March 16, 2018

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Sent via email to: scsawyer@fs.fed.us

Re: February 2018 Draft Conservation Strategy for the California Spotted Owl

Dear Sarah:

We appreciate the opportunity to comment on the Draft Conservation Strategy for the California Spotted Owl (Draft Strategy). In addition to defining and offering solutions to our higher-level concerns in this comment letter, we are providing a Word file of the Draft Strategy that includes comment balloons filled with questions, comments, and suggestions to consider while revising the Draft Strategy.

We do not believe that the Draft Strategy will provide for the conservation of spotted owls in the Sierra Nevada. The Draft Strategy does not clearly identify the habitat conditions necessary to support successfully breeding spotted owls and does not identify the measures necessary to protect and maintain this habitat. Instead, the Draft Strategy allows more aggressive logging of large trees compared to direction today. The Draft Strategy also relies on a risk assessment and other evaluations of habitat conditions that have not been completed. Lastly, the Draft Strategy relies on adaptive management without defining a program for tackling the most challenging aspect of the application – detecting declines in owl response may take decades, yet logging and other threats that need to be ameliorated occur each year.

We have identified several conservation measures that could provide a reasonable conservation foundation on which to build a strategy if they were modified and prioritized over other conservation measures. Presently, the Draft Strategy is unclear when the implementation of more protective conservation measures takes precedence over the implementation of management activities that could negatively impact spotted owls. We also found it contrary to conservation that the Draft Strategy provides little to no assurances that adequate amounts of higher quality habitat will be protected at the PAC or territory scales or that moderate quality habitat will be managed to develop into higher quality habitat. Also contrary to conservation is the provision that PACs can be removed from the system with three years of negative survey results, despite a 20% probability of recolonization four years after abandonment. Compounding our concerns is that implementation of the conservation measures appears to be at the discretion of the land managers who are under significant pressure to deliver increasing timber volume targets under a decreasing budget and workforce.

The Draft Strategy also relies heavily on unavailable science information; information that is "unpublished," "in review," "underway," "personal communication," and/or otherwise not available to us. This is of particular concern because we have identified numerous instances where we believe the Draft Strategy misrepresents or misinterprets the results of research (see Word file comment balloons). We also found the organization of the Conservation Measures to be difficult to navigate. Practically speaking, we were not always able to clearly identify each of the specific conservation measures, determine where such measures would apply, or when they would take precedence over a potentially conflicting measure. The Draft Strategy also does not adequately address recommendations on salvage logging in post-disturbance landscapes contained in the Conservation Objectives Report prepared by the U.S. Fish and Wildlife Service (Service). Finally, the monitoring and adaptive management element of the strategy must clearly address the short term risks and threats from logging and the inability for occupancy and other monitoring to detect negative impacts to the population in the short term.

Based on our review of the Draft Strategy, the following is a list of the specific areas where we recommend changes to the draft strategy:

- Direction to conduct protocol surveys prior to implementing vegetation management projects that will modify habitat;
- Guidance that allows for a PAC to be retired from the system after 5 years of surveys to better support owl colonization;
- Guidance that prioritizes prescribed burning and hand treatments over mechanical treatments in PACs, and limits mechanical treatment to address surface and ladder fuels;
- Direction that promotes the use of prescribed or managed fire in PACs and territories to improve resilience;
- Establishment of desired conditions in territories that reflects conditions that support owl pairs and population stability or expansion (i.e., managing to provide >60% of a territory in the highest quality habitat (North et al. 2017));
- Direction that logging and mechanical treatments does not reduce habitat quality in PACs or habitat relied on to meet desired conditions for nesting and roosting at the territory scale;
- Protection of large trees and recruitment of future large trees by significantly limiting the number of trees removed between 24" and 30" dbh and establishing a 30" diameter limit overall;
- Guidance that removal of dead or dying trees should not occur within occupied spotted owl territories, except to address hazard trees and provide for firefighter safety in strategic locations to facilitate landscape fire use for ecological restoration; and
- A well designed adaptive management and monitoring plan that includes continued monitoring of the four demographic study areas and addressing the limits to detecting impacts to the population in the short-term.

We describe each of these concerns in greater detail below. The line-by-line comments on the Draft Strategy we provide in the attached Word file identify additional areas that need to be revised or improved for a conservation strategy to adequately protect spotted owl.

I. Conservation Measures that Should Have the Highest Priority

The Draft Strategy includes several conservation measures that, with some necessary modifications and if given definitive priority over potentially competing management direction, would provide a stronger foundation on which to build a conservation strategy.

A. Protection and Conservation of Protected Activity Centers (PACs)

First, we agree with the Draft Strategy and the Service's Conservation Objectives Report that ecologically beneficial fire effects (and accompanying hand treatments) should be the primary tool for achieving restoration goals in PACs. We also believe that a reliance on low and mixed severity fire at the territory scale would be beneficial to the long-term conservation of the species. Mixed-severity wildfire, consistent with how fires would have burned prior to suppression policy, is a viable and effective restoration tool (Meyer 2015). However, the Draft Strategy does not provide conservation measures that assure that fire will be the primary management tool used to reduce surface fuels and small diameter ladder fuels in PACs or territories.

Under the current management paradigm, hand treatments and prescribed fire are allowed in PACs. However, it is our experience that these tools are rarely employed to reduce surface and ladder fuels in PACs, except where PAC-acres occur adjacent to human infrastructure at risk of wildfire. The Draft Strategy should establish an expectation that surface and ladder fuels should be reduced in PACs where they contribute to a significant high fire risk to the PAC.

Contrary to the direction that fire should be the primary tool used to increase resilience in PACs, the Draft Strategy allows for the mechanical removal of trees up to 24 inches dbh in PACs. Not only is it unclear how removing trees much larger than 12 inches from PACs would benefit the species,[1] this would be a significant increase in mechanical treatment intensity within PACs compared to what is currently allowed. Since managers are reluctant to implement hand treatments and prescribed burning in PACs for various reasons, including the high cost of such treatments, the allowance to remove significant numbers of large commercially valuable trees is likely to drastically increase the use of mechanical treatment in PACs over the current management trends. This would cause high levels of impact to a highly sensitive habitat use area and result in the opposite effect from what is intended.

The Draft Strategy does contemplate developing a PAC prioritization scheme to inform the use of mechanical treatment in PACs, but the prioritization scheme sets no limits on the number of PACs that could be treated and all PACs could be prioritized for removal of trees up to 24" dbh. Although the Draft Strategy does limit the scale of treatment within PACs to 100 acres, a limit on the pace of treating PAC-acres is not provided. In other words, there is nothing to prevent

[1] See for example North et al. (2009) regarding reducing fire risk.

treating 100 acres per year over three years in the same PAC, or for undertaking such treatments on all PACs within a 10,000-acre project area.

The Draft Strategy should provide mechanisms to ensure that ecologically beneficial fire and hand treatments will be the primary tools for achieving restoration goals in PACs. This could be achieved through specific conservation measures and/or by spatially identifying the PACs that would be subject to mechanical treatment. Regardless, conservation measures should be created to ensure that the use of mechanical treatments in PACs will be a last resort and not allow the habitat quality in PACs to be unnecessarily degraded. As was confirmed in Service (2017), wildfire resilience can be achieved through the removal of surface and ladder fuels and trees much larger than 12 inches dbh do not constitute ladder fuels; therefore, treatments for wildfire hazard reduction in PACs should focus on surface and ladder fuel reductions.

The Draft Strategy promotes retirement of PACs after three consecutive years of negative survey results. This measure appears to be based on unpublished information by Wood et al. (p. 8, Figure 3 of Draft Strategy) despite this figure showing that the probability of recolonization remains at or above 20% until about year 5. A 20% probability of colonization is relatively high for an imperiled species facing so many threats. This measure should be revised allow for the retirement of the PAC only after 5 years of negative survey results to provide for owl colonization. We were also unable to clearly identify the management direction for PACs and territories after retirement.

B. Habitat Management at the Territory Scale

We strongly concur with the following conservation measure, but find that it alone is not sufficient to provide for habitat management at the territory scale

> In territories needing restoration that do not yet meet the desired condition, do not reduce canopy cover or quadratic mean tree diameter in the existing large tree-high canopy cover habitat, regardless of habitat location.

(p. 47) North et al. (2017) found that spotted owls also selected areas dominated by tall trees and medium canopy cover. This indicates this conservation measure must also ensure that canopy cover and quadratic mean diameter are not reduced in areas dominated by large trees and **medium** canopy cover.

Although it is essential to limit treatment to the removal of surface and ladder fuels and maintaining quadratic mean diameter in high quality habitat when desired conditions have not been met for a territory, the Draft Strategy has not clearly defined the desired amount of nesting and roosting habitat for a territory. The Draft Strategy also does not define the smallest patch size of high quality habitat to be counted toward the desired amount or when this conservation measure takes precedence over other management guidance. For instance, the Draft Strategy states:

> Generally, each occupied territory should consist of at least 40 to 50 percent of the highest quality nesting and roosting habitat (defined here as large tree high cover;

> large tree medium cover; medium tree high cover; and medium tree medium cover habitat in descending order of priority). The remainder of the territory should consist of a mosaic of nesting, roosting, foraging, and dispersal habitat, informed by site conditions such as topography, climate, latitude, and site productivity. The long-term desired condition for each occupied territory is that at least 20 percent of the territory has habitat characterized by both high canopy cover and large, tall trees (Jones et al. 2017, North et al. 2017), and at least 10 percent of territory has habitat characterized by large, tall tree moderate canopy cover habitat. In the near term, for those occupied territories that do not currently meet the desired condition for large tree habitat, retention of additional medium tree habitat will be necessary to make up the remainder of the 40 to 50 percent as the territory moves toward desired conditions. Decisions regarding the retention of medium and large trees and medium and high canopy cover within a territory should be guided by the natural range of variation, latitude, elevation, landscape context, and location information about the owls.

(Draft Strategy, p. 47) Given a 1,000-acre territory size, the first sentence of this paragraph suggests that each territory should consist of 400-500 acres of the highest quality nesting and roosting habitat, but the third sentence indicates that each territory should provide 300 acres of high or moderate canopy cover forest dominated by large trees. Which is the desired condition and from what specific results from these studies is it based on? The second sentence also suggests that the remainder of the territory should consist of a mosaic of "nesting, roosting, foraging, and dispersal habitat", meaning that more nesting and roosting habitat would occur in each territory beyond the numerical targets. The conservation strategy should identify these amounts and also define the minimum size of a patch of nesting and roosting habitat that would be counted toward the desired condition target.

It is unclear to us how the Draft Strategy determined from North et al (2017) and Jones et al. (2017) what the desired conditions for nesting and roosting habitat should be at the territory scale. Jones et al. (2017) studied habitat conditions that provide for occupancy of a single territorial owl or pair and North et al. (2017) studied habitat conditions that owl pairs select for; therefore, to provide conditions that support spotted owl reproduction, the conservation strategy should rely on the results of North et al. (2017). According to Figure 6 in North et al. (2017), about 20% of each territory occupied by an owl pair in Sequoia-Kings Canyon National Park was composed of high canopy cover forest dominated by trees >48 meters tall, with another 10% in moderate canopy cover dominated by trees >48 meters, 15% with high canopy cover dominated by trees 32-48 meters, and 15% with moderate canopy cover dominated by trees 32-48 meters tall. In other words, for the only known stable California spotted owl population in existence, approximately 60% of each territory occupied **by an owl pair** was composed of higher quality nesting and roosting habitat. Although Jones et al. (2017) found that about 20% of each territory occupied **by a single territorial owl or pair** in Sequoia-Kings was composed of large trees with high canopy cover and about 10% was large trees with medium canopy cover, the study also found that about 18% of each territory was composed of medium trees with high canopy cover, a forest structure that is also important to nesting and roosting (Tempel et al. 2016). Given the findings of Jones et al. (2017) and North et al. (2017), the desired condition for a territory should be that >60% of each territory is composed of higher quality nesting and roosting habitat. The plan should also ensure that the quality of such habitat is not degraded to meet timber volume targets.

C. Survey Requirements

We were unable to identify any conservation measures requiring that project areas be surveyed for the species prior to implementing activities that may reduce habitat quality. We believe the current management direction in the 2004 Sierra Nevada Forest Plan Amendment Record of Decision (p. 54) is adequate:

> Conduct [California spotted owl] surveys in compliance with the Pacific Southwest Region's survey protocols during the planning process when proposed vegetation treatments are likely to reduce habitat quality in suitable California spotted owl habitat with unknown occupancy. Designate California spotted owl protected activity centers (PACs) where appropriate based on survey results.

If the Draft Strategy intends to change the survey requirement, through omission or otherwise, we ask that such a change in management direction be noted and that the change be justified.

II. Providing Limits to the Effects of Forest Health Treatments

Providing for fire resilience is relatively straightforward; under most fire weather conditions wildfire hazard is primarily due to a buildup of surface and ladder fuels and fire resilience is achieved by removing enough of the surface and ladder fuels. Consequently, trees >16 in. dbh rarely constitute a ladder fuel, and removal of trees larger than this is not necessary to provide fire resilience (North et al. 2009). Regardless of the initial treatment intensity, retreatment of the surface and ladder fuels is required about every 10-15 years to maintain resilience (Collins et al. 2011, van Wagtendonk et al. 2012). If thoughtfully implemented, surface and ladder fuels treatments are unlikely to have long-term negative effects on spotted owl demographic parameters. As such, landscape fire resilience can be achieved without long-term degradation of spotted owl habitat.

In contrast to fire resilience, providing drought and climate resilience is relatively site specific, being highly dependent on elevation, latitude, soils, slope position, and solar aspect. Resilience to climate and drought will also be a function of the unknown effects and severity of climate change. We do agree that forest types sometimes occur in places where they are not resilient to climate-related tree mortality and restoration is warranted. The Draft Strategy defines drastically different desired conditions for canopy cover and trees per acre in each size class between moist mixed conifer, dry mixed conifer, and yellow pine forest types. As a result, large differences in the quantity and quality of the habitat would be provided by each of these forest types, but the Draft Strategy appears to allow managers to decide where such forest types will occur. Without spatially defining where these forest types occur prior to finalizing the strategy, one cannot discern how much high-quality habitat will be managed for and if such habitat will be concentrated in ways that are capable of supporting spotted occupancy, reproduction, and survival.

As the Draft Strategy is currently written (i.e., without defining how much high-quality habitat will be provided and where it will be provided), it is not possible to determine the potential ability of the Draft Strategy to provide a well-distributed and persistent spotted owl population. If the Draft Strategy does not spatially define where the different forest types are to occur on the landscape, then quantitative conservation measures must be provided that can be used to demonstrate that achieving timber volume targets will not take precedence over providing for spotted owl viability.

III. Protection of Large Trees Is Not Assured

The Draft Strategy allows for the removal of larger diameter trees and does not ensure such trees will be recruited in climate resilient areas. The Draft Strategy also provides conflicting scientific evidence to justify diameter limits. In reference to tree diameter removal limits, the Draft Strategy states:

> Retain and protect all live conifers greater than 30 inches in diameter at breast height unless they are an impediment to attaining restoration or resilience goals. (p. 49)
>
> Preferentially retain trees greater than 35 inches in diameter at breast height… (p. 49)
>
> Exceptions to the recommendation to retain all conifers greater than 30 inches in diameter at breast height would apply only to trees outside protected activity centers and up to 40 inches in diameter at breast height. (p. 52)

At what scales do each of these measures apply and which measure takes precedence over the others? Is there a 30-inch diameter limit or a 35-inch diameter limit? How does a manager determine when there are too many 30 inch trees and removal is warranted? If this is not specifically identified, then one could assume that the diameter limit for all species is 35 inches and the diameter limit for non-pine species is 40 inches. Although there are very few natural forest stands with "too many" 30 inch dbh trees and few situations where one could justify removing a 39-inch white fir, it is our experience that pressure to achieve timber volume targets will result in an abuse of such management discretion. As defined, the diameter limits would likely result in significant increases in the removal of larger trees from high quality spotted owl habitat compared to current management direction. Additionally, removing larger white fir without also assuring that frequent ecologically beneficial fire is returned to the system would not achieve long-term restoration goals.

We contend that diameter limits are necessary for ecological and political reasons. From an ecological perspective, Dolanc et al. (2014) established in a landscape-scale study that there is a deficit of trees larger than 24 inches dbh for most species across the northern half of the Sierra Nevada. Based on this, the Draft Strategy should include conservation measures that minimize the loss of trees >24 inches dbh and increase in the number of trees >24 inches dbh at the landscape scale. Moreover, to achieve fire resilience, a factor identified as a threat to the species, there is rarely a need to remove trees larger than 16 inches dbh. At the same time, there is tremendous political pressure for managers to remove trees larger than 16 and 24 inches dbh. At a minimum, the landscape diameter limit should certainly be no more than 30 inches dbh and measures should be clearly defined to ensure there is in an increase in the number of trees >24 inches in most locations within territories and across the landscape. The strategy should also make it clear that removing trees larger than 24 inches dbh is not necessary in most locations due to the deficit of these trees. Due to naturally occurring mortality factors and to make up for the missing large tree cohort, the strategy should also plainly state that more trees in the 24” to 36” class may be required to compensate for the lack of larger trees. Large trees are not only scarce, but given the high level of uncertainly, the Draft Strategy must take into account the number of trees needed in each size-class cohort to develop into the missing large tree cohort that once included 60-, 70- and 80-inch diameter trees. These are the trees that deliver disproportionately high habitat value for spotted owls.

IV. Lack of Clarity in the Conservation Measures, Their Scale of Application, and Competing Measures

In our review of the conservation measures, it was not always clear to us when we encountered a conservation measure, because some conservation-like measures appeared in paragraphs and some appeared in a list of bullets. Adding to the confusion, it was also unclear to us at what scales (e.g., PAC, territory, or landscape) many of the conservation measures were to apply and when one conservation measure would take precedence over another conservation measure. Until these issues are resolved, the strategy is not implementable and the effects of the strategy cannot be determined.

To minimize implementation issues that would likely occur at the project level, we highly recommend that: (1) the conservation measures be organized by the scale at which they apply; (2) each conservation measure be numbered; and (3) if the potential attainment of one conservation measure conflicts with the potential attainment of another conservation measure at any scale, that it be clearly defined how to resolve the potential conflict.

V. Reliance on Unavailable Science Information

Throughout the Draft Strategy there is a reliance on science information that is unavailable to us. For example, the strategy relies on a “quantitative risk assessment currently underway (February 2018) by University partners.” The Draft Strategy spatially defines Protected Activity Centers (PACs) that are at risk of high intensity fire (Figure 8) and PACs that are at risk of density related tree mortality (Figure 9) without proving the methods used to create these figures. We ask that all information relied on to develop the conservation strategy be made available to the public prior to peer review.

At this time, we ask that the following be provided for review before commencing with the peer review:

- Wood et al. unpublished data
- Jones et al. unpublished data
- Keane unpublished data
- Keane et al. 2016 unpublished report
- Keane and Gerrard unpublished data

- Wolfe and J.J. Keane personal communication
- M. Raphael, personal communication

If this information, including the methods used to develop the information, cannot be made available for the public's review prior to the peer review then this information should not be considered the "best **available** science" information and the references to it should be removed from the Draft Strategy.

VI. Post Disturbance Logging

The effects of wildfire, and more specifically, high severity fire on spotted owl is nuanced. Most studies have found that the effects of low and mixed severity wildfire on spotted owl demographic parameters are neutral or beneficial. However, there remains uncertainty over the short- and long-term effects of larger patches of high severity fire. It has been demonstrated that spotted owls will forage in severely burned forests that have not been salvage logged (Bond et al. 2009, Eyes et al. 2017), with one study finding that some owls disproportionately selected for severely burned forest for foraging (Bond et al. 2009). However, habitat selection, use, and occupancy do not necessarily equate to adequate survival (Rockweit et al. 2017). High severity fire likely negatively affects the species when enough habitat within a territory burns severely (Lee et al. 2013, Jones et al. 2016, Rockweit et al. 2017). Although Rockweit et al. (2017) suggest that severely burned territories may act as population sinks, sink territories may help support population viability by providing "life boat" habitat for individuals to occupy and emigrate from in the event nearby source habitat becomes available.

Although the effects of high severity fire are nuanced, there is no debate that salvage logging negatively effects the species (Service 2017) and nearly all forest and fire ecologists and spotted owl biologists agree that fires that burn within NRV have beneficial ecological effects and are unlikely to negatively affect the species. Despite this, the U.S. Forest Service routinely salvage logs dead and "dying" trees from occupied spotted owl territories that burned within NRV, including low- and moderate-severity fire effects. The agency also salvage logs portions of occupied spotted owl territories that burn at high severity, regardless of the proportion of the territory that burned at high severity or the sizes of the high severity patches. In other words, there is relative consensus that low-, moderate-, and mixed-severity fire effects are consistent with NRV, do not negatively affect the species, increase forest resilience to future wildfires and climate-related tree morality, and salvage logging negatively effects the species, yet the Forest Service is unwilling to accept the beneficial effects of NRV-fire in areas accessible to salvage logging.

Jones et al. (2016) found that predicted occupancy rates were on average nine times lower when >50% of a territory burned high severity (>90% basal area mortality). However, Jones et al. (2016) did not report on the post-fire habitat conditions within burned territories and it is probable that occupancy could remain high in cases where >50% of the territory burned at high severity if sufficient amounts of high quality habitat also remained post-fire. Post-fire occupancy is likely influenced by the size, amount, and proximity of high severity patches to the territory center and the size, amount, and proximity of the remaining high quality habitat to the territory center.

The Service's Conservation Objectives Report states (p. 28, emphasis added): "California spotted owls persist in territories that experience low-moderate and mixed severity fire", and "in situations where over half a territory has burned at high severity (Jones et al. 2016a) **and individuals have abandoned the territory**, astute salvage could be warranted." This indicates that salvage logging is not warranted in occupied territories, regardless of habitat conditions. Despite this conservation objective, the Draft Strategy states (p. 40, emphasis added): "To determine if a disturbance is significant enough to retire a protected activity center, consider whether basal area mortality of greater than 75 percent has occurred over more than 50 percent of the territory (Jones et al. 2016), or less than 50 acres of suitable nesting and roosting habitat remain in the protected activity center. Where disturbance has reached these thresholds, **no surveys are required before retiring the protected activity center**." If no surveys are required before retiring a protected activity center that meets these criteria, then how will it be known if the activity center has been abandoned? Based on the available science and the Service's recommendation, the Draft Strategy should expressly state that the removal of dead trees should not occur within occupied spotted owl territories, except to address hazard trees and provide for firefighter safety in strategic locations to facilitate landscape fire use for ecological restoration.

VII. Misinterpretation of Science Information on the Effects of Logging

We have systematically compiled and outlined the results from all relevant peer reviewed demographic studies of which we are aware into the following tables that are attached to this comment letter:

- California spotted owl habitat selection (Table 1),
- The effects of logging on spotted owls (Table 2),
- The effects of wildfire and salvage logging on spotted owls (Table 3).

The effects of logging on demographic parameters likely depend on the interaction between the effects of the logging on the probability of habitat use and habitat quality; the amount of habitat logged and the amount of high quality habitat remaining; and the timeframe over which the logging occurred. To ensure species viability, conservation must address each of these factors. We include this review in these comments because the Draft Strategy does not fully incorporate this information into the strategy.

We are aware of only five published studies on the effects of thinning on California spotted owl demographic parameters: Seamans and Gutiérrez (2007), Tempel et al. (2014), Stephens et al. (2014), Tempel et al. (2015), and Tempel et al. (2016). Four of these studies identified negative effects of thinning on occupancy. Tempel et al. (2016), the only exception, found no support for an effect of logging less than 1% of a territory in the previous 3 years for the Lassen and Sierra study areas and a positive effect on the Eldorado study area. It is not surprising that logging less than 10 acres of a 1,000-acre spotted owl territory outside of a 300-acre Protected Activity Center (PAC) over a 3-year period would not have a detectable effect on occupancy probability. Of the five studies, only Tempel et al. (2014) and Tempel et al. (2015) considered the effects of logging on survival or reproduction, demographic parameters that are essential to distinguish a population source from a sink. Tempel et al. (2014) found that even a modest amount of medium intensity timber harvest was negatively associated with reproduction and that converting high canopy cover forest to a lower canopy cover class reduced survival. Tempel et al. (2015)[2] found that thinning would likely have negative effects on fitness and occupancy for more than 30 years after the treatment, long after the effectiveness of the fuel reduction treatment had diminished to pre-treatment levels (Collins et al. 2011). Although not definitive, the results of these studies support a conclusion that thinning has negative effects on occupancy, reproduction, and survival over the short- and long-term.

Recent studies confirm that spotted owls select forests dominated by large (>24 in dbh) trees with high (>70%) canopy cover (Blakesley et al. 2005, Seamans and Gutiérrez 2007, Tempel et al. 2014, Tempel et al. 2016, North et al. 2017, Jones et al. 2017). Jones et al. (2017) found that extinction rates increased as the amount of forest characterized by larger trees (≥24 in dbh) and high canopy cover (>70% cover) decreased. The median proportion of an owl site containing large trees and high canopy cover forest on National Forests ranged from 0.03-0.06, corresponding with higher predicted rates of local extinction and ongoing declines in occupancy. The median proportion of forest characterized by large trees and high canopy cover in owl territories on Sequoia-Kings Canyon was 0.19, which had a lower predicted extinction rate and stable occupancy. These findings are consistent with the results of North et al. (2017), finding that across four large study areas the average values of total canopy cover and cover in trees 32-48 m (104-157 ft) and >48 m (>157 ft) tall were highest at nest sites, and consistently decreased as area expanded to PACs, territories, and then the surrounding landscape. Similar to Jones et al. (2017), North et al. (2017) found that important habitat attributes (i.e., higher densities of taller trees) were limited on National Forests compared to the National Park study area. It has been speculated that California spotted owl populations are more robust today than they were historically due to an increase in the amount of high canopy cover forests (Gutiérrez et al. 2017); however, the findings of North et al. (2017) refute such speculation because the species has been shown to be strongly tied to larger trees and these structures were extensively logged and are now in deficit on National Forests.

The Draft Strategy states (p. 15):

> [M]ore recent studies failed to detect any negative impact of logging (mechanical treatment) to California spotted owl occupancy, survival, or productivity (Tempel et al. 2016, Irwin et al. 2015). Tempel and others (2016) found a nonsignificant positive impact of logging on occupancy at the Eldorado National Forest study site. Irwin and others (2015) found most harvests had no detectible effect on spotted owls and did not detect any site abandonment of occupied territories where up to 58 percent of the area was treated. This may be because forest management practices since the early 1990s have not reduced the amount of high-quality habitat found to be most important in determining occupancy over time (Jones et al., in review). In fact, J.D. Wolfe and J.J. Keane (personal communication) were unable to assess effects of logging across the demographic studies

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[2] When interpreting the results of Tempel et al. (2015), it should be recognized that mechanical treatments in the Last Chance study area did not occur in 3 of the 4 spotted owl territories and the only territory with mechanical fuels treatments was, counterintuitively, modeled to have more high severity fire effects post-treatment (Figure 4, p. 11). The study results support a conclusion that mechanical fuels treatments within owl territories were unnecessary to increase landscape-scale wildfire resilience.

over multiple decades because the number and amount of territories affected were so small.

We believe this is a misinterpretation and misapplication of the recent science on the effects of logging on the California spotted owl. Tempel et al. (2016) and Irwin et al. (2015) did not consider survival or "productivity" in their analyses. Tempel et al. (2016) was a study on occupancy of a single territorial owl or pair and Irwin et al. (2015) was a study on spotted owl nocturnal habitat use ≤2 years before and ≤2 years after logging.[3] Irwin et al. (2015) did not detect an effect of logging on nocturnal habitat use less than or equal to 2 years after harvest and Tempel et al. (2016) only considered the effects of logging outside of PACs within the 3 years preceding abandonment and logging affected on average less than 1% of a territory being logged within the previous 3 years. The fact that these studies did not detect an effect of logging is not surprising, giving the species has high site fidelity, is long lived, and has high survival rates. For example, the results of Conner et al. (2013), Conner et al. (2016) and Jones et al. (2017) show that it can take almost 20 years to detect a population decline and that the effects of management can take decades to be fully realized. In contrast, Tempel et al. (2014) considered the effects of medium intensity timber harvest throughout the study period, concluding that:

> When medium-intensity harvests were implemented within high-canopy-cover forests, they reduced the canopy sufficiently for mapped polygons to be reclassified into a lower-canopy-cover vegetation class in 90.1% of these treated areas (Fig. 5d). As we described previously, such changes were associated with reductions in survival and territory colonization rates, as well as increases in territory extinction rates. As a result, we believe that the most appropriate inference about the influence of medium-intensity harvesting practices is that they appear to reduce reproductive potential, and when implemented in forests with high canopy cover, are likely to reduce survival and territory occupancy as well. (p. 2103)

The Draft Strategy also routinely misinterprets the results of Jones et al. (2017) to support a conclusion that the past 20 years of Forest Service thinning practices have not contributed to the ongoing spotted owl decline. Jones et al. (2017) suggest that because the amount of high canopy cover forest dominated by large trees was stable over the 19-year study period the observed declines in occupancy on the Forest Service-managed sites may be attributable to an "extinction debt" or the legacy effect of large tree logging prior to the study period. The authors also suggest that without an increase in high canopy cover forest dominated by large trees, the species is likely to continue to decline and "total population extinction is not a foregone conclusion." (Jones et al. 2017, p. 7) **One explanation for why the amount of high canopy cover forest dominated by large trees remained stable throughout the study period, despite 19 years of forest growth, is that thinning has been sufficiently extensive to limit recruitment of this forest structure, thereby preventing habitat recovery.** For example, >90% of forest thinning treatments on the Eldorado study area were found to convert high canopy cover forests to a lower canopy cover class (Tempel et al. 2014).

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[3] Contrary to the Draft Strategy, Irwin et al. (2015) evaluated foraging in industrial forest lands and was not a demographic study.

The Draft Strategy also suggests that the results of Tempel et al. (2014) were mixed because some of the parameters that occur in the top Akaike's Information Criterion (AIC) model also had 95% confidence intervals for the beta coefficient that overlapped zero. We are not aware of a statistical rationale for dismissing a variable that appears in the top AIC model when the 95% confidence interval for the beta coefficient overlaps zero. In reference to this issue, Arnold (2010, p. 1177, emphasis added) states:

> For $n/K > 40$, AIC-based model selection will support additional variables whose approximately 85% confidence intervals exclude zero (i.e., if likelihood-ratio $\chi^2 > 2$ on 1 degree of freedom, then $P < 0.157$). **It makes little sense to select variables at P < 0.157 using AIC and then turn around and dismiss them at P > 0.05 using 95% confidence intervals.** A couple of authors made an important step in the right direction by using 90% confidence intervals for their parameter estimates (Hein et al. 2008, Long et al. 2008); those authors just needed to take it 5% further and use 85% confidence intervals and they would have been fully AIC compatible. If an ability to generate 85% confidence intervals were widely available in computer programs like MARK (White and Burnham 1999), then this might be a more highly favored solution. But using 95% confidence intervals with information-theoretic approaches leads to variable-selection ambivalence when β/standard error (SE)(β) = 1.4–2.0, and ambivalence is not a hallmark of good scientific writing.

Dismissing parameters included in top models based on 95% confidence intervals limits the consideration of important habitat variables in ways that are not scientifically supportable.

VIII. The Draft Strategy Does Not Include an Adequate Adaptive Management and Monitoring Plan

We are extremely concerned that the monitoring scheme proposed in the Draft Strategy relies entirely on monitoring occupancy and does not propose the continuation of the long-term demographic studies, including Sequoia-Kings Canyon. Spotted owl territory occupancy alone should not be relied on as the sole parameter by which to gauge population health or species viability (Tempel et al. 2014, Conner et al. 2016, Rockweit et al. 2017, Service 2017). Occupancy rates, especially when they do not distinguish between single birds, pairs, and nesting pairs, can mask the underlying dynamics that drive population trends.

The trends in spotted owl occupancy and trends in abundance diverge on all of the Sierra Nevada study sites. To explain this divergence, Tempel et al. (2014) and Conner et al. (2016) suggest that the divergent trends in occupancy and abundance on the Lassen, Sierra, and Eldorado study areas were caused by an increase in the number of territories occupied by single owls, while the number of territories occupied by pairs of breeding owls continued to decline. Given this, the Eldorado, Lassen, and Sierra study areas may be population sinks. In contrast, occupancy on the Sequoia-Kings Canyon National Park study area has stabilized, but abundance has increased due to an increase in the number of territories occupied by potentially reproductive pairs. This indicates that the National Park study area may be a population source. A recent study by

Rockweit et al. (2017) also provides evidence that spotted owl occupancy status may not be a reliable reflection of habitat quality or territory stability, finding that survival decreased and recruitment increased on some territories affected by large patches of moderate and high severity wildfire, resulting in what the authors determined to be sink territories.

Finally, the monitoring and adaptive management element of the Draft Strategy must clearly recognize and address the short-term risks and threats from logging and the inability for occupancy and other monitoring to detect negative impacts to the population in the short term. Adaptive management for spotted owls in the short term cannot rely on detecting the negative effects of management on demographic parameters. This means that other approaches to assessing the impacts on populations need to be pursued, e.g., habitat monitoring combined with the assignment of thresholds that indicate the need to review management direction.

Thank you for considering these comments in the revision of the Draft Strategy. Please contact Ben Solvesky (email ben@sierraforestlegacy.org, phone number 928-221-6102) if you have questions about these comments.

Sincerely,

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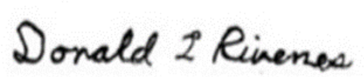

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References (cited in comment letter and tables)

Arnold, T.W. 2010. Uninformative parameters and model selection using Akaike's information criterion. Journal of Wildlife Management 74:1175-1178.

Blakesley, J.A., B.R. Noon, and D.R. Anderson. 2005. Site occupancy, apparent survival, and reproduction of California spotted owls in relation to forest stand characteristics. Journal of Wildlife Management 69:1554-1564.

Boisramé, G., S. Thompson, B. Collins, and S. Stephens. 2017. Managed wildfire effects on forest resilience and water in the Sierra Nevada. Ecosystems 20:717-732.

Bond, M.L., R.J. Gutiérrez, A.B. Franklin, W.S. LaHaye, C.A. May, and M.E. Seamans. 2002. Short-term effects of wildfires on spotted owl survival, site fidelity, mate fidelity, and reproductive success. Wildlife Society Bulletin 30:1022-1028.

Bond, M.L., D.E. Lee, R.B. Siegel, and J.P. Ward. 2009. Habitat use and selection by California spotted owls in a postfire landscape. Journal of Wildlife Management 73:1116-1124.

Clark, D.A., R.G. Anthony, and L.S. Andrews. 2011. Survival rates of northern spotted owls in post-fire landscapes of southwest Oregon. Journal of Raptor Research 45:38-47.

Clark, D.A., R.G. Anthony, and L.S. Andrews. 2013. Relationship between wildfire, salvage logging, and occupancy of nesting territories by northern spotted owls. Journal of Wildlife Management 77:672-688.

Collins, B.M., S.L. Stephens, G.B. Roller, and J.J. Battles. 2011. Simulating fire and forest dynamics for a landscape fuel treatment project in the Sierra Nevada. Forest Science 57:77-88.

Conner, M.M., J.J. Keane, C.V. Gallagher, T.E. Munton, and P.A. Shaklee. 2016. Comparing estimates of population change from occupancy and mark-recapture models for a territorial species. Ecosphere 7:1-20.

Dolanc, C.R., H.D. Safford, J.H. Thorne, and S.Z. Dobrowski. 2014. Changing forest structure across the landscape of the Sierra Nevada, CA, USA, since the 1930s. Ecosphere 5:1-26.

Eyes, S.A., S.L. Roberts, and M.D. Johnson. 2017. California Spotted Owl (*Strix occidentalis occidentalis*) habitat use patterns in a burned landscape. The Condor 119:375-388.

Gutiérrez, R.J.; P.N. Manley, and P.A. Stine. 2017. The California spotted owl: current state of knowledge. General Technical Report PSWGTR- 254. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 294 p.

Hood, S., A. Sala, E.K. Heyerdahl, and M. Boutin. 2015. Low-severity fire increases tree defense against bark beetle attacks. Ecology 96:1846-1855.

Jenness, J.S., P. Beier, and J.L. Ganey. 2004. Associations between forest fire and Mexican spotted owls. Forest Science 50:765-772.

Jones, G.M., R.J. Gutiérrez, D.J. Tempel, S.A. Whitmore, W.L. Berigan, and M.Z. Peery. 2016a. Megafires: an emerging threat to old-forest species. Frontiers in Ecology and the Environment 14:300-306.

Jones, G.M., R.J. Gutiérrez, D.J. Tempel, D.J., B. Zuckerberg, and M.Z. Peery. 2016. Using dynamic occupancy models to inform climate change adaptation strategies for California spotted owls. Journal of Applied Ecology 53:895-905.

Jones. G.M., J.J. Keane, R.J. Gutiérrez, and M.Z. Peery. 2017. Declining old-forest species as a legacy of large trees lost. Diversity and Distributions DOI: 10.1111/ddi.12682.

Lee, D.E., M.L. Bond, and R.B. Siegel. 2012. Dynamics of breeding-season site occupancy of the California spotted owl in burned forests. The Condor 114:792-802.

Lee, D.E., M.L. Bond, M.I. Borchert, and R. Tanner. 2013. Influence of fire and salvage logging on site occupancy of spotted owls in the San Bernardino and San Jacinto mountains of southern California. Journal of Wildlife Management 77:1327-1341.

Lee, D.E., and M.L. Bond. 2015a. Occupancy of California spotted owl sites following a large fire in the Sierra Nevada, California. The Condor 117:228-236.

Lee, D.E., and M.L. Bond. 2015b. Previous year's reproductive state affects spotted owl site occupancy and reproduction responses to natural and anthropogenic disturbances. The Condor 117:307-319.

Meyer. M.D. 2015. Forest fire severity patters of resource objective wildfires in the Southern Sierra Nevada. Journal of Forestry 113:49-56

North, M., A. Brough, J. Long, B. Collins, P. Bowden, D. Yasuda, J. Miller, and N. Sugihara. 2015a. Constraints on mechanized treatment significantly limit mechanical fuels reduction extent in the Sierra Nevada. Journal of Forestry 113:40-48.

North, M.P., S.L. Stephens, B.M. Collins, J.K. Agee, G. Aplet, J.F. Franklin, and P.Z. Fule. 2015b. Reform forest fire management: agency incentives undermine policy effectiveness. Science 349:1280-1281.

North, M.P., J.T. Kane, V.R. Kane, G.P. Asner, W. Berigan, D.J. Churchill, S. Conway, R.J. Gutiérrez, S. Jeronimo, J. Keane, A. Koltunov, T. Mark, M. Moskal, T. Munton, Z. Peery, C. Ramirez, R. Sollmann, A.M. White, and S. Whitmore. 2017. Cover of tall trees best predicts California spotted owl habitat. Forest Ecology and Management 405:166-178.

Potter, C.S. 2017. Satellite Image Mapping of Tree Mortality in the Sierra Nevada Region of California from 2013 to 2016. Journal of Biodiversity Management and Forestry 6:1-9.

Roberts S.L., J.W. van Wagtendonk, A.K. Miles, and D.A. Kelt. 2011. Effects of fire on spotted owl site occupancy in a late-successional forest. Biological Conservation 144:610-619.

Rockweit, J.T., A.B. Franklin, and P.C. Carlson. 2017. Differential impacts of wildfire on the population dynamics of an old-forest species. Ecology 98:1574-1582.

Safford, H.D., and J.T. Stevens. 2017. Natural range of variation for yellow pine and mixed-conifer forests in the Sierra Nevada, southern Cascades, and Modoc and Inyo National Forests, California, USA. General Technical Report PSW-GTR-256. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 229 p.

Seamans M.E., and R.J. Gutiérrez. 2007. Habitat selection in a changing environment: the relationship between habitat alteration and spotted owl territory occupancy and breeding dispersal. The Condor 109:566-576.

(Service) U.S. Fish and Wildlife Service. 2017. California spotted owl (*Strix occidentalis occidentalis*) Conservation Objectives Report. U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, CA. October 2017.

Stephens, S.L., S.W. Bigelow, R.D. Burnett, B.M. Collins, C.V. Gallagher, J. Keane, D.A. Kelt, M.P. North, L.J. Roberts, P.A. Stine, and D.H. Van Vuren. 2014. California spotted owl, songbird, and small mammal responses to landscape fuel treatments. BioScience 64:893-906.

Tempel, D.J., M.Z. Peery, and R.J. Gutiérrez. 2014a. Using integrated population models to improve conservation monitoring: California spotted owls as a case study. Ecological Modelling 289:86-95.

Tempel, D.J., R.J. Gutiérrez, S.A. Whitmore, M.J. Reetz, R.E. Stoelting, W.J. Berigan, M.E. Seamans, and M.Z. Peery. 2014b. Effects of forest management on California spotted owls: implications for reducing wildfire risk in fire-prone forests. Ecological Applications 24:2089-2106.

Tempel, D.J., R.J. Gutiérrez, J.J. Battles, D.L. Fry, Y. Su, Q. Guo, M.J. Reetz, S.A. Whitmore, G.M. Jones, B.M. Collins, and S.L. Stephens. 2015. Evaluating short-and long-term impacts of fuels treatments and simulated wildfire on an old-forest species. Ecosphere 6:1-18.

Tempel, D.J., J.J. Keane, R.J. Gutierres, J.D. Wolfe, G.M. Jones, A. Koltunov, C.M. Ramirez, W.J. Berijan, C.V. Gallagher, T.E. Munton, P.A. Shaklee, S.A. Whitmore, and MZ. Peery. 2016. Meta-analysis of California spotted owl (*Strix occidentalis occidentalis*) territory occupancy in the Sierra Nevada: Habitat associations and their implications for forest management. The Condor 118:747-765.

van Mantgem, P.J., A.C. Caprio, N.L. Stephenson, and A.J. Das. 2016. Does prescribed fire promote resistance to drought in low elevation forests of the Sierra Nevada, California, USA? Fire Ecology 12:13-25.

van Wagtendonk, J.W., K.A. van Wagtendonk, and A.E. Thode. 2012. Factors associated with the severity of intersecting fires in Yosemite National Park, California, USA. Fire Ecology 8:11-31.

Table 1. Summary of the results from studies on California spotted owl demographics and habitat selection.

Study	Study Location(s), Sample Size and Unit, and Period	Parameter	Habitat Selection
Blakesley et al. (2005)	Lassen Demographic Study Area, 63 territories, 11 years	Occupancy (pair or single)	The amount of nest area dominated by large trees (>24 in dbh) and canopy cover >70% was positively associated with site occupancy. The amount of nest area dominated by medium- trees (12-24 in dbh) with canopy cover >70% and the amount of area unforested or dominated by small trees (6-12 in dbh) were negatively associated with site occupancy.
		Survival	Apparent survival increased with greater amounts of forest dominated by large trees (>24 in dbh) with normal (40-70%) to good (>70%) canopy cover containing large (>30 in dbh) remnant trees.
		Reproduction	Reproductive decreased as the amount of nest area that was unforested or dominated by small trees increased.
		Nest Success	Nest success was higher when large remnant trees were present in the nest stand higher in stands dominated by medium-sized trees than by large trees.
Seamans and Gutierrez (2007)	Eldorado Demographic Study Area, 66 territories, 15 years	Extinction	The amound of conifer forest dominated by medium (12-24 in dbh trees) and large trees (>24 in dbh) with >70% canopy cover was negatively correlated with the probability of territory exinction.
		Colonization	The amount of conifer forest dominated by medium (12-24 in dbh trees) and large trees (>24 in dbh) with >70% canopy cover was positively correlated with the probability of territory colonization.
Roberts et al. (2011)	Yosemite National Park, 16 burned and 16 unburned territories, 2-14 years post-fire	Occupancy (pair)	The top model suggested that nest and roost site occupancy were best predicted by the combined positive effect of basal area and the negative effect of coarse woody debris. However, there was also support for an alternative model suggesting that higher canopy closure and tree basal area were also useful predictors of nest and roost site occupancy.
Tempel et al. (2014)	Eldorado Demographic Study Area, 70 territories, 20 years	Reproduction	Reproduction was negatively related to the area of hardwood forest with <10% conifer canopy cover.
		Survival	The amount of high (>70%) canopy cover forest dominated by 12-24 in and >24 in dbh trees occurred in the top-ranked models for survival, territory extinction, and territory colonization rates, and explained more variation in population growth rate and equilibrium occupancy than other covariates. Forests dominated by trees >24 in dbh and <30% canopy cover were not associated with demographic parameters.
		Extinction	
		Colonization	
		Occupancy (single or pair)	

Table 1 (continued). Summary of the results from studies on California spotted owl demographics and habitat selection.

Study	Study Location(s), Sample Size and Unit, and Period	Parameter	Habitat Selection
Tempel et al. (2016)	Lassen, Eldorado, Sierra, and Sequoia-Kings Canyon demographic study areas, 275 territories, 19 years	Extinction Colonization Occupancy (single or pair)	Forests with high (>70%) and medium (40-70%) canopy cover were the only habitat covariates that were consistently identified as important for all four study areas. Occupancy reached its lowest value when high and medium canopy cover were mininimized and occupancy reached its highest value when these covariates were maximized. Occupancy for the 40–49% canopy cover class was lower than occupancy for the 50–59% and 60–69% canopy cover classes. Occupancy rates are likely to be negatively affected if canopy cover is consistently reduced to 40%.
North et al. (2017)	Sequoia-Kings Canyon, Eldorado, and Sierra demographic study areas and Tahoe National Forest, 316 territories, sites that were occupied by an owl pair at least once between 2001 and 2013	Occupancy (pair)	Across the four study areas, the average values of total canopy cover and cover in trees >48 m (157 ft) was highest at nest sites, and consistently decreased as area expanded to PACs, territories and then the surrounding landscape. A similar trend of decreasing values from nest sites to landscape was identified for the 32–48 m (105-157 ft) strata on the three National Forest study areas but not on Sequoia-Kings Canyon. The amount of cover of trees in the 2-16 m (7-52 ft) height strata was lowest near nest sites and decreased as area expanded to PACs, territories, and then the surrounding landscape.
Jones et al. (2017)	Lassen, Eldorado, Sierra, and Sequoia-Kings Canyon demographic study areas, 275 territories, 19 years	Extinction Occupancy (pair or single)	Extinction rates increased as the amount of forest characterized by large trees (≥24 in dbh) and high canopy cover (>70% cover) decreased. Median proportion of an owl site containing large trees and high canopy cover forest on national forests ranged from 0.03-0.06, corresponding with higher predicted rates of local extinction and ongoing declines in occupancy. The median proportion of forest characterized by large trees and high canopy cover in owl territories on Sequoia-Kings Canyon was 0.19, which had a lower predicted extinction rate and stable occupancy.

Table 2. Summary of results from studies on the effects of logging on spotted owl demographics.

Study	Study Location(s), Sample Size and Unit, and Period	Disturbance Type(s) Evaluated	Parameter	Response (Effect on Demographic Parameter)
Seamans and Gutierrez (2007)	Eldorado Demographic Study Area, 66 territories, 15 years.	High Severity Fire (including salvage), Logging	Extinction	**Negative** - Alteration of ≥50 acres of mature conifer forest was positively correlated with territory extinction probability.
			Colonization	**Negative** - Probability of colonization was related to the amount of mature conifer forest habitat in the territory and the alteration of such habitat reduced the probability of colonization.
Clark et al. (2013)	Southwest Oregon, 31 burned/103 unburned territories, up to 15 years pre-fire and 4-5 years post-fire.	Logging, High Severity Fire, Salvage Logging	Extinction	**Negative** - Probability of extinction increased due to the interactive effect of past timber harvest, high severity fire, and salvage logging.
			Colonization	**Unclear** - Few colonization events were observed.
			Occupancy (pair)	**Negative** - Declines in occupancy were driven by increases in extinction, attributable to past timber harvest, high severity fire, and salvage logging.
Tempel et al. (2014)	Eldorado Demographic Study Area, 70 territories, 20 years.	High-intensity Logging, Wildfire (including salvage), and Medium-intensity Logging.	Reproduction	**Negative** - "[M]medium-intensity timber harvests characteristic of proposed fuel treatments were negatively related to reproduction of Spotted Owls in our study. Reproduction appeared sensitive to modest amounts of medium-intensity harvests, and was predicted to decline from 0.54 to 0.45 when 20 ha were treated." (pg. 2101)
			Survival	**Negative** - Medium-intensity logging, when implemented in high canopy cover forests, was associated with reductions in survival.
			Extinction	**Positive** - Extinction was negatively correlated with the area of high-intensity timber harvest. High intensity timber harvest occur on 5.4% of the total area within owl territories in the study.
			Colonization	**Negative** - Medium-intensity logging, when implemented in high canopy cover forests, were associated with reductions in colonization.
			Occupancy (single or pair)	**Negative** - Equilibrium occupancy was negatively correlated with wildfire.
Stephens et al. (2014)	Plumas National Forest, 8 territories, 4-5 years pre-treatment, 3-4 years post-treatment.	Group Selection and Fuels Treatments	Occupancy (single or pair)	**Negative** - By 3–4 years post-treatment, the number of occupied sites declined decline by 43% from the pretreatment numbers.

Table 2 (continued). Summary of results from studies on the effects of logging on spotted owl demographics.

Study	Study Location(s), Sample Size and Unit, and Period	Disturbance Type(s) Evaluated	Parameter	Response (Effect on Demographic Parameter)
Tempel et al. (2015)	Tahoe National Forest, 4 territories, modeled 30 years post-treatment.	Fuels Treatment, Wildfire	Fitness	**Negative** - Fuels treatment had a negative effect on fitness, an effect that was still present after 30 years of simulated forest growth. Negative - Simulated wildfire without fuels treatment negatively affected fitness. Negative - Fuels treatment with simulated wildfire negatively affected fitness, but the effect was not a great as the effect of simulated wildfire without fuels treatment.
			Occupancy (single and pair)	**Negative** - Fuels treatment alone had a negative effect on equilibrium occupancy, an effect that was still present after 30 years of simulated forest growth. Negative - Simulated wildfire without fuels treatment negatively affected equilibrium occupancy. Negative - Simulated wildfire with fuels treatment negatively affected equilibrium occupancy, but the effect was not a great as the effect of simulated wildfire without fuels treatment.
Tempel et al. (2016)	Lassen, Eldorado, Sierra, and Sequoia-Kings Canyon demographic study areas, 275 territories, 19 years.	Wildfire (including salvage on National Forests), Prescribed Fire, Logging	Extinction	**Positive** - On the ELD study area, logging less than 1% of a territory in the previous 3 years was negatively correlated with extinction. Neutral - No support for an effect of logging less than 1% of a territory in the previous 3 years was detected for the LAS or SIE study areas. Positive - On the SKC study area, wildfire was negatively related to extinction. Neutral - No support for an effect of wildfire was detected on the ELD, LAS, or SIE study areas.
			Colonization	**Neutral** - No support for an effect of logging less than 1% of a territory in the previous 3 years was detected for the ELD, LAS, or SIE study areas. Negative - On the SKC study area, prescribed fire was negatively associated with colonization.
			Occupancy (single or pair)	**Neutral** - No support for an effect of logging when less than 1% of a territory was logged in the previous 3 years for the LAS, or SIE study areas. **Positive** - On the ELD study area, logging less than 1% of a territory in the previous 3 years was positively associated with occupancy.

Table 3. Summary of the results from studies on the effects of fire and salvage logging on spotted owl demographics.

Study	Study Location(s), Sample Size and Unit, and Period	Disturbance Type(s) Evaluated	Parameter	Response (Effect on Parameter)
Bond et al. (2002)	Shasta-Trinity, Klamath, San Bernardino, Coconino, and Gila National Forests, 11 burned and >300 unburned territories, 9-16 years for unburned and 1 year post-fire for burned territories.	Wildfire	Survival	**Neutral** - No difference in survival was detected between burned and unburned territories.
			Reproduction	**Positive** - Reproductive success was higher in burned territories the year following fire than in unburned territories.
			Fidelity	**Neutral** - No difference in fidelity was detected between burned and unburned territories.
Jenness et al. (2004)	Coconino, Gila, Coronado, and Lincoln National Forests, 33 burned and 31 unburned territories, 1-4 years post-fire.	Wildfire and Prescribed Fire	Reproduction	**Negative -** Unburned territories tended to be occupied by pairs and more reproductive pairs than burned territories.
			Occupancy (single or pair)	**Negative** - Probability of occupancy was higher in unburned sites compared to burned sites.
Seamans and Gutierrez (2007)	Eldorado Demographic Study Area, 66 territories, 15 years.	High Severity Fire (including salvage), Logging	Extinction	**Negative** - Alteration of ≥50 acres of mature conifer forest was positively correlated with territory extinction probability.
			Colonization	**Negative** - Probability of colonization was related to the amount of mature conifer forest habitat in the territory and the alteration of such habitat reduced the probability of colonization.
Clark et al. (2011)	Southwest Oregon, 23 radio-marked birds, years 3 and 4 post-fire.	Wildfire (including salvage)	Survival	**Negative** - Average annual survival of owls living inside burn perimeters (also salvage logged) was lower than outside the burn perimeters and was lower than survival rates of spotted owls in all other areas with survival estimates at the time of the study.
Roberts et al. (2011)	Yosemite National Park, 16 burned and 16 unburned territories, 2-14 years post-fire.	Wildfire and Prescribed Fire	Occupancy (pair)	**Neutral** - Fire did not reduce the probability of occupancy.

Table 3 (continued). Summary of the results from studies on the effects of fire and salvage logging on spotted owl demographics.

Study	Study Location(s), Sample Size and Unit, and Period	Disturbance Type(s) Evaluated	Parameter	Response (Effect on Parameter)
Lee et al. (2012)	Sierra Nevada-wide, 41 burned/145 unburned territories, up to 7 years post-fire.	Wildfire (including salvage)	Extinction	**Neutral** - No significant difference between burned and unburned sites in probability of local extinction.
			Colonization	**Neutral** - No significant difference between burned and unburned sites in probability of colonization.
			Occupancy (single or pair)	**Neutral** - No significant effect of high severity fire on occupancy.
Clark et al. (2013)	Southwest Oregon, 31 burned/103 unburned territories, up to 15 years pre-fire and 4-5 years post-fire.	Logging, High Severity Fire, Salvage Logging	Extinction	**Negative** - Probability of extinction increased due to the interactive effect of past timber harvest, high severity fire, and salvage logging.
			Colonization	**Unclear** - Few colonization events were observed.
			Occupancy (pair)	**Negative** - Declines in occupancy were driven by increases in extinction, attributable to to past timber harvest, high severity fire, and salvage logging.
Lee et al. (2013)	San Bernardino National Forest, 78 unburned/58 burned territories, 9 years for unburned and 8 years post-fire for burned territories.	High Severity Fire, Savlage Logging	Extinction	**Negative** - Average annual extinction probability was higher in burned territories, increased as the amount of habitat that burned at high severity increased, and increased as the amount of habtiat that was salvage logged increased.
			Colonization	**Negative** - Mean annual probability of colonization was lower in burned sites than unburned sites, but was not affected by salvage logging.
			Occupancy (single and pair)	**Negative** - When >50 ha of forested habitat burned at high severity, site occupancy probability decreased by 0.003 for every additional hectare of forested habitat severely burned and post-fire salvage logging exacerbated the effect by decreasing occupancy probability an additional 0.05.

Table 3 (continued). Summary of the results from studies on the effects of fire and salvage logging on spotted owl demographics.

Study	Study Location(s), Sample Size and Unit, and Period	Disturbance Type(s) Evaluated	Parameter	Response (Effect on Parameter)
Tempel et al. (2014b)	Eldorado Demographic Study Area, 70 territories, 20 years.	High-intensity Logging, Wildfire (including salvage), and Medium-intensity Logging	Reproduction	**Negative** - "[M]edium-intensity timber harvests characteristic of proposed fuel treatments were negatively related to reproduction of Spotted Owls in our study. Reproduction appeared sensitive to modest amounts of medium-intensity harvests, and was predicted to decline from 0.54 to 0.45 when 20 ha were treated." (pg. 2101)
			Survival	**Negative** - Medium-intensity logging, when implemented in high canopy cover forests, was associated with reductions in survival.
			Extinction	**Positive** - Extinction was negatively correlated with the area of high-intensity timber harvest. High intensity timber harvest occur on 5.4% of the total area within owl territories in the study.
			Colonization	**Negative** - Medium-intensity logging, when implemented in high canopy cover forests, were associated with reductions in colonization.
			Occupancy (single or pair)	**Negative** - Equilibrium occupancy was negatively correlated with wildfire.
Lee and Bond (2015a)	Stanislaus National Forest, 45 territories, 1 year post-fire.	High Severity Fire	Occupancy (single and pair)	**Neutral** - Probability of occupancy of a single individual 1 year post-fire was relatively high, compared to other studies on the species in burned or unburned forest in the Sierra Nevada, with most sites being occupied by pairs.
Lee and Bond (2015b)	San Bernardino National Forest, 76 unburned/52 burned, 9 years for unburned and 4-8 years post-fire for burned territories.	High Severity Fire, Salvage Logging	Reproduction	**Neutral** - No significant effect of fire or logging on reproduction were detected.
			Occupancy (single or pair)	**Negative** - Significantly lower occupancy in burned vs. unburned sites. **Negative** - Occupancy was further reduced by the amount of salvage logging that occurred.

Table 3 (continued). Summary of the results from studies on the effects of fire and salvage logging on spotted owl demographics.

Study	Study Location(s), Sample Size and Unit, and Period	Disturbance Type(s) Evaluated	Parameter	Response (Effect on Parameter)
Tempel et al. (2016)	Lassen, Eldorado, Sierra, and Sequoia-Kings Canyon demographic study areas, 275 territories, 19 years.	Wildfire (including salvage on National Forests), Prescribed Fire, Logging	Extinction	**Positive** - On the ELD study area, logging less than 1% of a territory in the previous 3 years was negatively correlated with extinction. **Neutral** - No support for an effect of logging less than 1% of a territory in the previous 3 years was detected for the LAS or SIE study areas. **Positive** - On the SKC study area, wildfire was negatively related to extinction. **Neutral** - No support for an effect of wildfire was detected on the ELD, LAS, or SIE study areas.
			Colonization	**Neutral** - No support for an effect of logging less than 1% of a territory in the previous 3 years was detected for the ELD, LAS, or SIE study areas. **Negative** - On the SKC study area, prescribed fire was negatively associated with colonization.
			Occupancy (single or pair)	**Neutral** - No support for an effect of logging when less than 1% of a territory was logged in the previous 3 years for the LAS, or SIE study areas. **Positive** - On the ELD study area, logging less than 1% of a territory in the previous 3 years was positively associated with occupancy.
Jones et al. (2016)	Eldorado demographic study area, 15 unburned/30 burned territories, 22 years pre-fire/1 year post-fire.	High Severity Fire	Extinction	**Negative** - Probability of extinction increased as the proportion of high-severity fire increased and extinction was 7 times more likely in territories that burned with >50% high severity.
			Colonization	**Negative** - Sites that burned at <50% high-severity were more likely to be colonized after the fire than unburned territories or territories that burned with <50% high severity.
			Occupancy (single or pair)	**Negative** - Probability occupancy was nine times lower for territories that burned with >50% high-severity fire effects than unburned sites.
Rockweit et al. (2017)	Klamath Province, 24 burned/70 unburned territories, 26 years for unburned and 4-26 years post-fire for burned territories.	Wildfire	Survival	**Negative** - As the total amount of high severity and moderate severity fire effects increased, apparent survival decreased.
			Recruitment	**Neutral** or **Positive** - There was no significant difference between post-fire recruitment rates and the control group, except for owls affected by wildfire in 2008, where recruitment rates increased.