lower elevations), incense-cedar, sugar pine, black oak, and red fir (at higher elevations). Douglas-fir is an important component from Yosemite NP northward, and giant sequoia occurs in widely scattered localities.
4. *Red fir forest*-This type blends with the higher zones of mixed-conifer forest. It is dominated by red fir, with increasing amounts of white fir at lower elevations until it becomes mixed-conifer forest. At upper elevations it often includes some lodgepole pine and occasionally quaking aspen.
5. *Eastside pine forest*-This type occurs generally east of the Sierran crest and is dominated by ponderosa and/or Jeffrey pine.

Most known spotted owl sites (82 percent) on Federal lands in the Sierra Nevada are in mixed-conifer forests. Indeed, about 62 percent of all California spotted owl sites on Federal lands are in Sierran mixed-conifer forests, making this by far the most significant habitat for the subspecies (table 1B).

Approximately 8.6 million acres of forested or potentially forested lands occur in the Sierra Nevada; 71 percent are on public lands. Of these lands, 6.5 million acres are either suitable or potentially suitable owl habitat, and about 4 million acres are owned by the public. Because we lack a full understanding of all attributes that comprise suitable owl habitat, however, we cannot determine the exact amount of suitable habitat for the owls on any ownership.

### Forest Service

NFs of the western Sierra Nevada with major owl populations have a total land base of 6,978,900 acres; about 5,260,611 acres are forested and about half of that is current or potential habitat for spotted owls (Chapter 3). An estimated 1,028 spotted

owl sites, probably most capable of supporting a pair of owls, have been located on NFs in the Sierra Nevada (table 1A). About 80 percent of those are in the zone of mixed-conifer forests, about 10 percent in red fir forests, and about 7 percent in ponderosa pine/ hardwood habitats. The remaining 3 percent are in eastside pine forests and foothill riparian/ hardwood habitats in the western Sierran foothills (table 1B).

In July 1981, the Regional Office of R5 notified Forests with the California spotted owl to provide in their Land Management Plans (LMPs) a strategy for maintaining viability of the owls. This led to the designation of Spotted Owl Habitat Areas (SOHAs) in a "network" on each of the westside Sierra Nevada NFs with owl populations and major timber-management programs. The network concept was patterned after a similar approach adopted by the FS in Washington and Oregon to manage for northern spotted owls. SOHAs are designated stands of habitat to be managed to maintain suitable owl habitat. They may occur singly, in pairs, or in triplets. If single, they may be no more than 6 miles from at least two other SOHAs, edge-to-edge; if pairs or triplets, they may be up to 12 miles from other SOHAs. Management direction for SOHAs is to maintain at least 1,000 acres of suitable owl habitat within a 1.5-mile radius of the known or potential nest site. Suitable habitat is described as mature timber stands having (1) multi-storied canopies with 70 percent or greater total cover, (2) 40 percent or more of the total canopy in trees at least 21 inches in diameter at breast height (d.b.h.), and (3) extensive decadence-cavities, broken tops, snags, and so on (Chapter 3).

Directions for Sierran Forests resulted in the designation of 264 SOHAs in approved or draft Forest LMPs (Lassen 40; Plumas 54, Tahoe 33, Eldorado 32, Stanislaus 36, Sierra 29, and Sequoia 40). Of this number, 249 are on lands suitable and

**Table 1B-** *Distribution by major habitat types of known California spotted owl sites, based on 1987-1991 surveys in National Forests and National Parks (see tables 3A and 3I)<sup>1</sup>*

Forest type	Known sites	Percent of province	Percent of total
<b>Sierra Nevada Province</b>			
Mixed-conifer	959	81.5	62.4
Red fir	114	9.7	7.4
Ponderosa pine/hardwood	79	6.7	5.1
Foothill riparian/hardwood	19	1.6	1.2
Eastside pine	6	0.5	0.4
Subtotal	1,177	100.0	76.6
<b>Southern California Province</b>			
Live oak/bigcone Douglas-fir	147	40.8	9.6
Riparian/hardwood	116	32.2	7.6
Mixed-conifer	95	26.4	6.2
Redwood/California-laurel	2	0.6	0.1
Subtotal	360	100.0	23.4
<b>Grand total</b>	<b>1,537</b>		<b>100.0</b>

<sup>1</sup> Subtotals and totals do not match those in table 1A because values given here were based only on numbers supplied by National Forests and National Parks. The figures occasionally include habitat descriptions from sites on private lands within NF boundaries and from single owl locations. We believe the percentages shown here correctly display the relative proportions of owl sites in these habitat types.

otherwise available for timber management. The total allocation for the 264 SOHAs is about 454,000 acres, of which about 110,000 acres would be managed under low-yield, even- or uneven-aged management (Chapter 3).

### Other Public Ownerships

Lassen, Yosemite, Kings Canyon, and Sequoia NPs occur within the range of the California spotted owl in the Sierra Nevada. These have a total land base of 1,719,039 acres, but only about 28 percent of that is judged to be suitable owl habitat, and only 120 owl sites are known to occur in the four NPs combined (table 1A). Even though the NPs experience high recreation impacts in local areas, NP management has not been an issue, because the emphasis in the Parks generally is believed to be compatible with habitat needs of the owls.

The Bureau of Land Management (BLM) administers scattered public lands along the foothills and lower slopes of the Sierra Nevada and southern Cascades, some with forests, woodlands, and riparian habitats that are potentially suitable for California spotted owls. About 68,500 acres of BLM lands are potential for spotted owls (table 1A). Although owls have been observed at a few sites on BLM lands, a general lack of inventory precludes an estimate of the total number.

Seven State Parks (SPs) total an estimated 16,580 acres in the Sierra Nevada, with perhaps as many as six sites suitable for owls. Because all wildlife and plants are protected in SPs, habitat for any owls there is probably secure. Two State Forests (SFs) in the Sierra Nevada, totaling 13,830 acres, are managed for demonstration of forestry practices and to support cooperative research with other agencies. Uneven-aged silviculture is featured on these lands, which may have three or four pairs of owls. In addition, the University of California administers the 3,000-acre Blodgett Forest in El Dorado County and the 320-acre Whittaker Forest in Tulare County. About 2,000 acres at Blodgett are suitable owl habitat and typically one or two pairs nest in the area (Chapter 3).

### Private Lands

Industrial timberlands total 1,451,000 acres and miscellaneous private timberlands total 957,000 acres in the Sierra Nevada (table 3D). The latter group includes both large landowners, such as utilities and water districts, and small landowners. About 58 percent of the combined total of these private lands are surrounded by NF lands, much in the form of alternating sections of private and public lands in "checkerboard" pattern, especially in the Tahoe and Eldorado NFs. Significant additional parcels of private timberlands, not in checkerboard arrangement, are included within boundaries of the Lassen, Plumas, and Stanislaus NFs. Most of the best forest-growing lands in the Sierra Nevada are owned by commercial timber companies in the mixed-conifer zone. The majority of the private land has not been inventoried for owls yet, but it is apparent that some industry lands with a long history of logging have spotted owls comparable in density to adjacent NF lands. Other private lands lack nesting owls, however, even though nest sites occur in adjoining NF lands (Chapter 5). Decisions are still pending on

possible enactment of forestry reform legislation to provide new rules for logging on private lands in California. Although we cannot now assess the effects of any new forestry regulations on the capability of private lands to support spotted owls, we believe that any new regulations would be more beneficial for owls than past policies.

At the north end of the Sierra Nevada, private timberlands along the east side of Shasta County provide an essential habitat linkage for movement back and forth by both northern and California spotted owls, between the Lassen and Shasta-Trinity NFs. Maintenance of this connection is believed to be essential to the long-term conservation of both subspecies of spotted owls (Dawson et al. 1987, Thomas et al. 1990).

Spotted owls breed in dense stands of hardwoods along stream channels at low elevations on the western edge of the Sierra and Sequoia NFs. These habitats, generally not classified as commercial timberlands, are similar in most respects to habitats commonly used by spotted owls in southern California. Similar habitats occur along riparian zones west of the boundaries of all NFs in the Sierra Nevada. Livestock grazing, type conversions, firewood cutting, and logging in and adjacent to riparian zones have affected these habitats. Many are now being affected by an increasing trend of residential developments in the foothills. These potential habitats have not been adequately surveyed for spotted owls, although they may support many pairs (see fig. 4D).

### Areas of Concern

Our over-riding concerns for spotted owls in the Sierra Nevada conifer zone involve potential impacts of logging practices on their habitat (details in Chapter 13) and the extent to which selective logging and aggressive fire suppression in this century have created incendiary conditions in a majority of the low- to mid-elevation conifer forests (details in Chapters 11 and 12). In addition, we have identified several conditions that will bear further study and evaluation (table 3G, fig. 3A). These involve bottlenecks in the distribution of habitat or owl populations, gaps in the known distribution of owls, locally isolated populations, fragmented habitats, and areas with low densities of owls.

Concerns for spotted owls in foothill riparian/hardwood forests in the western Sierra Nevada primarily involve increasing development of residential properties. This is the case for dispersed, rural homesites and growth of existing communities in the foothills. Both potentially impact spotted owls directly by reducing the amount of owl habitat and by bringing dogs and cats into potential contact with fledgling owls that may spend some period of time on the ground before they are capable fliers. These developments would also affect the owls indirectly by reducing the area suitable for woodrats. Grazing in the foothills may also impact owls by influencing shrub cover needed by woodrats. We cannot evaluate possible effects on owls that may result from the increasing need for surface and ground water to provide for residential developments in the foothills. None of these potential impacts has been studied.

## Southern California Province

Spotted owls occur in all major mountainous areas of southern California, but they are not continuously distributed like those in the Sierra Nevada. Instead, we believe that each major mountain range has a relatively isolated subpopulation of birds that is separated from its nearest neighboring subpopulation by distances ranging from 6 to 45 miles (fig. 9A, table 9A). Inventories in these mountains since 1987 have produced a total count of 343 known owl sites; 295 of these are on Federal lands (table 1A). Estimates by biologists of additional sites in southern California range from 155 to 254 (table 3J); taking the midpoint of these gives an estimate of 204 additional sites or an estimated total of 547 spotted owl sites in southern California. This is not out of line with an independent estimate of 578 (known + potential) owl sites in southern California by Stephenson (1991). We have assigned owl sites in southern California to one of four general habitat types, based primarily on tree-species composition:

1. *Riparian/hardwood forest*-This type varies considerably in different parts of southern California. In deep canyons in the Los Padres NF, for example, it occurs in narrow strips adjacent to permanent or near-permanent streams. Common tree species include coast live oak (near coast), canyon live oak (interior locations), California sycamore, white alder, California-laurel, and cottonwood. In shallower canyons in the Cleveland NF, these forests may consist almost exclusively of coast live oak.
2. *Live oak/bigcone Douglas-fir forest*-This habitat occurs in a narrow band mostly at mid-elevations in mountains of all four NFs in southern California. Dominant tree species are canyon live oak, coast live oak, and bigcone Douglas-fir.
3. *Mixed-conifer forest*-This type is best developed at relatively high elevations in the San Gabriel and San Bernardino Mountains, and on Mount San Jacinto. Species composition is similar to that of Sierran mixed-conifer, although Coulter pine occurs and bigcone Douglas-fir occasionally occurs at lower elevations. Red fir, Douglas-fir, and giant sequoia are missing.
4. *Redwood/California-laurel forest*-These forests are restricted to the coast range, where coast redwood, California-laurel, tanoak, Pacific madrone, red and white alder, coast live oak, Santa Lucia fir, and bigleaf maple form various mixtures.

About 41 percent of the owl sites in southern California are in live oak/bigcone Douglas-fir forests, 32 percent are in riparian/hardwood forests, and 26 percent are in mixed-conifer forests, mainly in the San Bernardino Mountains (table 1B). Southern California has an estimated potential of about 573,000 acres of suitable owl habitat (table 1A), but we still cannot characterize the full range of conditions that comprise suitable habitats there.

## Federal and State Lands

Regional direction for the four NFs in southern California is to protect all known spotted owl sites and to manage the habitat based on local information about suitability and availability. One owl site is known on BLM lands, where only about 7,600 acres of potential owl habitat occur; habitats are managed for wildlife, riparian habitat quality, water quality, and dispersed recreation. Camp Pendleton probably had spotted owls in the past, but long-term effects of military training activities have degraded habitat to an extent that little exists today. State Parks have several thousand acres of potential owl habitat, perhaps enough for 13-15 pairs.

## Other Lands

Over the past 5 years, 41 owl sites have been found on private and Native American Nation lands in southern California (table 1A). Most private lands are at lower elevations than "traditional" spotted owl habitat.

## Areas of Concern

Several significant factors threaten the long-term maintenance of spotted owl populations in these relatively isolated mountain ranges in southern California. Probably of most concern is the likelihood of a decline in the capability of landscapes between the mountains to support owls that would otherwise disperse from one subpopulation to another. Only in this way can the decline in one subpopulation be offset naturally by immigration from other subpopulations (so-called demographic "rescue effects"). As urban and residential areas expand in the valleys between mountains, the suitability of dispersal habitat may decline to the point that successful dispersal is too restricted for demographic rescue. Subpopulations must then survive demographically on their own or decline to extinction (Chapters 8 and 9). We are similarly concerned about what appears to be a tenuous linkage between owls in the southern Sierra Nevada and owls in the Transverse Ranges (see fig. 9A).

In addition to maintaining connectivity, the integrity of each habitat "island" must be maintained. An additional concern, therefore, is a decline in the amount, or an increase in fragmentation, of currently suitable habitat within any of the many isolated mountain ranges.

Direct surface-water diversions and "mining" of ground water for human needs deplete water in permanent or near-permanent streams, threatening the associated riparian woodlands. Loss of the woodlands would mean the loss of spotted owls and numerous other riparian species found in these habitats. Stand-destroying fires, and increasing concentration of recreational activities in prime owl habitat are additional threats to spotted owls in southern California. Maintenance of a viable population of spotted owls in southern California may be impossible without changes in land-use policies on private lands, especially those that adjoin public lands.

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# Assessing the Owl's Status: The Sierra Nevada

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Determining the owl's status depends on answers to three fundamental questions: (1) Is the California spotted owl's population declining in all or part of its range? (2) Is the California spotted owl a habitat specialist? (3) If the answer to question 2 is yes, then is the habitat upon which the California spotted owl specializes declining? We have endeavored to answer these questions by attempting to falsify the implied null hypotheses:

$H_0$ : California spotted owl populations in demographic study areas are not declining.

$H_0$ : California spotted owls use all habitats in proportion to their availability.

$H_0$ : Habitats used in excess of availability by California spotted owls are not declining in abundance.

All sources of information available to us have been important in this effort, including common sense, professional judgment, empirical data, widely accepted concepts and theories, and mathematical modeling.

Failure to falsify a null hypothesis does not necessarily mean that it is true. When data are insufficient to provide a powerful test of the hypothesis, we are likely not to falsify the hypothesis even when it is false. This is known to statisticians as a type-II error. In all cases where it was possible, we have estimated the power of tests that failed to reject a null hypothesis. This information is critical to the conclusions and recommendations we have made in this report.

## ***Is the Owl's Population Declining in All or Part of Its Range?***

Demographic studies of California spotted owls are currently underway in five locations-Lassen NF (2 years), Eldorado NF (6 years), Sierra NF (2 years), Sequoia/Kings Canyon NPs (4 years), and San Bernardino NF (5 years). Owls are captured and color-banded with unique band combinations that can be identified in the field without recapturing the birds. In this way, a history of each color-banded bird can be accumulated for as long as it remains in the study area. Sex is determined by voice, and age (up to 2 years) can be determined by plumage characteristics. Critical parameters needed to determine whether a population is stable, increasing, or decreasing are stage-specific birth rates and death rates. The parameter we need to estimate is lambda ( $\lambda$ ), the finite rate of population growth ( $\lambda = 1.0$  indicates a stable population;  $\lambda > 1.0$  indicates an increasing population; and  $\lambda < 1.0$  indicates a declining population). Lambda is computed from estimates of three classes of parameters: age at first reproduction, age-specific survival rates, and age-specific fecundity (for simplicity in modeling population trends, we use a females-only model, so fecundity is defined here as the expected

number of female fledglings produced per female of age  $x$  per year). In the Lefkovitch stage-projection matrix model (Lefkovitch 1965) used for this assessment, the value of lambda indicates the annual rate of change in the size of a population.

## **Results**

Owl banding has been underway long enough to compute estimates of lambda for only three study areas-Eldorado NF, Sequoia/Kings Canyon NPs, and San Bernardino NF. We could estimate juvenile survival rate only for the San Bernardino study area, because data were insufficient for the Eldorado and Sequoia areas. Consequently, the San Bernardino value was used as a reasonable approximation for the other two locations. It was in line with estimates of juvenile survival rates from studies of northern spotted owls (Chapter 8), and lambda was not especially sensitive to variations in juvenile survival rate (figs. 8C and 8D). Results from the Eldorado and Sequoia/Kings Canyon studies follow; results from the San Bernardino are deferred to the section dealing with southern California.

Eldorado Study Area-The estimate of lambda for the Eldorado population was 0.947, suggesting about a 5 percent annual rate of population decline during the period of study (1986-91). This value was not significantly  $< 1.0$  ( $\alpha = 0.05$ ,  $P = 0.1271$ ), however, so we cannot reject the null hypothesis that the population is not declining. The test, however, had a power of only 0.30. Even if the population were truly declining at 5 percent per year, we would fail to detect that decline 70 times in every 100 studies of equivalent size. The low power resulted from a relatively small number of marked birds, and the large standard errors of parameter estimates (table 8E). The correct inference to draw from this result is that we are uncertain about the true trend of this population. The power of the test is much too low to infer that the population is stable.

Sequoia/Kings Canyon Study Area-The estimate of lambda for this population was 0.969 (table 8F), suggesting about a 3 percent annual rate of population decline during the period of the study (1988-91). As in the Eldorado study, the statistical test ( $\alpha = 0.05$ ,  $P = 0.2709$ ) failed to reject the null hypothesis of no decline in the population. The power of this test-0.30-was identical to that for the Eldorado study, so we must infer again that we are uncertain about the trend of this population.

## ***Is the California Spotted Owl a Habitat Specialist?***

### **Results from Landscape Studies**

This question was explored in several ways and at three scales, with details given in Chapters 5 and 6. We know, for example, that California spotted owls use forested habitats almost exclusively, although they occur and breed in a greater variety of habitats than does the northern spotted owl. Within forested landscapes, we found that 45 percent of all nests of California spotted owls in the conifer zone of the Sierra Nevada were in M4N and M4G stands, significantly more than expected based on availability (table 5A) [table 1C explains codes designating timber strata, or see "timber strata" in the glossary (Ap-

pendix B)]. All other habitat types that we evaluated were used less than or equal to their availability (table 5A). These results indicated that, for nesting, the owls selected stands with relatively large trees and closed canopies.

Densities of owl sites in 1:24,000 U.S. Geological Survey quadrangles were significantly related to the percentage of forests having medium-sized and larger trees and high canopy closure. These results generally corroborated those of the previous analysis.

## Results from Home-Range Studies

At a home-range scale, attributes in nest stands were compared with those in randomly selected stands in the general forest matrix. Significant differences were found for several attributes, most or all of which were consistent with the previous conclusion that the owls tended to select stands of large, old trees with closed canopies for nesting. Results of identical analyses in roost stands produced parallel results. Nest and roost stands showed consistent, often significant differences from random locations in the forest in having higher canopy cover, greater snag basal area, greater total basal area of live trees, and greater softwood basal area (tables 5B and 5D). Mean values for canopy cover ranged from about 75 to 96 percent in the different studies; similarly these studies suggested a range for total basal area of live trees from 185 to 350 square feet per acre, and basal area of large snags (>15 inches in d.b.h. and >20 feet tall) from 19 to 31 square feet per acre in nest and roost stands ("Recommendations" in Chapter 5). Many of these parameters varied considerably, and not all measures of habitat used by spotted owls and at random locations differed significantly within a given study. The data were, however, consistent and mutually supportive among all studies. California spotted owls in these various studies chose to nest and roost in stands that were denser than average and that contained a large-tree component. Most nest sites were selected in dense mixed-conifer stands with average quadratic mean diameters of canopy trees >24 inches in d.b.h. We know of no studies that consistently contradicted these findings.

**Table 1C--** Explanation of codes used to designate timber strata in the Sierra Nevada.

Attribute	Code used	Identification
Timber type	M	Mixed-conifer
	P	Ponderosa pine
	R	Red fir
Tree size-class <sup>1</sup>	2	<12 inches
	3	12-23.9 inches
	4	>24 inches <sup>2</sup>
Canopy closure	P	Poor 0-39 percent
	N	Normal 40-69 percent
	G	Good >70 percent

<sup>1</sup> Mean diameter at breast height of dominant trees.

<sup>2</sup> Code 5 has been used to designate larger size-classes, and code 6 has been used to designate multi-layered stands; most National Forests in the Sierra Nevada no longer make these distinctions in their timber inventories.

Results of similar analyses at foraging locations indicated that the owls foraged in stands characteristic of nest and roost sites, as well as in a wide variety of other habitats having lower canopy cover and a greater range of tree sizes and ages. Nonetheless, in comparison with random locations within the forest, owls tended to forage in sites with higher canopy closure; greater basal areas of live trees combined and of softwoods; greater basal areas of snags; and more dead-and-downed wood (tables 5G and 5H). In general, they foraged in forests of intermediate to old age, typically with >40 percent canopy closure.

## Results from Studies at Nest Locations

Data from 276 nests located throughout the range of the California spotted owl provided the most conclusive evidence of selection by the owls of very large, old trees. In Sierran conifer forests, for example, nest trees averaged about 96 feet in height and 45 inches in d.b.h., with a surrounding canopy cover of about 75 percent (table 5K). A prevalence in these forests of cavity nests (66 percent) and nests on broken-topped trees (10 percent) showed that most nest trees were not only large but also old and decadent. For example, many of the natural cavities used for nests were created when decay invaded a wound on the side of the tree where a branch tore out of the trunk. These cavities must have room to accommodate an owl's nest, the female, and her (usually) two nestlings, so only very large trees have branches and trunks of sufficient size to produce such cavities. Not only were the diameters of nest trees significantly larger than the average tree in today's conifer forest (fig. 5K), but also they exceeded the mean diameter of trees in plots sampled in the Sierra Nevada at the turn of this century. The owls are apparently nesting today in a legacy of very large, old trees that were present in 1900 and before.

## Results from Radio-Tracking Studies

Radio-tracking studies of California spotted owls in the Lassen NF and the Sierra NF provide some insights into habitat selection in conifer forests of the Sierra Nevada. Studies of this nature have shortcomings that can lower our ability to draw inferences from them, however. First is the need for a large number of owl locations during a brief period of the year (for example, the breeding period or the winter period). But to meet assumptions of independence in the locations, required by statistical tests, locations should be recorded only about every 2-3 days. In the 6-month period that approximates the breeding cycle of the spotted owl, only about 72 locations could be obtained without violating assumptions of independence. Second is the fact that a small sample size results in low power of the tests to detect habitat selection. A mean of 57 locations was available for the radio-tagged spotted owls reported in the home-range studies (Chapter 6) upon which the following summary is based. The power of statistical tests ranged from about 15 to 80 percent, so failure to detect significant overuse or underuse of habitats, based on availability, probably resulted from low power in many cases. This means that any consistent pattern in habitat selection among birds with samples large enough for tests with ample power should be given additional

weight when evaluating the suitability of habitats for spotted owls from studies of radio-tagged birds.

Habitat selection was more consistent and more pronounced for canopy closure than for tree size-class among radio-tagged California spotted owls in the Sierra Nevada. Chi-square values were consistently higher for canopy closure, and more owls had significant tests of habitat use for canopy closure than for tree size-class in 18 site-by-season comparisons. Differences between total and dominant canopy closure were minor (Chapter 6). Because more owls showed selection for cover of the dominant trees in a stand, however, it appears to be a better measure of habitat quality for California spotted owls than total canopy cover.

The amount of medium and large sawtimber in individual home ranges did not appear to be a good indicator of the amount of habitat needed to sustain the owls, unlike the case for the northern spotted owl (Chapter 6). Most owls did not have significant tests of habitat use for tree size-class. Nearly all owls in the Sierra NF used size-classes in proportion to their availability; patterns were stronger in the Lassen NF during the breeding season, where about half of the birds used medium and large sawtimber greater than expected.

Based on overall use by radio-tagged owls of habitats with  $\geq 40$  percent canopy cover and those with  $\leq 39$  percent canopy cover, stands with  $\geq 40$  percent canopy cover should generally be considered suitable owl habitat. Stands with  $\leq 39$  percent canopy cover should generally be considered unsuitable (Chapter 6). The data show that owls exhibited lower selectivity for habitats when foraging than they did when roosting (Chapters 5 and 6).

### **Results from Studies in Foothill Riparian/Hardwood Forest**

Results of habitat studies and home-range use by owls in lower-elevation, riparian/hardwood forests and adjacent stands of oak-pine woodlands in foothills of the Sierra Nevada generally agree with those in conifer forests. The birds nest and roost in stands with mean canopy cover of about 89 percent and in trees generally large for those habitats (mean d.b.h. = 29.5 inches, table 5K).

### ***Is the Habitat Used Selectively by the California Spotted Owl Declining?***

Having concluded that California spotted owls are not habitat generalists, particularly for nest stands, we next must determine whether any evidence indicates a decline in the amount of habitat used more than expected by the owl. Forests of the Sierra Nevada have been markedly impacted in a variety of ways by human intervention, especially during the past 150 years (Chapter 11). The first major perturbation was grazing by millions of sheep from about 1860 to the first decade or so of this century; peak numbers occurred in the early 1870s. Coincident with sheep grazing was extensive early logging, mainly at low elevations near towns, mines, and along transportation routes. Timber production in billions of board feet reached a peak about 1950, dropping some from that level but remaining relatively

high in most years since. Fire suppression began in the early part of this century and has become increasingly effective and aggressive since.

With removal of sheep and some measure of fire control in place, forest stands became subject to ingrowth of shade-tolerant conifers such as white fir and incense-cedar (Chapter 11). A combination of logging and natural attrition of the old forest led to a decline in the number of large, old trees. Past logging activities that concentrated on removal of the largest, most valuable trees broke up the patchy mosaic of the natural forest, further encouraging the development of dense conifer regeneration. These developments, especially in the ponderosa pine and mixed-conifer forests of the Sierra Nevada, reduced large-diameter trees in many areas to small remnant populations. Concurrently, surface fuels have been accumulating in forest stands and the extensive ingrowth of shade tolerant trees has resulted in vertical fuel ladders that essentially connect the surface fuels to the dominant tree crowns over much of the Sierra Nevada. These changes have not occurred to the same degree in the red fir type, where fires were less frequent historically, and logging was generally uncommon until recent decades.

Because of current stand structures and excessive fuel loadings in much of the Sierran mixed-conifer type, fires that escape initial suppression efforts—usually those occurring during extreme weather conditions—tend to become large and severe. Fire trends in the Sierra Nevada can be expected to continue along their current trajectories. As the human population increases in Sierran forests and woodlands, the presence of so many houses within the forest will shift further the emphasis of suppression from one of saving forests to one of saving property. The fuels will also continue to accumulate, with the recent drought-induced bark beetle infestations contributing a major pulse of new fuels over the next few decades. We expect the net result to be a much higher incidence of stand-destroying fires in the future than was characteristic of the Sierran fire regime prior to this century. And with those fires we will continue to lose remnant, individual old trees, stands of old trees, and other old-growth attributes.

Timber cutting trends also point to a continuing decline in the number of old trees and remnant old-growth stands. Sixty-five percent of the forested acres on all Sierran NFs are classified as suitable for timber production (Chapter 13). If we discount forested acres that cannot produce timber commercially because they are too poor in quality, they cannot be successfully regenerated, or they have unstable soils, 74 percent of the lands that can potentially produce timber will be harvested in some manner (table 13A). Seventy-two percent of the timber volume removed from these lands will be taken through even-aged systems—mostly clearcuts. Of the 528,474 acres of suitable timberlands on the Tahoe NF, for example, 68 percent will be managed for even-aged silviculture (24 percent long rotation, 44 percent short rotation) (Chapter 13). On the Plumas NF, 52,000 acres are scheduled for even-aged cutting per decade, with 8,000 acres in selection cutting methods.

Clearcut, seed-tree, and shelterwood cutting techniques all have the same goal: produce even-aged stands. In this regard,

seed-tree and shelterwood systems can generally be thought of as two-stage (sometimes three-stage) clearcuts. In all of these cutting systems, the original stand will be totally removed before the new stand is scheduled to be cut. In terms of owl biology, the primary impact of traditional, even-aged harvesting practices lies in the creation of simple stand structures and, probably more importantly, the removal of all large trees from vast areas of the forest. Even if prescriptions are modified so that snags and live culls are left at the first cutting, no provision is made for a predictable recruitment of replacement trees for these relics when they fall. This, in turn, will lead to a loss of large-diameter downed woody material important for production of the fungi that are a primary food source for flying squirrels—the main prey of spotted owls in the Sierra Nevada (Chapter 4). Log slash can create much small-diameter woody debris, but it cannot replace the large logs. In an even-aged system, these old-growth features can be created only by an extreme extension of the rotation interval. Even if the rotation is extended to 150 years, for instance, no trees will match the average age of the forest at the beginning of this century (Chapter 11). Decadent features in stands are functions of age, not just d.b.h. (fig. 13G); and any animals that depend on decadent features (cavities, broken-tops, snags), or the large woody debris that they create, will simply drop out of these forests (see Chapters 4, 5, and 10 for examples specific to the spotted owl and its prey species). The rate of conversion to even-aged systems in the western Sierra Nevada is estimated by the LMPs to be 229,000 acres per decade.

Even on lands planned for selection harvest (about 80,000 acres/decade), we have no guarantee that harvest prescriptions will leave any of the large, old trees. Ideally, stands managed for individual selection are harvested in a manner that brings the diameter distribution in the stand into conformity with an idealized distribution, which is characterized by a declining exponential function (in forestry referred to as an inverse "J"). The number of large trees in the stand is dictated by the slope of this curve and the designated diameter of the largest tree. In selection-logging systems, timber is removed from all diameter classes as required to maintain this diameter distribution. Little evidence exists, however, that historical patterns of partial cutting have followed the classic single-tree theory. "Selective" harvest in the Sierra Nevada has, in the past, primarily targeted the large trees. This system, sometimes called "pick and pluck," will not produce the simple, even-aged structures that characterize clearcutting techniques, but its effect on the presence of large, old trees is similar. If the large trees are removed and no stocking control is done on the smaller stems, replacement trees in these diameter classes will be produced very slowly, if at all, and they will consist primarily of the more shade-tolerant species. Even with classical single-tree selection, a gradual loss of shade-intolerant species would be likely.

The future forest of the Sierra Nevada, as projected by the LMPs, will very likely be split between areas of even-aged plantations and areas of dense and increasingly small-diameter stands. Given these projections, it seems most likely that the forest to be generated by adherence to current LMPs will be susceptible to fire disturbance, nearly devoid of large, old trees, and depauperate in terms both of plant and animal species that

depend on attributes of the older forests that were common last century. We conclude that the key elements of spotted owl nest and roost stands, under current LMPs, will decline sharply over most of the Sierra Nevada in the next few decades. If they disappear, a hiatus of well over 100 years will pass before more can be grown to take their place. In the process, the spotted owl would probably be markedly reduced in numbers over most of the Sierra Nevada, but probably with viable subpopulations surviving in Yosemite and Sequoia/Kings Canyon NPs.

## Conclusions

Is the Sierran population declining? We cannot be certain. Failure to detect significant declines in the two Sierran study areas must be interpreted cautiously, because the power of both tests was very low. We know nothing about the normal, long-term fluctuations of spotted owl populations in the Sierra Nevada. If the California spotted owl has experienced gradual declines in habitat quality in these mountains, the effects may be subtle and difficult to detect. Because we lack adequate, historical inventories of spotted owls in the Sierra Nevada, we have no basis for comparison with our current knowledge. Their current distribution and abundance, however, do not suggest that they have declined either in their overall distribution in the Sierra Nevada or that they have declined markedly in abundance within any forest type.

Selective logging of the largest trees from the most productive sites in the Sierra Nevada has resulted in significant changes in diameter distributions of trees, leaving relatively few very old, large trees that are clearly selected by the owls for nesting (Chapter 5). Consequently, we are far from comforted by results from the demographic studies. Before reaching a final conclusion on this matter, we need to continue these studies until the power of their tests on lambda is greatly increased.

Do Sierran owls exhibit selective use of habitats? Yes. The overwhelming weight of evidence is that California spotted owls in the Sierra Nevada select habitats differentially from among all habitats available to them. Selectivity is strongest for nesting and roosting habitats, weaker for foraging habitats. Even for foraging, however, we conclude that a target for suitable owl habitat should include at least 40 percent canopy cover in stands with trees averaging at least 11 inches in d.b.h. Data from direct measures of foraging stands further suggest that suitable foraging stands have snags, dead-and-downed woody debris, and some large trees (Chapter 5).

Are key habitat elements declining in the Sierra Nevada? Yes. Of greatest concern to us at this time is the rapid disappearance of the large, old, and generally decadent trees that are the focus of nesting by spotted owls. Given projections from approved and draft LMPs for NFs in the western Sierra Nevada, where the vast majority of Sierran owls occur, these important stand components will disappear at a rapid rate over the next few decades. They cannot be replaced quickly.

Considering the present state of our knowledge about spotted owls in the Sierra Nevada, we can identify eight major factors of concern about owl habitats there (table 1D). These have resulted from a combination of selective logging removing

**Table 1D**-Summary of major factors of concern in habitats of California spotted owls in the Sierra Nevada, reasons for those factors, and their impacts on the owls.

Factor	Reason(s) for the factor	Impact on spotted owls
Decline in abundance of very large, old trees	Selective logging of the largest trees from stands	Loss of the owl's preferred nest sites
Long recovery period for spotted owl habitat after logging	Selective logging of the largest trees from stands	Less of total landscape in suitable owl habitat at any given time
Ingrowth of shade-tolerant tree species, creating unnaturally dense stands with ground-to-crown fuel ladders	Selection harvest; aggressive fire suppression; sheep grazing, which created ideal seedbeds for conifer germination late last century	Increased threat of stand-destroying fires
Excessive build-up of surface fuels	Aggressive fire suppression over the last 90 years, leading to higher densities of trees, more competition for space and water, so a higher death rate of trees	Increased threat of stand-destroying fires
Loss of large-diameter logs from the decaying wood source on the ground	Intentional fires by shepherders; selective logging of largest trees; piling and burning logs after logging; domestic fuel-wood removal	Potential decline in flying squirrel densities via loss of fungi that are a dietary staple for the squirrels
Decline in snag density	Selective logging of the largest trees from stands; salvage logging; fuel-wood removal	Loss of potential nest sites for owls; loss of den sites for flying squirrels; loss of a source of large logs for decay needs on the ground
Disturbance and/or removal of duff and topsoil layers	Sheep grazing; mechanical disturbance from logging equipment, skid trails, and so on; increased surface fuels that burn hot enough to destroy duff layer	Potential decline in flying squirrel densities via loss of fungi that are a dietary staple for the squirrels
Change in composition of tree species (fewer pines and black oaks, more firs and incense-cedar)	Selective logging of the largest trees, particularly pine species, from stands; aggressive fire suppression	Some loss of nest sites; other effects unknown

mainly the largest trees from stands, aggressive fire suppression beginning shortly after the turn of this century, and the combination of human-ignited fires and extensive sheep grazing in the Sierra Nevada during most of the last half of last century.

## Assessing the Owl's Status: Southern California

Here we summarize available evidence for the spotted owl in southern California as it relates to the three fundamental questions, and null hypotheses, posited for Sierran owls. Less is known about the habitat relations of spotted owls in southern California, but we can say much about the likely stability of the owl population there in relation to its pattern of distribution-in relatively isolated blocks with potentially hostile habitat between them, through which the owls must disperse.

### ***Does Evidence Indicate a Decline in the Southern California Population?***

Yes. The estimate of lambda for the San Bernardino demographic study area was 0.827 (table 8G), suggesting about a 17 percent annual rate of decline in the resident, territorial population during the study period (1987-91). The statistical test (alpha = 0.05,  $P < 0.0001$ ) strongly rejected the null hypothesis of a nondeclining population. The correct inference for this population is that it has been in a steep decline for at least the past 5 years.

We do not know the reason(s) for this decline. Much logging occurred there in the 1960s, but we doubt whether that disturbance can explain the current decline. Chronic air pollution in southern California may be directly or indirectly linked to the declining population of owls, for example by way of the plant foods important to woodrats. A more plausible hypothesis involves either direct or indirect effects of the drought in southern California, where precipitation from 1984 through 1990 averaged about 60 percent of normal at one weather station and about 67 percent of normal at another near Big Bear Lake, near the center of this demographic study area. Precipitation was below normal in all 7 years at one station and above normal in only 1 of the 7 years at the other (figs. 8A and 8B). In 1991,

when precipitation was above normal, it exceeded the long-term average by about 10 percent. Most of this came in a series of strong storms that coincided with the laying period for most owl pairs that attempted to breed that year.

One working hypothesis is that numbers of dusky-footed woodrats, the primary prey of the owls in the San Bernardino Mountains (Chapter 4), have declined as a result of the drought. If the decline in owl numbers is related in some way to the drought, it suggests that the owl population there is subject to high levels of environmentally induced variation in its demographic parameters. As the population declines, individuals may be lost from marginal habitats, where survival and reproduction are possible only during "good" times (Chapter 8). Individuals that survive, and even reproduce, during the decline may be those occupying better, more stable, habitats, as where more mesic conditions prevail (for example, riparian areas). Such refuges would be critically important to the species' long-term persistence, and any destabilization of them-by logging, water diversion, depression in ground-water levels, excessive development of recreational activities, or further development of communities and dispersed housing-could pose a significant threat to the owl's survival.

### ***Do Spotted Owls in Southern California Exhibit Selective Use of Habitats?***

Yes. The same basic patterns found at the home-range scale for Sierran owls have been observed in studies of habitat use by spotted owls in southern California. The most detailed study was done in the San Bernardino Mountains (table 5C). Compared to randomly located sites, nesting and roosting stands had significantly higher canopy cover, total live basal area, hardwood basal area, softwood basal area, and snag basal area. Nest trees were very large for the area, averaging 37 inches in d.b.h. and 88 feet in height. The mean age of nest trees in the San Bernardino Mountains was 230 years based just on the core length that could be extracted from the trees (table 5M).

### ***Are Key Habitat Elements Declining in Southern California?***

We do not know. We were not able to bring quantitative information to bear on this question. Little commercial logging occurs in southern California, but "timber-sale improvements" and firewood cutting have negative impacts on owl habitat there. In addition, wildfires occasionally burn through suitable owl habitat, rendering it less suitable, or even useless. The extent to which these events result in a net loss of suitable owl habitat is unknown, however. We also know that urban and dispersed residential expansion is occurring in suitable owl habitat in southern California, especially at lower elevations between relatively isolated subpopulations of the owl. Those are the places where dispersing owls must move from one subpopulation to another, and such dispersal is the only method whereby a decline in one subpopulation can be compensated by "rescue" via immi-

grants from another. We also know that many owl pairs in southern California, especially in the southern portion of the Los Padres NF, occupy narrow strips of riparian/hardwood forest. These forests will survive there only as long as the stream system from which they get their water survives. In some of these areas, water mining in the forms both of diverting surface water and drilling into underground aquifers threatens to dry up streams to the point that they will lose their riparian forests.

### ***Stability Properties of the Spotted Owl Metapopulation in Southern California***

Spotted owls in the Southern California Province have an insular population structure, ranging in size from about 1-4 pair sites to about 125 pair sites, distributed among discrete mountain ranges (fig. 9A, table 9A). This distribution of habitat islands is discontinuous across the landscape, reflecting natural discontinuities in vegetation structure and composition, in topographic conditions, and in the effects of extensive human-induced habitat disturbance and fragmentation. The largest population is in the San Bernardino Mountains, with considerably lower population sizes in the other areas. This "archipelago" is estimated to have 376 pair sites (table 9A), with an approximate population of 300-350 pairs at any point in time. Based on theory and limited empirical data, we believe the ultimate stability of this metapopulation will depend on several factors, including the persistence of one or more populations of sufficient size to avoid negative effects of demographic stochasticity, and with demographic characteristics that result in production of excess individuals to serve as potential colonists for other local populations (Chapter 9).

The sensitivity of the southern California metapopulation to a variety of perturbations was tested by performing multiple simulations, using a spatially explicit model developed to examine effects of spatial aspects of the distribution of the northern spotted owl (Chapter 9). Interpreting model results in a visual and spatially explicit way allows insights into areas of the landscape that are especially vulnerable to local extinction events, as well as those areas that represent sources for immigrants to other local populations. We did not, however, project extinction likelihoods from the model runs.

The arrangement of owls and owl habitat across the landscape shows that most of the population is concentrated in the San Gabriel/San Bernardino Mountain complex. Smaller populations in the archipelago will continue to function as a part of the larger metapopulation only if they remain connected through dispersal. If these smaller populations become increasingly isolated, via reduction in size of their habitat islands or creation of barriers to dispersal, the likelihood of their extinction increases. Although these small, isolated populations will be the first to go, even the largest, most continuous ones will experience increased risks as smaller populations drop out of the metapopulation.

The many factors discussed earlier-for example, wildfires, urban and dispersed residential expansion, water mining, and increased recreational use of riparian areas that are prime owl habitat-can all add their seemingly insignificant, individual bits

of erosion into the existing population of spotted owls in southern California. To the extent that this leads eventually to fewer pairs overall, fewer pairs in individual "islands," greater distances between pairs, and reduction in the rate of successful dispersal between populations (to maintain smaller ones), the spotted owl population in southern California appears to be fragile.

On the other hand, we know that inventories of spotted owls in southern California have not been completed. If more pairs were known to occur in some of the habitat islands, it could markedly increase estimates of the stability properties of those subpopulations. Particularly important in this regard are the possibilities of more pairs in and near the Cleveland NF and in and near the San Rafael Wilderness in the Los Padres NF. Increasing cluster size (number of pairs with essentially shared home-range boundaries) to 45 or 50 pairs in each of these areas would have a strong stabilizing effect on the metapopulation in southern California.

## Conclusions

Several uncertainties are associated with the status of spotted owls in southern California. The only population studied demographically has been declining at a high rate for at least 5 years, but this has all taken place during the recent drought. We cannot separate the possible effects of the drought from other

possibilities. Indeed, no other explanations are immediately evident. It is possible that some subtle, even unsuspected phenomenon is the real cause of the decline. Although the owls in southern California use only a subset of all available habitats, we do not know if those selected types are undergoing a net decline. Our modeling suggests that the metapopulation structure of the owls, there is especially sensitive to diminishing sizes of smaller, local populations. And it is also especially sensitive to any reduction in the effectiveness of dispersal by owls among the various "island" populations. We have identified several factors that could be, and probably are, affecting the sizes of the "island" populations and the effectiveness of dispersal among them. For this reason, we believe that more inventories and research are needed on the spotted owl metapopulation in southern California.

Considering the present state of our knowledge about spotted owls in southern California, we have identified seven major areas of concern about owl habitats there (table 1E). These have resulted from a combination of two major factors: (1) The overall population is naturally fragmented into small, relatively isolated subpopulations by the topography, precipitation patterns, and fire regime. (2) Extensive growth in the human population in the Los Angeles basin, and in other valley and foothill areas within commuting distance of Los Angeles, is encroaching on owl habitat.

**Table 1E--Summary of major factors of concern in habitats of California spotted owls in southern California, reasons for those factors, and their impacts on the owls.**

Factor	Reason(s) for the factor	Impact on spotted owls
Fragmented distribution of suitable owl habitat into small, relatively isolated "islands"	Mainly a natural result of topography, precipitation patterns, and fire regime in southern California	Creation of a metapopulation structure overall population is fragmented into numerous relatively small populations
Small population units are relatively unstable	Demographic stochasticity (random events in breeding, such as most or all young in a given year being males)	Increased likelihood of local extinction of small population units
Extent of demographic rescue of small populations by immigration of owls from other populations is relatively impeded	Distances between isolated populations, and the nature of the habitat between them, directly affect the likelihood of successful dispersal among populations by owls	Increased likelihood of local extinction of small population units
Wildfires	Natural fire regimes in southern California; additional human-caused fires; difficulty of fire suppression in rugged, remote terrain	Loss of suitable habitat will exacerbate problems of small owl populations and restricted dispersal among populations
Expansion of communities and dispersed housing developments in suitable owl habitat, especially in dispersal areas between isolated owl populations	Human population growth in southern California	Further decline in effective dispersal among isolated owl populations; possible loss of suitable breeding habitat
Increasing recreational impacts in owl habitats	Human population growth in southern California	Possible loss of additional owl habitat; possible disturbance effects inducing owls to leave otherwise suitable habitat
Surface and subterranean mining of riparian water sources	Human population growth in southern California	Loss of suitable owl habitats in riparian/hard wood forests

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# An Assessment of Current Management

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## Forest Service Lands

### Regional Policy-The SOHA Network

Based on available information, we estimate that 83 percent of all California spotted owls occur on NFs, overall; 65 percent of the total are on NFs in the Sierra Nevada (table 1A), and only 4 percent of those are on reserved lands. All known spotted owl sites on NFs in southern California are to be protected. We were not able to assess the extent to which the implementation of this policy is adequate for those owls, because we have incomplete knowledge of the range of habitats in which the birds can maintain self-sustaining populations. In general, we agree with the policy. We are concerned, however, about the current level of information on owl sites in southern California, as well as with the ability of the FS to manage habitat to provide adequate protection from fire and other factors. We recommend that current policy be reviewed periodically to determine (1) that it is being implemented adequately, and (2) that measures taken to implement it reflect the latest information available on the owls in each locality.

The FS's Regional policy for maintaining a viable population of California spotted owls in the Sierra Nevada is the network of SOHAs described in a previous section of this chapter. Because SOHAs provide habitat for only one to three owl pairs in a unit, separated by 6-12 miles from other units, the Interagency Spotted Owl Scientific Committee (ISC) that proposed an alternate strategy for the northern spotted owl (Thomas et al. 1990) concluded that the SOHA strategy had an unacceptably low likelihood of maintaining the owl population over the next 50 to 100 years. We agree that a SOHA strategy, culminating in a network of small, relatively isolated "islands" of older forest suitable for breeding by spotted owls and separated by a "sea" of younger, less suitable or unsuitable habitat, is not a workable strategy to assure long-term maintenance of spotted owls. The underlying principles are the same whether for the northern or the California spotted owl:

1. Every empirical study available on the persistence of bird populations in relation to the number of pairs in the population shows that the likelihood of extinction increases dramatically with decreasing numbers of pairs in a block of habitat. Isolated pairs exhibit excessively high extinction rates. Modeling studies show the same thing. Consequently, we expect that owl pairs in SOHAs would disappear at a relatively high rate, leaving the SOHAs unoccupied and at least temporarily nonfunctional. This loss would considerably exacerbate dispersal problems. Replacement of members lost from pairs would occur very slowly because recruits would have to search extensive areas of unsuitable landscape before locating a vacancy in an isolated SOHA.

2. Social interactions among pairs of owls almost certainly increase calling frequency where several pairs of birds are clustered. If this were not true, observers should not be able to elicit calling from silent owls by imitating their calls. The increased calling rate in clusters of several pairs should provide a sort of "vocal guidance" that would help dispersing birds locate other owls of the opposite sex in good, occupied habitat. This effect would be minimal at SOHAs because calling neighbors could be too far away to hear, and thus to stimulate counter-calling (see Thomas et al. 1990, appendix O).
3. Although SOHAs must provide at least 1,000 acres of suitable owl habitat, and some specified amount of replacement habitat, this can be (and usually is) accumulated by summing acreages of several smaller patches. A result is that SOHAs have a high ratio of edge to area. Some studies indicate that fundamental changes occur in the microclimate of a forest interior, at about 525 feet from an edge (Harris 1984, Franklin and Forman 1987). A 20-acre circular patch, therefore, is essentially all "edge." A 100-acre circular patch has a core of only 32 acres that would be sheltered from edge effects. In addition, allowing a SOHA to consist of several small patches of habitat, instead of a single large one, results in each patch being more susceptible to blowdown of trees around its edges.
4. Being relatively small, SOHAs are vulnerable to small-scale catastrophes. Destruction of a SOHA removes it from the network for perhaps 80 to 150 years and increases the mean dispersal distance between remaining SOHAs, further reducing the chance of nonterritorial owls finding unoccupied but suitable sites.
5. Floaters (nonterritorial birds) behave toward populations of breeding birds in ways that seem unlikely toward isolated pairs of breeders. We believe SOHAs would fail to provide sufficient conditions for recruitment of floaters into a breeding population, because the extent of suitable habitat in a SOHA is too limited to accommodate much more than a nesting pair.

All of the above problems are markedly reduced if owl populations are maintained in relatively large clusters in extensive landscapes where most or all owl pairs have one or more adjoining neighbors (Thomas et al. 1990).

### Cumulative Effects Analysis

In 1991, the FS implemented a cumulative effects analysis (CEA) to evaluate green timber sales and other projects within the range of the California spotted owl in the Sierra Nevada. Its objective is to maintain a full range of options for managing spotted owls in the future, while still allowing logging. First, all known and probable spotted owl sites for pairs or resident singles are identified that could be directly or indirectly affected by a project that might remove or affect owl habitat. Directly affected sites are those in which project activities will occur; indirectly affected sites are those in which owl use areas during the breeding period adjoin directly affected sites. The analysis area generally corresponds to the combined use areas of the known and probable owls that are determined to be directly and

indirectly affected by a given project. The outer boundary of this combined area may be constrained on one or more sides by topographic barriers or unsuitable vegetation types.

The process next calls for mapping all nesting and foraging habitat available within the analysis area before the project is done, using the most current information. This can include recent aerial photography, Landsat imagery, LMP database, timber stand inventory, and especially ground verification. All components of suitable habitat—total canopy closure, dominant overstory trees, multi-storied canopy structure, decadence, dead-and-downed wood, and hardwoods—are considered. The amounts of suitable nesting and foraging habitat that will remain in each owl use area after completion of the proposed project are then mapped. Effects of other actions that are reasonably foreseeable are also considered (for example, other sales under contract, other projects with signed decision notices, timber harvest plans, or predictable actions on private lands that will remove suitable habitat). The amounts of suitable foraging and nesting habitat that will remain after project completion are next evaluated against that determined to be needed by the owls in that locality, using the best available information from research and other sources. If the proposed action would reduce the total suitable owl habitat below levels needed to support the current estimated number of owls in the analysis area, adjustments are made in the project. These may include deleting portions of the sale, modifying prescriptions so that suitable habitat remains after logging entry, or moving sale units into unsuitable habitat. If the project would leave the needed amount of suitable foraging and nesting habitat per owl use area, it may proceed subject to any other Forest standards and guidelines that apply.

We have reviewed this process and believe that it will accomplish its objectives in many cases. We are concerned, however, that it lacks specific guidance for retaining the very large trees that are selected for nesting by the owls. Although the procedure calls for at least half of the canopy cover retained in the project area to be in the dominant overstory, which would undoubtedly spare many larger trees in a project area, it would not necessarily spare the largest or the oldest trees. The process also lacks specific guidance for retaining snags and maintaining some quantity of dead-and-downed woody material in specific size-classes. Finally, the CEA process has no provision to retain important habitat attributes in areas not now classified as suitable nesting or foraging habitat, even though these may have the potential to become suitable at varying times in the future—some sooner and some later. Results presented in Chapter 5 of this report could be used to craft specific recommendations for these attributes.

### ***Other Public Ownerships***

Only 130 owl sites located from 1987 to 1991 were on SPs and NPs, where management appears to be consistent with maintaining their habitat. The single known owl site on BLM lands certainly underestimates the true number of owl pairs, present, although the final count is not likely to be large. Logging occurs on much of the forested land managed by the BLM. Even though BLM's stated management emphasis will shift

toward managing for old-growth, wood products, stand maintenance, and to meet wildlife and vegetation objectives, we cannot be certain that this will suffice to maintain the number of owl pairs that probably occur now on BLM lands. The matter needs to be addressed in detail along lines recommended in later sections of this chapter. A similar approach should be taken for State-owned forests where logging occurs.

### ***Private Timberlands***

Timberlands in the Sierra Nevada that are owned by commercial timber companies and miscellaneous private parties exceed 2 million acres. Presumably much of this acreage has habitat suitable for spotted owls. Inventories have not been completed on most of these lands, and we have not been provided with full information about results of some inventories that have been done. It is clear, however, that much commercial timberland still supports breeding pairs of spotted owls, even though that has not been an objective. Breeding pairs are missing from other private timberlands, however (Chapter 3). Management across all private timberlands is consistent to the extent that policies and practices mandated by the State Forest Practices Act are followed on all private lands. Even with these constraints, however, we cannot easily characterize timber management on private ownerships because practices differ markedly among them. The fact that some private timberlands have breeding pairs of owls, while others do not, suggests to us that existing State regulations do not assure maintenance of owl sites on private lands. The difference lies in the different policies and practices of individual land owners. Whether or not new forest management practices will be enacted by the State of California remains to be seen, as does their contribution to the maintenance of breeding pairs of spotted owls on private lands.

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## **Management Recommendations for Southern California**

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We regard the status of the spotted owl in southern California as serious and meriting annual attention into the foreseeable future. We are deeply concerned that the largest subpopulation in southern California, in the San Bernardino Mountains, has been declining at an average annual rate of about 17 percent, at least since 1987. Of equal concern is the fact that the overall population is fragmented into many smaller populations. This metapopulation structure is mainly a natural result of vegetation patterns created by topography, precipitation, and fire regimes. Consequently, we are unaware of significant management opportunities to create additional, large areas of suitable dispersal habitat between the isolated populations, or to add markedly to the amount of suitable breeding habitat within those population areas. Our modeling studies strongly suggest that the stability of

the entire southern California metapopulation depends on the populations in the San Bernardino and San Gabriel Mountains (Chapter 9). If they collapse, the entire metapopulation will collapse with them. Although the observed steep decline in the San Bernardino population may be related to current drought conditions, and so be transitory, this is not a certainty (Chapter 8). The large number of factors leading to concern for the owls in southern California (table IE) only add to our concern for what appears to be a very fragile balance for the spotted owl metapopulation. Accordingly, we recommend the following:

1. Immediately implement a program to complete inventories of spotted owls in the remainder of their range in southern California (Chapter 2). If inventories and assessments of total populations, based on our understanding of habitat, have led us to markedly underestimate the number of owls occurring in various parts of their range, it could significantly change conclusions from our modeling.
2. Continue to monitor the demographics of the San Bernardino population annually, and implement at least two additional demographic studies—one centered on Palomar Mountain and the other in an area with reasonable road access in the Los Padres NF. These additional demographic studies would help (1) to determine whether our conclusion from modeling is correct that owl subpopulations in these locations depend for their maintenance on immigrants from the San Bernardino and San Gabriel subpopulations, and (2) if so, to establish the rate of immigration from other subpopulations needed to maintain them.
3. Continue existing management direction on FS lands, and extend that policy to other Federal lands and to State lands, to maintain all known pairs of spotted owls in southern California. To the extent possible, implement the same policy on private lands.
4. Finally, we recommend that a team of specialists be assembled immediately to formulate guidelines that they believe would best assure maintenance of owl pairs in various parts of their distribution in southern California. This team should include biologists with the most knowledge of spotted owl biology and habitats in southern California, silviculturists, specialists in fuels management and wildfire suppression, county planners, and probably others.

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## Management Recommendations for Private Timberlands in the Sierra Nevada

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Management of private timberlands in California are regulated by the State, which appears to be in the process of promulgating new policies in this arena. We hope that some of the information provided in this full report may influence the final form of those new policies.

Recently, some of the larger private timber companies have begun to develop guidelines for their lands that they contend will maintain populations of breeding spotted owls. We laud those efforts and believe they should be encouraged, but under the provision that results are carefully studied and documented using standard, scientific methods, including scientific peer review, and that they are shared openly with the public at least annually. Specifically, for private timberlands, we recommend the following:

1. Private timber companies that have developed management practices that they contend will maintain nesting or foraging habitat, or both, for spotted owls, should be permitted to test those practices, contingent upon submission of detailed plans to, and subsequent approval from, the State Board of Forestry. It would be the Board's responsibility to determine whether a particular plan has reasonable merit, vis-à-vis spotted owl biology.
  - A. These plans should clearly identify how resulting forest structures and configurations are likely to provide owl habitat, as it is presently understood, or additional information presently known only to a given timber company should be made public, in detail, for evaluation.
  - B. Approval of a plan by the State Board of Forestry would be contingent upon the concurrent implementation by the timber company of a long-term demographic study (see Chapter 8) over a large enough sample of its ownership to determine whether or not its management leads to predicted results. Such a demographic study would follow the same standards and protocols already established for spotted owls, and results would be open for scrutiny, at any time, by the public.
2. Operations on other private timberlands should continue to be regulated by existing State policies.
  - A. All information about spotted owls on these lands should be shared openly with all adjoining ownerships. Indeed, this needs to be a two-way street so that all parties can maximize the efficiency of their planning and the evaluation of their land management, vis-à-vis the owls.
  - B. Further, overall plans for management of spotted owls need to result from coordinated efforts with adjoining landowners, including all public ownerships. This recommendation is not leveled as a criticism of private landowners. On the contrary, we believe that all parties—public and private—share equally in the general failure to work cooperatively to develop solutions to common problems.

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# Management Recommendations for Public Timberlands in the Sierra Nevada

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A successful strategy for the California spotted owl in the Sierra Nevada must be designed to ameliorate the negative effects on owls of several important trends that have been underway for at least the past 100 years (table 1D). Furthermore, if the FS moves ahead with its current generation of LMPs, the dramatic shift toward clearcutting would add considerably to the fragmentation of Sierran forests. This would lessen the ability of spotted owls to find mates and increase the distances that the birds would need to fly to find sufficient food. In addition to ameliorating the several negative trends itemized in table 1D, a successful long-term strategy for spotted owls in the Sierra Nevada must result in the clustering of pairs such that many occur as neighbors with overlapping home ranges in the same general area.—This is the same reasoning advanced by the ISC in the case of the northern spotted owl (Thomas et al. 1990), which recommended multiple Habitat Conservation Areas (HCAs) large enough to provide habitat for at least 20 pairs of owls.

## ***Evaluation of an HCA Strategy for the California Spotted Owl***

Both the northern and California spotted owls select forest conditions commonly associated with very old forests. Consequently, logging is responsible for much of the concern about long-term maintenance of the populations of both subspecies. As two of our five peer reviewers pointed out, the ISC strategy proposed for the northern spotted owl (Thomas et al. 1990) set new precedents in conservation biology, so it should not be lightly dismissed as an option for the California spotted owl. We agree. In five important ways, however, the current situation for the California subspecies differs from that of the northern subspecies.

First, by some estimates the numbers and distribution of the northern spotted owl have been reduced by about 60 percent as a direct result of logging, land clearing for agriculture, urbanization, and other human developments (Thomas et al. 1990, p. 20). We have no evidence of similar declines in the number or distribution of California spotted owls, however, either in the Sierra Nevada or in southern California. In spite of the fact that logging has occurred over nearly all of the conifer forests of the Sierra Nevada in the past 100 years, and especially in the past 50 years, spotted owls continue to be widely distributed throughout most of the conifer zone. Indeed, spotted owls may be more abundant in some areas of the Sierra Nevada today than they were 100 years ago. Late last century, sheep and sheepherders so depleted the understory vegetation and the supply of dead-and-downed wood at some locations in the Sierra Nevada

that flying squirrel populations may have been depressed. We would expect owl numbers to decline proportional to the decline in numbers of flying squirrels (see table 4A), unless the owls preyed mainly on other species in the latter part of last century. With the burst of regeneration that followed removal of the sheep and introduction of reasonably effective fire suppression (fig. 11I), stand densities increased markedly and this led to an increase in the amount of decaying wood on the ground. The absence of periodic fires also permitted greater accumulations of duff and decaying wood.

Second, clearcutting is still held by many foresters and silviculturists to be the prescription of choice for most of western Washington and Oregon, west of the Cascade crest. Partial cutting there leads to extensive blowdown of remaining trees, and regeneration of preferred timber species is poor after partial cutting compared with clearcutting. The result is a scant record of experience with partial cutting in most of the Pacific Northwest, and certainly no experience with how to maintain spotted owls in logged forests by applying a variety of partial-cutting prescriptions. As a result, the ISC opted for a strategy that separated HCAs from areas where logging could occur, and they prudently held that experience with silvicultural procedures that could both generate timber volume and maintain owls should be acquired outside of HCAs. On the other hand, partial cutting has been the predominant method over most of the Sierra Nevada for decades. We know that stands there do not "fall apart" when partially cut. We also know that most of what has been done there has not yet excluded spotted owls from Sierran forests.

Third, because clearcutting practices have dominated silviculture in the Pacific Northwest, most forests there today are either relatively undisturbed or they are in various stages of regeneration from clearcuts done mostly within the past 50 years. Consequently, distinguishing between suitable and unsuitable owl habitat in the Pacific Northwest was relatively easy, compared with the same task in most of the range of the California spotted owl. Tallying total acres of suitable owl habitat, although not easy, was nonetheless feasible over most of the range of the northern spotted owl. This has not been the case throughout the range of the California spotted owl for three primary reasons: (1) Logging practices in the Sierra Nevada and southern California have not typically involved the creation of nonforests where once forests stood. Instead, logging's impacts have been incremental. (2) We have no studies to show what sorts of forest stands can support *self-sustaining* populations of California spotted owls. (3) Nearly all of the quantitative research done on the California spotted owl began in 1987 or later—the same time the present drought began (fig. 4H). Therefore, all results must be interpreted against that background.

Fourth, fire is not a major threat to most existing stands west of the Cascade crest in Oregon and Washington (Agee and Edmonds 1992). Setting aside large blocks of forested land to be left nearly intact, with little or no logging or other stand-altering activities, does not entail a big risk that fires will destroy major portions of those blocks at an unacceptable rate. We have little confidence that the same is true in the Sierra Nevada. Sierran mixed-conifer forests, where most California spotted owls oc-

cur, are drier and, given the effects of fire exclusion, much more prone to stand-destroying fires than are most forests in western Washington and Oregon. This creates a challenge when trying to establish procedures for maintaining spotted owls in Sierran conifer forests. An HCA strategy there could deal with the uncertainties associated with logging, but HCAs would sometimes be reduced in extent by stand-destroying fires. Prescribed fires and other methods of fuel treatment can be used to reduce the excessive fuel loads that are now so common in Sierran forests (Chapter 12). These procedures are costly, however, and we believe it is folly to imagine that sufficient funds would be forthcoming to implement an effective fuels management program in HCAs excluded from logging. Furthermore, regulations on air quality standards are making it increasingly difficult for agencies to obtain the burning permits needed to implement effective prescribed burning programs.

Fifth, the northern spotted owl is considerably more numerous than the California spotted owl. This contrast is even greater, of course, for the Sierra Nevada—the only area where an HCA strategy might be considered for the California spotted owl (see prior discussion of the southern California case). Thomas et al. (1990, p. 20) stated that "...results indicate about 2000 pairs located during the last 5 years, representing some unknown fraction of the true number of pairs. Because a census of the total population is not available, we have no statistically reliable population estimate. Recent claims of actual counts of some 6000 birds in 1989 are not out of line with other information from monitoring and inventory efforts." The HCAs recommended by the ISC were estimated to set aside habitat for 1,743 pairs of northern spotted owls (Thomas et al. 1990, p. 33). "In a worst-case scenario, we estimate that the strategy could result in a 50 to 60% reduction in current owl numbers," stated Thomas et al. (1990, p. 34). Given the relatively large number of northern spotted owls, and the extensive distribution of HCAs throughout the range of the subspecies, the ISC believed that such a reduction in total population would not preclude attaining a stable, equilibrium population within 100 years.

We expect that an HCA strategy in the Sierra Nevada could be implemented only on Federal lands, where we have estimated 1,454 known and possible owl sites (table 1A). If 75 percent of the owl sites have pairs at any given time, and assuming that an HCA strategy in the Sierra Nevada might result in only a 40 percent decline in the number of owl pairs, we would expect only about 650 pairs of owls to be protected by HCAs (which would be structured to include reserved lands-NPs and Wilderness Areas). This number may be sufficient to maintain a viable population of owls over the short- to mid-term in the Sierra Nevada, depending on the sizes and positioning of the HCAs. But the number is small enough to introduce additional risks associated with catastrophic events, such as stand-destroying fires in HCAs. Because fire events and subsequent impacts on owl numbers are inevitable, we must maintain a balance between the rate of habitat loss to fires and the rate of habitat recovery from fires.

From the above considerations, we believe an HCA strategy for the Sierra Nevada has as many faults as it has benefits. It

should not be undertaken lightly, and evidence of the need for such a strategy must be compelling. Here we briefly summarize that evidence.

Although both study populations suggest the possibility of population declines, evidence of declining owl populations in the Sierra Nevada was inconclusive. Because the power of the test of the null hypothesis of no decline was very low in both cases, the correct inference to draw from results is that we are uncertain about the status of these populations. Condition this inference, however, with the additional facts that (1) one of the two demographic studies was done in Sequoia/Kings Canyon NPs, where logging and other habitat disturbances have not occurred, and (2) the second demographic study was done in an area of checkerboard ownership where owl density was considerably less than in areas of continuous public ownership in the Sierra Nevada, and where no nests and few roosts of owls were found on the private timberlands that were part of the checkerboard. Even if this population actually declined during the period of study, it may not have been representative of owl populations occupying areas of more contiguous, suitable habitat in Sierran conifer forests.

As for northern spotted owls, strong evidence from several sources indicates that California spotted owls select nest and roost sites in stands with very large, old trees, high canopy closure, and snags. Clear evidence from past logging practices and from the LMPs for Sierran NFs indicates that most of these stands will soon be gone if the direction of forest management in Sierran conifer forests is not changed. At the present time, however, the owls are widely and evenly distributed throughout nearly all of the westside conifer forests on NF lands. We know less about their occurrence on private lands, but we do know that owls occur on many of them. Apparently, even though the total amount of old-growth forest has been markedly reduced in the Sierra Nevada during the past century, enough very old trees remain today, widely distributed, that the owls do not exhibit major gaps in their distribution that can be clearly attributed to logging.

Given these circumstances, we do not find a case sufficiently compelling at this time to recommend setting aside large blocks of Sierran forests as HCAs for the California spotted owl. Instead, we believe the situation calls for several steps needed during an interim period to preserve for the future significant management options for owls in the Sierra Nevada. These are aimed primarily at saving the older forest elements that the owls appear to need for nesting and roosting, and at reducing the excessive build-up of surface and ladder fuels.

## ***A Recommended Interim Approach***

We believe the current status of the California spotted owl in the Sierra Nevada is more amenable to improved management practices throughout public lands (Federal and State) than it is to any of the variety of reserved block designs we have examined. Because spotted owls are still widely and fairly evenly distributed throughout the conifer forests of the western Sierra Nevada, we favor an alternative strategy that maintains that number and distribution at least for an interim period. Management of the

forests during this interim should not foreclose options for whatever long-term management scenario may be adopted for the owl at the end of the interim period. The desired objective, of course, would be to determine how to maintain spotted owls throughout Sierran conifer forests in a manner compatible with some sustainable level of timber production. The advantages of such a strategy are many. No decisions must be made about the number of owl pairs needed in blocks of habitat or how far apart to space blocks, because most of the Sierran conifer forest would be suitable for foraging by owls, and nesting and roosting habitat would be widely available. Commodity production associated with maintenance of suitable owl habitat would result in funds for fuels management. And much of the fuels management problem could be approached physically as part of the strategy to maintain suitable owl habitat by removing the dense surface and ladder fuels that now facilitate stand-destroying fires. Finally, we contend that such a strategy is more likely to sustain viable populations of most or all other plant and animal species in the Sierra Nevada than is any block strategy.

Whatever interim strategy may be adopted, it should accomplish three primary objectives: (1) protect known owl nest stands (or main roost stands if nest stands are not known) from any significant degradation; (2) protect very large, old trees throughout Sierran conifer forests; and (3) begin to cope with the excessive fuels problem. The duration of the interim period will depend on how quickly we can determine, with certainty, the status of the owl population in the Sierra Nevada and attain a relatively full understanding of the range of habitats in which the owls can maintain self-sustaining populations. We recommend an initial period of 5 years, although whatever period is chosen must extend well past the present drought into the next "normal" or "wet" climatic period.

## General Recommendations

1. Maintain all existing SOHAs, as presently specified in LMPs, until a long-term strategy is implemented. Although the SOHAs do not, by themselves, constitute a viable strategy for the owls, we cannot anticipate what role they may play, if any, in a long-term strategy.
2. Continue to monitor the demographics of spotted owls in the Lassen NF, Eldorado NF, Sierra NF, and Sequoia/Kings Canyon NPs. Enlarge these studies enough that the power of their tests of lambda can provide a reasonable likelihood of detecting real population declines when they occur (Chapter 8).
3. Implement ecological studies of the primary prey species of spotted owls in the Sierra Nevada Province, especially the northern flying squirrel in the conifer zone and the dusky-footed woodrat at lower elevations (Chapter 2). The objective should be to develop a full understanding of the key ecological linkages among trees, soil, water, prey, and owls (Chapter 4).
4. Undertake an extensive inventory of potential spotted owl habitat in riparian/hardwood forests and adjoining woodlands in the foothills of the western Sierra Nevada and in the

inner coast ranges to estimate the number of nesting pairs there (Chapter 2).

5. Through coordination between managers and researchers, initiate a program of experimental forestry in Sierran NFs within the interim period, as recommended in Chapter 2 and elucidated in Chapter 13, so that we may observe these modified forest systems and determine their effects on spotted owls.
6. Develop a time schedule that identifies specific, annual accomplishments that can be monitored to assure satisfactory progress toward attaining information needed to craft a longer-term strategy for the California spotted owl.

## Specific Recommendations

The following guidelines (table 1F) should not preclude options for the future. The protections afforded to owl sites and preferred nesting habitat are intended to stabilize owl habitat acreage in the short-term. Taking a longer look, the basal area retention in larger tree size-classes will ensure that old-growth elements will not be lost from these systems. Existing Experimental Forests and Demonstration Forests are expressly exempted from all of the following recommendations.

### Spotted Owl Sites on Public Lands

1. Establish a *Protected Activity Center* at all known California spotted owl sites in the Sierra Nevada. Locate owl sites using the California Department of Fish and Game's database, and identify the activity center in each, defined either by a known nest site or by what is judged by a Forest Biologist knowledgeable about owl biology to be the best roost location in the site. Delineate an area of 300 acres around this activity center (see "Size of Activity Centers" in Chapter 5) following boundaries of known habitat polygons and topographic features such as ridgelines, as appropriate. The *intent* here is to include in the 300 acres the best possible owl habitat available, blocked up into as compact a unit as possible. Ideally, each unit would consist of 300 acres of P4G, M4G, or better stands (M5G, M5N, M6) (see table 1C for code definitions), but this will likely not be possible in all instances. To assure that the unit includes the best owl habitat available, augment the acreage of P4G, M4G, or better with the following timber strata, arranged here in descending order of priority: M3G, P3G, M4N, M3N, P3N, R4G, R4N, P4P, and M2G (see table 5A and fig. 5B, and the discussion of ponderosa pine strata under the heading "Selective Use of Forest Types" in Chapter 5).
2. Undertake no stand-altering activities within *Protected Activity Centers*, other than light underburning.
3. Light underburning in these stands would be permissible, given careful review by biologists and fuels management specialists, on a case-by-case basis. Any underburning should be done in a manner that minimizes removal of duff and large woody debris.
4. Remove no snags or large culls from *Protected Activity Centers*.

**Table 1F**-Summary of primary recommendations for stand retention and special stand treatments to maintain options for spotted owls on public timberlands in the Sierra Nevada during an interim period.

Attributes	Protected <sup>1</sup> Activity Centers	Selected <sup>2</sup> Timber Strata	Other <sup>3</sup> Timber Strata
Large, old trees Basal area	No logging	Retain 40 percent basal area from the largest healthy trees and culls	Retain 30 percent basal area from the largest healthy trees and culls  Retain at least 50 square feet basal area per acre
D.b.h. <sup>4</sup>	No logging	Retain all live trees $\geq 30$ inches in d.b.h.	Retain all live trees $\geq 30$ inches in d.b.h.
Percent canopy cover	No reduction	$\geq 40$ percent	No restriction
Snags	No reduction	Save the largest snags $\geq 30$ inches in d.b.h., to a maximum of eight snags per acre; if this is $< 20$ square feet basal area per acre, save snags $< 30$ inches in d.b.h., from the largest down, to a total of eight snags per acre or 20 square feet basal area per acre, whichever comes first; need not retain snags $< 15$ inches in d.b.h. or $< 20$ feet tall	
Downed woody material	Reduction only in relation to light underburning	Beginning with the largest downed logs (by volume), sequentially retain pieces of downed wood until an average of <i>at least</i> 10-15 tons/acre are retained over a cut unit. Do not include pieces $< 11$ inches in diameter to meet the tonnage limit. The intent here is to retain as many as possible of the existing large pieces of decaying wood present on a site before any treatment (for example, a timber sale or prescribed burn). Cull logs created by a sale should be left at or near where they fall and be included when totalling the downed wood to be retained	
Fire threats	Light underburning	Positive fuels management	Positive fuels management

<sup>1</sup> Block of 300 acres of suitable nesting/roosting habitat delineated around nest site or primary roost site in all known spotted owl sites in the Sierra Nevada, as identified in the California Department of Fish and Game database.

<sup>2</sup> Timber strata selected for nesting by spotted owls in the Sierra Nevada (P4G, M4N, M4G, and better-strata codes explained in table 1C).

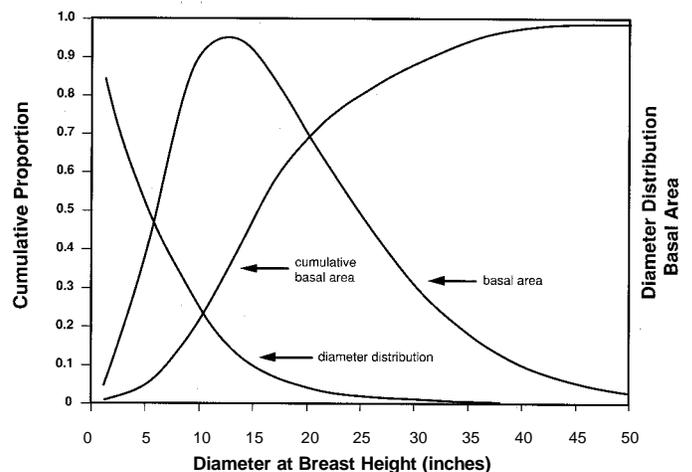
<sup>3</sup> Other timber strata used for nesting by spotted owls in the Sierra Nevada (MG, P3N, P4P, M2G, M3P, M3G, M3N, M4P, R3P, R3G, R4G, R4N-strata codes explained in table 1C).

<sup>4</sup> Diameter at breast height, in inches.

## Other Forested Public Lands

1. *Selected Timber Strata:* Stands shown to be selected for nesting by the owls (P4G, M4G, M4N, M5G, M5N, M6--see table 5A and section on "Selective Use of Forest Types" in Chapter 5) may be entered only once for commercial logging prior to implementing a long-term strategy for managing the California spotted owl on public lands. Remove no live tree  $\geq 30$  inches in d.b.h. Retain 40 percent of the basal area, consisting of the largest of the healthy trees and culls in each cut unit, using the following steps:

- A. Do not rely on current timber inventories to determine stand strata. Base this determination on field verification of each cut unit during stand inventories in preparation for sales. When a cut unit is borderline between two timber strata (for example, between M4N and M3N, between M4G and M3G, or between M4N and M4P), assign it to the stratum with higher canopy cover and/or larger stem diameter. Develop diameter distributions of live trees (including culls) from the inventory data for each cut unit separately, by 2- to 4-inch d.b.h. groupings.



**Figure 1A**-Diameter distribution (stems per acre), basal area distribution (square feet per acre), and cumulative basal area distribution of a hypothetical, uneven-aged stand of trees.

- B. For each cut unit separately, construct basal-area distributions for live trees.
- C. Next form *cumulative* basal-area distributions for live trees in each cut unit (see fig. 1A), and draw a horizontal line from the 0.6 proportion on the y axis to the cumulative basal-area distribution curve. From that point, draw a vertical line down to the x axis (see fig. 1B).
- D. Cut no live trees with diameters equal to or larger than the diameter intersected by the line perpendicular to the x axis.

Maintain an average crown closure  $\geq 40$  percent in the remaining overstory. If the largest live trees retained in the cut unit do not yield a canopy closure  $\geq 40$  percent, make up the difference with stems 12-24 inches in d.b.h. Treat surface and ladder fuels as necessary to create a mosaic of fuel profiles that will minimize the probability of extensive, stand-destroying wildfires. Fuel profiles should consider other objectives of land management, including the needs for site productivity and for habitat of species other than spotted owls.

- 2. *Other Timber Strata*: Stand types used for nesting by the owls, but not significantly selected based on availability (P3G, P3N, P4P, M2G, M3P, M3G, M3N, M4P, R3P, R3G, R3N, R4G, R4N-table 5A), may be entered only once for commercial logging prior to implementing a long-term strategy on public lands. Remove no live tree  $\geq 30$  inches in d.b.h. Retain 30 percent of the basal area, consisting of the largest of the healthy trees and culls in each cut unit, following the same steps described for *Selected Timber Strata*. In this case, begin the horizontal line to the cumulative basal area distribution curve from 0.7 on the y axis (fig. 1B). Live trees remaining in these stands must have a cumulative basal area of at least 50 square feet per acre. Remove surface and ladder fuels that would threaten to carry fire into the crowns of remaining trees, and undertake on the sale unit other fuels treatments that are considered necessary.
- 3. *Snag Retention*: Retain all snags in Protected Activity Centers. In all other habitat that is currently or potentially suitable for foraging, roosting, and/or nesting by spotted

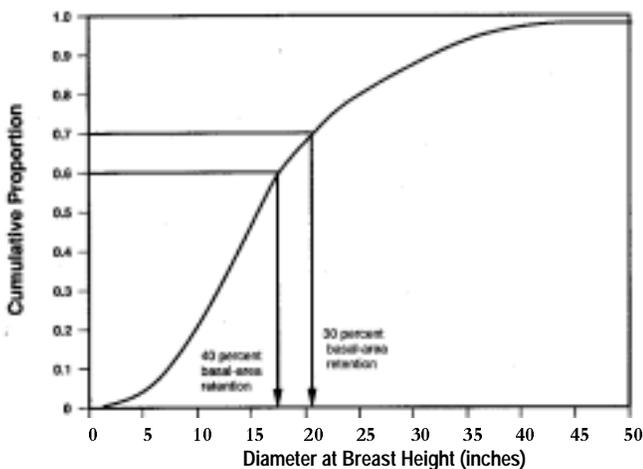


Figure 1 B-A cumulative basal-area function from a hypothetical stand, showing how to relate the proportion of the total basal area subject to logging to the diameter limit of the trees to be retained.

owls, including salvage sales and instances of catastrophic stand loss, use the following guidelines: Save the largest snags  $\geq 30$  inches in d.b.h. (starting with the largest snag and working down) to a maximum of eight snags per acre, averaged over the cut unit. If this guideline does not result in at least 20 square feet basal area of snags per acre, continue adding snags, from the largest ones remaining, down to a total of eight snags per acre or 20 square feet basal area, whichever comes first. Snags  $< 15$  inches in d.b.h. or  $< 20$  feet tall need not be retained.

- 4. *Downed Wood Retention*: In all habitat that is currently or potentially suitable for foraging, roosting, and/or nesting by spotted owls, use the following guidelines: Beginning with the largest downed logs (by volume), sequentially retain pieces of downed wood until an average of *at least* 10-15 tons/acre are retained over a cut unit. Do not include pieces smaller than 11 inches in diameter to meet the tonnage limit. The intent here is to retain as many as possible of the existing large pieces of decaying wood present on a site before any treatment (for example, a timber sale or prescribed burn). Cull logs created by a sale should be left at or near where they fall and included when totalling the downed wood to be retained. For the mass calculation, assume a specific gravity of 0.4.
- 5. *Exceptions to Guidelines 1 and 2*: Guidelines 1 and 2, above, require that large, live trees be left where they are found. In certain cases, based on concurrence between wildlife biologists and silviculturists, compelling reasons may exist to reduce the areas of tree crowns and roots in portions of a cut unit. These include the need to break up a uniform distribution of live trees to allow regeneration of shade intolerant species, to reduce the spread of dwarf mistletoe from the overstory to regenerating conifers in the under-story, or to protect dense live patches from bark beetle attack by killing high-risk trees. In such cases, we recommend the following guidelines:

If the total basal area of snags  $\geq 30$  inches in d.b.h. is less than 20 square feet per acre, live trees greater than the diameter limit for *Selected Timber Strata* or *Other Timber Strata*, as appropriate, may be girdled to create snags. Add the basal area of the girdled trees to the snag basal area, but leave an equivalent live basal area in the dominant and codominant tree classes to compensate for the loss in basal area of large live trees that were girdled. A maximum of 10 square feet basal area per acre, or one stem per acre if that stem contains  $\geq 10$  square feet basal area, may be girdled. As with all other retention figures, the evaluation is averaged over the cut unit, which means that a minimum of 40 trees may be treated in this manner on a 40-acre cut unit. The following steps would serve to implement this strategy:

- A. Develop a diameter distribution and mark live trees in a given cut unit.
- B. Determine whether the stand is deficient in large snags.
- C. If more large snags are desirable, mark desired snags as "wildlife" trees and measure their diameters at breast height.
- D. After all "wildlife" trees have been selected, mark to leave enough additional live trees from the dominant

**Table 1G**-Estimates of the effects of leaving the largest trees in stands, accumulating to various percentages of total stand basal area, for four timber strata, using actual mean stand-diameter distributions from the Tahoe NF. When the value in column seven ("Percent of basal area retained by 30-inch limit") exceeds the corresponding value in column one ("Percent basal-area retention"), the 30-inch limit is more constraining. Similarly, when the value in column five ("D.b.h. of smallest tree left") is larger than 30, the 30-inch limit is more constraining than "Percent basal-area retention."

Percent basal-area retention	Strata <sup>1</sup>	Initial basal area	Basal area left after logging	D.b.h. of smallest tree left <sup>2</sup>	Mean d.b.h. of trees remaining	Percent of basal area retained by 30-inch limit	Number of trees left per acre with basal-area rule
<b>Stands affected by the 40-percent retention rule</b>							
20	M4G <sup>3</sup>	254.61	50.92	34	37	27	6
25	M4G <sup>3</sup>	254.61	63.65	31	37	27	7
30	M4G	254.61	76.38	29	36	27	10
35	M4G	254.61	89.11	27	34	27	14
40	M4G	254.61	101.84	25	32	27	18
45	M4G	254.61	114.57	23	30	27	23
50	M4G	254.61	127.30	22	30	27	26
<b>Stands affected by the 30-percent retention rule</b>							
20	M4P <sup>3,4</sup>	126.45	25.29	32	38	24	5
	M3G <sup>3,4</sup>	213.43	42.69	34	38	26	4
	M3P <sup>4</sup>	138.06	27.62	30	38	19	3
25	M4P <sup>4</sup>	126.45	31.61	30	38	24	4
	M3G <sup>3</sup>	213.43	53.36	31	38	26	6
	M3P <sup>4</sup>	138.06	34.52	28	35	19	5
30	M4P <sup>4</sup>	126.45	37.94	26	35	24	6
	M3G	213.43	64.03	29	37	26	8
	M3P <sup>4</sup>	138.06	41.39	26	33	19	7
35	M4P <sup>4</sup>	126.45	44.26	24	33	24	7
	M3G	213.43	74.70	27	35	26	11
	M3P <sup>4</sup>	138.06	48.32	25	32	19	9
40	M4P	126.45	50.58	22	30	24	10
	M3G	213.43	85.37	25	32	26	15
	M3P	138.06	55.33	24	31	19	10
45	M4P	126.45	56.90	21	28	24	13
	M3G	213.43	96.04	24	31	26	17
	M3P	138.06	62.13	22	29	19	13
50	M4P	126.45	63.23	20	27	24	14
	M3G	213.43	106.72	22	30	26	21
	M3P	138.06	69.03	20	28	19	16

<sup>1</sup> Strata codes defined in table 1C.

<sup>2</sup> Diameter at breast height, in inches.

<sup>3</sup> Does not satisfy the 30-inch d.b.h. rule, which then takes effect.

<sup>4</sup> Does not satisfy the rule of retaining a basal area of at least 50 square feet.

and codominant classes to equal the basal area of trees to be girdled.

- E. Girdle the marked "wildlife" trees after the sale. If trees marked to leave were inadvertently removed during harvest, make up for the lost basal area by NOT girdling some of the "wildlife" trees.

### A Rationale for the Recommendations

Having decided that a major part of an interim strategy for spotted owls in the Sierra Nevada needed to save the largest, oldest trees, we then had to determine what level of retention would be sufficient. For this, we obtained plot-level data from timber-strata inventories in the Tahoe NF. From these data we defined diameter-distribution and basal-area functions for each stratum in the mixed-conifer group. We then generated cumulative distributions for each stratum, determined the diameter limits, and computed the number of trees per acre that would

remain for basal-area retentions between 20 and 50 percent (table 1G). Evaluation criteria were based on the need to leave both the large, old trees and to leave sufficient "dominants" as replacement trees so that these structures would be retained into the future. Because we wished to establish a limit, not a target, we aimed to set minimum retention values.

An additional objective for *Selected Timber Strata* was to leave such stands in or near a structural condition corresponding to suitable foraging habitat for spotted owls. For these stands, it is clear from study of values for M4G strata in table 1G that basal-area retentions of <30 percent would not accomplish our main objective of retaining large, old trees AND providing a succession of replacement trees for them. The smallest of the large trees under 20-percent retention would be 34 inches in d.b.h.-too large to be considered candidates for replacement of the large, old trees when they die and fall. Only six large trees per acre would remain with 20-percent retention, but the 30-inch

d.b.h. rule takes over in this case and leads to retention of 10 trees per acre. A 40-percent retention nearly doubles the number of trees retained per acre, and the smallest of the large trees would be 25 inches in d.b.h. Trees of this size can easily be produced in less than 100 years on most commercial timberlands in the Sierran mixed-conifer zone, providing ample replacements for the large, old trees that range upward in age from 200 years.

A challenge arises with stands having a very high proportion of very large trees. Even with a 40-percent retention rule, the smallest of the large trees retained could be too large to qualify as a replacement tree. For this reason, we added a recommendation to retain all trees  $\geq 30$  inches in d.b.h. When the basal-area retention rule fails to include such trees, the 30-inch rule is more constraining and determines the smallest stem diameter to be retained.

The criteria outlined above for retaining large trees will result in unique residual stand structures. In contrast to the uniform spacing of trees common to seed-tree and shelterwood methods, we expect large trees to be irregularly distributed in a stand and to exhibit varying degrees of clumping. This pattern of distribution would result in some large openings in the canopies of units logged following the retention guidelines, and thus promote the regeneration of shade-intolerant species like ponderosa pine and black oak. Our next concern was with the final canopy closure in these stands, which should be  $\geq 40$  percent to be within the range of suitable owl foraging habitat. Given 18 trees per acre with a 40-percent retention, and assuming an average crown diameter of 30 feet, final canopy closure would be  $< 30$  percent. This led to our final recommendation of retaining sufficient trees 12-24 inches in d.b.h. to bring total canopy closure up to  $\geq 40$  percent. Not only would this provide adequate canopy closure, but also it would provide an intermediate range of tree sizes as later candidates for replacement of large, old trees.

The thought process was similar for *Other Timber Strata*, represented by M4P, M3G, and M3P stands (table 1G), although it was not our intention that these should qualify structurally as suitable foraging habitat for owls after logging. Retaining 30 percent of the total basal area in the largest tree sizes would maintain some trees  $< 30$  inches in d.b.h., which would provide replacements for the largest trees. As added protection for very sparse stands, we have recommended a minimum basal area of 50 square feet per acre, accumulated from the largest trees in the stand. For the M3P and M4P stands (table 1G), approximately 40 percent of the basal area must be retained to leave 50 square feet per acre, and 10 of the largest trees per acre would remain.

As described in Chapter 5, under the section entitled "Selective Use of Forest Types," we lacked data to analyze whether or not spotted owls select nest sites in various ponderosa pine strata in excess of expectation. Because we have strong reason to believe that at least P4G strata would be selected, however, we recommend a cautious approach in treating ponderosa pine types during the proposed interim period, especially because NFs are likely to classify them as unsuitable owl habitat for lack of sufficient crown closure, even though they may have plenty of hardwood cover in the understory. Accordingly, we recommend that P4G stands, so classified *after* hardwood and understory conifer components have been included in an assessment of

**Table 1H** Summary of major factors of concern in habitats of California spotted owls in the Sierra Nevada, and which of the recommended actions are intended to ameliorate effects of those factors.

Factor	Recommended actions
Decline in abundance of very large, old trees	Saving live trees $\geq 30$ inches in diameter at breast height; saving the largest trees in stands, by percentage of basal area
Long recovery period for spotted owl habitat after logging	Emphasizing retention of largest, trees shortens the recovery period after logging
Ingrowth of shade-tolerant tree species, creating unnaturally dense stands with ground-to-crown fuel ladders	Thinning; emphasizing removal of small-diameter trees; clearing fuel ladders from around largest trees
Excessive build-up of surface fuels	Implementing aggressive fuels management program, especially to reduce amount of downed wood $< 10$ inches in diameter
Loss of large-diameter logs from the decaying wood source on the ground	Retaining the largest trees and snags in stands, which will eventually be recruited as logs; meeting guidelines for large-diameter logs on the ground
Decline in snag density	Retaining at least 20 square feet basal area per acre of the largest snags in stands; in addition, sparing the largest trees will assure a continuing source of large snags and downed logs
Disturbance and/or removal of duff and topsoil layers	Reducing surface fuels so ground fires burn cooler; reducing mechanical impact of logging and other projects on top soil and duff layers
Change in composition of tree species-fewer pines and black oaks, more firs and incense-cedar	Leaving largest trees and removing smaller trees should result in many openings large enough for germination by shade-intolerant species

stem diameter and canopy closure, should be treated as "*Selected Timber Strata*" during the proposed interim period. P3N, MG, and P4P, again as classified after inclusion of their hardwood components, should be treated as "*Other Timber Strata*."

### Evaluation of the Recommendations in Relation to the Problem

Our recommendations address all factors in Sierran conifer forests that we believe have negative effects on California spotted owls (table 1H). Of the eight factors identified, six would be alleviated by a strategy that saves the largest trees in stands and removes some significant proportion of the smaller trees. In effect, the approach recommended here tends to invert silvicultural practices of the last 100 years. What has been characterized as "top down" logging (concentrating on the largest trees) would become primarily a "bottom up" approach (leaving the largest trees and concentrating on the smaller trees). Although not

excluding certain kinds of silvicultural prescriptions that are sometimes associated with clearcut logging, the steps recommended here preclude "clearcutting" in the sense that much of the public perceives it-as creating unsightly patches of land from which all trees have been removed. It also prevents the high-grading of scattered remnant trees.

We do not contend that the approach recommended is without risks. No approach is risk-free. The guidelines suggested for *Other Timber Strata* are not so restrictive that they would guarantee stand conditions suitable for owls immediately after logging. We have focused on setting strong rules to retain stand components that are most at risk and hardest to replace. For instance, to replace large logs in late decay-classes after clearcutting, we first must grow large-diameter trees, allow them to become snags, fall over, and subsequently rot. This is a process measured in centuries. On the other hand, a clearcut site can return to a dense stand of small to medium sawlogs in a few decades (see figs. 11P-11S). We are therefore more concerned about the former than the latter. The spotted owl population in the Sierra Nevada persists despite 100 years of logging injurious to its habitat, and it is still widely and relatively evenly distributed. We thus believe the recommended changes in traditional silvicultural practices in Sierran forests are unlikely to significantly degrade spotted owl habitat over the short-term, and they may even improve habitat over the long-term.

In contrast to the case for *Other Timber Strata*, recommendations for *Protected Activity Centers* should maintain existing nest/roost habitats in a condition suitable for continued use by the owls for those purposes. And guidelines for *Selected Timber Strata* should at least maintain suitable foraging habitat, as recommendations would retain all structural attributes associated with foraging owls (Chapters 5 and 6). We know, for example, that spotted owls regularly used some stands, but not others, that had been recently logged in the Lassen NF (Chapter 7). We would not be surprised to find that a brief period (probably less than 5 years) elapses after logging operations before the owls resume foraging in *Selected Timber Strata*. This is a primary question to be studied through radio-tagged owls (see recommendation in Chapter 2). If the approaches recommended here can be implemented faithfully and studied carefully, we are hopeful that they might lead us to a feasible, long-term solution to the owl problem and to many other problems that follow from the loss of attributes associated primarily with forests in late seral stages.

The recommendations DO NOT REPRESENT TARGETS. Instead, they should be viewed as limits that allow a wide range of silvicultural options. Their main purposes are to arrest the decline of very large, old trees; to save younger, "dominant" trees as replacements for older trees as they die and fall; to reduce risks of catastrophic fire; to promote recruitment of shade-intolerant tree species; and to retain large-diameter dead-and-downed woody materials. These goals can be achieved, in most cases, by leaving *more* trees than the guidelines suggest. For instance, guidelines proposed for *Selected Timber Strata* would be perfectly acceptable for *Other Timber Strata*. Examples of some silvicultural options compatible with the recommendations are described in Chapter 13.

Most or all biomass sales (see glossary) are probably also consistent with the guidelines. In particular, these sales can deal effectively with the serious problem of accumulating surface and ladder fuels. This situation strikes us as being akin to the general deterioration in the nation's infrastructure-bridges, highways, railroads, and so on. We have enjoyed relative luxury while postponing the inevitable costs of maintaining these structures. Someday, someone must pay for this negligence, and it will certainly cost more in the long run than it would if we simply dealt with maintenance needs as they arise. In the case of the current, serious fire threats to conifer forests of the Sierra Nevada, the money spent to suppress just one very large, stand-destroying fire would go a long way toward lessening the threat of such fires if it were spent in an aggressive fuels management program. Instead, we continue to behave like a person who fails to see the wisdom of owning fire insurance on an expensive home.

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## Conclusions

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We suspect that some of the interim guidelines proposed here-those intended to retain various stand attributes found most often in older forests-would also be a necessary part of any strategy to maintain California spotted owls over the long-term. The best long-term solution for the owl in the Sierra Nevada would be to maintain the population in its current, relatively even distribution throughout the forests of the western slopes. If that distribution can be maintained, no need may arise to block up numerous areas large enough to contain many pairs of owls that can share home-range boundaries, as proposed for the northern spotted owl (Thomas et al. 1990). Such a policy in the Sierra Nevada would bring with it a high risk of stand-destroying fires (Chapter 12) that was not a major concern over most of the range of the northern spotted owl. Further, if an acceptable way can be found to maintain attributes of older forests generally throughout the Sierra Nevada, such a plan might go a long way toward meeting the needs of most or all other plant and animal species that thrive in older forests. The spotted owl issue is only the first in a potentially long list of such species awaiting our attention.

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