California Spotted Owl

(*Strix occidentalis occidentalis*)

Draft

Conservation Objectives Report

PEER REVIEWS

CSO COR Draft: Peer review went to 7 reviewers (all owl and forest ecologists whose worked has been cited in the report), coordinated and sent by the Regional office on July 24, 2017. Six were returned by August 9, 2017. Five of the reviews were largely positive, 4 of which provided comments primarily to clarify certain points or suggest additional references. The 5th review (Reviewer 4) commented that the science was solid and well-summarized, but that the objectives fell short by focusing on CSO rather than forest sustainability, and had concerns regarding the continued use of PACs to protect habitat. The 6th review was largely negative, suggesting that this report was not sufficient to protect the owl, and specifically disagreed with the science presented about large, high-severity fires and forest management. Reviewers 4 and 6 often had directly opposing comments and suggestions regarding these issues. We have addressed and responded to all comments as appropriate for this document below, which we note is not a listing or regulatory document, but rather aimed at pro-active conservation objectives. When comments were lengthy, they were summarized here; please see original reviews for full comments. Thank you.

Reviewer #	**Comment #**	**Reviewer**	**Comment Theme**	**Comment (summarized when lengthy, see original)**	**Response**
1	1	North	General	Overall this is very well done and covers much of the literature thoroughly.	Thank you.
1	2	North	Forest management	You've missed the following 2 citations which I think have useful information regarding management issues and options: North, et al. 2016. Current and projected condition of midelevation Sierra Nevada forests. Chapter 5 in Bioregional Assessment of the California Spotted Owl, and Peery, et al. 2016, Chapter 9. You do cite the whole work at Gutierrez et al. 2016 but the GTR is made up of 9 chapters which have more specific topics.	We have now specified each chapter referenced in the citations.
1	3	North	Habitat	I think its worth distinguishing between canopy closure and cover. I've inserted a comment about this in the manuscript as well as relevant citations. In general canopy cover has been roughly/poorly measured in many studies and therefore the high levels report are confounded with many structural attributes. In particular we examined this issue in a paper under review and found its the cover in tall trees that matters, not total canopy cover. See: North et al. in review. Cover of tall trees best predicts California spotted owl habitat. Forest Ecology and Management.	Thanks for this suggestion, we have clarified the difference. We have also added information from personal communication with the reviewer regarding this newest work (now in press).
1	4	North	Habitat	p. 9 "tree hair lichen" - This is a colloquialism and unclear what species is being referred to. The principle foraging lichen is Bryoria fremontii. See: Rambo, T.R. 2012. Association of the arboreal forage lichen Bryoria fremontii with Abies magnifica in the Sierra Nevada, California Canadian Journal of Forest Research Volume 42, Issue 8, August 2012, Pages 1587-1596	We have clarified the type of lichen.
1	5	North	Forest management	p. 23 - I believe here you want to cite a different paper than the North et al. 2015 in the biblio about mechanical constraints. The correct paper is: North, M., Stephens, S., Collins, B., Agee, J., Aplet, G., Franklin, J., and Fulé, P. 2015. Reform forest fire management: Agency incentives undermine policy effectiveness. Science 349: 1280-1281.	We corrected this citation.
1	6	North	Climate change	p. 24 - 2 other papers that get at this topic and may be worth citing here are: Lydersen, J. and M. North. 2012. Topographic variation in active-fire forest structure under current climate conditions. Ecosystems 15: 1134-1146. Underwood, E.C., J.H. Viers, J.F. Quinn, and M. North. 2010. Using topography to meet wildlife and fuels treatment objectives in fire-suppressed landscapes. Journal of Environmental Management 46: 809-819.	We added these citations.

1	7	North	Habitat	p. 25 - I think its worth noting that canopy cover measurements often don't distinguish between closure and cover. Owl nests have high closure (a point measure) but cover, a stand level average measure of porosity, has not been well measured and is often confounded. See Jenkins et al. 1999 (cited in North and Stine 2012 below) and (particularly figure 14-1). North, M. and P. Stine. 2012. Clarifying concepts. Pages 149-164 in M. North (ed.) Managing Sierra Nevada Forests, General Technical Report PSW-GTR-237. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. 184 pp	We have now made this distinction, and reference Jennings et al. 1999.
2	1	Keane	Habitat	p. 4 - I think this citation should be "Keane 2014". Could then remove Keane 2013 from Literature Cited.	We have changed this.
2	2	Keane	Climate change	p. 5 - Recommend incorporating results reported from Peery et al. 2012 into this discussion.	Thank you for this suggestion, and we discuss Peery et al. 2012 later in the report.
2	3	Keane	Habitat	p. 6 - "typical nest predators" is too general and unclear. Suggest adding specific reference to species of concern with appropriate citation(s).:	Because the main predators were already discussed, and this sentence was unclear, we deleted it.
2	4	Keane	Habitat	p. 6 - Larger trees are a critical habitat element so suggest being very specific with these statements. Please provide a citation for the avg of 49 inch dbh. Next sentence then states that "in general" nest trees are greater than 30" dbh. "In general" implies many nest trees less than 30" dbh. For conifers, most nest trees are much larger than 30" dbh in order to provide large enough cavities and broken tops that serve as nest substrate. Many times the smaller dbh trees lack these important features but may be used because they have a stick structure of some sort (raptor-corvid-squirrel nest, mistletoe, etc.).	We have made the statements regarding large nest tree sizes more specific and provided the citations.
2	5	Keane	Fire	p. 7 - Important to recognize that owls may use edges of high severity burn patches for foraging as reported by Bond et al. 2009, not just low and moderate severity habitat. This is important as high-severity fire was/is a component of a mixed-severity fire regime, and likely provided foraging benefits to owls when overall amounts and patch sizes were within the range of historical patterns. The concern is with recent increases in amounts and patch sizes of high-severity fire, coupled with future increases given current trends and projected climate scenarios. I have attached our recent paper on mixed-severity fire regimes for inclusion (Hessburg et al. 2016).	Yes, thank you for pointing this out. Although we did discuss this habitat use in other sections of the report, we agree it should be emphasized more here, and have now done so. We have also included the additional citation in the summary of stressors section.
2	6	Keane	Habitat	p. 8 - This paragraph addresses owls in the southern California mountains. Lee and Irwin's paper analyzes data from the Sierra National Forest in the southern Sierra Nevada, not the mountains of southern California.	Thank you for pointing out that error, we have moved discussion of Lee and Irwin's paper to the section on the Sierras.
2	7	Keane	Prey	p. 8 - Need citation because I do not know if this is true across all studies.	We have added the citation.

2	8	Keane	Prey	p. 9 - This statement may be true but neither of the cited studies provides empirical evidence to support this broad statement as presented. Sollman et al. 2016 found that flying squirrel numbers were generally the same pre- and post-treatment, with some shift in spatial distribution away from treated patches. This is not evidence for “enhanced” prey habitat for flying squirrels. Is the statement meant to imply there is enhanced habitat for other small mammal species beyond flying squirrels? Might just carefully restate this concept.	We have clarified this concept that heterogeneity may broadly result in diverse small mammal habitat, not just flying squirrels.
2	9	Keane	Populations	Table 1 - This table needs to be updated with results from Connor et al 2016 for the Lassen, Sierra, and SKC study areas. I have attached this paper. This paper is also useful because it compares estimates of population change from mark-recapture versus occupancy – something the USFWS may want to consider carefully for future monitoring endeavors.	Thanks for the updated paper, we have included the results, as well as discussed the population vs. occupancy estimates.
3	1	Eyes	General	It's evident that a lot of hard work went into this.	Thank you.
3	2	Eyes	Fire	I'm not sure if this is necessary, but one thought I had was addressing some of the contrary literature that describes a very different paradigm for Sierra Nevada fire regimes (i.e. Baker, Della Salla, Hanson, etc.), and then present the literature already shown in the article as the consensus. Perhaps this is not necessary, and is implied based on the way it's already written, but I've personally seen the way the media and public can misrepresent and accuse that information was left out on the issue of owls and fire. I think a fire/forest ecologist may speak to this need better than me, but if the goal is to present a thorough review of the literature, then perhaps presenting this contrary view is warranted. I also sense that certain authors of the Bond/Hanson spotted owl articles will find that a lot of the information in their articles was not included and perhaps should be addressed and acknowledged or dismissed, particularly their findings on high-severity fire and owls.	Thank you for this comment. We appreciate the need to acknowledge and discuss this literature briefly and we have now done so in the stressor section. The debate between the contrary literature is beyond the scope of this report, but regardless we can discuss current and future effects of fire severities and extents on owls. Also, we had included most of the fire/spotted owl papers you are referring to, and in this revision have endeavored to ensure all are properly highlighted.
3	3	Eyes	General	Overall, I thought the authors did a great job incorporating the latest science, however because some of it was in review or in press, I had a hard time with some of the sentences since I didn't have the context from the original source. For example, one sentence I struggled with is as follows, "Recent evidence suggest that these declines may be a result of previously altered habitat, rather than current forest management practices on national forests (Jones et al. in review)." (21). Without the context of the article, I read that statement as our current management practices and choices are having no impact on species' declines, which seems like just a small piece of the puzzle, and of that article. I noticed that in other places throughout the text; if you are unfamiliar with the article, you may take the summary statement out of context.	Thanks for this comment, we've expanded upon and clarified those statements to ensure appropriate context.
3	4	Eyes	Model	I think I may be completely misunderstanding the red versus blue arrows because I noticed that the text and the legend don't match leading me to be very confused! Is there some way that this could be inserted on its own page in landscape orientation? I am having a hard time seeing all the lines.	Thanks for catching that typo. It's been corrected and the image enlarged.

3	5	Eyes	Habitat	I also wonder if the habitat requirements that were chosen could be woven into the text more similarly to the stressors fields? I don't think they all need their own italicized titles like in the stressors section, but perhaps some way to make these pop out of the text somehow as the most logical habitat requirements to pick?	Thanks for this suggestion. Given the interwoven nature of the habitat requirements, we agree that separating them out similarly to stressors would not be appropriate. However, we have highlighted (bolded) them in text now to point readers to where they are discussed.
3	6	Eyes	Prey	The other thing I'm not sure I like about the habitat model is the fact that prey and prey requirements are not easily seen in this conceptual model. Ultimately, prey availability could be considered a stressor, since ultimately, we know so little about how prey respond in changing forest conditions compared to the wealth of knowledge on spotted owls (but we always need to know more as evident by this report). It seems impossible to include everything in this conceptual model, and I think you've done a really good job of trying to narrow it down to what's important, but for some reason prey always strikes me as one of the most important factors that is so hard and labor intensive to study, but is clearly driving a lot of the patterns we see happening in owl populations. Perhaps, an explanation of how/where prey fit in this conceptual model? I won't be offended if it doesn't show up. . .	We agree that prey availability is essential, and this was not immediately clear in the model. Because this model is habitat based from the perspective of the owl, we included some aspects that are specifically for the prey base (especially spatial heterogeneity and coarse woody debris). We have highlighted this more in the model description.
3	7	Eyes	Model	I also would appreciate more discussion on the 3 "R's": representation, resilience, and redundancy because those seem like the core principles this model is based on (yet only one appears in the model), and frankly they are all mouthfuls to take in.	The 3 R's are a typical practice for assessing species' status, but we have further explained how they were considered in this report. The model is only for populations (thus resilience). The objectives more broadly consider the other two R's here.
3	8	Eyes	Model	Also, I am no artist, but I wonder if there is a way to make the model look a little more fun than just shapes and colors? Like treat it as more of an art object? I don't mean to be too harsh, but it's not exactly the most beautiful looking conceptual model, and wonder if it could be pepped up somehow with illustrations or conceptual drawings? I really like this proposed food web dynamics conceptual model in Holm et al. 2016, "Potential trophic cascades triggered by the Barred Owl expansion".	While we agree the model is not particularly artistic, for the purposes of this type of document we kept it to a basic format.
3	9	Eyes	Objectives	I think the conservation objectives and measures were reasonably drawn from the information presented in the report, and include a description of things I found unclear. One thing, I was left lingering with in my head while reading them over though, was timelines associated with these impacts and perhaps ranking the conservation measures in order of importance? There is a lot of information in there, that all seems warranted, but given time, is there some way to at least acknowledge this? It seems like this is more appropriate for the professional spotted owl biologists who are working on conservation strategy and assessment, but sometimes I have a hard time teasing apart the differences in all these documents. Perhaps a more detailed description in the intro section 6.2 referring to this?	Because the model development identified the relative significance of the stressors, the document is in and of itself a prioritization for objectives for owl conservation.

3	10	Eyes	Objectives	I'm also confused in section 6.2 because it seems like some of the information presented here is new information, like citations and discussion of particular articles. To me, it seems like this section should be re-iterating already presented material and should perhaps just include very brief descriptions of the conservation objective and then conservation measures.	For the most part, new information is not being presented in the objectives, but is reiterated as necessary to support particular objectives.
4	1	Stephens	General	In general, the document has considered the best available science. I have provided 2 papers that were not in the document, one was recently accepted by Ecological Applications (Collins et al: Impacts of different land management histories on forest change) and the 2nd is still in review (Lydersen and Collins: Change in vegetation patterns over a large forested landscape based on historical and contemporary aerial photography).	Thank you, and thanks for providing summaries of your most recent work. We have incorporated the information presented and cited as personal communication.
4	2	Stephens	Habitat	Summary of new work (Collins et al. in press): "there have been substantial changes in Sierra Nevada forests over the last 100 years managed by both the US Forest Service and National Park Service. As in other paper the authors found that large trees were less common on USFS land and these are important elements to CSO habitat. The paper also found that live basal area and tree density significantly increased from 1911 to present in both logged and unlogged areas. Both shrub cover and the proportion of live basal area occupied by pine species declined from 1911 to present in lands managed by the USFS and NPS. In general, areas with no recent management activities experienced the greatest change from 1911 to present. This paper shows that both NPS and USFS lands in the Sierra Nevada have big issues regarding resilience and sustainability."	Thank you for providing this recent work. We have now included this information within the stressor section, regarding similar changes on NP and NF lands, but still fewer large trees on NF lands, and have cited as personal communication.

4	3	Stephens	Forest management	"The 2nd paper, Lydersen and Collins, used historical and recent aerial imagery to characterize historical vegetation patterns and assess contemporary change from those patterns in a large area of the Plumas National Forest. The authors created an orthorectified mosaic of air photos from 1941 covering approximately 100,000 ha."..... "This paper presents information that suggests that CSO nesting habitat (as characterized today with a focus on high canopy cover) was much less common in this large forest landscape in 1941. Today because of fire suppression the area with high canopy cover has increased greatly and the size of large canopy cover patches are huge when compared to 1941 (which already had approximately 40 years of fire suppression but no harvesting). Although this area includes east side pine it does have a number of PAC's today. However the sustainability of this large area today is poor (such what happened in the 2007 Moonlight Fire). This provides further evidence that forests have densified greatly over the last 100 years and any strategy to conserve the CSO long term needs to take this into account. Attempting to maintain high canopy cover in Sierra Nevada east side, ponderosa pine, and mixed conifer forests outside of areas that provide higher moisture and less water stress is not scientifically justified. Studies such this one provide additional information on how much our present forests have changed and with warming climates and more variability in future precipitation, this provides further evidence that current forest conditions and not resilient or sustainable into the future."	Thank you for providing this recent work. We have now included this information within the habitat section, regarding high canopy cover and CSO, and have cited as personal communication.
4	4	Stephens	Habitat	P2, 2nd paragraph. It would be better to define what the wildland-urban interface is. Is this a set area from a minimum housing density?	We have now specified that this was referencing the definition in the Sierra Nevada Framework.
4	5	Stephens	Habitat	P 6, end of 2nd paragraph. Can you define forest edges more precisely?	We have added "with sharp contrast between habitat types." Phillips et al. 2010 called them "high contrast" edges.
4	6	Stephens	Fire	P 7, end of 2nd paragraph. If nesting habitat is burned with low intensity fire is this also beneficial? It would reduce fire hazards in this region including the PAC. Keeping PAC's with elevated fire hazards is not a strategy that will work long-term with increasing temperatures and more variable climate.	This is discussed in detail later in the summary of stressors, but low-mod severity fire appears to have no negative effects on PACs. We have added some information here regarding foraging habitat and heterogeneity within territories.
4	7	Stephens	Habitat	P 9, 1st paragraph. Course woody debris has been shown to be important but materials < 3 inches in diameter also contributes to fire spread and intensity. Large course woody debris is not as problematic from a fire perspective if it is distributed in clumps. If it is homogeneously distributed it will increase fire hazards and fire severity when the area burns.	We have added "large" to clarify this.
4	8	Stephens	Habitat	P 9, 2nd paragraph. California black oak is known to be an important species to CSO. This species is shade intolerant and therefore needs small openings to regenerate. Oak seedlings and saplings can stay alive in shade but they will never become dominant trees producing acorns and important habitat under shade. If oaks are important the report should address them specifically. Millions of oaks in the Sierra Nevada mixed conifer zone continue to be overtopped by conifers and they die when this occurs from a lack of light. The plan should address this important species.	While the draft did discuss oaks, it now calls out California black oaks more explicitly in the habitat section and objectives.

4	9	Stephens	Populations	P 11, end of first paragraph. The report notes that the only stable CSO population is in SEKI National Park. Chapter 5 led by Malcolm North in Gutierrez et al. (in press and in your citations list) asks the important question of how big does the CSO population need to be to conserve it? With forest change in the last 100 years this has probably led to increased percentages of the Sierra Nevada having high canopy cover and maybe the CSO has increased in abundance? This is an important scientific question.	Although North et al. (chapter 5) does briefly point to Weatherspoon 1992's comment that dense forests may have led to increased owl habitat, it is primarily speculation. We have added the comment in the section on current condition that we do not know what MVP is necessary nor historical population sizes. We have also now pointed to this in the objectives.
4	10	Stephens	Fire	P 13, middle of 1st paragraph. Moderate intensity fire will kill small and moderate sized trees, it won't remove them. The standing dead trees will remain standing for around 10 years then will fall over. Next sentence reads that high severity fire consumes small trees. Again it will kill them but consumption will not be complete.	Thank you for this clarification, we have modified appropriately.
4	11	Stephens	Forest management	P 16, first third of first paragraph. '…. In areas treated up to 58%...' Not sure what this is referring too.	We removed this part of the sentence and clarified "partially harvested".
4	12	Stephens	Climate change	P 19, 1st sentence. Better to write 3-6 degrees F	We have fixed this typo.
4	13	Stephens	Climate change	P 19, 2nd paragraph. Chapter 5 in Gutierrez et al. (in press) provides more information on the expected impacts of climate change on CSO habitat and documents some very challenging issues. It could be better integrated into this section.	We have integrated more of this information here now, as well as into the objective for climate change.
4	14	Stephens	Objectives	P 22, last paragraph. Creating a region-wide monitoring program and adaptive management plan for the CSO is a good idea but this should not delay the needed work to move forests to a more sustainable condition. If we wait for all of the 'answers' before we take large scale action to modify our frequent-fire adapted forests to increase their resilience and sustainability, wildfire and insects are going to change them right in front us.	We agree, and did not specify that forest management necessitated waiting for all the answers, and hence the importance of adaptive planning.
4	15	Stephens	Objectives	The vast majority of studies on the CSO have been correlations. They provide some information on the habitat needs of the CSO but they cannot tell us what are the most important habitat features. The only way to do this is through replicated field experiments where specific forest structures are modified and then the response of the CSO is addressed. We need more of this type of research and less of the correlative type.	We agree and point to this in the objectives; however we also recognize that attempts at this with SNAMP and similar have proven very challenging.

4	16	Stephens	Objectives	P 24, item 4 on this list. PACs may only occupy 5-9% of the productive lands but when you also add in the home ranges associated with the PACs the amount of area increases dramatically. We worked in the El Dorado CSO demography study area and when you add in the standard home ranges around each PAC it takes up > 50% of the area and some home ranges overlap. If > 50% of the landscape cannot be manipulated to increase resilience and sustainability then the only option is full fire suppression which will not be successful (Stephens et al. 2016b). The Report states that low intensity fire does not cause large declines in habitat features and patchy, mixed severity fire can be applied to home ranges and can provide some positive benefits. This produces a scientifically justified approach where mixed severity fire is allowed to work in at least the home ranges and this could be augmented by ecologically based mechanical treatments using the ICO concepts (Lydersen et al. 2013, Fry et al. 2014: Contrasting spatial patterns in active-fire and fire-suppressed Mediterranean climate old-growth mixed conifer forests. PLOS ONE 9(2): e88985). Low intensity fire could be applied to PACs when they are not occupied and this would increase their resilience (Stephens et al. 2016b).	We agree that low-moderate severity fire has not been shown to negatively affect owl PAC use, and fire can certainly help create owl foraging habitat. We did not intend to imply that PACs had to be entirely avoided by management, just to avoid negative impacts to owls (e.g. avoid mechanical thinning if/where it would negatively affect an owl). We have clarified this throughout the objectives.
4	17	Stephens	Objectives	P 24, item 6 is the list. Increased emphasis of fire control methods with more fuel breaks will not conserve the CSO and the forests they depend on. This is a fallacy. No number of fire fighters or aircraft will stop a wildfire that is burning in heavy continuous fuels on a bad fire weather day and the Report includes references that have shown fire severity is increasing in the Sierra Nevada (Miller and Safford 2012). The only way to conserve the old forests in the Sierra Nevada is to prioritize them for management actions to increase their resiliency to fire, drought, and insects (this is discussed in Stephens et al. 2016b).	We acknowledge this, but do think efforts to coordinate management across different landownerships is warranted because CSO live across ownerships. We have removed the emphasis on fuel breaks.
4	18	Stephens	Model	Methods/assumptions for conceptual model - This was done well overall.	Thank you.
4	19	Stephens	General	Objectives - This is the area of the Report that has problems. The Report does a very good job of setting the stage concerning the Background, Current Conditions, and Summary of Stressors regarding the conservation of the CSO but then there is a discount of this information in the Conservation Objectives. (Note - see full review for description)	Please see responses to reviewer 4 comments 20-22.
4	20	Stephens	Objectives	With this scientific background I do not understand how a system of PACs and other connected habitat throughout the range of the SPO is the best idea to conserve the CSO? How is this different from the present strategy that is not working? I am afraid that this will lead to more large high severity fires that will continue to erode important CSO habitat. With the recent large scale forest mortality in the southern and central Sierra Nevada that killed the largest trees, CSO habitat is even more vulnerable than what is presented in Stephens et al. 2016b.	While we recognize the need for a resilient forest, and appreciate this comment, PACs remain the most consistently used areas by CSO and contain some of the largest, oldest trees, which are known to be essential for nesting. Protected areas for owls that maintain elements related to owl success will be important so that mechanical thinning in the name of fuels reduction does not unintentionally eliminate owl habitat at a faster rate than it can be grown. The report is careful now not to suggest that PACs need to be completely hands-off management, but rather minimize negative disturbance to owls. Additionally, protected areas do not need to continue to be through PACs as previously defined, but some protected areas and habitat characteristics are important.

4	21	Stephens	Objectives	The only logical scientific conclusion is to focus on ideas that will conserve and create the old, mature forests in the Sierra Nevada so they can provide the benefits to the CSO and other species. The report concludes with the following sentence: 'To support long term persistence of California spotted owls, it will be important to manage for forests that are resilient to fire and climate change while still maintaining essential habitat elements.' I agree with this closing sentence but the Conservation Objectives section emphasizes the CSO first and then the forest.	We agree this report emphasizes the CSO first, as it is intended to be from the perspective of the owl. The objectives for the owl as written are not intended to hamper forest ecologists from recommending land-specific management strategies for long-term forest resilience. We also recognize that there is still some dichotomy (acknowledged in this report) between owl ecologists and forest/fire ecologists on prioritizing known needs for CSO and for the forest ecosystem.
4	22	Stephens	Objectives	The long term conservation of the CSO will only occur if the forests of the Sierra Nevada and southern California are managed sustainability. This does not have to emulate historical conditions but could include the idea of Realignment (Stephens et al. 2010, Operational approaches to managing forests of the future in Mediterranean regions within a context of changing climates. Environmental Research Letters 5: 024003.). Realigning forests implies modifying forests to present and/or future conditions which can be quite different from the past. This could focus on the production of large, old trees with clumps of denser forests in topographical positions that are more likely to support these structures as suggested on Pg 27 under the Climate change section and North et al. 2009.	We have further emphasized the importance of forest sustainability, and added some of this additional information in the objectives (including Stephens et al. 2010).
4	23	Stephens	Objectives	I believe the Conservation Objectives section should be substantially revised to emphasize the creation and maintenance of the needed forests that then can provide important habitat for the conservation of the CSO long-term. Large, old trees have been shown to be a critical component of CSO habitat; this should be emphasized in a strategy to conserve the CSO. I see no way to scientifically justify a continued emphasis of PACs and connected habitat as the best idea to conserve the CSO long-term.	Thank you, please see responses to reviewer 4 comments 20 and 21.
5	1	Peery	General	This looks really good - nice job on some tricky topics. Only very minor comments attached.	Thank you.
5	2	Peery	Habitat	p. 4 - Peery et al. 2013	We re-checked the citation.
5	3	Peery	Demographic parameters	p. 5 - Maybe issue the caveat that studies were based on recaptures of banded birds rather than radio-telemetry.	We have added this caveat.
5	4	Peery	Demographic parameters	p. 6 - But Franklin 2001 points out that since repro is more variable can be more influential to population growth than survival	Thanks for pointing this out, we have now highlighted this important finding.
5	5	Peery	Habitat	p. 7 - I might just simplify and call it forests characterized by both large trees and high canopy cover.	We have simplified this as suggested.
5	6	Peery	Habitat	p. 7 - I don't think it is necessarily the case, the Tempel study also found that heterogeneity was important. This study actually tested for habitat diversity and didn't find a relationship.	We have now further explored both studies here - highlighting that the Tempel study did not find an effect of heterogeneity on occupancy in CSO, but the Franklin study found one on fitness in NSO.
5	7	Peery	Prey	p. 8 - Maybe make it clear that PG's are second in importance because they replace FS at low elevations and WR at high elevations.	We have clarified this difference.
5	8	Peery	Populations	p. 11 - There is a more recent demography paper by Mary Conner in Ecosphere.	Thank you, we have updated the table with the most recent paper.

5	9	Peery	Populations	p. 11 - Make it more clear that it is just that the proportion of singles appears to be increasing, not that it exceeds the proportion of pairs	We have clarified this.
5	10	Peery	Forest management	p. 16 - It wasn't so much that treatments led to a decline in demographic rates, but territories with less high CC forest had lower demographic rates. Territories could have less high CC for a range of reasons, one of which is forest management.	We have clarified this discussion.
5	11	Peery	Forest management	p. 16 - Important to recognize that fire and treatments were combined in this study so one cant isolate treatments impacts.	We have added this caveat.
5	12	Peery	Forest management	p. 21 - I would think drought-related mortality would be considered a roughly equal stressor.	While we agree that this may end up being the case, because of how recent the tree mortality is, we do not know how important a stressor it will become to CSO. We have emphasized that it is likely to become important (possibly in the near future).
5	13	Peery	Habitat	p. 21 Insert "partly".	We have inserted this.
5	14	Peery	Forest management	p. 23 - SNAMP and other attempts at experimentation indicates that this is really, really tough to do.	We agree, and have further acknowledged this challenge.
6	1	Lee	General		We thank the reviewer for his comments. This review differs substantially from the 5 other peer reviews of this document in both its scope and apparent intent. We respectfully submit the reviewer may have somewhat misunderstood the nature of this report. This is not a regulatory or listing document, nor is it meant to exhaustively cite all tangential information. Rather, this report's stated goal was to summarize the most relevant science, and develop broad conservation objectives for CSO. Many of this specific reviewer's comments thus were not necessarily applicable, though we have endeavored to respond to each below.
6	2	Lee	General	No, you have not assembled and considered the best available scientific and commercial information relevant to the species. I recommend USFWS perform its own independent, transparent, and thorough systematic review of the evidence from primary literature pertaining to: 1. Fire and owls; 2. Logging and owls; 3. California fire regimes and the ecological communities dependent upon high severity fire; and 4. Efficacy of fuels thinning treatments on large, high-severity fire behavior.	This report discusses and summarizes the most important, current, and relevant information regarding fire and owls, logging and owls, California fire regimes, and thinning treatments. However, the report does not attempt to address the specifics of different fuels thinning treatments, as that analysis is not within the scope of this document. This report was independently developed by the Service incorporating the best available science, including soliciting information from a wide-range of interested parties, and conducting independent external peer review.

6	3	Lee	General	No, the methods and assumptions used in deriving the California Spotted Owl conceptual model were not clear or logical. The conceptual model is also wrong in many aspects of its structure and purported effects (see detailed comments below). Furthermore, the underlying assumptions of the model were not supported by the best available science, for example there was a generic assumption that large, high-severity fires are inherently harmful even though the scientific literature does not support such a broad assumption. Similarly, there is an assumption that fuels thinning to address fire severity is necessary to conserve owl populations whereas the literature regarding thinning impacts (see e.g., Tempel et al. 2014, Stephens et al. 2014) and the population data (see e.g., Conner et al 2013, Conner et al. 2016, Tempel et al. 2016), all showing that only on lands where thinning does not occur (National Parks) are owls stable, strongly suggesting that thinning is a major stressor. Further, the literature regarding the efficacy of thinning shows that it is not always effective at reducing fire severity (see e.g., Lydersen et al. 2014), and the literature regarding historical fire is much broader than was discussed in the report (see e.g., Baker 2014). These issues must be more fully addressed to effectively manage owl conservation.	We agree that the model developed in this report is certainly not the only way one could potentially examine factors related to CSO. Indeed, this is not a quantitative model in any sense, but rather a visual representation of the complexity of the system. We have clarified this in the report. As supported in the report, large, high-severity fire is a potential serious stressor for owl habitat loss. Please note that this does not suggest that fire in and of itself is a negative stressor for owls. The model also indicates mechanical thinning to be a potential stressor, and the report acknowledges and discusses that mechanical thinning alone is not likely to move toward a resilient forest. The report also discusses differences in management on the national park and the three national forest study areas in the Sierras. Furthermore, we agree that the report draft failed to acknowledge the other literature regarding historical fire in the Sierras. This report now incorporates this, although does emphasize that the majority of scientific literature supports the regime already discussed (please see response to reviewer 3 comment 2).
6	4	Lee	General	The 'best available science' was not used in the report. The best available science does not support many of the proposed conclusions and conservation objectives. Many of the proposed conclusions and conservation objectives in the report could not be reasonably drawn from the best available science. Rather, the conclusions and objectives, such as with respect to fire and logging, are likely to exacerbate the owls' decline rather than arrest it. I discuss these problems below and respectfully urge the USFWS to better address these problems to avoid repeating the mistakes of the past that have led to the owl's current situation. As just one example, spotted owl abundance on the Eldorado demographic study area declined by about 50% and occupancy declined by about 30% largely in the absence of fire (Tempel et al. 2014). Yet this report is focused on high-severity fire rather than logging as the primary stressor/problem for CSO. This disconnect must be corrected, and the decline more carefully addressed, if CSO is to recover on USFS lands. The 'best available science' should consist of transparent, systematic reviews of the evidence from primary literature, not narratives developed from a non-exhaustive selection of the literature.	This report discusses both large high-severity fire and types of forest management as potential stressors for CSO. The report also points to differences in management between NPS and USFS lands and how that may have contributed to differences in the population trends. The report summarizes the evidence from the primary literature in both cases.
6	5	Lee	General	General comments: 1. "will almost certainly not stop California Spotted Owl (CSO) population declines because it does not sufficiently address harm from logging, especially logging in the name of fire risk reduction, which was a main threat cited in both of the listing petitions filed in 2015."	The report discusses how logging can be a stressor, but for the purposes of this report, logging is too broad of a term- it can be divided in many different ways based on purpose, scale, techniques, etc. This report chose one way to split logging into 3 practices that can be potentially stressful, have data available regarding their effects, and are represented in the model.
6	6	Lee	General	2. "is incomplete, likely due to its reliance upon a General Technical Report (GTR) by the USDA Forest Service (Conservation Assessment draft dated 27 July 2016 by Gutiérrez et al. in press) for its evidence"	This report does draw substantially from the peer-reviewed scientific assessment (Gutiérrez et al. 2017), but that is certainly not the only reference. The assessment is the most recent collection of the scientific literature to date.

6	7	Lee	General	3. "I strongly recommend the USFWS adopt a transparent, evidence-based decision-making process for the COR wherein the methods used for a systematic literature review and weighing of the evidence for conservation goals and objectives is explicitly stated (see e.g., Sutherland, W. J., Pullin, A. S., Dolman, P. M., & Knight, T. M. 2004. Pullin, A. S., & Knight, T. M. 2009.)"	The development of this report, as a non-regulatory document, aimed at proactive conservation, has been a transparent process including soliciting information from interested parties as well as undergoing this peer review.
6	8	Lee	Forest management	4. "I focus my attention in these comments primarily on management of USFS lands because USFS manages most of the available forest lands within the range of CSO, but their past and current management has led to population declines across all studied CSO populations on USFS lands while NPS lands are currently managed in a manner that sustainably conserves CSO populations (Conner et al. 2013, Tempel et al. 2016). In the COR, there is insufficient presentation of the data describing the negative effects of past and current logging for forest management goals of timber, fire suppression, forest health, restoration, or other monikers the USDA Forest Service (USFS) gives and has given to logging projects."	The reviewer's focus on USFS lands is noted, but the report is focused on CSO range, not ownership-specific lands. We have now further highlighted in the COR that differences in past management could have lead to different population trajectories. The report also discusses the nuances of forest management and techniques.
6	9	Lee	Forest management	5. "The preponderance of evidence shows large, high-severity forest fires are not a serious threat to the persistence of Spotted Owl populations in California, and actually provide a net benefit (see comments below and attached table summarizing fire and owl studies). The evidence also shows logging that removed large trees and reduced canopy cover was the primary reason the Northern Spotted Owl was listed, and the reason the California Spotted Owl has been petitioned for listing."	As discussed within the report and several of these responses, large, high-severity fire is likely to contribute to habitat loss if forests are not managed sustainably - which includes restoring an active fire regime of low-moderate and mixed-severity fire.
6	10	Lee	Fire	6. "The historical and pre-historical context given to the current CSO habitat situation vis a vis fire was an incomplete review of fire ecology literature. Based upon an extensive reading of the literature, I believe that large patches of high-severity burned forest has always been a part of the dynamic Sierra Nevada and SoCal forest ecologies." (Pierce et al. 2004, Power et al. 2008, Marlon et al 2012),	We agree the draft did not acknowledge the literature regarding alternative historical fire regime. We have now included this in the section on fire.
6	11	Lee	fire	7. "My attached table summarizing all published literature on Spotted Owls and fire (16 peer-reviewed papers) shows clearly that mixed-severity fires, including so-called megafires with large patches of high severity fire, that have burned during the past 20 years have mostly no significant effect on Spotted Owls"	Yes, the COR discusses how low-moderate and mixed-severity fire, as evidenced by multiple studies, do have "mostly no significant effect" on spotted owls. However, as suggested in Eyes 2014, Tempel et al. 2014, Jones et al. 2016, and Rockweit et al. 2017, large patches of high-severity fire can negatively affect spotted owls. Additionally, large, high-severity fire may result in future habitat loss.
6	12	Lee	Forest management	8. "Logging is the primary reason the Spotted Owl has declined, and additional logging, even logging which is called fuels thinning, is extremely unlikely to contribute meaningfully to conservation or recovery. Furthermore, 100% of the published peer-reviewed papers on owls and fire that looked at salvage logging found large, significant, negative effects from salvage logging on Spotted Owls. See also: Lindenmayer, D.B., Burton, P.J. and Franklin, J.F., 2012. Salvage logging and its ecological consequences. Island Press."	The report acknowledges historical logging, and discusses several types of logging that currently can be or become stressors to owl populations. The COR also points out areas of uncertainty, such as the confounding effects from salvaging logging and fire. The objectives in the COR were developed using the most current and widely accepted science to describe and develop broad objectives.

6	13	Lee	Forest management	9. "There was no evidence presented in the COR that describes the effectiveness of thinning at altering fire behavior or more importantly, the extent of high-severity fire on the landscape, especially under severe weather conditions." There was no evidence presented in the COR that describes the effectiveness of thinning at altering fire behavior or more importantly, the extent of high-severity fire on the landscape, especially under severe weather conditions." "See: Kalies, E.L. and Kent, L.L.Y., 2016. Tamm Review: Are fuel treatments effective at achieving ecological and social objectives? A systematic review. Forest Ecology and Management, 375, pp.84-95"	It is beyond the scope of this report to describe the effectiveness of all forms of forest management. However, we do note that mechanical thinning alone is unlikely to promote forest sustainability and encourage use of prescribed fire.
6	14	Lee	General	10. "My interpretation of the best available science indicates that: (1) private lands logging degrades Spotted Owl habitat; (2) thinning fuels treatments on USFS lands degrades nesting, roosting, and foraging habitat and reduces California Spotted Owl occupancy; (3) post-fire salvage logging on private and USFS lands degrades nesting, roosting, and foraging habitat and reduces California Spotted Owl occupancy and survival; (4) California Spotted Owls are clearly declining, except in Sequoia/Kings-Canyon National Park, which has been almost entirely protected from thinning fuels treatments and post fire logging for decades; and (5) CSO nesting and roosting habitat (old growth forest characterized by large trees and high canopy cover) is naturally resistant to high-severity fire (Weatherspoon and Skinner 1995, Odion et al 2004, Bond et al 2009a). Thus, logging is most likely the primary driver of historical and current Spotted Owl population declines and is the most significant threat to the subspecies' existence. Therefore, recovery plans and objectives should be primarily focused on eliminating or reducing logging, including fuels thinning, throughout the range of the CSO."	We acknowledge that peer reviewers did not agree on all points and as such, the report has striven to incorporate some of the nuances and complexity of the science, particularly regarding fire and owls. Specifically, the report now acknowledges differing views on fire regimes (please see response to reviewer 6 comment 10). Also, this report is aimed at proactive conservation and is not a regulatory document nor a recovery plan.
6	15	Lee	Forest management	11. "The notion that logging will somehow overcome the global climate change currently underway and avert large, high-severity forest fires is unsupported by the evidence."	This comment does not accurately reflect the report.
6	16	Lee	Forest management	12. "Another aspect of thinning and logging that was not mentioned in the COR document is the genetic variation among trees that is the raw material for forest adaptation to a changing climate (Kolb et al. 2016, Prunier et al. 2016, Pinnell 2016)."	As this is not a forestry document, this is not within the expertise of this report (please see response to reviewer 6 comment 13).
6	17	Lee	Forest management	13. "It is clear to me that the different land management policies, especially during the past 50 years, between USDA Forest Service (USFS) lands and National Park Service (NPS) lands has directly contributed to the differing population trajectories for CSO on those two land management types."	The report discusses how differences in historical management of NPS and USFS has contributed to different amounts of current available habitat. The report also acknowledges new research that indicates the decline of owls in the last 20 years may be the result of a lag effect from past management.
6	18	Lee	General	Specific comments: 1. "The GTR is a non-peer-reviewed technical report that was prepared by and for the USDA Forest Service, which has an explicit conflict of interest in the matters of fire, logging, and wildlife conservation due to the fact that the majority of the USDA Forest Service's budget is directly linked to fire suppression and logging."	The GTR is a peer-reviewed USFS report. As the COR presents the current best available science, the GTR is part of the best science available.
6	19	Lee	General	2. Use specific methods for systematic reviews.	We agree it is one of several ways to conduct a literature review, though not the method used here.

6	20	Lee	General	3. “Due to the complex and dynamic relationships among fire, timber management, and owl habitat, developing strategies that conserve spotted owl habitat and support sustainable forestry management are essential.” I suggest you delete this sentence. Why is a strategy that supports forestry on public lands essential?”	We have removed this sentence. However, because CSO live on public and private lands, FWS has determined that effective conservation objectives must reflect the on-the-ground reality of how these lands are managed (multiple use, private timberlands, etc.).
6	21	Lee	Habitat	4. “Sections 2.2, 2.3, and 2.4 refer almost exclusively to the breeding-season territories.”	We agree, these sections refer to the breeding season territories because that is where the vast majority of data comes from.
6	22	Lee	Habitat	5. “Breeding territories are not a sufficient proxy for year-round habitat requirements and relying on protections only in breeding areas will vastly underestimate the area and habitat requirements needed to conserve and recover CSO. Equal space and attention should be added that describes the habitat characteristics and importance of fall- and winter-season ranges, and how poorly CSO habitat needs during these critical seasons are understood. Applying the precautionary principal would suggest applying strong protections for year-round home ranges from unnatural habitat alterations, as the minimum guideline for recovery.”	We have issued a caveat regarding the uncertainty and lack of information about non-breeding habitat use. We have also clarified that the 1000 acre approximation is typically for breeding territories.
6	23	Lee	Habitat	6. ““As central place foragers, Spotted Owls spend a disproportionate amount of time near their territory center, or core“. This is an important fact, and underlies why the breeding-season foraging habitat selection portions of Williams et al. 2011 and Jones et al. 2016 studies are flawed in their analytical methods.”	We do note that spotted owls are central place foragers, but that does not negate the utility of including information from Williams et al. 2011 and Jones et al. 2016.
6	24	Lee	Habitat	7. “The above-mentioned reality about breeding-season foraging behavior (central place foraging) should not be used to downplay the importance of the larger, year-round home range habitat needs of Spotted Owls.”	We have noted the uncertainty about year-round habitat use in the COR.
6	25	Lee	Habitat	8. Section 2.2, last paragraph – “These results speak to the importance of reproduction and owl movements across the landscape and the critical nature of matrix habitat between and among nesting sites to permit and encourage natal and breeding dispersal movements. This leads to the conclusion that owl habitat needs to be managed at a much larger scale than the 300-acre PAC currently guiding CSO management in USFS lands. Much larger areas around all known historical owl breeding sites, on the order of 6000 ac around nests (mean year round home-range size), should be protected from logging to the maximum extent possible and allowed to naturally succeed towards old growth conditions.”	The COR acknowledges the uncertainty about the amount of different types of habitat that the owl requires for success. The objectives are developed from the current best available science.
6	26	Lee	Fire	9. “Sec 2.3: This should be rewritten to say: “Areas that have been burned at all severities, but especially at moderate and high severity, provide valuable foraging habitat and heterogeneity within territories (Bond et al. 2009, Bond et al. 2016, Eyes et al. 2017).”	This section now more highly emphasizes the importance of a range of fire severities for foraging.
6	27	Lee	Prey	10. “Sec. 2.4: This section should be rewritten following a comprehensive literature review. It omits the rich and informative literature about small mammals and fire which finds in almost every case, some species of small mammal populations increase after fire, and including specific studies of owl diet after fire e.g. Bond et al. 2013 “Diet and home range of owls in burned forest”.”	We have considered this suggestion and added Bond et al. 2013.

6	28	Lee	Forest management	11. Sec 3, paragraph 2: "The second sentence above should be replaced with: "Management of USFS lands at the scale of the 300-ac PAC has not averted observed population declines, so clearly protecting 300 ac of best available habitat (mature forest) near the nest is not a sufficient spatial scale for habitat protections promoting CSO conservation or recovery. It is clear from the evidence that in order to conserve CSO, much larger areas of USFS lands must be managed in a manner similar to NPS lands with little or no logging (including thinning) and more wildland fire use. We recommend 6000 ac around all known historical owl breeding sites be protected from logging to the maximum extent possible and allowed to naturally succeed into old growth conditions."	The report does not discuss PAC size, but rather that the locations and use of protected areas remains important. The report, in its intention to be broadly applicable, does not state a required acreage for protected areas, but presents available information regarding important habitat characteristics. The report discusses the differences in management between NPS and USFS lands, but also recognizes different mandates and restrictions among land managers.
6	29	Lee	Populations	12. Sec 3, paragraph 3: "This evidence, along with the lower CSO bulk density estimates from private lands, is compelling and should be the starting point and defining evidence for the COR."	The crude density estimates are highly variable across the study areas and land ownerships, not lower only on private lands.
6	30	Lee	Populations	13. Sec 3, paragraph 4: regarding the causes of decline not being conclusively identified – "There is ample evidence from the best available science that the populations of all three subspecies have declined due to widespread historical and ongoing habitat loss, primarily from logging large, old trees favored by the owls for nesting and roosting (USFWS, 2011, 2012; Conner et al. 2013; Tempel and Gutiérrez 2013)."	Although CSO have declined from the early 1990s on the three national forest study areas, we know little about historical population sizes, and have noted this uncertainty in the revision. The report recognizes the importance of large old trees, in particular with some of the newest available science.
6	31	Lee	Fire	14. "Sec 3, last paragraph: There have been studies showing that suitable habitat is not being diminished over the long term by fire. Please perform a thorough review of the primary literature."	Please see responses to reviewer 6 comments 9 and 11.
6	32	Lee	Fire	15. Sec 4 on large, high-severity fires and fire regime – same comment as 14	Please see responses to reviewer 6 comments 9 and 11.
6	33	Lee	Forest management	16. Stressors – "Logging has been, and continues to be the primary stressor and cause of Spotted Owl population declines." This comment is primarily copied from listing petition.	Please see earlier responses about logging (responses to reviewer 6 comments 12, 13, and 28).
6	34	Lee	Fire	17. Owls and fire – included Lee's personal review – "largely taken from the Gutiérrez et al. 2016 GTR which was insufficient for conservation planning"	While the CSO assessment is referenced heavily in this report, it is certainly not the only reference. Please also see response to reviewer 6 comments 10, 11, and 14.
6	35	Lee	Forest management	18. Forest management practices – "This section is incomplete. There is no mention of wildland fire use and only 1 sentence on prescribed fire."	The report encourages use of fire in forest management, but notably the draft did not overly focus on it because it is not considered a stressor. Please see responses to reviewer 6 comment 40.
6	36	Lee	Forest management	19. "Where is the discussion of the effectiveness (or ineffectiveness) of logging treatments to affect fire behavior?"	Please see response to reviewer 6 comment 13.
6	37	Lee	Fire	20. Tree mortality – "This section is without necessary context over longer time frames of millennia. It also fails to mention the myriad ecological benefits that propagate through the ecosystem during and after beetle outbreaks. I suggest additional discussion about how insect and drought driven mortality has accomplished thinning and heterogeneity goals. Also worth adding is the many papers showing mortality does not affect fire severity."	Tree mortality is discussed as a stressor in terms of the recent massive tree mortality events, not the typical and historically smaller scale tree mortality events.
6	38	Lee	Climate change	21. "Please perform a thorough review of the evidence for climate-change effects on California forest ecosystems and portray the breadth of knowledge and areas of uncertainty."	We note this is a summary and focused on the papers most directly relevant to CSO.

6	39	Lee	Model	22. "Conceptual model : The conceptual model has many serious flaws in its structure rendering it not useful in its current form. Furthermore, there is very little explanation of the construction and utility of the model."	We have incorporated the following suggestions into the model: 1) removing floaters because that was a confusing term and not a population parameter, 2) clarifying the large/very large trees, 3) fixing the arrow colors between a couple stressors. However, as other reviewers found the model to be well done and a useful visual tool, we have kept it within the report. We have further clarified its purpose though, which was primarily as one way to attempt to disentangle a complex system of effects, and not a quantitative exercise.
6	40	Lee	Fire	23. "Why is there no mention of wildland fire use and prescribed fire? Also, it seems clear to me that managing for PACs has not been sufficient and has led to the CSO decline on USFS lands. I propose protecting 6000 ac around every nest and minimizing logging and thinning within this CSO year-round home range ecological conservation zone."	We agree the draft did not include enough information on the use of fire in management, which was an oversight. The report focused on potential stressors, which as discussed, do not include managed fire and low-moderate and mixed severity fire. We have corrected this oversight and emphasized the potential positive benefits of fire use.
6	41	Lee	Forest management	24. ""There is an urgent need to reduce the likelihood of forest ecosystem conversion to chaparral." This is an unsupported sentence."	We have removed this sentence from this section of the COR and clarified the importance of a resilient landscape for the future of CSO.
6	42	Lee	Fire	25. "Fire is not a serious risk to Spotted Owl populations, so a fire risk assessment of PACs may not be the best use of resources. What is needed is protections from logging within 6000 ac around every nest and subsequent demographic monitoring to determine effects of this protection."	Large, high-severity fire is a potential stressor to CSO, and therefore habitat analysis of PACs for the purposes of future planning under climate change scenarios should take that into account. Please see response to reviewer 6 comment 28 regarding size of PACs.
6	43	Lee	General	26. "The COR and its conservation objectives should be derived from a transparent and systematic review of the evidence, weighted for reliability." …. "I strongly recommend a focus on actual results of empirical studies, not on the studies' interpretations especially if a study was funded by an agency with a conflict of interest."	Please see responses to reviewer 6 comments 1, 2, and 3.
6	44	Lee	Fire	27. "Re: Jones et al. 2016: This paper is filled with fatal errors of analysis that render it useless as evidence of the relationship between owls and fire."	This peer-reviewed paper was published in a well-respected journal and the information is directly applicable to the development of the COR.

Kirby, Rebecca <rebecca_kirby@fws.gov>

Fwd: Interest and Availability for Potential Peer Review - re: California Spotted Owl

Kirby, Rebecca <rebecca_kirby@fws.gov> Tue, Oct 24, 2017 at 1:00 PM
To: Rebecca Kirby <rebecca_kirby@fws.gov>

---------- Forwarded message ----------
From: **Malcolm North** <mnorth@ucdavis.edu>
Date: Tue, Aug 1, 2017 at 10:11 AM
Subject: Re: Interest and Availability for Potential Peer Review - re: California Spotted Owl
To: "Russell, Daniel" <daniel_russell@fws.gov>
Cc: Kim Turner <kim_s_turner@fws.gov>, Becky Miller <becky_miller@fws.gov>

Dan,
Attached is a CV, Conflict of Interest form and a copy of the paper with my comments imbedded using track changes. Overall this is very well done and covers much of the literature thoroughly. You've missed the following 2 citations which I think have useful information regarding management issues and options:

North, M.P., Schwartz, M.J., Collins, B.M., and Keane, J.J. 2016. Current and projected condition of mid-elevation Sierra Nevada forests. Chapter 5, pages 109-158 in Bioregional Assessment of the California Spotted Owl. USDA Forest Service, PSW-GTR-254.

Peery, M.Z., Gutierrez, R.J., Manley, P.N., Stine, P.A. and North, M.P. 2016. Synthesis and interpretation of California spotted owl research within the context of public forest management. Chapter 9, Pages 216-237 in Bioregional Assessment of the California Spotted Owl. USDA Forest Service, PSW-GTR-254.

You do cite the whole work at Gutierrez et al. 2016 but the GTR is made up of 9 chapters which have more specific topics.

I think its worth distinguishing between canopy closure and cover. I've inserted a comment about this in the manuscript as well as relevant citations.

In general canopy cover has been roughly/poorly measured in many studies and therefore the high levels report are confounded with many structural attributes. In particular we examined this issue in a paper under review and found its the cover in tall trees that matters, not total canopy cover. See:

Malcolm North[1], Jonathan Kane[2], Van Kane[2], Gregory P. Asner[3], William Berigan[4], Derek Churchill[2], Scott Conway[5], R.J. Gutiérrez[4,6], Sean Jeronimo[2], John Keane[1], Alex Koltunov[5,10], Tina Mark[7], Monika Moskal[2], Thomas Munton[8], Zachary Peery[4], Carlos Ramirez[5], Rahel Sollmann[9], Angela White[1], Sheila Whitmore[4]

In review. Cover of tall trees best predicts California spotted owl habitat. Forest Ecology and Management.

Thank you for the opportunity to review.

Malcolm North, PhD
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Caring for the land and serving people

Lab website: http://northlab.faculty.ucdavis.edu/

From: "Russell, Daniel" <daniel_russell@fws.gov>
Date: Friday, July 21, 2017 at 11:39 AM
To: Malcolm North <mnorth@ucdavis.edu>
Cc: Kim Turner <kim_s_turner@fws.gov>, Becky Miller <becky_miller@fws.gov>
Subject: Re: Interest and Availability for Potential Peer Review - re: California Spotted Owl

Dear Malcolm:

As we discussed previously the U.S. Fish and Wildlife Service (Service) is soliciting independent scientific reviews of the information contained in our 2017 *Draft* Conservation Objectives Report (COR) for the California Spotted Owl (attached). Once finalized, this COR will be used to assess the needs of the California Spotted Owl, develop conservation objectives, and make recommendations to reduce or ameliorate any potential stressors acting upon the species. The purpose of the report will be to provide guidance to ongoing and prospective collaborative conservation efforts.

This request is provided in accordance with our July 1, 1994, peer review policy (USFWS 1994, p. 34270) and our current internal guidance. This request also satisfies the peer review requirements of the Office of Management and Budget's "Final Information Quality Bulletin for Peer Review." The purpose of seeking independent peer review is to ensure use of the best scientific and commercial information available; to ensure and maximize the quality, objectivity, utility, and integrity of the information upon which we base Service actions. Please let us know if you would like us to provide any of the referenced materials to help facilitate your review.

Please note that we are not seeking advice on policy or recommendations on the legal status of the species. Rather, we request that peer reviewers focus their review on identifying and characterizing scientific uncertainties, and on ensuring the accuracy of the information in the COR. Specifically, we ask peer reviewers to focus their comments on the following:

1. Have we assembled and considered the best available scientific and commercial information relevant to the species? If any instances are found where the best available science was not used, please provide the specific information with literature citation.

2. Are the methods and assumptions used in deriving the California Spotted Owl conceptual model clear and logical? If not, please identify the specific methods or assumptions that are unclear.

3. Does the best available science used in the report support the proposed conclusions and conservation objectives? Were they reasonably drawn from the information used in the report?

Our updated peer review guidelines also require that all peer reviewers fill out a conflict of interest form. We will carefully assess any potential conflict of interest or bias using applicable standards issued by the Office of Government Ethics and the prevailing practices of the National Academy of Sciences (*http://www.nationalacademies.org/coi/index.html*). Divulging a conflict does not invalidate the comments of the reviewer; however, it will allow for transparency to the public regarding the reviewer's possible biases or associations. If we receive comments from a reviewer that we deem to have a substantial conflict of interest, we will evaluate the comments in light of those conflicts, and may choose not to give weight to those comments if the conflict is viewed as problematic. You may return the completed conflict of interest form either prior to or with your peer review.

So that we may fully consider any input and coordinate other peer review comments as we develop the final COR, we are requesting written peer review comments by letter or email by August 7th, 2017.

I have attached both a pdf version of the document, as well as a Word version. The Word version is being provided in case you find it easier to provide comments within the document itself. However, if you would like to do this, please do so in track changes. We would also appreciate receiving a copy of your Curriculum Vitae for our records.

If you have any questions about the COR, please feel free to contact me at any time at (916) 978-6191. Please submit your comments and associated materials to the contact information below.

Thank you for your consideration.

Sincerely,

Dan Russell

****
Daniel Russell - Regional Listing Coordinator
Pacific Southwest Regional Office, Region 8
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2606
Sacramento, CA 95825
Office (916) 978-6191
Cell (916) 335-9060
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3 attachments

Malcolm North CV July 2017.doc
97K

20170720_CSO_COR_DRAFT with Malcolm North comments.docx
3517K

Malcolm North Conflict of Interest Disclosure Form_template (1).pdf
69K

California Spotted Owl
(*Strix occidentalis occidentalis*)
Draft
Conservation Objectives Report
July 2017

Photo by Tim Demers. Used with permission.

US Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Pacific Southwest Region

TABLE OF CONTENTS

1. BACKGROUND AND PURPOSE

The California spotted owl (*Strix occidentalis occidentalis*) occurs on public forestlands and private timberlands throughout the Sierra Nevada and southern forests in California. In 2015, the U.S. Fish and Wildlife Service received two petitions to list the California spotted owl (CSO) under the Endangered Species Act of 1973, as amended. The Service's initial evaluation in our 90-day finding, published in the Federal Register on September 18, 2015, found that the petitions presented substantial information indicating that the petitioned action may be warranted. The species will undergo a full status review, with a listing decision due before September 30, 2019. The Service and other agencies are currently working on multiple CSO conservation efforts. To assist in informing these efforts, the Service developed this California spotted owl Conservation Objectives Report (COR).

Due to the complex and dynamic relationships among fire, timber management, and owl habitat, developing strategies that conserve spotted owl habitat and support sustainable forestry management are essential. The goal of this Conservation Objectives Report is to describe the ecological needs of CSO, identify and summarize the current and future stressors to viability of the species, and develop broad range-wide conservation objectives to assist in the development of ongoing and future conservation efforts. For the most recent thorough scientific assessment of CSO and its stressors, please refer to the U.S. Forest Service Pacific Southwest Research Station's Conservation Assessment from July, 2016 (Gutiérrez et al. in press). This COR draws substantially from this assessment as well as subsequent emerging research and information received in response to our March 17, 2017, letters sent via email to a wide range of interested parties requesting current information relevant to CSO. The goal of this COR is not to be prescriptive, but rather to identify ecologically relevant goals to guide the development of regional conservation strategies and other conservation efforts for CSO.

2. CALIFORNIA SPOTTED OWL ECOLOGY

2.1 Range and distribution

California spotted owls are continuously distributed throughout the forests of the western Sierra Nevada mountains in California, from Shasta County south to the Tehachapi Pass (Verner et al. 1992). The drier eastern side of the Sierras supports limited amounts of CSO habitat and relatively fewer CSO than the western slopes. California spotted owls also occur in southern and central coastal California (hereafter referred to as southern California), with a gap in their distribution between the Sierras and southern California forests (Verner et al. 1992). The CSO can be found at 1,000 – 7,700 ft. elevation in the Sierras, and up to 8,400 ft. in southern California (Verner et al. 1992). Just north of Lassen Peak to south of the Pit River, the range of the CSO transitions into that of the Northern spotted owl (NSO) (Barrowclough et al. 2011).

The American Ornithological Union currently recognizes three genetically distinct subspecies of spotted owl: California spotted owl (*Strix occidentalis occidentalis*), Northern spotted owl (*Strix occidentalis caurina*), and Mexican spotted owl (*Strix occidentalis lucida*) (Haig et al. 2004) (Figure 1). Relative to the other two subspecies, CSO exhibit low genetic variation (Barrowclough et al. 1999), although no negative effects of inbreeding have been found (Funk et al. 2008). Additionally, the Sierra populations are distinct from the southern California populations due to a lack of gene flow (Barrowclough et al. 1999, Haig et al. 2004, Barrowclough et al. 2005, Funk et al. 2008). California spotted owls in southern California are assumed to function as a metapopulation, though little movement has been recorded between isolated mountain populations (LaHaye et al. 1994, Barrowclough et al. 2005, LaHaye and Gutiérrez 2005). Because the three subspecies of spotted owls share many habitat and behavioral characteristics, for the purposes of this COR "spotted owl" refers generally to all three subspecies.

In the Sierras CSO are primarily found in mature, multi-layered mixed-conifer and yellow pine forest (80-90% of known sites), but also in red fir and riparian/hardwood forests (Verner et al. 1992). About half of known territories are within or adjacent to the wildland-urban interface (Blakesley et al. 2010). In southern California, habitat availability is more restricted and fragmented, so CSO are more frequently found in forests other than mixed-conifer, likely because mixed-conifer is only present at the highest elevations (Verner et al. 1992).

Figure 1. Approximate ranges for the three spotted owl subspecies (from NatureServe data).

2.2 Territoriality and reproduction

The spotted owl is a medium-sized brown owl with a mottled appearance, round face, large pale brown facial disks, dark brown eyes, and a yellowish green bill. Like most raptors, females are slightly larger than males (19-27 oz. vs. 17-24 oz., Verner et al. 1992). First and second year adults (subadults) can be distinguished by the tips of tail feathers, which are white and taper to a sharp point (Gutiérrez et al. 1995).

Spotted owls are long-lived species (can live over 15 years in the wild), with high adult survival and low reproduction; as a result, they are slow to recover from population declines (Keane 2013). They have a monogamous mating system, remaining with the same mate from year to year, although occasionally mates will separate, or "divorce." A pair occupies and defends a territory from neighbor and stranger individuals (Gutiérrez et al. 1995, Waldo 2002). In the central Sierra, territories are approximately 1000 acres (Seamans and Gutiérrez 2007a, Tempel et al. 2014b) based on a radius equal to half the "mean-neighbor distance" between the centers of adjacent owl sites (1.1 km). As central place foragers, spotted owls spend a disproportionate amount of time near their territory center, or core (Carey et al. 1992, Carey and Peeler 1995). When available, radio-telemetry has been used to approximate territory size and core use areas, resulting in some variation in size estimates (Bingham and Noon 1997). Home ranges include all habitat required for nesting, roosting, foraging, and other life functions. Home ranges will overlap each other and their size varies by latitude and study area (~1500-5400 acres), being smaller in the southern Sierras, where oaks are dominant (Zabel et al. 1992). An individual typically begins exhibiting territorial behavior in 1-4 years. Those individuals that have not yet established a territory (mostly subadults) are referred to as floaters, and little is known about their habitat requirements (Franklin 1992). The presence of conspecifics and an open territory determines settlement as owls are more likely to settle in territories that were occupied the previous year (LaHaye et al. 2001).

Breeding season begins in mid-February and can last through mid-September, starting earlier in southern California and at lower elevations throughout its range, with the peak of egg-laying in mid-April (Verner et al. 1992). Pairs divide the nesting roles; the male CSO provisions the female while she sits on the nest (Gutiérrez et al. 1995). Females lay 1-3 eggs, but survival of the offspring is highest when two young fledge (Peery and Gutiérrez 2013). Eggs take approximately 30 days to hatch, and owlets fledge about 35 days later. Fledglings will "branch out," leaving the nest before they can fly and roosting near the nest and their parents. During this early developmental stage, juvenile owls rely on multi-layered forest structure to move about above the forest floor. Within several weeks, juveniles are able to fly and will generally disperse in the fall.

Spotted owls appear to follow a bet-hedging strategy of reproduction (Stearns 1976, Franklin et al. 2000). In good years with sufficient resources, they attempt a nest, but in poor years they do not. This often leads to an even-odd pattern of reproduction, where a majority of pairs will nest one year but not the next (Blakesley et al. 2010, Forsman et al. 2011). Importantly though, lack of reproduction at any given site for a few years does not necessarily mean the site itself is of poor habitat quality, but rather may reflect overall poor environmental or climatic conditions in those years (Stoelting et al. 2014). Annual mean reproductive output for the spotted owl is the lowest among North American owls (Johnsgard 1988), with 0.555-0.988 young/female CSO (Franklin et al. 2004, Blakesley et al. 2010).

Reproductive success is particularly dependent upon local weather conditions, especially during the previous winter or early in the nesting season (e.g. MacKenzie et al. 2012). Colder temperatures and greater precipitation early in the breeding season (March to May) was negatively correlated with reproductive success in Sierra National Forest and Sequoia-Kings Canyon National Park (North et al. 2000). Also, in Eldorado National Forest, El Niño events, which result in warm, wet winters, negatively influenced reproduction (Seamans and Gutiérrez 2007b). Northern spotted owls have also shown similar patterns in response to cold (Franklin et al. 2000). Cold temperatures during nesting may increase energetic requirements, risk of egg exposure, or interfere with foraging, resulting in decreased nesting success (Franklin et al. 2000, Rockweit et al. 2012).

California spotted owls have high site fidelity, returning to the same territory year after year. However, a small percentage of adults (7-9%) (Blakesley et al. 2006, Seamans and Gutiérrez 2007a) will disperse each year, often due to events such as the loss or change of configuration of their nest tree or a mate replacement (Berigan et al. 2012). Dispersing owls tend to be younger, and either join a mate or move to an adjacent territory of higher quality (Seamans and Gutiérrez 2007a, Gutiérrez et al. 2011). Although spotted owls are non-migratory, some will move downslope during winter (Laymon 1988, Verner et al. 1992, Gutiérrez et al. 1995). Downslope movement occurs in October to mid-December, from 9-40 miles, and a change in elevation of 1640-4921 feet (Gutiérrez et al. 1995). Pairs return to their territory in late February to late March. Juveniles undergo natal dispersal in September, averaging 6-10 miles, though dispersal distance can range between 2-47 miles (LaHaye et al. 2001, Blakesley et al. 2006).

In contrast to relatively low reproduction rates, spotted owls have apparent high adult survival in the Sierras (0.810-0.891), and male survival is slightly higher than female (Blakesley et al. 2010, Tempel et al. 2014a). Juvenile survival is more difficult to measure because of natal dispersal and emigration. However, the few studies that have estimated juvenile survival found it to be substantially lower than adult survival (0.368 in San Bernardino National Forest, LaHaye et al. 2004; 0.333 in Lassen National Forest, Blakesley et al. 2001).

Temporal variation in survival is not as well-explained by weather covariates as reproduction is. However, survival does appear to have a quadratic relationship with the Southern Oscillation Index so that survival is greatest in years not dominated by either El Niño or La Niña weather patterns (mild, intermediate winters) (Seamans and Gutiérrez 2007b). Spotted owls can be preyed upon by great horned owls (*Bubo virginianus*), as well as northern goshawks (*Accipiter gentilis*) and red-tailed hawks (*Buteo jamaicensis*) (Gutiérrez et al. 1995). There has also been one instance of a likely predation by a barred owl (*Strix varia*) (Leskiw and Gutiérrez 1998). Juveniles and eggs may be taken by typical nest predators. Although variability in the population growth rate is driven by both reproductive rate and survival, growth rate is more sensitive to changes in adult survival (Blakesley et al. 2001, Seamans and Gutiérrez 2007a). Juvenile survival provides the smallest contribution to changes in the population growth rate (Tempel et al. 2014a).

2.3 Habitat requirements

Spotted owls prefer residual old growth forest with high structural diversity (Laymon 1988, LaHaye et al. 1997, Moen and Gutiérrez 1997, Seamans and Gutiérrez 2007a). The nest tree itself is critical for CSO success, and is typically the oldest, largest live or dead tree with many defects like cracks or decaying wood (Verner et al. 1992, Blakesley et al. 2005). Spotted owls are frequently cavity nesters, using live trees and snags, broken top trees, platforms (mistletoe brooms), debris platforms, and even old raptor or squirrel nests. In the Sierras, the average nest tree is 103 ft. tall, 49 in. diameter at breast height (dbh), with the nest at 74 ft. high. In general, nest trees in mixed-conifer forest are >30 in. dbh and can be a variety of species (Verner et al. 1992, North et al. 2000, Blakesley 2003). In hardwood forests, the typical nest tree is ~30 in. dbh and 55 ft. tall (Verner et al. 1992). California spotted owls prefer nest trees that are located further from forest edges (Phillips et al. 2010).

The habitat structure immediately above and near the nest site has been the focus of a considerable amount of research and is important to CSO occupancy, fecundity, and survival. In general, CSO nesting habitat consists of dense overhead canopy cover, large trees, a high basal area (total cross-sectional area of all trees at 4.5 ft. above ground, 185-350 ft^2/ac), multiple canopy layers, and an abundance of limbs and large logs on the ground (Bias and Gutiérrez 1992, Verner et al. 1992, Moen and Gutiérrez 1997, North et al. 2000, Blakesley et al. 2005, Chatfield 2005, Seamans 2005, Roberts et al. 2011). For the purposes of analysis, canopy cover is typically broken into three classes: high (≥70%), moderate (40-69%), and low (<40%) (Tempel et al. 2016). For tree size definitions, we refer to the standard Forest Service categories of very large (≥36 in. dbh), large (≥24 in.), medium (12-23.9 in.), and small (<12 in.) (Tempel et al. 2014b). Reproduction in particular has been associated with high canopy cover at multiple scales (Hunsaker et al. 2002, Tempel et al. 2014b). On Lassen National Forest, reproductive success was correlated with forests dominated by high canopy cover and medium or large trees, and

negatively correlated with non-forest or forest dominated by small trees (Blakesley et al. 2005). On Eldorado National Forest, a higher amount of hardwoods (and thus lower canopy cover) within a territory negatively influenced reproduction (Seamans 2005, Tempel et al. 2014b). At the immediate nest area (0.12 acre), productivity is also positively correlated with foliage volume above the nest site (North et al. 2000). Additionally, large trees have been shown to be particularly important for NSO within 400 m of the nest (Irwin et al. 2011). Besides nesting success, high canopy cover may also be important for post-fledging rearing, as juveniles tend to roost within 800 m of their nest (Whitmore 2009). The complex vertical structure is important for shading and avoidance of overheating in the hot summers (Barrows 1981, Weathers et al. 2001).

Territories have greater habitat heterogeneity than nest stands, but occupancy, colonization, adult survival and reproductive success are still positively associated with the proportion of core area containing structurally complex conifer forest with large trees and high canopy cover (Blakesley et al. 2005, Seamans and Gutiérrez 2007a, Tempel et al. 2014b). Recent evidence suggests that the most important predictor of occupancy is the intersection of high canopy cover and large trees (Jones et al. in review). Spatial heterogeneity including small gaps or openings within the territory is thought to be particularly important for the development of a sufficient prey base. There does appear to be evidence that once a certain amount of high canopy cover is reached, additional moderate canopy cover can similarly benefit occupancy (Tempel et al. 2016). Thus, areas of both high and moderate canopy cover can be important. However, if the overall CSO territory is <40% canopy cover, that certainly reduces quality (Tempel et al. 2016). Northern spotted owls have similarly been found to maximize fitness within territories that are heterogeneous in forest stages (Franklin et al. 2000). California spotted owls will forage primarily in contiguous patches of moderate to high canopy cover, but will also use edge habitat (Williams et al. 2011, Eyes 2014). Riparian habitats can be particularly important for prey (Irwin et al. 2007, 2011, Bond et al. 2016). Furthermore, areas that have been burned at primarily low and moderate severity fire may also provide valuable foraging habitat and heterogeneity within territories (Bond et al. 2009, Eyes et al. 2017).

Although less is known about minimum habitat requirements at the scale of a home range, CSO still consistently use areas that contain greater abundance of large trees and greater proportion of mature forest than the average forest composition on the landscape (Call et al. 1992, Moen and Gutiérrez 1997, Williams et al. 2011). As heterogeneity increases, so does the size of a CSO home range, so there may be a negative effect if too much heterogeneity exists within CSO habitat (Williams et al. 2011, Eyes 2014). In managed landscapes, studies on CSO habitat use may be influenced and limited by the habitat types that are available, so the findings may not reflect optimal CSO habitat (Gutiérrez et al. in press).

In southern California forests, most CSO live in forests other than mixed-conifer because that forest type is restricted to the highest elevations in the isolated mountain ranges (Verner et al. 1992). These forests include riparian/hardwood forests and woodlands, live oak/big cone-fir forest, and redwood/California laurel forest. In San Bernardino National Forest, the most used cover types are canyon live oak/big cone fir (Smith et al. 2002). This habitat might be preferred due to high densities of prey in the chaparral that surrounds it (LaHaye et al. 1997). Still, in the Southern forests, on average 70% of a territory is in moderate or high canopy cover (Lee and Irwin 2005). Even with less access to mature forest, owls select for more closed canopy and less non-forest at four different scales up to the size of a territory (Smith et al. 2002), and still select for large trees and higher basal area at nest sites (LaHaye et al. 1997). The presence of large residual trees (those that are significantly larger or older than the contemporaneous stand) also greatly increases the likelihood of CSO use for foraging activities (Bias and Gutiérrez 1992, Moen and Gutiérrez 1997, Williams et al. 2011).

2.4 Foraging and diet

Because spotted owls are central place foragers, they concentrate most of their foraging and activity around the nest or roost, and their activity declines further out from the nest (Carey et al. 1992, Ward et al. 1998). Spotted owls rarely fly above the forest canopy, except for dispersal (Gutiérrez et al. 1995). As perch and pounce predators, spotted owls are agile but not particularly fast fliers. Spotted owls are primarily active at night, but will also hunt during the day, especially when they have young to feed (Verner et al. 1992). Later in the nesting season, owls may also forage further from the nest to feed growing fledglings.

Although CSO will eat a variety of prey, they are considered to be small mammal specialists because they select a few key species for the majority of their diet. At upper elevations (above 4,000 feet) in the Sierra Nevada conifer forests, Northern flying squirrels (*Glaucomys sabrinus*) are the primary prey (Laymon 1988, Munton et al. 2002). At lower elevations in the Sierras, as well as in southern California, where oak woodlands and riparian-deciduous forests are dominant, CSO prey more on woodrats (*Neotoma* spp.) (Verner et al. 1992, Smith et al. 1999, Munton et al. 2002). Flying squirrels dominate CSO diet at about 75% of known owl sites (Verner et al. 1992). California spotted owls have low metabolic rates relative to other birds and would require one flying squirrel every 1.8 days or one woodrat every 3.7 days (Weathers et al. 2001). Individuals tend to have smaller home ranges where woodrats are the prey base compared to flying squirrels, presumably because woodrats provide a higher caloric gain per successful spotted owl foraging bout and occur in higher densities (Zabel et al. 1995). By biomass, regardless of elevation, pocket gophers (*Thomomys* sp.) are the second largest component of CSO diet. Although CSO will prey upon some birds, reptiles, amphibians, and insects, mammals make up the most biomass (Munton et al. 2002).

Flying squirrels are found more in closed-canopy forests (Pyare and Longland 2002, Meyer et al. 2005, Roberts et al. 2015). A moderate to high canopy closure, large trees, thick litter layer and sparsely distributed coarse woody debris are particularly important for developing a good prey base in these habitats (Waters and Zabel 1995, Pyare and Longland 2002, Meyer et al. 2005, 2007, Kelt et al. 2014, Roberts et al. 2015). Coarse woody debris is critical, but does not need to be overly dense (Knapp et al. 2005). Riparian habitat and other relatively mesic sites in particular yields truffle and tree hair lichen, which are important to flying squirrel diet (Meyer et al. 2008, Smith 2007).

Commented [MN1]: This is a colloquialism and unclear what species is being referred to. The principle foraging lichen is Bryoria fremontii. See: Rambo, T.R. 2012.
Association of the arboreal forage lichen Bryoria fremontii with Abies magnifica in the Sierra Nevada, California
Canadian Journal of Forest Research Volume 42, Issue 8, August 2012, Pages 1587-1596

Woodrats are found more often in open habitats, oak woodlands, and early seral-stage forests (Innes et al. 2007). Specifically, at lower elevations, woodrats (both dusky-footed and big-eared) and brush mouse are associated with oak cover and the density of large oaks >13 in. dbh (Innes et al. 2007, Roberts et al. 2008, Kelt et al. 2014). Heterogeneous forest conditions often provide higher primary productivity than homogenous closed canopy forests and thus, generally enhance prey habitat (Jones et al. 2016b, Sollmann et al. 2016). Transitional areas (habitat with conifer stands and a significant hardwood component) where prey distributions overlap offer a rich and diverse prey base (Verner et al. 1992). Small mammal diversity is enhanced by increased structural heterogeneity at large spatial scale and greater development of mature forest structure (Kelt et al. 2014, Roberts et al. 2015).

3. CURRENT CONDITION

The California Department of Fish and Wildlife (CDFW) maintains a record of CSO locations and activity centers (areas of repeated detection, nesting/roosting areas) in the California Natural Diversity Database (CNDDB). Although many sightings have not be reconfirmed outside of ongoing study areas, since 1993, 1,416 unique CSO activity centers have been recorded, the majority of which are in the Sierras (Figure 2). Rather than estimating overall population size, then, most of our knowledge of the status of CSO is derived from population trends in four long-term demography studies in the Sierras, and one in southern California. In the Sierras, data collection began in 1986 on the Eldorado National Forest and in 1990 on the Lassen National Forest, Sierra National Forest, and Sequoia-Kings Canyon National Park. In southern California, the San Bernardino National Forest was studied from 1987-2010, with some gaps in sampling. Multiple meta-analyses have utilized different techniques to analyze the population trends of CSO in these study areas. The nuances of these techniques are beyond the scope of this discussion (see Gutiérrez et al. in press for a full comparison), but the overall trends are consistent and we focus on the most recent analyses here.

On Forest Service lands, since the early 1990s, CSO nesting sites have been managed as Protected Activity Centers (PACs), which include ~300 acres of the "best available" contiguous habitat. This scale has proven to be a useful management tool and biologically relevant because

habitat characteristics at this scale are related to demographic parameters (occupancy, reproduction, and survival) (Blakesley et al. 2005), and CSO have repeatedly used these areas over the long-term (Berigan et al. 2012). Most data analysis relies on trends in the occupancy of territories or trends in the abundance of a study area.

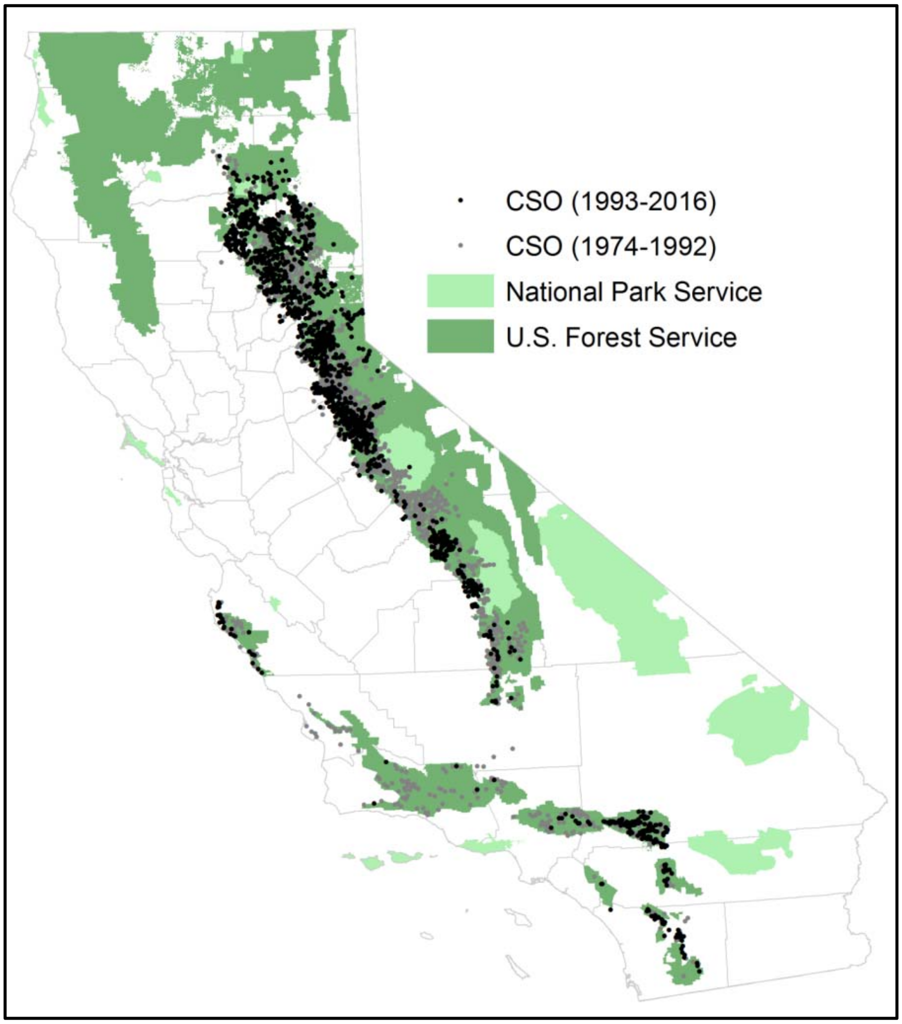

Figure 2. Map of California spotted owl activity center locations from CNDDB, before and after 1993. Shown with federal lands.

Evidence is clear that CSO have declined in both occupancy and abundance on the three national forests in the Sierras (Lassen, Eldorado, and Sierra), as well as in southern California. In the Sierras, CSO have experienced a decline in abundance of 11% on Sierra National Forest, 22% on Lassen National Forest, and 50% on Eldorado National Forest (Connor et al. 2013, Tempel et al. 2014a). San Bernardino National Forest has seen a similar decline of 50% from 1989-2010 (Eliason and Loe 2011) in territory occupancy, and a 9% per year decline in abundance from 1987-1998 (LaHaye et al. 2004). The only stable CSO population on public lands appears to be in Sequoia-Kings Canyon National Park, the only national park with a long-term CSO demography study (Table 1).

Table 1. California spotted owl population trends from 5 long-term demography studies.

Study area	Population change	Time period	Study area size (km^2)	Citation
Eldorado	- 50%	1990-2012	355	Tempel et al. 2014
Lassen	- 22%	1990-2011	1,254	Connor et al. 2013
Sierra	- 11%	1990-2011	562	Connor et al. 2013
Sequoia-Kings Canyon	+ 16%	1990-2011	182	Connor et al. 2013
San Bernardino	- 65%	1987-1998	2,140	LaHaye et al. 2004

The causes of the CSO population declines have not been conclusively identified. However, recent work suggests that rather than current management practices on national forests, the declines may be the result of a lag effect from the past removal of large trees prior to the early 1990s (Jones et al. in review). Although the populations are declining, reproduction appears to be relatively constant in all study areas in the Sierras except Eldorado, where measured parameters continue to be highly variable between years (Blakesley et al. 2010). Additionally, on national forests, studies found that more territories were being occupied by single CSO rather than pairs (Tempel and Gutiérrez 2013).

The only recent CSO population information from private lands is from five study areas on mixed ownership lands scattered through the northern half of the Sierras. From 2012-2016, systematic surveys found a high proportion of occupied territories each year that remained occupied during the study period (Roberts et al. in press). Additionally, CSO crude densities reported on the private timberlands were similar or higher than those on public lands (Roberts et al. in press, Table 2). Crude densities may not be a reliable indicator of habitat quality because an area could be a population sink supported by continued immigration from more productive source habitats (Pulliam 1988). Additionally, given the short duration of this survey effort and because CSO are long-lived and exhibit high site fidelity, returning to the same territories year after year, it is difficult to ascertain population trends from this survey data at this time.

However, of 45 CSO territories documented prior to 1996, all 45 were occupied at least once during the study period (2012-2016). These preliminary results warrant further monitoring and analysis with demographic data on individually marked owls if we are to determine if there is a difference in current CSO status between public and private lands.

Table 2. California spotted owl crude densities in study areas (most recent estimates). Primary land ownership is defined by >60% of study area, otherwise labeled as mixed ownership.

Study Area	Crude density	Study area size (km^2)	Primary land ownership	Citation
Fall River	0.056	89	Private	Roberts et al. in press
Lassen	0.051	355	National Forest	Gutiérrez et al. in press
Chalk Bluff	0.152	86	Mixed	Roberts et al. in press
Eldorado	0.16	1,254	National Forest	Gutiérrez et al. in press
Stumpy Meadows	0.035	115	Private	Roberts et al. in press
South Fork Cosumnes River	0.141	137	Private	Roberts et al. in press
South Fork Mokelumne River	0.071	122	Mixed	Roberts et al. in press
Sierra	0.151	562	National Forest	Gutiérrez et al. in press
Sequoia-Kings Canyon	0.184	182	National Park	Gutiérrez et al. in press
San Bernardino	*No recent estimate*	2,140	National Forest	Gutiérrez et al. in press

Most forest types have been defined by California Wildlife Habitat Relations (CWHR) categories with existing vegetation classification and mapping (EVEG). In the Sierras, 4M or greater CWHR translates to ≥40% canopy cover and trees ≥12 in. dbh, which include potential habitats used by CSO. Currently, there are approximately 4.9 million acres of 4M or greater CWHR in the Sierras, just over half of which is Sierra mixed conifer forest (Gutiérrez et al. in press). Of this habitat, 75% is on national forests, 7% on national parks, and 18% on private or other lands. In the southern California national forests, there are only about 400,000 acres of 4M or greater CWHR, about 16% of which is Sierra mixed conifer; however there are about 1.2 million acres of general habitat types in which CSO have been known to reproduce (Stephenson and Calcarone 1999). The realized amount of suitable habitat is likely far less though, in particular after major losses from wildfire and drought over the last decade and a half.

4. SUMMARY OF STRESSORS

Large, high-severity fires

Historically, the natural fire regime in the Sierra Nevada and southern California forests included frequent fires at primarily mixed-severity (mostly low-moderate, with patches of high-severity) (Van de Water and Safford 2011, Mallek et al. 2013). Past forest management, namely fire suppression and loss of large trees, however, has led to dense forests with high fuel load conditions and shade-tolerant trees, resulting in an increased frequency and patch size of high-severity fires (Miller et al. 2009, Mallek et al. 2013, McIntyre et al. 2015, Steel et al. 2015). In defining fire severity, in general, low-severity fire consumes surface fuels but not canopy trees (<25% upper canopy layer is lost or <25% basal area mortality); moderate-severity fire removes small trees (up to 75% canopy layer or basal area mortality); and high-severity fire consumes all surface fuels and nearly all mature plants (>75% canopy or basal area mortality) (Key and Benson 2005, Barrett et al. 2010). Prior to Euro-American settlement, frequent low-moderate severity fires occurred every 5-15 years (Van de Water and Safford 2011, Mallek et al. 2013). In areas with high fuel loads or during hot, dry weather patterns, some high-severity patches likely burned too, but were generally limited in size. In mixed-conifer forest in the Sierras, any given fire would not have included more than 5-10% high-severity fire (Miller and Safford 2017). The patches of high-severity fire averaged only 10 acres in size, with a maximum historic patch size of 250 acres (Collins and Stephens 2010, Miller and Safford 2012, Safford and Stevens in press).

Consequently, forests were likely made up of an abundance of large, fire resistant trees at a lower density (Taylor 2004, Scholl and Taylor 2010, Collins et al. 2011a). Basal area for historical conditions in the Sierras ranged from 91-235 ft^2/acre, depending on site productivity, with a mean of 150 ft^2/acre (Safford and Stevens in press). Additionally, snags in today's forest are significantly smaller and at a higher density (Agee 2002), resulting in an overall denser and more homogenous forest (Hessburg et al. 2005).

In southern California shrub-dominated landscapes, patches of high-severity fire have always been more common than in the Sierras (Steel et al. 2015). However, the area impacted by fires in southern California has also been increasing recently, in part due to continued human population growth and the conversion of cover types to grasses (Syphard et al. 2017). Although temperature is clearly a factor related to the area burned in higher elevation forests, prior-year precipitation is more strongly related to fire activity in the Sierra foothills and southern California (Keeley and Syphard 2017).

Both CSO and NSO will readily use habitat that has been subject to low and moderate severity patches of fire (Clark 2007, Eyes 2014). However, large patches of high-severity fire significantly reduce colonization, occupancy, and use (Roberts et al. 2011, Eyes 2014, Tempel et

al. 2014b). The year after the King Fire, the probability of CSO site extirpation was seven times higher in severely burned sites (when greater than half the territory burned at high-severity) than others (Jones et al. 2016a). In southern California, when patches of high-severity exceeded 123.5 acres (of a 500 acre territory), territory extinction probability increased (Lee et al. 2013). High-severity fire has also been shown to negatively affect survival of NSO (Rockweit et al. 2017). Northern spotted owls showed an increased turnover of territory occupancy in response to high-severity fire, suggesting that continued occupancy of the territories may be temporary and overall quality of the territory is reduced (Rockweit et al. 2017). There is likely some threshold of high-severity fire owls can tolerate within their territory, although the exact size and configuration is unknown.

While CSO will forage in habitat subject to a variety of burn severities, they still tend to use primarily low and moderate severity patches, avoiding large, high-severity areas (Jones et al. 2016a, Eyes et al. 2017). The size and configuration of the patch of high-severity fire appears to be critical. Some work suggests that CSO will use high severity patches in proportion to availability 3-4 years after the fire (Bond et al. 2009, 2016), although the sizes of the foraging patches in these studies were not reported. In Yosemite National Park, the mean size of a high severity patch used for foraging was 16 acres (Eyes 2014). Additionally, CSO were found to selectively forage in fire-created edge habitats, rather than contiguous edges (Eyes et al. 2017). Many prey species important to CSO are negatively correlated with fire severity including flying squirrels and deer mice (Roberts et al. 2008, 2015). Landscapes with restored fire regimes (such as Yosemite National Park) show greater small mammal species evenness, which could promote stability and resilience in CSO prey populations (Roberts et al. 2015). So while it appears that often California spotted owls will avoid large, high-severity patches, smaller patches and mixed severity can be beneficial because they support the prey base.

Habitat loss to large, high-severity fire is a substantial threat to CSO persistence. Within the next 75 years, based on fire activity trends, the amount of nesting habitat burned at moderate or high-severity fire will likely exceed the total existing habitat in the Sierras, and therefore there is a critical need to avoid losses of older forests (Stephens et al. 2016b). Closed canopy forests (such as those in PACs) do tend to have uncharacteristically large and severe fires (Agee and Skinner 2005). However, from 1993-2013, 88,000 acres of CSO PACs burned, 28% of which were at high-severity, which was a similar proportion to the overall landscape (Gutiérrez et al. in press). So while PACs themselves are not necessarily more vulnerable to high-severity fire than the surrounding landscape is, the proportion of PACs burned at high-severity is greater than would be expected under a natural fire regime (<5-15% Mallek et al. 2013). California spotted owls are similarly losing habitat in southern California, which has experienced increasing widespread wildfires, particularly in the early 2000s (Keeley et al. 2009). Repeated high-severity fires in the same area can convert the type of habitat, resulting in long-term habitat loss (Stephens et al.

2013). Addressing the potential effects of large, high-severity fires on owl habitat will require collaborative landscape-level efforts.

Forest management practices

The effects of specific forest management practices on spotted owls are not well understood. Some practices may act as stressors on spotted owls, while others may improve habitat. Commercial timber harvest no longer occurs within the CSO range in southern California on public lands (Eliason and Loe 2011), though it continues to occur on private lands, and is conducted in the Sierras on both public and private lands. Additionally, in order to reduce the likelihood of high severity fires, fuels reduction activities on public lands have been slowly implemented. Forest fuels are typically split into four categories: ground (material that has begun to degrade), surface (downed wood, herbaceous vegetation and shrubs), ladder/bridge (small trees and larger shrubs), and aerial/crown fuels (within the crowns of standing trees, separated from surface fuels) (Jenkins et al. 2014). Management for fuels reduction in the forest includes reducing surface fuels, increasing the height to the live crown (reducing ladder fuels and removing small trees), decreasing crown densities, and retaining/recruiting large fire-resistant tree species (Agee and Skinner 2005). Data on the effects of various fuel treatments on owls has been mixed, due to minimal experimentally designed studies, confounding factors, and a lack of consistency in defining types of treatments. For the purposes of discussion we broadly classified the methods of fuels reduction into prescribed fire, hand thinning, and mechanical treatments. For the most part, prescribed fire that has the potential to lead to low or moderate severity fires, or mixed severity with small patches of high-severity fires can be good for owl habitat. Additionally, hand thinning of smaller trees does little to disturb CSO. These small scale treatments typically leave high canopy cover and large trees, which are important to spotted owl nesting. Chainsaws and helicopter noises do not appear to decrease reproductive success (Delaney et al. 1999) nor increase stress hormones like corticosterone (Tempel and Gutiérrez 2003, 2004). However, NSO nesting near loud roads have lower reproductive success than those near quiet roads (Hayward et al. 2011), and males show higher levels of corticosterone (Wasser et al. 1997), suggesting there may be some non-lethal effects from noise-causing human disturbances.

Forest management: mechanical thinning

Owl response to mechanical treatments is less clear and appears to rely on scale and intensity of the treatments. Mechanical treatments (or thinning) refer to machine-based fuels reduction for purposes of reducing large fires and tree harvest (North et al. 2015). Generally, territories with greater amounts of mature conifer forest have a higher probability of colonization by CSO (Seamans and Gutierrez 2007a), so actions that alter mature forest to a large degree could result in a less desirable territory. Specifically,

converting mature conifer forest from high to moderate canopy cover was negatively correlated with demographic parameters in one meta-analysis (Tempel et al. 2014b). In an earlier study, territories with >50 acres of altered mature forest showed a 2.5% decline in occupancy and an increase in dispersal (Seamans and Gutiérrez 2007a). However, minimal effects were found on NSO two years after territories were treated, and no abandonment of a territory was detected in areas that were treated up to 58% (Irwin et al. 2015). Modeling projected over a 30 year time frame suggested that while treatments can reduce the risk of high-severity fire to CSO, in the absence of fire, such treatments could have a negative effect on fitness (Tempel et al. 2015). At the landscape-scale, another study examined the effects of mechanically-produced wide shaded fuel breaks (Defensible Fuel Profile Zones) on CSO and found that the fuel breaks were avoided for 1-2 years after treatments (Stephens et al. 2014). Additionally, occupied territories declined by >40% within four years after treatment, and the remaining individuals used larger areas. Mechanical thinning that results in widely and regularly spaced trees tend to be avoided by CSO (Gallagher 2010). However, the most recent meta-analysis of the long-term demography studies in the Sierras did not find any impact to occupancy, survival, or productivity from mechanical thinning (Tempel et al. 2016), and in fact some populations exhibited small positive effects on occupancy.

Forest management: salvage logging

Salvage logging refers to the removal of dead or damaged trees to recover economic value that would otherwise be lost (Society of American Foresters' Dictionary). It typically occurs after a fire, or large tree mortality event, and can be a controversial activity (Long et al. 2013). Because CSO can persist in low-moderate severity fires, salvage logging of viable habitat may negatively affect occupancy (Gutiérrez et al. in press). In high-severity fires, it was found that salvage logged sites had a slightly lower probability of being occupied than sites that only burned and did not undergo salvage logging treatment, although the difference was not statistically significant (Lee et al. 2013). Recent work on NSO found that high severity-fire interacts with salvage logging to jointly contribute to declines in site occupancy (Clark et al. 2013). Salvage logging may reduce the quality of foraging habitat through the removal of legacy snags, although it is difficult to disentangle the effects of salvage logging from high-severity fire.

Forest management: clearcutting

Timber harvest can cover all types of tree removal, which would include some fuels reduction activities as well as salvage logging. Clearcutting is one form of timber harvest that can take various shapes and sizes, though in general tends to leave large, regularly shaped patches with clean edges (Tempel et al. 2014b). In addition to outright habitat

loss, timber harvest can eliminate important CSO habitat elements such as old, large trees and large downed logs (McKelvey and Weatherspoon 1992). The overstory trees that remain in commercial thinning prior to a clearcut tend to be regularly spaced with little forest floor and understory diversity, and low heterogeneity in stand structure (Knapp et al. 2012). No research has explicitly examined spotted owl response to an even-aged management strategy using clearcuts, but these forest practices generally occur on private timberlands. California spotted owls have been observed avoiding private lands (Thraikill and Bias et al. 1989), and tend to forage on private lands proportionately less than the amount of private lands available on the landscape (Williams et al. 2014). These observations were not linked to management practices in these studies. However, CSO do nest on private timberlands in the Sierras. Additionally, crude density estimates of CSO territories are similar across public and private lands (Roberts et al. in press), although, as discussed above, there is limited information regarding population trends on private lands. While some gaps in canopy cover can be beneficial for the prey base, current clearcutting practices probably do not create the collection of patches observed in spotted owl territories with high-fitness (Franklin et al. 2000).

Tree mortality

Tree mortality has substantially increased throughout the Sierras, particularly in the southern Sierra region (van Mantgem et al. 2009, Asner et al. 2015). In 2015 in the southern Sierra, about 345 trees/km^2 died (Young et al. 2017), and very large trees in general are disproportionately affected by tree mortality (Smith et al. 2005). Drought combined with dense forest conditions have led to severe water stress (Asner et al. 2015, Young et al. 2017) in forest trees. This stress interacts with pathogens, insects and air pollution (Lutz et al. 2009, McIntyre et al. 2015). Bark beetles in particular are exacerbated by climatic conditions (Bentz et al. 2010), and measures of stand density are correlated with levels of mortality attributed to bark beetles, suggesting the density of trees (and indirectly competition) is a contributing factor (Hayes et al. 2009). The full extent of the mortality and effects on CSO is unknown, but the tree mortality is likely to contribute to habitat loss.

Barred owls

Barred owls were historically confined to eastern North America, but have expanded west over the past century (Livezy 2009). Whether barred owl expansion is human-caused is uncertain, but it is thought to be a combination of settlement of the central plains combined with climate change. Currently barred owls threaten NSO in parts of its range. They use a broader suite of vegetation, though still show a preference for old growth, large trees, and high canopy cover like spotted owls (Wiens et al. 2014). Because barred and spotted owls use similar habitat, natural segregation and coexistence is unlikely (Yackulic et al. 2012, 2014). Barred owls are

competitively superior and have a smaller home range (2-4 times smaller), probably due to a broader diet (Wiens et al. 2014). Barred owls can thus live at substantially higher densities than spotted owls.

Where barred owls occur in the NSO range, they decrease NSO occupancy by increasing territory extinction and lowering colonization (Olson et al. 2005, Dugger et al. 2011, Yackulic et al. 2014). Northern spotted owls show a lower overall probability of habitat use (Van Lanen et al. 2011) and lower nesting success; barred owls produced 4.4 times more young over a three year study period (Wiens et al. 2014). Furthermore, because barred owls can live at higher densities and consume a wider variety of prey species than spotted owls, their expansion has the potential to alter the prey on the landscape and affect a variety of other native species (Holm et al. 2016). In the range of NSO, there are ongoing removal experiments that suggest NSO may reoccupy a site within one year after barred owls are removed; however 1-4 years after the initial removal, barred owls again occupied some sites (Diller et al. 2012). These removal experiments are being conducted in areas of relatively high barred owl densities. In the range of CSO, however, barred owl detections have been low, suggesting the edge of barred owl expansion is just at the northern extent of CSO range.

A barred owl was first detected in the northern Sierras in 1989 and in the central and southern Sierras in 2004 (Steger et al. 2006). As of 2013, there were 51 barred owls detected in the Sierras (Gutiérrez et al. in press). Currently there are over 140 barred owl detections recorded in CNDDB, although these records do not necessarily reflect unique individuals. However, no systematic surveys have been conducted and all detections are incidental, therefore, they may be at a low density throughout the region (Dark et al. 1998, Keane 2014). There have also been a number of sparred owl detections, hybrids between the two species. As their range continues to expand, barred owls will likely become a significant threat to CSO (Gutiérrez et al. 2007). If control measures were to be implemented, they are more likely to be successful now, while the densities of barred owls are still low in CSO range (Dugger et al. 2016).

Contaminants

Although they have not yet been found in CSO, environmental contaminants may be an emerging threat. Rodenticides associated with illegal marijuana cultivations have been found in barred owls in northern California (Gutiérrez et al. in press). In the southern Sierra, large amounts of rodenticides and other pesticides have been found in national forests (Thompson et al. 2013), and fishers (*Pekania pennanti*) are experiencing high rates of exposure (Gabriel et al. 2012). Given that CSO share similar habitats and prey with fisher and barred owl, CSO are likely to be affected by rodenticides as well (Gutiérrez et al. in press).

Climate change

Current predictions suggest there will be a 3-6 degrees increase in temperature in the Sierras within the 21st century, and although changes in precipitation patterns are less certain, winter snowpack will likely decrease with a corresponding increase in ecosystem moisture stress during the dry, hot summer months (Cayan et al. 2013, Pierce et al. 2013). The direct effects of such climate changes on spotted owls will be complex as they exhibit population-specific demographic responses to local weather and regional climates (Franklin et al. 2000, Glenn et al. 2010, 2011, Peery et al. 2012). Additionally, spotted owls tend to only attempt nests in years with sufficient resources, following a bet-hedging strategy (Franklin et al. 2000). Drought and high temperatures in the previous summer can result in lower survival and recruitment (Franklin et al. 2000, Seamans et al. 2002, Glenn et al. 2011, Jones et al 2016b). Warm, dry springs, on the other hand increase reproductive success (Glenn et al. 2010, 2011, Peery et al. 2012, Jones et al. 2016b). Potential projected decreases in precipitation will likely reduce the plant production important for spotted owl prey (Seamans et al. 2002, Olson et al. 2004, Glenn et al. 2010, 2011).

With climate change, mixed-conifer forests, like many communities, are projected to advance upslope, which could develop habitat for CSO where none now exists (Peery et al. 2012). While these changes in habitat may mitigate some effects of climate change, the creation of new habitat will likely not keep pace with the loss (Stephens et al. 2016b). Climate change is likely to exacerbate the risk of large, high-severity fires and drought-induced tree mortality (Miller and Safford 2012, Mallek et al. 2013), which both have negative impacts on CSO habitat. The effects of climate change on fire activity, however, will likely vary across landscapes. Lower elevations and latitudes (e.g. southern California), where fire is more limited by ignition than climate, will be less likely to experience an increase in fire activity with hotter and drier conditions (Keeley and Syphard 2016).

5. CONSERVATION FRAMEWORK

Our conservation framework consisted of 1) identifying CSO population and habitat status and stressors, 2) defining broad conservation goals, and 3) developing conservation objectives and measures for ameliorating stressors and addressing CSO needs. We used three parameters: population and habitat representation, redundancy, and resilience (Shaffer and Stein 2010, Redford et al. 2011), as broad guiding concepts in developing our conservation objectives. Representation is the retention of various types of diversity (genetic, ecological, etc.) of the species so that the adaptive capacity of the species is conserved; resilience is the ability to recover from stochastic environmental variation and disturbances; and redundancy is multiple, geographically dispersed populations and habitats across the species' range that helps species withstand catastrophic events. In this COR, we relied on the best available science, including the latest Conservation Assessment (Gutiérrez et al. in press), recent emerging scientific research,

information received related to our March 17, 2017, letter soliciting new information from interested parties, and expert elicitation.

5.1 Conceptual model

Recognizing that many CSO habitat requirements vary based on scale, we have developed a conceptual model to examine how factors interact to influence CSO resiliency (Figure 2). The model includes population parameters that are typically measured for CSO, important broad habitat requirements, as well as the potential stressors discussed above. This model is not quantitative, but rather illustrates the interactions between stressors and habitat requirements to influence population parameters. Red arrows indicate one factor increases another, blue arrows indicate the factor decreases another, and purple indicates it may increase or decrease depending on other parameters. Thicker lines suggest a stronger relationship, and dashed lines indicate some uncertainty of the relative strength.

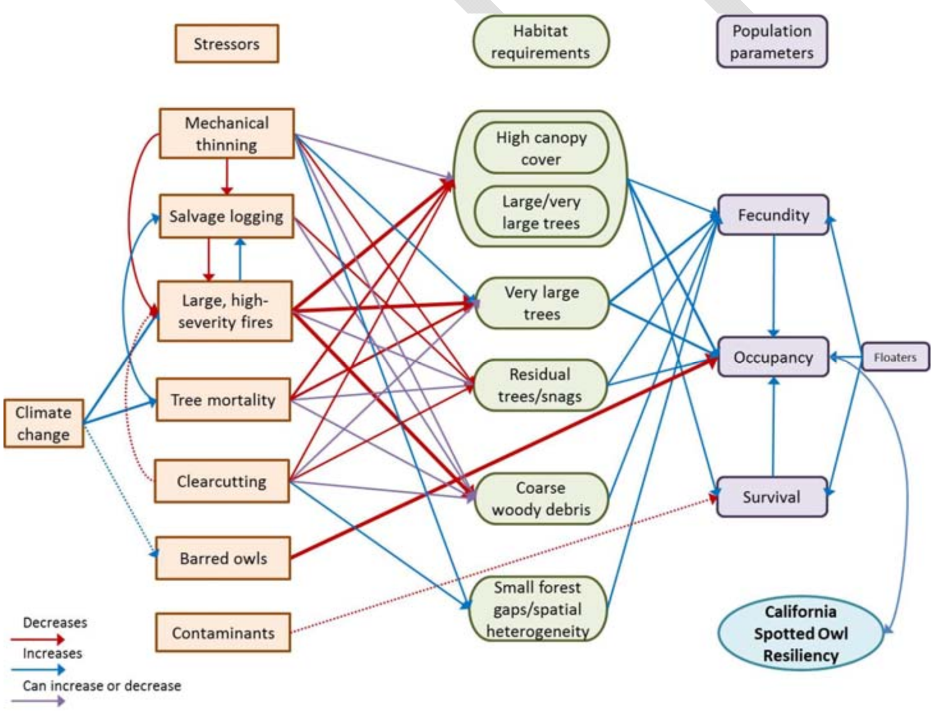

Figure 2. Conceptual model illustrating relationships among primary habitat needs, stressors, and California spotted owl population resiliency.

Population parameters include CSO territory occupancy, as well as fecundity and survival. Floaters, or non-territorial CSO, may contribute to populations because they can fill in when territories become available. Habitat requirements are broadly categorized into areas of high canopy cover with large (or very large) trees, very large trees, residual trees/snags, coarse woody debris, and small forest gaps/spatial heterogeneity. Some characteristics, such as high canopy cover and large/very large trees affect all population parameters. Other habitat components like coarse woody debris and forest heterogeneity are related to maintaining a sufficient prey base, and thus are more likely to affect fecundity than other parameters. Most potential stressors can affect multiple habitat components or population parameters as well as interact with each other. The most substantial stressor to habitat is large, high-severity fire, which may be modulated somewhat by various forest management practices. However, depending on scale and implementation, these same practices could also decrease certain habitat components. Additionally, barred owls are likely to emerge as a significant stressor to CSO resiliency by decreasing CSO occupancy. Finally, although we know little about contaminants as a stressor to CSO, we suspect the negative effects of contaminants have been going undetected thus far, and could become a more significant stressor to CSO. Managing for the interaction of these stressors will require a comprehensive region-wide conservation strategy and forest-specific plans.

5.2 Conservation Goal

Our goal is the long-term conservation of CSO and its habitat throughout its range by maintaining viable, connected, and well-distributed populations and habitats through amelioration of stressors and conservation of key habitat components.

6. CONSERVATION OBJECTIVES

6.1 General conservation objectives

Attenuate the population declines of California spotted owl

Although it is unclear exactly why CSO are declining, there is now substantial evidence that populations on national forests have declined significantly over the past two decades. Recent evidence suggests that these declines may be a result of previously altered habitat, rather than current forest management practices on national forests (Jones et al. in review). To that end, we need to continue to investigate the causes of the declines, and in the meantime preserve habitat elements we know are critical for CSO conservation. Stopping a population decline is an important part of any conservation strategy (Caughley 1994). Because PACs have been demonstrated as useful for CSO management (Berigan et al. 2012), focusing on maintaining a network of PACs, as well as other connected habitat throughout the range of CSO should be emphasized.

Manage habitat for spotted owl use and the long-term establishment of natural fire regimes
Among CSO and forest ecology experts there is an ongoing discussion about the need to balance the protection of CSO habitat elements with the reduction of the likelihood of large scale fires (Gutiérrez et al. in press). The only stable CSO population on public lands appears to be in Sequoia Kings Canyon National Park, which has not only more large trees but more of a restored fire regime (Blakesley et al. 2010, Tempel et al. 2014b). California spotted owls prefer high canopy cover, large trees, and complex forest structure, which can coincide with high fuel loads (Gutiérrez et al. in press). Any proposed conservation actions need to be strategic in balancing these seemingly conflicting needs. PACs should be avoided as much as possible, but territories can tolerate more habitat heterogeneity. It will be a challenge to balance enhancing habitat heterogeneity with maintaining sufficient mature closed canopy forest (Kane et al. 2013, Stephens et al. 2014). Short term losses of high canopy cover in some habitat, for example, may be necessary for reducing fuel loads, but could be acceptable to CSO persistence if other critical elements like large trees remain (Tempel et al. 2016). Specific fuel reduction activities should be designed in relation to known CSO territories, but also elevation, latitude, and forest site productivity. Mechanical treatment on its own will not achieve fire resilient landscape conditions, as it can be implemented on less than half of the productive forestlands in the Sierras regardless (North et al. 2015). The massive tree mortality in the southern Sierras may also make this goal more challenging. However, efforts to move the broader landscape toward a more natural fire regime will be important for long-term persistence (Stephens et al. 2016a).

Develop and encourage voluntary conservation actions
About 75% of CSO habitat and territories are on national forests or parks, with the rest on private timberlands. To conserve CSO and habitat resilience, redundancy, and representation, federal and state agencies and other stakeholders should work together to develop plans that include clear mechanisms for addressing the threats to CSO. In developing conservation plans, we encourage entities to coordinate closely with the Service. Implementation of mechanisms to conserve CSO will benefit from stakeholder participation in conservation planning across land ownership boundaries.

Create a region-wide monitoring program and develop adaptive management plans
Ensuring active monitoring and reporting is critical for understanding region-wide and population-specific changes. The development and implementation of a robust range-wide occupancy based monitoring program would expand upon the few existing long-term demography studies. Such a system would require standardized data collection across forests and land ownerships, and would ideally be implemented within each forest structure. The current demography studies could be compared across landownerships as well to understand the nuances of CSO responses to forest management practices. Without this information, it is difficult to measure the benefit of conservation activities and there would be limited capacity to adaptively manage if current management is ineffective and new science emerges.

Prioritize and support research to address additional uncertainties
In spite of the breadth of research, there are a number of uncertainties that remain about CSO. Most notably, although recent work is beginning to understand the causes of the declines on national forestlands, such causes of CSO declines have not been conclusively determined. We also require more information about the southern California populations in particular, as well as dispersal and recruitment dynamics across a larger landscape. Understanding such parameters across the landscape would help set more specific targets for population sizes and habitat connectivity. Designing experimental studies to test sensitivities to different fuels reduction treatments, as well as different habitat uses on private and public lands would aid in habitat management. Additionally, the future effects from recent tree mortality on spotted owl habitat and use is largely uncertain. Effective amelioration of stressors can only be accomplished if we understand how they affect CSO resiliency, redundancy, and representation.

6.2 Stressor-specific conservation objectives

The following stressor-specific conservation objectives are designed to ameliorate the stressors identified and discussed in this document. These goals are intended to be developed with more specificity within any conservation plan or strategy. In developing CSO plans and strategies, entities should coordinate with the Service to help ensure the specific conservation plans and strategies adequately address the stressors and conservation needs of the species.

Large, high-severity fires

Conservation objective: Retain and restore resilient forests throughout the range of California spotted owls.

As a result of a century of fire suppression, CSO habitat is threatened by large, high-severity fires (Stephens et al. 2016b). The majority of areas burned on private and national forest lands occurs as result of wildfire that escape suppression under extreme conditions that are more likely to result in high-severity effects (Lydersen et al. 2014, North et al. 2015). Lower elevations have a higher burn probability, and habitat subjected to high-severity fire is more likely to grow back as chaparral rather than forest, and increase the likelihood of burning again (Lydersen et al. 2014). These effects are exacerbated as the time since the previous fire increases. There is an urgent need to reduce the likelihood of forest ecosystem conversion to chaparral and the associated loss of high quality nesting habitat due to large, high-severity fire.

Commented [MN2]: I believe here you want to cite a different paper than the North et al. 2015 in the biblio about mechanical constraints. The correct paper is: North, M., Stephens, S., Collins, B., Agee, J., Aplet, G., Franklin, J., and Fulé, P. 2015. Reform forest fire management: Agency incentives undermine policy effectiveness. Science 349: 1280-1281.

Conservation measures:

1. Increase the use of prescribed and managed fire for low-moderate and mixed severity burn as an active management tool. Mixed-severity fire can reduce surface and ladder

fuels, acting as natural fuel breaks. Historically about 486,000 acres a year in the Sierras would burn, mostly at low-moderate severity, with small patches of high-severity (North et al. 2012). Efforts should be made to move the forests towards a more natural fire regime. Restoration of the fire frequency that would mimic pre-settlement rates may not be achievable due to ownership patterns and smoke restrictions (Quinn-Davidson and Varner 2012). However, increasing burning under moderate weather conditions will be beneficial (Schweizer and Cisneros 2014).

2. Develop a quantitative risk assessment of CSO PACs and other habitat for large, high-severity fires.
3. Design and implement fuels reduction activities, prioritizing areas by risk of high-severity fire (see *Forest management practices* below for specific recommendations).
4. Focus fuel reductions outside of CSO PACs and core use areas. As PACs occupy a relatively small percentage of the landscape anyway, only 5-9% of productive lands, limiting the alteration of PACs would not hamper an effort to move the landscape towards a natural fire regime (North et al. 2015).
5. Recruit and preserve new CSO habitat outside of the current PACs. We recognize that habitat conditions in some CSO territories might not be viable long-term because of low drought tolerance or high burn probabilities. As some PACs are likely to experience high-severity fire, it will be important to strategically plan for recruiting new CSO habitat suitable under future climate conditions. Such habitat should be focused in topographic positions that will support high canopy cover and large trees under future forest conditions, such as north facing slopes and drainage bottoms (North et al. 2009, 2012). Modeling could build upon existing efforts to create a habitat reserve network across CSO range to ensure connectivity among PACs and populations.
6. Develop a fire management plan across land ownerships. Minimally, coordination of fuel breaks would enhance control of fires and potentially minimize loss of CSO habitat.

Commented [MN3]: 2 other papers that get at this topic and may be worth citing here are:
Lydersen, J. and M. North. 2012. Topographic variation in active-fire forest structure under current climate conditions. Ecosystems 15: 1134-1146.
Underwood, E.C., J.H. Viers, J.F. Quinn, and M. North. 2010. Using topography to meet wildlife and fuels treatment objectives in fire-suppressed landscapes. Journal of Environmental Management 46: 809-819.

<u>Forest management practices</u>

Conservation objective: Utilize forest management tools that are compatible with maintaining essential habitat elements for CSO.

There is a critical need to manage for resilience in our forests while preserving connected CSO habitat. This will require some fuels reduction activities at a landscape level (Stephens et al. 2016a). The development of a regional risk assessment for fire in order to prioritize fuels reduction activities in relation to owl habitat is needed. Generally, overstory forest patterns are most associated with the climatic water deficit (Tague et al. 2009), whereas understory conditions are more shaped by the fire history (Lydersen and North 2012). Loss of habitat or abandonment of territories from certain forest management practices can be a serious concern for CSO persistence. Avoiding primary CSO use areas and maintaining the most important habitat

elements can ameliorate the effects of some activities. The effects on CSO from clearcutting and even-aged management practices, as well as salvage logging, likely depend on scale, and some industrial forestlands do have nesting individuals.

Conservation measures:

1. Design thinning treatments to leave large (≥24 in) and very large (≥36 in. dbh) trees and snags. Modeling indicates that thinning treatments of trees at 12, 20, and 30 in. dbh could yield a similar reduction in burn probability (Collins et al. 2011b), so removal of smaller trees, rather than larger ones important to CSO habitat, should be prioritized.
2. Manage mechanical thinning toward individual trees, clumps, and openings (ICO) (Lydersen et al. 2013). Some work suggests that about 200-300 acres of high canopy forest in a CSO territory could maximize fitness (Tempel et al. 2014b), though this is not a firm target. In general, contiguous patches of mature closed canopy forest that is embedded with small forest openings and some variable forest composition (such as large oaks) may promote foraging, and would be consistent with a natural fire regime (van Wagtendonk and Lutz 2007). Heterogeneity may somewhat compensate for decreased canopy cover from fuel treatments in the maintenance of flying squirrels (Sollmann et al. 2016).
3. Focus treatments on fostering the growth rate of larger trees, which are then retained long-term. Enhancing important attributes like large and defect trees might be able to maintain viable CSO populations when less high canopy cover is present (Gutiérrez et al. in press).
4. Design some fuels reduction treatments to experimentally test CSO responses. This is obviously challenging in a long-lived species with high site fidelity, but would improve our understanding of CSO resiliency to particular fuels reduction activities. In spite of some studies, the effectiveness of fuel treatments and the balance between reducing fire risk and effects on CSO fitness remains unclear.
5. Although it is difficult to disentangle fire and salvage logging effects on CSO, it seems prudent to avoid salvage logging of viable habitat, where possible. California spotted owls persist in territories that experience low-moderate severity fire, with some mixed-severity as well (Bond et al. 2002, Roberts et al. 2011, Lee et al. 2012, Lee et al. 2013, Lee and Bond 2015). However, in situations where over half a territory has burned at high-severity (Jones et al. 2016a) and individuals have abandoned the territory due to severe natural alteration, astute salvage could be warranted. Such salvage would require leaving large snags and downed logs, as well as subsequent replanting to maximize heterogeneity and habitat restoration.
6. In timber harvest plans that utilize a clearcutting strategy, design harvests to retain essential habitat elements. This would include multiple, non-uniformly distributed and irregularly shaped patches, balancing for old growth and some early seral stage forests to

Commented [MN4]: I think its worth noting that canopy cover measurements often don't distinguish between closure and cover. Owl nests have high closure (a point measure) but cover, a stand level average measure of porosity, has not been well measured and is often confounded. See Jenkins et al. 1999 (cited in North and Stine 2012 below) and (particularly figure 14-1)
North, M. and P. Stine. 2012. Clarifying concepts. Pages 149-164 in M. North (ed.) Managing Sierra Nevada Forests, General Technical Report PSW-GTR-237. USDA Forest Service, Pacific Southwest Research Station, Albany, CA. 184 pp.

maximize biodiversity (Burnett and Roberts 2015). Such patches on industrial forestlands can enhance small mammal abundance (Gray et al. 2016). For NSO, for example, tree stands at 109-152 ft^2/acre had the highest probability of foraging use, particularly when streamside (Irwin et al. 2015). Focus on retaining such riparian habitat.

7. Harvest plans should be strategically designed to maintain CSO habitat for long-term resiliency. Monitoring plans will be required to adequately address any negative or positive effects from management activities.

<u>Tree mortality</u>

Conservation objective: Monitor the effects of tree mortality on CSO.

We do not yet know how the tree mortality will affect CSO. Continued drought and dense forests could lead to additional mortality events. Though direct management options are limited, managing the forests toward more resilient conditions as recommended could aid in reducing the likelihood of tree mortality (van Mantgem et al. 2016). This may include some combination of prescribed fire and thinning treatments. For ponderosa pine stands in northern California, for example, a threshold stand density index (SDI; total basal area of all trees in a stand) of 230-365 ft. SDI has been suggested for ponderosa pine stands (Oliver 1995, Hayes et al. 2009) to avoid drought and stress induced tree mortality.

<u>Barred owls</u>

Conservation objective: Establish and implement a monitoring and management study or plan for barred owls.

Barred owls are a threat to NSO, and are set to become an imminent threat to CSO. Current knowledge of barred owl presence in CSO range is primarily incidental. California spotted owls will require a comprehensive monitoring and management plan to address this issue. Ongoing research suggests that while removal of barred owls will allow NSO to reoccupy territories, barred owls may return to some territories within a few years (Diller et al. 2014). Because California spotted owl range is currently at the edge of barred owl expansion, if the expansion is to be slowed or halted, a proactive plan to address the threat of barred owl expansion should be implemented. Control measures would likely be most effective now, while barred owls are still at low densities (Dugger et al. 2016) within the range of CSO. However, advocating removal of one species for another is a controversial decision.

Conservation measures:

1. We recommend the immediate development of an active monitoring scheme.

2. Given the substantial effects barred owls have had on NSO, we recommend the development of a comprehensive barred owl management study or plan for CSO. Such a plan would be intended to get ahead of this emerging threat before full barred owl expansion occurs within the range of CSO.

Contaminants

Conservation objective: Identify rodenticide exposure rates in California spotted owls.

Little information regarding the exposure rate of contaminants on CSO exists. However, the high exposure rates to rodenticides in barred owls and fisher would suggest CSO rates could be high as well (Gutiérrez et al. 2007, Gabriel et al. 2012). Thus, minimizing exposure to contaminants and beginning to test individuals for rodenticides would be prudent. Working with law enforcement partners to monitor the amount of rodenticides on the landscape will be of importance to long-term conservation of CSO.

Climate change

Conservation objective: Align habitat planning and protection with areas likely to support high canopy cover and large trees under future climate scenarios.

Although CSO might not be among the bird species most vulnerable to direct effects from climate change in the Sierras (Siegel et al. 2014), associated increases in large fires and tree mortality are likely to negatively affect CSO habitat. Thus it will be important not only to protect current habitat, but also to recruit new habitat. CSO tend to use topographic areas associated with higher productivity anyway, such as canyon bottoms, lower slopes, and northeast aspect positions, which are likely to support older forests (Underwood et al. 2010). Recent work suggests that managing for greater amounts of closed canopy habitat at higher elevations in particular might be beneficial to ensure available habitat in the long-term (Jones et al. 2016b).

To support long term persistence of California spotted owls, it will be important to manage for forests that are resilient to fire and climate change while still maintaining essential habitat elements.

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Kirby, Rebecca <rebecca_kirby@fws.gov>

Fwd: Interest and Availability for Potential Peer Review - re: California Spotted Owl

Keane, John -FS <jkeane@fs.fed.us> Mon, Aug 7, 2017 at 6:07 PM
To: "Russell, Daniel" <daniel_russell@fws.gov>
Cc: Kim Turner <kim_s_turner@fws.gov>, Rebecca Kirby <rebecca_kirby@fws.gov>

Dear Dan – please find attached my comments on the CSO COR. I embedded the comments in the text of the Word document. Also attached are the signed COI document and two papers I recommend be cited in the document. Of the two papers, Conner et al. 2016 needs to be cited to update the estimates of CSO population change reported in Table 1 on page 11. This paper is also useful because it compares estimates of population change from mark-recapture versus occupancy – something the USFWS may want to consider carefully for future monitoring endeavors. Please contact me with any follow-up questions or if I can be of future assistance.

Sincerely,

John Keane

From: Russell, Daniel [mailto:daniel_russell@fws.gov]
Sent: Friday, July 21, 2017 12:28 PM
To: Keane, John -FS <jkeane@fs.fed.us>
Cc: Kim Turner <kim_s_turner@fws.gov>; Rebecca Kirby <rebecca_kirby@fws.gov>

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4 attachments

Conner_CompOccMR-Ecsph2016.pdf
689K

Hessburg et al 2016 Mgt of mixed severity fire regime forests.pdf
5400K

20170720_CSO_COR_DRAFT JJKeane Review 7August2017.docx
3318K

Conflict of Interest Disclosure Form_template JJKeane.pdf
79K

California Spotted Owl
(*Strix occidentalis occidentalis*)
Draft
Conservation Objectives Report
July 2017

Photo by Tim Demers. Used with permission.

US Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Pacific Southwest Region

TABLE OF CONTENTS

1. BACKGROUND AND PURPOSE

The California spotted owl (*Strix occidentalis occidentalis*) occurs on public forestlands and private timberlands throughout the Sierra Nevada and southern forests in California. In 2015, the U.S. Fish and Wildlife Service received two petitions to list the California spotted owl (CSO) under the Endangered Species Act of 1973, as amended. The Service's initial evaluation in our 90-day finding, published in the Federal Register on September 18, 2015, found that the petitions presented substantial information indicating that the petitioned action may be warranted. The species will undergo a full status review, with a listing decision due before September 30, 2019. The Service and other agencies are currently working on multiple CSO conservation efforts. To assist in informing these efforts, the Service developed this California spotted owl Conservation Objectives Report (COR).

Due to the complex and dynamic relationships among fire, timber management, and owl habitat, developing strategies that conserve spotted owl habitat and support sustainable forestry management are essential. The goal of this Conservation Objectives Report is to describe the ecological needs of CSO, identify and summarize the current and future stressors to viability of the species, and develop broad range-wide conservation objectives to assist in the development of ongoing and future conservation efforts. For the most recent thorough scientific assessment of CSO and its stressors, please refer to the U.S. Forest Service Pacific Southwest Research Station's Conservation Assessment from July, 2016 (Gutiérrez et al. in press). This COR draws substantially from this assessment as well as subsequent emerging research and information received in response to our March 17, 2017, letters sent via email to a wide range of interested parties requesting current information relevant to CSO. The goal of this COR is not to be prescriptive, but rather to identify ecologically relevant goals to guide the development of regional conservation strategies and other conservation efforts for CSO.

2. CALIFORNIA SPOTTED OWL ECOLOGY

2.1 Range and distribution

California spotted owls are continuously distributed throughout the forests of the western Sierra Nevada mountains in California, from Shasta County south to the Tehachapi Pass (Verner et al. 1992). The drier eastern side of the Sierras supports limited amounts of CSO habitat and relatively fewer CSO than the western slopes. California spotted owls also occur in southern and central coastal California (hereafter referred to as southern California), with a gap in their distribution between the Sierras and southern California forests (Verner et al. 1992). The CSO can be found at 1,000 – 7,700 ft. elevation in the Sierras, and up to 8,400 ft. in southern California (Verner et al. 1992). Just north of Lassen Peak to south of the Pit River, the range of the CSO transitions into that of the Northern spotted owl (NSO) (Barrowclough et al. 2011).

The American Ornithological Union currently recognizes three genetically distinct subspecies of spotted owl: California spotted owl (*Strix occidentalis occidentalis*), Northern spotted owl (*Strix occidentalis caurina*), and Mexican spotted owl (*Strix occidentalis lucida*) (Haig et al. 2004) (Figure 1). Relative to the other two subspecies, CSO exhibit low genetic variation (Barrowclough et al. 1999), although no negative effects of inbreeding have been found (Funk et al. 2008). Additionally, the Sierra populations are distinct from the southern California populations due to a lack of gene flow (Barrowclough et al. 1999, Haig et al. 2004, Barrowclough et al. 2005, Funk et al. 2008). California spotted owls in southern California are assumed to function as a metapopulation, though little movement has been recorded between isolated mountain populations (LaHaye et al. 1994, Barrowclough et al. 2005, LaHaye and Gutiérrez 2005). Because the three subspecies of spotted owls share many habitat and behavioral characteristics, for the purposes of this COR "spotted owl" refers generally to all three subspecies.

In the Sierras CSO are primarily found in mature, multi-layered mixed-conifer and yellow pine forest (80-90% of known sites), but also in red fir and riparian/hardwood forests (Verner et al. 1992). About half of known territories are within or adjacent to the wildland-urban interface (Blakesley et al. 2010). In southern California, habitat availability is more restricted and fragmented, so CSO are more frequently found in forests other than mixed-conifer, likely because mixed-conifer is only present at the highest elevations (Verner et al. 1992).

Figure 1. Approximate ranges for the three spotted owl subspecies (from NatureServe data).

2.2 Territoriality and reproduction

The spotted owl is a medium-sized brown owl with a mottled appearance, round face, large pale brown facial disks, dark brown eyes, and a yellowish green bill. Like most raptors, females are slightly larger than males (19-27 oz. vs. 17-24 oz., Verner et al. 1992). First and second year adults (subadults) can be distinguished by the tips of tail feathers, which are white and taper to a sharp point (Gutiérrez et al. 1995).

Spotted owls are long-lived species (can live over 15 years in the wild), with high adult survival and low reproduction; as a result, they are slow to recover from population declines (Keane 2013). They have a monogamous mating system, remaining with the same mate from year to year, although occasionally mates will separate, or "divorce." A pair occupies and defends a territory from neighbor and stranger individuals (Gutiérrez et al. 1995, Waldo 2002). In the central Sierra, territories are approximately 1000 acres (Seamans and Gutiérrez 2007a, Tempel et al. 2014b) based on a radius equal to half the "mean-neighbor distance" between the centers of adjacent owl sites (1.1 km). As central place foragers, spotted owls spend a disproportionate amount of time near their territory center, or core (Carey et al. 1992, Carey and Peeler 1995). When available, radio-telemetry has been used to approximate territory size and core use areas, resulting in some variation in size estimates (Bingham and Noon 1997). Home ranges include all habitat required for nesting, roosting, foraging, and other life functions. Home ranges will overlap each other and their size varies by latitude and study area (~1500-5400 acres), being smaller in the southern Sierras, where oaks are dominant (Zabel et al. 1992). An individual typically begins exhibiting territorial behavior in 1-4 years. Those individuals that have not yet established a territory (mostly subadults) are referred to as floaters, and little is known about their habitat requirements (Franklin 1992). The presence of conspecifics and an open territory determines settlement as owls are more likely to settle in territories that were occupied the previous year (LaHaye et al. 2001).

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Breeding season begins in mid-February and can last through mid-September, starting earlier in southern California and at lower elevations throughout its range, with the peak of egg-laying in mid-April (Verner et al. 1992). Pairs divide the nesting roles; the male CSO provisions the female while she sits on the nest (Gutiérrez et al. 1995). Females lay 1-3 eggs, but survival of the offspring is highest when two young fledge (Peery and Gutiérrez 2013). Eggs take approximately 30 days to hatch, and owlets fledge about 35 days later. Fledglings will "branch out," leaving the nest before they can fly and roosting near the nest and their parents. During this early developmental stage, juvenile owls rely on multi-layered forest structure to move about above the forest floor. Within several weeks, juveniles are able to fly and will generally disperse in the fall.

Spotted owls appear to follow a bet-hedging strategy of reproduction (Stearns 1976, Franklin et al. 2000). In good years with sufficient resources, they attempt a nest, but in poor years they do not. This often leads to an even-odd pattern of reproduction, where a majority of pairs will nest one year but not the next (Blakesley et al. 2010, Forsman et al. 2011). Importantly though, lack of reproduction at any given site for a few years does not necessarily mean the site itself is of poor habitat quality, but rather may reflect overall poor environmental or climatic conditions in those years (Stoelting et al. 2014). Annual mean reproductive output for the spotted owl is the lowest among North American owls (Johnsgard 1988), with 0.555-0.988 young/female CSO (Franklin et al. 2004, Blakesley et al. 2010).

Reproductive success is particularly dependent upon local weather conditions, especially during the previous winter or early in the nesting season (e.g. MacKenzie et al. 2012). Colder temperatures and greater precipitation early in the breeding season (March to May) was negatively correlated with reproductive success in Sierra National Forest and Sequoia-Kings Canyon National Park (North et al. 2000). Also, in Eldorado National Forest, El Niño events, which result in warm, wet winters, negatively influenced reproduction (Seamans and Gutiérrez 2007b). Northern spotted owls have also shown similar patterns in response to cold (Franklin et al. 2000). Cold temperatures during nesting may increase energetic requirements, risk of egg exposure, or interfere with foraging, resulting in decreased nesting success (Franklin et al. 2000, Rockweit et al. 2012).

Commented [KJ-2]: Recommend incorporating results reported from Peery et al. 2012 into this discussion.

California spotted owls have high site fidelity, returning to the same territory year after year. However, a small percentage of adults (7-9%) (Blakesley et al. 2006, Seamans and Gutiérrez 2007a) will disperse each year, often due to events such as the loss or change of configuration of their nest tree or a mate replacement (Berigan et al. 2012). Dispersing owls tend to be younger, and either join a mate or move to an adjacent territory of higher quality (Seamans and Gutiérrez 2007a, Gutiérrez et al. 2011). Although spotted owls are non-migratory, some will move downslope during winter (Laymon 1988, Verner et al. 1992, Gutiérrez et al. 1995). Downslope movement occurs in October to mid-December, from 9-40 miles, and a change in elevation of 1640-4921 feet (Gutiérrez et al. 1995). Pairs return to their territory in late February to late March. Juveniles undergo natal dispersal in September, averaging 6-10 miles, though dispersal distance can range between 2-47 miles (LaHaye et al. 2001, Blakesley et al. 2006).

In contrast to relatively low reproduction rates, spotted owls have apparent high adult survival in the Sierras (0.810-0.891), and male survival is slightly higher than female (Blakesley et al. 2010, Tempel et al. 2014a). Juvenile survival is more difficult to measure because of natal dispersal and emigration. However, the few studies that have estimated juvenile survival found it to be substantially lower than adult survival (0.368 in San Bernardino National Forest, LaHaye et al. 2004; 0.333 in Lassen National Forest, Blakesley et al. 2001).

Temporal variation in survival is not as well-explained by weather covariates as reproduction is. However, survival does appear to have a quadratic relationship with the Southern Oscillation Index so that survival is greatest in years not dominated by either El Niño or La Niña weather patterns (mild, intermediate winters) (Seamans and Gutiérrez 2007b). Spotted owls can be preyed upon by great horned owls (*Bubo virginianus*), as well as northern goshawks (*Accipiter gentilis*) and red-tailed hawks (*Buteo jamaicensis*) (Gutiérrez et al. 1995). There has also been one instance of a likely predation by a barred owl (*Strix varia*) (Leskiw and Gutiérrez 1998). Juveniles and eggs may be taken by typical nest predators. Although variability in the population growth rate is driven by both reproductive rate and survival, growth rate is more sensitive to changes in adult survival (Blakesley et al. 2001, Seamans and Gutiérrez 2007a). Juvenile survival provides the smallest contribution to changes in the population growth rate (Tempel et al. 2014a).

Commented [KJ-3]: "typical nest predators" is too general and unclear. Suggest adding specific reference to species of concern with appropriate citation(s).

2.3 Habitat requirements

Spotted owls prefer residual old growth forest with high structural diversity (Laymon 1988, LaHaye et al. 1997, Moen and Gutiérrez 1997, Seamans and Gutiérrez 2007a). The nest tree itself is critical for CSO success, and is typically the oldest, largest live or dead tree with many defects like cracks or decaying wood (Verner et al. 1992, Blakesley et al. 2005). Spotted owls are frequently cavity nesters, using live trees and snags, broken top trees, platforms (mistletoe brooms), debris platforms, and even old raptor or squirrel nests. In the Sierras, the average nest tree is 103 ft. tall, 49 in. diameter at breast height (dbh), with the nest at 74 ft. high. In general, nest trees in mixed-conifer forest are >30 in. dbh and can be a variety of species (Verner et al. 1992, North et al. 2000, Blakesley 2003). In hardwood forests, the typical nest tree is ~30 in. dbh and 55 ft. tall (Verner et al. 1992). California spotted owls prefer nest trees that are located further from forest edges (Phillips et al. 2010).

Commented [KJ-4]: Larger trees are a critical habitat element so suggest being very specific with these statements. Please provide a citation for the avg of 49 inch dbh. Next sentence then states that "in general" nest trees are greater than 30" dbh. "In general" implies many nest trees less than 30" dbh. For conifers, most nest trees are much larger than 30" dbh in order to provide large enough cavities and broken tops that serve as nest substrate. Many times the smaller dbh trees lack these important features but may be used because they have a stick structure of some sort (raptor-corvid-squirrel nest, mistletoe, etc.).

The habitat structure immediately above and near the nest site has been the focus of a considerable amount of research and is important to CSO occupancy, fecundity, and survival. In general, CSO nesting habitat consists of dense overhead canopy cover, large trees, a high basal area (total cross-sectional area of all trees at 4.5 ft. above ground, 185-350 ft^2/ac), multiple canopy layers, and an abundance of limbs and large logs on the ground (Bias and Gutiérrez 1992, Verner et al. 1992, Moen and Gutiérrez 1997, North et al. 2000, Blakesley et al. 2005, Chatfield 2005, Seamans 2005, Roberts et al. 2011). For the purposes of analysis, canopy cover is typically broken into three classes: high (≥70%), moderate (40-69%), and low (<40%) (Tempel et al. 2016). For tree size definitions, we refer to the standard Forest Service categories of very large (≥36 in. dbh), large (≥24 in.), medium (12-23.9 in.), and small (<12 in.) (Tempel et al. 2014b). Reproduction in particular has been associated with high canopy cover at multiple scales (Hunsaker et al. 2002, Tempel et al. 2014b). On Lassen National Forest, reproductive success was correlated with forests dominated by high canopy cover and medium or large trees, and

negatively correlated with non-forest or forest dominated by small trees (Blakesley et al. 2005). On Eldorado National Forest, a higher amount of hardwoods (and thus lower canopy cover) within a territory negatively influenced reproduction (Seamans 2005, Tempel et al. 2014b). At the immediate nest area (0.12 acre), productivity is also positively correlated with foliage volume above the nest site (North et al. 2000). Additionally, large trees have been shown to be particularly important for NSO within 400 m of the nest (Irwin et al. 2011). Besides nesting success, high canopy cover may also be important for post-fledging rearing, as juveniles tend to roost within 800 m of their nest (Whitmore 2009). The complex vertical structure is important for shading and avoidance of overheating in the hot summers (Barrows 1981, Weathers et al. 2001).

Territories have greater habitat heterogeneity than nest stands, but occupancy, colonization, adult survival and reproductive success are still positively associated with the proportion of core area containing structurally complex conifer forest with large trees and high canopy cover (Blakesley et al. 2005, Seamans and Gutiérrez 2007a, Tempel et al. 2014b). Recent evidence suggests that the most important predictor of occupancy is the intersection of high canopy cover and large trees (Jones et al. in review). Spatial heterogeneity including small gaps or openings within the territory is thought to be particularly important for the development of a sufficient prey base. There does appear to be evidence that once a certain amount of high canopy cover is reached, additional moderate canopy cover can similarly benefit occupancy (Tempel et al. 2016). Thus, areas of both high and moderate canopy cover can be important. However, if the overall CSO territory is <40% canopy cover, that certainly reduces quality (Tempel et al. 2016). Northern spotted owls have similarly been found to maximize fitness within territories that are heterogeneous in forest stages (Franklin et al. 2000). California spotted owls will forage primarily in contiguous patches of moderate to high canopy cover, but will also use edge habitat (Williams et al. 2011, Eyes 2014). Riparian habitats can be particularly important for prey (Irwin et al. 2007, 2011, Bond et al. 2016). Furthermore, areas that have been burned at primarily low and moderate severity fire may also provide valuable foraging habitat and heterogeneity within territories (Bond et al. 2009, Eyes et al. 2017).

Commented [KJ-5]: Important to recognize that owls may use edges of high severity burn patches for foraging as reported by Bond et al. 2009, not just low and moderate severity habitat. This is important as high-severity fire was/is a component of a mixed-severity fire regime, and likely provided foraging benefits to owls when overall amounts and patch sizes were within the range of historical patterns. The concern is with recent increases in amounts and patch sizes of high-severity fire, coupled with future increases given current trends and projected climate scenarios. I have attached our recent paper on mixed-severity fire regimes for inclusion (Hessburg et al. 2016).

Although less is known about minimum habitat requirements at the scale of a home range, CSO still consistently use areas that contain greater abundance of large trees and greater proportion of mature forest than the average forest composition on the landscape (Call et al. 1992, Moen and Gutiérrez 1997, Williams et al. 2011). As heterogeneity increases, so does the size of a CSO home range, so there may be a negative effect if too much heterogeneity exists within CSO habitat (Williams et al. 2011, Eyes 2014). In managed landscapes, studies on CSO habitat use may be influenced and limited by the habitat types that are available, so the findings may not reflect optimal CSO habitat (Gutiérrez et al. in press).

In southern California forests, most CSO live in forests other than mixed-conifer because that forest type is restricted to the highest elevations in the isolated mountain ranges (Verner et al. 1992). These forests include riparian/hardwood forests and woodlands, live oak/big cone-fir forest, and redwood/California laurel forest. In San Bernardino National Forest, the most used cover types are canyon live oak/big cone fir (Smith et al. 2002). This habitat might be preferred due to high densities of prey in the chaparral that surrounds it (LaHaye et al. 1997). Still, in the Southern forests, on average 70% of a territory is in moderate or high canopy cover (Lee and Irwin 2005). Even with less access to mature forest, owls select for more closed canopy and less non-forest at four different scales up to the size of a territory (Smith et al. 2002), and still select for large trees and higher basal area at nest sites (LaHaye et al. 1997). The presence of large residual trees (those that are significantly larger or older than the contemporaneous stand) also greatly increases the likelihood of CSO use for foraging activities (Bias and Gutiérrez 1992, Moen and Gutiérrez 1997, Williams et al. 2011).

Commented [KJ-6]: This paragraph addresses owls in the southern California mountains. Lee and Irwin's paper analyzes data from the Sierra National Forest in the southern Sierra Nevada, not the mountains of southern California.

2.4 Foraging and diet

Because spotted owls are central place foragers, they concentrate most of their foraging and activity around the nest or roost, and their activity declines further out from the nest (Carey et al. 1992, Ward et al. 1998). Spotted owls rarely fly above the forest canopy, except for dispersal (Gutiérrez et al. 1995). As perch and pounce predators, spotted owls are agile but not particularly fast fliers. Spotted owls are primarily active at night, but will also hunt during the day, especially when they have young to feed (Verner et al. 1992). Later in the nesting season, owls may also forage further from the nest to feed growing fledglings.

Although CSO will eat a variety of prey, they are considered to be small mammal specialists because they select a few key species for the majority of their diet. At upper elevations (above 4,000 feet) in the Sierra Nevada conifer forests, Northern flying squirrels (*Glaucomys sabrinus*) are the primary prey (Laymon 1988, Munton et al. 2002). At lower elevations in the Sierras, as well as in southern California, where oak woodlands and riparian-deciduous forests are dominant, CSO prey more on woodrats (*Neotoma* spp.) (Verner et al. 1992, Smith et al. 1999, Munton et al. 2002). Flying squirrels dominate CSO diet at about 75% of known owl sites (Verner et al. 1992). California spotted owls have low metabolic rates relative to other birds and would require one flying squirrel every 1.8 days or one woodrat every 3.7 days (Weathers et al. 2001). Individuals tend to have smaller home ranges where woodrats are the prey base compared to flying squirrels, presumably because woodrats provide a higher caloric gain per successful spotted owl foraging bout and occur in higher densities (Zabel et al. 1995). By biomass, regardless of elevation, pocket gophers (*Thomomys* sp.) are the second largest component of CSO diet. Although CSO will prey upon some birds, reptiles, amphibians, and insects, mammals make up the most biomass (Munton et al. 2002).

Commented [KJ-7]: Need citation because I do not know if this is true across all studies.

Flying squirrels are found more in closed-canopy forests (Pyare and Longland 2002, Meyer et al. 2005, Roberts et al. 2015). A moderate to high canopy closure, large trees, thick litter layer and sparsely distributed coarse woody debris are particularly important for developing a good prey base in these habitats (Waters and Zabel 1995, Pyare and Longland 2002, Meyer et al. 2005, 2007, Kelt et al. 2014, Roberts et al. 2015). Coarse woody debris is critical, but does not need to be overly dense (Knapp et al. 2005). Riparian habitat and other relatively mesic sites in particular yields truffle and tree hair lichen, which are important to flying squirrel diet (Meyer et al. 2008, Smith 2007).

Woodrats are found more often in open habitats, oak woodlands, and early seral-stage forests (Innes et al. 2007). Specifically, at lower elevations, woodrats (both dusky-footed and big-eared) and brush mouse are associated with oak cover and the density of large oaks >13 in. dbh (Innes et al. 2007, Roberts et al. 2008, Kelt et al. 2014). Heterogeneous forest conditions often provide higher primary productivity than homogenous closed canopy forests and thus, generally enhance prey habitat (Jones et al. 2016b, Sollmann et al. 2016). Transitional areas (habitat with conifer stands and a significant hardwood component) where prey distributions overlap offer a rich and diverse prey base (Verner et al. 1992). Small mammal diversity is enhanced by increased structural heterogeneity at large spatial scale and greater development of mature forest structure (Kelt et al. 2014, Roberts et al. 2015).

Commented [KJ-8]: This statement may be true but neither of the cited studies provides empirical evidence to support this broad statement as presented. Sollman et al. 2016 found that flying squirrel numbers were generally the same pre- and post-treatment, with some shift in spatial distribution away from treated patches. This is not evidence for "enhanced" prey habitat for flying squirrels. Is the statement meant to imply there is enhanced habitat for other small mammal species beyond flying squirrels? Might just carefully restate this concept.

3. CURRENT CONDITION

The California Department of Fish and Wildlife (CDFW) maintains a record of CSO locations and activity centers (areas of repeated detection, nesting/roosting areas) in the California Natural Diversity Database (CNDDB). Although many sightings have not be reconfirmed outside of ongoing study areas, since 1993, 1,416 unique CSO activity centers have been recorded, the majority of which are in the Sierras (Figure 2). Rather than estimating overall population size, then, most of our knowledge of the status of CSO is derived from population trends in four long-term demography studies in the Sierras, and one in southern California. In the Sierras, data collection began in 1986 on the Eldorado National Forest and in 1990 on the Lassen National Forest, Sierra National Forest, and Sequoia-Kings Canyon National Park. In southern California, the San Bernardino National Forest was studied from 1987-2010, with some gaps in sampling. Multiple meta-analyses have utilized different techniques to analyze the population trends of CSO in these study areas. The nuances of these techniques are beyond the scope of this discussion (see Gutiérrez et al. in press for a full comparison), but the overall trends are consistent and we focus on the most recent analyses here.

On Forest Service lands, since the early 1990s, CSO nesting sites have been managed as Protected Activity Centers (PACs), which include ~300 acres of the "best available" contiguous habitat. This scale has proven to be a useful management tool and biologically relevant because

habitat characteristics at this scale are related to demographic parameters (occupancy, reproduction, and survival) (Blakesley et al. 2005), and CSO have repeatedly used these areas over the long-term (Berigan et al. 2012). Most data analysis relies on trends in the occupancy of territories or trends in the abundance of a study area.

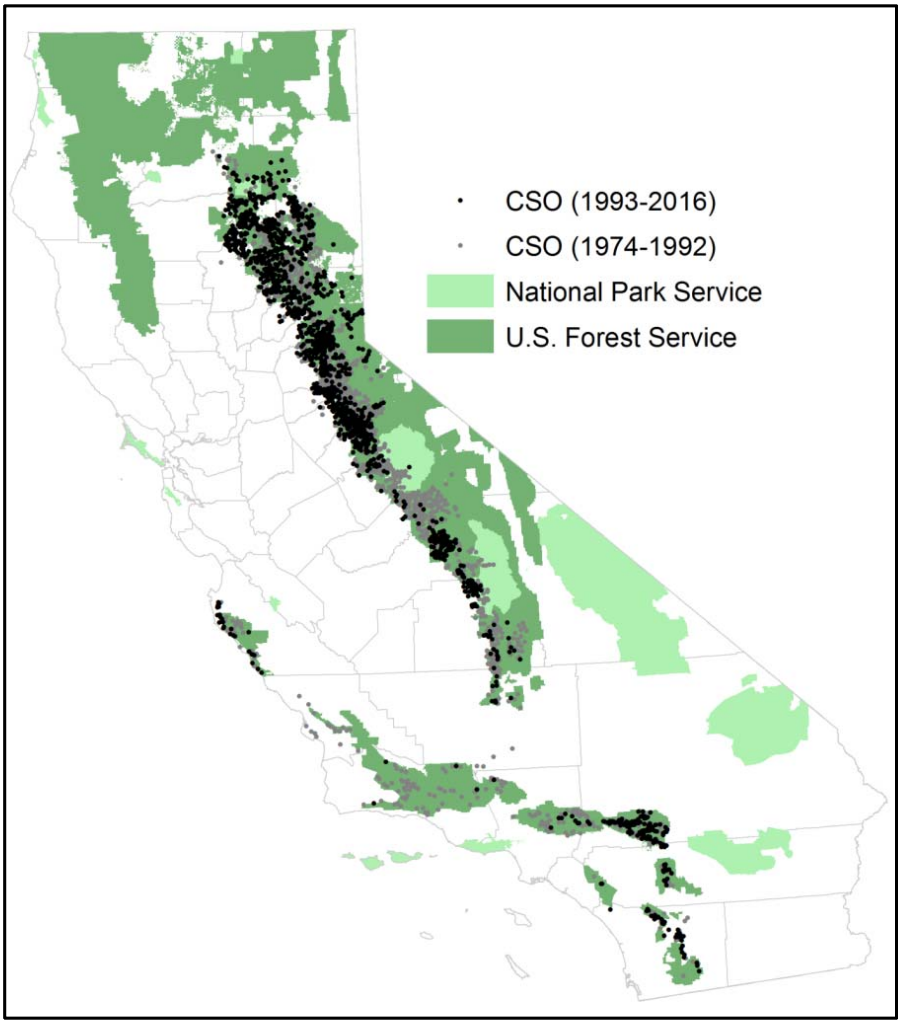

Figure 2. Map of California spotted owl activity center locations from CNDDB, before and after 1993. Shown with federal lands.

Evidence is clear that CSO have declined in both occupancy and abundance on the three national forests in the Sierras (Lassen, Eldorado, and Sierra), as well as in southern California. In the Sierras, CSO have experienced a decline in abundance of 11% on Sierra National Forest, 22% on Lassen National Forest, and 50% on Eldorado National Forest (Connor et al. 2013, Tempel et al. 2014a). San Bernardino National Forest has seen a similar decline of 50% from 1989-2010 (Eliason and Loe 2011) in territory occupancy, and a 9% per year decline in abundance from 1987-1998 (LaHaye et al. 2004). The only stable CSO population on public lands appears to be in Sequoia-Kings Canyon National Park, the only national park with a long-term CSO demography study (Table 1).

Table 1. California spotted owl population trends from 5 long-term demography studies.

Commented [KJ-9]: This table needs to be updated with results from Connor et al 2016 for the Lassen, Sierra, and SKC study areas. I have attached this paper.

Study area	Population change	Time period	Study area size (km^2)	Citation
Eldorado	- 50%	1990-2012	355	Tempel et al. 2014
Lassen	- 22%	1990-2011	1,254	Connor et al. 2013
Sierra	- 11%	1990-2011	562	Connor et al. 2013
Sequoia-Kings Canyon	+ 16%	1990-2011	182	Connor et al. 2013
San Bernardino	- 65%	1987-1998	2,140	LaHaye et al. 2004

The causes of the CSO population declines have not been conclusively identified. However, recent work suggests that rather than current management practices on national forests, the declines may be the result of a lag effect from the past removal of large trees prior to the early 1990s (Jones et al. in review). Although the populations are declining, reproduction appears to be relatively constant in all study areas in the Sierras except Eldorado, where measured parameters continue to be highly variable between years (Blakesley et al. 2010). Additionally, on national forests, studies found that more territories were being occupied by single CSO rather than pairs (Tempel and Gutiérrez 2013).

The only recent CSO population information from private lands is from five study areas on mixed ownership lands scattered through the northern half of the Sierras. From 2012-2016, systematic surveys found a high proportion of occupied territories each year that remained occupied during the study period (Roberts et al. in press). Additionally, CSO crude densities reported on the private timberlands were similar or higher than those on public lands (Roberts et al. in press, Table 2). Crude densities may not be a reliable indicator of habitat quality because an area could be a population sink supported by continued immigration from more productive source habitats (Pulliam 1988). Additionally, given the short duration of this survey effort and because CSO are long-lived and exhibit high site fidelity, returning to the same territories year after year, it is difficult to ascertain population trends from this survey data at this time.

However, of 45 CSO territories documented prior to 1996, all 45 were occupied at least once during the study period (2012-2016). These preliminary results warrant further monitoring and analysis with demographic data on individually marked owls if we are to determine if there is a difference in current CSO status between public and private lands.

Table 2. California spotted owl crude densities in study areas (most recent estimates). Primary land ownership is defined by >60% of study area, otherwise labeled as mixed ownership.

Study Area	Crude density	Study area size (km^2)	Primary land ownership	Citation
Fall River	0.056	89	Private	Roberts et al. in press
Lassen	0.051	355	National Forest	Gutiérrez et al. in press
Chalk Bluff	0.152	86	Mixed	Roberts et al. in press
Eldorado	0.16	1,254	National Forest	Gutiérrez et al. in press
Stumpy Meadows	0.035	115	Private	Roberts et al. in press
South Fork Cosumnes River	0.141	137	Private	Roberts et al. in press
South Fork Mokelumne River	0.071	122	Mixed	Roberts et al. in press
Sierra	0.151	562	National Forest	Gutiérrez et al. in press
Sequoia-Kings Canyon	0.184	182	National Park	Gutiérrez et al. in press
San Bernardino	*No recent estimate*	2,140	National Forest	Gutiérrez et al. in press

Most forest types have been defined by California Wildlife Habitat Relations (CWHR) categories with existing vegetation classification and mapping (EVEG). In the Sierras, 4M or greater CWHR translates to ≥40% canopy cover and trees ≥12 in. dbh, which include potential habitats used by CSO. Currently, there are approximately 4.9 million acres of 4M or greater CWHR in the Sierras, just over half of which is Sierra mixed conifer forest (Gutiérrez et al. in press). Of this habitat, 75% is on national forests, 7% on national parks, and 18% on private or other lands. In the southern California national forests, there are only about 400,000 acres of 4M or greater CWHR, about 16% of which is Sierra mixed conifer; however there are about 1.2 million acres of general habitat types in which CSO have been known to reproduce (Stephenson and Calcarone 1999). The realized amount of suitable habitat is likely far less though, in particular after major losses from wildfire and drought over the last decade and a half.

4. SUMMARY OF STRESSORS

Large, high-severity fires

Historically, the natural fire regime in the Sierra Nevada and southern California forests included frequent fires at primarily mixed-severity (mostly low-moderate, with patches of high-severity) (Van de Water and Safford 2011, Mallek et al. 2013). Past forest management, namely fire suppression and loss of large trees, however, has led to dense forests with high fuel load conditions and shade-tolerant trees, resulting in an increased frequency and patch size of high-severity fires (Miller et al. 2009, Mallek et al. 2013, McIntyre et al. 2015, Steel et al. 2015). In defining fire severity, in general, low-severity fire consumes surface fuels but not canopy trees (<25% upper canopy layer is lost or <25% basal area mortality); moderate-severity fire removes small trees (up to 75% canopy layer or basal area mortality); and high-severity fire consumes all surface fuels and nearly all mature plants (>75% canopy or basal area mortality) (Key and Benson 2005, Barrett et al. 2010). Prior to Euro-American settlement, frequent low-moderate severity fires occurred every 5-15 years (Van de Water and Safford 2011, Mallek et al. 2013). In areas with high fuel loads or during hot, dry weather patterns, some high-severity patches likely burned too, but were generally limited in size. In mixed-conifer forest in the Sierras, any given fire would not have included more than 5-10% high-severity fire (Miller and Safford 2017). The patches of high-severity fire averaged only 10 acres in size, with a maximum historic patch size of 250 acres (Collins and Stephens 2010, Miller and Safford 2012, Safford and Stevens in press).

Consequently, forests were likely made up of an abundance of large, fire resistant trees at a lower density (Taylor 2004, Scholl and Taylor 2010, Collins et al. 2011a). Basal area for historical conditions in the Sierras ranged from 91-235 ft^2/acre, depending on site productivity, with a mean of 150 ft^2/acre (Safford and Stevens in press). Additionally, snags in today's forest are significantly smaller and at a higher density (Agee 2002), resulting in an overall denser and more homogenous forest (Hessburg et al. 2005).

In southern California shrub-dominated landscapes, patches of high-severity fire have always been more common than in the Sierras (Steel et al. 2015). However, the area impacted by fires in southern California has also been increasing recently, in part due to continued human population growth and the conversion of cover types to grasses (Syphard et al. 2017). Although temperature is clearly a factor related to the area burned in higher elevation forests, prior-year precipitation is more strongly related to fire activity in the Sierra foothills and southern California (Keeley and Syphard 2017).

Both CSO and NSO will readily use habitat that has been subject to low and moderate severity patches of fire (Clark 2007, Eyes 2014). However, large patches of high-severity fire significantly reduce colonization, occupancy, and use (Roberts et al. 2011, Eyes 2014, Tempel et

al. 2014b). The year after the King Fire, the probability of CSO site extirpation was seven times higher in severely burned sites (when greater than half the territory burned at high-severity) than others (Jones et al. 2016a). In southern California, when patches of high-severity exceeded 123.5 acres (of a 500 acre territory), territory extinction probability increased (Lee et al. 2013). High-severity fire has also been shown to negatively affect survival of NSO (Rockweit et al. 2017). Northern spotted owls showed an increased turnover of territory occupancy in response to high-severity fire, suggesting that continued occupancy of the territories may be temporary and overall quality of the territory is reduced (Rockweit et al. 2017). There is likely some threshold of high-severity fire owls can tolerate within their territory, although the exact size and configuration is unknown.

While CSO will forage in habitat subject to a variety of burn severities, they still tend to use primarily low and moderate severity patches, avoiding large, high-severity areas (Jones et al. 2016a, Eyes et al. 2017). The size and configuration of the patch of high-severity fire appears to be critical. Some work suggests that CSO will use high severity patches in proportion to availability 3-4 years after the fire (Bond et al. 2009, 2016), although the sizes of the foraging patches in these studies were not reported. In Yosemite National Park, the mean size of a high severity patch used for foraging was 16 acres (Eyes 2014). Additionally, CSO were found to selectively forage in fire-created edge habitats, rather than contiguous edges (Eyes et al. 2017). Many prey species important to CSO are negatively correlated with fire severity including flying squirrels and deer mice (Roberts et al. 2008, 2015). Landscapes with restored fire regimes (such as Yosemite National Park) show greater small mammal species evenness, which could promote stability and resilience in CSO prey populations (Roberts et al. 2015). So while it appears that often California spotted owls will avoid large, high-severity patches, smaller patches and mixed severity can be beneficial because they support the prey base.

Habitat loss to large, high-severity fire is a substantial threat to CSO persistence. Within the next 75 years, based on fire activity trends, the amount of nesting habitat burned at moderate or high-severity fire will likely exceed the total existing habitat in the Sierras, and therefore there is a critical need to avoid losses of older forests (Stephens et al. 2016b). Closed canopy forests (such as those in PACs) do tend to have uncharacteristically large and severe fires (Agee and Skinner 2005). However, from 1993-2013, 88,000 acres of CSO PACs burned, 28% of which were at high-severity, which was a similar proportion to the overall landscape (Gutiérrez et al. in press). So while PACs themselves are not necessarily more vulnerable to high-severity fire than the surrounding landscape is, the proportion of PACs burned at high-severity is greater than would be expected under a natural fire regime (<5-15% Mallek et al. 2013). California spotted owls are similarly losing habitat in southern California, which has experienced increasing widespread wildfires, particularly in the early 2000s (Keeley et al. 2009). Repeated high-severity fires in the same area can convert the type of habitat, resulting in long-term habitat loss (Stephens et al.

2013). Addressing the potential effects of large, high-severity fires on owl habitat will require collaborative landscape-level efforts.

Forest management practices

The effects of specific forest management practices on spotted owls are not well understood. Some practices may act as stressors on spotted owls, while others may improve habitat. Commercial timber harvest no longer occurs within the CSO range in southern California on public lands (Eliason and Loe 2011), though it continues to occur on private lands, and is conducted in the Sierras on both public and private lands. Additionally, in order to reduce the likelihood of high severity fires, fuels reduction activities on public lands have been slowly implemented. Forest fuels are typically split into four categories: ground (material that has begun to degrade), surface (downed wood, herbaceous vegetation and shrubs), ladder/bridge (small trees and larger shrubs), and aerial/crown fuels (within the crowns of standing trees, separated from surface fuels) (Jenkins et al. 2014). Management for fuels reduction in the forest includes reducing surface fuels, increasing the height to the live crown (reducing ladder fuels and removing small trees), decreasing crown densities, and retaining/recruiting large fire-resistant tree species (Agee and Skinner 2005). Data on the effects of various fuel treatments on owls has been mixed, due to minimal experimentally designed studies, confounding factors, and a lack of consistency in defining types of treatments. For the purposes of discussion we broadly classified the methods of fuels reduction into prescribed fire, hand thinning, and mechanical treatments. For the most part, prescribed fire that has the potential to lead to low or moderate severity fires, or mixed severity with small patches of high-severity fires can be good for owl habitat. Additionally, hand thinning of smaller trees does little to disturb CSO. These small scale treatments typically leave high canopy cover and large trees, which are important to spotted owl nesting. Chainsaws and helicopter noises do not appear to decrease reproductive success (Delaney et al. 1999) nor increase stress hormones like corticosterone (Tempel and Gutiérrez 2003, 2004). However, NSO nesting near loud roads have lower reproductive success than those near quiet roads (Hayward et al. 2011), and males show higher levels of corticosterone (Wasser et al. 1997), suggesting there may be some non-lethal effects from noise-causing human disturbances.

<u>*Forest management: mechanical thinning*</u>

Owl response to mechanical treatments is less clear and appears to rely on scale and intensity of the treatments. Mechanical treatments (or thinning) refer to machine-based fuels reduction for purposes of reducing large fires and tree harvest (North et al. 2015). Generally, territories with greater amounts of mature conifer forest have a higher probability of colonization by CSO (Seamans and Gutierrez 2007a), so actions that alter mature forest to a large degree could result in a less desirable territory. Specifically,

converting mature conifer forest from high to moderate canopy cover was negatively correlated with demographic parameters in one meta-analysis (Tempel et al. 2014b). In an earlier study, territories with >50 acres of altered mature forest showed a 2.5% decline in occupancy and an increase in dispersal (Seamans and Gutiérrez 2007a). However, minimal effects were found on NSO two years after territories were treated, and no abandonment of a territory was detected in areas that were treated up to 58% (Irwin et al. 2015). Modeling projected over a 30 year time frame suggested that while treatments can reduce the risk of high-severity fire to CSO, in the absence of fire, such treatments could have a negative effect on fitness (Tempel et al. 2015). At the landscape-scale, another study examined the effects of mechanically-produced wide shaded fuel breaks (Defensible Fuel Profile Zones) on CSO and found that the fuel breaks were avoided for 1-2 years after treatments (Stephens et al. 2014). Additionally, occupied territories declined by >40% within four years after treatment, and the remaining individuals used larger areas. Mechanical thinning that results in widely and regularly spaced trees tend to be avoided by CSO (Gallagher 2010). However, the most recent meta-analysis of the long-term demography studies in the Sierras did not find any impact to occupancy, survival, or productivity from mechanical thinning (Tempel et al. 2016), and in fact some populations exhibited small positive effects on occupancy.

Forest management: salvage logging

Salvage logging refers to the removal of dead or damaged trees to recover economic value that would otherwise be lost (Society of American Foresters' Dictionary). It typically occurs after a fire, or large tree mortality event, and can be a controversial activity (Long et al. 2013). Because CSO can persist in low-moderate severity fires, salvage logging of viable habitat may negatively affect occupancy (Gutiérrez et al. in press). In high-severity fires, it was found that salvage logged sites had a slightly lower probability of being occupied than sites that only burned and did not undergo salvage logging treatment, although the difference was not statistically significant (Lee et al. 2013). Recent work on NSO found that high severity-fire interacts with salvage logging to jointly contribute to declines in site occupancy (Clark et al. 2013). Salvage logging may reduce the quality of foraging habitat through the removal of legacy snags, although it is difficult to disentangle the effects of salvage logging from high-severity fire.

Forest management: clearcutting

Timber harvest can cover all types of tree removal, which would include some fuels reduction activities as well as salvage logging. Clearcutting is one form of timber harvest that can take various shapes and sizes, though in general tends to leave large, regularly shaped patches with clean edges (Tempel et al. 2014b). In addition to outright habitat

loss, timber harvest can eliminate important CSO habitat elements such as old, large trees and large downed logs (McKelvey and Weatherspoon 1992). The overstory trees that remain in commercial thinning prior to a clearcut tend to be regularly spaced with little forest floor and understory diversity, and low heterogeneity in stand structure (Knapp et al. 2012). No research has explicitly examined spotted owl response to an even-aged management strategy using clearcuts, but these forest practices generally occur on private timberlands. California spotted owls have been observed avoiding private lands (Thraikill and Bias et al. 1989), and tend to forage on private lands proportionately less than the amount of private lands available on the landscape (Williams et al. 2014). These observations were not linked to management practices in these studies. However, CSO do nest on private timberlands in the Sierras. Additionally, crude density estimates of CSO territories are similar across public and private lands (Roberts et al. in press), although, as discussed above, there is limited information regarding population trends on private lands. While some gaps in canopy cover can be beneficial for the prey base, current clearcutting practices probably do not create the collection of patches observed in spotted owl territories with high-fitness (Franklin et al. 2000).

Tree mortality

Tree mortality has substantially increased throughout the Sierras, particularly in the southern Sierra region (van Mantgem et al. 2009, Asner et al. 2015). In 2015 in the southern Sierra, about 345 trees/km^2 died (Young et al. 2017), and very large trees in general are disproportionately affected by tree mortality (Smith et al. 2005). Drought combined with dense forest conditions have led to severe water stress (Asner et al. 2015, Young et al. 2017) in forest trees. This stress interacts with pathogens, insects and air pollution (Lutz et al. 2009, McIntyre et al. 2015). Bark beetles in particular are exacerbated by climatic conditions (Bentz et al. 2010), and measures of stand density are correlated with levels of mortality attributed to bark beetles, suggesting the density of trees (and indirectly competition) is a contributing factor (Hayes et al. 2009). The full extent of the mortality and effects on CSO is unknown, but the tree mortality is likely to contribute to habitat loss.

Barred owls

Barred owls were historically confined to eastern North America, but have expanded west over the past century (Livezy 2009). Whether barred owl expansion is human-caused is uncertain, but it is thought to be a combination of settlement of the central plains combined with climate change. Currently barred owls threaten NSO in parts of its range. They use a broader suite of vegetation, though still show a preference for old growth, large trees, and high canopy cover like spotted owls (Wiens et al. 2014). Because barred and spotted owls use similar habitat, natural segregation and coexistence is unlikely (Yackulic et al. 2012, 2014). Barred owls are

competitively superior and have a smaller home range (2-4 times smaller), probably due to a broader diet (Wiens et al. 2014). Barred owls can thus live at substantially higher densities than spotted owls.

Where barred owls occur in the NSO range, they decrease NSO occupancy by increasing territory extinction and lowering colonization (Olson et al. 2005, Dugger et al. 2011, Yackulic et al. 2014). Northern spotted owls show a lower overall probability of habitat use (Van Lanen et al. 2011) and lower nesting success; barred owls produced 4.4 times more young over a three year study period (Wiens et al. 2014). Furthermore, because barred owls can live at higher densities and consume a wider variety of prey species than spotted owls, their expansion has the potential to alter the prey on the landscape and affect a variety of other native species (Holm et al. 2016). In the range of NSO, there are ongoing removal experiments that suggest NSO may reoccupy a site within one year after barred owls are removed; however 1-4 years after the initial removal, barred owls again occupied some sites (Diller et al. 2012). These removal experiments are being conducted in areas of relatively high barred owl densities. In the range of CSO, however, barred owl detections have been low, suggesting the edge of barred owl expansion is just at the northern extent of CSO range.

A barred owl was first detected in the northern Sierras in 1989 and in the central and southern Sierras in 2004 (Steger et al. 2006). As of 2013, there were 51 barred owls detected in the Sierras (Gutiérrez et al. in press). Currently there are over 140 barred owl detections recorded in CNDDB, although these records do not necessarily reflect unique individuals. However, no systematic surveys have been conducted and all detections are incidental, therefore, they may be at a low density throughout the region (Dark et al. 1998, Keane 2014). There have also been a number of sparred owl detections, hybrids between the two species. As their range continues to expand, barred owls will likely become a significant threat to CSO (Gutiérrez et al. 2007). If control measures were to be implemented, they are more likely to be successful now, while the densities of barred owls are still low in CSO range (Dugger et al. 2016).

Contaminants

Although they have not yet been found in CSO, environmental contaminants may be an emerging threat. Rodenticides associated with illegal marijuana cultivations have been found in barred owls in northern California (Gutiérrez et al. in press). In the southern Sierra, large amounts of rodenticides and other pesticides have been found in national forests (Thompson et al. 2013), and fishers (*Pekania pennanti*) are experiencing high rates of exposure (Gabriel et al. 2012). Given that CSO share similar habitats and prey with fisher and barred owl, CSO are likely to be affected by rodenticides as well (Gutiérrez et al. in press).

Climate change

Current predictions suggest there will be a 3-6 degrees increase in temperature in the Sierras within the 21st century, and although changes in precipitation patterns are less certain, winter snowpack will likely decrease with a corresponding increase in ecosystem moisture stress during the dry, hot summer months (Cayan et al. 2013, Pierce et al. 2013). The direct effects of such climate changes on spotted owls will be complex as they exhibit population-specific demographic responses to local weather and regional climates (Franklin et al. 2000, Glenn et al. 2010, 2011, Peery et al. 2012). Additionally, spotted owls tend to only attempt nests in years with sufficient resources, following a bet-hedging strategy (Franklin et al. 2000). Drought and high temperatures in the previous summer can result in lower survival and recruitment (Franklin et al. 2000, Seamans et al. 2002, Glenn et al. 2011, Jones et al 2016b). Warm, dry springs, on the other hand increase reproductive success (Glenn et al. 2010, 2011, Peery et al. 2012, Jones et al. 2016b). Potential projected decreases in precipitation will likely reduce the plant production important for spotted owl prey (Seamans et al. 2002, Olson et al. 2004, Glenn et al. 2010, 2011).

With climate change, mixed-conifer forests, like many communities, are projected to advance upslope, which could develop habitat for CSO where none now exists (Peery et al. 2012). While these changes in habitat may mitigate some effects of climate change, the creation of new habitat will likely not keep pace with the loss (Stephens et al. 2016b). Climate change is likely to exacerbate the risk of large, high-severity fires and drought-induced tree mortality (Miller and Safford 2012, Mallek et al. 2013), which both have negative impacts on CSO habitat. The effects of climate change on fire activity, however, will likely vary across landscapes. Lower elevations and latitudes (e.g. southern California), where fire is more limited by ignition than climate, will be less likely to experience an increase in fire activity with hotter and drier conditions (Keeley and Syphard 2016).

5. CONSERVATION FRAMEWORK

Our conservation framework consisted of 1) identifying CSO population and habitat status and stressors, 2) defining broad conservation goals, and 3) developing conservation objectives and measures for ameliorating stressors and addressing CSO needs. We used three parameters: population and habitat representation, redundancy, and resilience (Shaffer and Stein 2010, Redford et al. 2011), as broad guiding concepts in developing our conservation objectives. Representation is the retention of various types of diversity (genetic, ecological, etc.) of the species so that the adaptive capacity of the species is conserved; resilience is the ability to recover from stochastic environmental variation and disturbances; and redundancy is multiple, geographically dispersed populations and habitats across the species' range that helps species withstand catastrophic events. In this COR, we relied on the best available science, including the latest Conservation Assessment (Gutiérrez et al. in press), recent emerging scientific research,

information received related to our March 17, 2017, letter soliciting new information from interested parties, and expert elicitation.

5.1 Conceptual model

Recognizing that many CSO habitat requirements vary based on scale, we have developed a conceptual model to examine how factors interact to influence CSO resiliency (Figure 2). The model includes population parameters that are typically measured for CSO, important broad habitat requirements, as well as the potential stressors discussed above. This model is not quantitative, but rather illustrates the interactions between stressors and habitat requirements to influence population parameters. Red arrows indicate one factor increases another, blue arrows indicate the factor decreases another, and purple indicates it may increase or decrease depending on other parameters. Thicker lines suggest a stronger relationship, and dashed lines indicate some uncertainty of the relative strength.

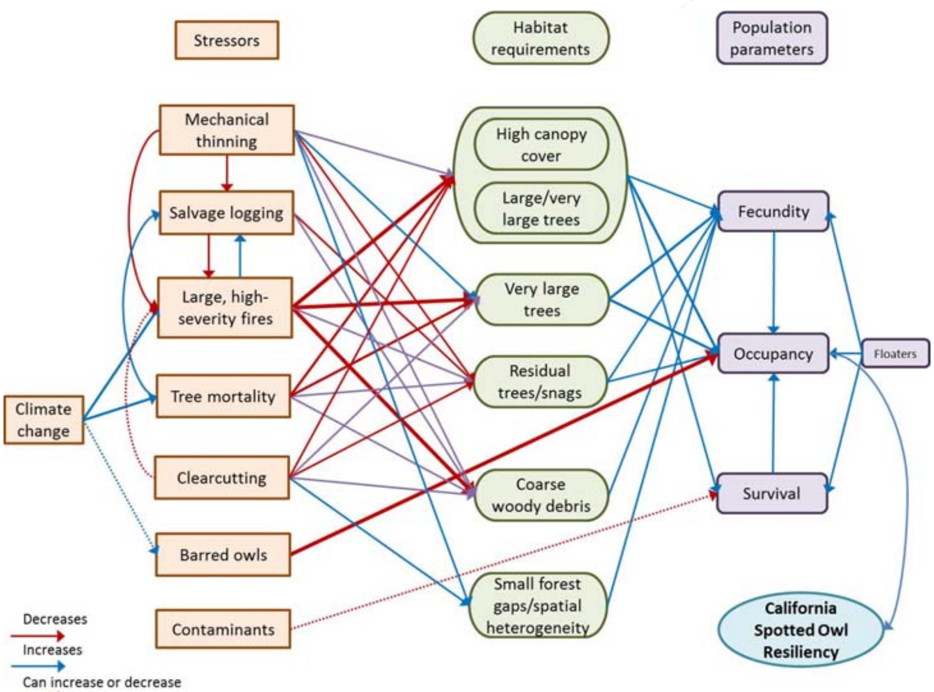

Figure 2. Conceptual model illustrating relationships among primary habitat needs, stressors, and California spotted owl population resiliency.

Population parameters include CSO territory occupancy, as well as fecundity and survival. Floaters, or non-territorial CSO, may contribute to populations because they can fill in when territories become available. Habitat requirements are broadly categorized into areas of high canopy cover with large (or very large) trees, very large trees, residual trees/snags, coarse woody debris, and small forest gaps/spatial heterogeneity. Some characteristics, such as high canopy cover and large/very large trees affect all population parameters. Other habitat components like coarse woody debris and forest heterogeneity are related to maintaining a sufficient prey base, and thus are more likely to affect fecundity than other parameters. Most potential stressors can affect multiple habitat components or population parameters as well as interact with each other. The most substantial stressor to habitat is large, high-severity fire, which may be modulated somewhat by various forest management practices. However, depending on scale and implementation, these same practices could also decrease certain habitat components. Additionally, barred owls are likely to emerge as a significant stressor to CSO resiliency by decreasing CSO occupancy. Finally, although we know little about contaminants as a stressor to CSO, we suspect the negative effects of contaminants have been going undetected thus far, and could become a more significant stressor to CSO. Managing for the interaction of these stressors will require a comprehensive region-wide conservation strategy and forest-specific plans.

5.2 Conservation Goal

Our goal is the long-term conservation of CSO and its habitat throughout its range by maintaining viable, connected, and well-distributed populations and habitats through amelioration of stressors and conservation of key habitat components.

6. CONSERVATION OBJECTIVES

6.1 General conservation objectives

Attenuate the population declines of California spotted owl

Although it is unclear exactly why CSO are declining, there is now substantial evidence that populations on national forests have declined significantly over the past two decades. Recent evidence suggests that these declines may be a result of previously altered habitat, rather than current forest management practices on national forests (Jones et al. in review). To that end, we need to continue to investigate the causes of the declines, and in the meantime preserve habitat elements we know are critical for CSO conservation. Stopping a population decline is an important part of any conservation strategy (Caughley 1994). Because PACs have been demonstrated as useful for CSO management (Berigan et al. 2012), focusing on maintaining a network of PACs, as well as other connected habitat throughout the range of CSO should be emphasized.

Manage habitat for spotted owl use and the long-term establishment of natural fire regimes
Among CSO and forest ecology experts there is an ongoing discussion about the need to balance the protection of CSO habitat elements with the reduction of the likelihood of large scale fires (Gutiérrez et al. in press). The only stable CSO population on public lands appears to be in Sequoia Kings Canyon National Park, which has not only more large trees but more of a restored fire regime (Blakesley et al. 2010, Tempel et al. 2014b). California spotted owls prefer high canopy cover, large trees, and complex forest structure, which can coincide with high fuel loads (Gutiérrez et al. in press). Any proposed conservation actions need to be strategic in balancing these seemingly conflicting needs. PACs should be avoided as much as possible, but territories can tolerate more habitat heterogeneity. It will be a challenge to balance enhancing habitat heterogeneity with maintaining sufficient mature closed canopy forest (Kane et al. 2013, Stephens et al. 2014). Short term losses of high canopy cover in some habitat, for example, may be necessary for reducing fuel loads, but could be acceptable to CSO persistence if other critical elements like large trees remain (Tempel et al. 2016). Specific fuel reduction activities should be designed in relation to known CSO territories, but also elevation, latitude, and forest site productivity. Mechanical treatment on its own will not achieve fire resilient landscape conditions, as it can be implemented on less than half of the productive forestlands in the Sierras regardless (North et al. 2015). The massive tree mortality in the southern Sierras may also make this goal more challenging. However, efforts to move the broader landscape toward a more natural fire regime will be important for long-term persistence (Stephens et al. 2016a).

Develop and encourage voluntary conservation actions
About 75% of CSO habitat and territories are on national forests or parks, with the rest on private timberlands. To conserve CSO and habitat resilience, redundancy, and representation, federal and state agencies and other stakeholders should work together to develop plans that include clear mechanisms for addressing the threats to CSO. In developing conservation plans, we encourage entities to coordinate closely with the Service. Implementation of mechanisms to conserve CSO will benefit from stakeholder participation in conservation planning across land ownership boundaries.

Create a region-wide monitoring program and develop adaptive management plans
Ensuring active monitoring and reporting is critical for understanding region-wide and population-specific changes. The development and implementation of a robust range-wide occupancy based monitoring program would expand upon the few existing long-term demography studies. Such a system would require standardized data collection across forests and land ownerships, and would ideally be implemented within each forest structure. The current demography studies could be compared across landownerships as well to understand the nuances of CSO responses to forest management practices. Without this information, it is difficult to measure the benefit of conservation activities and there would be limited capacity to adaptively manage if current management is ineffective and new science emerges.

Prioritize and support research to address additional uncertainties
In spite of the breadth of research, there are a number of uncertainties that remain about CSO. Most notably, although recent work is beginning to understand the causes of the declines on national forestlands, such causes of CSO declines have not been conclusively determined. We also require more information about the southern California populations in particular, as well as dispersal and recruitment dynamics across a larger landscape. Understanding such parameters across the landscape would help set more specific targets for population sizes and habitat connectivity. Designing experimental studies to test sensitivities to different fuels reduction treatments, as well as different habitat uses on private and public lands would aid in habitat management. Additionally, the future effects from recent tree mortality on spotted owl habitat and use is largely uncertain. Effective amelioration of stressors can only be accomplished if we understand how they affect CSO resiliency, redundancy, and representation.

6.2 Stressor-specific conservation objectives

The following stressor-specific conservation objectives are designed to ameliorate the stressors identified and discussed in this document. These goals are intended to be developed with more specificity within any conservation plan or strategy. In developing CSO plans and strategies, entities should coordinate with the Service to help ensure the specific conservation plans and strategies adequately address the stressors and conservation needs of the species.

Large, high-severity fires

Conservation objective: Retain and restore resilient forests throughout the range of California spotted owls.

As a result of a century of fire suppression, CSO habitat is threatened by large, high-severity fires (Stephens et al. 2016b). The majority of areas burned on private and national forest lands occurs as result of wildfire that escape suppression under extreme conditions that are more likely to result in high-severity effects (Lydersen et al. 2014, North et al. 2015). Lower elevations have a higher burn probability, and habitat subjected to high-severity fire is more likely to grow back as chaparral rather than forest, and increase the likelihood of burning again (Lydersen et al. 2014). These effects are exacerbated as the time since the previous fire increases. There is an urgent need to reduce the likelihood of forest ecosystem conversion to chaparral and the associated loss of high quality nesting habitat due to large, high-severity fire.

Conservation measures:

1. Increase the use of prescribed and managed fire for low-moderate and mixed severity burn as an active management tool. Mixed-severity fire can reduce surface and ladder

fuels, acting as natural fuel breaks. Historically about 486,000 acres a year in the Sierras would burn, mostly at low-moderate severity, with small patches of high-severity (North et al. 2012). Efforts should be made to move the forests towards a more natural fire regime. Restoration of the fire frequency that would mimic pre-settlement rates may not be achievable due to ownership patterns and smoke restrictions (Quinn-Davidson and Varner 2012). However, increasing burning under moderate weather conditions will be beneficial (Schweizer and Cisneros 2014).

2. Develop a quantitative risk assessment of CSO PACs and other habitat for large, high-severity fires.
3. Design and implement fuels reduction activities, prioritizing areas by risk of high-severity fire (see *Forest management practices* below for specific recommendations).
4. Focus fuel reductions outside of CSO PACs and core use areas. As PACs occupy a relatively small percentage of the landscape anyway, only 5-9% of productive lands, limiting the alteration of PACs would not hamper an effort to move the landscape towards a natural fire regime (North et al. 2015).
5. Recruit and preserve new CSO habitat outside of the current PACs. We recognize that habitat conditions in some CSO territories might not be viable long-term because of low drought tolerance or high burn probabilities. As some PACs are likely to experience high-severity fire, it will be important to strategically plan for recruiting new CSO habitat suitable under future climate conditions. Such habitat should be focused in topographic positions that will support high canopy cover and large trees under future forest conditions, such as north facing slopes and drainage bottoms (North et al. 2009, 2012). Modeling could build upon existing efforts to create a habitat reserve network across CSO range to ensure connectivity among PACs and populations.
6. Develop a fire management plan across land ownerships. Minimally, coordination of fuel breaks would enhance control of fires and potentially minimize loss of CSO habitat.

<u>Forest management practices</u>

Conservation objective: Utilize forest management tools that are compatible with maintaining essential habitat elements for CSO.

There is a critical need to manage for resilience in our forests while preserving connected CSO habitat. This will require some fuels reduction activities at a landscape level (Stephens et al. 2016a). The development of a regional risk assessment for fire in order to prioritize fuels reduction activities in relation to owl habitat is needed. Generally, overstory forest patterns are most associated with the climatic water deficit (Tague et al. 2009), whereas understory conditions are more shaped by the fire history (Lydersen and North 2012). Loss of habitat or abandonment of territories from certain forest management practices can be a serious concern for CSO persistence. Avoiding primary CSO use areas and maintaining the most important habitat

elements can ameliorate the effects of some activities. The effects on CSO from clearcutting and even-aged management practices, as well as salvage logging, likely depend on scale, and some industrial forestlands do have nesting individuals.

Conservation measures:

1. Design thinning treatments to leave large (≥24 in) and very large (≥36 in. dbh) trees and snags. Modeling indicates that thinning treatments of trees at 12, 20, and 30 in. dbh could yield a similar reduction in burn probability (Collins et al. 2011b), so removal of smaller trees, rather than larger ones important to CSO habitat, should be prioritized.
2. Manage mechanical thinning toward individual trees, clumps, and openings (ICO) (Lydersen et al. 2013). Some work suggests that about 200-300 acres of high canopy forest in a CSO territory could maximize fitness (Tempel et al. 2014b), though this is not a firm target. In general, contiguous patches of mature closed canopy forest that is embedded with small forest openings and some variable forest composition (such as large oaks) may promote foraging, and would be consistent with a natural fire regime (van Wagtendonk and Lutz 2007). Heterogeneity may somewhat compensate for decreased canopy cover from fuel treatments in the maintenance of flying squirrels (Sollmann et al. 2016).
3. Focus treatments on fostering the growth rate of larger trees, which are then retained long-term. Enhancing important attributes like large and defect trees might be able to maintain viable CSO populations when less high canopy cover is present (Gutiérrez et al. in press).
4. Design some fuels reduction treatments to experimentally test CSO responses. This is obviously challenging in a long-lived species with high site fidelity, but would improve our understanding of CSO resiliency to particular fuels reduction activities. In spite of some studies, the effectiveness of fuel treatments and the balance between reducing fire risk and effects on CSO fitness remains unclear.
5. Although it is difficult to disentangle fire and salvage logging effects on CSO, it seems prudent to avoid salvage logging of viable habitat, where possible. California spotted owls persist in territories that experience low-moderate severity fire, with some mixed-severity as well (Bond et al. 2002, Roberts et al. 2011, Lee et al. 2012, Lee et al. 2013, Lee and Bond 2015). However, in situations where over half a territory has burned at high-severity (Jones et al. 2016a) and individuals have abandoned the territory due to severe natural alteration, astute salvage could be warranted. Such salvage would require leaving large snags and downed logs, as well as subsequent replanting to maximize heterogeneity and habitat restoration.
6. In timber harvest plans that utilize a clearcutting strategy, design harvests to retain essential habitat elements. This would include multiple, non-uniformly distributed and irregularly shaped patches, balancing for old growth and some early seral stage forests to

maximize biodiversity (Burnett and Roberts 2015). Such patches on industrial forestlands can enhance small mammal abundance (Gray et al. 2016). For NSO, for example, tree stands at 109-152 ft^2/acre had the highest probability of foraging use, particularly when streamside (Irwin et al. 2015). Focus on retaining such riparian habitat.

7. Harvest plans should be strategically designed to maintain CSO habitat for long-term resiliency. Monitoring plans will be required to adequately address any negative or positive effects from management activities.

Tree mortality

Conservation objective: Monitor the effects of tree mortality on CSO.

We do not yet know how the tree mortality will affect CSO. Continued drought and dense forests could lead to additional mortality events. Though direct management options are limited, managing the forests toward more resilient conditions as recommended could aid in reducing the likelihood of tree mortality (van Mantgem et al. 2016). This may include some combination of prescribed fire and thinning treatments. For ponderosa pine stands in northern California, for example, a threshold stand density index (SDI; total basal area of all trees in a stand) of 230-365 ft. SDI has been suggested for ponderosa pine stands (Oliver 1995, Hayes et al. 2009) to avoid drought and stress induced tree mortality.

Barred owls

Conservation objective: Establish and implement a monitoring and management study or plan for barred owls.

Barred owls are a threat to NSO, and are set to become an imminent threat to CSO. Current knowledge of barred owl presence in CSO range is primarily incidental. California spotted owls will require a comprehensive monitoring and management plan to address this issue. Ongoing research suggests that while removal of barred owls will allow NSO to reoccupy territories, barred owls may return to some territories within a few years (Diller et al. 2014). Because California spotted owl range is currently at the edge of barred owl expansion, if the expansion is to be slowed or halted, a proactive plan to address the threat of barred owl expansion should be implemented. Control measures would likely be most effective now, while barred owls are still at low densities (Dugger et al. 2016) within the range of CSO. However, advocating removal of one species for another is a controversial decision.

Conservation measures:

1. We recommend the immediate development of an active monitoring scheme.

2. Given the substantial effects barred owls have had on NSO, we recommend the development of a comprehensive barred owl management study or plan for CSO. Such a plan would be intended to get ahead of this emerging threat before full barred owl expansion occurs within the range of CSO.

Contaminants

Conservation objective: Identify rodenticide exposure rates in California spotted owls.

Little information regarding the exposure rate of contaminants on CSO exists. However, the high exposure rates to rodenticides in barred owls and fisher would suggest CSO rates could be high as well (Gutiérrez et al. 2007, Gabriel et al. 2012). Thus, minimizing exposure to contaminants and beginning to test individuals for rodenticides would be prudent. Working with law enforcement partners to monitor the amount of rodenticides on the landscape will be of importance to long-term conservation of CSO.

Climate change

Conservation objective: Align habitat planning and protection with areas likely to support high canopy cover and large trees under future climate scenarios.

Although CSO might not be among the bird species most vulnerable to direct effects from climate change in the Sierras (Siegel et al. 2014), associated increases in large fires and tree mortality are likely to negatively affect CSO habitat. Thus it will be important not only to protect current habitat, but also to recruit new habitat. CSO tend to use topographic areas associated with higher productivity anyway, such as canyon bottoms, lower slopes, and northeast aspect positions, which are likely to support older forests (Underwood et al. 2010). Recent work suggests that managing for greater amounts of closed canopy habitat at higher elevations in particular might be beneficial to ensure available habitat in the long-term (Jones et al. 2016b).

To support long term persistence of California spotted owls, it will be important to manage for forests that are resilient to fire and climate change while still maintaining essential habitat elements.

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BISON CONNECT

Kirby, Rebecca <rebecca_kirby@fws.gov>

Fwd: Interest and Availability for Potential Peer Review - re: California Spotted Owl

Eyes, Stephanie <stephanie_eyes@nps.gov> Mon, Aug 7, 2017 at 11:49 PM
To: "Russell, Daniel" <daniel_russell@fws.gov>
Cc: Kim Turner <kim_s_turner@fws.gov>, Rebecca Kirby <rebecca_kirby@fws.gov>

Hi all-

I've pasted my relevant comments as they relate to each question.

It's evident that a lot of hard work went into this.

1. Have we assembled and considered the best available scientific and commercial information relevant to the species? If any instances are found where the best available science was not used, please provide the specific information with literature citation.

I'm not sure if this is necessary, but one thought I had was addressing some of the contrary literature that describes a very different paradigm for Sierra Nevada fire regimes (i.e. Baker, Della Salla, Hanson, etc.), and then present the literature already shown in the article as the consensus. Perhaps this is not necessary, and is implied based on the way it's already written, but I've personally seen the way the media and public can misrepresent and accuse that information was left out on the issue of owls and fire. I think a fire/forest ecologist may speak to this need better than me, but if the goal is to present a thorough review of the literature, then perhaps presenting this contrary view is warranted. I also sense that certain authors of the Bond/Hanson spotted owl articles will find that a lot of the information in their articles was not included and perhaps should be addressed and acknowledged or dismissed, particularly their findings on high-severity fire and owls.

Overall, I thought the authors did a great job incorporating the latest science, however because some of it was in review or in press, I had a hard time with some of the sentences since I didn't have the context from the original source. For example, one sentence I struggled with is as follows, "Recent evidence suggest that these declines may be a result of previously altered habitat, rather than current forest management practices on national forests (Jones et al. in review)." (21). Without the context of the article, I read that statement as our current management practices and choices are having no impact on species' declines, which seems like just a small piece of the puzzle, and of that article. I noticed that in other places throughout the text; if you are unfamiliar with the article, you may take the summary statement out of context.

2. Are the methods and assumptions used in deriving the California Spotted Owl conceptual model clear and logical? If not, please identify the specific methods or assumptions that are unclear.

I think I may be completely misunderstanding the red versus blue arrows because I noticed that the text and the legend don't match leading me to be very confused!

Is there some way that this could be inserted on its own page in landscape orientation? I am having a hard time seeing all the lines.

I also wonder if the habitat requirements that were chosen could be woven into the text more similarly to the stressors fields? I don't think they all need their own italicized titles like in the stressors section, but perhaps some way to make these pop out of the text somehow as the most logical habitat requirements to pick?

The other thing I'm not sure I like about the habitat model is the fact that prey and prey requirements are not easily seen in this conceptual model. Ultimately, prey availability could be considered a stressor, since ultimately, we know so little about how prey respond in changing forest conditions compared to the wealth of knowledge on spotted owls (but we always need to know more as evident by this report). It seems impossible to include everything in this conceptual model, and I think you've done a really good job of trying to narrow it down to what's important, but for some reason prey always strikes me as one of the most important factors that is so hard and labor intensive to study, but is clearly driving a lot of the patterns we see happening in owl populations. Perhaps, an explanation of how/where prey fit in this conceptual model? I won't be offended if it doesn't show up. . .

I also would appreciate more discussion on the 3 "R's": representation, resilience, and redundancy because those seem like the core principles this model is based on (yet only one appears in the model), and frankly they are all mouthfuls to take in.

Also, I am no artist, but I wonder if there is a way to make the model look a little more fun than just shapes and colors? Like treat it as more of an art object? I don't mean to be too harsh, but it's not exactly the most beautiful looking conceptual model, and wonder if it could be pepped up somehow with illustrations or conceptual drawings? I really like this proposed food web dynamics conceptual model in Holm et al. 2016, "Potential trophic cascades triggered by the Barred Owl expansion".

3. Does the best available science used in the report support the proposed conclusions and conservation objectives? Were they reasonably drawn from the information used in the report?

I think the conservation objectives and measures were reasonably drawn from the information presented in the report, and include a description of things I found unclear. One thing, I was left lingering with in my head while reading them over though, was timelines associated with these impacts and perhaps ranking the conservation measures in order of importance? There is a lot of information in there, that all seems warranted, but given time, is there some way to at least acknowledge this? It seems like this is more appropriate for the professional spotted owl biologists who are working on conservation strategy and assessment, but sometimes I have a hard time teasing apart the differences in all these documents. Perhaps a more detailed description in the intro section 6.2 referring to this?

I'm also confused in section 6.2 because it seems like some of the information presented here is new information, like citations and discussion of particular articles. To me, it seems like this section should be re-iterating already presented material and should perhaps just include very brief descriptions of the conservation objective and then conservation measures.

Please let me know if you have questions regarding my comments.

Thanks for all the work everyone put into this.

Stephanie
[Quoted text hidden]

Kirby, Rebecca <rebecca_kirby@fws.gov>

Fwd: Interest and Availability for Potential Peer Review - re: California Spotted Owl

Scott Stephens <sstephens@berkeley.edu> Mon, Aug 7, 2017 at 4:01 PM
To: "Russell, Daniel" <daniel_russell@fws.gov>
Cc: Kim Turner <kim_s_turner@fws.gov>, Rebecca Kirby <rebecca_kirby@fws.gov>

Hello Dan,

I have attached my review.

Scott

Scott L. Stephens
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Berkeley, CA 94720
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On 7/21/2017 12:34 PM, Russell, Daniel wrote:
[Quoted text hidden]

4 attachments

CA spotted owl USFWS review Stephens 8-17.pdf
145K

CollinsEt_EcolAppl_inPress.pdf
1425K

LydersenCollins_MoonlightVeg_Submitted.pdf
1415K

Stephens conflict of interest 8-17.pdf
555K

Berkeley
UNIVERSITY OF CALIFORNIA
College of Natural Resources
DEPARTMENT OF ENVIRONMENTAL SCIENCE, POLICY & MANAGEMENT

Daniel Russell - Regional Listing Coordinator 8/7/17
Pacific Southwest Regional Office, Region 8
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2606
Sacramento, CA 95825

Subject: Review of California spotted owl draft Conservation Objectives Report (dated July 2017)

I was asked to focus my comments on the following:

1. Have we assembled and considered the best available scientific and commercial information relevant to the species? If any instances are found where the best available science was not used, please provide the specific information with literature citation.

In general, the document has considered the best available science. I have provided 2 papers that were not in the document, one was recently accepted by Ecological Applications (Collins et al: Impacts of different land management histories on forest change) and the 2nd is still in review (Lydersen and Collins: Change in vegetation patterns over a large forested landscape based on historical and contemporary aerial photography). These were provided because I think they provide important information. I see in the Literature Cited section that one reference (Jones et al.) is listed as in review, this is the same designation in the Lydersen and Collins paper that I included. Please don't share these papers with people outside of those involved in writing the Conservation Objectives Report.

The Collins et al. paper found there have been substantial changes in Sierra Nevada forests over the last 100 years managed by both the US Forest Service and National Park Service. As in other paper the authors found that large trees were less common on USFS land and these are important elements to CSO habitat. The paper also found that live basal area and tree density significantly increased from 1911 to present in both logged and unlogged areas. Both shrub cover and the proportion of live basal area occupied by pine species declined from 1911 to present in lands managed by the USFS and NPS. In general, areas with no recent management activities experienced the greatest change from 1911 to present. This paper shows that both NPS and USFS lands in the Sierra Nevada have big issues regarding resilience and sustainability.

The 2nd paper, Lydersen and Collins, used historical and recent aerial imagery to characterize historical vegetation patterns and assess contemporary change from those patterns in a large area of the Plumas National Forest. The authors created an orthorectified mosaic of air photos from 1941 covering approximately 100,000 ha. Even though fire suppression began in this area around 1900 which would have changed forests in this unroaded area before the 1941 photos were taken, the authors still found the amount of dense forest cover increased from 1941 to 2005, replacing moderate forest cover as the most dominant class. Concurrent with the increase in extent, the area weighted mean patch size of dense forest cover increased ten-fold, indicating greater continuity of dense forest cover and more homogenous vegetation patterns across the contemporary landscape. Historically, dense forest cover was rare on southwesterly aspects, but in the contemporary forest it was common across a broad range of aspects. Figures 4 and 5 show this clearly. This paper presents information that suggests that CSO nesting habitat (as characterized today with a focus on high canopy cover) was much less common in this large forest landscape in 1941. Today because of fire suppression the area with high canopy cover has increased greatly and the size of large canopy cover patches are huge when compared to 1941 (which already had approximately 40 years of fire suppression but no harvesting). Although this area includes east side pine it does have a number of PAC's today. However the sustainability of this large area today is poor (such what happened in the 2007 Moonlight Fire). This provides further evidence that forests have densified greatly over the last 100 years and any strategy to conserve the CSO long term needs to take this into account. Attempting to maintain high canopy cover in Sierra Nevada east side, ponderosa pine, and mixed conifer forests outside of areas that provide higher moisture and less water stress is not scientifically justified. Studies such this one provide additional information on how much our present forests have changed and with warming climates and more variability in future precipitation, this provides further evidence that current forest conditions and not resilient or sustainable into the future.

I provide some specific comments to sections of the Report below.

P2, 2nd paragraph. It would be better to define what the wildland-urban interface is. Is this a set area from a minimum housing density?

P 6, end of 2nd paragraph. Can you define forest edges more precisely?

P 7, end of 2nd paragraph. If nesting habitat is burned with low intensity fire is this also beneficial? It would reduce fire hazards in this region including the PAC. Keeping PAC's with elevated fire hazards is not a strategy that will work long-term with increasing temperatures and more variable climate.

P 9, 1st paragraph. Course woody debris has been shown to be important but materials < 3 inches in diameter also contributes to fire spread and intensity. Large course woody debris is not as problematic from a fire perspective if it is distributed in clumps. If it is homogeneously distributed it will increase fire hazards and fire severity when the area burns.

P 9, 2nd paragraph. California black oak is known to be an important species to CSO. This species is shade intolerant and therefore needs small openings to regenerate. Oak seedlings and saplings can stay alive in shade but they will never become dominant trees producing acorns and important habitat under shade. If oaks are important the report should address them specifically. Millions of oaks in the Sierra Nevada mixed conifer zone continue to be overtopped by conifers and they die when this occurs from a lack of light. The plan should address this important species.

P 11, end of first paragraph. The report notes that the only stable CSO population is in SEKI National Park. Chapter 5 led by Malcolm North in Gutierrez et al. (in press and in your citations list) asks the important question of how big does the CSO population need to be to conserve it? With forest change in the last 100 years this has probably led to increased percentages of the Sierra Nevada having high canopy cover and maybe the CSO has increased in abundance? This is an important scientific question.

P 13, middle of 1st paragraph. Moderate intensity fire will kill small and moderate sized trees, it won't remove them. The standing dead trees will remain standing for around 10 years then will fall over. Next sentence reads that high severity fire consumes small trees. Again it will kill them but consumption will not be complete.

P 16, first third of first paragraph. '…. In areas treated up to 58%...' Not sure what this is referring too.

P 19, 1st sentence. Better to write 3-6 degrees F

P 19, 2nd paragraph. Chapter 5 in Gutierrez et al. (in press) provides more information on the expected impacts of climate change on CSO habitat and documents some very challenging issues. It could be better integrated into this section.

P 22, last paragraph. Creating a region-wide monitoring program and adaptive management plan for the CSO is a good idea but this should not delay the needed work to move forests to a more sustainable condition. If we wait for all of the 'answers' before we take large scale action to modify our frequent-fire adapted forests to increase their resilience and sustainability, wildfire and insects are going to change them right in front us.

The vast majority of studies on the CSO have been correlations. They provide some information on the habitat needs of the CSO but they cannot tell us what are the most important habitat features. The only way to do this is through replicated field experiments where specific forest structures are modified and then the response of the CSO is addressed. We need more of this type of research and less of the correlative type.

P 24, item 4 on this list. PACs may only occupy 5-9% of the productive lands but when you also add in the home ranges associated with the PACs the amount of area increases dramatically. We worked in the El Dorado CSO demography study area and when you add in the standard home ranges around each PAC it takes up > 50% of the area and some home ranges overlap. If > 50% of the landscape cannot be manipulated to increase resilience and sustainability then the only option is full fire suppression which will not be successful (Stephens et al. 2016b). The Report states that low intensity fire does not cause large declines in habitat features and patchy, mixed severity fire can be applied to home ranges and can provide some positive benefits. This produces a scientifically justified approach where mixed severity fire is allowed to work in at least the home ranges and this could be augmented by ecologically based mechanical treatments using the ICO concepts (Lydersen et al. 2013, Fry et al. 2014: Contrasting spatial patterns in active-fire and fire-suppressed Mediterranean climate old-growth mixed conifer forests. PLOS ONE 9(2): e88985). Low intensity fire could be applied to PACs when they are not occupied and this would increase their resilience (Stephens et al. 2016b).

P 24, item 6 is the list. Increased emphasis of fire control methods with more fuel breaks will not conserve the CSO and the forests they depend on. This is a fallacy. No number of fire fighters or aircraft will stop a wildfire that is burning in heavy continuous fuels on a bad fire weather day and the Report includes references that have shown fire severity is increasing in the Sierra Nevada (Miller and Safford 2012). The only way to conserve the old forests in the Sierra Nevada is to prioritize them for management actions to increase their resiliency to fire, drought, and insects (this is discussed in Stephens et al. 2016b).

<u>2. Are the methods and assumptions used in deriving the California Spotted Owl conceptual model clear and logical? If not, please identify the specific methods or assumptions that are unclear.</u>

This was done well overall.

<u>3. Does the best available science used in the report support the proposed conclusions and conservation objectives? Were they reasonably drawn from the information used in the report?</u>

This is the area of the Report that has problems. The Report does a very good job of setting the stage concerning the Background, Current Conditions, and Summary of Stressors regarding the conservation of the CSO but then there is a discount of this information in the Conservation Objectives.

In the Conservation Framework section of the report it states (page 21, middle of 1st paragraph) 'The most substantial stressor to habitat is large, high severity fire, which may be modulated somewhat by various for management practices.' The report also discusses the large-scale tree mortality from drought and bark beetles as being a potential problem for the conservation of the CSO. I spoke to Dr. John Keane this summer about what he was finding in areas of severe mortality in the southern Sierra Nevada regarding the CSO and he said there seems to be a strong negative effect when the largest trees have were killed by the bark beetles.

The Report also works to summarize the most recent climate science which is going to further stress the forests the CSO depends on. North et al. (chapter 5 of Gutierrez et al. (in press)) write 'Projections of forest change suggest that under warmer and drier future climate scenarios, all Sierra Nevada forest types are at risk of conversion to some other plant community over the majority of their current distributions. This includes the mid-elevation coniferous forests upon which California spotted owls currently depend.' This provides further evidence that current conditions are not sustainable for the long-term conservation of the CSO.

In Stephens et al. 2016a (listed in the literature cited) we emphasize that the conservation of the frequent fire adapted forests (historic fire return intervals < 25 years) is probably the most important issue since this is the only way that other benefits from these forests can be sustained long-term. Sections 1-4 in the Report bring this message clearly forward but there is a disconnect to Section 6.

In the first paragraph of section 6 (Conservation Objectives) the report states 'Because PAC's have been demonstrated as useful for CSO management (Berigan et al. 2012), focusing on maintaining a network of PAC's, as well as other connected habitat throughout the range of the CSO should be emphasized.' Later in the same section (Pg. 23, 3rd paragraph) the report states that the CSO is threatened by high severity fire and this is in agreement with the most recent science on this subject.

With this scientific background I do not understand how a system of PACs and other connected habitat throughout the range of the SPO is the best idea to conserve the CSO? How is this different from the present strategy that is not working? I am afraid that this will lead to more large high severity fires that will continue to erode important CSO habitat. With the recent large scale forest mortality in the southern and central Sierra Nevada that killed the largest trees, CSO habitat is even more vulnerable than what is presented in Stephens et al. 2016b.

The only logical scientific conclusion is to focus on ideas that will conserve and create the old, mature forests in the Sierra Nevada so they can provide the benefits to the CSO and other species. The report concludes with the following sentence: 'To support long term persistence of California spotted owls, it will be important to manage for forests that are resilient to fire and climate change while still maintaining essential habitat elements.' I agree with this closing sentence but the Conservation Objectives section emphasizes the CSO first and then the forest. The long term conservation of the CSO will only occur if the forests of the Sierra Nevada and southern California are managed sustainability. This does not have to emulate historical conditions but could include the idea of Realignment (Stephens et al. 2010, Operational approaches to managing forests of the future in Mediterranean regions within a context of changing climates. Environmental Research Letters 5: 024003.). Realigning forests implies modifying forests to present and/or future conditions which can be quite different from the past. This could focus on the production of large, old trees with clumps of denser forests in topographical positions that are more likely to support these structures as suggested on Pg 27 under the Climate change section and North et al. 2009.

I believe the Conservation Objectives section should be substantially revised to emphasize the creation and maintenance of the needed forests that then can provide important habitat for the conservation of the CSO long-term. Large, old trees have been shown to be a critical component of CSO habitat; this should be emphasized in a strategy to conserve the CSO. I see no way to scientifically justify a continued emphasis of PACs and connected habitat as the best idea to conserve the CSO long-term.

Sincerely,

Scott Stephens

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BISON CONNECT

Kirby, Rebecca <rebecca_kirby@fws.gov>

Fwd: Interest and Availability for Potential Peer Review - re: California Spotted Owl

Kirby, Rebecca <rebecca_kirby@fws.gov> Tue, Oct 24, 2017 at 12:58 PM
To: Rebecca Kirby <rebecca_kirby@fws.gov>

---------- Forwarded message ----------
From: **M Peery** <mpeery@wisc.edu>
Date: Wed, Aug 9, 2017 at 3:42 PM
Subject: RE: Interest and Availability for Potential Peer Review - re: California Spotted Owl
To: "Russell, Daniel" <daniel_russell@fws.gov>
Cc: Kim Turner <kim_s_turner@fws.gov>, Becky Miller <becky_miller@fws.gov>

Hi Dan

This looks really good - nice job on some tricky topics. Only very minor comments attached.

Apologies it is a little tardy – have been in the field much of the last two weeks.

Zach

From: Russell, Daniel [mailto:daniel_russell@fws.gov]
Sent: Friday, July 21, 2017 2:11 PM
To: M Peery <mpeery@wisc.edu>
Cc: Kim Turner <kim_s_turner@fws.gov>; Becky Miller <becky_miller@fws.gov>
Subject: Re: Interest and Availability for Potential Peer Review - re: California Spotted Owl

Dear Zach:

As we discussed previously the U.S. Fish and Wildlife Service (Service) is soliciting independent scientific reviews of the information contained in our 2017 Draft Conservation Objectives Report (COR) for the California Spotted Owl (attached). Once finalized, this COR will be used to assess the needs of the California Spotted Owl, develop conservation objectives, and make recommendations to reduce or ameliorate any potential stressors acting upon the species. The purpose of the report will be to provide guidance to ongoing and prospective collaborative conservation efforts.

This request is provided in accordance with our July 1, 1994, peer review policy (USFWS 1994, p. 34270) and our current internal guidance. This request also satisfies the peer review requirements of the Office of Management and Budget's "Final Information Quality Bulletin for Peer Review." The purpose of seeking independent peer review is to ensure use of the best scientific and commercial information available; to ensure and maximize the quality, objectivity, utility, and integrity of the information upon which we base Service actions. Please let us know if you would like us to provide any of the referenced materials to help facilitate your review.

Please note that we are not seeking advice on policy or recommendations on the legal status of the species. Rather, we request that peer reviewers focus their review on identifying and characterizing scientific uncertainties, and on ensuring the accuracy of the information in the COR. Specifically, we ask peer reviewers to focus their comments on the following:

1. Have we assembled and considered the best available scientific and commercial information relevant to the species? If any instances are found where the best available science was not used, please provide the specific information with literature citation.

2. Are the methods and assumptions used in deriving the California Spotted Owl conceptual model clear and logical? If not, please identify the specific methods or assumptions that are unclear.

3. Does the best available science used in the report support the proposed conclusions and conservation objectives? Were they reasonably drawn from the information used in the report?

Our updated peer review guidelines also require that all peer reviewers fill out a conflict of interest form. We will carefully assess any potential conflict of interest or bias using applicable standards issued by the Office of Government Ethics and the prevailing practices of the National Academy of Sciences (http://www.nationalacademies.org/coi/index.html). Divulging a conflict does not invalidate the comments of the reviewer; however, it will allow for transparency to the public regarding the reviewer's possible biases or associations. If we receive comments from a reviewer that we deem to have a substantial conflict of interest, we will evaluate the comments in light of those conflicts, and may choose not to give weight to those comments if the conflict is viewed as problematic. You may return the completed conflict of interest form either prior to or with your peer review.

So that we may fully consider any input and coordinate other peer review comments as we develop the final COR, we are requesting written peer review comments by letter or email by August 7th, 2017.

I have attached both a pdf version of the document, as well as a Word version. The Word version is being provided in case you find it easier to provide comments within the document itself. However, if you would like to do this, please do so in track changes. We would also appreciate receiving a copy of your Curriculum Vitae for our records.

If you have any questions about the COR, please feel free to contact me at any time at (916) 978-6191. Please submit your comments and associated materials to the contact information below.

Thank you for your consideration.

Sincerely,

Dan Russell

****

Daniel Russell - Regional Listing Coordinator

Pacific Southwest Regional Office, Region 8
U.S. Fish and Wildlife Service
2800 Cottage Way, Room W-2606
Sacramento, CA 95825

Office (916) 978-6191

Cell (916) 335-9060

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California Spotted Owl
(*Strix occidentalis occidentalis*)
Draft
Conservation Objectives Report
July 2017

Photo by Tim Demers. Used with permission.

US Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Pacific Southwest Region

TABLE OF CONTENTS

1. BACKGROUND AND PURPOSE

The California spotted owl (*Strix occidentalis occidentalis*) occurs on public forestlands and private timberlands throughout the Sierra Nevada and southern forests in California. In 2015, the U.S. Fish and Wildlife Service received two petitions to list the California spotted owl (CSO) under the Endangered Species Act of 1973, as amended. The Service's initial evaluation in our 90-day finding, published in the Federal Register on September 18, 2015, found that the petitions presented substantial information indicating that the petitioned action may be warranted. The species will undergo a full status review, with a listing decision due before September 30, 2019. The Service and other agencies are currently working on multiple CSO conservation efforts. To assist in informing these efforts, the Service developed this California spotted owl Conservation Objectives Report (COR).

Due to the complex and dynamic relationships among fire, timber management, and owl habitat, developing strategies that conserve spotted owl habitat and support sustainable forestry management are essential. The goal of this Conservation Objectives Report is to describe the ecological needs of CSO, identify and summarize the current and future stressors to viability of the species, and develop broad range-wide conservation objectives to assist in the development of ongoing and future conservation efforts. For the most recent thorough scientific assessment of CSO and its stressors, please refer to the U.S. Forest Service Pacific Southwest Research Station's Conservation Assessment from July, 2016 (Gutiérrez et al. in press). This COR draws substantially from this assessment as well as subsequent emerging research and information received in response to our March 17, 2017, letters sent via email to a wide range of interested parties requesting current information relevant to CSO. The goal of this COR is not to be prescriptive, but rather to identify ecologically relevant goals to guide the development of regional conservation strategies and other conservation efforts for CSO.

2. CALIFORNIA SPOTTED OWL ECOLOGY

2.1 Range and distribution

California spotted owls are continuously distributed throughout the forests of the western Sierra Nevada mountains in California, from Shasta County south to the Tehachapi Pass (Verner et al. 1992). The drier eastern side of the Sierras supports limited amounts of CSO habitat and relatively fewer CSO than the western slopes. California spotted owls also occur in southern and central coastal California (hereafter referred to as southern California), with a gap in their distribution between the Sierras and southern California forests (Verner et al. 1992). The CSO can be found at 1,000 – 7,700 ft. elevation in the Sierras, and up to 8,400 ft. in southern California (Verner et al. 1992). Just north of Lassen Peak to south of the Pit River, the range of the CSO transitions into that of the Northern spotted owl (NSO) (Barrowclough et al. 2011).

The American Ornithological Union currently recognizes three genetically distinct subspecies of spotted owl: California spotted owl (*Strix occidentalis occidentalis*), Northern spotted owl (*Strix occidentalis caurina*), and Mexican spotted owl (*Strix occidentalis lucida*) (Haig et al. 2004) (Figure 1). Relative to the other two subspecies, CSO exhibit low genetic variation (Barrowclough et al. 1999), although no negative effects of inbreeding have been found (Funk et al. 2008). Additionally, the Sierra populations are distinct from the southern California populations due to a lack of gene flow (Barrowclough et al. 1999, Haig et al. 2004, Barrowclough et al. 2005, Funk et al. 2008). California spotted owls in southern California are assumed to function as a metapopulation, though little movement has been recorded between isolated mountain populations (LaHaye et al. 1994, Barrowclough et al. 2005, LaHaye and Gutiérrez 2005). Because the three subspecies of spotted owls share many habitat and behavioral characteristics, for the purposes of this COR "spotted owl" refers generally to all three subspecies.

In the Sierras CSO are primarily found in mature, multi-layered mixed-conifer and yellow pine forest (80-90% of known sites), but also in red fir and riparian/hardwood forests (Verner et al. 1992). About half of known territories are within or adjacent to the wildland-urban interface (Blakesley et al. 2010). In southern California, habitat availability is more restricted and fragmented, so CSO are more frequently found in forests other than mixed-conifer, likely because mixed-conifer is only present at the highest elevations (Verner et al. 1992).

Figure 1. Approximate ranges for the three spotted owl subspecies (from NatureServe data).

2.2 Territoriality and reproduction

The spotted owl is a medium-sized brown owl with a mottled appearance, round face, large pale brown facial disks, dark brown eyes, and a yellowish green bill. Like most raptors, females are slightly larger than males (19-27 oz. vs. 17-24 oz., Verner et al. 1992). First and second year adults (subadults) can be distinguished by the tips of tail feathers, which are white and taper to a sharp point (Gutiérrez et al. 1995).

Spotted owls are long-lived species (can live over 15 years in the wild), with high adult survival and low reproduction; as a result, they are slow to recover from population declines (Keane 2013). They have a monogamous mating system, remaining with the same mate from year to year, although occasionally mates will separate, or "divorce." A pair occupies and defends a territory from neighbor and stranger individuals (Gutiérrez et al. 1995, Waldo 2002). In the central Sierra, territories are approximately 1000 acres (Seamans and Gutiérrez 2007a, Tempel et al. 2014b) based on a radius equal to half the "mean-neighbor distance" between the centers of adjacent owl sites (1.1 km). As central place foragers, spotted owls spend a disproportionate amount of time near their territory center, or core (Carey et al. 1992, Carey and Peeler 1995). When available, radio-telemetry has been used to approximate territory size and core use areas, resulting in some variation in size estimates (Bingham and Noon 1997). Home ranges include all habitat required for nesting, roosting, foraging, and other life functions. Home ranges will overlap each other and their size varies by latitude and study area (~1500-5400 acres), being smaller in the southern Sierras, where oaks are dominant (Zabel et al. 1992). An individual typically begins exhibiting territorial behavior in 1-4 years. Those individuals that have not yet established a territory (mostly subadults) are referred to as floaters, and little is known about their habitat requirements (Franklin 1992). The presence of conspecifics and an open territory determines settlement as owls are more likely to settle in territories that were occupied the previous year (LaHaye et al. 2001).

Breeding season begins in mid-February and can last through mid-September, starting earlier in southern California and at lower elevations throughout its range, with the peak of egg-laying in mid-April (Verner et al. 1992). Pairs divide the nesting roles; the male CSO provisions the female while she sits on the nest (Gutiérrez et al. 1995). Females lay 1-3 eggs, but survival of the offspring is highest when two young fledge (Peery and Gutiérrez 2013). Eggs take approximately 30 days to hatch, and owlets fledge about 35 days later. Fledglings will "branch out," leaving the nest before they can fly and roosting near the nest and their parents. During this early developmental stage, juvenile owls rely on multi-layered forest structure to move about above the forest floor. Within several weeks, juveniles are able to fly and will generally disperse in the fall.

Commented [M1]: Peery et al. 2013

Spotted owls appear to follow a bet-hedging strategy of reproduction (Stearns 1976, Franklin et al. 2000). In good years with sufficient resources, they attempt a nest, but in poor years they do not. This often leads to an even-odd pattern of reproduction, where a majority of pairs will nest one year but not the next (Blakesley et al. 2010, Forsman et al. 2011). Importantly though, lack of reproduction at any given site for a few years does not necessarily mean the site itself is of poor habitat quality, but rather may reflect overall poor environmental or climatic conditions in those years (Stoelting et al. 2014). Annual mean reproductive output for the spotted owl is the lowest among North American owls (Johnsgard 1988), with 0.555-0.988 young/female CSO (Franklin et al. 2004, Blakesley et al. 2010).

Reproductive success is particularly dependent upon local weather conditions, especially during the previous winter or early in the nesting season (e.g. MacKenzie et al. 2012). Colder temperatures and greater precipitation early in the breeding season (March to May) was negatively correlated with reproductive success in Sierra National Forest and Sequoia-Kings Canyon National Park (North et al. 2000). Also, in Eldorado National Forest, El Niño events, which result in warm, wet winters, negatively influenced reproduction (Seamans and Gutiérrez 2007b). Northern spotted owls have also shown similar patterns in response to cold (Franklin et al. 2000). Cold temperatures during nesting may increase energetic requirements, risk of egg exposure, or interfere with foraging, resulting in decreased nesting success (Franklin et al. 2000, Rockweit et al. 2012).

California spotted owls have high site fidelity, returning to the same territory year after year. However, a small percentage of adults (7-9%) (Blakesley et al. 2006, Seamans and Gutiérrez 2007a) will disperse each year, often due to events such as the loss or change of configuration of their nest tree or a mate replacement (Berigan et al. 2012). Dispersing owls tend to be younger, and either join a mate or move to an adjacent territory of higher quality (Seamans and Gutiérrez 2007a, Gutiérrez et al. 2011). Although spotted owls are non-migratory, some will move downslope during winter (Laymon 1988, Verner et al. 1992, Gutiérrez et al. 1995). Downslope movement occurs in October to mid-December, from 9-40 miles, and a change in elevation of 1640-4921 feet (Gutiérrez et al. 1995). Pairs return to their territory in late February to late March. Juveniles undergo natal dispersal in September, averaging 6-10 miles, though dispersal distance can range between 2-47 miles (LaHaye et al. 2001, Blakesley et al. 2006).

Commented [M2]: Maybe issue the caveat that studies were based on recaptures of banded birds rather than radio-telemetry.

In contrast to relatively low reproductiveon rates, spotted owls have apparent high adult survival in the Sierras (0.810-0.891), and male survival is slightly higher than female (Blakesley et al. 2010, Tempel et al. 2014a). Juvenile survival is more difficult to measure because of natal dispersal and emigration. However, the few studies that have estimated juvenile survival found it to be substantially lower than adult survival (0.368 in San Bernardino National Forest, LaHaye et al. 2004; 0.333 in Lassen National Forest, Blakesley et al. 2001).

Temporal variation in survival is not as well-explained by weather covariates as reproduction is. However, survival does appear to have a quadratic relationship with the Southern Oscillation Index so that survival is greatest in years not dominated by either El Niño or La Niña weather patterns (mild, intermediate winters) (Seamans and Gutiérrez 2007b). Spotted owls can be preyed upon by great horned owls (*Bubo virginianus*), as well as northern goshawks (*Accipiter gentilis*) and red-tailed hawks (*Buteo jamaicensis*) (Gutiérrez et al. 1995). There has also been one instance of a likely predation by a barred owl (*Strix varia*) (Leskiw and Gutiérrez 1998). Juveniles and eggs may be taken by typical nest predators. Although variability in the population growth rate is driven by both reproductive rate and survival, growth rate is more sensitive to changes in adult survival (Blakesley et al. 2001, Seamans and Gutiérrez 2007a). Juvenile survival provides the smallest contribution to changes in the population growth rate (Tempel et al. 2014a).

Commented [M3]: But Franklin 2001 points out that since repro is more variable can be more influential to population growth than survival

2.3 Habitat requirements

Spotted owls prefer residual old growth forest with high structural diversity (Laymon 1988, LaHaye et al. 1997, Moen and Gutiérrez 1997, Seamans and Gutiérrez 2007a). The nest tree itself is critical for CSO success, and is typically the oldest, largest live or dead tree with many defects like cracks or decaying wood (Verner et al. 1992, Blakesley et al. 2005). Spotted owls are frequently cavity nesters, using live trees and snags, broken top trees, platforms (mistletoe brooms), debris platforms, and even old raptor or squirrel nests. In the Sierras, the average nest tree is 103 ft. tall, 49 in. diameter at breast height (dbh), with the nest at 74 ft. high. In general, nest trees in mixed-conifer forest are >30 in. dbh and can be a variety of species (Verner et al. 1992, North et al. 2000, Blakesley 2003). In hardwood forests, the typical nest tree is ~30 in. dbh and 55 ft. tall (Verner et al. 1992). California spotted owls prefer nest trees that are located further from forest edges (Phillips et al. 2010).

The habitat structure immediately above and near the nest site has been the focus of a considerable amount of research and is important to CSO occupancy, fecundity, and survival. In general, CSO nesting habitat consists of dense overhead canopy cover, large trees, a high basal area (total cross-sectional area of all trees at 4.5 ft. above ground, 185-350 ft^2/ac), multiple canopy layers, and an abundance of limbs and large logs on the ground (Bias and Gutiérrez 1992, Verner et al. 1992, Moen and Gutiérrez 1997, North et al. 2000, Blakesley et al. 2005, Chatfield 2005, Seamans 2005, Roberts et al. 2011). For the purposes of analysis, canopy cover is typically broken into three classes: high (≥70%), moderate (40-69%), and low (<40%) (Tempel et al. 2016). For tree size definitions, we refer to the standard Forest Service categories of very large (≥36 in. dbh), large (≥24 in.), medium (12-23.9 in.), and small (<12 in.) (Tempel et al. 2014b). Reproduction in particular has been associated with high canopy cover at multiple scales (Hunsaker et al. 2002, Tempel et al. 2014b). On Lassen National Forest, reproductive success was correlated with forests dominated by high canopy cover and medium or large trees, and

negatively correlated with non-forest or forest dominated by small trees (Blakesley et al. 2005). On Eldorado National Forest, a higher amount of hardwoods (and thus lower canopy cover) within a territory negatively influenced reproduction (Seamans 2005, Tempel et al. 2014b). At the immediate nest area (0.12 acre), productivity is also positively correlated with foliage volume above the nest site (North et al. 2000). Additionally, large trees have been shown to be particularly important for NSO within 400 m of the nest (Irwin et al. 2011). Besides nesting success, high canopy cover may also be important for post-fledging rearing, as juveniles tend to roost within 800 m of their nest (Whitmore 2009). The complex vertical structure is important for shading and avoidance of overheating in the hot summers (Barrows 1981, Weathers et al. 2001).

Territories have greater habitat heterogeneity than nest stands, but occupancy, colonization, adult survival and reproductive success are still positively associated with the proportion of core area containing structurally complex conifer forest with large trees and high canopy cover (Blakesley et al. 2005, Seamans and Gutiérrez 2007a, Tempel et al. 2014b). Recent evidence suggests that the most important predictor of occupancy is the intersection of high canopy cover and large trees (Jones et al. in review). Spatial heterogeneity including small gaps or openings within the territory is thought to be particularly important for the development of a sufficient prey base. There does appear to be evidence that once a certain amount of high canopy cover is reached, additional moderate canopy cover can similarly benefit occupancy (Tempel et al. 2016). Thus, areas of both high and moderate canopy cover can be important. However, if the overall CSO territory is <40% canopy cover, that ~~certainly~~ reduces quality (Tempel et al. 2016). Northern spotted owls have similarly been found to maximize fitness within territories that are heterogeneous in forest stages (Franklin et al. 2000). California spotted owls will forage primarily in contiguous patches of moderate to high canopy cover, but will also use edge habitat (Williams et al. 2011, Eyes 2014). Riparian habitats can be particularly important for prey (Irwin et al. 2007, 2011, Bond et al. 2016). Furthermore, areas that have been burned at primarily low and moderate severity fire may also provide valuable foraging habitat and heterogeneity within territories (Bond et al. 2009, Eyes et al. 2017).

Although less is known about minimum habitat requirements at the scale of a home range, CSO still consistently use areas that contain greater abundance of large trees and greater proportion of mature forest than the average forest composition on the landscape (Call et al. 1992, Moen and Gutiérrez 1997, Williams et al. 2011). As heterogeneity increases, so does the size of a CSO home range, so there may be a negative effect if too much heterogeneity exists within CSO habitat (Williams et al. 2011, Eyes 2014). In managed landscapes, studies on CSO habitat use may be influenced and limited by the habitat types that are available, so the findings may not reflect optimal CSO habitat (Gutiérrez et al. in press).

Commented [M4]: I might just simplify and call it forests characterized by both large trees and high canopy cover.

Commented [M5]: I don't think it is necessarily the case the Tempel also found that heterogeneity was important. This study actually tested for habitat diversity and didn't find a relationship.

In southern California forests, most CSO live in forests other than mixed-conifer because that forest type is restricted to the highest elevations in the isolated mountain ranges (Verner et al. 1992). These forests include riparian/hardwood forests and woodlands, live oak/big cone-fir forest, and redwood/California laurel forest. In San Bernardino National Forest, the most used cover types are canyon live oak/big cone fir (Smith et al. 2002). This habitat might be preferred due to high densities of prey in the chaparral that surrounds it (LaHaye et al. 1997). Still, in the Southern forests, on average 70% of a territory is in moderate or high canopy cover (Lee and Irwin 2005). Even with less access to mature forest, owls select for more closed canopy and less non-forest at four different scales up to the size of a territory (Smith et al. 2002), and still select for large trees and higher basal area at nest sites (LaHaye et al. 1997). The presence of large residual trees (those that are significantly larger or older than the contemporaneous stand) also greatly increases the likelihood of CSO use for foraging activities (Bias and Gutiérrez 1992, Moen and Gutiérrez 1997, Williams et al. 2011).

2.4 Foraging and diet

Because spotted owls are central place foragers, they concentrate most of their foraging and activity around the nest or roost, and their activity declines further out from the nest (Carey et al. 1992, Ward et al. 1998). Spotted owls rarely fly above the forest canopy, except for dispersal (Gutiérrez et al. 1995). As perch and pounce predators, spotted owls are agile but not particularly fast fliers. Spotted owls are primarily active at night, but will also hunt during the day, especially when they have young to feed (Verner et al. 1992). Later in the nesting season, owls may also forage further from the nest to feed growing fledglings.

Although CSO will eat a variety of prey, they are considered to be small mammal specialists because they select a few key species for the majority of their diet. At upper elevations (above 4,000 feet) in the Sierra Nevada conifer forests, Northern flying squirrels (*Glaucomys sabrinus*) are the primary prey (Laymon 1988, Munton et al. 2002). At lower elevations in the Sierras, as well as in southern California, where oak woodlands and riparian-deciduous forests are dominant, CSO prey more on woodrats (*Neotoma* spp.) (Verner et al. 1992, Smith et al. 1999, Munton et al. 2002). Flying squirrels dominate CSO diet at about 75% of known owl sites (Verner et al. 1992). California spotted owls have low metabolic rates relative to other birds and would require one flying squirrel every 1.8 days or one woodrat every 3.7 days (Weathers et al. 2001). Individuals tend to have smaller home ranges where woodrats are the prey base compared to flying squirrels, presumably because woodrats provide a higher caloric gain per successful spotted owl foraging bout and occur in higher densities (Zabel et al. 1995). By biomass, regardless of elevation, pocket gophers (*Thomomys* sp.) are the second largest component of CSO diet. Although CSO will prey upon some birds, reptiles, amphibians, and insects, mammals make up the most biomass (Munton et al. 2002).

Commented [M6]: Maybe make it clear that PG's are second in importance because they replace FS at low elevations and WR at high elevations.

Flying squirrels are found more in closed-canopy forests (Pyare and Longland 2002, Meyer et al. 2005, Roberts et al. 2015). A moderate to high canopy closure, large trees, thick litter layer and sparsely distributed coarse woody debris are particularly important for developing a good prey base in these habitats (Waters and Zabel 1995, Pyare and Longland 2002, Meyer et al. 2005, 2007, Kelt et al. 2014, Roberts et al. 2015). Coarse woody debris is critical, but does not need to be overly dense (Knapp et al. 2005). Riparian habitat and other relatively mesic sites in particular yields truffle and tree hair lichen, which are important to flying squirrel diet (Meyer et al. 2008, Smith 2007).

Woodrats are found more often in open habitats, oak woodlands, and early seral-stage forests (Innes et al. 2007). Specifically, at lower elevations, woodrats (both dusky-footed and big-eared) and brush mouse are associated with oak cover and the density of large oaks >13 in. dbh (Innes et al. 2007, Roberts et al. 2008, Kelt et al. 2014). Heterogeneous forest conditions often provide higher primary productivity than homogenous closed canopy forests and thus, generally enhance prey habitat (Jones et al. 2016b, Sollmann et al. 2016). Transitional areas (habitat with conifer stands and a significant hardwood component) where prey distributions overlap offer a rich and diverse prey base (Verner et al. 1992). Small mammal diversity is enhanced by increased structural heterogeneity at large spatial scale and greater development of mature forest structure (Kelt et al. 2014, Roberts et al. 2015).

3. CURRENT CONDITION

The California Department of Fish and Wildlife (CDFW) maintains a record of CSO locations and activity centers (areas of repeated detection, nesting/roosting areas) in the California Natural Diversity Database (CNDDB). Although many sightings have not be reconfirmed outside of ongoing study areas, since 1993, 1,416 unique CSO activity centers have been recorded, the majority of which are in the Sierras (Figure 2). Rather than estimating overall population size, then, most of our knowledge of the status of CSO is derived from population trends in four long-term demography studies in the Sierras, and one in southern California. In the Sierras, data collection began in 1986 on the Eldorado National Forest and in 1990 on the Lassen National Forest, Sierra National Forest, and Sequoia-Kings Canyon National Park. In southern California, the San Bernardino National Forest was studied from 1987-2010, with some gaps in sampling. Multiple meta-analyses have utilized different techniques to analyze the population trends of CSO in these study areas. The nuances of these techniques are beyond the scope of this discussion (see Gutiérrez et al. in press for a full comparison), but the overall trends are consistent and we focus on the most recent analyses here.

On Forest Service lands, since the early 1990s, CSO nesting sites have been managed as Protected Activity Centers (PACs), which include ~300 acres of the “best available” contiguous habitat. This scale has proven to be a useful management tool and biologically relevant because

habitat characteristics at this scale are related to demographic parameters (occupancy, reproduction, and survival) (Blakesley et al. 2005), and CSO have repeatedly used these areas over the long-term (Berigan et al. 2012). Most data analysis relies on trends in the occupancy of territories or trends in the abundance of a study area.

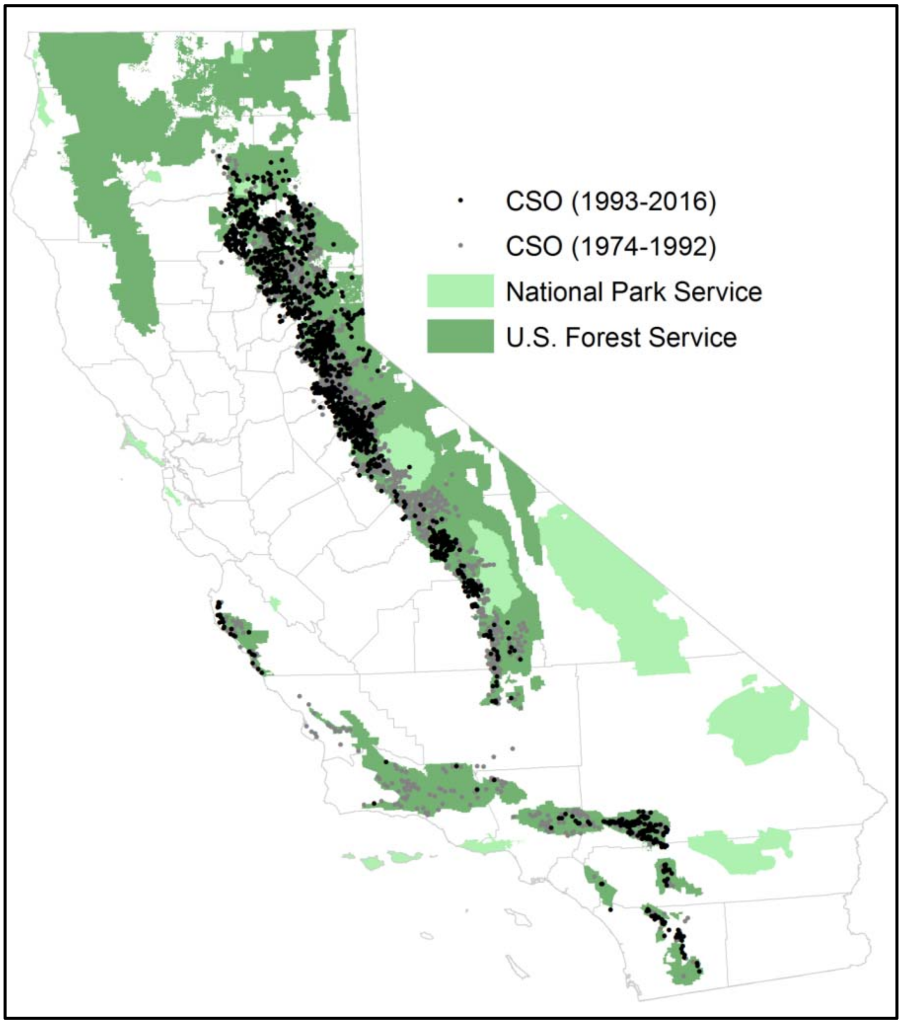

Figure 2. Map of California spotted owl activity center locations from CNDDB, before and after 1993. Shown with federal lands.

Evidence is clear that CSO have declined in both occupancy and abundance on the three national forests in the Sierras (Lassen, Eldorado, and Sierra), as well as in southern California. In the Sierras, CSO have experienced a decline in abundance of 11% on Sierra National Forest, 22% on Lassen National Forest, and 50% on Eldorado National Forest (Connor et al. 2013, Tempel et al. 2014a). San Bernardino National Forest has seen a similar decline of 50% from 1989-2010 (Eliason and Loe 2011) in territory occupancy, and a 9% per year decline in abundance from 1987-1998 (LaHaye et al. 2004). The only stable CSO population on public lands appears to be in Sequoia-Kings Canyon National Park, the only national park with a long-term CSO demography study (Table 1).

Commented [M7]: There is a more recent demography paper by Mary Conner in Ecosphere.

Table 1. California spotted owl population trends from 5 long-term demography studies.

Study area	Population change	Time period	Study area size (km^2)	Citation
Eldorado	- 50%	1990-2012	355	Tempel et al. 2014
Lassen	- 22%	1990-2011	1,254	Connor et al. 2013
Sierra	- 11%	1990-2011	562	Connor et al. 2013
Sequoia-Kings Canyon	+ 16%	1990-2011	182	Connor et al. 2013
San Bernardino	- 65%	1987-1998	2,140	LaHaye et al. 2004

The causes of the CSO population declines have not been conclusively identified. However, recent work suggests that rather than current management practices on national forests, the declines may partly be the result of a lag effect from the past removal of large trees prior to the early 1990s (Jones et al. in review). Although the populations are declining, reproduction appears to be relatively constant in all study areas in the Sierras except Eldorado, where measured parameters continue to be highly variable between years (Blakesley et al. 2010). Additionally, on national forests, studies found that more territories were being occupied by single CSO rather than pairs (Tempel and Gutiérrez 2013).

Commented [M8]: Make it more clear that it is just that the proportion of singles appears to be increasing, not that it exceeds the proportion of pairs

The only recent CSO population information from private lands is from five study areas on mixed ownership lands scattered through the northern half of the Sierras. From 2012-2016, systematic surveys found a high proportion of occupied territories each year that remained occupied during the study period (Roberts et al. in press). Additionally, CSO crude densities reported on the private timberlands were similar or higher than those on public lands (Roberts et al. in press, Table 2). Crude densities may not be a reliable indicator of habitat quality because an area could be a population sink supported by continued immigration from more productive source habitats (Pulliam 1988). Additionally, given the short duration of this survey effort and because CSO are long-lived and exhibit high site fidelity, returning to the same territories year after year, it is difficult to ascertain population trends from this survey data at this time.

However, of 45 CSO territories documented prior to 1996, all 45 were occupied at least once during the study period (2012-2016). These preliminary results warrant further monitoring and analysis with demographic data on individually marked owls if we are to determine if there is a difference in current CSO status between public and private lands.

Table 2. California spotted owl crude densities in study areas (most recent estimates). Primary land ownership is defined by >60% of study area, otherwise labeled as mixed ownership.

Study Area	Crude density	Study area size (km^2)	Primary land ownership	Citation
Fall River	0.056	89	Private	Roberts et al. in press
Lassen	0.051	355	National Forest	Gutiérrez et al. in press
Chalk Bluff	0.152	86	Mixed	Roberts et al. in press
Eldorado	0.16	1,254	National Forest	Gutiérrez et al. in press
Stumpy Meadows	0.035	115	Private	Roberts et al. in press
South Fork Cosumnes River	0.141	137	Private	Roberts et al. in press
South Fork Mokelumne River	0.071	122	Mixed	Roberts et al. in press
Sierra	0.151	562	National Forest	Gutiérrez et al. in press
Sequoia-Kings Canyon	0.184	182	National Park	Gutiérrez et al. in press
San Bernardino	*No recent estimate*	2,140	National Forest	Gutiérrez et al. in press

Most forest types have been defined by California Wildlife Habitat Relations (CWHR) categories with existing vegetation classification and mapping (EVEG). In the Sierras, 4M or greater CWHR translates to ≥40% canopy cover and trees ≥12 in. dbh, which include potential habitats used by CSO. Currently, there are approximately 4.9 million acres of 4M or greater CWHR in the Sierras, just over half of which is Sierra mixed conifer forest (Gutiérrez et al. in press). Of this habitat, 75% is on national forests, 7% on national parks, and 18% on private or other lands. In the southern California national forests, there are only about 400,000 acres of 4M or greater CWHR, about 16% of which is Sierra mixed conifer; however there are about 1.2 million acres of general habitat types in which CSO have been known to reproduce (Stephenson and Calcarone 1999). The realized amount of suitable habitat is likely far less though, in particular after major losses from wildfire and drought over the last decade and a half.

4. SUMMARY OF STRESSORS

Large, high-severity fires

Historically, the natural fire regime in the Sierra Nevada and southern California forests included frequent fires at primarily mixed-severity (mostly low-moderate, with patches of high-severity) (Van de Water and Safford 2011, Mallek et al. 2013). Past forest management, namely fire suppression and loss of large trees, however, has led to dense forests with high fuel load conditions and shade-tolerant trees, resulting in an increased frequency and patch size of high-severity fires (Miller et al. 2009, Mallek et al. 2013, McIntyre et al. 2015, Steel et al. 2015). In defining fire severity, in general, low-severity fire consumes surface fuels but not canopy trees (<25% upper canopy layer is lost or <25% basal area mortality); moderate-severity fire removes small trees (up to 75% canopy layer or basal area mortality); and high-severity fire consumes all surface fuels and nearly all mature plants (>75% canopy or basal area mortality) (Key and Benson 2005, Barrett et al. 2010). Prior to Euro-American settlement, frequent low-moderate severity fires occurred every 5-15 years (Van de Water and Safford 2011, Mallek et al. 2013). In areas with high fuel loads or during hot, dry weather patterns, some high-severity patches likely burned too, but were generally limited in size. In mixed-conifer forest in the Sierras, any given fire would not have included more than 5-10% high-severity fire (Miller and Safford 2017). The patches of high-severity fire averaged only 10 acres in size, with a maximum historic patch size of 250 acres (Collins and Stephens 2010, Miller and Safford 2012, Safford and Stevens in press).

Consequently, forests were likely made up of an abundance of large, fire resistant trees at a lower density (Taylor 2004, Scholl and Taylor 2010, Collins et al. 2011a). Basal area for historical conditions in the Sierras ranged from 91-235 ft^2/acre, depending on site productivity, with a mean of 150 ft^2/acre (Safford and Stevens in press). Additionally, snags in today's forest are significantly smaller and at a higher density (Agee 2002), resulting in an overall denser and more homogenous forest (Hessburg et al. 2005).

In southern California shrub-dominated landscapes, patches of high-severity fire have always been more common than in the Sierras (Steel et al. 2015). However, the area impacted by fires in southern California has also been increasing recently, in part due to continued human population growth and the conversion of cover types to grasses (Syphard et al. 2017). Although temperature is clearly a factor related to the area burned in higher elevation forests, prior-year precipitation is more strongly related to fire activity in the Sierra foothills and southern California (Keeley and Syphard 2017).

Both CSO and NSO will readily use habitat that has been subject to low and moderate severity patches of fire (Clark 2007, Eyes 2014). However, large patches of high-severity fire significantly reduce colonization, occupancy, and use (Roberts et al. 2011, Eyes 2014, Tempel et

al. 2014b). The year after the King Fire, the probability of CSO site extirpation was seven times higher in severely burned sites (when greater than half the territory burned at high-severity) than others (Jones et al. 2016a). In southern California, when patches of high-severity exceeded 123.5 acres (of a 500 acre territory), territory extinction probability increased (Lee et al. 2013). High-severity fire has also been shown to negatively affect survival of NSO (Rockweit et al. 2017). Northern spotted owls showed an increased turnover of territory occupancy in response to high-severity fire, suggesting that continued occupancy of the territories may be temporary and overall quality of the territory is reduced (Rockweit et al. 2017). There is likely some threshold of high-severity fire owls can tolerate within their territory, although the exact size and configuration is unknown.

While CSO will forage in habitat subject to a variety of burn severities, they still tend to use primarily low and moderate severity patches, avoiding large, high-severity areas (Jones et al. 2016a, Eyes et al. 2017). The size and configuration of the patch of high-severity fire appears to be critical. Some work suggests that CSO will use high severity patches in proportion to availability 3-4 years after the fire (Bond et al. 2009, 2016), although the sizes of the foraging patches in these studies were not reported. In Yosemite National Park, the mean size of a high severity patch used for foraging was 16 acres (Eyes 2014). Additionally, CSO were found to selectively forage in fire-created edge habitats, rather than contiguous edges (Eyes et al. 2017). Many prey species important to CSO are negatively correlated with fire severity including flying squirrels and deer mice (Roberts et al. 2008, 2015). Landscapes with restored fire regimes (such as Yosemite National Park) show greater small mammal species evenness, which could promote stability and resilience in CSO prey populations (Roberts et al. 2015). So while it appears that often California spotted owls will avoid large, high-severity patches, smaller patches and mixed severity can be beneficial because they support the prey base.

Habitat loss to large, high-severity fire is a substantial threat to CSO persistence. Within the next 75 years, based on fire activity trends, the amount of nesting habitat burned at moderate or high-severity fire will likely exceed the total existing habitat in the Sierras, and therefore there is a critical need to avoid losses of older forests (Stephens et al. 2016b). Closed canopy forests (such as those in PACs) do tend to have uncharacteristically large and severe fires (Agee and Skinner 2005). However, from 1993-2013, 88,000 acres of CSO PACs burned, 28% of which were at high-severity, which was a similar proportion to the overall landscape (Gutiérrez et al. in press). So while PACs themselves are not necessarily more vulnerable to high-severity fire than the surrounding landscape is, the proportion of PACs burned at high-severity is greater than would be expected under a natural fire regime (<5-15% Mallek et al. 2013). California spotted owls are similarly losing habitat in southern California, which has experienced increasing widespread wildfires, particularly in the early 2000s (Keeley et al. 2009). Repeated high-severity fires in the same area can convert the type of habitat, resulting in long-term habitat loss (Stephens et al.

2013). Addressing the potential effects of large, high-severity fires on owl habitat will require collaborative landscape-level efforts.

Forest management practices

The effects of specific forest management practices on spotted owls are not well understood. Some practices may act as stressors on spotted owls, while others may improve habitat. Commercial timber harvest no longer occurs within the CSO range in southern California on public lands (Eliason and Loe 2011), though it continues to occur on private lands, and is conducted in the Sierras on both public and private lands. Additionally, in order to reduce the likelihood of high severity fires, fuels reduction activities on public lands have been slowly implemented. Forest fuels are typically split into four categories: ground (material that has begun to degrade), surface (downed wood, herbaceous vegetation and shrubs), ladder/bridge (small trees and larger shrubs), and aerial/crown fuels (within the crowns of standing trees, separated from surface fuels) (Jenkins et al. 2014). Management for fuels reduction in the forest includes reducing surface fuels, increasing the height to the live crown (reducing ladder fuels and removing small trees), decreasing crown densities, and retaining/recruiting large fire-resistant tree species (Agee and Skinner 2005). Data on the effects of various fuel treatments on owls has been mixed, due to minimal experimentally designed studies, confounding factors, and a lack of consistency in defining types of treatments. For the purposes of discussion we broadly classified the methods of fuels reduction into prescribed fire, hand thinning, and mechanical treatments. For the most part, prescribed fire that has the potential to lead to low or moderate severity fires, or mixed severity with small patches of high-severity fires can be good for owl habitat. Additionally, hand thinning of smaller trees does little to disturb CSO. These small scale treatments typically leave high canopy cover and large trees, which are important to spotted owl nesting. Chainsaws and helicopter noises do not appear to decrease reproductive success (Delaney et al. 1999) nor increase stress hormones like corticosterone (Tempel and Gutiérrez 2003, 2004). However, NSO nesting near loud roads have lower reproductive success than those near quiet roads (Hayward et al. 2011), and males show higher levels of corticosterone (Wasser et al. 1997), suggesting there may be some non-lethal effects from noise-causing human disturbances.

Forest management: mechanical thinning

Owl response to mechanical treatments is less clear and appears to rely on scale and intensity of the treatments. Mechanical treatments (or thinning) refer to machine-based fuels reduction for purposes of reducing large fires and tree harvest (North et al. 2015). Generally, territories with greater amounts of mature conifer forest have a higher probability of colonization by CSO (Seamans and Gutierrez 2007a), so actions that alter mature forest to a large degree could result in a less desirable territory. Specifically,

converting mature conifer forest from high to moderate canopy cover was negatively correlated with demographic parameters in one meta-analysis (Tempel et al. 2014b). In an earlier study, territories with >50 acres of altered mature forest showed a 2.5% decline in occupancy and an increase in dispersal (Seamans and Gutiérrez 2007a). However, minimal effects were found on NSO two years after territories were treated, and no abandonment of a territory was detected in areas that were treated up to 58% (Irwin et al. 2015). Modeling projected over a 30 year time frame suggested that while treatments can reduce the risk of high-severity fire to CSO, in the absence of fire, such treatments could have a negative effect on fitness (Tempel et al. 2015). At the landscape-scale, another study examined the effects of mechanically-produced wide shaded fuel breaks (Defensible Fuel Profile Zones) on CSO and found that the fuel breaks were avoided for 1-2 years after treatments (Stephens et al. 2014). Additionally, occupied territories declined by >40% within four years after treatment, and the remaining individuals used larger areas. Mechanical thinning that results in widely and regularly spaced trees tend to be avoided by CSO (Gallagher 2010). However, the most recent meta-analysis of the long-term demography studies in the Sierras did not find any impact to occupancy, survival, or productivity from mechanical thinning (Tempel et al. 2016), and in fact some populations exhibited small positive effects on occupancy.

Commented [M9]: It wasn't so much that treatments led to a decline in demographic rates, but territories with less high CC forest had lower demographic rates. Territories could have less high CC for a range of reasons, one of which is forest management.

Commented [M10]: Important to recognize that fire and treatments were combined in this study so one cant isolate treatments impacts.

Forest management: salvage logging

Salvage logging refers to the removal of dead or damaged trees to recover economic value that would otherwise be lost (Society of American Foresters' Dictionary). It typically occurs after a fire, or large tree mortality event, and can be a controversial activity (Long et al. 2013). Because CSO can persist in low-moderate severity fires, salvage logging of viable habitat may negatively affect occupancy (Gutiérrez et al. in press). In high-severity fires, it was found that salvage logged sites had a slightly lower probability of being occupied than sites that only burned and did not undergo salvage logging treatment, although the difference was not statistically significant (Lee et al. 2013). Recent work on NSO found that high severity-fire interacts with salvage logging to jointly contribute to declines in site occupancy (Clark et al. 2013). Salvage logging may reduce the quality of foraging habitat through the removal of legacy snags, although it is difficult to disentangle the effects of salvage logging from high-severity fire.

Forest management: clearcutting

Timber harvest can cover all types of tree removal, which would include some fuels reduction activities as well as salvage logging. Clearcutting is one form of timber harvest that can take various shapes and sizes, though in general tends to leave large, regularly shaped patches with clean edges (Tempel et al. 2014b). In addition to outright habitat

loss, timber harvest can eliminate important CSO habitat elements such as old, large trees and large downed logs (McKelvey and Weatherspoon 1992). The overstory trees that remain in commercial thinning prior to a clearcut tend to be regularly spaced with little forest floor and understory diversity, and low heterogeneity in stand structure (Knapp et al. 2012). No research has explicitly examined spotted owl response to an even-aged management strategy using clearcuts, but these forest practices generally occur on private timberlands. California spotted owls have been observed avoiding private lands (Thraikill and Bias et al. 1989), and tend to forage on private lands proportionately less than the amount of private lands available on the landscape (Williams et al. 2014). These observations were not linked to management practices in these studies. However, CSO do nest on private timberlands in the Sierras. Additionally, crude density estimates of CSO territories are similar across public and private lands (Roberts et al. in press), although, as discussed above, there is limited information regarding population trends on private lands. While some gaps in canopy cover can be beneficial for the prey base, current clearcutting practices probably do not create the collection of patches observed in spotted owl territories with high-fitness (Franklin et al. 2000).

Tree mortality

Tree mortality has substantially increased throughout the Sierras, particularly in the southern Sierra region (van Mantgem et al. 2009, Asner et al. 2015). In 2015 in the southern Sierra, about 345 trees/km^2 died (Young et al. 2017), and very large trees in general are disproportionately affected by tree mortality (Smith et al. 2005). Drought combined with dense forest conditions have led to severe water stress (Asner et al. 2015, Young et al. 2017) in forest trees. This stress interacts with pathogens, insects and air pollution (Lutz et al. 2009, McIntyre et al. 2015). Bark beetles in particular are exacerbated by climatic conditions (Bentz et al. 2010), and measures of stand density are correlated with levels of mortality attributed to bark beetles, suggesting the density of trees (and indirectly competition) is a contributing factor (Hayes et al. 2009). The full extent of the mortality and effects on CSO is unknown, but the tree mortality is likely to contribute to habitat loss.

Barred owls

Barred owls were historically confined to eastern North America, but have expanded west over the past century (Livezy 2009). Whether barred owl expansion is human-caused is uncertain, but it is thought to be a combination of settlement of the central plains combined with climate change. Currently barred owls threaten NSO in parts of its range. They use a broader suite of vegetation, though still show a preference for old growth, large trees, and high canopy cover like spotted owls (Wiens et al. 2014). Because barred and spotted owls use similar habitat, natural segregation and coexistence is unlikely (Yackulic et al. 2012, 2014). Barred owls are

competitively superior and have a smaller home range (2-4 times smaller), probably due to a broader diet (Wiens et al. 2014). Barred owls can thus live at substantially higher densities than spotted owls.

Where barred owls occur in the NSO range, they decrease NSO occupancy by increasing territory extinction and lowering colonization (Olson et al. 2005, Dugger et al. 2011, Yackulic et al. 2014). Northern spotted owls show a lower overall probability of habitat use (Van Lanen et al. 2011) and lower nesting success; barred owls produced 4.4 times more young over a three year study period (Wiens et al. 2014). Furthermore, because barred owls can live at higher densities and consume a wider variety of prey species than spotted owls, their expansion has the potential to alter the prey on the landscape and affect a variety of other native species (Holm et al. 2016). In the range of NSO, there are ongoing removal experiments that suggest NSO may reoccupy a site within one year after barred owls are removed; however 1-4 years after the initial removal, barred owls again occupied some sites (Diller et al. 2012). These removal experiments are being conducted in areas of relatively high barred owl densities. In the range of CSO, however, barred owl detections have been low, suggesting the edge of barred owl expansion is just at the northern extent of CSO range.

A barred owl was first detected in the northern Sierras in 1989 and in the central and southern Sierras in 2004 (Steger et al. 2006). As of 2013, there were 51 barred owls detected in the Sierras (Gutiérrez et al. in press). Currently there are over 140 barred owl detections recorded in CNDDB, although these records do not necessarily reflect unique individuals. However, no systematic surveys have been conducted and all detections are incidental, therefore, they may be at a low density throughout the region (Dark et al. 1998, Keane 2014). There have also been a number of sparred owl detections, hybrids between the two species. As their range continues to expand, barred owls will likely become a significant threat to CSO (Gutiérrez et al. 2007). If control measures were to be implemented, they are more likely to be successful now, while the densities of barred owls are still low in CSO range (Dugger et al. 2016).

Contaminants

Although they have not yet been found in CSO, environmental contaminants may be an emerging threat. Rodenticides associated with illegal marijuana cultivations have been found in barred owls in northern California (Gutiérrez et al. in press). In the southern Sierra, large amounts of rodenticides and other pesticides have been found in national forests (Thompson et al. 2013), and fishers (*Pekania pennanti*) are experiencing high rates of exposure (Gabriel et al. 2012). Given that CSO share similar habitats and prey with fisher and barred owl, CSO are likely to be affected by rodenticides as well (Gutiérrez et al. in press).

Climate change

Current predictions suggest there will be a 3-6 degrees increase in temperature in the Sierras within the 21st century, and although changes in precipitation patterns are less certain, winter snowpack will likely decrease with a corresponding increase in ecosystem moisture stress during the dry, hot summer months (Cayan et al. 2013, Pierce et al. 2013). The direct effects of such climate changes on spotted owls will be complex as they exhibit population-specific demographic responses to local weather and regional climates (Franklin et al. 2000, Glenn et al. 2010, 2011, Peery et al. 2012). Additionally, spotted owls tend to only attempt nests in years with sufficient resources, following a bet-hedging strategy (Franklin et al. 2000). Drought and high temperatures in the previous summer can result in lower survival and recruitment (Franklin et al. 2000, Seamans et al. 2002, Glenn et al. 2011, Jones et al 2016b). Warm, dry springs, on the other hand increase reproductive success (Glenn et al. 2010, 2011, Peery et al. 2012, Jones et al. 2016b). Potential projected decreases in precipitation will likely reduce the plant production important for spotted owl prey (Seamans et al. 2002, Olson et al. 2004, Glenn et al. 2010, 2011).

With climate change, mixed-conifer forests, like many communities, are projected to advance upslope, which could develop habitat for CSO where none now exists (Peery et al. 2012). While these changes in habitat may mitigate some effects of climate change, the creation of new habitat will likely not keep pace with the loss (Stephens et al. 2016b). Climate change is likely to exacerbate the risk of large, high-severity fires and drought-induced tree mortality (Miller and Safford 2012, Mallek et al. 2013), which both have negative impacts on CSO habitat. The effects of climate change on fire activity, however, will likely vary across landscapes. Lower elevations and latitudes (e.g. southern California), where fire is more limited by ignition than climate, will be less likely to experience an increase in fire activity with hotter and drier conditions (Keeley and Syphard 2016).

5. CONSERVATION FRAMEWORK

Our conservation framework consisted of 1) identifying CSO population and habitat status and stressors, 2) defining broad conservation goals, and 3) developing conservation objectives and measures for ameliorating stressors and addressing CSO needs. We used three parameters: population and habitat representation, redundancy, and resilience (Shaffer and Stein 2010, Redford et al. 2011), as broad guiding concepts in developing our conservation objectives. Representation is the retention of various types of diversity (genetic, ecological, etc.) of the species so that the adaptive capacity of the species is conserved; resilience is the ability to recover from stochastic environmental variation and disturbances; and redundancy is multiple, geographically dispersed populations and habitats across the species' range that helps species withstand catastrophic events. In this COR, we relied on the best available science, including the latest Conservation Assessment (Gutiérrez et al. in press), recent emerging scientific research,

information received related to our March 17, 2017, letter soliciting new information from interested parties, and expert elicitation.

5.1 Conceptual model

Recognizing that many CSO habitat requirements vary based on scale, we have developed a conceptual model to examine how factors interact to influence CSO resiliency (Figure 2). The model includes population parameters that are typically measured for CSO, important broad habitat requirements, as well as the potential stressors discussed above. This model is not quantitative, but rather illustrates the interactions between stressors and habitat requirements to influence population parameters. Red arrows indicate one factor increases another, blue arrows indicate the factor decreases another, and purple indicates it may increase or decrease depending on other parameters. Thicker lines suggest a stronger relationship, and dashed lines indicate some uncertainty of the relative strength.

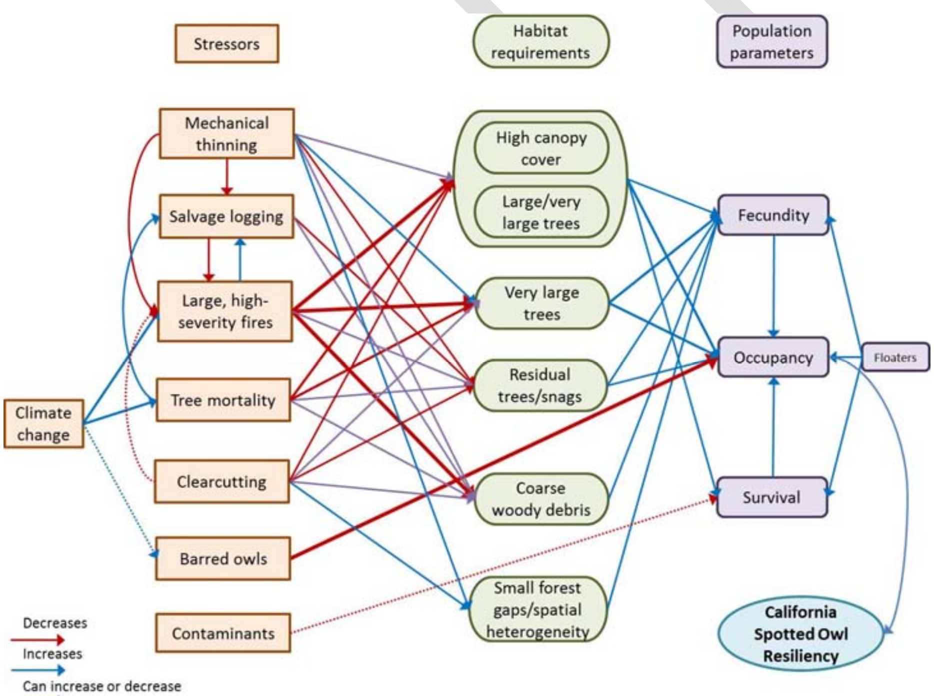

Figure 2. Conceptual model illustrating relationships among primary habitat needs, stressors, and California spotted owl population resiliency.

Population parameters include CSO territory occupancy, as well as fecundity and survival. Floaters, or non-territorial CSO, may contribute to populations because they can fill in when territories become available. Habitat requirements are broadly categorized into areas of high canopy cover with large (or very large) trees, very large trees, residual trees/snags, coarse woody debris, and small forest gaps/spatial heterogeneity. Some characteristics, such as high canopy cover and large/very large trees affect all population parameters. Other habitat components like coarse woody debris and forest heterogeneity are related to maintaining a sufficient prey base, and thus are more likely to affect fecundity than other parameters. Most potential stressors can affect multiple habitat components or population parameters as well as interact with each other. The most substantial stressor to habitat is large, high-severity fire, which may be modulated somewhat by various forest management practices. However, depending on scale and implementation, these same practices could also decrease certain habitat components. Additionally, barred owls are likely to emerge as a significant stressor to CSO resiliency by decreasing CSO occupancy. Finally, although we know little about contaminants as a stressor to CSO, we suspect the negative effects of contaminants have been going undetected thus far, and could become a more significant stressor to CSO. Managing for the interaction of these stressors will require a comprehensive region-wide conservation strategy and forest-specific plans.

Commented [M11]: I would think drought-related mortality would be consider a roughly equal stressor.

5.2 Conservation Goal

Our goal is the long-term conservation of CSO and its habitat throughout its range by maintaining viable, connected, and well-distributed populations and habitats through amelioration of stressors and conservation of key habitat components.

6. CONSERVATION OBJECTIVES

6.1 General conservation objectives

Attenuate the population declines of California spotted owl

Although it is unclear exactly why CSO are declining, there is now substantial evidence that populations on national forests have declined significantly over the past two decades. Recent evidence suggests that these declines may be partly a result of previously altered habitat, rather than current forest management practices on national forests (Jones et al. in review). To that end, we need to continue to investigate the causes of the declines, and in the meantime preserve habitat elements we know are critical for CSO conservation. Stopping a population decline is an important part of any conservation strategy (Caughley 1994). Because PACs have been demonstrated as useful for CSO management (Berigan et al. 2012), focusing on maintaining a network of PACs, as well as other connected habitat throughout the range of CSO should be emphasized.

Manage habitat for spotted owl use and the long-term establishment of natural fire regimes

Among CSO and forest ecology experts there is an ongoing discussion about the need to balance the protection of CSO habitat elements with the reduction of the likelihood of large scale fires (Gutiérrez et al. in press). The only stable CSO population on public lands appears to be in Sequoia Kings Canyon National Park, which has not only more large trees but more of a restored fire regime (Blakesley et al. 2010, Tempel et al. 2014b). California spotted owls prefer high canopy cover, large trees, and complex forest structure, which can coincide with high fuel loads (Gutiérrez et al. in press). Any proposed conservation actions need to be strategic in balancing these seemingly conflicting needs. PACs should be avoided as much as possible, but territories can tolerate more habitat heterogeneity. It will be a challenge to balance enhancing habitat heterogeneity with maintaining sufficient mature closed canopy forest (Kane et al. 2013, Stephens et al. 2014). Short term losses of high canopy cover in some habitat, for example, may be necessary for reducing fuel loads, but could be acceptable to CSO persistence if other critical elements like large trees remain (Tempel et al. 2016). Specific fuel reduction activities should be designed in relation to known CSO territories, but also elevation, latitude, and forest site productivity. Mechanical treatment on its own will not achieve fire resilient landscape conditions, as it can be implemented on less than half of the productive forestlands in the Sierras regardless (North et al. 2015). The massive tree mortality in the southern Sierras may also make this goal more challenging. However, efforts to move the broader landscape toward a more natural fire regime will be important for long-term persistence (Stephens et al. 2016a).

Develop and encourage voluntary conservation actions

About 75% of CSO habitat and territories are on national forests or parks, with the rest on private timberlands. To conserve CSO and habitat resilience, redundancy, and representation, federal and state agencies and other stakeholders should work together to develop plans that include clear mechanisms for addressing the threats to CSO. In developing conservation plans, we encourage entities to coordinate closely with the Service. Implementation of mechanisms to conserve CSO will benefit from stakeholder participation in conservation planning across land ownership boundaries.

Create a region-wide monitoring program and develop adaptive management plans

Ensuring active monitoring and reporting is critical for understanding region-wide and population-specific changes. The development and implementation of a robust range-wide occupancy based monitoring program would expand upon the few existing long-term demography studies. Such a system would require standardized data collection across forests and land ownerships, and would ideally be implemented within each forest structure. The current demography studies could be compared across landownerships as well to understand the nuances of CSO responses to forest management practices. Without this information, it is difficult to measure the benefit of conservation activities and there would be limited capacity to adaptively manage if current management is ineffective and new science emerges.

Prioritize and support research to address additional uncertainties
In spite of the breadth of research, there are a number of uncertainties that remain about CSO. Most notably, although recent work is beginning to understand the causes of the declines on national forestlands, such causes of CSO declines have not been conclusively determined. We also require more information about the southern California populations in particular, as well as dispersal and recruitment dynamics across a larger landscape. Understanding such parameters across the landscape would help set more specific targets for population sizes and habitat connectivity. Designing experimental studies to test sensitivities to different fuels reduction treatments, as well as different habitat uses on private and public lands would aid in habitat management. Additionally, the future effects from recent tree mortality on spotted owl habitat and use is largely uncertain. Effective amelioration of stressors can only be accomplished if we understand how they affect CSO resiliency, redundancy, and representation.

Commented [M12]: SNAMP and other attempts at experimentation indicates that this is really, really tough to do.

6.2 Stressor-specific conservation objectives

The following stressor-specific conservation objectives are designed to ameliorate the stressors identified and discussed in this document. These goals are intended to be developed with more specificity within any conservation plan or strategy. In developing CSO plans and strategies, entities should coordinate with the Service to help ensure the specific conservation plans and strategies adequately address the stressors and conservation needs of the species.

<u>Large, high-severity fires</u>

Conservation objective: Retain and restore resilient forests throughout the range of California spotted owls.

As a result of a century of fire suppression, CSO habitat is threatened by large, high-severity fires (Stephens et al. 2016b). The majority of areas burned on private and national forest lands occurs as result of wildfire that escape suppression under extreme conditions that are more likely to result in high-severity effects (Lydersen et al. 2014, North et al. 2015). Lower elevations have a higher burn probability, and habitat subjected to high-severity fire is more likely to grow back as chaparral rather than forest, and increase the likelihood of burning again (Lydersen et al. 2014). These effects are exacerbated as the time since the previous fire increases. There is an urgent need to reduce the likelihood of forest ecosystem conversion to chaparral and the associated loss of high quality nesting habitat due to large, high-severity fire.

Conservation measures:

1. Increase the use of prescribed and managed fire for low-moderate and mixed severity burn as an active management tool. Mixed-severity fire can reduce surface and ladder

fuels, acting as natural fuel breaks. Historically about 486,000 acres a year in the Sierras would burn, mostly at low-moderate severity, with small patches of high-severity (North et al. 2012). Efforts should be made to move the forests towards a more natural fire regime. Restoration of the fire frequency that would mimic pre-settlement rates may not be achievable due to ownership patterns and smoke restrictions (Quinn-Davidson and Varner 2012). However, increasing burning under moderate weather conditions will be beneficial (Schweizer and Cisneros 2014).

2. Develop a quantitative risk assessment of CSO PACs and other habitat for large, high-severity fires.
3. Design and implement fuels reduction activities, prioritizing areas by risk of high-severity fire (see *Forest management practices* below for specific recommendations).
4. Focus fuel reductions outside of CSO PACs and core use areas. As PACs occupy a relatively small percentage of the landscape anyway, only 5-9% of productive lands, limiting the alteration of PACs would not hamper an effort to move the landscape towards a natural fire regime (North et al. 2015).
5. Recruit and preserve new CSO habitat outside of the current PACs. We recognize that habitat conditions in some CSO territories might not be viable long-term because of low drought tolerance or high burn probabilities. As some PACs are likely to experience high-severity fire, it will be important to strategically plan for recruiting new CSO habitat suitable under future climate conditions. Such habitat should be focused in topographic positions that will support high canopy cover and large trees under future forest conditions, such as north facing slopes and drainage bottoms (North et al. 2009, 2012). Modeling could build upon existing efforts to create a habitat reserve network across CSO range to ensure connectivity among PACs and populations.
6. Develop a fire management plan across land ownerships. Minimally, coordination of fuel breaks would enhance control of fires and potentially minimize loss of CSO habitat.

Forest management practices

Conservation objective: Utilize forest management tools that are compatible with maintaining essential habitat elements for CSO.

There is a critical need to manage for resilience in our forests while preserving connected CSO habitat. This will require some fuels reduction activities at a landscape level (Stephens et al. 2016a). The development of a regional risk assessment for fire in order to prioritize fuels reduction activities in relation to owl habitat is needed. Generally, overstory forest patterns are most associated with the climatic water deficit (Tague et al. 2009), whereas understory conditions are more shaped by the fire history (Lydersen and North 2012). Loss of habitat or abandonment of territories from certain forest management practices can be a serious concern for CSO persistence. Avoiding primary CSO use areas and maintaining the most important habitat

elements can ameliorate the effects of some activities. The effects on CSO from clearcutting and even-aged management practices, as well as salvage logging, likely depend on scale, and some industrial forestlands do have nesting individuals.

Conservation measures:

1. Design thinning treatments to leave large (≥24 in) and very large (≥36 in. dbh) trees and snags. Modeling indicates that thinning treatments of trees at 12, 20, and 30 in. dbh could yield a similar reduction in burn probability (Collins et al. 2011b), so removal of smaller trees, rather than larger ones important to CSO habitat, should be prioritized.
2. Manage mechanical thinning toward individual trees, clumps, and openings (ICO) (Lydersen et al. 2013). Some work suggests that about 200-300 acres of high canopy forest in a CSO territory could maximize fitness (Tempel et al. 2014b), though this is not a firm target. In general, contiguous patches of mature closed canopy forest that is embedded with small forest openings and some variable forest composition (such as large oaks) may promote foraging, and would be consistent with a natural fire regime (van Wagtendonk and Lutz 2007). Heterogeneity may somewhat compensate for decreased canopy cover from fuel treatments in the maintenance of flying squirrels (Sollmann et al. 2016).
3. Focus treatments on fostering the growth rate of larger trees, which are then retained long-term. Enhancing important attributes like large and defect trees might be able to maintain viable CSO populations when less high canopy cover is present (Gutiérrez et al. in press).
4. Design some fuels reduction treatments to experimentally test CSO responses. This is obviously challenging in a long-lived species with high site fidelity, but would improve our understanding of CSO resiliency to particular fuels reduction activities. In spite of some studies, the effectiveness of fuel treatments and the balance between reducing fire risk and effects on CSO fitness remains unclear.
5. Although it is difficult to disentangle fire and salvage logging effects on CSO, it seems prudent to avoid salvage logging of viable habitat, where possible. California spotted owls persist in territories that experience low-moderate severity fire, with some mixed-severity as well (Bond et al. 2002, Roberts et al. 2011, Lee et al. 2012, Lee et al. 2013, Lee and Bond 2015). However, in situations where over half a territory has burned at high-severity (Jones et al. 2016a) and individuals have abandoned the territory due to severe natural alteration, astute salvage could be warranted. Such salvage would require leaving large snags and downed logs, as well as subsequent replanting to maximize heterogeneity and habitat restoration.
6. In timber harvest plans that utilize a clearcutting strategy, design harvests to retain essential habitat elements. This would include multiple, non-uniformly distributed and irregularly shaped patches, balancing for old growth and some early seral stage forests to

maximize biodiversity (Burnett and Roberts 2015). Such patches on industrial forestlands can enhance small mammal abundance (Gray et al. 2016). For NSO, for example, tree stands at 109-152 ft^2/acre had the highest probability of foraging use, particularly when streamside (Irwin et al. 2015). Focus on retaining such riparian habitat.

7. Harvest plans should be strategically designed to maintain CSO habitat for long-term resiliency. Monitoring plans will be required to adequately address any negative or positive effects from management activities.

<u>Tree mortality</u>

Conservation objective: Monitor the effects of tree mortality on CSO.

We do not yet know how the tree mortality will affect CSO. Continued drought and dense forests could lead to additional mortality events. Though direct management options are limited, managing the forests toward more resilient conditions as recommended could aid in reducing the likelihood of tree mortality (van Mantgem et al. 2016). This may include some combination of prescribed fire and thinning treatments. For ponderosa pine stands in northern California, for example, a threshold stand density index (SDI; total basal area of all trees in a stand) of 230-365 ft. SDI has been suggested for ponderosa pine stands (Oliver 1995, Hayes et al. 2009) to avoid drought and stress induced tree mortality.

<u>Barred owls</u>

Conservation objective: Establish and implement a monitoring and management study or plan for barred owls.

Barred owls are a threat to NSO, and are set to become an imminent threat to CSO. Current knowledge of barred owl presence in CSO range is primarily incidental. California spotted owls will require a comprehensive monitoring and management plan to address this issue. Ongoing research suggests that while removal of barred owls will allow NSO to reoccupy territories, barred owls may return to some territories within a few years (Diller et al. 2014). Because California spotted owl range is currently at the edge of barred owl expansion, if the expansion is to be slowed or halted, a proactive plan to address the threat of barred owl expansion should be implemented. Control measures would likely be most effective now, while barred owls are still at low densities (Dugger et al. 2016) within the range of CSO. However, advocating removal of one species for another is a controversial decision.

Conservation measures:

1. We recommend the immediate development of an active monitoring scheme.

2. Given the substantial effects barred owls have had on NSO, we recommend the development of a comprehensive barred owl management study or plan for CSO. Such a plan would be intended to get ahead of this emerging threat before full barred owl expansion occurs within the range of CSO.

Contaminants

Conservation objective: Identify rodenticide exposure rates in California spotted owls.

Little information regarding the exposure rate of contaminants on CSO exists. However, the high exposure rates to rodenticides in barred owls and fisher would suggest CSO rates could be high as well (Gutiérrez et al. 2007, Gabriel et al. 2012). Thus, minimizing exposure to contaminants and beginning to test individuals for rodenticides would be prudent. Working with law enforcement partners to monitor the amount of rodenticides on the landscape will be of importance to long-term conservation of CSO.

Climate change

Conservation objective: Align habitat planning and protection with areas likely to support high canopy cover and large trees under future climate scenarios.

Although CSO might not be among the bird species most vulnerable to direct effects from climate change in the Sierras (Siegel et al. 2014), associated increases in large fires and tree mortality are likely to negatively affect CSO habitat. Thus it will be important not only to protect current habitat, but also to recruit new habitat. CSO tend to use topographic areas associated with higher productivity anyway, such as canyon bottoms, lower slopes, and northeast aspect positions, which are likely to support older forests (Underwood et al. 2010). Recent work suggests that managing for greater amounts of closed canopy habitat at higher elevations in particular might be beneficial to ensure available habitat in the long-term (Jones et al. 2016b).

To support long term persistence of California spotted owls, it will be important to manage for forests that are resilient to fire and climate change while still maintaining essential habitat elements.

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Kirby, Rebecca <rebecca_kirby@fws.gov>

Fwd: Interest and Availability for Potential Peer Review - re: California Spotted Owl

Derek Lee <derek@wildnatureinstitute.org> Fri, Aug 4, 2017 at 8:46 AM
To: "Russell, Daniel" <daniel_russell@fws.gov>
Cc: Kim Turner <kim_s_turner@fws.gov>, Rebecca Kirby <rebecca_kirby@fws.gov>, Derek Lee <1dereklee@gmail.com>

Dear Dan Russell, Kim Turner and Rebecca Kirby,
Attached, please find my comments on the 2017 draft Conservation Objectives Report for California Spotted Owl.
The file "Peer Review COR DEL.pdf" is my comment letter including my CV and conflict of interest form.
The file "20170720_CSO_COR_DRAFT_DELcomments.doc" is a word version of the draft COR with many edits and comments using track changes and comments.
Both documents should be considered as parts of my peer review for the draft COR.
Please don't hesitate to contact me if you have any questions or need clarifications.
Please send an acknowledgment that these files have been received.
Sincerely,
Derek Lee

___
Derek Lee, Ph.D.
Principal Scientist
Wild Nature Institute
[Quoted text hidden]

2 attachments

Peer Review COR DEL.pdf
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Peer Review Comments on 2017 Draft Conservation Objectives Report (COR) for the California Spotted Owl

by Derek E. Lee, PhD

I am one of the most-published scientific experts on Spotted Owls and fire (8 peer-reviewed scientific papers) with 17 years of experience in Spotted Owl population biology. I have never received funding from the USDA Forest Service nor any timber company, and I have no other conflict of interest pertaining to forest management. I appreciate the opportunity to provide these peer review comments.

I have attached my conflict of interest form and a current CV.

Please note that in addition to the comments provided in this letter, I have provided other suggested corrections and citations in the document using track changes and comments (20170720_CSO_COR_DRAFT_DELcomments.doc).

Sincerely,

Derek E. Lee
1DerekLee@gmail.com
415-763-0348

In response to your specific questions:

We request that peer reviewers focus their review on identifying and characterizing scientific uncertainties, and on ensuring the accuracy of the information in the COR. Specifically, we ask peer reviewers to focus their comments on the following:

1. Have we assembled and considered the best available scientific and commercial information relevant to the species? If any instances are found where the best available science was not used, please provide the specific information with literature citation.

Reply: **No**, you have not assembled and considered the best available scientific and commercial information relevant to the species. I recommend USFWS perform its own independent, transparent, and thorough systematic review of the evidence from primary literature pertaining to: 1. Fire and owls; 2. Logging and owls; 3. California fire regimes and the ecological communities dependent upon high-severity fire; and 4. Efficacy of fuels thinning treatments on large, high-severity fire behavior.

I have provided an example systematic review of the evidence from primary literature on the topic of fire and owls which is appropriate for use to support evidence-based decision making.

I have also provided many suggestions and citations in the document using track changes and comments (20170720_CSO_COR_DRAFT_DELcomments.doc), and have listed in this commentary (below) some of the most important suggestions for ensuring the best available scientific and commercial information relevant to the species is used.

2. Are the methods and assumptions used in deriving the California Spotted Owl conceptual model clear and logical? If not, please identify the specific methods or assumptions that are unclear.

Reply: **No**, the methods and assumptions used in deriving the California Spotted Owl conceptual model were not clear or logical. The conceptual model is also wrong in many aspects of its structure and purported effects (see detailed comments below). Furthermore, the underlying assumptions of the model were not supported by the best available science, for example there was a generic assumption that large, high-severity fires are inherently harmful even though the scientific literature does not support such a broad assumption. Similarly, there is an assumption that fuels thinning to address fire severity is necessary to conserve owl populations whereas the literature regarding thinning impacts (see e.g., Tempel et al. 2014, Stephens et al. 2014) and the population data (see e.g., Conner et al 2013, Conner et al. 2016, Tempel et al. 2016), all showing that only on lands where thinning does not occur (National Parks) are owls stable, strongly suggesting that thinning is a major stressor. Further, the literature regarding the efficacy of thinning shows that it is not always effective at reducing fire severity (see e.g., Lydersen et al. 2014), and the literature regarding historical fire is much broader than was discussed in the report (see e.g., Baker 2014). These issues must be more fully addressed to effectively manage owl conservation.

3. Does the best available science used in the report support the proposed conclusions and conservation objectives? Were they reasonably drawn from the information used in the report?

Reply: **The 'best available science' was not used in the report**. The best available science does not support many of the proposed conclusions and conservation objectives. Many of the proposed conclusions and conservation objectives in the report could not be reasonably drawn from the best available science. Rather, the conclusions and objectives, such as with respect to fire and logging, are likely to exacerbate the owls' decline rather than arrest it. I discuss these problems below and respectfully urge the USFWS to better address these problems to avoid repeating the mistakes of the past that have led to the owl's current situation. As just one example, spotted owl abundance on the Eldorado demographic study area declined by about 50% and occupancy declined by about 30% largely in the absence of fire (Tempel et al. 2014). Yet this report is focused on high-severity fire rather than logging as the primary stressor/problem for CSO. This disconnect must be corrected, and the decline more carefully addressed, if CSO is to recover on USFS lands. The 'best available science' should consist of transparent, systematic reviews of the evidence from primary literature, not narratives developed from a non-exhaustive selection of the literature.

General Comments:

1. This U.S. Fish and Wildlife Service Conservation Objectives Report document (COR), and the conservation objectives it espouses, will almost certainly not stop California Spotted Owl (CSO) population declines because it does not sufficiently address harm from logging, especially logging in the name of fire risk reduction, which was a main threat cited in both of the listing petitions filed in 2015. Without a clear and complete exposition of how logging during the past 200 years, including present

forest management on USDA Forest Service (USFS) lands has led to the current serious decline of Spotted Owls on USFS and private lands, the document is incomplete. If this COR document is intended to describe or lead to 'conservation efforts' sufficient to recover CSO populations in lieu of the US Endangered Species Act protections, it falls short of this objective.

2. This draft of the U.S. Fish and Wildlife Service (USFWS) Conservation Objectives Report (COR) document is incomplete, likely due to its reliance upon a General Technical Report (GTR) by the USDA Forest Service (Conservation Assessment draft dated 27 July 2016 by Gutiérrez et al. in press) for its evidence. While the Conservation Assessment contains some useful guidance, it does not meet the criteria of a systematic review for evidence-based decision making, and it contains some significant errors, particularly in sections regarding fire regimes and the relationship between Spotted Owls and fire. I address a number of these errors below.

3. I strongly recommend the USFWS adopt a transparent, evidence-based decision-making process for the COR wherein the methods used for a systematic literature review and weighing of the evidence for conservation goals and objectives is explicitly stated (see e.g., Sutherland, W. J., Pullin, A. S., Dolman, P. M., & Knight, T. M. 2004. The need for evidence-based conservation. *Trends in ecology & evolution*, *19*, 305-308.; Pullin, A. S., & Knight, T. M. 2009. Doing more good than harm–Building an evidence-base for conservation and environmental management. *Biological conservation*, *142*, 931-934.).

   Systematic reviews differ from conventional literature reviews as they follow a strict methodological protocol and provide a comprehensive assessment of all available empirical evidence (Khan et al. 2003). They are therefore extensive, repeatable and minimise the chance of incorporating bias into the review process, whereas a conventional review may reflect the personal view of author(s) and may be based on a (potentially biased) selection of literature (Roberts et al. 2006). There is a rich literature describing the methods and benefits of systematic literature reviews from the biomedical field, where evidence-based decision making has been used for many years to advance science and save lives, and many other applied disciplines benefit from utilizing an evidence-based framework for knowledge transfer requiring systematic reviews of evidence (Stevens & Milne 1997; Khan et al. 2003).

   I recommend USFWS conduct systematic reviews pertaining to: 1. Fire and owls; 2. Logging and owls; 3. California fire regimes and the ecological communities dependent upon high-severity fire; and 4. Efficacy of fuels thinning treatments with respect to large, high-severity fire behavior while following clear and transparent guidelines (see: Pullin, A.S. and Stewart, G.B., 2006. Guidelines for systematic review in conservation and environmental management. *Conservation biology*, *20*(6), pp.1647-1656.; Gough, D., Oliver, S. and Thomas, J. eds., 2017. *An introduction to systematic reviews*. Sage.). The need for such a framework in conservation has been argued repeatedly (Pullin & Knight 2001; Fazey et al. 2004; Pullin et al. 2004; Sutherland et al. 2004), and I suggest such an approach be used to develop the USFWS COR for CSO.

   I have provided an example below of a transparent review on the topic of owls and fire.

4. I focus my attention in these comments primarily on management of USFS lands because USFS manages most of the available forest lands within the range of CSO, but their past and current management has led to population declines across all studied CSO populations on USFS lands while NPS lands are currently managed in a manner that sustainably conserves CSO populations (Conner et al. 2013, Tempel et al. 2016). In the COR, there is insufficient presentation of the data describing the negative effects of past and current logging for forest management goals of timber, fire suppression, forest health, restoration, or other monikers the USDA Forest Service (USFS) gives and has given to logging projects.

5. The preponderance of evidence shows large, high-severity forest fires are not a serious threat to the persistence of Spotted Owl populations in California, and actually provide a net benefit (see comments below and attached table summarizing fire and owl studies). The evidence also shows logging that removed large trees and reduced canopy cover was the primary reason the Northern Spotted Owl was listed, and the reason the California Spotted Owl has been petitioned for listing.

6. The historical and pre-historical context given to the current CSO habitat situation vis a vis fire was an incomplete review of fire ecology literature. Based upon an extensive reading of the literature, I believe that large patches of high-severity burned forest has always been a part of the dynamic Sierra Nevada and SoCal forest ecologies. A more reasonable and balanced review of the fire ecology literature would have found that there is ample evidence that mixed severity fires that includes large patches of high-severity fire have likely often been found in California forests, and even if one is uncertain of exactly how much high-severity fire was on the landscape at different points in time, it is clear that at least a few times in the past few thousand years, there have been droughts and climate swings that led to much more fire than is currently observed (Pierce et al. 2004, Power et al. 2008, Marlon et al 2012), and that the CSO has survived those episodes. Furthermore, the preponderance of evidence from recent studies shows that Spotted Owl populations are likely not seriously threatened by mixed-severity fire with large patches of high-severity burn (see comments below and attached table summarizing all published fire and owl studies). Therefore, it is clear that large patches of high-severity fire is something owls are inherently resilient to and have adapted to over the past several thousands of years of their evolutionary history.

7. My attached table summarizing all published literature on Spotted Owls and fire (16 peer-reviewed papers) shows clearly that mixed-severity fires, including so-called megafires with large patches of high-severity fire, that have burned during the past 20 years have mostly no significant effect on Spotted Owls (**88% of studies [14/16] found no significant effect of fire on owls**). **Most studies found positive effects from fire on owls** (63% of studies [10/16] found any positive effects of fire on owls). Fewer studies found any negative effects from fire on owls (56% of studies [9/16] found any negative effects of fire on owls). The mean effect sizes from all studies, including non-significant effects, found an overall positive effect from fire on owls (mean of all effects = 0.050, mean of significant effects = 0.072). Therefore, **the preponderance of evidence supports the view that fire is not a grave threat, and may in fact be a net benefit to Spotted Owls.** If fire is considered a threat worthy of mitigation, it should be treated as a secondary threat after the much larger threat of logging, including thinning, has been sufficiently addressed.

8. Logging, in contrast to fire, is a novel and unique disturbance with only a couple hundred years of existence in California's forest ecosystems that Spotted Owls depend upon for their survival. Logging is unique and unnatural because never in the evolutionary history of Spotted Owls or the forest ecosystems where they live, has a situation existed where 85% of the mature old-growth trees have been cut down and removed from the ecosystem over the course of ~200 years (Beardsley et al. 1999). Even the biggest most intense fire leaves all the dead big old trees standing for decades, providing many ecological goods and services to the dynamic forest ecosystems. Logging is the primary reason the Spotted Owl has declined, and additional logging, even logging which is called fuels thinning, is extremely unlikely to contribute meaningfully to conservation or recovery. Furthermore, 100% of the published peer-reviewed papers on owls and fire that looked at salvage logging found large, significant, negative effects from salvage logging on Spotted Owls. See also: Lindenmayer, D.B., Burton, P.J. and Franklin, J.F., 2012. *Salvage logging and its ecological consequences*. Island Press.

9. There was no evidence presented in the COR that describes the effectiveness of thinning at altering fire behavior or more importantly, the extent of high-severity fire on the landscape, especially under severe weather conditions. This is a critical omission, particularly when my reading of the literature is that thinning, and even clearcutting, does little to reduce the extent of large, high-severity fire patches because ~90% of the large, high severity fire acreage burned each year is overwhelmingly climate and weather driven (Flanagan and Wotten 2001, Williams 2004). In fact, some evidence supports the observation that thinning can exacerbate fire severity (Raymond and Peterson 2005, Cram et al 2006, Wimberly et al 2009), while CSO nesting and roosting habitat (old growth forest characterized by large trees and high canopy cover) is naturally resistant to high-severity fire (Weatherspoon and Skinner 1995, Odion et al 2004, Bond et al 2009a).

   See: Kalies, E.L. and Kent, L.L.Y., 2016. Tamm Review: Are fuel treatments effective at achieving ecological and social objectives? A systematic review. *Forest Ecology and Management*, *375*, pp.84-95

10. My interpretation of the best available science indicates that: (1) private lands logging degrades Spotted Owl habitat; (2) thinning fuels treatments on USFS lands degrades nesting, roosting, and foraging habitat and reduces California Spotted Owl occupancy; (3) post-fire salvage logging on private and USFS lands degrades nesting, roosting, and foraging habitat and reduces California Spotted Owl occupancy and survival; (4) California Spotted Owls are clearly declining, except in Sequoia/Kings-Canyon National Park, which has been almost entirely protected from thinning fuels treatments and post-fire logging for decades; and (5) CSO nesting and roosting habitat (old growth forest characterized by large trees and high canopy cover) is naturally resistant to high-severity fire (Weatherspoon and Skinner 1995, Odion et al 2004, Bond et al 2009a). Thus, logging is most likely the primary driver of historical and current Spotted Owl population declines and is the most significant threat to the subspecies' existence. Therefore, recovery plans and objectives should be primarily focused on eliminating or reducing logging, including fuels thinning, throughout the range of the CSO.

11. The notion that logging will somehow overcome the global climate change currently underway and avert large, high-severity forest fires is unsupported by the evidence. Much of the evidence I have seen points to the fact that ~90% of the forest acres burned at high severity occur each year in a few extreme climate- and weather-driven fire events that thinning or fuels treatments are unlikely to slow or stop (Williams 2004, Lyderson et al. 2014) .

12. Another aspect of thinning and logging that was not mentioned in the COR document is the genetic variation among trees that is the raw material for forest adaptation to a changing climate (Kolb et al. 2016, Prunier et al. 2016, Pinnell 2016). Until foresters can identify exactly which individual trees are most genetically and epigenetically adapted to be resilient and resistant to drought, higher temperatures, disease, and insects, and use that genetic information to preserve those specific, locally well-adapted trees, then thinning and logging will invariably impoverish the genetic variation of our forests and impair their natural processes of adapting to a changing climate.

13. It is clear to me that the different land management policies, especially during the past 50 years, between USDA Forest Service (USFS) lands and National Park Service (NPS) lands has directly contributed to the differing population trajectories for CSO on those two land management types. USFS lands have been subjected to heavy logging and fire suppression and CSO is declining everywhere it is studied on USFS lands. In contrast, although much NPS land was also logged in the past 2 centuries, it has in recent decades had healthy wildland fire use and very little logging, and the CSO population studied on NPS lands are increasing. If USFWS were to begin with these undeniable facts and built its conservation objectives from this and other evidence, then in an adaptive management framework, USFWS should be promoting an adaptive management experiment on USFS lands where half the USFS lands within the range of CSO, and including at least 2 long term demography study sites, is managed exactly as NPS lands are managed with extremely limited logging, and liberal wildland fire use. This is where the best available science leads, and this should be the position espoused by the USFWS in this COR document to guide the development of regional or USFS conservation strategies to conserve (i.e. recover) California Spotted Owls.

Specific Comments:

1. Section 1, Paragraph 2, regarding U.S. Forest Service Pacific Southwest Research Station's Conservation Assessment (A General Technical Report [GTR] by Gutiérrez et al., draft published 27 July 2016) which was given as the primary source of evidence for the COR: This document contains some good information, but should not serve as the primary source of evidence for the COR. The COR should be based upon a thorough, independent, and unbiased systematic review of all the relevant primary literature, with evidence weighted by reliability, not a GTR prepared by and for the USFS. The GTR is a non-peer-reviewed technical report that was prepared by and for the USDA Forest Service, which has an explicit conflict of interest in the matters of fire, logging, and wildlife conservation due to the fact that the majority of the USDA Forest Service's budget is directly linked to fire suppression and logging. The GTR document was never subjected to formal public comments, or objective external scientific peer

review, and parts of the document contain substantial errors of scholarship. The most inaccurate portions of the GTR were the portions pertaining to fire.

2. There is a rich literature describing the methods and benefits of systematic literature reviews from the biomedical field, where evidence-based decision making has been used for many years to advance science and save lives, and many other applied disciplines benefit from utilizing an evidence-based framework for knowledge transfer involving systematic reviews of evidence (Stevens & Milne 1997; Khan et al. 2003). Systematic reviews should be undertaken following clear and transparent guidelines (see: Pullin, A.S. and Stewart, G.B., 2006. Guidelines for systematic review in conservation and environmental management. *Conservation biology*, *20*(6), pp.1647-1656.
Also see: Gough, D., Oliver, S. and Thomas, J. eds., 2017. *An introduction to systematic reviews*. Sage.).

   The need for such a framework in conservation has been argued repeatedly (Pullin & Knight 2001; Fazey et al. 2004; Pullin et al. 2004; Sutherland et al. 2004), and I suggest such an approach be used to develop the USFWS COR for CSO.

   There are transparent methods for weighing the evidence according to reliability (Meade, M. O., & Richardson, W. S. 1997. Selecting and appraising studies for a systematic review. Annals of internal medicine, 127, 531-537.) I suggest similar methods be used in the systematic reviews of evidence for the COR.

3. Background and Purpose says: "Due to the complex and dynamic relationships among fire, timber management, and owl habitat, developing strategies that conserve spotted owl habitat and support sustainable forestry management are essential."

   I suggest you delete this sentence. Why is a strategy that supports forestry on public lands essential? I suggest you mention other forest economic activities that are much more important than forestry. US Forest Service data say 33 million people visit California's National Forest lands for recreation each year. California's forest wood-products industries create jobs for 2,000 private-sector workers, while outdoor recreation on California's forests create 38,000 private-sector jobs. Recreation in National Forests now contributes five times more money to California's GDP than wood products industries.
At $20.8 billion of direct expenditures in California related to outdoor recreation, this industry now ranks among the top 10% of economic sectors in the state.
In addition, National Forests provide approximately 50% of California's water supply, which is estimated to be worth about $9.5 billion annually. Forests provide a source of safe, clean water to Californians, and supports the state's agricultural economy worth $37.5 billion.
These numbers tell us that the recreation and water supply values of National Forests to the economy and society vastly outweigh the timber.
I suggest a review of the scientific evidence regarding logging and thinning effects on recreation value and water quality should be added.

4. Sections 2.2, 2.3, and 2.4 refer almost exclusively to the breeding-season territories. Although breeding-season territories are undeniably important to owls, it must be explicitly acknowledged that equally important is the winter range used for roosting and foraging during the extremely difficult winter season when much mortality occurs, as well as the matrix habitat among territories that is critical to both natal and breeding dispersal movements.

   I suggest the COR add text explicitly defining year-round home ranges, breeding-season territories, and winter ranges, as well as a discussion of the matrix between best available habitat, and carefully address what is known and not known about each of those zones. Territories and habitat associations as currently described in the COR seems to focus mostly the breeding-season range, but the COR also reports some year-round data (e.g., Zabel). The COR must clarify when it is referring to breeding-season territories, when it is referring to winter ranges, and when it is referring to year-round home ranges.

5. Breeding territories are not a sufficient proxy for year-round habitat requirements and relying on protections only in breeding areas will vastly underestimate the area and habitat requirements needed to conserve and recover CSO. Equal space and attention should be added that describes the habitat characteristics and importance of fall- and winter-season ranges, and how poorly CSO habitat needs during these critical seasons are understood. Applying the precautionary principal would suggest applying strong protections for year-round home ranges from unnatural habitat alterations, as the minimum guideline for recovery.

6. From the COR: "As central place foragers, Spotted Owls spend a disproportionate amount of time near their territory center, or core". This is an important fact, and underlies why the breeding-season foraging habitat selection portions of Williams et al. 2011 and Jones et al. 2016 studies are flawed in their analytical methods. Both of these studies failed to account for distance from nest or roost center in their breeding-season foraging habitat selection analyses, making all results and conclusions regarding habitat selection in these papers unreliable. Analysis of foraging habitat selection aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. The proper habitat use analysis is a 'resource selection function', a mathematical function that explicitly accounts for the fact that Spotted Owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest/core roost area is much higher than the probability of using habitats farther away from the nest. Every Spotted Owl foraging habitat selection paper has found distance from nest has a highly significant effect on a point's probability of use. However, Williams et al. 2011 and Jones et al. 2016 did not do a proper resource selection function analysis accounting for foraging point's distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fundamental mistake renders their radiotelemetry results and discussion unreliable.

7. The above-mentioned reality about breeding-season foraging behavior (central place foraging) should not be used to downplay the importance of the larger, year-round home range habitat needs of Spotted Owls. Foraging habitat far from the territory center is critical for survival of Spotted Owls during the autumn and winter seasons, and many Spotted Owls rely on overwintering habitat that is far from their nest site as they have depleted prey resources in the core nest/roost areas during breeding (Carey et al. 1992). Protection of year-round home range areas from anthropogenic disturbances should be a priority of effective species conservation.

8. Section 2.2, last paragraph: "Although variability in the population growth rate is driven by both reproductive rate and survival, growth rate is more sensitive to changes in adult survival (Blakesley et al. 2001, Seamans and Gutiérrez 2007a). Juvenile survival provides the smallest contribution to changes in the population growth rate (Tempel et al. 2014a)"

   These sentences mischaracterize the data on demography and population dynamics of CSO. Seamans and Gutiérrez (2007a) and Tempel et al (2014a) looked at observed contributions to growth rate. Seamans and Gutiérrez 2007a actually said: 'we estimated that [reproduction] contributed as much as [survival of individuals ≥1 year old] to the observed annual variability in [population growth rate].' And Tempel et al 2014a said: 'We calculated the correlation coefficients between the population growth rate and each of the demographic rates …. All demographic rates were positively correlated with [population growth rate]. The correlation was strongest for [immigration rates] and weakest for [juvenile apparent survival]. The correlations with [adult apparent survival] and [reproduction] were intermediate in strength. The magnitude of the regression slope was also greatest for immigration rate, which further suggested that [population growth rate] was most sensitive to changes in immigration rate.'

   These results speak to the importance of reproduction and owl movements across the landscape and the critical nature of matrix habitat between and among nesting sites to permit and encourage natal and breeding dispersal movements. This leads to the conclusion that owl habitat needs to be managed at a much larger scale than the 300-acre PAC currently guiding CSO management in USFS lands. Much larger areas around all known historical owl breeding sites, on the order of 6000 ac around nests (mean year-round home-range size), should be protected from logging to the maximum extent possible and allowed to naturally succeed towards old growth conditions.

9. Sec 2.3: This should be rewritten to say: "Areas that have been burned at all severities, but especially at moderate and high severity, provide valuable foraging habitat and heterogeneity within territories (Bond et al. 2009, Bond et al. 2016, Eyes et al. 2017). All properly analyzed studies of Spotted Owl foraging habitat selection have shown Spotted Owls either use all severities of burned forest in proportion to its availability, or prefer foraging in moderate- or high-severity burned forest (Bond et al. 2009, Bond et al. 2016, Eyes et al. 2017). None have shown significant avoidance of any type of burned

forest. Thus, all burned forest, including large patches of high-severity burned forest, is Spotted Owl habitat that should be protected as CSO habitat within the 6000-ac mean CSO home range (Zabel et al. 1992)."

10. Sec. 2.4: This section should be rewritten following a comprehensive literature review. It omits the rich and informative literature about small mammals and fire which finds in almost every case, some species of small mammal populations increase after fire, and including specific studies of owl diet after fire e.g. Bond et al. 2013 "Diet and home range of owls in burned forest". Some relevant data include:

    Spotted Owls foraged over winter in burned areas that had small mammal biomass 2-6 times greater than was present in breeding season core areas (Ganey et al. 2014).

    Pocket gophers were the most important prey item by percent biomass for Spotted Owls in burned forests 4 years after the McNally Fire in the southern Sierra Nevada (Bond et al. 2013) and the second most important prey item for California Spotted Owls in a long-unburned landscape in the Sierra National Forest (Munton et al. 2002). Pocket gophers are uncommon in mature and older forests with little or no herbaceous ground cover (Williams et al. 1992) and thus are likely to benefit from the habitat created by severe fire.

    A review of deer mouse responses to disturbances such as fire and logging found deer mice increased significantly after wildfire and logging, but wildfire response was greater (Zwolak 2009). Deer mice increased significantly over time in moderate and severely burned mixed-conifer forests in the Butler II Fire in the San Bernardino Mountains of southern California over a 5-year postfire period (Borchert et al. 2014). Tevis (1956) captured nearly twice as many deer mice just 2.5 weeks after a postlogging burn as before in a Douglas-fir forest in northwestern California. Gashwiler (1959) also documented rapid increases in deer mice populations in forests following a postlogging prescribed burn. Tietje et al. (2008) found no difference in survival of three *Peromyscus* species among prescribed burned and unburned oak woodlands in coastal central California. In North America, generalist deer mice respond strongly and positively to high-severity fire in both shrubland and conifer forest types and are often the most abundant rodent after severe fire (Borchert et al. 2014).

    Woodrats had no negative effects of survival following a low-medium intensity, prescribed understory fire in oak woodlands in coastal central California (Lee and Tietje 2005).

    One paper examined capture rate of small mammals in unburned versus forests burned 1–14 years prior and found capture rates for 9 small mammal species (including deer mice and flying squirrel) were higher in unburned forest, while capture rates for 7 small mammal species (including wood rats) were higher in burned forest (Roberts et al. 2015).

11. Sec 3, paragraph 2: "On Forest Service lands, since the early 1990s, CSO nesting sites have been managed as Protected Activity Centers (PACs), which include ~300 acres of the 'best available' contiguous habitat. This scale has proven to be a useful management tool and biologically relevant because habitat characteristics at this scale are related to demographic parameters (occupancy, reproduction, and survival)."

    The second sentence above should be replaced with: "Management of USFS lands at the scale of the 300-ac PAC has not averted observed population declines, so clearly protecting 300 ac of best available habitat (mature forest) near the nest is not a sufficient spatial scale for habitat protections promoting CSO conservation or recovery. It is clear from the evidence that in order to conserve CSO, much larger areas of USFS lands must be managed in a manner similar to NPS lands with little or no logging (including thinning) and more wildland fire use. We recommend 6000 ac around all known historical owl breeding sites be protected from logging to the maximum extent possible and allowed to naturally succeed into old growth conditions. Estimates of average year-round home range sizes of CSO have been known since the 1990s, mean = 6000 ac, mean range 800–12,000 ac (Zabel et al. 1992), and thus 6000 ac should be considered the minimum management scale around nests where old growth forest regeneration is promoted and logging is minimized for CSO recovery."

    Home ranges vary according to latitude and habitat type, so most likely some regions would be best served with larger home range protections, some smaller, but 6000 ac is a simple rule of thumb that I will reiterate throughout this commentary.

12. Sec 3, paragraph 3: "Evidence is clear that CSO have declined in both occupancy and abundance on the three national forests in the Sierras (Lassen, Eldorado, and Sierra), as well as in southern California."… "The only stable [actually growing] CSO population on public lands appears to be in Sequoia-Kings Canyon National Park, the only national park with a long-term CSO demography study."

    This evidence, along with the lower CSO bulk density estimates from private lands, is compelling and should be the starting point and defining evidence for the COR. In what ways are USFS and NPS lands managed differently and which management practices likely led to this difference in population trajectories? How can USFS lands be managed more like NPS lands and less like private lands? If an adaptive management framework is to be followed to guide USFS land management for conservation (i.e. recovery) of CSO, then USFWS should be promoting an adaptive management experiment such as one where half the USFS land in the range of the CSO, and including at least 2 long-term demography study areas, is managed exactly like NPS lands are managed. This adaptive management experiment should run for at least three generations of CSO (27–30 years) with intensive monitoring to determine whether population recovery is taking place.

13. Sec 3, paragraph 4: "The causes of the CSO population declines have not been conclusively identified."

There is ample evidence from the best available science that the populations of all three subspecies have declined due to widespread historical and ongoing habitat loss, primarily from logging large, old trees favored by the owls for nesting and roosting (USFWS, 2011, 2012; Conner et al. 2013; Tempel and Gutiérrez 2013). I suggest you do a systematic review of the literature pertaining to Spotted Owl population declines in California and elsewhere, and add discussion of the management differences between private, USFS, and NPS lands in recent decades, including logging and fire suppression, and how those differences likely led to the divergent population trajectories of CSO on USFS vs NPS lands.

The data from the private timber lands (Roberts et al. in press) also supports the idea that private timber lands and USDA Forest Service lands have similarities with regards to management and owl populations, while NPS lands are clearly managed much more effectively for CSO recovery. Mean crude densities by land management shows a clear negative relationship between intensity of timber management and CSO populations (mean crude density = 0.08 on private timber lands, 0.12 on USFS lands, and 0.18 on NPS lands).

14. Sec 3, last paragraph: There have been studies showing that suitable habitat is not being diminished over the long term by fire. Please perform a thorough review of the primary literature. See, for example:

Baker, W.L., 2015. Are high-severity fires burning at much higher rates recently than historically in dry-forest landscapes of the Western USA?. *PLoS One*, 10(9), p.e0136147.

Parks, S.A., Miller, C., Parisien, M.A., Holsinger, L.M., Dobrowski, S.Z. and Abatzoglou, J., 2015. Wildland fire deficit and surplus in the western United States, 1984–2012. *Ecosphere*, *6*(12), pp.1-13.

Hanson, C.T., Odion, D.C., Dellasala, D.A. and Baker, W.L., 2009. Overestimation of fire risk in the Northern Spotted Owl recovery plan. *Conservation Biology*, *23*(5), pp.1314-1319.

Hanson, C.T., Odion, D.C., Dellasala, D.A. and Baker, W.L., 2010. More-Comprehensive Recovery Actions for Northern Spotted Owls in Dry Forests: Reply to Spies et al. *Conservation Biology*, *24*(1), pp.334-337.

Odion, D.C. and Hanson, C.T., 2006. Fire severity in conifer forests of the Sierra Nevada, California. *Ecosystems*, *9*(7), pp.1177-1189.

Odion, D.C. and Hanson, C.T., 2008. Fire severity in the Sierra Nevada revisited: conclusions robust to further analysis. *Ecosystems*, 11(1), pp.12-15.

15. Sec 4 on Large, high-severity fires and fire regime: This section needs substantial revision. Please perform a thorough and transparent review of the primary literature. I have provided examples of a few pieces of evidence that were missed in the COR.

Fire extent is below historic annual extent of burning in western U.S. forests (Medler 2006, Stephens et al. 2007, Parks et al. 2015).

Western U.S. conifer forests and forests of the Sierra Nevada remain in a "fire deficit" (Medler 2006, Parks et al. 2015).
Historical data and reconstructions of historical fire regimes indicate that high-intensity fire was common in most conifer forests of western North America prior to fire suppression and logging, even in pine-dominated forests with frequent fire regimes (Beaty and Taylor 2001, Nagel and Taylor 2005, Baker et al. 2007, Hessburg et al. 2007, Klenner et al. 2008, Whitlock et al. 2008, Baker 2014, Baker et al. 2009, 2015).

16. Sec 4. Pertaining to stressors: Logging has been, and continues to be the primary stressor and cause of Spotted Owl population declines. The first portion of the stressors section should reflect this reality. I have provided here a few pieces of evidence that were missed in the COR, but I recommend a thorough and transparent review of the primary literature. The following section is largely taken from one of the 2015 listing petitions.

Logging

Timber harvest has been the most significant historical factor impacting California Spotted Owl habitat (Gutiérrez 1994, Verner et al. 1992a). Selective harvest of merchantable trees in the Sierras—often old-growth trees—was the norm during the late 1800s through the 1970s, resulting in the loss of much suitable habitat and the production of forests with younger average tree ages. In the Sierra Nevada, timber harvest steadily intensified from the railroad building and mining eras of the 1800s until the 1950s, then remained at relatively high levels through the 1980s (McKelvey and Johnston 1992). From the 1970s onward, clearcut harvests became increasingly more common (McKelvey and Johnston 1992). Since the late 1980s, the volume of timber harvested in the Sierra Nevada has declined, but cutting became increasingly based on salvage logging (McKelvey and Johnston 1992). And, while the timber volume removed annually on national forests of the Sierra Nevada is less now than it was two decades ago or more, much of the logging that occurs presently is mechanical thinning, which removes fewer board feet per acre than past clearcuts, but nonetheless degrades habitat over large areas through reduction of canopy cover and removal of mature trees and also through creation and maintenance of logging roads (USDA 2004a). Forest Service management direction, as laid out in the 2004 SNFPA promotes landscape-level mechanical thinning as well as salvage logging in California Spotted Owl habitat.

Verner et al. (1992a) discussed five major factors of concern for California Spotted Owl habitat that have resulted from historical timber-harvest strategies: (1) Decline in the abundance of very large, old trees; (2) decline in snag density; (3) decline in large-diameter logs; (4) disturbance or removal of duff and topsoil layers; and (5) change in the composition of tree species. Thus, extensive commercial logging directly affected key structural components of California Spotted Owl habitat. It will take many decades for these forests to regain these late-successional components, such that there are long-lasting effects of past logging that persist many decades beyond the point when logging levels began to decline.

Late-successional/old-growth forests provide habitat attributes selected by California Spotted Owls, including large trees, high canopy closure, multi-layered canopies, snags, and logs (University of California 1996). The current extent of old forests in the Sierra Nevada is substantially less than in pre-historic times. The University of California (1996; Sierra Nevada Ecosystem Project Report) reported that on all Federal lands in the Sierra Nevada, late-successional/old-growth forest conditions are now found on only 19 percent of forest lands, mostly in National Parks. Beardsley et al. (1999) estimated that approximately 15 percent of coniferous forests in the Sierra Nevada remain in high quality late-successional/old-growth stages; most of these stands are at high elevations and in national parks (Franklin and Fites-Kaufmann 1996). Less than two percent of 3 million ac of private land was classified as high quality late-successional/old-growth habitat (Franklin and Fites- Kaufmann 1996).

At the turn of the previous century, the majority of mixed-conifer and ponderosa pine forests in the Sierra Nevada were characterized by very large trees and a high degree of structural complexity (Sudworth 1900, Leiberg 1902, McKelvey and Johnston 1992, Franklin and Fites-Kaufmann 1996 on p. 652). Primarily because of logging, present-day Sierran forests are drastically different from those in pre-settlement times.

Zielinski et al. (2005) examined changes in old forest cover in the Sierra Nevada over the previous century, as part of a study on changes in the distribution of forest carnivores. Alterations in mature/old-forest cover were represented by the difference between the historical Weislander Vegetation Type Map Survey (1929 and 1934; published in 1946) and contemporary vegetation data from the Sierra Nevada Ecosystem Project (1996). In 1945, old-growth (where > 50 percent of cover was from large, mature trees) comprised 50 percent of the forested area in the Sierra Nevada, and young growth/old-growth (where 20–50 percent of cover was from large, mature trees) comprised an additional 26 percent of the area. The remaining 24 percent was young growth (immature forest), poorly-stocked forest, and non-commercial areas incapable of producing mature forest. By 1996, only 3 percent of the forested area in the Sierra Nevada was highest-ranking old forest, with 38 percent of the Sierra Nevada being low to high-quality old forest—equating to the loss of approximately half of the old forest between the 1940s and the 1990s. These changes were most evident in the portion of the Sierra Nevada north of Yosemite National Park, where the loss of old forest conditions has been greatest since the 1940s.

Overall, synthesizing all of the available lines of scientific evidence, as a result of past logging, old forest has declined from 50–90 percent of the landscape historically to only about 11 percent currently (USDA 2001 [FEIS, Vol. 2, Chpt. 3, part 3.2, pp. 141, 149]). In other words, historically there was several times more old-growth forest than there is today.

Current forest management

On private lands in California, logging practices harmful to Spotted Owls include clear-cutting, commercial thinning, sanitation “salvage,” group selection, selection, and post-fire logging. These practices eliminate or reduce canopy cover, large trees, canopy layers, understory, snags, and downed wood. Private lands logging has been and continues to be extensive, and degrades the forest complexity that Spotted Owls rely upon.

Mechanical thinning, including fuels treatments, on USFS lands harms Spotted Owls, and Spotted Owls are declining as a result of such logging. Seamans and Gutiérrez (2007a) examined the effects of habitat alteration caused by logging on territory colonization, extinction, and breeding-dispersal of color-banded Spotted Owls in the Eldorado Study Area from 1990 to 2004. The probability of territory colonization decreased significantly, and territory occupancy was significantly decreased, with as little as 20 ha of logging. Further, the probability of breeding dispersal away from a territory was related to the area of mature conifer forest in a territory and increased when > 20 ha of this habitat was altered.

The general prescription of fuels treatments is reducing forest canopy cover to 40 percent, removing many/most trees up to 30 inches diameter, and reducing tree density and ‘ladder’ fuels (USFS 2004a). Stephens et al. (2014) found a 43 percent loss of California Spotted Owl occupancy within a few years following mechanical thinning and group selection logging in a study area in the northern Sierra Nevada.

Tempel et al. (2014b) found that mechanical thinning is significantly harming California Spotted Owls. The authors found that the amount of mature forest with high canopy cover (70–100 percent) was a critical variable for California Spotted Owl viability (survival, territory extinction rates, and territory colonization rates), and determined that “medium-intensity” logging—mechanical thinning under the 2004 Amendment, and earlier prescriptions generally consistent with the 2004 Amendment— significantly adversely affects California Spotted Owls at all spatial scales by targeting dense, mature forests with high canopy cover, degrading the quality of such habitat by reducing it to moderate canopy cover. This is adversely affecting California Spotted Owl reproduction (Tempel et al. 2014b). The authors noted that the adverse effects of mechanical thinning on California Spotted Owls is likely even larger than their results indicated: “Understory removal is generally an important component of fuel-reduction strategies, but we caution that medium-intensity harvesting with understory treatments occurred on only 5.2% of the total area within owl territories, which could have limited our power to detect effects . . . ” In other words, the adverse effects of mechanical thinning were apparent even with a relatively small portion of the breeding season territory affected by such logging.

17. Sec 4. Pertaining to owls and fire: The original text of this section was largely taken from the Gutiérrez et al. 2016 GTR which was insufficient for conservation planning. I suggest the USFWS conduct its own

comprehensive literature review and synthesis of the primary literature, but I have provided here an example of a systematic review of the fire literature to provide a start. I also am providing a table summarizing the results of all papers relevant to owls and fire, a technique I also suggest the USFWS use when gathering evidence for their reviews.

Spotted Owls and Forest Fire: A Systematic Review of the Evidence

By Derek E. Lee

Abstract: It is widely believed that severe wildfire is a cause of recent declines in populations of Spotted Owls, and that mixed-severity fires that include large high-severity patches pose a primary threat to population viability. This systematic review summarizes the available scientific literature on the effects of wildfire on aspects of Spotted Owl demography, life history, and ecology, from studies using empirical data to answer the question, “How does fire, especially mixed-severity fire with substantial patches of high-severity fire within their home ranges, affect Spotted Owl habitat selection, demography, and life history parameters?” Sixteen high-quality papers reported evidence pertaining to natural mixed-severity fires that had burned during the past few decades and included representative areas of high-severity burn. The evidence indicates Spotted Owls are usually not significantly affected by mixed-severity fire with substantial portions of high severity, as 88% of all studies found no significant effects of fire on owl demographic parameters. Furthermore, more than half the evidence discovered in this review (63%) found positive effects from fire, while a smaller proportion of the evidence presented negative effects (56%). Mean effect sizes across all studies indicated overall positive effects of fire on owl life-history parameters (5.0%). Contrary to current perceptions and recovery efforts for the Spotted Owl, mixed-severity fire does not appear to be a serious threat to owl populations, rather wildfire has arguably more benefits than costs.

Introduction: Wildfires are the primary natural disturbance in western forests of the United States, and native plants and animals have been living with fire for thousands of years of their evolutionary history. Forest fires typically burn as mixed severity in a mosaic of different severities. ‘High-severity’ fire kills most or all of the dominant vegetation in a stand and creates what scientists have termed ‘complex early seral forests,’ where standing dead trees, fallen logs, resprouting shrubs, tree seedlings, and herbaceous plants comprise the structure (Swanson et al. 2011, DellaSala et al. 2014). Complex early seral forests differ from postfire harvested forests in that dead trees remain on-site, providing food sources and shelter for numerous wildlife species (Hutto 2006, Swanson et al. 2011, DellaSala et al. 2014).

The Spotted Owl (*Strix occidentalis*) is one of the rarest birds to breed in the mainland of the United States. The species is strongly associated with mature and old-growth (i.e., late-successional) conifer and mixed-conifer–hardwood forests with thick overhead canopy and many dense, old, live, and dead trees and fallen logs (Gutiérrez et al. 1995). These owls feed primarily upon small mammals (Gutiérrez et al. 1995).

Spotted Owls have been intensively studied since the 1970s, but research on these owls in fire-affected landscapes did not begin until the early 2000s. Thus, much of what scientists previously understood about habitat associations of Spotted Owls was derived from studies in forests that had not experienced recent fire. The scientific literature has established that the optimal habitat for Spotted Owl nesting, roosting, and foraging in long-unburned forests is provided by conifer and mixed-conifer–hardwood forests dominated by large (30–61 cm but typically >61 cm) trees with medium (50–70) but typically high (>70) percent canopy cover (Gutiérrez et al. 1995). The populations of all three subspecies have declined due to widespread historical and ongoing habitat loss, primarily from logging large, old trees favored by the owls for nesting and roosting (Seamans et al. 2002, Forsman et al. 2011, USFWS 2011; 2012, Conner et al. 2013, Tempel and Gutiérrez 2013).

For decades, studies on Spotted Owl habitat relations and correlations to survival and reproductive success were conducted in areas that had not experienced recent fire, where the 'nonsuitable' owl habitat was typically a result of logging (Gutierrez et al. 1992, Franklin et al. 2000, Seamans et al. 2002, Blakesley et al. 2005, Seamans and Gutiérrez 2007a, Forsman et al. 2011, Tempel et al. 2014). As Spotted Owls are associated with dense, late-successional forests, biologists typically assumed that fires that burned at high intensity were similar to clearcut logging and had a negative effect on long-term survival of the species. It is widely believed that severe wildfire is a cause of recent declines (USFWS 2011, 2012), and many land managers now believe that high-severity fires pose the greatest natural risk to owl habitat and a primary threat to population viability (Davis et al. 2016). Narrative literature reviews have tried to summarize the effects of fire on Spotted Owls (Gutierrex et al. in press GTR), but evidence-based conservation decisions should be based upon systematic, transparent reviews of primary literature (Sutherland et al. 2004, Pullin and Stewart 2006, Pullin and Knight 2009).

Evidence-based decision making requires a systematic review of the primary scientific literature (Pullin and Stewart 2006). The following systematic review summarizes the available scientific literature on the effects of wildfire on aspects of Spotted Owl demography, life history, and ecology, from studies using empirical data to answer the question, "How does fire, especially mixed-severity fire with substantial patches of high-severity fire within their home ranges, affect Spotted Owl habitat selection, demography, and life history parameters?" Studies that modeled effects of simulated fires on Spotted Owl habitat and demography were not considered here.

Methods: I conducted a systematic review of the primary scientific literature and weighed the evidence for the direct effects of wildfire on Spotted Owl demography and foraging ecology. I searched the following electronic databases: Agricola, BIOSIS previews, ISI Web of Science, and Google Scholar. Search terms were: spotted AND owl AND *fire, Strix AND occidentalis AND *fire.

Studies underwent a three-fold filtering process before being accepted into the final systematic review. Initially, all articles were filtered by title and any obviously irrelevant material was removed from the list of articles found in my search. Subsequently, the abstracts of the remaining studies were examined with regard to possible relevance to the systematic review question, using inclusion criteria based on the subject matter and the presentation of empirical data. Articles were accepted for viewing at full text if it appeared that they may contain information pertinent to the review question or if the abstract was ambiguous and did not allow inferences to be drawn about the content of the article. Finally, all remaining studies were read at full text and either rejected or accepted into the final review (Davies et al. 2008).

Papers were evaluated for methodological flaws to ensure equivalent quality standards in all evidence. Evidence was extracted by carefully reading every paper and extracting all quantified results from text, tables, and figures. Extracted data were collated in a table. I noted sample sizes, sampling unit, whether the result was 'statistically significant,' and also noted the effect size of any significant and non-significant results. I categorized every paper for gross effects by assigning up to 3 codes for: the presence of no statistically significant effect (0); any negative effect (-); and any positive effect (+) of fire on the parameters of interest in the paper. Papers were permitted to have more than one effect, and indeed most had multiple effects because there was often no statistically significant effect (0), combined with a non-significant positive (+) or negative (-) effect.

I noted the effect sizes and signs (positive or negative) for all reported effects, regardless of their statistical significance. Fortunately most papers reported effects as probabilities (specifically the change in probability after a fire, or the difference in probabilities between burned and unburned sites) so effects were mostly already scaled between zero and one, making comparison among studies easy. If a parameter was not a probability (e.g., reproduction as fledgling per pair as in Bond et al. 2002), I computed the difference between burned and unburned groups and multiplied by the unburned group estimate to produce a percent change effect that could be compared with the other changes or differences in probabilities. When papers reported multiple effects (e.g., occupancy and reproduction, or survival and recruitment), I recorded each effect individually. I estimated mean effect sizes for all papers, and also estimated mean effect sizes stratified by study type according to whether the study estimated occupancy, foraging habitat selection, or demographic rates such as survival and reproduction. I also estimated mean effect sizes for significant effects only.

Results: I found 20 papers reporting empirical evidence relevant to direct fire effects on owls (Table S1), but 3 were only concerned with salvage-logged areas versus unburned areas, so these 3 papers were considered separately from the 17 papers that dealt directly with fire and owls. One paper was found to have methodological flaws that made the evidence it contained of suspect quality (Jones et al. 2016, see Addendum for explanation).

Fourteen (14) of the 16 high-quality papers reported evidence explicitly pertaining to natural mixed-severity fires that had burned during the past few decades and included representative areas of high-severity burn, while 2 reported evidence from an undifferentiated mix of natural and prescribed fires. Papers reported effects of fire on site occupancy (8), foraging habitat selection (5), reproduction (4), apparent survival (3), site fidelity (1), mate fidelity (1), nesting and roosting habitat selection (1), and recruitment (1).

Of the 16 papers with no substantial quality issues, the majority reported no significant effects of fire on Spotted Owls (88% of papers reported no statistically significant effects of fire on Spotted Owls). Most of the studies reporting any effect reported positive effects of fire on owls (63%), and the smallest proportion of the papers reporting effects reported negative effects of fire on owls (56%). Looking only at papers with statistically significant fire effects, the majority reported positive significant effects of fire on owls (3/5), and the minority reported negative significant effects (2/5).

Overall effect sizes were variable, but mean overall effect size was positive (+0.050), and mean effect size for statistically significant effects only was also positive (+0.072). Mean effect sizes from studies of fire effects on habitat selection were strongly positive (+0.172 overall; +0.164 for statistically significant effects only). Mean effect sizes from studies of occupancy were negative (-0.051 overall; -0.021 for statistically significant effects only). Mean effect sizes from demographic studies were overall positive (+0.052), and slightly negative for statistically significant effects only (-0.020).

Salvage logging was found to have negative effects on Spotted Owls in 100% of the papers that examined this disturbance, with large effect sizes.

Conclusions: This systematic review and weighing of the effects from the primary literature pertinent to Spotted Owls and mixed-severity fire demonstrates that the preponderance of evidence indicates Spotted Owls are usually not significantly affected by mixed-severity fire, including fire with substantial portions of high severity as is usually found in recent mixed-severity fires, as 88% of all studies found no significant effects of fire on owl demographic parameters. Furthermore, more than half the evidence discovered in this review (63%) found positive effects from fire, while a smaller proportion of the evidence presented negative effects (56%). Mean effect sizes across all studies indicated overall positive effects of fire on owl life-history parameters (+5.0%), with strong positive effects in foraging habitat selection (+17%), small negative effects when estimating occupancy (-5.1%), and small positive effects when estimating demographic rates (+5.2%).

Contrary to current perceptions and recovery efforts for the Spotted Owl (USFWS 2011, 2012, Gutierrez et al in press GTR), high-severity fire does not appear to be an immediate, dire threat to owl populations that requires massive landscape-level fuel-reduction treatments to mitigate fire effects. Empirical studies reviewed here conducted from 1 to 15 years after fires demonstrated that most burned sites occupied by Spotted Owl pairs remain occupied and reproductive at the same rates as long-unburned sites, regardless of the amount of high-severity fire in core areas. Severely burned sites can be expected to have occupancy probability reduced by 2.1% to 5.1%, on average. Burned sites where owls are not detected immediately after fire are often recolonized later, demonstrating the mistake of concluding those sites are permanently 'lost' to Spotted Owls. In the unlikely event of large amounts of high-severity fire within most owl core areas, populations may be impacted over the long term, because lower-quality sites had a higher probability of extinction after fire, and these lower-quality sites may represent important opportunities for colonization by floater owls (those without mates and territories) and for recruitment (young owls entering the breeding population). However, overall effects on occupancy were small, and severe fire appears to benefit adult and juvenile owls by creating foraging habitat with abundant small mammal prey that is preferred over unburned habitat by 18% to 20%, but only if fire-killed trees are not salvage logged after fire.

In any given fire, relatively few owl sites experience levels of high-severity fire greater than the territory threshold above which occupancy probability was reduced in southern California (Lee et al. 2013). Potential harm to Spotted Owls by the temporary loss of late-successional nesting and roosting habitat from high-severity fire is certainly compounded and exacerbated by postfire logging, prefire fuel treatments, urbanization, drought, and increasingly warmer temperatures. Harvesting timber to lower risk of fire has adverse effects on Spotted Owls (e.g., Tempel et al. 2014), whereas fire itself has arguably more benefits than costs.

Descriptions of all relevant papers:

Site Occupancy Dynamics

The first peer-reviewed published study on Spotted Owl occupancy in burned landscapes was an examination of site and mate fidelity of northern, California, and Mexican Spotted Owls (*S. o. lucida*) 1 year after fire (Bond et al. 2002). Sixteen of 18 (89%) surviving owls (of all subspecies) were in the same breeding sites after fire, and all pairs were faithful to their prefire breeding site and mate.

Mexican Spotted Owl

Jenness et al. (2004) reported pre- and postfire occupancy of 64 Mexican Spotted Owl sites in mixed-conifer, pine (*Pinus* sp.), and pine-oak forests in four national forests in New Mexico and Arizona. The authors selected owl breeding sites in fires that burned from 1993 to 1996 and compared levels of occupancy (single, pair, failed reproduction and successful reproduction) in 1997 in 33 burned and 31 unburned sites, including 29 paired burned and long-unburned sites within 12 km of each other. Postfire occupancy rates were not significantly different between burned and unburned sites and did not statistically differ with time since fire. The percent of high-severity fire in a burned site had no significant influence on whether the site was occupied. Postfire logging was minor in most of the fires.

California Spotted Owl

Roberts et al. (2011) compared longer-term effects of wildfire on occupancy of California Spotted Owls residing in burned (<15 years since fire) and long-unburned mixed-conifer forests in Yosemite National Park, the only study of this kind in an unmanaged landscape and the first to use modern statistical techniques to model occupancy probabilities (MacKenzie et al. 2006). This study compared occupancy of breeding sites in 16 randomly selected burned and 16 unburned 'owl survey areas,' each 3.75 km^2. A total of 19 owl pairs were monitored for a single year, and vegetation at owl sites was compared with sites that yielded no owl response to build detectability and occupancy models. The mean 'owl survey area' that burned at high severity was 12%, with the greatest amount of high-severity burn in a survey area being 52%. Because this study was conducted in a national park, no postfire or recent prefire logging had occurred to confound results. The authors found no support for a model of occupancy rates that distinguished between burned and unburned sites. Occupancy and detection rates and densities of Spotted Owls were similar between burned and unburned sites. Vegetation structure was the main determinant of occupancy rather than whether or not the site had burned: the total basal area was higher at burned and unburned sites with owls than at sites without owls.

Lee et al. (2012) published an 11-year study of California Spotted Owl occupancy on national forest lands in the Sierra Nevada, the most extensive study of pre- and postfire occupancy ever conducted in this mountain range. This study also was the first in a burned landscape to use statistical methods for estimating rates of local extinction and colonization while accounting for imperfect detectability (MacKenzie et al. 2006) because multiple years of surveys were available. The authors used data collected by the US Forest Service to compile occupancy-survey histories at 41 breeding sites within six large fires that occurred from 2000 to 2007 throughout the Sierra Nevada and at 145 long-unburned control sites. Fires had no significant effect on occupancy probability. The mean probability of colonization of burned sites was 0.381, similar to rates in long-unburned sites, which demonstrates the value of long-term monitoring to better understand wildfire effects on population dynamics, and underscores why managers must not presume a breeding site is permanently 'lost' if owls are not detected immediately after fire. Based on simulation results, the authors recommended that managers should survey >200 burned and >200 long-unburned sites throughout the Sierra Nevada and that burned sites should be surveyed at least 2 years after fire to determine site occupancy prior to implementing postfire management activities.

The 2013 Rim Fire near Yosemite National Park was the largest fire in recent recorded Sierra Nevada history, burning more than 100,000 ha. The fires burned through 45 known California Spotted Owl breeding sites in the Stanislaus National Forest and all sites were surveyed by US Forest Service personnel the following year. This provided an unparalleled opportunity to examine the effects of a large fire on Spotted Owl site occupancy within a single fire area, in a study area with relatively little private timber land. Increasing amounts of severe fire surrounding nest and roost sites decreased occupancy probability, but did not affect occupancy by pairs of owls (Lee and Bond 2015a).

Furthermore, single-season modeled occupancy rates 1 year after the Rim Fire were significantly higher than other previously published occupancy rates in both burned and long-unburned

forests (Lee and Bond 2015a). The relatively high occupancy rate could indicate either that owl sites in the Rim Fire area before and/or after fire were of above-average quality relative to the other fire areas or that owls remained in burned sites because of strong site fidelity.
A long-term (>20 years) demographic study of California Spotted Owls in the Eldorado and Tahoe National Forests of the central Sierra Nevada is providing a wealth of information on the effects of habitat, weather, and forest management activities. Tempel et al. (2014) examined the influence of timber harvest and wildfire on reproduction, survival, and occupancy over a 6-year timescale using data from 74 breeding sites, although only 12 sites experienced fire during the course of the study. Fire did not significantly affect survival, reproduction, or site extinction. The coefficient for the effect of fire on site colonization was negative, but the standard error of the coefficient could not be estimated due to the fact all sites remained occupied after fire.

Surveys by the US Forest Service at Spotted Owl breeding sites in southern California from 2003 to 2011 offered a unique opportunity to study the long-term fire effects in this especially fire-prone region, as more sites were influenced by wildfire during this period there than anywhere else in the range of the species. Lee et al. (2013) used survey data from 97 long-unburned and 71 burned breeding sites to examine the influence of fire and postfire logging on local rates of extinction, colonization, and occupancy probability. Postfire logging occurred on 21 of the burned sites.

None of the fire and logging coefficients were statistically significant, but model-averaged effect sizes suggested that high severity fire that burned >50% of forest in the 203-ha core area was correlated with lower colonization, greater extinction, and lower occupancy relative to unburned sites, for all detections as well as pairs only. Postfire logging further increased extinction probability. The majority (75%) of sites burned below the 50% threshold.
Spotted Owls in two study areas continued to occupy burned forests in winter. Bond et al. (2010) documented three of five radiomarked California Spotted Owls in the southern Sierra Nevada roosted within a burned landscape overwinter. Ganey et al. (2014) reported four radiomarked Mexican Spotted Owls moving to burned overwintering areas in New Mexico.

Tempel et al. 2016 examined occupancy dynamics in 43 burned breeding season territories and 232 unburned territories in 4 study areas across the Sierra Nevada using 19 years of data. They found no significant effects of fire on occupancy, but their top ranked model for one study area (Sequoia Kings Canyon) included a covariate for proportion of the core area that had canopy cover reduced by >10% by wildfire. This covariate was negatively correlated with territory extinction probability, meaning more area burned reduced the site extinction probability, thereby increasing occupancy probability.

Northern Spotted Owl

The only study to investigate the occupancy dynamics of northern Spotted Owls in burned landscapes was conducted in three fire areas and an adjacent long-unburned demographic study area in mixed-conifer and mixed-evergreen forests in the southern Oregon Cascade

Mountains (Clark et al. 2013). The three fires all burned within 1 year of each other. Modeled occupancy rates of 103 Spotted Owl sites in the long-unburned area were compared with 40 burned sites before fire and after postfire logging. This extensive study also investigated survival rates and movements of 23 radiomarked owls in and just outside two of the fires (see Survival, later). Postfire logging was prevalent on private lands in all the fire areas; thus, it was not possible to quantify the influence of fire alone on occupancy dynamics and survival, but this research provided important insights into the effects of postfire logging on a federally threatened species whose numbers are continuing to decline (Forsman et al. 2011).

Extinction rates were greater after postfire logging in the burned area (Timbered Rock) than the long-unburned area (South Cascades; Fig. 6; Clark et al. 2013). Occupancy probability declined more steeply after postfire logging than in the unburned area. The high rate of adult dispersal following postfire logging suggested that insufficient habitat remained at abandoned sites to support Spotted Owls. At all three fire areas, extinction probability of sites increased with greater amounts of combined area that was previously harvested, burned at high severity, or postfire logged.

Survival

Bond et al. (2002) examined short-term (1-year) postfire survival of 21 color-banded Spotted Owls in four separate study areas encompassing all subspecies: in mixed-conifer and mixed-evergreen forests of northwestern California, southern California, and New Mexico and in pine-oak forests in Arizona. All nest and roost areas were burned, and no postfire logging had occurred before owls were surveyed the year after fire. Vegetation burn severity maps were available for only eight of the 11 breeding sites. Four of the eight breeding sites where fire severities were mapped burned at low to moderate severity, and the other four burned 36–88% at high severity. Each breeding site was defined as a circle approximately 150–400 ha, depending on study area. The authors found that 18 of 21 (86%) individual owls were resighted after fire. These survival rates are the same as those for individuals in unburned sites.
In a long-term demographic study of color-banded California Spotted Owls in the central Sierra Nevada, Tempel et al. (2014) found fire did not significantly affect survival.

Clark et al. (2011) examined the monthly survival rates of northern Spotted Owls 3–4 years after fire and postfire logging in two fire areas in southwestern Oregon. The authors color-banded and radiomarked 11 Spotted Owls inside and six owls adjacent to fire areas where much of the forest burned at high severity had been postfire logged. A third group of six owls had moved outside the perimeter after fire and subsequent logging. Owls that remained within the postfire logged landscape had lower survival rates than those reported throughout the range of the subspecies. Owls that moved had the lowest monthly survival rates of the three groups. Owls outside the burned and logged areas had the highest annual survival, but there was no evidence for an effect of fire severity on survival. The authors suggested past logging activities coupled with loss of habitat from severe fire followed by postfire logging contributed to the lower survival rates of owls in burned forests.

Rockweit et al. (2017) examined 70 unburned sites and 28 sites burned in 4 fires. They reported wildfires with different mixtures of burn severity resulted in different effects on survival and recruitment. However, I respectfully suggest that their results are somewhat mischaracterized when the authors overemphasizing the results from the 4 territories burned at mostly high severity during the fire year 2004. For comparison, 10 territories burned with mostly low-severity fire (year 1987 and 1999 fires), and 14 territories burned with moderate amounts of high- and low-severity fire (fire year 2008). The differences among the burned territory groups (those burned in fire years 1987, 1999, 2004, and 2008) was largely due to differences in how much low-severity fire and how much high-severity fire burned in their core areas. Owl territory cores that were burned at mostly low severity (1987 and 1999 fires) were associated with no significant effects on survival or recruitment. When territory cores burned with more high severity fire and less low severity (2008 fire), the result was a significant reduction in survival and a significant increase in recruitment. When territory cores burned at predominantly high severity (2004 fire), there was a significant reduction in survival. The reported variation in significant survival and recruitment effects should be summarized as territory fitness. Fitness of a territory is survival + reproduction. Reproductive output is considered the primary driving force in defining habitat fitness (Franklin et al. 2000). However, Rockweit et al. did not report reproduction, even though these data were available, so I cannot compute true fitness consequences of the fires. I can estimate relative fitness of the territories burned by fires using survival and recruitment (see **Table R1**).

Table R1. Territory fitness (apparent survival + recruitment) as a measure of habitat quality for four groups of Northern Spotted Owl territories burned by wildfire in different years. Of fire years examined, 50% resulted in no fitness effect, 25% resulted in a decrease in fitness, and 25% resulted in an increase in fitness. Of burned territories, 36% showed no fitness consequences, 14% showed decreased fitness, and 50% showed increased fitness after being burned.

Group (year of fire)	Sample size (# of territories in group)	Pre-fire average territory fitness	Post-fire average territory fitness	Results, change in territory fitness
control	70	0.98	0.98	
1987	8	n.a.	0.98	no significant effects
1999	2	0.98	0.98	no significant effects
2004	4	0.98	0.73	reduced fitness

2008	14	0.98	1.02	increased fitness

Reproduction

High annual variability in reproductive rates is typical of Spotted Owls and has been associated primarily with weather and to a lesser extent with habitat structure (Franklin et al., 2000; Seamans et al. 2002; Seamans and Gutierrez 2007b). While weather is a key factor, productivity also differs by site; thus, any impacts of wildfire on reproduction should account for prefire reproductive rates of the site and, ideally, be compared with long-unburned areas.
Jenness et al. (2004) found that the number of successfully reproducing Mexican Spotted Owl sites did not differ between burned and unburned forests. Spotted Owls successfully reproduced at three sites with 8%, 31%, and 32% high-severity fire within a 1-km circle of their nest. Moreover, reproductively successful sites had a higher percentage of burned area than other occupied sites affected by fire (including single owls and nonreproducing pairs).
Bond et al. (2002) also found that productivity of burned California Spotted Owl sites was higher than overall annual rates of reproduction for long-unburned sites. Fire was not a significant variable influencing reproduction of California Spotted Owls in southern California (Lee and Bond 2015b), or the central Sierra Nevada (Tempel et al. 2014).

As described in the preceding text, Lee et al. (2013) found that more high-severity fire in a site's core use area reduced occupancy by Spotted Owls in southern California. Lee and Bond (2015b) used the same dataset to examine how the quality of a site influenced occupancy and reproduction after severe fire. Site quality was measured by whether the site supported a single owl, pair of owls, or pair of owls with offspring the previous year. The influence of severe fire on occupancy was minor in sites that had been occupied and reproductive the previous year (high quality), and if a site remained occupied, severe fire did not affect the probability of reproduction compared with unburned sites (Lee and Bond 2015b). In other words, lower-quality sites that were often vacant and nonreproductive typically had lower occupancy with increasing amounts of severe forest fire, whereas in higher-quality sites that were consistently occupied and reproductive, the amount of severe fire that occurred in the core area had negligible effects on occupancy and reproduction. This was similar to the Rim Fire results that indicated that severe fire did not affect occupancy by pairs.

Nesting, Roosting, and Foraging in Burned Forests

Only one published study has documented roosting locations in burned forests (Bond et al. 2009). In this study, no nests were found in stands burned at high severity. California Spotted Owls roosted in all fire intensity classes 4 years after the McNally Fire in the Sequoia National Forest, southern Sierra Nevada, but most roosts were associated with low-severity fire. Only 1 of 60 roosts occurred in an area that burned at high severity, and owls selected roost sites burned at low severity and avoided sites burned at moderate severity. Roost sites averaged 63% canopy cover and had an abundance of large (average 63 cm) trees. Thus, roosting habitat in burned landscapes was comparable with roosting habitat identified in unburned forests (Gutiérrez et al. 1995). These results underscore the importance of the burn severity mosaic of within an owl's home range.

Most studies of selection of habitat by Spotted Owls have focused on nesting and roosting habitat. Foraging habitat is just as critical for the persistence of owls, but is more difficult to identify because it requires radiotelemetry. Bond et al. (2009) were the first to quantify foraging habitat selection by Spotted Owls in a burned landscape. Selection studies compare how much owls used forest that burned at a particular severity with the availability of that burn severity. The authors banded and radiomarked seven California Spotted Owls occupying the McNally Fire 4 years after fire. Very little (<3%) of the foraging ranges of these owls had been postfire logged, so effects of high-severity fire were not confounded with postfire logging. All owls had access to sufficient amounts of unburned, low, moderate, and highly burned patches of forest in their home ranges from which to choose, so the authors could quantify whether owls selected or avoided any of these burn severities. The probability of an owl using a site for foraging was significantly greater in burned—especially high-severity burned—forests than unburned forest, after accounting for distance from nest. Selection for a particular burn class occurred within 1.5 km from nest. Thus, recently burned complex early seral forest should be considered a potentially suitable foraging habitat for this subspecies.

Spotted Owls in the McNally Fire area fed primarily on pocket gophers (*Thomomys* spp., 40.3% by biomass) and northern flying squirrels (*Glaucomys sabrinus*, 25.9% by biomass), whereas owls fed primarily on flying squirrel and woodrats (*Neotoma* spp.) in long-unburned study areas (Bond et al. 2013). The mean home-range sizes of the McNally Fire owls were similar to those recorded in unburned forests using similar time periods and methodology (Bond et al. 2013). Bond et al. (2016) analyzed foraging habitat selection by eight California Spotted Owls in the Slide Fire in the San Bernardino National Forest of southern California 3 and 4 years after fire. Habitat selection with sensitivity analysis at three spatial extents of available habitat showed owls used forests burned at all severities in proportion to their availability, with the exception of significant selection for moderately burned forest farther from core areas.

Comfort et al. (2016) examined foraging habitat selection by 23 northern Spotted Owls in the Timbered Rock Fire in southwest Oregon in relation to edges created by fire and postfire logging. Because postfire logging occurred immediately following fire on extensive private lands in the study area, and their remote-sensing methodology could not distinguish between fire and postfire logged areas, the authors created a combined burned–logged variable called the "disturbance severity." The edges between forested habitats and burned–logged areas were defined as "hard" edges. At smaller spatial scales (3.2 and 51.8 ha surrounding telemetry locations), increases in disturbance severity decreased the probability of use, but at larger spatial scales (829 ha), the opposite was true. The use of a location for foraging was maximized when about 20% of a 3.2-ha area surrounding the location was composed of hard edge. Thus, foraging owls selected some amount of edge, possibly because edges offer access for hunting small mammals while still providing adjacent closed-canopy habitat. Owls avoided areas with larger amounts of hard edge, but selected smaller amounts of edge, suggesting that small patches of high-severity fire surrounded by relatively undisturbed land are potentially suitable for foraging. Larger, more contiguous hard edges were described as intensively managed edges created by postfire logging.

Eyes et al. (2017) radiotracked 13 owls over 3 years and collected data on foraging habitat selection in Yosemite National Park. They analyzed foraging for owls nesting in and near forest burned 1-14 years previously from a mix of wildfires and prescribed burns. Eyes et al. (2017) found no significant effect of burn severity on foraging habitat selection, but non-significant effects were reported that showed a 6% decrease in probability of use for the most severely-burned locations relative to unburned locations.

A sample of four radiomarked Mexican Spotted Owls in the Sacramento Mountains, New Mexico, moved to wintering areas that had burned 4–6 years earlier and that had two to six times greater abundance and biomass of small mammal prey than nest core areas associated with those owls (Ganey et al. 2014). This study indicates that wintering areas provided foraging habitats during an energetically stressful time of year.

Addendum, rationale for excluding evidence from Jones et al. 2016:
This paper is filled with fatal errors of analysis that render it entirely unusable as evidence of the relationship between owls and fire.

First, their owl population has documented long-term trends of decreasing site colonization and increasing site extinction probabilities, before the King Fire (Tempel and Gutiérrez 2013). However, Jones et al. did not account for these important pre-fire trends in their site occupancy analyses. Site occupancy analysis measures, each year, the probability that occupied sites are abandoned (called site extinction), and the probability that empty sites are colonized and become occupied again, and uses those colonization and extinction probabilities to calculate a yearly average probability of site occupancy. The population has had 22 years of documented trends of ever-lower site colonization probability, and ever-increasing site extinction probability (Tempel and Gutiérrez 2013), yet the authors simply compared their 1 year of post-fire data against the average of all previous years without accounting for those known year-to-year trends in colonization and extinction probabilities. The pre-fire trend means 2015 (the year after fire) was expected follow the trend of having higher extinction probability relative to all previous years, even if there was no fire. Fig. 3f clearly shows that the 2015 post-fire year of decrease in occupancy was not significantly different from the 10 previous years of decrease.

The ‘trend analysis’ Jones et al. did was not what I described in the previous paragraph. Rather, Jones et al. took annual estimates of site occupancy and compared a few models to describe the

23 years of annual occupancy rates. This trend analysis is not the same as including the pre-fire trends in extinction and colonization probabilities described above.

Second, Jones et al. used compositional analysis of foraging habitat use, a method that is inappropriate for central place foragers like Spotted Owls (Rosenberg and McKelvey 1999, Bond et al. 2009, Bond et al. 2016). Foraging habitat selection analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. Compositional analysis compares simplistic ratios of the proportion of foraging points in a habitat type relative to the proportion of territory area in that type. The proper habitat use analysis is a 'resource selection function', a math model that accounts for the fact that Spotted Owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every Spotted Owl foraging habitat use paper has found distance from nest is a highly significant effect on a point's probability of use – but Jones et al. did not account for the distance of a foraging site to the nest. Because Jones et al. did not do a proper resource selection function analysis, they were essentially ignoring each foraging point's distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fundamental error makes their radiotelemetry results and discussion unreliable.

Third, Jones et al. reported extinction for a territory in WebFigure 4 when the owls shifted their location by a distance that is less than the diameter of a territory as defined by the authors. The owls' shift was also less than mean foraging distance reported by the authors. Because the authors did not follow their own definition of a territory, they arbitrarily declared the short-distance shift to signify the extinction of the 'old' territory and creation of a 'new' territory a few hundred meters away. This was an arbitrary reclassification of a continuously occupied territory whose occupants shifted a few hundred meters, an occurrence that happens in Spotted Owl territories. This decision inflated their 'burned site' extinction probability by classifying a normal within-territory movement as site extinction.

The sites that were occupied in 2014 are those most relevant to extinction probability in 2015, the only significant 'fire-related' effect Jones et al. found in 2015 and attributed to the King Fire. 2014 occupied site sample sizes indicates Jones et al. make their claim of 'large extinction effects' from only 8 severely burned sites that were occupied in 2014. Considering that Jones et al. did not account for the long-term increasing site extinction probability (meaning site extinction probability was getting bigger every year leading up to the fire), and the fact that only 8 sites in the burned area were occupied before the fire in 2014, and at least one site that they declared extinct from the fire actually just moved a few hundred meters, means their results are not correct.

Given the analytical shortcomings I described, I suggest the results reported by Jones et al. be viewed with caution and not used to justify management actions that harm Spotted Owls.

Additionally, errors of scholarship in Jones et al. 2016 include:

Pg. 304 "The observation that lower-severity fire is benign, and perhaps even moderately beneficial, to Spotted Owls is consistent with previous studies (Roberts et al. 2011, Lee et al. 2012)"
Both those studies found mixed-severity fire (rather than lower-severity fire) had no effect on occupancy. Mixed severity fire is common historically and currently in the Sierra Nevada and explicitly includes low-, moderate-, and high-severity burned patches.

Pg. 305, "because owls were not individually marked in the Rim Fire study, some detections at "occupied" sites may have involved individuals from neighboring territories or non-territorial "floaters" (Lee and Bond 2015), both of which may have contributed to inflated estimates of territory occupancy."
This exact same situation exists in the data analysed by Jones et al. Data were collected as described in Tempel and Gutiérrez (2013), "We included both nocturnal and diurnal surveys in our occupancy analyses." During nocturnal surveys leg bands were usually not resighted, therefore detections at occupied sites would have been similarly inflated by individuals from neighboring territories or non-territorial floaters.

18. Forest Management Practices: This section is incomplete. There is no mention of wildland fire use and only 1 sentence on prescribed fire. I suggest USFWS perform a comprehensive review and rewrite this. For example:

    Prescribed burning is typically cheaper than mechanical thinning and can often be done without heavy equipment that impacts soils. It releases nutrients into the system and often results in a flush of herbaceous growth, thereby more closely emulating natural fire regimes than thinning alone. Burning may be the most successful fuel treatment combination (Strom 2005). Prescribed fire alone can reduce potential fire behavior for a maximum of about ten years (Finney et al. 2005, Strom 2005).

19. Where is the discussion of the effectiveness (or ineffectiveness) of logging treatments to affect fire behavior? There should be a section devoted to the empirical studies of fire behavior through logging treatments, with particular attention to fire behavior through treatments under the extreme weather and climate conditions that burn 90% of the large high-severity forest fires each year (Flanagan and Wotten 2001, Williams 2004). The evidence I am familiar with shows that treatments are largely ineffective at reducing large, high-severity fires, and may in fact exacerbate them. Space should also be given to discussing the cost and feasibility of repeatedly treating the landscape. I recommend a thorough and transparent literature review, but a few examples missed in the COR were:

The Rim Fire burned through treated areas with high severity. Lydersen, J.M., North, M.P. and Collins, B.M., 2014. Severity of an uncharacteristically large wildfire, the Rim Fire, in forests with relatively restored frequent fire regimes. *Forest Ecology and Management*, *328*, pp.326-334.

The 2002 Rodeo-Chediski Fire in Arizona burned through a mosaic of previously thinned and unthinned areas. A postfire assessment showed that 35% of stands that had been thinned within the previous 15 years (with an average stand density of 157 stems per acre) experienced high-severity crown fire (Schoennagel et al. 2004).

A study assessing treatment effects on the behavior of the Hayman Fire in Colorado concluded that treatments were unsuccessful at reducing fire severity (Finney et al. 2003). On days of extremely low humidity and high wind speeds of up to 84 mph, the fire burned through treated areas. Researchers concluded that areas that had been recently broadcast burned (within the previous year) appeared to be more effective at reducing fire severity than areas that were broadcast burned years earlier.

Prescribed burning is typically cheaper than mechanical thinning and can often be done without heavy equipment that impacts soils. It releases nutrients into the system and often results in a flush of herbaceous growth, thereby more closely emulating natural fire regimes than thinning alone. Burning in combination with thinning may be the most successful fuel treatment combination (Strom 2005).

20. Tree Mortality: This section is without necessary context over longer time frames of millennia. It also fails to mention the myriad ecological benefits that propagate through the ecosystem during and after beetle outbreaks. I suggest additional discussion about how insect and drought driven mortality has accomplished thinning and heterogeneity goals. Also worth adding is the many papers showing mortality does not affect fire severity. Such as:

Robert A. Andrus et al. Fire severity unaffected by spruce beetle outbreak in spruce-fir forests in southwestern Colorado, Ecological Applications (2016). DOI: 10.1890/15-1121

Sarah J. Hart et al. Area burned in the western United States is unaffected by recent mountain pine beetle outbreaks, Proceedings of the National Academy of Sciences (2015). DOI: 10.1073/pnas.1424037112

Nathan Mietkiewicz et al. Relative importance of climate and mountain pine beetle outbreaks on the occurrence of large wildfires in the western US, Ecological Applications (2016). DOI: 10.1002/eap.1400

The last sentence is unsupported. Again, I suggest a thorough and transparent review of the evidence be conducted, but I propose the following:

Given that high-severity fire has no serious effect on Spotted Owl occupancy, and that owls use all severities of burned forest for foraging, and because beetle kill does not affect fire severity, and may reduce fire severity, I would argue that beetle and drought mortality of trees is likely to create foraging habitat while simultaneously lowering fire risk in the landscape.

21. Climate Change: "Climate change is likely to exacerbate the risk of large, high-severity fires and drought-induced tree mortality (Miller and Safford 2012, Mallek et al. 2013)"

Please perform a thorough review of the evidence for climate-change effects on California forest ecosystems and portray the breadth of knowledge and areas of uncertainty.

22. Conceptual Model:

The conceptual model has many serious flaws in its structure rendering it not useful in its current form. Furthermore, there is very little explanation of the construction and utility of the model. How is this model supposed to guide conservation and increase resiliency? It would be much more useful to make a properly researched and objective document that carefully synthesizes all available evidence about owls, fire, and logging into an evidence-based decision-support framework.

1. Many stressors directly affect population parameters without acting through habitat. Therefore, the model needs to be reorganized into a triangle so all stressors (not just Barred Owls) can act directly on population parameters. Furthermore, the model misrepresents the stressors. Thinning and clearcutting have been and continue to be the most substantive stressors on canopy cover and large trees. Furthermore, there has been no evidence presented that describes the effectiveness of thinning at altering fire behavior or more importantly, the extent of high-severity fire on the landscape.

2. Habitat requirements are muddled. Why are very large trees listed twice? Why is there the combined canopy cover and large trees? Spatial heterogeneity is a vague term with little usefulness. What about prey habitat, shouldn't that be included as an explicit box to manage for? Where is complex early seral forest (burned forest) habitat present? The available evidence shows owls use burned forest of all severities for foraging in proportion to its availability or even prefer moderate or high severity. Burned forest foraging habitat should be added as an explicit type.

3. Many of the effects are not supported by the evidence. How can large high-severity fire decrease residual trees / snags? How can clearcutting increase very large trees? Mechanical thinning can also decrease very large trees, as I have witnessed first-hand in thinning treatments implemented in NSO critical habitat on USDA Forest Service projects in California. Why would tree mortality and fire necessarily increase salvage logging? Salvage is a policy that can be stopped. There is no evidence that

salvage decreases large, high-severity fires. Thinning can increase fires. Clearcutting can also decrease heterogeneity.

4. Population parameters should include movements as a distinct parameter. Floaters are not a parameter, they are a population segment and if they are included, then other groups and ages should be added. How do floaters affect survival?

5. How are CSO resiliency and occupancy related? Why are other parameters and habitat requirements not contributing to resiliency?

23. Conservation Objectives: Why is there no mention of wildland fire use and prescribed fire? Also, it seems clear to me that managing for PACs has not been sufficient and has led to the CSO decline on USFS lands. I propose protecting 6000 ac around every nest and minimizing logging and thinning within this CSO year-round home range ecological conservation zone. Adaptive management requires changes be made to management in an experimental design. I propose designating at least 2 demography study areas on USFS lands including sizable buffer zones as zero cut, zero thinning, and active wildland fire use for the next 20 years to monitor effects on the forest ecosystem and Spotted Owl populations (as well as populations of many other native species). Currently, the only 'control' sites to compare with USFS are the NPS lands. USFS lands need to be managed more like NPS lands if CSO are to be recovered.

24. Conservation Objectives: "There is an urgent need to reduce the likelihood of forest ecosystem conversion to chaparral."

    This is an unsupported sentence. Where was this established? What unique community of species are you condemning by making it a priority to stop naturally occurring chaparral habitat? Chaparral is a natural successional step between severe fire and the regrowth of forest in unlogged stands (Nagel and Taylor 2005).

25. As the systematic literature review has demonstrated, fire is not a serious risk to Spotted Owl populations, so a fire risk assessment of PACs may not be the best use of resources. What is needed is protections from logging within 6000 ac around every nest and subsequent demographic monitoring to determine effects of this protection.

26. The COR and its conservation objectives should be derived from a transparent and systematic review of the evidence, weighted for reliability. Knowing which interpretations should be down-weighted due to conflicts of interest is a critical step in the evidence-based decision making that should be followed during this document's revision (see e.g., Sutherland, W. J., Pullin, A. S., Dolman, P. M., & Knight, T. M. 2004. The need for evidence-based conservation. *Trends in ecology & evolution*, *19*, 305-308.; Pullin, A. S., & Knight, T. M. 2009. Doing more good than harm–Building an evidence-base for conservation and

environmental management. *Biological conservation*, *142*, 931-934.) I strongly recommend a focus on actual results of empirical studies, not on the studies' interpretations especially if a study was funded by an agency with a conflict of interest.

27. Re: Jones et al. 2016: This paper is filled with fatal errors of analysis that render it useless as evidence of the relationship between owls and fire.

    First, their Spotted Owl population has documented long-term trends of decreasing site colonization and increasing site extinction probabilities, before the King Fire (Tempel and Gutiérrez 2013). However, Jones et al. did not account for these important pre-fire trends in their site occupancy analyses. Site occupancy analysis measures, each year, the probability that occupied sites are abandoned (called site extinction), and the probability that empty sites are colonized and become occupied again, and uses those colonization and extinction probabilities to calculate a yearly average probability of site occupancy. The population has had 22 years of documented trends of ever-lower site colonization probability, and ever-increasing site extinction probability, yet the authors simply compared their 1 year of post-fire data against the average of all previous years without accounting for those known year-to-year trends in colonization and extinction probabilities. The pre-fire trend means 2015 (the year after fire) was expected follow the trend of having higher extinction probability relative to all previous years, <u>even if there was no fire</u>. Fig. 3f clearly shows that the 2015 post-fire year of decrease in occupancy was not significantly different from the 10 previous years of decrease.

    The 'trend analysis' Jones et al. did was not what I just described. Rather, Jones et al. simply took annual estimates of site occupancy and compared a few models to describe the 23 years of annual occupancy rates. This trend analysis is not the same as including the pre-fire trends in extinction and colonization probabilities described above.

    The second flaw was that Jones et al. used compositional analysis of foraging habitat use, a method that is inappropriate for central place foragers like Spotted Owls (Rosenberg and McKelvey 1999, Bond et al. 2009, Bond et al. 2016). Foraging habitat use analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. Compositional analysis compares simplistic ratios of the proportion of foraging points in a habitat type relative to the proportion of territory area in that type. The proper habitat use analysis is a 'resource selection function', a math model that accounts for the fact that Spotted Owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every Spotted Owl foraging habitat use paper has found distance from nest is a <u>highly significant</u> effect on a point's probability of use – but Jones et al. did not account for the distance of a foraging site to the nest. Because Jones *et al*. did not do a proper resource selection function analysis, they were essentially ignoring each foraging point's distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fatal mistake makes their radiotelemetry results and discussion unreliable.

Third, Jones et al*.* reported extinction for a territory in WebFigure 4 when the owls shifted their location by a distance that is less than the diameter of a territory as defined by the authors. The owls' shift was also less than mean foraging distance reported by the authors. Because the authors ignored their own definition of a territory, they arbitrarily declared the short-distance shift to signify the extinction of the 'old' territory and creation of a 'new' territory a few hundred meters away. This was an arbitrary reclassification of a continuously occupied territory whose occupants shifted a few hundred meters, an occurrence that happens quite often in Spotted Owl territories. This decision inflated their 'burned site' extinction probability by classifying a normal within-territory movement as site extinction.

The sites that were occupied in 2014 are those most relevant to extinction probability in 2015, the only significant 'fire-related' effect Jones et al. found in 2015 and attributed to the King Fire. 2014 occupied site sample sizes indicates Jones et al. make their claim of 'large extinction effects' from only 8 severely burned sites that were occupied in 2014. Considering that Jones et al. did not account for the long-term increasing site extinction probability (meaning site extinction probability was getting bigger every year leading up to the fire), and the fact that only 8 sites in the burned area were occupied before the fire in 2014, and at least one site that they declared extinct from the fire actually just moved a few hundred meters, means their results are not correct.

Given the analytical shortcomings I described, and the fact that their conclusions contradict eight previous studies on the topic of Spotted Owls and fire, I suggest the results reported by Jones et al*.* be viewed with caution and not used to justify management actions that harm Spotted Owls.

Additionally, errors of scholarship in Jones et al. 2016 include:

Pg. 304 "The observation that lower-severity fire is benign, and perhaps even moderately beneficial, to Spotted Owls is consistent with previous studies (Roberts et al. 2011, Lee et al. 2012)"

Both those studies found mixed-severity fire (rather than lower-severity fire) had no effect on occupancy. Mixed severity fire is common historically and currently in the Sierra Nevada and explicitly includes low, moderate, and high severity burned patches.

Pg. 305, "because owls were not individually marked in the Rim Fire study, some detections at "occupied" sites may have involved individuals from neighboring territories or non-territorial "floaters" (Lee and Bond 2015), both of which may have contributed to inflated estimates of territory occupancy."

This exact same situation exists in the data analysed by Jones *et al*. Data were collected as described in Tempel and Gutiérrez (2013), "We included both nocturnal and diurnal surveys in our occupancy analyses." During nocturnal surveys leg bands were usually not resighted, therefore detections at occupied sites would have been similarly inflated by individuals from neighboring territories or non-territorial floaters.

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Table S1. Summary of systematic review of studies examining effects of fire on Spotted Owls. F/O/S/R indicates foraging, occupancy, survival, and reproduction.

#	Reference	Sample size	F/O/S/R	Context	Results	Fire Effects (* = statistically significant, NS = non=significant)	FIRE	Any Effect	Signif. Effect	Salvage Logging
1	Bond et al. 2002	21 owls in burned sites	SR	1 year after fire	No effect of fire on survival, all site faithful, all mate faithful, no effect on reproduction.	No effect from fire. (3% higher survival NS, 1% lower site fidelity NS, 35% higher repro NS)	**0/+/-**	+0.03 -0.01 +0.35		
2	Jenness et al. 2004	33 burned and 31 unburned breeding sites	OR	1-year study, 1-4 years post fire	No effect of fire on occupancy, no effect of amount of high severity fire on occupancy. No effect of fire on reproduction.	No effects of fire. (14% lower occupancy NS, 7% lower repro in burn NS)	**0/-**	-0.14 -0.07		
3	Bond et al. 2009	7 radioed owls	F	1 year study, 4 years post fire	Owls preferred burned forest for foraging, especially high-severity burned forest. Owls preferred roost sites burned at low severity and avoided unburned sites & sites burned at moderate and high severity.	Positive effect from fire on foraging habitat (+40%, +40% +35% *), negative and positive effect of fire on roosting nesting habitat (-3%, +28%, -12%, -13%*).	**+/-**	+0.40 +0.40 +0.35 -0.03 +0.28 -0.12 -0.13	+0.40 +0.40 +0.35 -0.03 +0.28 -0.12 -0.13	
4	Bond et al. 2010	5 radioed owls in occupied burned sites	O	1 year study, 4 years post fire	3 of 5 owls occupied burned forest over winter	No effect, perhaps some positive effect (most used burn over winter)	**0/+**			
5	Clark et al. 2011	11 radioed owls in salvage logged sites, 6 radioed owls in unburned sites		2-year study, 3-4 years post salvage logging	Reduced survival of owls in salvage-logged areas relative to owls in unburned forest.	Negative effect from salvage logging.				-
6	Roberts et al. 2011	randomly selected 16 burned and 16 unburned survey areas	O	1-year study, 1-14 years post fire	No effect of fire on survey area occupancy (mean of 12% of burned survey area burned at high severity).	No effect of fire. Possible negative effect (19% lower occupancy in burned survey area NS)	**0/-**	-0.190		
7	Lee et al. 2012	41 burned and 145 unburned breeding sites	O	11-year study, 1-7 years post fire from 6 large fires	Fires had no statistically significant effect on occupancy probability.	No effect, perhaps a slightly positive effect (4% higher occupancy in burned sites NS).	**0/+**	+0.041		
8	Bond et al. 2013	7 radioed owls	F	1 year study, 4 years post fire	Owls in burned forest have home ranges the same size as owls in unburned forest.	No effect from fire, possible positive effect (HR size 13% smaller in burned area NS).	**0/+**			

Table S1. Summary of systematic review of studies examining effects of fire on Spotted Owls. F/O/S/R indicates foraging, occupancy, survival, and reproduction.

#	Reference	Sample size	F/O/S/R	Context	Results	Fire Effects (* = statistically significant, NS = non=significant)	FIRE	Any Effect	Signif. Effect	Salvage Logging
9	Clark et al. 2013	40 salvage logged sites and 103 unburned sites.		13-year study, 1-4 years post fire	25% reduction in site occupancy and 64% reduction in pair occupancy on salvage logged sites relative to unburned sites.	Negative effect from salvage logging				**-**
10	Lee et al. 2013	71 burned and 97 unburned breeding sites, postfire logging on 21 of the burned sites.	O	8-year study, 1-8 years post fire	No statistically significant effects from fire or logging. Burned site occupancy 6.2% lower than unburned sites. Salvage-logged sites occupancy 4.6% lower than unlogged burned sites.	No effect from fire, slight negative effect (6% lower occupancy in burn NS).	**0/-**	-0.062		**-**
11	Ganey et al. 2014	4 radioed owls	O	1-year study, 4-6 years post fire	Owls moved to burned forest over winter. Burned wintering sites had 2-6 times more prey biomass relative to unburned core areas	Positive effect from fire	**+**			
12	Tempel et al. 2014	12 burned, 62 unburned sites	SRO	20-year study of survival and reproduction, 6-year study of occupancy.	Fire did not significantly affect survival, reproduction, or site extinction. Reproduction was negatively associated with the area of medium-intensity timber harvests characteristic of fuel treatments. Reported negative effect of fire on colonization rate, but colonization parameter was unestimable because all sites remained occupied post fire.	No effect of fire. Possible negative effect from fire (6% lower occupancy when fire frequency doubled in simulations that assumed zero post fire colonizations), negative effect from thinning.	**0/-**	-0.060		
13	Lee and Bond 2015a	45 burned breeding sites	O	1-year study, 1 year post fire	Higher occupancy rates than any published unburned area. 100% high-severity fire surrounding nest and roost sites reduced single owl occupancy probability 5% relative to sites with 0% high-severity. Amount of high-severity fire did not affect occupancy by pairs of owls	Positive (13-22% higher occupancy rates than any published unburned area *). Small negative effect on site occupancy (5% lower occupancy in burn *). No effect on pair occupancy.	**+/0**	+0.175 -0.050	+0.175 -0.050	
14	Lee and Bond 2015b	71 burned and 97 unburned breeding sites, postfire logging on 21 of the burned sites.	OR	8-year study, 1-8 years post fire	Occupancy of high-quality sites (previously reproductive) that burned was 2% lower than unburned site occupancy. Occupancy of high quality sites that were salvage logged was 3% lower. Occupancy of low-quality sites (previously non-reproductive) was 19% lower in burned versus unburned sites, and 26% lower after salvage logging. Fire did not affect reproduction.	Negative effect on site occupancy (2% & 19% lower *), No effect on reproduction.	**-/0**	-0.02 -0.19	-0.02 -0.19	**-**

Table S1. Summary of systematic review of studies examining effects of fire on Spotted Owls. F/O/S/R indicates foraging, occupancy, survival, and reproduction.

#	Reference	Sample size	F/O/S/R	Context	Results	Fire Effects (* = statistically significant, NS = non=significant)	FIRE	Any Effect	Signif. Effect	Salvage Logging
15	Bond et al. 2016	8 radioed owls	F	2-year study, 3-4 years post fire	Owls used forests burned at all severities in proportion to their availability, with the exception of significant selection for moderately burned forest farther from core areas.	No effect from fire, some positive effect (46% higher probability of use in burned forest NS)	**0/+**	+0.462		
16	Comfort et al. 2016	23 radioed owls in salvage-logged area		2-year study, 3-4 years post salvage logging	Owls avoided hard edges around salvaged stands	Negative effect from salvage logging				**-**
17	Jones et al. 2016			1 year post fire	This study had fatal error of analysis (no accounting for distance from center in foraging habitat selection, and no accounting for long-term decline in occupancy before fire), so their results are not reliable and should be ignored.	No reliable results				
18	Tempel et al 2016	43 burned sites and 232 unburned sites in 4 study areas	O	19 year study, examined 3-year postfire effects	No significant effects of fire. 1 study area had positive effect of fire. Lower site extinction probability correlated with proportion of site where wildfire reduced canopy >10%	No effect, some positive effect (1% lower extinction rate in burned sites NS)	**0/+**	+0.010		
19	Eyes et al. 2017	13 radioed owls (14 owl-year data sets)	F	3-year study, 1-14 years post fire	No significant effect of fire on foraging habitat selection, owls foraged in all burn severities in proportion to their availability.	No effect from fire. Possibly some slight negative effect (6% lower probability of use for highest burn severity NS)	**0/-**	-0.060		
20	Rockweit et al. 2017	193 burned and 386 unburned encounter histories from 28 burned and 70 unburned sites	SR	26-year study, 4-26 years post fire	4 fires had different effects. Combining survival and recruitment into a measure of fitness at each set of sites found overall, 2 fires had no fitness effect, 1 fire resulted in increased site fitness, 1 fire resulted in reduced site fitness.	2 fires had no significant effects on survival or recruitment. 2 fires had reduced survival (-17% & -25% *), one of which had increased recruitment (+36% *).	**0/+/-**	-0.17 -0.25 +0.36	-0.17 -0.25 +0.36	

California Spotted Owl

(*Strix occidentalis occidentalis*)

Draft

Conservation Objectives Report

July 2017

Photo by Tim Demers. Used with permission.

US Fish and Wildlife Service
Sacramento Fish and Wildlife Office
Pacific Southwest Region

TABLE OF CONTENTS

1. BACKGROUND AND PURPOSE

The California spotted owl (*Strix occidentalis occidentalis*) occurs on public forestlands and private timberlands throughout the Sierra Nevada and southern forests in California. In 2015, the U.S. Fish and Wildlife Service received two petitions to list the California spotted owl (CSO) under the Endangered Species Act of 1973, as amended. The Service's initial evaluation in our 90-day finding, published in the Federal Register on September 18, 2015, found that the petitions presented substantial information indicating that the petitioned action may be warranted. The species will undergo a full status review, with a listing decision due before September 30, 2019. The Service and other agencies are currently working on multiple CSO conservation efforts. To assist in informing these efforts, the Service developed this California spotted owl Conservation Objectives Report (COR).

~~Due to the complex and dynamic relationships among fire, timber management, and owl habitat, developing strategies that conserve spotted owl habitat and support sustainable forestry management are essential~~. The goal of this Conservation Objectives Report is to describe the ecological needs of CSO, identify and summarize the current and future stressors to viability of the species, and develop broad range-wide conservation objectives to assist in the development of ongoing and future conservation efforts. ~~For the most recent thorough scientific assessment of CSO and its stressors, please refer to the U.S. Forest Service Pacific Southwest Research Station's Conservation Assessment from July, 2016 (Gutiérrez et al. in press). This COR draws substantially from this assessment as well as subsequent emerging research and information received in response to our March 17, 2017, letters sent via email to a wide range of interested parties requesting current information relevant to CSO.~~ The goal of this COR is ~~not to be prescriptive, but rather~~ to identify ecologically relevant goals to guide the development of regional conservation strategies and other conservation efforts for CSO.

2. CALIFORNIA SPOTTED OWL ECOLOGY

2.1 Range and distribution

California spotted owls are continuously distributed throughout the forests of the western Sierra Nevada mountains in California, from Shasta County south to the Tehachapi Pass (Verner et al. 1992). The drier eastern side of the Sierras supports limited amounts of CSO habitat and relatively fewer CSO than the western slopes. California spotted owls also occur in southern and central coastal California (hereafter referred to as southern California), with a gap in their distribution between the Sierras and southern California forests (Verner et al. 1992). The CSO can be found at 1,000 – 7,700 ft. elevation in the Sierras, and up to 8,400 ft. in southern California (Verner et al. 1992). Just north of Lassen Peak to south of the Pit River, the range of the CSO transitions into that of the Northern spotted owl (NSO) (Barrowclough et al. 2011).

Commented [R1]: The comments and edits I have made here should be considered along with the separate comment letter I sent (Peer Review Comments on CSO 2017 Draft Conservation Objectives Report DEL.doc).

Commented [R2]: This COR document, and the conservation objectives it espouses are not likely to arrest the CSO decline because it does nothing to reduce harm from logging, especially logging in the name of fire risk reduction, which was the main threat cited in the listing petitions filed in 2015. Without a clear and complete exposition of how logging during the past 200 years and including present management on USDA Forest Service lands has led to population declines, the document is incomplete. If this COR document is intended to guide 'conservation efforts' that are sufficient to recover the CSO in lieu of US Endangered Species Act protections, it falls short of this objective.

Commented [R3]: I suggest you delete this sentence.

Commented [R4]: I strongly recommend the USFWS adopt a transparent, evidence-based decision-making process for the COR wherein the methods used for a systematic literature review and weighing of the evidence for conservation goals and objectives is explicitly stated (see e.g., Sutherland, W. J., Pullin, A. S., Dolman, P. M., & Knight, T. M. 2004. The need for evidence-based conservation. *Trends in ecology & evolution*, *19*, 305-308.; Pullin, A. S., & Knight, T. M. 2009. Doing more good than harm–Building an evidence-base for conservation and environmental management. *Biological conservation*, *142*, 931-934.). There is a rich literature describing the methods and benefits of systematic literature reviews from the biomedical field, where evidence-based decision making has been used for many years to advance science and save lives, and many other applied disciplines benefit from utilizing an evidence-based framework for knowledge transfer involving systematic reviews of evidence (Stevens & Milne 1997; Khan et al. 2003).

I recommend USFWS conduct systematic reviews pertaining to: 1. Fire and owls; 2. Logging and owls; 3. California fire regimes and the ecological communities dependent upon high-severity fire; and 4. Efficacy of fuels thinning treatments on large, high-severity fire behavior while following clear and transparent guidelines (see: Pullin, A.S. and Stewart, G.B., 2006. Guidelines for systematic review in conservation and environmental management. *Conservation biology*, *20*(6), pp.1647-1656.; Gough, D., Oliver, S. and Thomas, J. eds., 2017. *An introduction to systematic reviews*. Sage.).
The need for such a framework in conservation has been argued repeatedly (Pullin & Knight 2001; Fazey et al. 2004; Pullin et al. 2004; Sutherland et al. 2004), and I suggest such an approach be used to develop the USFWS COR for CSO.

I have provided an example below of a transparent review on the topic of owls and fire.

Commented [R5]: This document is not a sufficient reference upon which to base the COR document. While the Conservation Assessment contains some useful guidance, it does not meet the criteria of a systematic review for evidence-based decision making, and it contains some significant errors, particularly in sections regarding fire regimes and the relationship between owls and fire.

The American Ornithological Union currently recognizes three genetically distinct subspecies of spotted owl: California spotted owl (*Strix occidentalis occidentalis*), Northern spotted owl (*Strix occidentalis caurina*), and Mexican spotted owl (*Strix occidentalis lucida*) (Haig et al. 2004) (Figure 1). Relative to the other two subspecies, CSO exhibit low genetic variation (Barrowclough et al. 1999), although no negative effects of inbreeding have been found (Funk et al. 2008). Additionally, the Sierra populations are distinct from the southern California populations due to a lack of gene flow (Barrowclough et al. 1999, Haig et al. 2004, Barrowclough et al. 2005, Funk et al. 2008). California spotted owls in southern California are assumed to function as a metapopulation, though little movement has been recorded between isolated mountain populations (LaHaye et al. 1994, Barrowclough et al. 2005, LaHaye and Gutiérrez 2005). Because the three subspecies of spotted owls share many habitat and behavioral characteristics, for the purposes of this COR "spotted owl" refers generally to all three subspecies.

In the Sierras CSO are primarily found in mature, multi-layered mixed-conifer and yellow pine forest (80-90% of known sites), but also in red fir and riparian/hardwood forests (Verner et al. 1992). About half of known territories are within or adjacent to the wildland-urban interface (Blakesley et al. 2010). In southern California, habitat availability is more restricted and fragmented, so CSO are more frequently found in forests other than mixed-conifer, likely because mixed-conifer is only present at the highest elevations (Verner et al. 1992).

Commented [R6]: Is this description from this old reference still valid? It has been almost 25 years since Verner et al. 1992. No doubt more current territory maps and their distribution in different vegetation types is available.

I assume the authors are referring here to breeding sites, an important, but very small portion of the forest lands required to support a pair of owls. I suggest the authors explicitly define owl territories, including the seasonal sub-areas used as breeding season ranges and winter ranges, to clarify this statement.

I suggest this paragraph be moved from this section and placed in habitat associations, after the territoriality (2.2) has been described.

Figure 1. Approximate ranges for the three spotted owl subspecies (from NatureServe data).

2.2 Territoriality and reproduction

The spotted owl is a medium-sized brown owl with a mottled appearance, round face, large pale brown facial disks, dark brown eyes, and a yellowish green bill. Like most raptors, females are slightly larger than males (19-27 oz. vs. 17-24 oz., Verner et al. 1992). First and second year adults (subadults) can be distinguished by the tips of tail feathers, which are white and taper to a sharp point (Gutiérrez et al. 1995).

Spotted owls are long-lived species (can live over 15 years in the wild), with high adult survival and low reproduction; as a result, they are slow to recover from population declines (Keane 2013). They have a monogamous mating system, remaining with the same mate from year to year, although occasionally mates will separate, or "divorce." A pair occupies and defends a territory from neighbor and stranger individuals (Gutiérrez et al. 1995, Waldo 2002). In the central Sierra, territories are approximately 1000 acres (Seamans and Gutiérrez 2007a, Tempel et al. 2014b) based on a radius equal to half the "mean-neighbor distance" between the centers of adjacent owl sites (1.1 km). As central place foragers, spotted owls spend a disproportionate amount of time near their territory center, or core (Carey et al. 1992, Carey and Peeler 1995). When available, radio-telemetry has been used to approximate territory size and core use areas, resulting in some variation in size estimates (Bingham and Noon 1997). Home ranges include all habitat required for nesting, roosting, foraging, and other life functions. Home ranges will overlap each other and their size varies by latitude and study area (~1500-5400 acres), being smaller in the southern Sierras, where oaks are dominant (Zabel et al. 1992). An individual typically begins exhibiting territorial behavior in 1-4 years. Those individuals that have not yet established a territory (mostly subadults) are referred to as floaters, and little is known about their habitat requirements (Franklin 1992). The presence of conspecifics and an open territory determines settlement as owls are more likely to settle in territories that were occupied the previous year (LaHaye et al. 2001).

Breeding season begins in mid-February and can last through mid-September, starting earlier in southern California and at lower elevations throughout its range, with the peak of egg-laying in mid-April (Verner et al. 1992). Pairs divide the nesting roles; the male CSO provisions the female while she sits on the nest (Gutiérrez et al. 1995). Females lay 1-3 eggs, but survival of the offspring is highest when two young fledge (Peery and Gutiérrez 2013). Eggs take approximately 30 days to hatch, and owlets fledge about 35 days later. Fledglings will "branch out," leaving the nest before they can fly and roosting near the nest and their parents. During this early developmental stage, juvenile owls rely on multi-layered forest structure to move about above the forest floor. Within several weeks, juveniles are able to fly and will generally disperse in the fall.

Commented [R7]: Citations for these 2 statements?

Commented [R8]: Sections 2.2, 2.3, and 2.4 refer almost exclusively to the breeding season territories. Although breeding season territories are undeniably important to owls, it must be explicitly acknowledged that equally important is the winter range used for roosting and foraging during the extremely difficult winter season when much mortality occurs, as well as the matrix habitat among territories that is critical to both natal and breeding dispersal movements.

The COR needs to add text explicitly defining year-round home ranges, breeding-season territories, and winter ranges, as well as a discussion of the matrix between best available habitat, and carefully address what is known and not known about each of those zones. Territories and habitat associations as currently described here seems to focus mostly the breeding season range, but also reports some year round data (e.g., Zabel). The COR must clarify when it is referring to breeding season territories, when it is referring to winter ranges, and when it is referring to year-round home ranges.

Breeding territories are not a sufficient proxy for year-round habitat requirements and relying on protections only in breeding areas will vastly underestimate the area and habitat requirements needed to conserve and recover CSO. Equal space and attention should be added that describes the habitat characteristics and importance of fall- and winter-season ranges, and how poorly CSO habitat needs during these critical seasons are understood.

Commented [R9]: This is an important fact, and underlies why the breeding season foraging habitat selection portions of Williams et al 2011 and Jones et al 2016 studies are fatally flawed. Both of these studies ignored distance from nest or roost center in their breeding season foraging habitat selection analyses, making all results and conclusions regarding habitat selection in these papers unreliable.

Foraging habitat use analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. The proper habitat use analysis is a 'resource selection function', a math model that explicitly accounts for the fact that spotted owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every spotted owl foraging habitat use paper has found distance from nest is a highly significant effect on a point's probability of use. However, Williams et al 2011 and Jones et al. 2016 did not do a proper resource selection function analysis accounting for foraging point's distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fatal mistake makes their radiotelemetry results and discussion unreliable.

Spotted owls appear to follow a bet-hedging strategy of reproduction (Stearns 1976, Franklin et al. 2000). In good years with sufficient resources, they attempt a nest, but in poor years they do not. This often leads to an even-odd pattern of reproduction, where a majority of pairs will nest one year but not the next (Blakesley et al. 2010, Forsman et al. 2011). Importantly though, lack of reproduction at any given site for a few years does not necessarily mean the site itself is of poor habitat quality, but rather may reflect overall poor environmental or climatic conditions in those years (Stoelting et al. 2014). Annual mean reproductive output for the spotted owl is the lowest among North American owls (Johnsgard 1988), with 0.555-0.988 young/female CSO (Franklin et al. 2004, Blakesley et al. 2010).

Reproductive success is particularly dependent upon local weather conditions, especially during the previous winter or early in the nesting season (e.g. MacKenzie et al. 2012). Colder temperatures and greater precipitation early in the breeding season (March to May) was negatively correlated with reproductive success in Sierra National Forest and Sequoia-Kings Canyon National Park (North et al. 2000). Also, in Eldorado National Forest, El Niño events, which result in warm, wet winters, negatively influenced reproduction (Seamans and Gutiérrez 2007b). Northern spotted owls have also shown similar patterns in response to cold (Franklin et al. 2000). Cold temperatures during nesting may increase energetic requirements, risk of egg exposure, or interfere with foraging, resulting in decreased nesting success (Franklin et al. 2000, Rockweit et al. 2012).

California spotted owls have high site fidelity, returning to the same territory year after year. However, a small percentage of adults (7-9%) (Blakesley et al. 2006, Seamans and Gutiérrez 2007a) will disperse each year, often due to events such as the loss or change of configuration of their nest tree or a mate replacement (Berigan et al. 2012). Dispersing owls tend to be younger, and either join a mate or move to an adjacent territory of higher quality (Seamans and Gutiérrez 2007a, Gutiérrez et al. 2011). Although spotted owls are non-migratory, some will move downslope during winter (Laymon 1988, Verner et al. 1992, Gutiérrez et al. 1995). Downslope movement occurs in October to mid-December, from 9-40 miles, and a change in elevation of 1640-4921 feet (Gutiérrez et al. 1995). Pairs return to their territory in late February to late March. Juveniles undergo natal dispersal in September, averaging 6-10 miles, though dispersal distance can range between 2-47 miles (LaHaye et al. 2001, Blakesley et al. 2006).

In contrast to relatively low reproduction rates, spotted owls have ~~apparent~~ high adult apparent survival in the Sierras (0.810-0.891), and male survival is slightly higher than female (Blakesley et al. 2010, Tempel et al. 2014a). Juvenile survival is more difficult to measure because of natal dispersal and emigration. However, the few studies that have estimated juvenile survival found it to be substantially lower than adult survival (0.368 in San Bernardino National Forest, LaHaye et al. 2004; 0.333 in Lassen National Forest, Blakesley et al. 2001).

Commented [R10]: Missing data from
Bond, M. L., Lee, D. E., & Siegel, R. B. (2010). Winter movements by California spotted owls in a burned landscape. *Western Birds*, *41*, 174-180.
Also
Ganey JL, Kyle SC, Rawlinson TA, Apprill DL, and Ward JP Jr (2014) Relative abundance of small mammals in nest core areas and burned wintering areas of Mexican spotted owls in the Sacramento Mountains, New Mexico. Wilson Journal of Ornithology 126: 47–52.

Temporal variation in survival is not as well-explained by weather covariates as reproduction is. However, survival does appear to have a quadratic relationship with the Southern Oscillation Index so that survival is greatest in years not dominated by either El Niño or La Niña weather patterns (mild, intermediate winters) (Seamans and Gutiérrez 2007b). Spotted owls can be preyed upon by great horned owls (*Bubo virginianus*), as well as northern goshawks (*Accipiter gentilis*) and red-tailed hawks (*Buteo jamaicensis*) (Gutiérrez et al. 1995). There has also been one instance of a likely predation by a barred owl (*Strix varia*) (Leskiw and Gutiérrez 1998). Juveniles and eggs may be taken by typical nest predators. Although variability in the population growth rate is driven by both reproductive rate and survival, growth rate is more sensitive to changes in adult survival (Blakesley et al. 2001, Seamans and Gutiérrez 2007a). Juvenile survival provides the smallest contribution to changes in the population growth rate (Tempel et al. 2014a).

2.3 Habitat ~~requirements~~associations

Spotted owls prefer residual old growth forest with high structural diversity (Laymon 1988, LaHaye et al. 1997, Moen and Gutiérrez 1997, Seamans and Gutiérrez 2007a). The nest tree itself is critical for CSO success, and is typically the oldest, largest live or dead tree with many defects like cracks or decaying wood (Verner et al. 1992, Blakesley et al. 2005). Spotted owls are frequently cavity nesters, using live trees and snags, broken top trees, platforms (mistletoe brooms), debris platforms, and even old raptor or squirrel nests. In the Sierras, the average nest tree is 103 ft. tall, 49 in. diameter at breast height (dbh), with the nest at 74 ft. high. In general, nest trees in mixed-conifer forest are >30 in. dbh and can be a variety of species (Verner et al. 1992, North et al. 2000, Blakesley 2003). In hardwood forests, the typical nest tree is ~30 in. dbh and 55 ft. tall (Verner et al. 1992). California spotted owls prefer nest trees that are located further from forest edges (Phillips et al. 2010).

The habitat structure immediately above and near the nest site has been the focus of a considerable amount of research and is important to CSO occupancy, fecundity, and survival. In general, CSO nesting habitat consists of dense overhead canopy cover, large trees, a high basal area (total cross-sectional area of all trees at 4.5 ft. above ground, 185-350 ft^2/ac), multiple canopy layers, and an abundance of limbs and large logs on the ground (Bias and Gutiérrez 1992, Verner et al. 1992, Moen and Gutiérrez 1997, North et al. 2000, Blakesley et al. 2005, Chatfield 2005, Seamans 2005, Roberts et al. 2011). For the purposes of analysis, canopy cover is typically broken into three classes: high (≥70%), moderate (40-69%), and low (<40%) (Tempel et al. 2016). For tree size definitions, we refer to the standard Forest Service categories of very large (≥36 in. dbh), large (≥24 in.), medium (12-23.9 in.), and small (<12 in.) (Tempel et al. 2014b). Reproduction in particular has been associated with high canopy cover at multiple scales (Hunsaker et al. 2002, Tempel et al. 2014b). On Lassen National Forest, reproductive success was correlated with forests dominated by high canopy cover and medium or large trees, and

Commented [R11]: The document as currently written focuses heavily on the natural stressor of high severity fire. Why not devote just as much space to the natural stressors of predation by goshawks, red-tailed hawks, and great horned owls and give lengthy discussion about what management actions forest managers can do to reduce predation on spotted owls?

Commented [R12]: These sentences mischaracterize the data on demography and population dynamics of CSO. Seamans and Gutierrez (2007a) and Tempel et al (2014a) looked at observed contributions to growth rate. Seamans and Gutierrez 2007a actually said: 'we estimated that [reproduction] contributed as much as [survival of individuals ≥1 year old] to the observed annual variability in [population growth rate].' And Tempel et al 2014 said: 'We calculated the correlation coefficients between the population growth rate and each of the demographic rates …. All demographic rates were positively correlated with [population growth rate]. The correlation was strongest for [Immigration rates] and weakest for [juvenile apparent survival]. The correlations with [adult apparent survival] and [reproduction] were intermediate in strength. The magnitude of the regression slope was also greatest for immigration rate, which further suggested that [population growth rate] was most sensitive to changes in immigration rate.'
These results speak to the importance of reproduction and owl movements across the landscape and the critical nature of matrix habitat between and among nesting sites to permit and encourage natal and breeding dispersal movements. This leads to the conclusion that owl habitat needs to be managed at a much larger scale than the PAC currently guiding owl management in USFS lands. Much larger areas around all known historical owl breeding sites, on the order of 6000ac around nests (mean year-round home range size), should be protected from all logging and allowed to naturally succeed towards old growth conditions.

Commented [R13]: Please do not lose sight of this important aspect of owl ecology when discussing logging and thinning of habitat occupied by this precipitously declining species.

negatively correlated with non-forest or forest dominated by small trees (Blakesley et al. 2005). On Eldorado National Forest, a higher ~~amount~~ number of patches of hardwoods ~~(and thus lower canopy cover)~~ within a territory negatively influenced reproduction (Seamans 2005, Tempel et al. 2014b). At the immediate nest area (0.12 acre), productivity is also positively correlated with foliage volume above the nest site (North et al. 2000). Additionally, large trees have been shown to be particularly important for NSO within 400 m of the nest (Irwin et al. 2011). Besides nesting success, high canopy cover may also be important for post-fledging rearing, as juveniles tend to roost within 800 m of their nest (Whitmore 2009). The complex vertical structure is important for shading and avoidance of overheating in the hot summers (Barrows 1981, Weathers et al. 2001).

Territories have greater habitat heterogeneity than nest stands, but occupancy, colonization, adult survival and reproductive success are still positively associated with the proportion of core area containing structurally complex conifer forest with large trees and high canopy cover (Blakesley et al. 2005, Seamans and Gutiérrez 2007a, Tempel et al. 2014b). ~~Recent evidence suggests that the most important predictor of occupancy is the intersection of high canopy cover and large trees (Jones et al. in review)~~. Spatial heterogeneity including small gaps or openings within the territory is thought to be particularly important for the development of a sufficient prey base. There does appear to be evidence that once a certain amount of high canopy cover is reached, additional moderate canopy cover can similarly benefit occupancy (Tempel et al. 2016). Thus, areas of both high and moderate canopy cover can be important. However, if the overall CSO territory is <40% canopy cover, that certainly reduces quality (Tempel et al. 2016). Northern spotted owls have similarly been found to maximize fitness within territories that are heterogeneous in forest stages (Franklin et al. 2000). ~~California spotted owls will forage primarily in contiguous patches of moderate to high canopy cover, but will also use edge habitat (Williams et al. 2011, Eyes 2014)~~. Riparian habitats can be particularly important for prey (Irwin et al. 2007, 2011, Bond et al. 2016). Mixed severity fire does not have significant adverse effects on breeding-site (territory) occupancy by spotted owls (Bond et al. 2002, Jenness et al 2004, Roberts et al. 2011, Lee et al. 2012, Lee et al. 2013, Lee and Bond 2015a), especially in sites occupied by reproductive pairs of owls (Lee and Bond 2015a, Lee and Bond 2015b). Large amounts of high-severity fire in a core area may reduce occupancy probability in southern California (Lee et al. 2013, Lee and Bond 2015b), but in the Sierra Nevada the amount of high-severity fire in the core does not affect occupancy (Lee and Bond 2015a). Furthermore, areas that have been burned ~~at primarily low and moderate severity fire may~~,at all severities, but especially at high severity ~~also~~ provide valuable foraging habitat and heterogeneity within territories (Bond et al. 2009, Bond et al. 2016, Comfort et al 2016, Eyes et al. 2017). All properly analyzed studies of foraging habitat selection has shown spotted owls either use all severities of burned forest in proportion to its availability, or prefer foraging in moderate and high severity burned forest. None have shown avoidance of any type of burned forest.

Commented [R14]: This sentence incorrectly mischaracterizes the findings. Please re-read the papers and rewrite this sentence, or delete it.

Commented [R15]: It is inappropriate to cite papers in review. I suggest the authors remove these instances and focus on doing a thorough and complete review of existing peer-reviewed literature.

Commented [R16]: The radiotelemetry of foraging habitat in this paper (Williams et al 2011) did not control for distance from center in their analysis, therefore the conclusions are not to be trusted. As central place foragers, omitting this factor makes all results unreliable. Foraging habitat use analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. The proper habitat use analysis is a 'resource selection function', a math model that explicitly accounts for the fact that spotted owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every spotted owl foraging habitat use paper has found distance from nest is a highly significant effect on a point's probability of use. However, Williams et al 2011 and Jones et al. 2016 did not do a proper resource selection function analysis accounting for foraging point's distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fatal mistake makes their radiotelemetry results and discussion unreliable.

Commented [R17]: I suggest the authors remove this reference and focus on doing a thorough and complete review of existing peer-reviewed literature.

Commented [R18]: This inaccurately worded sentence mischaracterizes the details of the studies cited. Please reread the papers and rewrite the sentence, or delete it.

Commented [R19]: This sentence as it was written mischaracterizes the results from studies of foraging in burned landscapes, (Bond et al.2009, Bond et al. 2016, Comfort et al 2016, Eyes 2017). I have edited it and added the next sentence to correct it.

Although less is known about minimum habitat requirements at the scale of a home range, CSO still consistently use areas that contain greater abundance of large trees and greater proportion of mature forest than the average forest composition on the landscape (Call et al. 1992, Moen and Gutiérrez 1997, ~~Williams et al. 2011~~). As heterogeneity increases, so does the size of a CSO home range, so there may be a negative effect if too much heterogeneity exists within CSO habitat (Williams et al. 2011, ~~Eyes 2014~~). In managed landscapes, studies on CSO habitat use may be influenced and limited by the habitat types that are available, so the findings may not reflect optimal CSO habitat (Gutiérrez et al. in press).

In southern California forests, most CSO live in forests other than mixed-conifer because that forest type is restricted to the highest elevations in the isolated mountain ranges (Verner et al. 1992). These forests include riparian/hardwood forests and woodlands, live oak/big cone-fir forest, and redwood/California laurel forest. In San Bernardino National Forest, the most used cover types are canyon live oak/big cone fir (Smith et al. 2002). This habitat might be preferred due to high densities of prey in the chaparral that surrounds it (LaHaye et al. 1997). Still, in the Southern forests, on average 70% of a territory is in moderate or high canopy cover (Lee and Irwin 2005). Even with less access to mature forest, owls select for more closed canopy and less non-forest at four different scales up to the size of a territory (Smith et al. 2002), and still select for large trees and higher basal area at nest sites (LaHaye et al. 1997). The presence of large residual trees (those that are significantly larger or older than the contemporaneous stand) also greatly increases the likelihood of CSO use for foraging activities (Bias and Gutiérrez 1992, Moen and Gutiérrez 1997, Williams et al. 2011).

2.4 Foraging and diet

Because spotted owls are central place foragers, they concentrate most of their foraging and activity around the nest or roost, and their activity declines further out from the nest (Carey et al. 1992, Ward et al. 1998). Spotted owls rarely fly above the forest canopy, except for dispersal (Gutiérrez et al. 1995). As perch and pounce predators, spotted owls are agile but not particularly fast fliers. Spotted owls are primarily active at night, but will also hunt during the day, especially when they have young to feed (Verner et al. 1992). Later in the nesting season, owls may also forage further from the nest to feed growing fledglings.

Although CSO will eat a variety of prey, they are considered to be small mammal specialists because they select a few key species for the majority of their diet. At upper elevations (above 4,000 feet) in the Sierra Nevada conifer forests, Northern flying squirrels (*Glaucomys sabrinus*) are the primary prey (Laymon 1988, Munton et al. 2002). At lower elevations in the Sierras, as well as in southern California, where oak woodlands and riparian-deciduous forests are dominant, CSO prey more on woodrats (*Neotoma* spp.) (Verner et al. 1992, Smith et al. 1999, Munton et al. 2002). Flying squirrels dominate CSO diet at about 75% of known owl sites

Commented [R20]: These studies did not contain burned landscapes, and it should be clear to the reader when studies included burned forest in their analyses and when they did not. Also, these studies were not done year-round (only breeding season). Whenever the COR speaks of home range it should be referring to year-round range, not just breeding season. Explicitly say breeding season home range when that is the subject.

Commented [R21]: The home range portion of this paper is ok.

Commented [R22]: This study did not analyze home range size variation due to habitat heterogeneity.
I suggest the authors remove thesis references and focus on doing a thorough and complete review of existing peer-reviewed literature.

Commented [R23]: Bias and Gutiérrez 1992, Moen and Gutiérrez 1997 are not telemetry studies, so cannot speak to foraging habitat. Re-read the literature and find an appropriate reference for this sentence, or rewrite the sentence to reflect those papers, or delete.

Commented [R24]: This sentence does not refer to So Cal, why is it here?

Commented [R25]: Why is this section called Foraging when so much foraging info was in the above section?

Commented [R26]: This section on diet needs to be researched more thoroughly and rewritten. It omits the rich and informative literature about small mammals and fire including specific studies of owl diet after fire e.g. Bond et al. 2013 Diet and home range of owls in burned forest.

Commented [R27]: To reiterate, this is important, and underlies why the foraging habitat selection portions of Williams et al 2011 and Jones et al 2016 studies are fatally flawed. Both of these studies ignored distance from nest or roost center in their foraging habitat selection analyses, making all subsequent results and conclusions in those papers about foraging unreliable.

Foraging habitat use analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. The proper habitat use analysis is a 'resource selection function', a math model that explicitly accounts for the fact that spotted owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every spotted owl foraging habitat use paper has found distance from nest is a highly significant effect on a point's probability of use. However, Williams et al 2011 and Jones et al. 2016 did not do a proper resource selection function analysis accounting for foraging point's distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fatal mistake makes their radiotelemetry results and discussion unreliable.

(Verner et al. 1992). California spotted owls have low metabolic rates relative to other birds and would require one flying squirrel every 1.8 days or one woodrat every 3.7 days (Weathers et al. 2001). Individuals tend to have smaller home ranges where woodrats are the prey base compared to flying squirrels, presumably because woodrats provide a higher caloric gain per successful spotted owl foraging bout and occur in higher densities (Zabel et al. 1995). By biomass, regardless of elevation, pocket gophers (*Thomomys* sp.) are the second largest component of CSO diet. Although CSO will prey upon some birds, reptiles, amphibians, and insects, mammals make up the most biomass (Munton et al. 2002).
Flying squirrels are found more in closed-canopy forests (Pyare and Longland 2002, Meyer et al. 2005, Roberts et al. 2015). A moderate to high canopy closure, large trees, thick litter layer and sparsely distributed coarse woody debris are particularly important for developing a good prey base in these habitats (Waters and Zabel 1995, Pyare and Longland 2002, Meyer et al. 2005, 2007, Kelt et al. 2014, Roberts et al. 2015). Coarse woody debris is critical, but does not need to be overly dense (Knapp et al. 2005). Riparian habitat and other relatively mesic sites in particular yields truffle and tree hair lichen, which are important to flying squirrel diet (Meyer et al. 2008, Smith 2007).

Woodrats are found more often in open habitats, oak woodlands, and early seral-stage forests (Innes et al. 2007). Specifically, at lower elevations, woodrats (both dusky-footed and big-eared) and brush mouse are associated with oak cover and the density of large oaks >13 in. dbh (Innes et al. 2007, Roberts et al. 2008, Kelt et al. 2014). Heterogeneous forest conditions often provide higher primary productivity than homogenous closed canopy forests and thus, generally enhance prey habitat (Jones et al. 2016b, Sollmann et al. 2016). Transitional areas (habitat with conifer stands and a significant hardwood component) where prey distributions overlap offer a rich and diverse prey base (Verner et al. 1992). Small mammal diversity is enhanced by increased structural heterogeneity at large spatial scale and greater development of mature forest structure (Kelt et al. 2014, Roberts et al. 2015).

3. CURRENT CONDITION

The California Department of Fish and Wildlife (CDFW) maintains a record of CSO locations and activity centers (areas of repeated detection, nesting/roosting areas) in the California Natural Diversity Database (CNDDB). Although many sightings have not be reconfirmed outside of ongoing study areas, since 1993, 1,416 unique CSO activity centers have been recorded, the majority of which are in the Sierras (Figure 2). Rather than estimating overall population size, then, most of our knowledge of the status of CSO is derived from population trends in four long-term demography studies in the Sierras, and one in southern California. In the Sierras, data collection began in 1986 on the Eldorado National Forest and in 1990 on the Lassen National Forest, Sierra National Forest, and Sequoia-Kings Canyon National Park. In southern California, the San Bernardino National Forest was studied from 1987-2010, with some gaps in sampling.

Multiple meta-analyses have utilized different techniques to analyze the population trends of CSO in these study areas. The nuances of these techniques are beyond the scope of this discussion (see Gutiérrez et al. in press for a full comparison), but the overall trends are consistent and we focus on the most recent analyses here.

On Forest Service lands, since the early 1990s, CSO nesting sites have been managed as Protected Activity Centers (PACs), which include ~300 acres of the "best available" contiguous habitat and CSO have repeatedly used these areas over the long-term (Berigan et al. 2012). Management of USFS lands at the scale of the 300-ac PAC has not averted observed population declines, so clearly protecting 300ac of old growth near the nest is not a sufficient spatial scale for habitat protections promoting CSO conservation or recovery. It is clear from the evidence that in order to conserve CSO, much larger areas of USFS lands must be managed in a manner similar to NPS lands with no logging or thinning and more wildland fire use. I recommend 6000ac around all known historical owl breeding sites be protected from all logging and allowed to naturally succeed into old growth conditions. Estimates of average year-round home range sizes of CSO have been known since the 1990s, mean = 6000ac, mean range 800-12,000ac (Zabel et al. 1992), and thus 6000ac should be considered the minimum management scale around nests where old growth forest regeneration is promoted and logging is excluded for CSO recovery~~This scale has proven to be a useful management tool and biologically relevant because habitat characteristics at this scale are related to demographic parameters (occupancy, reproduction, and survival) (Blakesley et al. 2005), and CSO have repeatedly used these areas over the long-term (Berigan et al. 2012). Most data analysis relies on trends in the occupancy of territories or trends in the abundance of a study area.~~

Commented [R28]: Management at this scale has only exacerbated population declines, so clearly this is not a sufficient spatial scale for CSO conservation or recovery. It is clear that much larger areas of USFS lands must be managed in a manner similar to NPS lands with no logging or thinning and more wildland fire use. I suggest additional text be added that discusses the inadequacy of PACs as suitable management units for CSO recovery on USFS lands.

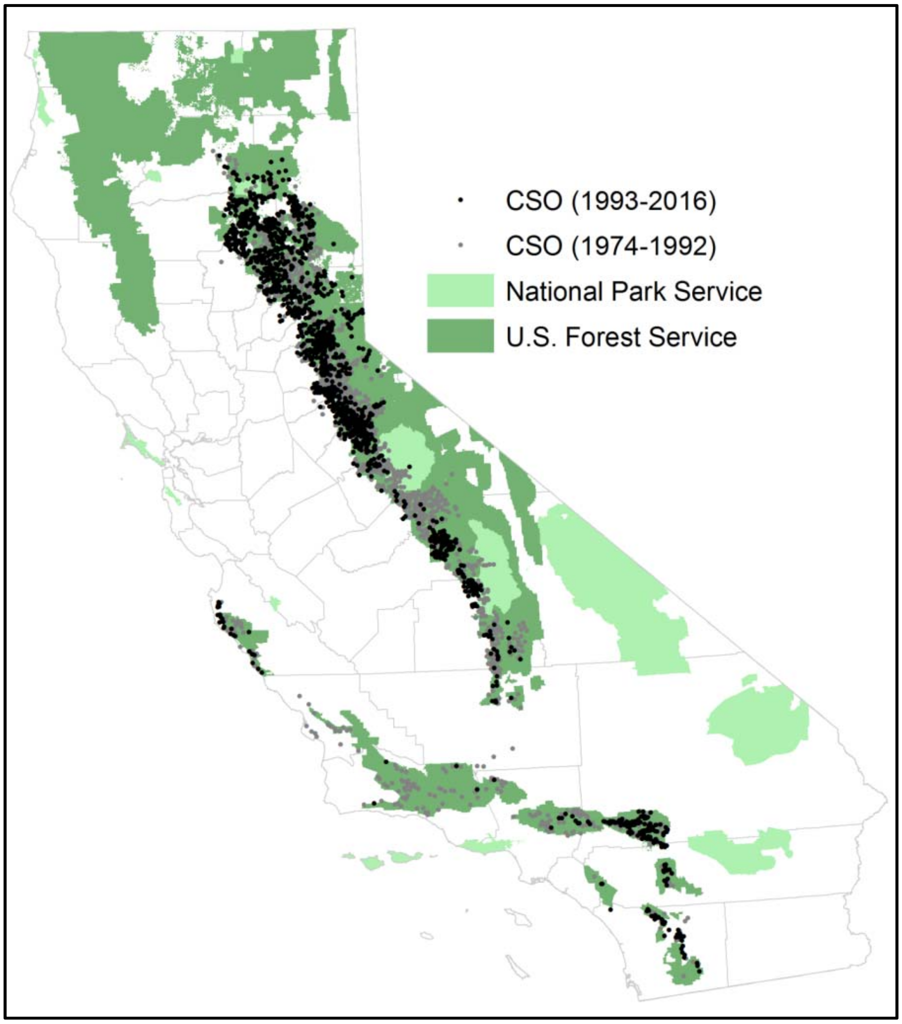

Figure 2. Map of California spotted owl activity center locations from CNDDB, before and after 1993. Shown with federal lands.

Evidence is clear that CSO have declined in both occupancy and abundance on the three national forests in the Sierras (Lassen, Eldorado, and Sierra), as well as in southern California. In the Sierras, CSO have experienced a decline in abundance of 11% on Sierra National Forest, 22% on Lassen National Forest, and 50% on Eldorado National Forest (Connor et al. 2013, Tempel et al. 2014a). San Bernardino National Forest has seen a similar decline of 50% from 1989-2010

(Eliason and Loe 2011) in territory occupancy, and a 9% per year decline in abundance from 1987-1998 (LaHaye et al. 2004). The only stable CSO population on public lands appears to be in Sequoia-Kings Canyon National Park, the only national park with a long-term CSO demography study (Table 1).

Table 1. California spotted owl population trends from 5 long-term demography studies.

Study area	Population change	Time period	Study area size (km^2)	Citation
Eldorado NF	- 50%	1990-2012	355	Tempel et al. 2014
Lassen NF	- 22%	1990-2011	1,254	Connor et al. 2013
Sierra NF	- 11%	1990-2011	562	Connor et al. 2013
Sequoia-Kings Canyon NP	+ 16%	1990-2011	182	Connor et al. 2013
San Bernardino NF	- 65%	1987-1998	2,140	LaHaye et al. 2004

~~The causes of the CSO population declines have not been conclusively identified. However, recent work suggests that rather than current management practices on national forests, the declines may be the result of a lag effect from the past removal of large trees prior to the early 1990s (Jones et al. in review). Although~~ All ~~the~~ national forest populations are declining, but reproduction appears to be relatively constant in all study areas in the Sierras except Eldorado, where measured parameters continue to be highly variable between years (Blakesley et al. 2010). Additionally, on national forests, studies found that more territories were being occupied by single CSO rather than pairs (Tempel and Gutiérrez 2013).

The only recent CSO population information from private lands is from five study areas on mixed ownership lands scattered through the northern half of the Sierras. From 2012-2016, systematic surveys found a high proportion of occupied territories each year that remained occupied during the study period (Roberts et al. in press). Additionally, CSO crude densities reported on the private timberlands were similar or higher than those on public lands (Roberts et al. in press, Table 2). Crude densities may not be a reliable indicator of habitat quality because an area could be a population sink supported by continued immigration from more productive source habitats (Pulliam 1988). Additionally, given the short duration of this survey effort and because CSO are long-lived and exhibit high site fidelity, returning to the same territories year after year, it is difficult to ascertain population trends from this survey data at this time. However, of 45 CSO territories documented prior to 1996, all 45 were occupied at least once during the study period (2012-2016). These preliminary results warrant further monitoring and analysis with demographic data on individually marked owls if we are to determine if there is a difference in current CSO status between public and private lands.

Commented [R29]: This difference between the USFS and NPS lands should be the starting point and defining evidence for your report. How are USFS and NPS lands managed differently with regards to logging and fire that likely led to this difference in population trajectories? How should USFS land management change within an adaptive management framework to be more like NPS management?

Commented [R30]: What about differences in management between USFS and NPS lands? Furthermore, there is a rich literature examining the relationship of logging and land management.

There is ample evidence that the populations of all three subspecies have declined due to widespread historical and ongoing habitat loss, primarily from logging large, old trees favored by the owls for nesting and roosting (USFWS, 2011, 2012; Conner et al., 2013; Tempel and Gutierrez, 2013). I suggest you do a systematic review of the literature pertaining to spotted owl population declines, and add discussion of the management differences between private, USFS and NPS in recent decades, including logging and fire suppression, and how those differences likely led to the divergent population trajectories of CSO on USFS vs NPS lands.

The data from the private timber lands (Roberts et al. in press) also supports the idea that private timber lands and USDA Forest Service lands have similarities with regards to management and owl populations, while NPS lands are clearly managed much more effectively for CSO recovery. Mean crude densities by land management shows a clear negative relationship between intensity of timber management and CSO populations (mean crude density = 0.08 on private timber lands, 0.12 on USFS lands, and 0.18 on NPS lands).

Commented [R31]: Do not cite in review papers. Take this space to discuss the management differences between USFS and NPS in recent decades, including logging and fire suppression, and how those differences likely led to the divergent population trajectories of CSO on the two land management types.

Commented [R32]: This analysis supports the idea that private timber lands and USDA Forest Service lands have similarly low CSO densities, while NPS lands are clearly managed much more effectively for CSO recovery.

This would be a good section to devote ample space to how private lands are managed with intensive logging, and how much logging has taken place in USFS lands.

It would also be prudent to provide caveats to data from private timber companies due to their clear conflict of interest regarding logging and owl habitat conservation. Also, review and cite papers from NSO relevant to owls and private timber lands management.

Table 2. California spotted owl crude densities in study areas (most recent estimates). Primary land ownership is defined by >60% of study area, otherwise labeled as mixed ownership.

Study Area	Crude density	Study area size (km^2)	Primary land ownership	Citation
Fall River	0.056	89	Private	Roberts et al. in press
Lassen	0.051	355	National Forest	Gutiérrez et al. in press
Chalk Bluff	0.152	86	Mixed	Roberts et al. in press
Eldorado	0.16	1,254	National Forest	Gutiérrez et al. in press
Stumpy Meadows	0.035	115	Private	Roberts et al. in press
South Fork Cosumnes River	0.141	137	Private	Roberts et al. in press
South Fork Mokelumne River	0.071	122	Mixed	Roberts et al. in press
Sierra	0.151	562	National Forest	Gutiérrez et al. in press
Sequoia-Kings Canyon	0.184	182	National Park	Gutiérrez et al. in press
San Bernardino	*No recent estimate*	2,140	National Forest	Gutiérrez et al. in press

Most forest types have been defined by California Wildlife Habitat Relations (CWHR) categories with existing vegetation classification and mapping (EVEG). In the Sierras, 4M or greater CWHR translates to ≥40% canopy cover and trees ≥12 in. dbh, which include potential habitats used by CSO. Currently, there are approximately 4.9 million acres of 4M or greater CWHR in the Sierras, just over half of which is Sierra mixed conifer forest (Gutiérrez et al. in press). Of this habitat, 75% is on national forests, 7% on national parks, and 18% on private or other lands. In the southern California national forests, there are only about 400,000 acres of 4M or greater CWHR, about 16% of which is Sierra mixed conifer; however there are about 1.2 million acres of general habitat types in which CSO have been known to reproduce (Stephenson and Calcarone 1999). ~~The realized amount of suitable habitat is likely far less though, in particular after major losses from wildfire and drought over the last decade and a half.~~

The causes of the CSO population declines have not been conclusively identified. However, stark differences in past and current land management practices exist among private lands, USFS lands, and NPS lands, especially regarding logging and fire suppression, and these factors are most likely responsible for the differences in CSO population health on lands managed under these three different regimes. Mean crude densities by land management shows a clear negative

Commented [R33]: There have also been studies showing the amount of suitable habitat is not being diminished over the long term by fire.

e.g. Baker, W.L., 2015. Are high-severity fires burning at much higher rates recently than historically in dry-forest landscapes of the Western USA?. PLoS One, 10(9), p.e0136147.
Parks, S.A., Miller, C., Parisien, M.A., Holsinger, L.M., Dobrowski, S.Z. and Abatzoglou, J., 2015. Wildland fire deficit and surplus in the western United States, 1984–2012. *Ecosphere*, *6*(12), pp.1-13.
Hanson, C.T., Odion, D.C., Dellasala, D.A. and Baker, W.L., 2009. Overestimation of fire risk in the Northern Spotted Owl recovery plan. *Conservation Biology*, *23*(5), pp.1314-1319.
Hanson, C.T., Odion, D.C., Dellasala, D.A. and Baker, W.L., 2010. More‐Comprehensive Recovery Actions for Northern Spotted Owls in Dry Forests: Reply to Spies et al. *Conservation Biology*, *24*(1), pp.334-337.
Odion, D.C. and Hanson, C.T., 2006. Fire severity in conifer forests of the Sierra Nevada, California. *Ecosystems*, *9*(7), pp.1177-1189.
Odion, D.C. and Hanson, C.T., 2008. Fire severity in the Sierra Nevada revisited: conclusions robust to further analysis. Ecosystems, 11(1), pp.12-15.

Please do a thorough review, and rewrite, or delete.

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relationship between intensity of timber management and CSO populations (mean crude density = 0.08 on private lands, 0.12 on USFS lands, and 0.18 on NPS lands).

The best available science now indicates that: (a) private lands logging often eliminates or degrades spotted owl habitat; (b) mechanical thinning and mechanical thinning fuels treatments reduce California spotted owl occupancy; (c) post-fire logging reduces California spotted owl occupancy and survival; and (d) California spotted owls are now clearly declining, except in Sequoia/Kings-Canyon National Park, which is protected from mechanical thinning fuels treatments and post-fire logging. Thus, logging is likely the primary driver of past and current spotted owl declines and is the most significant threat to the subspecies' existence.

It is clear that the different land management policies, especially during the past 50 years, between USDA Forest Service (USFS) lands and National Park Service (NPS) lands has directly contributed to the differing population trajectories for CSO on those two land management types. USFS lands have had heavy logging and fire suppression and CSO is declining everywhere it is studied on USFS lands. In contrast, although much NPS land was also logged 100 years ago, it has in recent decades had healthy wildland fire use and no logging, and the CSO population studied on NPS land is increasing.

4. SUMMARY OF STRESSORS

Commented [R35]: The original text of this section was insufficient for conservation planning. I have partially rewritten it using material from one of the petitions filed to reflect the more accurate rank of stressors by placing logging at the top of the list.

Logging

Timber harvest has been the most significant historical factor impacting California Spotted Owl habitat (Gutiérrez 1994, Verner et al. 1992a). Selective harvest of merchantable trees in the Sierras—often old-growth trees—was the norm during the late 1800s through the 1970s, resulting in the loss of much suitable habitat and the production of forests with younger average tree ages. In the Sierra Nevada, timber harvest steadily intensified from the railroad building and mining eras of the 1800s until the 1950s, then remained at relatively high levels through the 1980s (McKelvey and Johnston 1992). From the 1970s onward, clearcut harvests became increasingly more common (McKelvey and Johnston 1992). Since the late 1980s, the volume of timber harvested in the Sierra Nevada has declined, but cutting became increasingly based on salvage logging (McKelvey and Johnston 1992). And, while the timber volume removed annually on national forests of the Sierra Nevada is less now than it was two decades ago or more, much of the logging that occurs presently is mechanical thinning, which removes fewer board feet per acre than past clearcuts, but nonetheless degrades habitat over large areas through reduction of canopy cover and removal of mature trees and also through creation and maintenance of logging roads (USDA 2004a). Forest Service management direction, as laid out in the 2004 SNFPA promotes landscape-level mechanical thinning as well as salvage logging in California Spotted Owl habitat.

Verner et al. (1992a) discussed five major factors of concern for California Spotted Owl habitat that have resulted from historical timber-harvest strategies: (1) Decline in the abundance of very large, old trees; (2) decline in snag density; (3) decline in large-diameter logs; (4) disturbance or removal of duff and topsoil layers; and (5) change in the composition of tree species. Thus, extensive commercial logging directly affected key structural components of California Spotted Owl habitat. It will take many decades for these forests to regain these late-successional components, such that there are long-lasting effects of past logging that persist many decades beyond the point when logging levels began to decline.

Late-successional/old-growth forests provide habitat attributes selected by California Spotted Owls, including large trees, high canopy closure, multi-layered canopies, snags, and logs (University of California 1996). The current extent of old forests in the Sierra Nevada is substantially less than in pre-historic times. The University of California (1996; Sierra Nevada Ecosystem Project Report) reported that on all Federal lands in the Sierra Nevada, late-successional/old-growth forest conditions are now found on only 19 percent of forest lands, mostly in National Parks. Beardsley et al. (1999) estimated that approximately 15 percent of coniferous forests in the Sierra Nevada remain in high quality late-successional/old-growth stages; most of these stands are at high elevations and in national parks (Franklin and Fites-Kaufmann 1996). Less than two percent of 3 million ac of private land was classified as high quality late-successional/old-growth habitat (Franklin and Fites- Kaufmann 1996).

At the turn of the previous century, the majority of mixed-conifer and ponderosa pine forests in the Sierra Nevada were characterized by very large trees and a high degree of structural complexity (Sudworth 1900, Leiberg 1902, McKelvey and Johnston 1992, Franklin and Fites-Kaufmann 1996 on p. 652). Primarily because of logging, present-day Sierran forests are drastically different from those in pre-settlement times.

Zielinski et al. (2005) examined changes in old forest cover in the Sierra Nevada over the previous century, as part of a study on changes in the distribution of forest carnivores. Alterations in mature/old-forest cover were represented by the difference between the historical Weislander Vegetation Type Map Survey (1929 and 1934; published in 1946) and contemporary vegetation data from the Sierra Nevada Ecosystem Project (1996). In 1945, old-growth (where > 50 percent of cover was from large, mature trees) comprised 50 percent of the forested area in the Sierra Nevada, and young growth/old-growth (where 20–50 percent of cover was from large, mature trees) comprised an additional 26 percent of the area. The remaining 24 percent was young growth (immature forest), poorly-stocked forest, and non-commercial areas incapable of producing mature forest. By 1996, only 3 percent of the forested area in the Sierra Nevada was highest-ranking old forest, with 38 percent of the Sierra Nevada being low to high-quality old forest—equating to the loss of approximately half of the old forest between the 1940s and the 1990s. These changes were most evident in the portion of the Sierra Nevada north of Yosemite National Park, where the loss of old forest conditions has been greatest since the 1940s.

Overall, synthesizing all of the available lines of scientific evidence, as a result of past logging, old forest has declined from 50–90 percent of the landscape historically to only about 11 percent currently (USDA 2001 [FEIS, Vol. 2, Chpt. 3, part 3.2, pp. 141, 149]). In other words, historically there was several times more old-growth forest than there is today. Regenerating this lost old growth on public lands should be the highest priority for forest managers concerned with CSO recovery.

Current forest management

Forest management practices

Commercial timber harvest is conducted in the Sierras on both public and private lands, although it no longer occurs within the CSO range in southern California on public lands (Eliason and Loe 2011). Additionally, in an attempt to reduce the likelihood of high severity fires, fuels reduction activities on public lands have been implemented. Forest fuels are typically split into four categories: ground (material that has begun to degrade), surface (downed wood, herbaceous vegetation and shrubs), ladder/bridge (small trees and larger shrubs), and aerial/crown fuels (within the crowns of standing trees, separated from surface fuels) (Jenkins et al. 2014). Management for fuels reduction in the forest includes reducing surface fuels, increasing the height to the live crown (reducing ladder fuels and removing small trees), decreasing crown densities, and retaining/recruiting large fire-resistant tree species (Agee and Skinner 2005).

Data on the effects of various fuel treatments on owls has been mixed, but most studies have found thinning is harmful to owls. For the purposes of discussion we broadly classified the methods of fuels reduction into prescribed fire, hand thinning, and mechanical treatments. For the most part, prescribed fire that has the potential to lead to low or moderate severity fires, or mixed severity with small patches of high-severity fires can be good for owl habitat.

Chainsaws and helicopter noises do not appear to decrease reproductive success (Delaney et al. 1999) nor increase stress hormones like corticosterone (Tempel and Gutiérrez 2003, 2004). However, NSO nesting near loud roads have lower reproductive success than those near quiet roads (Hayward et al. 2011), and males show higher levels of corticosterone (Wasser et al. 1997), suggesting there may be some non-lethal effects from noise-causing human disturbances.

Forest management: mechanical thinning

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Commented [R38]: Please add much more discussion of wildland fire use and prescribed fire to the document.

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Mechanical treatments (or thinning) refer to machine-based fuels reduction with the intent of reducing large fires and tree harvest (North et al. 2015). The general prescription of fuels treatments is reducing forest canopy cover to 40 percent, removing many/most trees up to 30 inches diameter, and reducing tree density and 'ladder' fuels (USFS 2004a). Mechanical thinning, including fuels treatments, on USFS lands is generally found to be harmful to spotted owls, and recent spotted owl declines are likely a result of such logging which degrades the scant suitable habitat remaining after more than a century of widespread removal of old growth forests. Seamans and Gutiérrez (2007a) examined the effects of habitat alteration by logging on territory colonization, extinction, and breeding-dispersal of color-banded owls in the Eldorado Study Area from 1990 to 2004. The probability of territory colonization decreased significantly with as little as 20 ha of logging, and territory occupancy was significantly decreased with as little as 20 ha of logging. Further, the probability of breeding dispersal away from a territory was related to the area of mature conifer forest in a territory and increased when > 20 ha of this habitat was altered.

Commented [R40]: Please add a review of literature describing the efficacy of these treatments at influencing real fire behavior during extreme weather events that drive the large, high-severity burns.

Owl response to mechanical treatments is generally negative, but may depend on scale and intensity of the treatments. Generally, territories with greater amounts of mature conifer forest have a higher probability of colonization by CSO (Seamans and Gutierrez 2007a), so actions that alter mature forest result in a less desirable territory. Specifically, converting mature conifer forest from high to moderate canopy cover was negatively correlated with demographic parameters (Tempel et al. 2014b). NSO foraging habitat selection was found to increase (n = 4), remain the same (n = 4), or decrease (n = 2) among 10 owl pairs in areas that were treated on average 25% in their 450ha core area (Irwin et al. 2015).

Modeling simulations projected over a 30 year time frame suggested that while treatments can reduce the risk of high-severity fire to CSO, in the absence of fire, such treatments could have a negative effect on fitness (Tempel et al. 2015). At the landscape-scale, another study examined the effects of mechanically-produced wide shaded fuel breaks (Defensible Fuel Profile Zones) on CSO and found that the fuel breaks were avoided for 1-2 years after treatments (Stephens et al. 2014). Additionally, occupied territories declined by >40% within four years after treatment, and the remaining individuals used larger areas. Stephens et al. (2014) found a 43 percent loss of California spotted owl occupancy within a few years following mechanical thinning and group selection logging in a study area in the northern Sierra Nevada.

Tempel et al. (2014b) found that mechanical thinning is significantly harming California spotted owls. The authors found that the amount of mature forest with high canopy cover (70–100 percent) was a critical variable for California spotted owl viability (survival, territory extinction rates, and territory colonization rates), and determined that "medium-intensity" logging—mechanical thinning under the 2004 Amendment, and earlier prescriptions generally consistent with the 2004 Amendment— significantly adversely affects California spotted owls at all spatial scales by targeting dense, mature forests with high canopy cover, degrading the quality of such habitat by reducing it to moderate canopy cover. This is adversely affecting California spotted owl reproduction (Tempel et al. 2014b). The authors (on page 2,103) noted specifically that the adverse effects of mechanical thinning on California spotted owls is likely even larger than their results indicated: "Understory removal is generally an important component of fuel-reduction strategies, but we caution that medium-intensity harvesting with understory treatments occurred on only 5.2% of the total area within owl territories, which could have limited our power to detect effects . . . " In other words, the adverse effects of mechanical thinning were apparent even with a relatively small portion of the study area affected by such logging.

Forest management: salvage logging

Salvage logging refers to the removal of dead or damaged trees to recover economic value from timber that would otherwise be lost (Society of American Foresters' Dictionary). It typically occurs after a fire, or large tree mortality event (Long et al. 2013). Salvage logging negatively affects spotted owl survival and occupancy (Clark et al. 2011, Clark et al. 2013, Lee et al. 2013, Lee and Bond 2015b, Comfort 2016, Gutiérrez et al. in press). In high-severity fires, it was found that salvage logged sites had a lower probability of being occupied than sites that only burned and did not undergo salvage logging treatment, (Lee et al. 2013). Recent work on NSO found that salvage logging after high-severity fire led to declines in site occupancy and survival (Clark et al. 2011, 2013).

Commented [R41]: There are actually many possible reasons why salvage degrades habitat quality of burned forests. It would be helpful here to elaborate on them like you did for different logging treatments.
It is not at all difficult to disentangle the effects of fire and salvage, if only high severity burned forest was ever left alone in large areas we could learn what those differences are. This sentence as it was originally written does not acknowledge that fact that many studies individually could not disentangle the effects because there was no unlogged high severity burned forest in the study, it was all salvage logged. Some studies of unlogged high severity burn do exist, but were ignored in this poorly researched review.

Forest management: clearcutting

Timber harvest can cover all types of tree removal, which would include some fuels reduction activities as well as salvage logging. Clearcutting is one form of timber harvest that can take various shapes and sizes, though in general tends to leave large, regularly shaped patches with clean edges (Tempel et al. 2014b). In addition to outright habitat loss, timber harvest can eliminate important CSO habitat elements such as old, large trees and large downed logs (McKelvey and Weatherspoon 1992). The overstory trees that remain in commercial thinning prior to a clearcut tend to be regularly spaced with little forest floor and understory diversity, and low heterogeneity in stand structure (Knapp et al. 2012). No research has explicitly examined spotted owl response to an even-aged management strategy using clearcuts, but these forest practices generally occur on private timberlands. California spotted owls have been observed avoiding private lands (Thraikill and Bias et al. 1989), and tend to forage on private lands proportionately less than the amount of private lands available on the landscape (Williams et al. 2014). These observations were not linked to management practices in these studies. However, CSO do nest on private timberlands in the Sierras. While some gaps in canopy cover can be beneficial for the prey base, current clearcutting practices probably do not create the collection of patches observed in spotted owl territories with high-fitness (Franklin et al. 2000).

On private lands in California, logging practices harmful to spotted owls include clear-cutting, commercial thinning, sanitation "salvage," group selection, selection, and post-fire logging. These practices eliminate or reduce canopy cover, large trees, canopy layers, understory, snags, and downed wood. In short, they eliminate the forest complexity that spotted owls are documented to rely on. Private lands logging has been and continues to be extensive.

Forest management: Wildland fire use

Forest management: Prescribed fire

Large, high-severity fires

Historically, the natural fire regime in the Sierra Nevada and southern California forests included frequent fires that burned at primarily with mixed-severity (mostly approximately equal proportions of low-, moderate-, with patches ofand high-severity) (Van de Water and Safford 2011, Mallek et al. 2013, Hanson and Odion 2014, Lyderson et al. 2014). Past forest management, namely fire suppression and loss of large trees, however, has led to dense forests with high fuel load conditions and shade-tolerant trees, resulting in an increased frequency and patch size of high-severity fires (Miller et al. 2009, Mallek et al. 2013, McIntyre et al. 2015, Steel et al. 2015). In defining fire severity, in general, low-severity fire consumes surface fuels but not canopy trees (<25% upper canopy layer is lost or <25% basal area mortality); moderate-severity fire removes small trees (up to 75% canopy layer or basal area mortality); and high-severity fire consumes all surface fuels and nearly allmost mature plants (>75% canopy or basal area mortality) (Key and Benson 2005, Barrett et al. 2010). Prior to Euro-American settlement, frequent low-moderate severity fires occurred every 5-15 years (Van de Water and Safford 2011, Mallek et al. 2013). In areas with high fuel loads or during hot, dry weather patterns, some high-severity patches likely burned too, but were generally limited in size. In mixed-conifer forest in the Sierras, any given fire would not have included more than 5-10% high-severity fire (Miller and Safford 2017). The patches of high-severity fire averaged only 10 acres in size, with a maximum historic patch size of 250 acres (Collins and Stephens 2010, Miller and Safford 2012, Safford and Stevens in press). Overall, the data indicate that there may have been 2-4 times more high-intensity fire historically in western U.S. conifer forests than there is currently (Beaty and Taylor 2001, Nagel and Taylor 2005, Baker et al. 2007, Hessburg et al. 2007, Klenner et al. 2008, Whitlock et al. 2008, Baker et al. 2009, 2015, Medler 2006, Stephens et al. 2007, Parks et

Commented [R42]: These sections need to be added and addressed with a thorough literature review. Fire is one of the main differences between NPS lands and USFS lands and the evidence shows fire is the most effective tool for restoring forests degraded by logging and altered by fire suppression.

Commented [R43]: This section as originally written leaves out a large body of literature that paints a much different picture than what was addressed here. Specifically, additional published literature shows that much more high-severity fire existed in the Sierra than was previously believed, and shows the importance of severely burned forest to wildlife.
This section needs to be completely rewritten after a thorough review of the literature. I rewrote some of it as a suggestion.

Fire extent in is below historic annual extent of burning in western U.S. forests (Medler 2006, Stephens et al. 2007, Parks et al. 2015).
Western U.S. conifer forests and forests of the Sierra Nevada remain in a "fire deficit" (Medler 2006, Parks et al. 2015).
Historic data and reconstructions of historic fire regimes indicate that high-intensity fire was common in most conifer forests of western North America prior to fire suppression and logging, even in pine-dominated forests with frequent fire regimes (Beaty and Taylor 2001, Nagel and Taylor 2005, Baker et al. 2007, Hessburg et al. 2007, Klenner et al. 2008, Whitlock et al. 2008, Baker et al. 2009, 2015).

al. 2015). This fire deficit translates to serious deficits in ecologically-important snag forest habitat.

~~Consequently, forests were likely made up of an abundance of large, fire resistant trees at a lower density (Taylor 2004, Scholl and Taylor 2010, Collins et al. 2011a). Basal area for historical conditions in the Sierras ranged from 91-235 ft^2/acre, depending on site productivity, with a mean of 150 ft^2/acre (Safford and Stevens in press). Additionally, snags in today's forest are significantly smaller and at a higher density (Agee 2002), resulting in an overall denser and more homogenous forest (Hessburg et al. 2005).~~

In southern California shrub-dominated landscapes, patches of high-severity fire have always been more common than in the Sierras (Steel et al. 2015). ~~However, the area impacted by fires in southern California has also been increasing recently, in part due to continued human population growth and the conversion of cover types to grasses (Syphard et al. 2017).~~ Although temperature is clearly a factor related to the area burned in higher elevation forests, prior-year precipitation is more strongly related to fire activity in the Sierra foothills and southern California (Keeley and Syphard 2017).

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~~Both CSO and NSO will readily use habitat that has been subject to low and moderate severity patches of fire (Clark 2007, Eyes 2014). However, large patches of high-severity fire significantly reduce colonization, occupancy, and use (Roberts et al. 2011, Eyes 2014, Tempel et al. 2014b). The year after the King Fire, the probability of CSO site extirpation was seven times higher in severely burned sites (when greater than half the territory burned at high-severity) than others (Jones et al. 2016a). In southern California, when patches of high-severity exceeded 123.5 acres (of a 500 acre territory), territory extinction probability increased (Lee et al. 2013). High-~~

Commented [R44]: See e.g., Bond et al. 2009, 2013; Buchalski et al. 2013; Burnett et al. 2010, 2012; Campos and Burnett 2015, 2016; Fogg et al. 2015, 2016; Hanson and North 2008; Hanson 2014; Malison and Baxter 2010; Manley and Tarbill 2012; Seavey et al. 2012; Siegel et al. 2012, 2013, 2014a, 2014b, 2016; Tingley et al. 2014; Tingley et al. 2016; White et al. 2016.

Commented [R45]: Robert 2011, Eyes 2014, Eyes 2017 found no significant effect of fire, so this section needs to be rewritten. I have inserted a sample of a systematic review of owls and fire.

Commented [R46]: Jones et al 2016 is a fatally flawed paper with multiple errors of analyses that make it unreliable.

First, their owl population has documented long-term trends of decreasing site colonization and increasing site extinction probabilities, before the King Fire (Tempel and Gutiérrez 2013). However, Jones et al. did not account for these important pre-fire trends in their site occupancy analyses. Site occupancy analysis measures, each year, the probability that occupied sites are abandoned (called site extinction), and the probability that empty sites are colonized and become occupied again, and uses those colonization and extinction probabilities to calculate a yearly average probability of site occupancy. The population has had 22 years of documented trends of ever-lower site colonization probability, and ever-increasing site extinction probability (Tempel and Gutiérrez 2013), yet the authors simply compared their 1 year of post-fire data against the average of all previous years without accounting for those known year-to-year trends in colonization and extinction probabilities. The pre-fire trend means 2015 (the year after fire) was expected follow the trend of having higher extinction probability relative to all previous years, even if there was no fire. Fig. 3f clearly shows that the 2015 post-fire year of decrease in occupancy was not significantly different from the 10 previous years of decrease.

The 'trend analysis' Jones et al. did was not what I just described. Rather, Jones et al. simply took annual estimates of site occupancy and compared a few models to describe the 23 years of annual occupancy rates. This trend analysis is not the same as including the pre-fire trends in extinction and colonization probabilities described above.

The second flaw was, Jones et al. used compositional analysis of foraging habitat use, a method that is inappropriate for central place foragers like spotted owls (Rosenberg and McKelvey 1999; Bond et al. 2009; Bond et al. 2016). Foraging habitat selection analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. Compositional analysis compares simplistic ratios of the proportion of foraging points in a habitat type relative to the proportion of territory area in that type. The proper habitat use analysis is a 'resource selection function', a math model that accounts for the fact that spotted owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every spotted owl foraging habitat use paper has found distance from nest is a highly significant effect on a point's probability of use – but Jones et al. did not account for the distance of a foraging site to the nest. Because Jones et al. did not do a proper resource selection function analysis, they were essentially ignoring each foraging point's distance from the nest, and the distribution of different habitat types at ... [1]

severity fire has also been shown to negatively affect survival of NSO (Rockweit et al. 2017). Northern spotted owls showed an increased turnover of territory occupancy in response to high-severity fire, suggesting that continued occupancy of the territories may be temporary and overall quality of the territory is reduced (Rockweit et al. 2017). There is likely some threshold of high-severity fire owls can tolerate within their territory, although the exact size and configuration is unknown.

While CSO will forage in habitat subject to a variety of burn severities, they still tend to use primarily low and moderate severity patches, avoiding large, high-severity areas (Jones et al. 2016a, Eyes et al. 2017). The size and configuration of the patch of high-severity fire appears to be critical. Some work suggests that CSO will use high severity patches in proportion to availability 3-4 years after the fire (Bond et al. 2009, 2016), although the sizes of the foraging patches in these studies were not reported. In Yosemite National Park, the mean size of a high severity patch used for foraging was 16 acres (Eyes 2014). Additionally, CSO were found to selectively forage in fire-created edge habitats, rather than contiguous edges (Eyes et al. 2017). Many prey species important to CSO are negatively correlated with fire severity including flying squirrels and deer mice (Roberts et al. 2008, 2015). Landscapes with restored fire regimes (such as Yosemite National Park) show greater small mammal species evenness, which could promote stability and resilience in CSO prey populations (Roberts et al. 2015). So while it appears that often California spotted owls will avoid large, high-severity patches, smaller patches and mixed severity can be beneficial because they support the prey base.

Habitat loss to large, high-severity fire is a substantial threat to CSO persistence. Within the next 75 years, based on fire activity trends, the amount of nesting habitat burned at moderate or high-severity fire will likely exceed the total existing habitat in the Sierras, and therefore there is a critical need to avoid losses of older forests (Stephens et al. 2016b). Closed canopy forests (such as those in PACs) do tend to have uncharacteristically large and severe fires (Agee and Skinner 2005). However, from 1993-2013, 88,000 acres of CSO PACs burned, 28% of which were at high-severity, which was a similar proportion to the overall landscape (Gutiérrez et al. in press). So while PACs themselves are not necessarily more vulnerable to high-severity fire than the surrounding landscape is, the proportion of PACs burned at high-severity is greater than would be expected under a natural fire regime (<5-15% Mallek et al. 2013). California spotted owls are similarly losing habitat in southern California, which has experienced increasing widespread wildfires, particularly in the early 2000s (Keeley et al. 2009). Repeated high-severity fires in the same area can convert the type of habitat, resulting in long-term habitat loss (Stephens et al. 2013). Addressing the potential effects of large, high-severity fires on owl habitat will require collaborative landscape-level efforts.

Spotted owls and fire

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I also added some text from Bond 2016, The Heat Is On: Spotted Owls and Wildfire.
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Spotted Owls and Forest Fire: A Systematic Review of the Evidence

By Derek E. Lee

Abstract: It is widely believed that severe wildfire is a cause of recent declines in populations of Spotted Owls, and that mixed-severity fires that include large high-severity patches pose a primary threat to population viability. This systematic review summarizes the available scientific literature on the effects of wildfire on aspects of Spotted Owl demography, life history, and ecology, from studies using empirical data to answer the question, "How does fire, especially mixed-severity fire with substantial patches of high-severity fire within their home ranges, affect Spotted Owl habitat selection, demography, and life history parameters?" Sixteen high-quality papers reported evidence pertaining to natural mixed-severity fires that had burned during the past few decades and included representative areas of high-severity burn. The evidence indicates Spotted Owls are generally not significantly affected by mixed-severity fire with substantial portions of high severity, as 88% of all studies found no significant effects of fire on owl demographic parameters. Furthermore, more than half the evidence discovered in this review (63%) found positive effects from fire, while a smaller proportion of the evidence presented negative effects (56%). Mean effect sizes across all studies indicated overall positive effects of fire on owl life-history parameters (5.0%). Contrary to current perceptions and recovery efforts for the Spotted Owl, mixed-severity fire does not appear to be a serious threat to owl populations, rather wildfire has arguably more benefits than costs.

Introduction: Wildfires are the primary natural disturbance in western forests of the United States, and native plants and animals have been living with fire for thousands of years of their evolutionary history. Forest fires typically burn as mixed severity in a mosaic of different severities. 'High-severity' fire kills most or all of the dominant vegetation in a stand and creates what scientists have termed 'complex early seral forests,' where standing dead trees, fallen logs, resprouting shrubs, tree seedlings, and herbaceous plants comprise the structure (Swanson et al. 2011, DellaSala et al. 2014). Complex early seral forests differ from postfire harvested forests in that dead trees remain on-site, providing food sources and shelter for numerous wildlife species (Hutto 2006, Swanson et al. 2011, DellaSala et al. 2014).

The Spotted Owl (*Strix occidentalis*) is one of the rarest birds to breed in the mainland of the United States. The species is strongly associated with mature and old-growth (i.e., late-successional) conifer and mixed-conifer–hardwood forests with thick overhead canopy and many dense, old, live, and dead trees and fallen logs (Gutiérrez et al. 1995). These owls feed primarily upon small mammals (Gutiérrez et al. 1995).

Spotted Owls have been intensively studied since the 1970s, but research on these owls in fire-affected landscapes did not begin until the early 2000s. Thus, much of what scientists previously understood about habitat associations of Spotted Owls was derived from studies in forests that had not experienced recent fire. The scientific literature has established that the optimal habitat for Spotted Owl nesting, roosting, and foraging in long-unburned forests is provided by conifer and mixed-conifer–hardwood forests dominated by large (30–61 cm but typically >61 cm) trees with medium (50–70) but typically high (>70) percent canopy cover (Gutiérrez et al. 1995). The populations of all three subspecies have declined due to widespread historical and ongoing habitat loss, primarily from logging large, old trees favored by the owls for nesting and roosting (Seamans et al. 2002, Forsman et al. 2011, USFWS 2011; 2012, Conner et al. 2013, Tempel and Gutiérrez 2013).

For decades, studies on Spotted Owl habitat relations and correlations to survival and reproductive success were conducted in areas that had not experienced recent fire, where the 'nonsuitable' owl habitat was typically a result of logging (Gutierrez et al. 1992, Franklin et al. 2000, Seamans et al. 2002, Blakesley et al. 2005, Seamans and Gutiérrez 2007a, Forsman et al. 2011, Tempel et al. 2014). As Spotted Owls are associated with dense, late-successional forests, biologists typically assumed that fires that burned at high intensity were similar to clearcut logging and had a negative effect on long-term survival of the species. It is widely believed that severe wildfire is a cause of recent declines (USFWS 2011, 2012), and many land managers now believe that high-severity fires pose the greatest natural risk to owl habitat and a primary threat to population viability (Davis et al. 2016). Narrative literature reviews have tried to summarize the effects of fire on Spotted Owls (Gutierrex et al. in press GTR), but evidence-based conservation decisions should be based upon systematic, transparent reviews of primary literature (Sutherland et al. 2004, Pullin and Stewart 2006, Pullin and Knight 2009).

Evidence-based decision making requires a systematic review of the primary scientific literature (Pullin and Stewart 2006). The following systematic review summarizes the available scientific literature on the effects of wildfire on aspects of Spotted Owl demography, life history, and ecology, from studies using empirical data to answer the question, "How does fire, especially mixed-severity fire with substantial patches of high-severity fire within their home ranges, affect Spotted Owl habitat selection, demography, and life history parameters?" Studies that modeled effects of simulated fires on Spotted Owl habitat and demography were not considered here.

Methods: I conducted a systematic review of the primary scientific literature and weighed the evidence for the direct effects of wildfire on Spotted Owl demography and foraging ecology. I searched the following electronic databases: Agricola, BIOSIS previews, ISI Web of Science, and Google Scholar. Search terms were: spotted AND owl AND *fire, Strix AND occidentalis AND *fire.

Studies underwent a three-fold filtering process before being accepted into the final systematic review. Initially, all articles were filtered by title and any obviously irrelevant material was removed from the list of articles found in my search. Subsequently, the abstracts of the remaining studies were examined with regard to possible relevance to the systematic review question, using inclusion criteria based on the subject matter and the presentation of empirical data. Articles were accepted for viewing at full text if it appeared that they may contain information pertinent to the review question or if the abstract was ambiguous and did not allow inferences to be drawn about the content of the article. Finally, all remaining studies were read at full text and either rejected or accepted into the final review (Davies et al. 2008).

Papers were evaluated for methodological flaws to ensure equivalent quality standards in all evidence. Evidence was extracted by carefully reading every paper and extracting all quantified results from text, tables, and figures. Extracted data were collated in a table. I noted sample sizes, sampling unit, whether the result was 'statistically significant,' and also noted the effect size of any significant and non-significant results. I categorized every paper for gross effects by assigning up to 3 codes for: the presence of no statistically significant effect (0); any negative effect (-); and any positive effect (+) of fire on the parameters of interest in the paper. Papers were permitted to have more than one effect, and indeed most had multiple effects because there was often no statistically significant effect (0), combined with a non-significant positive (+) or negative (-) effect.

I noted the effect sizes and signs (positive or negative) for all reported effects, regardless of their statistical significance. Fortunately most papers reported effects as probabilities (specifically the change in probability after a fire, or the difference in probabilities between burned and unburned sites) so effects were mostly already scaled between zero and one, making comparison among studies easy. If a parameter was not a probability (e.g., reproduction as fledgling per pair as in Bond et al. 2002), I computed the difference between burned and unburned groups and multiplied by the unburned group estimate to produce a percent change effect that could be compared with the other changes or differences in probabilities. When papers reported multiple effects (e.g., occupancy and reproduction, or survival and recruitment), I recorded each effect individually. I estimated mean effect sizes for all papers, and also estimated mean effect sizes stratified by study type according to whether the study estimated occupancy, foraging habitat selection, or demographic rates such as survival and reproduction. I also estimated mean effect sizes for significant effects only.

Results: I found 20 papers reporting empirical evidence relevant to direct fire effects on owls (Table S1), but 3 were only concerned with salvage-logged areas versus unburned areas, so these 3 papers were considered separately from the 17 papers that dealt directly with fire and owls. One paper was found to have methodological flaws that made the evidence it contained of suspect quality (Jones et al. 2016, see Addendum for explanation).

Fourteen (14) of the 16 high-quality papers reported evidence explicitly pertaining to natural mixed-severity fires that had burned during the past few decades and included representative areas of high-severity burn, while 2 reported evidence from an undifferentiated mix of natural and prescribed fires. Papers reported effects of fire on site occupancy (8), foraging habitat selection (5), reproduction (4), apparent survival (3), site fidelity (1), mate fidelity (1), nesting and roosting habitat selection (1), and recruitment (1).

Of the 16 papers with no substantial quality issues, the majority reported no significant effects of fire on Spotted Owls (88% of papers reported no statistically significant effects of fire on Spotted Owls). Most of the studies reporting any effect reported positive effects of fire on owls (63%), and the smallest proportion of the papers reporting effects reported negative effects of fire on owls (56%). Looking only at papers with statistically significant fire effects, the majority reported positive significant effects of fire on owls (3/5), and the minority reported negative significant effects (2/5).

Overall effect sizes were variable, but mean overall effect size was positive (+0.050), and mean effect size for statistically significant effects only was also positive (+0.072). Mean effect sizes from studies of habitat selection were strongly positive (+0.172 overall; +0.164 for statistically significant effects only). Mean effect sizes from studies of occupancy were negative (-0.051 overall; -0.021 for statistically significant effects only). Mean effect sizes from demographic studies were overall positive (+0.052), and negative for statistically significant effects only (-0.020).

Salvage logging was found to have negative effects on Spotted Owls in 100% of the papers that examined this disturbance, with large effect sizes.

Conclusions: This systematic review and weighing of the effects from the primary literature pertinent to Spotted Owls and mixed-severity fire demonstrates that the preponderance of evidence indicates Spotted Owls are generally not significantly affected by mixed-severity fire, including fire with substantial portions of high severity as is usually found in recent mixed-severity fires, as 88% of all studies found no significant effects of fire on owl demographic parameters. Furthermore, more than half the evidence discovered in this review (63%) found positive effects from fire, while a smaller proportion of the evidence presented negative effects (56%). Mean effect sizes across all studies indicated overall positive effects of fire on owl life-history parameters (+5.0%), with strong positive effects in foraging habitat selection (+17%), small negative effects when estimating occupancy (-5.1%), and small positive effects when estimating demographic rates (+5.2%).

Contrary to current perceptions and recovery efforts for the Spotted Owl (USFWS 2011, 2012, Gutierrez et al in press GTR), high-severity fire does not appear to be an immediate, dire threat to owl populations that requires massive landscape-level fuel-reduction treatments to mitigate fire effects. Empirical studies reviewed here conducted from 1 to 15 years after fires demonstrated that most burned sites occupied by Spotted Owl pairs remain occupied and reproductive at the same rates as long-unburned sites, regardless of the amount of high-severity fire in core areas. Severely burned sites can be expected to have occupancy probability reduced by 2.1% to 5.1%, on average. Burned sites where owls are not detected immediately after fire are often recolonized later, demonstrating the mistake of concluding those sites are permanently ‘lost’ to Spotted Owls. In the unlikely event of large amounts of high-severity fire within most owl core areas, populations may be impacted over the long term, because lower-quality sites had a higher probability of extinction after fire, and these lower-quality sites may represent important opportunities for colonization by floater owls (those without mates and territories) and for recruitment (young owls entering the breeding population). However, overall effects on occupancy were small, and severe fire appears to benefit adult and juvenile owls by creating foraging habitat with abundant small mammal prey that is preferred over unburned habitat by 18% to 20%, but only if fire-killed trees are not salvage logged after fire.

In any given fire, relatively few owl sites experience levels of high-severity fire greater than the territory threshold above which occupancy probability was reduced in southern California (Lee et al. 2013). Potential harm to Spotted Owls by the temporary loss of late-successional nesting and roosting habitat from high-severity fire is certainly compounded and exacerbated by postfire logging, prefire fuel treatments, urbanization, drought, and increasingly warmer temperatures. Harvesting timber to lower risk of fire has adverse effects on Spotted Owls (e.g., Tempel et al. 2014), whereas fire itself has arguably more benefits than costs.

Descriptions of all relevant papers:

Site Occupancy Dynamics

The first peer-reviewed published study on Spotted Owl occupancy in burned landscapes was an examination of site and mate fidelity of northern, California, and Mexican Spotted Owls (*S. o. lucida*) 1 year after fire (Bond et al. 2002). Sixteen of 18 (89%) surviving owls (of all subspecies) were in the same breeding sites after fire, and all pairs were faithful to their prefire breeding site and mate.

Mexican Spotted Owl

Jenness et al. (2004) reported pre- and postfire occupancy of 64 Mexican Spotted Owl sites in mixed-conifer, pine (*Pinus* sp.), and pine-oak forests in four national forests in New Mexico and Arizona. The authors selected owl breeding sites in fires that burned from 1993 to 1996 and compared levels of occupancy (single, pair, failed reproduction and successful reproduction) in 1997 in 33 burned and 31 unburned sites, including 29 paired burned and long-unburned sites within 12 km of each other. Postfire occupancy rates were not significantly different between burned and unburned sites and did not statistically differ with time since fire. The percent of high-severity fire in a burned site had no significant influence on whether the site was occupied. Postfire logging was minor in most of the fires.

California Spotted Owl

Roberts et al. (2011) compared longer-term effects of wildfire on occupancy of California Spotted Owls residing in burned (<15 years since fire) and long-unburned mixed-conifer forests in Yosemite National Park, the only study of this kind in an unmanaged landscape and the first to use modern statistical techniques to model occupancy probabilities (MacKenzie et al. 2006). This study compared occupancy of breeding sites in 16 randomly selected burned and 16 unburned 'owl survey areas,' each 3.75 km^2. A total of 19 owl pairs were monitored for a single year, and vegetation at owl sites was compared with sites that yielded no owl response to build detectability and occupancy models. The mean 'owl survey area' that burned at high severity was 12%, with the greatest amount of high-severity burn in a survey area being 52%. Because this study was conducted in a national park, no postfire or recent prefire logging had occurred to confound results. The authors found no support for a model of occupancy rates that distinguished between burned and unburned sites. Occupancy and detection rates and densities of Spotted Owls were similar between burned and unburned sites. Vegetation structure was the main determinant of occupancy rather than whether or not the site had burned: the total basal area was higher at burned and unburned sites with owls than at sites without owls.

Lee et al. (2012) published an 11-year study of California Spotted Owl occupancy on national forest lands in the Sierra Nevada, the most extensive study of pre- and postfire occupancy ever conducted in this mountain range. This study also was the first in a burned landscape to use statistical methods for estimating rates of local extinction and colonization while accounting for imperfect detectability (MacKenzie et al. 2006) because multiple years of surveys were available. The authors used data collected by the US Forest Service to compile occupancy-survey histories at 41 breeding sites within six large fires that occurred from 2000 to 2007 throughout the Sierra Nevada and at 145 long-unburned control sites. Fires had no significant effect on occupancy probability. The mean probability of colonization of burned sites was 0.381, similar to rates in long-unburned sites, which demonstrates the value of long-term monitoring to better understand wildfire effects on population dynamics, and underscores why managers must not presume a breeding site is permanently 'lost' if owls are not detected immediately after fire. Based on simulation results, the authors recommended that managers should survey >200 burned and >200 long-unburned sites throughout the Sierra Nevada and that burned sites should be surveyed at least 2 years after fire to determine site occupancy prior to implementing postfire management activities.

The 2013 Rim Fire near Yosemite National Park was the largest fire in recent recorded Sierra Nevada history, burning more than 100,000 ha. The fires burned through 45 known California Spotted Owl breeding sites in the Stanislaus National Forest and all sites were surveyed by US Forest Service personnel the following year. This provided an unparalleled opportunity to examine the effects of a large fire on Spotted Owl site occupancy within a single fire area, in a study area with relatively little private timber land. Increasing amounts of severe fire surrounding nest and roost sites decreased occupancy probability, but did not affect occupancy by pairs of owls (Lee and Bond 2015a).

Furthermore, single-season modeled occupancy rates 1 year after the Rim Fire were significantly higher than other previously published occupancy rates in both burned and long-unburned forests (Lee and Bond 2015a). The relatively high occupancy rate could indicate either that owl sites in the Rim Fire area before and/or after fire were of above-average quality relative to the other fire areas or that owls remained in burned sites because of strong site fidelity.

A long-term (>20 years) demographic study of California Spotted Owls in the Eldorado and Tahoe National Forests of the central Sierra Nevada is providing a wealth of information on the effects of habitat, weather, and forest management activities. Tempel et al. (2014) examined the influence of timber harvest and wildfire on reproduction, survival, and occupancy over a 6-year timescale using data from 74 breeding sites, although only 12 sites experienced fire during the course of the study. Fire did not significantly affect survival, reproduction, or site extinction. The coefficient for the effect of fire on site colonization was negative, but the standard error of the coefficient could not be estimated due to the fact all sites remained occupied after fire.

Surveys by the US Forest Service at Spotted Owl breeding sites in southern California from 2003 to 2011 offered a unique opportunity to study the long-term fire effects in this especially fire-prone region, as more sites were influenced by wildfire during this period there than anywhere else in the range of the species. Lee et al. (2013) used survey data from 97 long-unburned and 71 burned breeding sites to examine the influence of fire and postfire logging on local rates of extinction, colonization, and occupancy probability. Postfire logging occurred on 21 of the burned sites.

None of the fire and logging coefficients were statistically significant, but model-averaged effect sizes suggested that high severity fire that burned >50% of forest in the 203-ha core area was correlated with lower colonization, greater extinction, and lower occupancy relative to unburned sites, for all detections as well as pairs only. Postfire logging further increased extinction probability. The majority (75%) of sites burned below the 50% threshold.
Spotted Owls in two study areas continued to occupy burned forests in winter. Bond et al. (2010) documented three of five radiomarked California Spotted Owls in the southern Sierra Nevada roosted within a burned landscape overwinter. Ganey et al. (2014) reported four radiomarked Mexican Spotted Owls moving to burned overwintering areas in New Mexico.

Tempel et al. 2016 examined occupancy dynamics in 43 burned breeding season territories and 232 unburned territories in 4 study areas across the Sierra Nevada using 19 years of data. They found no significant effects of fire on occupancy, but their top ranked model for one study area (Sequoia Kings Canyon) included a covariate for proportion of the core area that had canopy cover reduced by >10% by wildfire. This covariate was negatively correlated with territory extinction probability, meaning more area burned reduced the site extinction probability, thereby increasing occupancy probability.

Northern Spotted Owl

The only study to investigate the occupancy dynamics of northern Spotted Owls in burned landscapes was conducted in three fire areas and an adjacent long-unburned demographic study area in mixed-conifer and mixed-evergreen forests in the southern Oregon Cascade Mountains (Clark et al. 2013). The three fires all burned within 1 year of each other. Modeled occupancy rates of 103 Spotted Owl sites in the long-unburned area were compared with 40 burned sites before fire and after postfire logging. This extensive study also investigated survival rates and movements of 23 radiomarked owls in and just outside two of the fires (see Survival, later). Postfire logging was prevalent on private lands in all the fire areas; thus, it was not possible to quantify the influence of fire alone on occupancy dynamics and survival, but this research provided important insights into the effects of postfire logging on a federally threatened species whose numbers are continuing to decline (Forsman et al. 2011).

Extinction rates were greater after postfire logging in the burned area (Timbered Rock) than the long-unburned area (South Cascades; Fig. 6; Clark et al. 2013). Occupancy probability declined more steeply after postfire logging than in the unburned area. The high rate of adult dispersal following postfire logging suggested that insufficient habitat remained at abandoned sites to support Spotted Owls. At all three fire areas, extinction probability of sites increased with greater amounts of combined area that was previously harvested, burned at high severity, or postfire logged.

Survival

Bond et al. (2002) examined short-term (1-year) postfire survival of 21 color-banded Spotted Owls in four separate study areas encompassing all subspecies: in mixed-conifer and mixed-evergreen forests of northwestern California, southern California, and New Mexico and in pine-oak forests in Arizona. All nest and roost areas were burned, and no postfire logging had occurred before owls were surveyed the year after fire. Vegetation burn severity maps were available for only eight of the 11 breeding sites. Four of the eight breeding sites where fire severities were mapped burned at low to moderate severity, and the other four burned 36–88% at high severity. Each breeding site was defined as a circle approximately 150–400 ha, depending on study area. The authors found that 18 of 21 (86%) individual owls were resighted after fire. These survival rates are the same as those for individuals in unburned sites.
In a long-term demographic study of color-banded California Spotted Owls in the central Sierra Nevada, Tempel et al. (2014) found fire did not significantly affect survival.

Clark et al. (2011) examined the monthly survival rates of northern Spotted Owls 3–4 years after fire and postfire logging in two fire areas in southwestern Oregon. The authors color-banded and radiomarked 11 Spotted Owls inside and six owls adjacent to fire areas where much of the forest burned at high severity had been postfire logged. A third group of six owls had moved outside the perimeter after fire and subsequent logging. Owls that remained within the postfire logged landscape had lower survival rates than those reported throughout the range of the subspecies. Owls that moved had the lowest monthly survival rates of the three groups. Owls outside the burned and logged areas had the highest annual survival, but there was no evidence for an effect of fire severity on survival. The authors suggested past logging activities coupled with loss of habitat from severe fire followed by postfire logging contributed to the lower survival rates of owls in burned forests.

Rockweit et al. (2017) examined 70 unburned sites and 28 sites burned in 4 fires. They reported wildfires with different mixtures of burn severity resulted in different effects on survival and recruitment. However, I respectfully suggest that their results are somewhat mischaracterized when the authors overemphasizing the results from the 4 territories burned at mostly high severity during the fire year 2004. For comparison, 10 territories burned with mostly low-severity fire (year 1987 and 1999 fires), and 14 territories burned with moderate amounts of high- and low-severity fire (fire year 2008). The differences among the burned territory groups (those burned in fire years 1987, 1999, 2004, and 2008) was largely due to differences in how much low-severity fire and how much high-severity fire burned in their core areas. Owl territory cores that were burned at mostly low severity (1987 and 1999 fires) were associated with no significant effects on survival or recruitment. When territory cores burned with more high severity fire and less low severity (2008 fire), the result was a significant reduction in survival and a significant increase in recruitment. When territory cores burned at predominantly high severity (2004 fire), there was a significant reduction in survival. The reported variation in significant survival and recruitment effects should be summarized as territory fitness. Fitness of a territory is survival + reproduction. Reproductive output is considered the primary driving force in defining habitat fitness (Franklin et al. 2000). However, Rockweit et al. did not report reproduction, even though these data were available, so I cannot compute true fitness consequences of the fires. I can estimate relative fitness of the territories burned by fires using survival and recruitment (see **Table R1**).

Table R1. Territory fitness (apparent survival + recruitment) as a measure of habitat quality for four groups of Northern Spotted Owl territories burned by wildfire in different years. Of fire years examined, 50% resulted in no fitness effect, 25% resulted in a decrease in fitness, and 25% resulted in an increase in fitness. Of burned territories, 36% showed no fitness consequences, 14% showed decreased fitness, and 50% showed increased fitness after being burned.

Group (year of fire)	Sample size (# of territories in group)	Pre-fire average territory fitness	Post-fire average territory fitness	Results, change in territory fitness
control	70	0.98	0.98	
1987	8	n.a.	0.98	no significant effects
1999	2	0.98	0.98	no significant effects
2004	4	0.98	0.73	reduced fitness
2008	14	0.98	1.02	increased fitness

Reproduction

High annual variability in reproductive rates is typical of Spotted Owls and has been associated primarily with weather and to a lesser extent with habitat structure (Franklin et al., 2000; Seamans et al. 2002; Seamans and Gutierrez 2007b). While weather is a key factor, productivity also differs by site; thus, any impacts of wildfire on reproduction should account for prefire reproductive rates of the site and, ideally, be compared with long-unburned areas.

Jenness et al. (2004) found that the number of successfully reproducing Mexican Spotted Owl sites did not differ between burned and unburned forests. Spotted Owls successfully reproduced at three sites with 8%, 31%, and 32% high-severity fire within a 1-km circle of their nest. Moreover, reproductively successful sites had a higher percentage of burned area than other occupied sites affected by fire (including single owls and nonreproducing pairs).

Bond et al. (2002) also found that productivity of burned California Spotted Owl sites was higher than overall annual rates of reproduction for long-unburned sites. Fire was not a significant variable influencing reproduction of California Spotted Owls in southern California (Lee and Bond 2015b), or the central Sierra Nevada (Tempel et al. 2014).

As described in the preceding text, Lee et al. (2013) found that more high-severity fire in a site's core use area reduced occupancy by Spotted Owls in southern California. Lee and Bond (2015b) used the same dataset to examine how the quality of a site influenced occupancy and reproduction after severe fire. Site quality was measured by whether the site supported a single owl, pair of owls, or pair of owls with offspring the previous year. The influence of severe fire on occupancy was minor in sites that had been occupied and reproductive the previous year (high quality), and if a site remained occupied, severe fire did not affect the probability of reproduction compared with unburned sites (Lee and Bond 2015b). In other words, lower-quality sites that were often vacant and nonreproductive typically had lower occupancy with increasing amounts of severe forest fire, whereas in higher-quality sites that were consistently occupied and reproductive, the amount of severe fire that occurred in the core area had negligible effects on occupancy and reproduction. This was similar to the Rim Fire results that indicated that severe fire did not affect occupancy by pairs.

Nesting, Roosting, and Foraging in Burned Forests

Only one published study has documented roosting locations in burned forests (Bond et al. 2009). In this study, no nests were found in stands burned at high severity. California Spotted Owls roosted in all fire intensity classes 4 years after the McNally Fire in the Sequoia National Forest, southern Sierra Nevada, but most roosts were associated with low-severity fire. Only 1 of 60 roosts occurred in an area that burned at high severity, and owls selected roost sites burned at low severity and avoided sites burned at moderate severity. Roost sites averaged 63% canopy cover and had an abundance of large (average 63 cm) trees. Thus, roosting habitat in burned landscapes was comparable with roosting habitat identified in unburned forests (Gutiérrez et al. 1995). These results underscore the importance of the burn severity mosaic of within an owl's home range.

Most studies of selection of habitat by Spotted Owls have focused on nesting and roosting habitat. Foraging habitat is just as critical for the persistence of owls, but is more difficult to identify because it requires radiotelemetry. Bond et al. (2009) were the first to quantify foraging habitat selection by Spotted Owls in a burned landscape. Selection studies compare how much owls used forest that burned at a particular severity with the availability of that burn severity. The authors banded and radiomarked seven California Spotted Owls occupying the McNally Fire 4 years after fire. Very little (<3%) of the foraging ranges of these owls had been postfire logged, so effects of high-severity fire were not confounded with postfire logging. All owls had access to sufficient amounts of unburned, low, moderate, and highly burned patches of forest in their home ranges from which to choose, so the authors could quantify whether owls selected or avoided any of these burn severities. The probability of an owl using a site for foraging was significantly greater in burned—especially high-severity burned—forests than unburned forest, after accounting for distance from nest. Selection for a particular burn class occurred within 1.5 km from nest. Thus, recently burned complex early seral forest should be considered a potentially suitable foraging habitat for this subspecies.

Spotted Owls in the McNally Fire area fed primarily on pocket gophers (*Thomomys* spp., 40.3% by biomass) and northern flying squirrels (*Glaucomys sabrinus*, 25.9% by biomass), whereas owls fed primarily on flying squirrel and woodrats (*Neotoma* spp.) in long-unburned study areas (Bond et al. 2013). The mean home-range sizes of the McNally Fire owls were similar to those recorded in unburned forests using similar time periods and methodology (Bond et al. 2013). Bond et al. (2016) analyzed foraging habitat selection by eight California Spotted Owls in the Slide Fire in the San Bernardino National Forest of southern California 3 and 4 years after fire. Habitat selection with sensitivity analysis at three spatial extents of available habitat showed owls used forests burned at all severities in proportion to their availability, with the exception of significant selection for moderately burned forest farther from core areas.

Comfort et al. (2016) examined foraging habitat selection by 23 northern Spotted Owls in the Timbered Rock Fire in southwest Oregon in relation to edges created by fire and postfire logging. Because postfire logging occurred immediately following fire on extensive private lands in the study area, and their remote-sensing methodology could not distinguish between fire and postfire logged areas, the authors created a combined burned–logged variable called the "disturbance severity." The edges between forested habitats and burned–logged areas were defined as "hard" edges. At smaller spatial scales (3.2 and 51.8 ha surrounding telemetry locations), increases in disturbance severity decreased the probability of use, but at larger spatial scales (829 ha), the opposite was true. The use of a location for foraging was maximized when about 20% of a 3.2-ha area surrounding the location was composed of hard edge. Thus, foraging owls selected some amount of edge, possibly because edges offer access for hunting small mammals while still providing adjacent closed-canopy habitat. Owls avoided areas with larger amounts of hard edge, but selected smaller amounts of edge, suggesting that small patches of high-severity fire surrounded by relatively undisturbed land are potentially suitable for foraging. Larger, more contiguous hard edges were described as intensively managed edges created by postfire logging.

Eyes et al. (2017) radiotracked 13 owls over 3 years and collected data on foraging habitat selection in Yosemite National Park. They analyzed foraging for owls nesting in and near forest burned 1-14 years previously from a mix of wildfires and prescribed burns. Eyes et al. (2017) found no significant effect of burn severity on foraging habitat selection, but non-significant effects were reported that showed a 6% decrease in probability of use for the most severely-burned locations relative to unburned locations.

A sample of four radiomarked Mexican Spotted Owls in the Sacramento Mountains, New Mexico, moved to wintering areas that had burned 4–6 years earlier and that had two to six times greater abundance and biomass of small mammal prey than nest core areas associated with those owls (Ganey et al. 2014). This study indicates that wintering areas provided foraging habitats during an energetically stressful time of year.

Addendum, rationale for excluding evidence from Jones et al. 2016:
This paper is filled with fatal errors of analysis that render it entirely unusable as evidence of the relationship between owls and fire.

First, their owl population has documented long-term trends of decreasing site colonization and increasing site extinction probabilities, before the King Fire (Tempel and Gutiérrez 2013). However, Jones et al. did not account for these important pre-fire trends in their site occupancy analyses. Site occupancy analysis measures, each year, the probability that occupied sites are abandoned (called site extinction), and the probability that empty sites are colonized and become occupied again, and uses those colonization and extinction probabilities to calculate a yearly average probability of site occupancy. The population has had 22 years of documented trends of ever-lower site colonization probability, and ever-increasing site extinction probability (Tempel and Gutiérrez 2013), yet the authors simply compared their 1 year of post-fire data against the average of all previous years without accounting for those known year-to-year trends in colonization and extinction probabilities. The pre-fire trend means 2015 (the year after fire) was expected follow the trend of having higher extinction probability relative to all previous years, even if there was no fire. Fig. 3f clearly shows that the 2015 post-fire year of decrease in occupancy was not significantly different from the 10 previous years of decrease.

The ‘trend analysis’ Jones et al. did was not what I described in the previous paragraph. Rather, Jones et al. took annual estimates of site occupancy and compared a few models to describe the 23 years of annual occupancy rates. This trend analysis is not the same as including the pre-fire trends in extinction and colonization probabilities described above.

Second, Jones et al. used compositional analysis of foraging habitat use, a method that is inappropriate for central place foragers like Spotted Owls (Rosenberg and McKelvey 1999, Bond et al. 2009, Bond et al. 2016). Foraging habitat selection analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. Compositional analysis compares simplistic ratios of the proportion of foraging points in a habitat type relative to the proportion of territory area in that type. The proper habitat use analysis is a 'resource selection function', a math model that accounts for the fact that Spotted Owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every Spotted Owl foraging habitat use paper has found distance from nest is a highly significant effect on a point's probability of use – but Jones et al. did not account for the distance of a foraging site to the nest. Because Jones et al. did not do a proper resource selection function analysis, they were essentially ignoring each foraging point's distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fundamental error makes their radiotelemetry results and discussion unreliable.

Third, Jones et al. reported extinction for a territory in WebFigure 4 when the owls shifted their location by a distance that is less than the diameter of a territory as defined by the authors. The owls' shift was also less than mean foraging distance reported by the authors. Because the authors did not follow their own definition of a territory, they arbitrarily declared the short-distance shift to signify the extinction of the 'old' territory and creation of a 'new' territory a few hundred meters away. This was an arbitrary reclassification of a continuously occupied territory whose occupants shifted a few hundred meters, an occurrence that happens in Spotted Owl territories. This decision inflated their 'burned site' extinction probability by classifying a normal within-territory movement as site extinction.

The sites that were occupied in 2014 are those most relevant to extinction probability in 2015, the only significant 'fire-related' effect Jones et al. found in 2015 and attributed to the King Fire. 2014 occupied site sample sizes indicates Jones et al. make their claim of 'large extinction effects' from only 8 severely burned sites that were occupied in 2014. Considering that Jones et al. did not account for the long-term increasing site extinction probability (meaning site extinction probability was getting bigger every year leading up to the fire), and the fact that only 8 sites in the burned area were occupied before the fire in 2014, and at least one site that they declared extinct from the fire actually just moved a few hundred meters, means their results are not correct.

Given the analytical shortcomings I described, I suggest the results reported by Jones et al. be viewed with caution and not used to justify management actions that harm Spotted Owls.

Additionally, errors of scholarship in Jones et al. 2016 include:

Pg. 304 "The observation that lower-severity fire is benign, and perhaps even moderately beneficial, to Spotted Owls is consistent with previous studies (Roberts et al. 2011, Lee et al. 2012)"
Both those studies found mixed-severity fire (rather than lower-severity fire) had no effect on occupancy. Mixed severity fire is common historically and currently in the Sierra Nevada and explicitly includes low-, moderate-, and high-severity burned patches.

Pg. 305, "because owls were not individually marked in the Rim Fire study, some detections at "occupied" sites may have involved individuals from neighboring territories or non-territorial "floaters" (Lee and Bond 2015), both of which may have contributed to inflated estimates of territory occupancy."
This exact same situation exists in the data analysed by Jones et al. Data were collected as described in Tempel and Gutiérrez (2013), "We included both nocturnal and diurnal surveys in our occupancy analyses." During nocturnal surveys leg bands were usually not resighted, therefore detections at occupied sites would have been similarly inflated by individuals from neighboring territories or non-territorial floaters.

Forest management practices

The effects of specific forest management practices on spotted owls are not well understood. Some practices may act as stressors on spotted owls, while others may improve habitat. Commercial timber harvest no longer occurs within the CSO range in southern California on public lands (Eliason and Loe 2011), though it continues to occur on private lands, and is conducted in the Sierras on both public and private lands. Additionally, in order to reduce the likelihood of high severity fires, fuels reduction activities on public lands have been slowly implemented. Forest fuels are typically split into four categories: ground (material that has begun to degrade), surface (downed wood, herbaceous vegetation and shrubs), ladder/bridge (small trees and larger shrubs), and aerial/crown fuels (within the crowns of standing trees, separated from surface fuels) (Jenkins et al. 2014). Management for fuels reduction in the forest includes reducing surface fuels, increasing the height to the live crown (reducing ladder fuels and removing small trees), decreasing crown densities, and retaining/recruiting large fire-resistant tree species (Agee and Skinner 2005). Data on the effects of various fuel treatments on owls has been mixed, due to minimal experimentally designed studies, confounding factors, and a lack of consistency in defining types of treatments. For the purposes of discussion we broadly classified the methods of fuels reduction into prescribed fire, hand thinning, and mechanical treatments. For the most part, prescribed fire that has the potential to lead to low or moderate severity fires, or mixed severity with small patches of high-severity fires can be good for owl habitat. Additionally, hand thinning of smaller trees does little to disturb CSO. These small scale treatments typically leave high canopy cover and large trees, which are important to spotted owl nesting. Chainsaws and helicopter noises do not appear to decrease reproductive success

Commented [R48]: I suggest moving this section up to be a part of the logging section of stressors, before the fire section.

This section is incomplete scholarship, please do a thorough, systematic review.

Commented [R49]: There is a rich literature on how forest management affects spotted owls. I suggest a thorough systematic review and rewriting.

(Delaney et al. 1999) nor increase stress hormones like corticosterone (Tempel and Gutiérrez 2003, 2004). However, NSO nesting near loud roads have lower reproductive success than those near quiet roads (Hayward et al. 2011), and males show higher levels of corticosterone (Wasser et al. 1997), suggesting there may be some non-lethal effects from noise-causing human disturbances.

Forest management: mechanical thinning

Owl response to mechanical treatments is less clear and appears to rely on scale and intensity of the treatments. Mechanical treatments (or thinning) refer to machine-based fuels reduction for purposes of reducing large fires and tree harvest (North et al. 2015). Generally, territories with greater amounts of mature conifer forest have a higher probability of colonization by CSO (Seamans and Gutierrez 2007a), so actions that alter mature forest to a large degree could result in a less desirable territory. Specifically, converting mature conifer forest from high to moderate canopy cover was negatively correlated with demographic parameters in one meta-analysis (Tempel et al. 2014b). In an earlier study, territories with >50 acres of altered mature forest showed a 2.5% decline in occupancy and an increase in dispersal (Seamans and Gutiérrez 2007a). However, minimal effects were found on NSO two years after territories were treated, and no abandonment of a territory was detected in areas that were treated up to 58% (Irwin et al. 2015). Modeling projected over a 30 year time frame suggested that while treatments can reduce the risk of high-severity fire to CSO, in the absence of fire, such treatments could have a negative effect on fitness (Tempel et al. 2015). At the landscape-scale, another study examined the effects of mechanically-produced wide shaded fuel breaks (Defensible Fuel Profile Zones) on CSO and found that the fuel breaks were avoided for 1-2 years after treatments (Stephens et al. 2014). Additionally, occupied territories declined by >40% within four years after treatment, and the remaining individuals used larger areas. Mechanical thinning that results in widely and regularly spaced trees tend to be avoided by CSO (Gallagher 2010). However, the most recent meta-analysis of the long-term demography studies in the Sierras did not find any impact to occupancy, survival, or productivity from mechanical thinning (Tempel et al. 2016), and in fact some populations exhibited small positive effects on occupancy.

Forest management: salvage logging

Salvage logging refers to the removal of dead or damaged trees to recover economic value that would otherwise be lost (Society of American Foresters' Dictionary). It typically occurs after a fire, or large tree mortality event, and can be a controversial activity (Long et al. 2013). Because CSO can persist in low-moderate severity fires, salvage logging of viable habitat may negatively affect occupancy (Gutiérrez et al. in press). In high-severity fires, it was found that salvage logged sites had a slightly lower probability of being occupied than sites that only burned and did not undergo salvage logging treatment, although the difference was not statistically significant (Lee et al. 2013). Recent work on NSO found that high severity fire interacts with salvage logging to jointly contribute to declines in site occupancy (Clark et al. 2013). Salvage logging may reduce the quality of foraging habitat through the removal of legacy snags, although it is difficult to disentangle the effects of salvage logging from high-severity fire.

Forest management: clearcutting

Timber harvest can cover all types of tree removal, which would include some fuels reduction activities as well as salvage logging. Clearcutting is one form of timber harvest that can take various shapes and sizes, though in general tends to leave large, regularly shaped patches with clean edges (Tempel et al. 2014b). In addition to outright habitat loss, timber harvest can eliminate important CSO habitat elements such as old, large trees and large downed logs (McKelvey and Weatherspoon 1992). The overstory trees that remain in commercial thinning prior to a clearcut tend to be regularly spaced with little forest floor and understory diversity, and low heterogeneity in stand structure (Knapp et al. 2012). No research has explicitly examined spotted owl response to an even-aged management strategy using clearcuts, but these forest practices generally occur on private timberlands. California spotted owls have been observed avoiding private lands (Thraikill and Bias et al. 1989), and tend to forage on private lands proportionately less than the amount of private lands available on the landscape (Williams et al. 2014). These observations were not linked to management practices in these studies. However, CSO do nest on private timberlands in the Sierras. Additionally, crude density estimates of CSO territories are similar across public and private lands (Roberts et al. in press), although, as discussed above, there is limited information regarding population trends on private lands. While some gaps in canopy cover can be beneficial for the prey base, current clearcutting practices probably do not create the collection of patches observed in spotted owl territories with high-fitness (Franklin et al. 2000).

Tree mortality

Tree mortality has substantially increased throughout the Sierras, particularly in the southern Sierra region (van Mantgem et al. 2009, Asner et al. 2015). In 2015 in the southern Sierra, about 345 trees/km^2 died (Young et al. 2017), and very large trees in general are disproportionately affected by tree mortality (Smith et al. 2005). Drought combined with dense forest conditions have led to severe water stress (Asner et al. 2015, Young et al. 2017) in forest trees. This stress interacts with pathogens, insects and air pollution (Lutz et al. 2009, McIntyre et al. 2015). Bark beetles in particular are exacerbated by climatic conditions (Bentz et al. 2010), and measures of

Commented [R50]: There are actually many possible reasons why salvage degrades habitat quality of burned forests. Perhaps you should elaborate on them like you did for different logging treatments.
It is not at all difficult to disentangle the effects of fire and salvage, if only high severity burned forest was ever left alone in large areas we could learn what those differences are. This sentence ignores that fact that many studies individually could not disentangle the effects because there was no unlogged high severity burned forest in the study, it was all salvage logged. Some studies of unlogged high severity burn do exist, but were ignored in this poorly researched review.

Commented [R51]: Here would be a good section to reiterate the past and current management of forests that resulted in 85% of old growth being cut down and removed during the past 200 years and how that likely is the greatest contribution to Spotted Owl declines.

Commented [R52]: Over what time period? This section is without necessary context over longer time frames of millennia. It also fails to mention the myriad ecological benefits that propagate through the ecosystem during and after beetle outbreaks. I suggest additional discussion about how insect and drought driven mortality has accomplished thinning and heterogeneity goals. Also worth adding is the many papers showing mortality does not affect fire severity.
Robert A. Andrus et al. Fire severity unaffected by spruce beetle outbreak in spruce-fir forests in southwestern Colorado, Ecological Applications (2016). DOI: 10.1890/15-1121
Sarah J. Hart et al. Area burned in the western United States is unaffected by recent mountain pine beetle outbreaks, Proceedings of the National Academy of Sciences (2015). DOI: 10.1073/pnas.1424037112
Nathan Mietkiewicz et al. Relative importance of climate and mountain pine beetle outbreaks on the occurrence of large wildfires in the western US, Ecological Applications (2016). DOI: 10.1002/eap.1400

stand density are correlated with levels of mortality attributed to bark beetles, suggesting the density of trees (and indirectly competition) is a contributing factor (Hayes et al. 2009). The full extent of the mortality and effects on CSO is unknown~~, but the tree mortality is likely to contribute to habitat loss.~~

Commented [R53]: Given that high severity fire has no serious effect on owl occupancy, and that owls use all severities of burned forest for foraging, and because beetle kill does not affect fire severity, and may reduce fire severity, I would argue that beetle and drought mortality of trees is likely to create foraging habitat while simultaneously lowering fire risk in the landscape.

Barred owls

Barred owls were historically confined to eastern North America, but have expanded west over the past century (Livezy 2009). Whether barred owl expansion is human-caused is uncertain, but it is thought to be a combination of settlement of the central plains combined with climate change. Currently barred owls threaten NSO in parts of its range. They use a broader suite of vegetation, though still show a preference for old growth, large trees, and high canopy cover like spotted owls (Wiens et al. 2014). Because barred and spotted owls use similar habitat, natural segregation and coexistence is unlikely (Yackulic et al. 2012, 2014). Barred owls are competitively superior and have a smaller home range (2-4 times smaller), probably due to a broader diet (Wiens et al. 2014). Barred owls can thus live at substantially higher densities than spotted owls.

Where barred owls occur in the NSO range, they decrease NSO occupancy by increasing territory extinction and lowering colonization (Olson et al. 2005, Dugger et al. 2011, Yackulic et al. 2014). Northern spotted owls show a lower overall probability of habitat use (Van Lanen et al. 2011) and lower nesting success; barred owls produced 4.4 times more young over a three year study period (Wiens et al. 2014). Furthermore, because barred owls can live at higher densities and consume a wider variety of prey species than spotted owls, their expansion has the potential to alter the prey on the landscape and affect a variety of other native species (Holm et al. 2016). In the range of NSO, there are ongoing removal experiments that suggest NSO may reoccupy a site within one year after barred owls are removed; however 1-4 years after the initial removal, barred owls again occupied some sites (Diller et al. 2012). These removal experiments are being conducted in areas of relatively high barred owl densities. In the range of CSO, however, barred owl detections have been low, suggesting the edge of barred owl expansion is just at the northern extent of CSO range.

A barred owl was first detected in the northern Sierras in 1989 and in the central and southern Sierras in 2004 (Steger et al. 2006). As of 2013, there were 51 barred owls detected in the Sierras (Gutiérrez et al. in press). Currently there are over 140 barred owl detections recorded in CNDDB, although these records do not necessarily reflect unique individuals. However, no systematic surveys have been conducted and all detections are incidental, therefore, they may be at a low density throughout the region (Dark et al. 1998, Keane 2014). There have also been a number of sparred owl detections, hybrids between the two species. As their range continues to expand, barred owls will likely become a significant threat to CSO (Gutiérrez et al. 2007). If control measures were to be implemented, they are more likely to be successful now, while the densities of barred owls are still low in CSO range (Dugger et al. 2016).

Contaminants

Although they have not yet been found in CSO, environmental contaminants may be an emerging threat. Rodenticides associated with illegal marijuana cultivations have been found in barred owls in northern California (Gutiérrez et al. in press). In the southern Sierra, large amounts of rodenticides and other pesticides have been found in national forests (Thompson et al. 2013), and fishers (*Pekania pennanti*) are experiencing high rates of exposure (Gabriel et al. 2012). Given that CSO share similar habitats and prey with fisher and barred owl, CSO are likely to be affected by rodenticides as well (Gutiérrez et al. in press).

Climate change

Current predictions suggest there will be a 3-6 degrees increase in temperature in the Sierras within the 21st century, and although changes in precipitation patterns are less certain, winter snowpack will likely decrease with a corresponding increase in ecosystem moisture stress during the dry, hot summer months (Cayan et al. 2013, Pierce et al. 2013). The direct effects of such climate changes on spotted owls will be complex as they exhibit population-specific demographic responses to local weather and regional climates (Franklin et al. 2000, Glenn et al. 2010, 2011, Peery et al. 2012). Additionally, spotted owls tend to only attempt nests in years with sufficient resources, following a bet-hedging strategy (Franklin et al. 2000). Drought and high temperatures in the previous summer can result in lower survival and recruitment (Franklin et al. 2000, Seamans et al. 2002, Glenn et al. 2011, Jones et al 2016b). Warm, dry springs, on the other hand increase reproductive success (Glenn et al. 2010, 2011, Peery et al. 2012, Jones et al. 2016b). Potential projected decreases in precipitation will likely reduce the plant production important for spotted owl prey (Seamans et al. 2002, Olson et al. 2004, Glenn et al. 2010, 2011).

With climate change, mixed-conifer forests, like many communities, are projected to advance upslope, which could develop habitat for CSO where none now exists (Peery et al. 2012). While these changes in habitat may mitigate some effects of climate change, the creation of new habitat will likely not keep pace with the loss (Stephens et al. 2016b). Climate change is likely to exacerbate the risk of large, high-severity fires and drought-induced tree mortality (Miller and Safford 2012, Mallek et al. 2013), ~~which both have negative impacts on CSO habitat~~. The effects of climate change on fire activity, however, will likely vary across landscapes. Lower elevations and latitudes (e.g. southern California), where fire is more limited by ignition than climate, will be less likely to experience an increase in fire activity with hotter and drier conditions (Keeley and Syphard 2016).

Commented [R54]: There is evidence that contradicts this statement. Please perform a thorough review of the evidence for climate-change effects on California forest ecosystems and portray the breadth of knowledge and areas of uncertainty.

Commented [R55]: This has not been established.

5. CONSERVATION FRAMEWORK

Our conservation framework consisted of 1) identifying CSO population and habitat status and stressors, 2) defining broad conservation goals, and 3) developing conservation objectives and measures for ameliorating stressors and addressing CSO needs. We used three parameters: population and habitat representation, redundancy, and resilience (Shaffer and Stein 2010, Redford et al. 2011), as broad guiding concepts in developing our conservation objectives. Representation is the retention of various types of diversity (genetic, ecological, etc.) of the species so that the adaptive capacity of the species is conserved; resilience is the ability to recover from stochastic environmental variation and disturbances; and redundancy is multiple, geographically dispersed populations and habitats across the species' range that helps species withstand catastrophic events. In this COR, we relied on the best available science, including the latest Conservation Assessment (Gutiérrez et al. in press), recent emerging scientific research, information received related to our March 17, 2017, letter soliciting new information from interested parties, and expert elicitation.

5.1 Conceptual model

Recognizing that many CSO habitat requirements vary based on scale, we have developed a conceptual model to examine how factors interact to influence CSO resiliency (Figure 2). The model includes population parameters that are typically measured for CSO, important broad habitat requirements, as well as the potential stressors discussed above. This model is not quantitative, but rather illustrates the interactions between stressors and habitat requirements to influence population parameters. Red arrows indicate one factor increases another, blue arrows indicate the factor decreases another, and purple indicates it may increase or decrease depending on other parameters. Thicker lines suggest a stronger relationship, and dashed lines indicate some uncertainty of the relative strength.

Commented [R56]: The **conceptual model** has many serious flaws in its structure rendering it not useful in its current form. Furthermore, there is very little explanation of the construction and utility of the model. How is this model supposed to guide conservation and increase resistance and resiliency? It would be much more useful to make a properly-researched and objective document that properly synthesizes all available evidence about owls, fire, and logging into an evidence-based decision-support framework.
1. Many stressors directly affect population parameters without acting through habitat. Therefore, the model needs to be reorganized into a triangle so all stressors (not just barred owls) can act directly on population parameters. Furthermore, the model misrepresents the stressors. Thinning and clearcutting have been and continue to be the most substantive stressors on canopy cover and large trees. Furthermore, there has been no evidence presented that describes the effectiveness of thinning at altering fire behavior or more importantly, the extent of high-severity fire on the landscape.
2. Habitat requirements are muddled. Why are very large trees listed twice? Why is there the combined canopy cover and large trees? Spatial heterogeneity is a vague term with little usefulness. What about prey habitat, shouldn't that be included as an explicit box to manage for? Where is complex early seral forest (burned forest) habitat present? Evidence has shown owls use burned forest of all severities for foraging in proportion to its availability or even prefer moderate or high severity. Burned forest foraging habitat should be added as an explicit type.
3. Many of the effects are not supported by the evidence. How can large high severity fire decrease residual trees / snags? How can clearcutting increase very large trees? Mechanical thinning can also decrease very large trees, as I have witnessed first-hand in thinning treatments implemented in NSO critical habitat on USDA Forest Service projects in California. Why would tree mortality and fire necessarily increase salvage logging? Salvage is a policy that can be stopped. There is no evidence that salvage decreases large, high severity fires. Thinning can increase fires. Clearcutting can also decrease heterogeneity.
4. Population parameters should include movements as a distinct parameter. Floaters are not a parameter, they are a population segment and if they are included, then other groups and ages should be added. How do floater affect survival?
5. How are CSO resiliency and occupancy related? Why are other parameters and habitat requirements not contributing to resiliency?

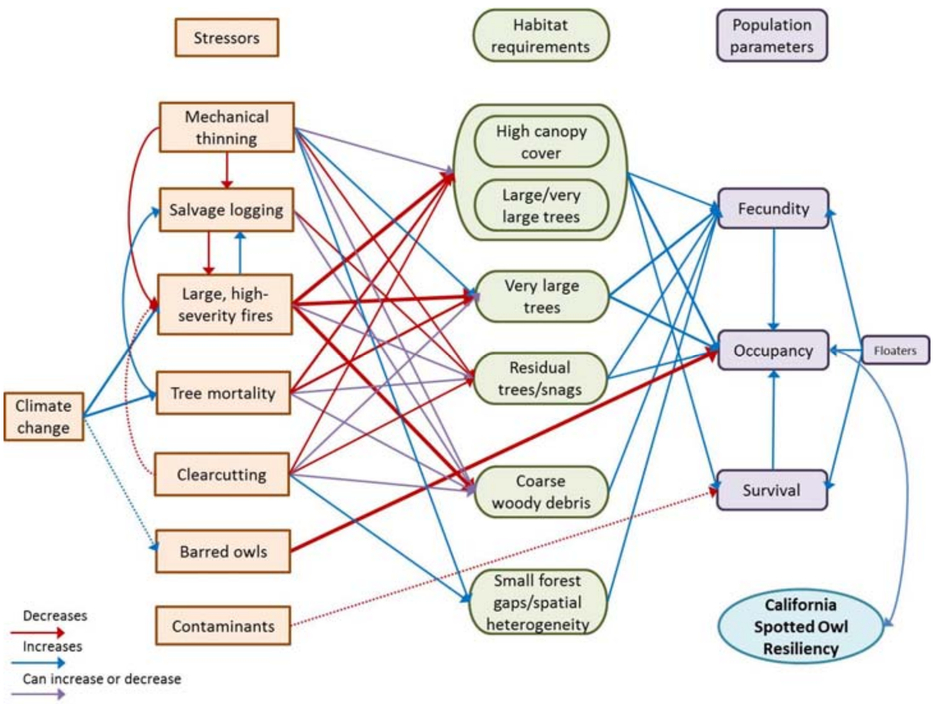

Figure 2. Conceptual model illustrating relationships among primary habitat needs, stressors, and California spotted owl population resiliency.

Population parameters include CSO territory occupancy, as well as fecundity and survival. Floaters, or non-territorial CSO, may contribute to populations because they can fill in when territories become available. Habitat requirements are broadly categorized into areas of high canopy cover with large (or very large) trees, very large trees, residual trees/snags, coarse woody debris, and small forest gaps/spatial heterogeneity. Some characteristics, such as high canopy cover and large/very large trees affect all population parameters. Other habitat components like coarse woody debris and forest heterogeneity are related to maintaining a sufficient prey base, and thus are more likely to affect fecundity than other parameters. Most potential stressors can affect multiple habitat components or population parameters as well as interact with each other. ~~The most substantial stressor to habitat is large, high-severity fire, which may be modulated somewhat by various forest management practices.~~ However, depending on scale and implementation, these same practices could also decrease certain habitat components. Additionally, barred owls are likely to emerge as a significant stressor to CSO resiliency by decreasing CSO occupancy. Finally, although we know little about contaminants as a stressor to CSO, we suspect the negative effects of contaminants have been going undetected thus far, and

Commented [R57]: The most substantial stressor is logging.

could become a more significant stressor to CSO. Managing for the interaction of these stressors will require a comprehensive region-wide conservation strategy and forest-specific plans.

5.2 Conservation Goal

Our goal is the long-term conservation of CSO and its habitat throughout its range by maintaining viable, connected, and well-distributed populations and habitats through amelioration of stressors and conservation of key habitat components.

6. CONSERVATION OBJECTIVES

6.1 General conservation objectives

Attenuate the population declines of California spotted owl

~~Although it is unclear exactly why CSO are declining, t~~There is now substantial evidence that populations on national forests have declined significantly over the past two decades. ~~Recent evidence suggests that these declines may be a result of previously altered habitat, rather than current forest management practices on national forests (Jones et al. in review).~~ To that end, we need to continue to investigate the causes of the declines, and in the meantime preserve habitat elements we know are critical for CSO conservation. Stopping a population decline is an important part of any conservation strategy (Caughley 1994). Because PACs have been demonstrated as ~~useful~~ insufficient for CSO management (Berigan et al. 2012), focusing on maintaining a network of PACs, ~~as well as other connected~~while increasing the amount of suitable habitat throughout the range of CSO should be emphasized.

Manage habitat for spotted owl use and the long-term establishment of natural fire regimes

~~Among CSO and forest ecology experts there is an ongoing discussion about the need to balance the protection of CSO habitat elements with the reduction of the likelihood of large scale fires (Gutiérrez et al. in press).~~ The only stable CSO population on public lands appears to be in Sequoia Kings Canyon National Park, which has not only more large trees but more of a restored fire regime (Blakesley et al. 2010, Tempel et al. 2014b). California spotted owls prefer high canopy cover, large trees, and complex forest structure, ~~which can coincide with high fuel loads~~ (Gutiérrez et al. in press). Any proposed conservation actions need to ~~be strategic in balancing these seemingly conflicting needs~~maintain these elements at all costs. ~~PACs should be avoided as much as possible, but territories can tolerate more habitat heterogeneity. It will be a challenge to balance enhancing habitat heterogeneity with maintaining sufficient mature closed canopy forest (Kane et al. 2013, Stephens et al. 2014). Short term losses of high canopy cover in some habitat, for example, may be necessary for reducing fuel loads, but could be acceptable to CSO persistence if other critical elements like large trees remain (Tempel et al. 2016). Specific fuel reduction activities should be designed in relation to known CSO territories, but also elevation,~~

Commented [R58]: Why no mention of wildland fire use and prescribed fire?

Commented [R59]: It seems clear to me that managing for PACs has not been sufficient and has led to the CSO decline on USFS lands. I propose making 6000ac protected zone (equivalent to the mean year-round home range size of CSO) around every nest to protect mean year-round home ranges and recruit more old growth forest.

latitude, and forest site productivity. Mechanical treatment on its own will not achieve fire resilient landscape conditions, as it can be implemented on less than half of the productive forestlands in the Sierras regardless (North et al. 2015). The massive tree mortality in the southern Sierras may also make this goal more challenging. However, eEfforts to move the broader landscape toward a more natural fire regime using wildland fire use and prescribed fire with no thinning or logging will be important for long-term persistence (Stephens et al. 2016a).

Develop and encourage voluntary conservation actions

About 75% of CSO habitat and territories are on national forests or parks, with the rest on private timberlands. To conserve CSO and habitat resilience, redundancy, and representation, federal and state agencies and other stakeholders should work together to develop plans that include clear mechanisms for addressing the threats to CSO. In developing conservation plans, we encourage entities to coordinate closely with the Service. Implementation of mechanisms to conserve CSO will benefit from stakeholder participation in conservation planning across land ownership boundaries.

Create a region-wide monitoring program and develop adaptive management plans

Commented [R60]: Adaptive management requires changes be made to management in an experimental design. I propose making at least 2 demography study areas protected from all but absolute minimal thinning, and active wildland fire use for the next 20 years to see what happens. Currently, the only 'control' sites to compare with USFS are the NPS lands. Obviously, USFS lands need to be managed more like NPS lands to see if CSO can be recovered.

Ensuring active monitoring and reporting is critical for understanding region-wide and population-specific changes. The development and implementation of a robust range-wide occupancy based monitoring program would expand upon the few existing long-term demography studies. Such a system would require standardized data collection across forests and land ownerships, and would ideally be implemented within each forest structure. The current demography studies could be compared across landownerships as well to understand the nuances of CSO responses to forest management practices. Without this information, it is difficult to measure the benefit of conservation activities and there would be limited capacity to adaptively manage if current management is ineffective and new science emerges.

Prioritize and support research to address additional uncertainties

In spite of the breadth of research, there are a number of uncertainties that remain about CSO. Most notably, although recent work is beginning to understand the causes of the declines on national forestlands, such causes of CSO declines have not been conclusively determined. We also require more information about the southern California populations in particular, as well as dispersal and recruitment dynamics across a larger landscape. Understanding such parameters across the landscape would help set more specific targets for population sizes and habitat connectivity. Designing experimental studies to test sensitivities to different fuels reduction treatments, as well as different habitat uses on private and public lands would aid in habitat management. Additionally, the future effects from recent tree mortality on spotted owl habitat and use is largely uncertain. Effective amelioration of stressors can only be accomplished if we understand how they affect CSO resiliency, redundancy, and representation.

6.2 Stressor-specific conservation objectives

The following stressor-specific conservation objectives are designed to ameliorate the stressors identified and discussed in this document. These goals are intended to be developed with more specificity within any conservation plan or strategy. In developing CSO plans and strategies, entities should coordinate with the Service to help ensure the specific conservation plans and strategies adequately address the stressors and conservation needs of the species.

Large, high-severity fires

Conservation objective: Retain and restore resilient forests throughout the range of California spotted owls.

~~As a result of a century of fire suppression, CSO habitat is threatened by large, high-severity fires (Stephens et al. 2016b).~~ The majority of areas burned on private and national forest lands occurs as result of wildfire that escape suppression under extreme conditions that are more likely to result in high-severity effects (Lydersen et al. 2014, North et al. 2015). Lower elevations have a higher burn probability, and habitat subjected to high-severity fire is more likely to grow back as chaparral rather than forest, and increase the likelihood of burning again (Lydersen et al. 2014). These effects are exacerbated as the time since the previous fire increases. ~~There is an urgent need to reduce the likelihood of forest ecosystem conversion to chaparral and the associated loss of high quality nesting habitat due to large, high-severity fire.~~

Conservation measures:

1. Increase the use of prescribed and managed fire for low-moderate and mixed severity burn as an active management tool. ~~Mixed-severity fire can reduce surface and ladder fuels, acting as natural fuel breaks.~~ Historically about 486,000 acres a year in the Sierras would burn~~, mostly at low-moderate severity, with small patches of high-severity (North et al. 2012).~~ Efforts should be made to ~~move the forests towards a more natural~~allow forests to establish their own natural fire regime. Restoration of the fire frequency that would mimic pre-settlement rates may not be achievable due to ownership patterns and smoke restrictions and climate change (Quinn-Davidson and Varner 2012). However, increasing burning ~~under moderate weather conditions~~ will be beneficial (Schweizer and Cisneros 2014).
2. ~~Develop a quantitative risk assessment of CSO PACs and other habitat for large, high-severity fires.~~
3. ~~Design and implement fuels reduction activities, prioritizing areas by risk of high-severity fire (see *Forest management practices* below for specific recommendations).~~
4. ~~Focus fuel reductions outside of CSO PACs and core use areas. As PACs occupy a relatively small percentage of the landscape anyway, only 5-9% of productive lands,~~

Commented [R61]: Incorrect. Not all habitat is threatened, please be more careful in the scholarship.

Commented [R62]: Chapparal is a natural successional step between severe fire and the regrowth of forest in unlogged stands (Nagel and Taylor 2005).
This is a completely unsupported sentence. Where was this established? What unique community of species are you damning by making it a priority to stop naturally-occurring chapparal habitat?

Commented [R63]: Fire is not a serious risk to owls, so there is no need for assessment.

limiting the alteration of PACs would not hamper an effort to move the landscape towards a natural fire regime (North et al. 2015).

5.2. Recruit and preserve new CSO habitat outside of the current PACs. We recognize that habitat conditions in some CSO territories might not be viable long-term because of low drought tolerance or high burn probabilities. As some PACs are likely to experience high-severity fire, it will be important to strategically plan for recruiting new CSO habitat suitable under future climate conditions. Such habitat should be focused in topographic positions that will support high canopy cover and large trees under future forest conditions, such as north facing slopes and drainage bottoms (North et al. 2009, 2012). Modeling could build upon existing efforts to create a habitat reserve network across CSO range to ensure connectivity among PACs and populations.

6. Develop a fire management plan across land ownerships. Minimally, coordination of fuel breaks would enhance control of fires and potentially minimize loss of CSO habitat.

Forest management practices

Conservation objective: Utilize forest management tools that are compatible with maintaining essential habitat elements for CSO.

Two centuries of logging has greatly diminished the availability of suitable spotted owl habitat. This threat should be removed from as much land in the range of the species as possible under an adaptive management framework where at least half the USFS lands and including 2 long term demography studies are managed as closely as possible to NPS management with no logging and ample use of wildland fire. There is a critical need to manage for resilience in our forests while preserving connected CSO habitat. This will require some fuels reduction activities at a landscape level (Stephens et al. 2016a). The development of a regional risk assessment for fire in order to prioritize fuels reduction activities in relation to owl habitat is needed. Generally, overstory forest patterns are most associated with the climatic water deficit (Tague et al. 2009), whereas understory conditions are more shaped by the fire history (Lydersen and North 2012). Loss of habitat or abandonment of territories from certain forest management practices can be a serious concern for CSO persistence. Avoiding primary CSO use areas and maintaining the most important habitat elements can ameliorate the effects of some activities. The effects on CSO from clearcutting and even-aged management practices, as well as salvage logging, likely depend on scale, and some industrial forestlands do have nesting individuals.

Conservation measures:

1. Initiate an immediate moratorium on all logging, thinning, and mechanical treatments and encourage wildland fire use and prescribed burning on half of all forested lands within the range of the CSO that are managed by USFS (including at least 2 long-term demography study areas)

as an adaptive management experiment to determine whether NPS-style land management will reverse the CSO declines on USFS lands.

2. Thinning treatments should be limited to within 500m of communities and structures and should leave all large (>24in dbh) and very large (>36in dbh) trees and snags.

3. End all salvage logging in the range of the CSO. It serves no ecological purpose, causes significant harm to forest recruitment and hydrology, and destroys one of the rarest and most biodiverse habitat types in California.

0. Design thinning treatments to leave large (≥24 in) and very large (≥36 in. dbh) trees and snags. Modeling indicates that thinning treatments of trees at 12, 20, and 30 in. dbh could yield a similar reduction in burn probability (Collins et al. 2011b), so removal of smaller trees, rather than larger ones important to CSO habitat, should be prioritized.
0. Manage mechanical thinning toward individual trees, clumps, and openings (ICO) (Lydersen et al. 2013). Some work suggests that about 200-300 acres of high canopy forest in a CSO territory could maximize fitness (Tempel et al. 2014b), though this is not a firm target. In general, contiguous patches of mature closed canopy forest that is embedded with small forest openings and some variable forest composition (such as large oaks) may promote foraging, and would be consistent with a natural fire regime (van Wagtendonk and Lutz 2007). Heterogeneity may somewhat compensate for decreased canopy cover from fuel treatments in the maintenance of flying squirrels (Sollmann et al. 2016).
0. Focus treatments on fostering the growth rate of larger trees, which are then retained long-term. Enhancing important attributes like large and defect trees might be able to maintain viable CSO populations when less high canopy cover is present (Gutiérrez et al. in press).
0. Design some fuels reduction treatments to experimentally test CSO responses. This is obviously challenging in a long-lived species with high site fidelity, but would improve our understanding of CSO resiliency to particular fuels reduction activities. In spite of some studies, the effectiveness of fuel treatments and the balance between reducing fire risk and effects on CSO fitness remains unclear.
0. Although it is difficult to disentangle fire and salvage logging effects on CSO, it seems prudent to avoid salvage logging of viable habitat, where possible. California spotted owls persist in territories that experience low-moderate severity fire, with some mixed-severity as well (Bond et al. 2002, Roberts et al. 2011, Lee et al. 2012, Lee et al. 2013, Lee and Bond 2015). However, in situations where over half a territory has burned at high-severity (Jones et al. 2016a) and individuals have abandoned the territory due to severe natural alteration, astute salvage could be warranted. Such salvage would require

leaving large snags and downed logs, as well as subsequent replanting to maximize heterogeneity and habitat restoration.

0. In timber harvest plans that utilize a clearcutting strategy, design harvests to retain essential habitat elements. This would include multiple, non-uniformly distributed and irregularly shaped patches, balancing for old growth and some early seral stage forests to maximize biodiversity (Burnett and Roberts 2015). Such patches on industrial forestlands can enhance small mammal abundance (Gray et al. 2016). For NSO, for example, tree stands at 109-152 ft^2/acre had the highest probability of foraging use, particularly when streamside (Irwin et al. 2015). Focus on retaining such riparian habitat.
0. Harvest plans should be strategically designed to maintain CSO habitat for long-term resiliency. Monitoring plans will be required to adequately address any negative or positive effects from management activities. 1.

Tree mortality

Conservation objective: Monitor the effects of tree mortality on CSO.

We do not yet know how the tree mortality will affect CSO. Continued drought and dense forests could lead to additional mortality events. Though direct management options are limited, managing the forests toward more resilient conditions as recommended could aid in reducing the likelihood of tree mortality (van Mantgem et al. 2016). This may include some combination of prescribed fire and thinning treatments. For ponderosa pine stands in northern California, for example, a threshold stand density index (SDI; total basal area of all trees in a stand) of 230-365 ft. SDI has been suggested for ponderosa pine stands (Oliver 1995, Hayes et al. 2009) to avoid drought and stress induced tree mortality.

Commented [R64]: Why are you concerned about natural mortality?

Barred owls

Conservation objective: Establish and implement a monitoring and management study or plan for barred owls.

Barred owls are a threat to NSO, and are set to become an imminent threat to CSO. Current knowledge of barred owl presence in CSO range is primarily incidental. California spotted owls will require a comprehensive monitoring and management plan to address this issue. Ongoing research suggests that while removal of barred owls will allow NSO to reoccupy territories, barred owls may return to some territories within a few years (Diller et al. 2014). Because California spotted owl range is currently at the edge of barred owl expansion, if the expansion is to be slowed or halted, a proactive plan to address the threat of barred owl expansion should be implemented. Control measures would likely be most effective now, while barred owls are still at low densities (Dugger et al. 2016) within the range of CSO. However, advocating removal of one species for another is a controversial decision.

Conservation measures:

1. We recommend the immediate development of an active monitoring scheme.
2. Given the substantial effects barred owls have had on NSO, we recommend the development of a comprehensive barred owl management study or plan for CSO. Such a plan would be intended to get ahead of this emerging threat before full barred owl expansion occurs within the range of CSO.

Contaminants

Conservation objective: Identify rodenticide exposure rates in California spotted owls.

Little information regarding the exposure rate of contaminants on CSO exists. However, the high exposure rates to rodenticides in barred owls and fisher would suggest CSO rates could be high as well (Gutiérrez et al. 2007, Gabriel et al. 2012). Thus, minimizing exposure to contaminants and beginning to test individuals for rodenticides would be prudent. Working with law enforcement partners to monitor the amount of rodenticides on the landscape will be of importance to long-term conservation of CSO.

Climate change

Conservation objective: Align habitat planning and protection with areas likely to support high canopy cover and large trees under future climate scenarios.

Although CSO might not be among the bird species most vulnerable to direct effects from climate change in the Sierras (Siegel et al. 2014), ~~associated~~ if predicted increases in large fires and tree mortality occur, they ~~are likely to~~may negatively affect CSO habitat. Thus it will be important not only to protect current habitat, but also to recruit new habitat. CSO tend to use topographic areas associated with higher productivity anyway, such as canyon bottoms, lower slopes, and northeast aspect positions, which are likely to support older forests (Underwood et al. 2010). Recent work suggests that managing for greater amounts of closed canopy habitat at higher elevations in particular might be beneficial to ensure available habitat in the long-term (Jones et al. 2016b).

~~To support long term persistence of California spotted owls, it will be important to manage for forests that are resilient to fire and climate change while still maintaining essential habitat elements.~~

7. LITERATURE CITED

Commented [R65]: I have added a list of literature that should be considered during revision in my separate comment letter. The list is by no means exhaustive and I recommend a thorough, systematic review of the topics important to the development of this COR.

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Commented [R66]: This paper is filled with errors of analysis that render it entirely unreliable. First, their owl population has documented long-term trends of decreasing site colonization and increasing site extinction probabilities, before the King Fire (Tempel and Gutiérrez 2013). However, Jones *et al.* did not account for these important pre-fire trends in their site occupancy analyses. Site occupancy analysis measures, each year, the probability that occupied sites are abandoned (called site extinction), and the probability that empty sites are colonized and become occupied again, and uses those colonization and extinction probabilities to calculate a yearly average probability of site occupancy. The population has had 22 years of documented trends of ever-lower site colonization probability, and ever-increasing site extinction probability, yet the authors simply compared their 1 year of post-fire data against the average of all previous years without accounting for those known year-to-year trends in colonization and extinction probabilities. The pre-fire trend means 2015 (the year after fire) was expected follow the trend of having higher extinction probability relative to all previous years, <u>even if there was no fire</u>. Fig. 3f clearly shows that the 2015 post-fire year of decrease in occupancy was not significantly different from the 10 previous years of decrease. The 'trend analysis' Jones et al. did was not what I just described. Rather, Jones et al. took annual estimates of site occupancy and compared a few models to describe the 23 years of annual occupancy rates. This trend analysis is not the same as including the pre-fire trends in extinction and colonization probabilities described above.
Second, Jones *et al.* used compositional analysis of foraging habitat use, a method that is inappropriate for central place foragers like spotted owls (Rosenberg and McKelvey 1999; Bond *et al.* 2009; Bond *et al.* 2016). Foraging habitat use analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal's territory. Compositional analysis compares simplistic ratios of the proportion of foraging points in a habitat type relative to the proportion of territory area in that type. The proper habitat use analysis is a 'resource selection function', a math model that accounts for the fact that spotted owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every spotted owl foraging habitat use paper has found distance from nest is a <u>highly significant</u> effect on a point's probability of use – but Jones *et al.* did not account for the distance of a foraging site to the nest. Because Jones *et al.* did not do a proper resource selection function analysis, they were essentially ignoring each foraging point's distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fatal mistake makes their radiotelemetry results and discussion unreliable.
Third, Jones *et al.* reported extinction for a territory in WebFigure 4 when the owls shifted their location by a distance that is less than the diameter of a territory as defined by the authors. The owls' shift was also less than mean foraging distance reported by the authors. Because the authors ignored their own definition of a territory, they arbitrarily declared the short-distance shift to signify the extinction of the 'old' territory and creation of a 'new' territory a few hundred meters away. This was an arbitrary reclassification of a continuously occupied territory whose occupants shifted a few hundred meters, an occurrence that happens quite often in spotted owl territories. This decision inflated their 'burned site' extinction probability by classifying a normal within-territory movement as site extinction. ... [2]

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Jones et al 2016 is a fatally flawed paper with multiple errors of analyses that make it unreliable.

First, their owl population has documented long-term trends of decreasing site colonization and increasing site extinction probabilities, before the King Fire (Tempel and Gutiérrez 2013). However, Jones et al. did not account for these important pre-fire trends in their site occupancy analyses. Site occupancy analysis measures, each year, the probability that occupied sites are abandoned (called site extinction), and the probability that empty sites are colonized and become occupied again, and uses those colonization and extinction probabilities to calculate a yearly average probability of site occupancy. The population has had 22 years of documented trends of ever-lower site colonization probability, and ever-increasing site extinction probability (Tempel and Gutiérrez 2013), yet the authors simply compared their 1 year of post-fire data against the average of all previous years without accounting for those known year-to-year trends in colonization and extinction probabilities. The pre-fire trend means 2015 (the year after fire) was expected follow the trend of having higher extinction probability relative to all previous years, even if there was no fire. Fig. 3f clearly shows that the 2015 post-fire year of decrease in occupancy was not significantly different from the 10 previous years of decrease.

The ‘trend analysis’ Jones et al. did was not what I just described. Rather, Jones et al. simply took annual estimates of site occupancy and compared a few models to describe the 23 years of annual occupancy rates. This trend analysis is not the same as including the pre-fire trends in extinction and colonization probabilities described above.

The second flaw was, Jones et al. used compositional analysis of foraging habitat use, a method that is inappropriate for central place foragers like spotted owls (Rosenberg and McKelvey 1999; Bond et al. 2009; Bond et al. 2016). Foraging habitat selection analysis aims to determine whether a habitat type, for example severely burned forest, was used more often or less often than it would if the animal was foraging randomly and used the habitat type in proportion to its availability in the animal’s territory. Compositional analysis compares simplistic ratios of the proportion of foraging points in a habitat type relative to the proportion of territory area in that type. The proper habitat use analysis is a ‘resource selection function’, a math model that accounts for the fact that spotted owls, as central place foragers, will return to their nest or roost trees many times during the night, so their probability of using habitats near the nest is much higher than the probability of using habitats farther away from the nest. Every spotted owl foraging habitat use paper has found distance from nest is a highly significant effect on a point’s probability of use – but Jones et al. did not account for the distance of a foraging site to the nest. Because Jones et al. did not do a proper resource selection function analysis, they were essentially ignoring each foraging point’s distance from the nest, and the distribution of different habitat types at different distances from the nest, and this fatal mistake makes their radiotelemetry results and discussion unreliable.

Third, Jones et al. reported extinction for a territory in WebFigure 4 when the owls shifted their location by a distance that is less than the diameter of a territory as defined by the authors. The owls’ shift was also less than mean foraging distance reported by the authors. Because the authors ignored their own definition of a territory, they arbitrarily declared the short-distance shift to signify the extinction of the ‘old’ territory and creation of a ‘new’ territory a few hundred meters away. This was an arbitrary reclassification of a continuously occupied territory whose occupants shifted a few hundred meters, an occurrence that happens quite often in spotted owl territories. This decision inflated their ‘burned site’ extinction probability by classifying a normal within-territory movement as site extinction.

The sites that were occupied in 2014 are those most relevant to extinction probability in 2015, the only significant ‘fire-related’ effect Jones et al. found in 2015 and attributed to the King Fire. 2014 occupied site sample sizes indicates Jones et al. make their claim of ‘large extinction effects’ from only 8 severely burned sites that were occupied in 2014. Considering that Jones et al. did not account for the long-term increasing site extinction probability (meaning site extinction probability was getting bigger every year leading up to the fire), and the fact that only 8 sites in the burned area were occupied before the fire in 2014, and at least one site that they declared extinct from the fire actually just moved a few hundred meters, means their results are not correct.

Given the analytical shortcomings I described, I suggest the results reported by Jones et al. be viewed with caution and not used to justify management actions that harm spotted owls.

Additionally, errors of scholarship in Jones et al. 2016 include:

Pg. 304 “The observation that lower-severity fire is benign, and perhaps even moderately beneficial, to spotted owls is consistent with previous studies (Roberts et al. 2011; Lee et al. 2012)”
Both those studies found mixed-severity fire (rather than lower-severity fire) had no effect on occupancy. Mixed severity fire is common historically and currently in the Sierra Nevada and explicitly includes low, moderate, and high severity burned patches.

Pg. 305, “because owls were not individually marked in the Rim Fire study, some detections at “occupied” sites may have involved individuals from neighboring territories or non-territorial “floaters” (Lee and Bond 2015), both of which may have contributed to inflated estimates of territory occupancy.”
This exact same situation exists in the data analysed by Jones et al. Data were collected as described in Tempel and Gutiérrez (2013), “We included both nocturnal and diurnal surveys in our occupancy analyses.” During nocturnal surveys leg bands were usually not resighted, therefore detections at occupied sites would have been similarly inflated by individuals from neighboring territories or non-territorial floaters.

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This paper is filled with errors of analysis that render it entirely unreliable. First, their owl population has documented long-term trends of decreasing site colonization and increasing site extinction probabilities, before the King Fire (Tempel and Gutiérrez 2013). However, Jones *et al.* did not account for these important pre-fire trends in their site occupancy analyses. Site occupancy analysis measures, each year, the probability that occupied sites are abandoned (called site extinction), and the probability that empty sites are colonized and become occupied again, and uses those colonization and extinction probabilities to calculate a yearly average probability of site occupancy. The population has had 22 years of documented trends of ever-lower site colonization probability, and ever-increasing site extinction probability, yet the authors simply compared their 1 year of post-fire data against the average of all previous years without accounting for those known year-to-year trends in colonization and extinction probabilities. The pre-fire trend means 2015 (the year after fire) was expected follow the trend of having higher extinction probability relative to all previous years, even if there was no fire. Fig. 3f clearly shows that the 2015 post-fire year of decrease in occupancy was not significantly different from the 10 previous years of decrease.
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