Chapter 3: California Spotted Owl Habitat Characteristics and Use

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Introduction

California spotted owls (*Strix occidentalis occidentalis*) establish large home ranges averaging about 1279 ha (3,160 ac) (table 3-1), and within these home ranges individual owls select habitat at different scales, depending on their activity. At the smallest spatial scale, the nest tree, it appears there is very limited flexibility in the requirements. However, as owls select habitat at larger scales and for different activities, from nest stand to core area to foraging habitat, there is greater variability in the habitat characteristics, which suggests greater flexibility in selection. Currently, researchers have not established definitions of the size of a nest stand or core area, nor have they reached consensus on how to calculate these aspects of owl habitat. This is at least partially because each researcher uses a certain method to estimate the nest stand or core area that is relevant only to the particular question they are investigating, and as those questions differ between research projects, the methods and definitions for those terms also differ. This chapter presents the current research describing spotted owl habitat characteristics and is organized by spatial scale, starting with the nest tree, followed by the nest stand, core area, foraging habitat, prey habitat, and finally the home range. Next is a brief assessment of the current research on the effects of fire on spotted owl habitat, and followed by relevant management implications.

Habitat Characteristics

Nest and Nest Tree Characteristics

California spotted owls are habitat specialists that are strongly associated with older, closed-canopy forests with multiple layers in the mid and upper canopies. All research shows they use large, old trees and snags as structures for nest and roost sites, embedded in a forest stand that has complex structure (Blakesley et al. 2005, Gutiérrez et al. 1992, Verner et al. 1992a). Owls nest in cavities, broken tree tops, and occasionally on platforms such as old nests or mistletoe brooms located in large conifers, oaks, and snags (Verner et al. 1992a). Often, these are the largest and oldest trees in the stand and many have structural defects, such as a broken or split tops that have multiple terminal leaders (North et al. 2000). In mixed-conifer forests

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Table 3-1—Estimates of individual California spotted owl home ranges in mixed-conifer forests for the breeding season from various telemetry studies using the 100 percent minimum convex polygon estimation method[a]

Study authors	Mean home range size	Home range standard error	Study area[a]	Sample size
	- - - - - -*Hectares (acres)* - - - - - -			
Zabel et al. 1992	2195 (5,423)	701 (1,731)	Lassen NF	9
Gallagher 2010	1653 (4,085)	336 (830)	Plumas NF	9
Call et al. 1992	1520 (3,756)	Not reported	Tahoe NF	5
Williams et al. 2011	946 (2,338)	Not reported	El Dorado NF, Tahoe NF	14
Eyes 2014	634 (1,567)	200 (494)	Yosemite NP	14
Zabel et al. 1992	728 (1,799)	65 (160)	Sierra NF	24

NF = national forest, NP = national park.

[a] Study results are organized by latitude of the study area from north to south.

of the Sierra Nevada, across 141 spotted owl nests, the owls show no preference for any particular tree species, and the average nest tree is 124 cm (49 in) in diameter at breast height (d.b.h.) and 31 m (103 ft) tall with an average nest height of 23 m (74 ft) (Gutiérrez et al. 1992, Roberts et al. 2011). Owls using nests with an overhead canopy of "high foliage volume" have higher reproductive success than owls using sites with low foliage volume (North et al. 2000). In hardwood forests, of the 13 nests observed, nests were typically in live hardwood tree species with an average nest height of 12 m (38 ft), and an average nest tree d.b.h. and total height of 76 cm (30 in) and 17 m (55 ft), respectively (Gutiérrez et al. 1992). Occasionally, owls nest in giant sequoia (*Sequoiadendron giganteum* (Lindl.) J. Buchholz) or Coulter pine (*Pinus coulteri* D. Don).

Nest Stand Characteristics

Nest stands of California spotted owls typically have high canopy closure and cover (≥75 percent for both) [Note: when citing studies, we use terminology consistent with Jennings et al. (1999); however, many studies fail to accurately distinguish between canopy closure and cover (see chapter 5 for clarification)], an abundance of large (>61 cm [24 in] d.b.h.) trees, and multiple canopy layers comprising trees of different sizes, but numerically dominated by medium-sized trees (30 to 61 cm [12 to 24 in]) (Bias and Gutiérrez 1992, Blakesley et al. 2005, Chatfield 2005, Moen and Gutiérrez 1997, North et al. 2000, Roberts et al. 2011, Seamans 2005) (fig. 3-1).

There is no definitive estimate of the size of nest stands as each researcher used a stand size that was relevant to the question(s) they were investigating and

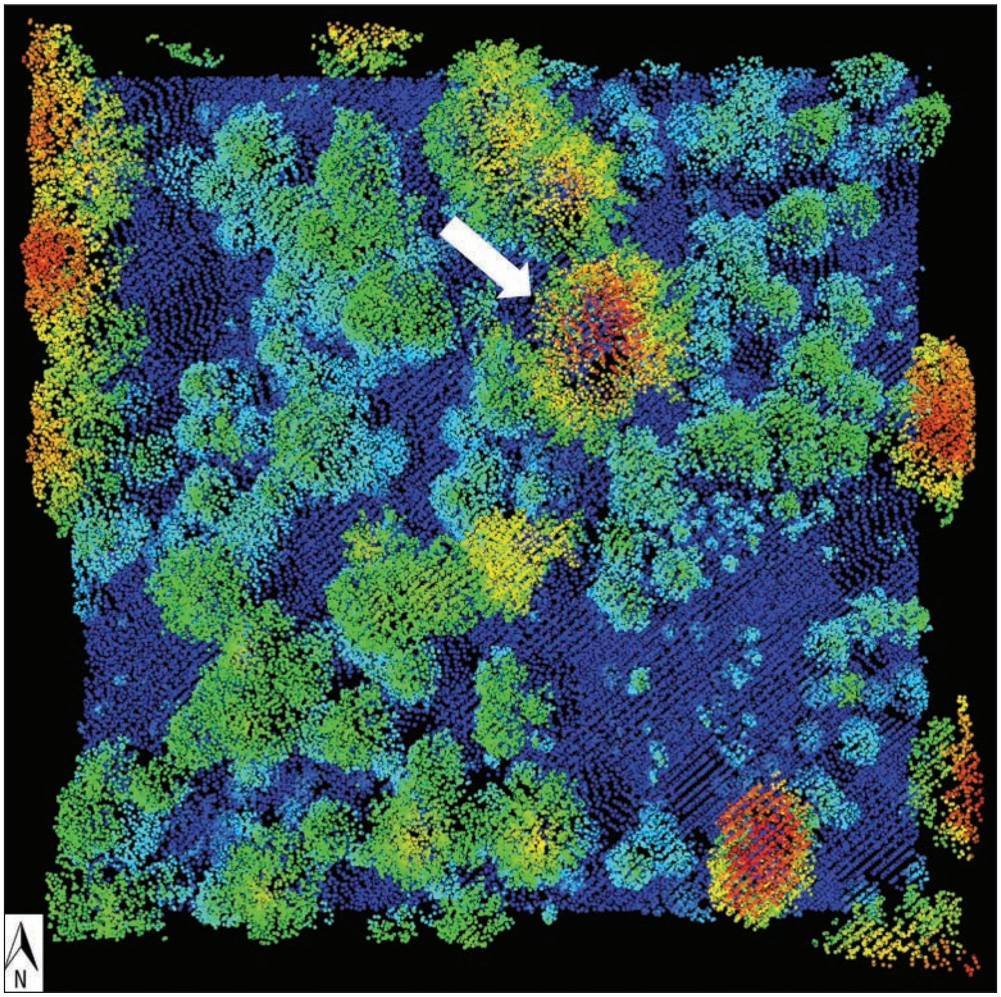

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Figure 3-1—Light detection and ranging (LiDAR) point cloud data of 1 ha (2.47 ac) illustrating multidimensional forest structure at a California spotted owl nest in a forest that burned at low to moderate severity 6 years prior to this LiDAR collection in Yosemite National Park, California. Tree heights are represented along a continuous color gradient with warmer colors (yellow to red) showing increasing crown height and bright blue showing ground level. The nest tree (50 m [167 ft] tall and 172 cm [68 in] diameter at breast height), is the tallest tree in the stand and located just northwest of center (see white arrow).

the methods they applied. Gutiérrez et al. (1992) reported that compared to random stands, nest stands had greater basal area of live trees and snags (42 to 80 m^2/ha [185 to 350 ft^2/ac] and 4 to 7 m^2/ha [19 to 31 ft^2/ac], respectively) and often had an abundance of large coarse woody debris (i.e., logs and large limbs on the ground). The association of large trees and snags and high canopy cover and closure were consistent regardless of the amount of area measured at the nest stand, which varied among studies (e.g., 0.04 ha [0.1 ac] in Moen and Gutiérrez 1997; 0.2 ha [0.5 ac] in North et al. 2000, Blakesley et al. 2005, and Roberts et al. 2011; or 40 ha [99 ac] in Chatfield 2005). Importantly, numerous studies showed that owl site occupancy and adult survivorship increased with a greater proportion of area of the nest stand containing these critical nest stand characteristics (e.g., high canopy cover or closure and basal area) (Blakesley et al. 2005, Chatfield 2005, Franklin et al. 2000, Roberts et al. 2011, Seamans and Gutiérrez 2007, Tempel et al. 2014).

Specific nest stand characteristics are highly correlated with juvenile spotted owl habitat selection. During the postfledging rearing period (after fledging and before dispersal), juveniles roosted within 800 m (875 yd) of the nest and in areas with high canopy closure (≥70 percent) and snag density (Whitmore 2009). Whitmore (2009) also estimated the mean area encompassing juvenile roosts was 125 ha (308 ac) suggesting this area around the nest provides critical habitat during a sensitive time (i.e., juvenile rearing). The complex vertical structure in late-successional forests (e.g., multiple layers in the mid- and upper canopy) provides deeper shading and protects juvenile and adult owls from overheating in areas that frequently reach 38 °C (100 °F) in summer (Barrows 1981, Weathers et al. 2001). This complex vertical canopy structure may also protect owls from predation. Phillips et al. 2010 showed owls select nest sites that are farther from high-contrast edges (i.e., mature forest patches that abruptly change to shrub-dominated or early-seral patches) than expected by chance despite other researchers observing owls foraging in those edge habitats.

Core Area Habitat Characteristics

As central-place foragers, spotted owls concentrate their activities around nests and roosts, with foraging activity reduced the farther they get from their nest or roost (Carey et al. 1992, Ward et al. 1998). This concentrated use area is commonly referred to as the "core area," which is the amount of habitat a territorial owl or pair and young use consistently, including the nesting, roosting, and foraging habitat that contains vital habitat characteristics essential to each pair's survival and reproductive success (Bingham and Noon 1997, Blakesley et al. 2005, Rosenberg and McKelvey 1999, Swindle et al. 1999, Williams et al. 2011). The core area is smaller than a home range, which is all of the area used by an individual owl.

Researchers have applied various criteria to identify and represent owl core use areas for the purpose of habitat analysis. Commonly, to delineate an area for habitat analysis that would be used by a territorial pair (by reducing spatial overlap between neighboring pairs), researchers apply either half of the minimum (0.8 km [0.5 mi]; Blakesley et al. 2005), or the average (1.1 km [0.7 mi]; Seamans and Gutiérrez 2007, Tempel et al. 2014) distance between adjacent nests (i.e., nearest-neighbor distance) as the radius to define their core area. These two examples define core areas of 203 ha (500 ac) and 400 ha (988 ac), respectively.

If radiotelemetry data is available, researchers can refine their core area sizes by using actual owl location data rather than estimating core use areas via distances between nests (e.g., Bingham and Noon 1997). Alternatively, Berigan et al. (2012) used 95 percent of each owl's locations to delineate a core area and averaged across all 38 of their radiotagged owls to define an average core area of 140 ha (347 ac) for their study.

Regardless of the amount of area different researchers use to define owl core area, the results of habitat analyses based on these defined areas demonstrate consistency in habitat characteristics of owl core areas. Occupancy, site colonization, adult survival, and reproductive success are positively associated with the proportion of the core area containing structurally complex conifer forest with large trees and high canopy cover (Blakesley et al. 2005, Seamans and Gutiérrez 2007, Tempel et al. 2014). Further, as the proportion of forest types that are not used for nesting (e.g., homogeneous forests consisting of only smaller, similar-aged young trees) increases in the core area, owl occupancy and reproductive success decline (Blakesley et al. 2005). However, the variation in the habitat classes available was relatively low (i.e., homogeneous habitat) where the non-nesting habitat mostly consisted of pole-sized stands, and there were not many other habitat types represented in their study area. This lack of variation in non-nesting habitat types could have potentially masked the influence of structural heterogeneity in core areas on owl occupancy and reproduction. Several other studies suggest that core areas of spotted owls have greater structural heterogeneity (e.g., increased edge between forest structure classes) than the nest stand and often include areas of lower canopy cover (e.g., 40 to 70 percent, Call et al. 1992; 30 to 50 percent, Tempel et al. 2014) and a wider range of forest structure classes, including shrub/sapling patches and especially habitat patch edges (Eyes 2014, Tempel et al. 2014). This habitat heterogeneity can promote increased prey diversity, abundance, and population stability throughout the long owl breeding and juvenile dependency period (March through September) (Roberts et al. 2015). Studies of northern spotted owls suggest reproductive success is positively associated with foraging habitat quality, and fledging success improves with increasing prey abundance (Carey et al. 1992, Rosenberg et al. 2003). However, it is difficult to determine a threshold of heterogeneity and find a balance between habitat heterogeneity and minimal fragmentation. California spotted owl reproductive success is negatively correlated with the proportion of nonforested areas and forest types not used for nesting or foraging within the 203-ha (500-ac) core areas (Blakesley et al. 2005). Spotted owls may need a connected matrix of high canopy cover/closure throughout their core area to maintain protection from predators because they have to return to their nest or roost after foraging. Having to cross large, open areas could expose them to predation, especially if those open areas are connected to areas inhabited by great horned owls (*Bubo virginianus*), known predators of spotted owls (Verner et al. 1992b).

Foraging Habitat Characteristics

Spotted owl foraging habitat is characterized by a mosaic of vegetation types and seral stages infused within mature forest (fig. 3-2). This juxtaposition of mature closed-canopy forest and open-canopy patches may promote higher prey diversity and abundance by increasing habitat diversity across the forest landscape (Franklin et al. 2000, Tempel et al. 2014, Ward et al. 1998, Zabel et al. 1995). This habitat mosaic is correlated with higher reproductive output and survival in northern spotted owls (*Strix occidentalis caurina*) (Franklin et al. 2000). Northern and California

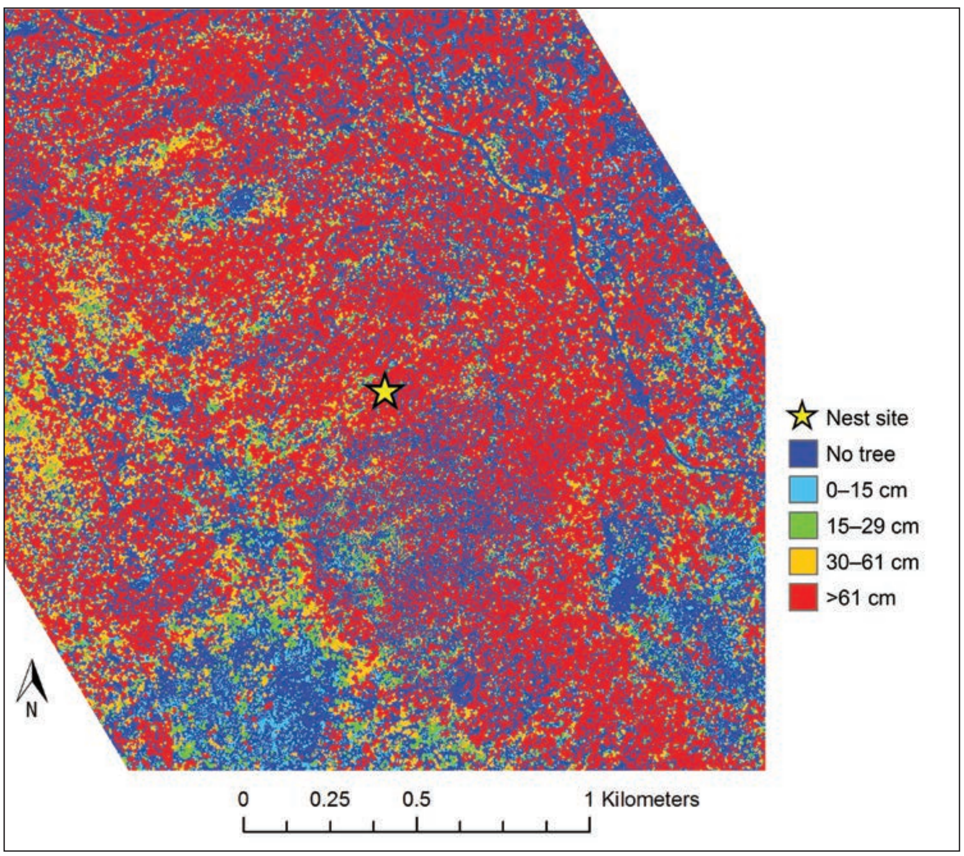

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Figure 3-2—Light detection and ranging (LiDAR) data illustrats canopy height modeling of an area equivalent to a spotted owl “Protected Activity Center” 121 ha (300 ac) in Yosemite National Park, California. The legend displays the modeled tree size classes in diameter at breast height for individual trees. The “cropped” corners are due to the confinement of the LiDAR data collection (the collection footprint) and have nothing to do with habitat structure or connectivity.

spotted owls forage in high-contrast edges more often than in interior patches (i.e., non-edges) characterized by greater structural homogeneity (Clark 2007, Eyes 2014, Folliard et al. 2000, Ward et al. 1998). In the Sierra Nevada, California spotted owls select edge habitat for foraging (Eyes 2014, Williams et al. 2011) suggesting that foraging owls exploit a heterogeneous forest matrix when foraging. These results are consistent with prey studies in the Sierra Nevada, suggesting small mammal diversity is enhanced by increased structural heterogeneity at large spatial scales and greater development of mature forest structure (Kelt et al. 2014, Roberts et al. 2015).

Within the larger mosaic of vegetation types, contiguous patches of mature closed-canopy forests are an important characteristic of spotted owl foraging habitat. Williams et al. (2011) found foraging owls selected mature forests with higher canopy cover (≥40 percent) in greater proportion relative to its availability in the landscape. Mature forests with an abundance of large trees and patches of greater canopy cover and closure (generally >50 percent) provide both important roosting habitat for spotted owls and foraging habitat for northern flying squirrels (*Glaucomys sabrinus*), a principal prey species of spotted owls in Sierra Nevada forests (Meyer et al. 2007a, 2007b; Roberts et al. 2011, 2015; Waters and Zabel 1995). The inclusion of larger California black oaks (*Quercus kelloggii* Newberry) in these forests may also benefit dusky-footed woodrats (*Neotoma fuscipes*) (Innes et al. 2007), another important spotted owl prey species.

The enhancement of habitat heterogeneity without fragmenting existing mature closed-canopy forest represents a significant challenge in forest management (Stephens et al. 2010, 2014). One approach, based on retrospective analysis of fire effects, suggests creation of a dynamic mosaic of tree clumps and openings (≥0.3 ha [0.7 ac]) of variable sizes, shapes, spatial configurations, and seral stages (Kane et al. 2013). This approach can enhance forest resilience to fire and other disturbances and protect existing stands of mature, multicanopied forest that is preferred spotted owl habitat. However, fuel and restoration treatments designed to increase ecological resilience should strive to balance the short-term impacts of fuel reduction on habitat quality with the long-term benefits of these treatments (Stephens et al. 2010, 2014). Of the number of forest treatments executed within owl foraging areas to reduce fuels, Gallagher (2010) showed foraging spotted owls avoided recently treated Defensible Fuel Profile Zones where the mechanical treatments create stands with widely and regularly spaced trees to reduce fire spread. Gallagher's results were less clear for other fuel treatments (e.g., understory thinning), possibly due to a lack of statistical power to detect a treatment effect. These and other fuel treatments may fragment spotted owl habitat, especially when applied uniformly across the forest landscape or in sensitive habitat areas (e.g., nest sites). Nest stands and owl core areas are especially important because California spotted owls forage close to the nest or roost (Eyes 2014, Gallagher 2010, Irwin et al. 2007). Moreover, Stephens et al. (2014) showed that landscape-level strategy of applying fuels treatments reduced the number of owl territories. Therefore, improving or maintaining forest structure in nest stands and core areas for both survival and reproduction (e.g., unfragmented, high canopy cover with some structural heterogeneity) could greatly benefit California spotted owls. Forest openings and habitat edges created by mechanical treatments or fire may enhance oak (*Quercus* spp.) and pine (*Pinus* spp.) regeneration and growth (Bigelow et al. 2011, York and Battles 2008). These forest openings are also associated with increased densities of woodrats, a large-bodied prey species, and other spotted owl prey species (Innes et al. 2007, Kelt et al. 2014, Roberts et al. 2015), and owl fitness may be positively linked to woodrat abundance (Smith et al. 1999). Clearly, there is a key uncertainty in Sierra Nevada spotted owl biology concerning a balance of connectivity between forest patches with high canopy cover and adjacent forest openings and habitat edges.

Prey Habitat Characteristics

Habitat characteristics of most spotted owl prey remains largely unstudied in the Sierra Nevada, with limited additional information published since Williams et al. (1992). However, several recent studies have contributed to a better understanding of prey habitat characteristics, especially for northern flying squirrels, dusky-footed and big-eared (*N. macrotis*) woodrats, and deer (*Peromyscus maniculatus*) and brush mice (*P. boylii*). These combined species represent the primary prey of California spotted owls in the Sierra Nevada and elsewhere (e.g., southern California) (Williams et al. 1992).

In the mid-elevation forests of the Sierra Nevada, northern flying squirrels are associated with mature forest stands with patches of moderate to high canopy closure (often exceeding 70 percent), large (>75 cm [30 in] d.b.h.) live or dead trees, thick (≥3 cm [1 in]) and extensively distributed litter layers, and sparsely distributed coarse woody debris or understory cover (e.g., shrubs and tall herbaceous plants) (Kelt et al. 2014; Meyer et al. 2005a, 2007; Pyare and Longland 2002; Roberts et al. 2015; Waters and Zabel 1995). Northern flying squirrels may select nesting or foraging sites in proximity to riparian habitat (Meyer et al. 2005a, 2007a, 2007b) or in moist mixed-conifer stands (Meyer et al. 2005a, Wilson et al. 2008). Riparian habitat is also associated with increased truffle (i.e., the fruiting bodies of ectomychorrizal fungi) (Meyer and North 2005) and tree hair lichen (*Bryoria fremontii*) (Rambo 2010) abundance, which compose the primary diet of northern flying squirrels (Meyer et al. 2005b, Smith et al. 2007). Truffle diversity is also positively associated with proximity to riparian areas, which are generally characterized by wetter soils with denser vegetation (Meyer and North 2005). Although flying squirrel foraging habitat may be associated with coarse woody debris cover in many parts of its geographic range (Smith 2007), most studies in the Sierra Nevada find either no association (e.g., Meyer et al. 2007a, Pyare and Longland 2002) or a weak association between flying squirrel occurrence and coarse woody debris abundance (e.g., Kelt et al. 2014). Excessive or widespread woody debris and understory vegetation (e.g., saplings) may hinder movements of this volant species during foraging bouts or predator evasion (Kelt et al. 2014, Roberts et al. 2015), but sparse and spatially variable patches of woody debris (within the natural range of variation) may benefit flying squirrels by providing protective cover or foraging cues for truffles (e.g., Pyare and Longland 2001). Fire that occurs under the natural range of variation for the region will remove rotten down woody material, but much of the large, sound logs will remain after fire, providing sparse, spatially variable patches of woody debris (Knapp et al. 2005).

In lower elevation forests, woodlands, and shrublands of the west-side Sierra Nevada, the dusky-footed woodrat (located in the northern Sierra Nevada), big-eared woodrat (located in the central and southern Sierra Nevada), and brush mouse are positively associated with oak cover or large oak (>33 cm [13 in] d.b.h.) density (Innes et al. 2007, Kelt et al. 2014, Roberts et al. 2008). Oaks (especially, California black oak) provide woodrats and brush mice with valuable food resources, especially acorns (Carraway and Verts 1991, Innes et al. 2007). Brush mice also tend to favor sites with greater herbaceous plant or shrub cover (Kelt et al. 2014, Laudenslayer and Fargo 2002) and may also be associated with riparian areas or dense clumps of tanoak (*Lithocarpus densiflorus*) (Amacher et al. 2008). Dusky-footed woodrats and brush mice exhibit moderate avoidance of areas with greater canopy cover, tree basal area, and large snag densities, especially at broader spatial scales; although woodrats may favor these habitat features at finer scales (Kelt et al. 2014) as well as logs and steep slopes (Innes et al. 2007). These scale-dependent habitat features emphasize the importance of promoting broad-scale structural heterogeneity and habitat complexity for small-mammal communities (Kelt et al. 2014, Roberts et al. 2008).

The deer mouse occupies a diverse array of habitats in lower and upper montane forest, woodland, and shrubland habitats of the Sierra Nevada (Verner and Boss 1980). This habitat generalist species is also one of the most numerous and widespread of all small mammals in North America with highly variable habitat associations across the Sierra Nevada (e.g., Amacher et al. 2008; Coppeto et al.

2006; Kelt et al. 2014; Monroe and Converse 2006; Roberts et al. 2008, 2015). Studies of the short-term effects of mechanical thinning or fire on deer mice are also varied in the Sierra Nevada, with posttreatment responses ranging from positive to negative to inconsequential. However, most studies agree that the effects of mechanical and prescribed fire treatments on deer mouse populations are either negligible or short lived, both in the Sierra Nevada (Stephens et al. 2014) and across the larger United States (Converse et al. 2006).

A few recent studies provide insights in the habitat use patterns of flying squirrels and deer mice in burned landscapes of the Sierra Nevada. Roberts et al. (2015) found unburned refugia (i.e., unburned patches within fire perimeters) were positively associated with northern flying squirrels in mid-elevation forests of Yosemite National Park. Unburned patches and low- to moderate-severity fire may also promote truffle diversity across these forest landscapes in Yosemite (Meyer et al. 2008). In contrast, greater fire severity (and mechanical thinning intensity) eliminates suitable habitat for flying squirrels by removing tree canopy cover, overall biomass, and litter depth below thresholds generally suitable for this species (e.g., ≤55 percent canopy cover) (Lehmkuhl et al. 2006, Meyer et al. 2007a, Roberts et al. 2015). In contrast to flying squirrels, deer mice occupy a variety of burned and unburned habitats in lower and upper montane habitats of the Sierra Nevada, but respond negatively to increased fire severity in mid-elevation forests of Yosemite (Roberts et al. 2008, 2015). Information pertaining to fire effects on woodrats is currently lacking in the Sierra Nevada, although Lee and Tietje (2005) found virtually no effect of prescribed fire on dusky-footed woodrat demography in the Central Coast Range of California.

Home Range Characteristics

A home range is defined as the area used by an individual to meet its requirements for survival and reproduction (to distinguish from “territory” see chapter 2) and understanding home range requirements is essential for the conservation of a species. Theoretically, smaller home ranges should be of greater habitat quality because individuals expend less energy to satisfy their needs (McNab 1963). For higher level trophic predators such as spotted owls, large home ranges are typical for a variety of reasons (see chapter 2 for details).

California spotted owls establish and defend large, year-round home ranges that contain higher habitat diversity than their northern subspecies (Forsman et al. 1984, Gutiérrez et al. 1992, Moen and Gutiérrez 1997, Verner et al. 1992b). Home range size estimates vary among studies (634 to 2195 ha [1,567 to 5,423 ac]), study area (latitude), and individual owls (table 3-1). Generally, California spotted owl home ranges are largest in the northern Sierra Nevada and smallest in the southern Sierra Nevada. In the southern Sierra Nevada, specifically Sierra National Forest, where oaks are the dominant tree, owl home ranges are significantly smaller (Zabel et al. 1992). Home range size is similar between years, sexes (Eyes 2014, Gallagher 2010, Williams et al. 2011, Zabel et al. 1992), and seasons, but there are often seasonal shifts in territorial delineations among neighboring pairs (Zabel et al. 1992). Owl home ranges frequently include heterogeneity and habitat edges; however, increases in heterogeneity lead to increases in home range size, suggesting a negative correlation of too much heterogeneity on habitat quality (Eyes 2014, Williams et al. 2011).

Consistently across studies and study areas, owl home ranges contain a greater abundance of large trees and greater proportion of mature forest than is randomly available across the landscape (Call et al. 1992, Moen and Gutiérrez 1997, Williams et al. 2011). Owls will forage in patches of smaller sized trees ("pole-sized" 15 to 28 cm [6 to 11 in] d.b.h.), but the presence of residual, large (super-canopy) trees greatly influenced owl use (Bias and Gutiérrez 1992, Moen and Gutiérrez 1997, Williams et al. 2011). Although there is substantial variation among individual owls, Williams et al. (2011) found that the average home range in their study was comprised of patches of low canopy cover (11.8 percent), hardwood forest (3.5 percent), pole-size conifer forest with ≥40 percent canopy cover (6.3 percent), medium-sized (28.1 to 61 cm [11.1 to 24 in] d.b.h.) conifer forest with >70 percent canopy cover (47.1 percent), mature (>61 cm d.b.h.) forest with >70 percent canopy cover (10.7 percent) and mature forest with 40 to 70 percent canopy cover (1.6 percent). However, their study reflects an area with limited availability of patches of mature forest >30 ha (74 ac) owing to timber harvesting, and this forest type may have been underrepresented in terms of owl selection (Williams et al. 2011). Further, when investigating the habitat type composition of owl home ranges in heavily managed forests, the results are confounded by what habitat types are available to the owl and do not truly reflect spotted owl preferences.

Delineating the proportions and configuration of habitat patches in owl home ranges is nearly impossible using ground-based data because of the large-scale, landscape-level habitat metrics necessary for the analyses. Therefore, researchers typically use remotely sensed data, most commonly derived from satellites (see chapter 6 for details on remote sensing). However, vegetation maps available at this scale are often inaccurate, especially for residual trees (Moen and Gutiérrez 1997, Williams et al. 2011). Further research is needed to determine the size, composition, and configuration of habitat patches contained in an owl's average home range. The use of light detection and range (LiDAR) technology can greatly assist this research (see chapter 6). For example, important forest characteristics such as canopy cover and tree heights (fig. 3-1) can be quantified within spotted owl home ranges (e.g., fig. 3-2).

Effects of Fire on Spotted Owl Habitat

Fire is a dynamic ecological process in Sierra Nevada forests that varies greatly over space and time (Sugihara et al. 2006, van Wagtendonk and Lutz 2007). The effects of fire on spotted owl habitat are complex because fire burns heterogeneously across the landscape, resulting in a mosaic of variable fire severities (please refer to chapter 5 for more details on the regime and natural range of variation for fire frequency and severity for the Sierra Nevada). In low-fire-severity patches, fire consumed the surface fuels (e.g., low vegetation, coarse woody debris, and litter) and many shrubs and some small trees, but in these patches, nearly all canopy trees survived (Key and Benson 2005). In moderate-severity patches, fire consumed most of the surface fuels and small trees, as well as removed up to 75 percent of the canopy trees. In high-severity patches, all of the surface fuels were consumed by fire as well as nearly all mature plants, including >75 percent of canopy trees as determined from ground-based measurements (Composite Burn Index) (Key and Benson 2005) or >95-percent reduction in tree basal area or canopy cover as determined from remotely sensed data (Relative Differenced Normalized Burn Ratio) (Miller et al. 2009). In Yosemite National Park (central Sierra Nevada), where forests have a very minimal history of mechanical treatments, managers have allowed fires (prescribed and wild) to burn since the 1970s. Under the natural fire regime for mixed-conifer forests in Yosemite, with fires burning every 2 to 14 years that resulted in a mosaic of low to moderate fire severities, fire had no effect on spotted owl occupancy (Roberts et al. 2011). Further, although their study did not differentiate the fire-severity proportions within their burned areas, Bond et al. (2002) found that fire did not negatively affect spotted owl pair bonds, site fidelity, or reproductive success. High-severity patches, however, affected colonization on two territories in another area in the central Sierra Nevada, but did not affect territory extinction (Tempel et al. 2014), although it is unknown how their results may or may not be confounded by postfire salvage logging of their study area. Fires that result in large patches of high-severity fire significantly reduce owl colonization, occupancy, and use of these forest types (Eyes 2014, Roberts et al. 2011, Tempel et al. 2014). In southern California, Lee et al. (2013) found that owl extinction probability increased as high-fire-severity patches exceeded 50 ha (123.5 ac). In Yosemite National Park, the largest high-severity patch size foraging owls used more than once was 36.0 ha (89.0 ac), and the mean high-severity patch size used by foraging owls was 6.5 ha (16.1 ac) (SE = 10.5 ha [25.9 ac]) (Eyes 2104). Ideally, fire-resilient landscapes that contain contiguous patches of closed-canopy mature forest embedded with smaller forest openings and variable forest structure and composition (e.g., presence of large oaks) may sustain long-term foraging opportunities for spotted owls. A landscape with this forest structure would be largely consistent with the currently understood forest structure under a natural fire regime for this region (van Wagtendonk and Lutz 2007). Indeed, fires that burn within the natural range of variation for the Sierra Nevada, such as frequent low to moderate fires, tend to maintain habitat characteristics (e.g., retention of large trees and higher canopy closure) essential for spotted owl occupancy (Roberts et al. 2011).

Restoring and maintaining forest resilience to fire is currently a major concern for forest managers, especially when considering the needs of sensitive species such as the California spotted owl. The closed-canopy forests that are important to spotted owl occupancy and nesting, tend to have spatially contiguous high fuel volumes that increase the vulnerability of these forests to uncharacteristically large and severe fires (Agee and Skinner 2005, Agee et al. 2000, Weatherspoon et al. 1992). The impacts of climate change, longer fire seasons, and extended droughts, compounded by a century of fire suppression, have led to larger and more severe fires across the range of the California spotted owl, most notably in mixed-conifer forests (Mallek et al. 2013, Miller and Safford 2012). These trends are critical, because while California and northern spotted owls will forage throughout burned forests, they tend to avoid large high-severity patches (Clark 2007, Eyes 2014). Additionally, the abundances of many owl prey species (e.g., northern flying squirrel, deer mouse) are negatively correlated with fire severity (Roberts et al. 2008, 2015). In contrast, Bond et al. (2009) reported that owls frequently used high-severity patches for foraging, but based their conclusion on a limited owl sample size and a single year (4 years after the fire) of postfire data, which may fail to account for potential time-lag responses of a territorial species with high site fidelity. Since the completion of their brief study, anecdotal observations indicate that at least one of their four study owls abandoned their territory within the burn, switched mates, and shifted their habitat use away from high-severity patches.[2] However, while owls may be avoiding the interior of these high-severity patches, they will forage in the high-contrast edges created by high-severity fire (Eyes 2014), further suggesting that habitat heterogeneity may be important to owls. The

[2] **Galloway, R. 2015.** Personal communication. Wildlife biologist, Sequoia National Forest, 1839 S Newcomb St., Porterville, CA 93257.

balance between enough habitat heterogeneity for successful owl foraging and too much heterogeneity leading to owl habitat fragmentation remains elusive. Importantly, there may need to be an essential connection between the juxtaposition of those edges to forest with dense canopy for spotted owls to avoid depredation. The only two cases of observed spotted owl depredation in Yosemite National Park occurred along high-contrast edges created by recent (<5 years) high-severity fire (Roberts pers. obs.).

New Findings Relative to Management Guidelines

The current standards and guidelines used by the U.S. Forest Service (USFS) to manage California spotted owl (USDA FS 2004) are founded on the core area concept, as described in the California spotted owl report (Verner et al. 1992b). Based on the recommendations of Verner et al. (1992b), the Sierra Nevada Forest Plan Amendment (i.e., Sierra Framework; USDA FS 2004) formally established the 121-ha (300-ac) protected activity centers (PACs) that USFS biologists delineate around a spotted owl activity center, such as a nest (fig. 3-2). These PACs were designed to include either the observed or the suspected nest stands and the best available habitat in a contiguous and compact arrangement. These designated areas are managed to contain:

- ≥ two layers of tree canopy
- ≥ 60 percent canopy cover
- An average d.b.h. ≥61 cm (24 in) for the dominant and codominant trees
- Some snags ≥114 cm (45 in) d.b.h.
- Higher than average volume of snags and down woody debris

Biologists designate a home range core area (HRCA) around each PAC, and the sizes of HRCAs are based on the average breeding pair home range of spotted owls (USDA FS 2004). Because spotted owl home range sizes increase with latitude, managers vary sizes of HRCAs as follows: 243 ha (600 ac) on the Sequoia and Sierra National Forests; 405 ha (1,000 ac) on the Modoc, Inyo, Humboldt-Toiyabe, Plumas, Tahoe, Eldorado, and Stanislaus National Forests, and the southern district of the Lassen National Forest; and 971 ha (2,400 ac) on the northern two districts of the Lassen National Forest. Managers attempt to maintain or develop desired conditions within HCRAs using five criteria:

- ≥ two layers of tree canopy
- ≥50 percent canopy cover
- ≥61 cm (24 in) d.b.h. for the dominant and codominant trees
- A “number” of live trees >114 cm (45 in) d.b.h.
- Higher than average volume of snags and down woody debris

These are the areas USFS managers must consider, as defined by the existing forest plan standards and guidelines, when developing forest treatment prescriptions, especially for mechanical treatments. Unless exempted for specific reasons, the USFS generally avoids mechanical treatments inside PACs, but prescribed fire can be used inside a PAC, and any management activity (though typically limited) can occur in HRCAs.

Research investigating the efficacy of USFS spotted owl PACs in protecting essential habitat around owl activity centers (i.e., nests or roosts) is limited. Berigan et al. (2012) found that PACs, as estimated and updated by USFS staff following the directives established in the Sierra Framework (USFS 2004), protected essential high-use habitat for California spotted owls. They showed that the mean PAC area (116.3 ± 3.4 ha [287.5 ± 8.4 ac]) for 29 owls was similar to the mean size of their estimated core areas actually used by those same 29 owls (135.4 ± 31.9 ha [334.7 ± 78.8 ac]) over 24 years of observations. They also found 70 percent spatial overlap between delineated PACs and observed use areas using 90 percent of the locations for each individual of a pair.

Research has yet to provide an estimate of the threshold value for the amount of mature or late-successional conifer forests that is required to support a pair of spotted owls. However, habitat alteration (e.g., mechanical tree removal) involving ≥20 ha (49 ac) of a 121-ha PAC was negatively correlated with site colonization and occupancy (Seamans and Gutiérrez 2007). Seamans and Gutiérrez (2007) also suggested that this human-caused habitat alteration was correlated with either decreased owl survival or increased emigration from their study population. These researchers did not use radiotelemetry to follow their study owls, thereby making it difficult to know the fate (i.e., survival) of an owl that abandoned its territory. Regardless of their true fate, it is concerning when owls disappear from their long-established territories after mechanical treatments of ≥20 ha (49 ac) occurred within their PAC.

Chapter Summary

- Fuel and forest restoration treatments, including the use of fire, could attempt to balance the short-term impacts of these treatments on habitat quality with the long-term benefits to the ecosystem.
- Although one study showed that the current size for spotted owl PACs (121 ha [300 ac]) may be adequate to protect current core use areas, there is insufficient evidence (i.e., large-scale experimental research) to ascertain whether PACs provide long-term spotted owl persistence on national forest lands.

- All of the research strongly indicates that large, old trees are important aspects of spotted owl habitat, providing complex vertical structure and canopy layering as well as potential nesting cavities. Although the presence of large trees alone is insufficient for the persistence of spotted owls, restoration treatments that prioritize the retention of large and old trees, even in marginal habitat, can form the foundation for future high-quality habitat where the site potential is adequate.
- Conservation efforts would be enhanced by prioritizing areas on the landscape that may enable the protection of spotted owl habitat from stand-replacing fire. This could include the strategic identification of areas targeted for (1) fuel treatments to reduce wildfire risk to occupied forest landscapes and (2) protection objectives during incident management to minimize the impacts of wildfire and fire management operations to critical habitat. To begin this landscape prioritization, there is a need for accurate, landscape-level vegetation maps and a better understanding of the importance of vegetation types (and their patch sizes) to spotted owl occupancy, reproduction, and long-term population persistence and viability. Using accurate vegetation maps to identify important habitat needs to be coupled with our understanding of fire behavior across the landscape. It may be important to incorporate in our forest restoration planning how topography will affect fire behavior and how fire and topography will interact with the vegetation to influence the fire effects in an area. There are tools available (e.g., ArcFuels; http://www.arcfuels.org/) that could act as a place to start for managers to assess wildfire risk and aid in fuels management planning.
- Forest restoration treatments may increase the abundance of spotted owl prey by promoting late-seral forest conditions, vegetation heterogeneity, and shrub and oak patches. In addition, managing fires for a mosaic of burn severities (dominated by low- and moderate-severity patches), including contiguous patches of unburned refugia, promotes suitable habitat for diverse small-mammal assemblages including northern flying squirrels, deer mice, and woodrats.
- Wildland fires (prescribed fire and wildfire) that burn primarily at low to moderate severity (including unburned patches) likely maintain spotted owl occupancy while increasing resilience of the forest landscape in the long term. Although high-severity (i.e., stand-replacing) fires may also benefit spotted owls in smaller patches and proportions more consistent with the natural range of variation, large high-severity-burn patches may significantly

curtail habitat use and occupancy and long-term persistence of suitable nesting and roosting habitat. There is insufficient information available to allow a determination of the potential threshold responses of spotted owls to high-severity fire.

- Managers focusing forest treatments on enhancing spotted owl habitat may wish to juxtapose nesting or roosting habitat structures in some stands (or larger habitat patches) and foraging habitat in others, keeping in mind that it is important to maintain a balance to minimize habitat fragmentation. Consider using the biophysical environment (e.g., topography, soils, and climate water deficit) as well as fire behavior and crew safety to guide the treatment placement and prescriptions.
- For stands where the enhancement of nesting or roosting habitat is the objective, the research reviewed above suggests increasing or maintaining the abundance of large live trees and snags and canopy cover with complex layering. In stands where the promotion of foraging habitat is the objective, the research reviewed above suggests facilitating shrub or hardwood patches, large oaks, and small canopy gaps that provide sufficient edge habitat and foraging opportunities. Forest landscapes that contain a greater proportion of mature forest with old and large trees will provide more suitable habitat for spotted owls.

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