Chapter X. Summary of Key Findings in the California Spotted Owl Conservation Assessment

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CA Spotted Owl Ecological Areas of Significance

Core nesting/roosting (activity center). California spotted owl core areas in the Sierra Nevada have been delineated as 121-ha (300 ac) Protected Activity Centers (PACs), which were created to encompass habitat likely essential for nesting and roosting, but not for foraging or territorial defense (Verner et al. 1992b). PACs were designated by contiguous association of preferred habitats at and around nest and roost sites (Verner et al. 1992b), and generally accommodate spotted owl nesting and roosting activities over the long term (25 years; Berigan et al. 2012).

Territory/Core Area. A territory represents the area within a home range that is defended by the resident pair of owls from conspecifics. An owl pair's territory is smaller than the collective home range, as not all areas within home ranges are defended against other owls. To date, the precise size and location of spotted owl territories has not been estimated. The term "territory scale" has been adopted for management purposes (e.g., 1000 acre management circles in the California Spotted Owl Interim Guidelines), although it is perhaps more appropriate to refer to this as the core area scale given uncertainties in territory size. Core Areas are geographic areas in which a pair of territorial owls concentrates its nesting, roosting, and foraging activities. Core areas size in the Sierra Nevada likely varies geographically and by ecotype (as is the case with home range size; *see below*), but geographic variation in core area size has not yet been characterized. Based on radio-marked owls, Bingham and Noon (1997) suggested that core area size for California spotted owls was ~813 ha (2000 ac) in the northern Sierra Nevada. However, Blakesley et al. (2005) noted that core areas of this size overlap considerably among adjacent owl sites and therefore considered circular analysis areas of 203 ha (~ 520 ac), a size that was based on half the "minimum-nearest-neighbor distance" between adjacent owl sites. Because core area size has not been described on other regions within the Sierra Nevada, circular analysis areas have also been delineated using a radius equal to half "mean-nearest-neighbor distance" between the centers of adjacent owl sites (1.1 km) in several habitat-demography analyses in the

central Sierra Nevada (Seamans et al. 2007, Tempel et al. 2014a, Jones et al., In Review), yielding circles 400 ha (1000 ac) in size.

Home range. A home range is defined as the area used by an individual to meet its life-history requirements and typically includes all nesting, roosting, foraging, and territorial activities within a period of interest (e.g., breeding season). Home range size estimates vary among studies (634 – 2,195 ha; 1500 – 5400 ac), study area (latitude), and individuals. Generally, California spotted owl home ranges are the largest in the northern Sierra Nevada and smallest in the southern Sierra Nevada, particularly where oaks (*Quercus* spp.) are the dominant tree type (Zabel et al. 1992).

CA Spotted Owl Ecology

Habitat Selection

California spotted owls nest in the oldest and largest live and dead trees, especially those having structural defects like cavities, broken tops, and platforms ((Verner et al. 1992a, Gutiérrez et al. 1992 North et al. 2000), and those that are removed from high-contrast edges (Phillips et al. 2010). Selected nest stands are characterized by high canopy closure and cover (≥75 % for both), an abundance of large (>61 cm dbh; 24 in) trees, higher than average basal area, an abundance of coarse woody debris, and multiple canopy layers comprised of trees of different sizes, but numerically dominated by medium-sized trees (30 to 61 cm) (Bias and Gutiérrez 1992, Blakesley et al. 2005, Moen and Gutiérrez 1997, North et al. 2000).

California spotted owls seem to prefer mature forests with high canopy (≥40%) for foraging (Williams et al. 2011), but also tend to select edge habitat for foraging, perhaps using the complex structure within mature patches to access abundant prey in early seral stage patches (Williams et al. 2011, Eyes 2014). Thus, owls may benefit from the juxtaposition of mature forests with a mosaic of vegetation types and seral stage, which may promote higher prey diversity and abundance by increasing habitat diversity within foraging areas (Zabel et al. 1995, Ward et al. 1998, Franklin et al. 2000, Williams 2001, Tempel et al. 2014a).

Dietary Habits

In the Sierra Nevada, dusky-footed woodrats (*Neotoma* spp.) and flying squirrels (*Glaucomys sabrinus*) comprise the majority of the diet of California spotted owl by biomass, although a

wide array of other small mammals, as well as a smaller amount of birds, lizards, and insects are also consumed (Gutiérrez et al. 1995, Munton et al. 1997). In the southern Sierra Nevada, woodrats tend to dominate (74% by biomass) spotted owl diets within oak woodlands and riparian-deciduous forests (i.e., low elevation), and mid elevation habitats (Laymon 1988, Thrailkill and Bias 1989), whereas northern flying squirrels (*Glaucomys sabrinus*) became more important in conifer forests at higher elevations during the breeding season and comprise 46% of owls diets (Munton et al. 2002). Pocket gophers comprise the second most important food by biomass at both low and higher elevations (Munton et al. 2002). Flying squirrels often occur in closed-canopy forests, whereas woodrats often occur in more open habitats and early seral-stage forests. Thus, at high elevations, mature forests may be the most critical for the California spotted owl prey base, whereas heterogenous forest conditions is more likely to enhance prey habitat at lower elevations (see also Jones et al. *In Review*).

Population Trends

California spotted owl populations appear to have declined over the past *ca*. 20 years on the three demographic study areas occurring primarily on national forest lands in the Sierra Nevada. Estimates of the total percentage declines in abundance range from 11% on the Sierra to 22% on the Plumas-Lassen to 50% on the Eldorado (Tempel et al. 2014b, Connor et al. 2014). Results from the demography studies suggest that California spotted owl populations are declining on many landscapes in the Sierra Nevada. The cause of observed declines has not been established conclusively. All three declining populations are located on national forests, with the only stationary population occurring within Sequoia-Kings Canyon National Park. As such, differences in population trends among study areas may be related to differences in forest management between national forest and national parks (Blakesley et al. 2005, Seamans and Gutierrez 2007, Tempel et al. 2014a). Additionally, several ecological factors differ between landownerships, including the presence of giant sequoia groves on SKC and the prevalence of oak woodlands that could also be contributing to differences in population trends (Blakesley et al. 2010). The declining populations have likely not been exposed to significant impacts by barred owls (*Strix varia*) or high severity fire (Tempel et al. 2014b).

Threats

Forest Management. The effects of specific forest management activities on owls is not well understood (USFWS 2011). Moreover, the specific vegetation conditions (e.g., density of large trees, canopy cover levels) and the area of suitable habitat required to maintain viable populations remain a source of uncertainty. However, all three correlative studies addressing the effects of post-CASPO habitat change on the demography of California spotted owls have detected negative impacts (Seamans and Gutiérrez 2007, Tempel et al. 2014a, Stephens et al. 2014). Seamans and Gutiérrez (2007) found that California spotted owl territories in which > 20 ha of mature forest was altered experienced a 2.5% decline in territory occupancy probability. Stephens et al. (2014) showed that the number of occupied owl territories declined from 7-9 before and during implementation of landscape-scale treatments (2002-2007) to four 3-4 years after treatments were completed.

Timber harvesting on private lands, generally using even-aged silvicultural approaches that likely reduce spotted owl habitat quality, remains high and constituted approximately 83% of the timber harvested from the Sierra Nevada from 1994-2013. A recent study suggests that California spotted owls may occur on private timberlands at greater density than expected (Roberts et al. 2015), but additional work is required to determine the quality of habitats on private lands and their contribution the viability of the regional spotted owl population. Spotted owls have also been observed avoiding private lands, presumably because of a dearth of key habitats (Bias et al. 1989).

Wildfire. Prior to Euro-American settlement, fires in the Sierra Nevada occurred frequently (5-15 year), generally burned at low- to moderate-severity (North et al., *In Review*), and maintained low-density stands across much of the landscape, composed of primarily large, fire-resistant trees (Taylor 2004, Scholl and Taylor 2010, Collins et al. 2011). A century of fire suppression, however, as led to an ingrowth of shade-tolerant trees and an accumulation of surface fuels that have increased the frequency and burn patch size of high-severity fires in the Sierra Nevada (Miller et al. 2009, Mallek et al. 2013, Steel et al. 2015). High-severity fires now pose a significant threat to California spotted owls and their habitat, a threat that is expected to increase under most climate change scenarios (*see below*). While recent studies indicate that California spotted owls continue to occupy sites that experience low, moderate, and mixed-severity wildfire

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(Roberts et al. 2011; Lee et al. 2012, 2013), there is likely an upper threshold to the amount of high-severity fire that owls can tolerate within their territory (Lee et al. 2012; but see Lee and Bond 2015). One particularly salient management concern involves the susceptibility of spotted owl to high-severity fire given it is typically characterized by forest conditions that are prone to severe fire (e.g., high levels of woody debris, stem density, canopy cover). Indeed, approximately 88,000 acres of owl PACs, representing about 15% of the total PACs acres, burned from 1993 to 2013 (Keane, *In Review*). However, approximately 28% of burned PAC area experienced high-severity, which was similar to the overall landscape (26%) during this period (Keane, *In Review*).

Climate Change. Projected changes in climate constitute an emerging threat to California spotted owls and their forest habitat, and may have significant impacts to owl populations in the Sierra Nevada over the coming decades. General climate change model projections for the Sierra Nevada indicate that temperatures will increase by 3-6 ^{o}C during the 21st century and, while projections of changes to precipitation patterns are less certain, decreased winter snowpack and increased ecosystem moisture stress are expected (Cayan et al 2013). Increases in temperature and changes in precipitation patterns associated with climate change may impact spotted owls via (i) direct, physiological effects on individuals; (ii) alterations to prey communities, interactions with predators and competitors, and disease dynamics; and (iii) changes in habitat quantity, quality and distribution. In some parts of the spotted owl's range, drought and high temperatures during the previous summer have been linked to lower survival and recruitment of spotted owls (Franklin et al. 2000, Glenn et al. 2011, Jones et al. *In review*), and decreases in precipitation (and associated moisture stress) may reduce plant production, seeds and fungi that are important food for small mammal prey (Seamans et al. 2002; Olson et al. 2004; Glenn et al. 2010; 2011). Impacts to owl populations, however, are likely to be complex as warm, dry springs tend to increase reproductive success and spotted owls exhibit population-specific demographic responses to regional climate and weather patterns (Glenn et al. 2010, Glenn et al. 2011, Peery et al. 2012, Jones et al *In Review*).

Climate change projections of future vegetation distribution in the Sierra Nevada suggest that much of the low and mid-elevation forests that currently comprise owl habitat are vulnerable to conversion to woodlands, shrublands, and grasslands. Moreover, projected increases in

temperature and decreases in snow pack for the Sierra Nevada (Safford et al. 2012) are likely to continue the increasing trend in the size of stand-replacing fires and proportion of landscape impacted by stand-replacing fire (Stephens et al. 2013). These threats may be somewhat mitigated by the upslope advancement of mixed-conifer forests and the development of habitat for owls where none now exists (Peery et al. 2012). However, to the extent that it occurs, development of suitable forest structure at higher elevations will likely take many decades and may not keep pace with the loss of habitat at lower elevations due to the aforementioned processes.

Barred Owls. Barred owls have invaded western North America over the past century (Livezy 2009) and threaten northern spotted owls in many parts of this subspecies' range (USFWS 2011, Wiens et al. 2014). While they presently occur in relatively low densities in the Sierra Nevada, they are expanding their range (Dark et al. 1998, Keane 2014), may soon colonize large parts of the Sierra Nevada and become a primary threat of the California spotted owl (Gutierrez et al. 2007, USFWS 2011, Wiens et al. 2014). Barred owl are competitively dominant to spotted owls, and interspecific interactions lead to negative impacts on spotted owl population (Dugger et al. 2011; Yackulic et al. 2012, 2014; Wiens et al. 2014). Northern spotted owls have greater territory extinction probabilities, lower colonization probabilities (Olson et al. 2005, Dugger et al. 2011, Yackulic et al. 2014), lower nest success (Wiens et al. 2014), and lower probability of habitat use (Van Lanan et al. 2011) when barred owls are present. Similar studies have not been conducted or California spotted owls but little reason exists to suspect interspecific interactions will be different in the Sierra Nevada. Barred owl removal experiments indicate that spotted owls re-occupy sites within one year but that barred owls again displace spotted owls at some sites withinin 1-4 years after initial removal.

Disturbance. Disturbance resulting from human recreation and management activities (e.g., noise from chainsaws or motorized vehicles) has the potential to impact California spotted owls, although considerable uncertainty remains in how much and what types of disturbance are detrimental. One study found that nesting Mexican spotted owls exhibited behavioral responses when exposed to helicopter and chainsaw noise, although no differences in reproductive success were detected (Delaney et al. 1999). Mexican spotted owls exhibited little behavioral response to

hikers within ≥55 m distance, and juveniles and adults were unlikely to flush from hikers at distances >12 or >24 m, respectively (Swarthout and Steidl 2001), although cumulative effects of high levels of recreational hiking near nests may be detrimental (Swarthout and Steidl 2003). Wasser et al. (1997) reported higher stress levels (as indicated by fecal corticosterone) in male northern spotted owls within 0.41 km of roads in Washington, suggesting higher stress levels were correlated with proximity to roads, although Tempel and Gutierrez (2004) did not detect elevated stress hormones in California spotted owls exposed to disturbance from chainsaws and roads. Hayward et al. (2011) also did not detect an association between hormone levels and distance to road, but did find that owls had higher corticosterone levels and lower reproductive success when exposed to continuous traffic exposure and that response varied age and body condition. Thus, while owls likely tolerate various levels and types of disturbance, some disturbance may affect behavior and reproduction.