CONSERVATION CONCERNS FOR SIERRA NEVADA BIRDS ASSOCIATED WITH HIGH-SEVERITY FIRE

CHAD T. HANSON, Earth Island Institute, 2150 Allston Way, Suite #460, Berkeley, California 94704; cthanson1@gmail.com

ABSTRACT: Numerous avian species are positively associated with "snag forest" habitat created by patches of high-severity fire, mainly because of the abundance of standing fire-killed trees (snags) and fire-following shrubs. There is now considerably less severe fire than there was historically in the forests of California's Sierra Nevada, owing to fire suppression. Moreover, under current policies for management of public and private forest, much of the snag forest created by fire is subjected to post-fire logging of snags. Mechanical mastication and herbicide spraying of shrubs, followed by planting of conifers, are also common, and large-scale programs of mechanical thinning seek to prevent creation of this habitat. Thus there is reason for concern for birds associated with snag forest. I synthesized existing research to identify the species positively associated with this habitat and assessed their population trends according to the Breeding Bird Survey. In the Sierra Nevada 24 species are associated with snag forest, and half of these are declining or are too rare for the Breeding Bird Survey to detect any trend. For snag-forest species, there are significantly more declines than increases (all snag-forest species with statistically significant population trends are declining), whereas species of unburned forest manifest no such pattern. These results indicate a need for more managed wildland fire, and for current management policies, both pre- and post-fire, to be revisited, particularly in national forests where most of the post-fire habitat exists.

Recently there has been increased research interest in birds and post-fire environments of conifer forests of the western U.S., including in the Sierra Nevada of California. Numerous bird species have been found to select post-fire habitat created by severe fires (i.e., patches in which most or all trees are killed) (e.g., Hanson and North 2008, Fontaine et al. 2009, Bond et al. 2012, Odion and Hanson 2013, DellaSala et al. 2014). This "snag forest" habitat, also known as "complex early seral forest" (DellaSala et al. 2014), is rich in standing fire-killed trees, or "snags," used by woodpeckers and secondary cavity-nesters, and has an abundance of fire-following flowering shrubs, which attract flying insects and, in turn, aerial insectivores (Hanson 2007, Fontaine et al. 2009, DellaSala et al. 2014). Biodiversity and wildlife abundance in snag forest is high, particularly among birds, and is comparable to, and often higher than, that found in unburned old forest (Fontaine et al. 2009, Burnett et al. 2012, Swanson et al. 2011, DellaSala et al. 2014).

Since the early 20th century, however, snag forest has become rare in the Sierra Nevada because of fire-suppression policies, resulting in a twofold (Mallek et al. 2013) to fourfold (Odion and Hanson 2013, Hanson and Odion 2014, Odion et al. 2014) decline in severe fire. Moreover, on both public and private lands, when fires do occur, much of the post-fire habitat—especially in severely burned areas—is subjected to intensive post-fire logging, with no restrictions on logging around nest sites for most species, as well as mechanical mastication and herbicide-spraying of shrubs, followed by planting of conifers (USFS 2004). These practices exacerbate the deficit in snag forest caused by fire suppression (Swanson et al. 2011, DellaSala et al. 2014). Furthermore, the U.S. Forest Service is currently proposing

as much as a tenfold increase in large-scale projects of mechanical thinning designed to prevent severe fires in the first place (North 2012). After a fire, logging, reduction/removal of native shrubs, and planting of conifers are the common current practice on private lands and much of national forest lands (USFS 2014a–c). For these reasons, researchers' concern about conservation of species associated with snag forest is justified.

My objectives in this study were three. First, to synthesize existing data to determine which forest birds native to the Sierra Nevada are positively associated with the habitat conditions created by severe fire and which are associated with unburned forests. Second, to determine the extent to which species in these two habitats are at risk because of either declining populations or rarity. Third, to determine whether declining species are disproportionately represented in one habitat or the other (snag forest or unburned).

METHODS

This paper contains both a synthesis of existing literature on habitat associations of Sierra Nevada bird species with regard to wildland fire and an analysis of population trends in two sets of species: those associated with severe fire and those associated with unburned forest.

First, I synthesized existing studies that have investigated the relationships between severe fire and birds native to the Sierra Nevada to identify those species that tend to select snag forest during the breeding season. Four published, peer-reviewed studies addressing this question, Raphael and White (1984), Raphael et al. (1987), Hanson and North (2008), and Fontaine et al. (2009), are the basis for my categorization.

Raphael and White (1984) and Raphael et al. (1987) compared use of unburned forest and severely burned forest by various species in the northern Sierra Nevada. The former used a cluster analysis with a threshold of 0.75 for overlap in selection of nesting habitat. The latter evaluated species' habitat associations in a severely burned area versus an adjacent unburned forest by using frequencies of detection in surveys during three intervals, 6–8, 15–19, and 21–25 years after the fire. Raphael et al. (1987) did not include a statistical analysis, so I characterized species as being associated with severe fire or unburned forest if, during the breeding season, they were at least twice as abundant in one forest type than in the other. Hanson and North (2008), using point counts, investigated the relationship between three woodpecker species and fire severity in the Sierra Nevada in terms of foraging-habitat selection in three burned areas at 2 to 4 years after the fire. Fontaine et al. (2009) used point counts to evaluate differences in birds' use of unburned versus severely burned forest of two ages in southwestern Oregon. Though their study was not in the Sierra Nevada, it was useful in identifying the habitat association of a few of the rarer Sierra Nevada species for which the Sierra Nevada studies had too few (or no) detections for habitat selection to be assessed effectively. From Hanson and North (2008) and Fontaine et al. (2009) I categorized a species as associated with severe fire or unburned forest if the studies reported a statistically significant association with such habitat (at $\alpha = 0.05$).

In some cases the literature identifies a species as being associated

with severe fire only in the early years after the fire (e.g., Black-backed Woodpecker, Hairy Woodpecker, and Dark-eyed Junco [scientific names in Table 1]) but not in older burns, or vice versa (e.g., Orange-crowned Warbler, MacGillivray's Warbler). I have included both categories in the list of species associated with severe fire.

I restricted the list to species whose California breeding ranges lie primarily or exclusively in the montane and foothill forests of the Sierra Nevada, not extending to other nearby ecosystems such as the Central Valley to the west or the desert to the east. For this selection I used range maps from field guides to birds of western North America in general and northern California in particular (Fix and Bezener 2000, Peterson 2010).

Once the list of bird species associated with severely burned areas was determined, I used population-trend data (1966–2012) for the Sierra Nevada region from the Breeding Bird Survey (BBS) (http://www.mbr-pwrc.usgs.gov/cgi-bin/atlasa12.pl?S15&2&12) as the basis for which species are declining or increasing or are too rare for BBS data to reveal trends with confidence. I categorized a declining species as being at risk only if the long-term trend (1966–2012) was statistically significant, as coded by red at the BBS website (http://www.mbr-pwrc.usgs.gov/bbs/trend_info10.html).

I characterized species with serious data deficiencies due to rarity (coded by a red dot in BBS data: http://www.mbr-pwrc.usgs.gov/bbs/credhm09.html)—those with so little data that no trend could be estimated—as being at risk because of the inherent vulnerability of small populations (Traill et al. 2007).

Second, I used these sources to also identify the Sierra Nevada birds most strongly associated with the opposite end of the spectrum: unburned forest. To identify species at risk within this group, I used the BBS data as described above for snag-forest species.

To base the assessment on sets of species with a clear contrast, I excluded from the analysis species that were significantly associated neither with snag forest nor with unburned forest, for example, those species for which habitat associations are not yet well understood or which are more associated with intermediate levels of fire severity.

I used a chi-squared test for goodness of fit (Rosner 2000) to determine whether the proportions of increasing and declining species—those with statistically significant BBS trends—differed from the expectation under the null hypothesis of an equal proportion of increasing and decreasing species.

RESULTS

I identified 24 forest birds native to Sierra Nevada that are associated with severely burned areas (Table 1). Of these 24 species, 10 have a population trend in the Sierra Nevada with a statistically significant decline, and six of these are also experiencing significant population declines across the United States as a whole (Table 1). Data for an additional two species are insufficient for a trend to be estimated (Table 1). Of the remaining species, most have downward trends, but these are not statistically significant. All of the snag-forest species with statistically significant population trends are in decline.

I identified 17 forest birds associated with unburned forests (Table 2). Of

Table 1 Birds Associated with Severely Burned Areas in the Sierra Nevada and Their Population Trends

Nesting guild and species	Studies indicating habitat association	BBS trend, 1966–2012[a]
Canopy		
Calliope Hummingbird *Selasphorus calliope*	Raphael et al. 1987	
Olive-sided Flycatcher *Contopus cooperi*	Raphael et al. 1987 Fontaine et al. 2009	–3.71[b]
Western Wood-Pewee *Contopus sordidulus*	Raphael et al. 1987	–1.68
Warbling Vireo *Vireo gilvus*	Fontaine et al. 2009	
Purple Finch *Haemorhous purpureus*	Fontaine et al. 2009	–2.14[b]
Shrub and ground		
Mountain Quail *Oreortyx pictus*	Fontaine et al. 2009	
Common Nighthawk *Chordeiles minor*	Raphael et al. 1987	
Dusky Flycatcher *Empidonax oberholseri*	Fontaine et al. 2009	
Wrentit *Chamaea fasciata*	Fontaine et al. 2009	–1.98
Orange-crowned Warbler *Oreothlypis celata*	Fontaine et al. 2009	–2.32[b]
Nashville Warbler *Oreothlypis ruficapilla*	Fontaine et al. 2009	–1.54[b]
MacGillivray's Warbler *Geothlypis tolmiei*	Fontaine et al. 2009	
Yellow Warbler *Setophaga petechia*	Raphael et al. 1987	–1.26[b]
Green-tailed Towhee *Pipilo chlorurus*	Raphael et al. 1987 Fontaine et al. 2009	
Chipping Sparrow *Spizella passerina*	Raphael et al. 1987	–2.85
Brewer's Sparrow *Spizella breweri*	Raphael et al. 1987	
Fox Sparrow *Passerella iliaca*	Raphael et al. 1987 Fontaine et al. 2009	
White-crowned Sparrow *Zonotrichia leucophrys*	Fontaine et al. 2009	
Dark-eyed Junco *Junco hyemalis*	Fontaine et al. 2009	–1.12[b]
Cavity		
Lewis's Woodpecker *Melanerpes lewis*	Raphael and White 1984	NA[c]
Hairy Woodpecker *Picoides villosus*	Raphael et al. 1987 Fontaine et al. 2009	
Black-backed Woodpecker *Picoides arcticus*	Raphael et al. 1987 Hanson and North 2008	NA[c]
Pygmy Nuthatch *Sitta pygmaea*	Raphael and White 1984 Raphael et al. 1987	–2.93
Mountain Bluebird *Sialia currucoides*	Raphael and White 1984 Raphael et al. 1987	

[a]Percent change per year in Sierra Nevada. Only statistically significant trends are shown.

[b]Species also experiencing significant long-term (1966–2012) and short-term (2002–2012) population declines nationally, according to the BBS (http://www.mbr-pwrc.usgs.gov/cgi-bin/atlasa12.pl?US&2&12).

[c]Detections during the BBS, at both the regional and national scales, too few for any trend to be estimated, and there are major deficiencies in the data (BBS red dot category).

Table 2 Birds Associated with Unburned Forest in the Sierra Nevada and Their Population Trends

Nesting guild and species	Studies indicating habitat association	BBS trend, 1966–2012[a]
Canopy		
Pacific-slope Flycatcher *Empidonax difficilis*	Fontaine et al. 2009	
Hutton's Vireo *Vireo huttoni*	Fontaine et al. 2009	+5.33
Steller's Jay *Cyanocitta stelleri*	Raphael et al. 1987	
Brown Creeper *Certhia americana*	Raphael and White 1984 Raphael et al. 1987 Fontaine et al. 2009	
Golden-crowned Kinglet *Regulus satrapa*	Raphael et al. 1987 Fontaine et al. 2009	
Black-throated Gray Warbler *Setophaga nigrescens*	Fontaine et al. 2009	–1.61[b]
Hermit Warbler *Setophaga occidentalis*	Fontaine et al. 2009	
Western Tanager *Piranga ludoviciana*	Raphael et al. 1987	+1.21
Red Crossbill *Loxia curvirostra*	Raphael et al. 1987	NA[c]
Evening Grosbeak *Coccothraustes vespertinus*	Raphael et al. 1987	NA[c]
Shrub and ground		
Hermit Thrush *Catharus guttatus*	Raphael et al. 1987 Fontaine et al. 2009	
Wilson's Warbler *Cardellina pusilla*	Fontaine et al. 2009	-4.71[b]
Cavity		
Williamson's Sapsucker *Sphyrapicus thyroideus*	Raphael and White 1984	+3.14
Red-breasted Sapsucker *Sphyrapicus ruber*	Raphael and White 1984	
Chestnut-backed Chickadee *Poecile rufescens*	Fontaine et al. 2009	NA[c]
Red-breasted Nuthatch *Sitta canadensis*	Raphael and White 1984 Raphael et al. 1987 Fontaine et al. 2009	
Pacific Wren *Troglodytes pacificus*	Fontaine et al. 2009	

[a]Percent change per year in Sierra Nevada. Only statistically significant trends are shown.

[b]Species also experiencing significant long-term (1966–2012) and short-term (2002–2012) population declines nationally, according to the BBS (http://www.mbr-pwrc.usgs.gov/cgi-bin/atlasa12.pl?US&2&12).

[c]Detections during the BBS, at both the regional and national scales, too few for any trend to be estimated, and there are major deficiencies in the data (BBS red dot category).

these 17, two have experienced a statistically significant decline in the Sierra Nevada, three have experienced an increase, and three are too rare for their trend to be determined (Table 2).

Among snag-forest species associated with severely burned areas, the ratio of declining species to increasing species was significantly greater

than expected, contradicting the null hypothesis ($\chi^2 = 10.0$, $P = 0.002$). The observed numbers of increasing and decreasing snag-forest species were zero and ten, respectively, whereas the expected values for both were five. The number of species of unburned forest with statistically significant population trends was insufficient for this analysis, but there were more increasing species than decreasing species. Thus, while it cannot be said that significantly more species of unburned forest are increasing rather than decreasing, the possibility that more of these species are decreasing than increasing can be ruled out.

DISCUSSION

These results imply that about half of the Sierra Nevada bird species associated with severe fire are at risk, including some nesting in the canopy, in shrubs, and in cavities. BBS data also suggest that most of these are experiencing population decline nationally as well (Table 1). Moreover, all of the Sierra Nevada snag-forest species with statistically significant population trends are declining, a pattern not evident for the species of unburned forest.

Stephens et al. (2012) analyzed the effects of mechanical forest thinning intended to inhibit fires, but they did not include the effects of such fire reduction on species associated with habitat created by severe fire. They suggested that such projects have "few unintended consequences" (p. 558). However, the substantial number of bird species that select severely burned areas, and the pattern of declines among these species, indicate that the effects on snag-forest associates from management designed to reduce fire cannot be so easily dismissed.

White et al. (2013) suggested that mechanical thinning could be used to create "open" forests, with which many species are aligned. However, White et al. did not distinguish between open conditions created by intensive mechanical thinning, which is designed to minimize snags and reduce shrubs, versus open conditions created by natural disturbance, which contain an abundance of snags and patches of chaparral. For this reason, White et al. (2013) categorized species such as the Olive-sided Flycatcher and Black-backed Woodpecker, which are associated with severe fire, as associated with "open" forest rather than burned habitat. However, logging creates an ecological trap for the former (Robertson and Hutto 2007), and, once the forest is burned, severely degrades it for the latter by reducing the density of snags (Hutto 2008). This underscores the need for the rather specific nature of burned habitat, and the species associated with it, to be to recognized (DellaSala et al. 2014).

The species associated with fire-following shrubs may be particularly vulnerable, as this group contains the largest number of species at risk. The threats to these species—as well as to other species associated with snag forest—from current policies for forest/fire management are compounded by a lack of protection during nesting season. Much of the post-fire logging and pre-fire mechanical thinning is ground-based, and heavy machinery crushes shrub patches, potentially affecting nesting birds, since there are currently no restrictions to prevent this (USFS 2004). The U.S. Forest Service's conservation strategy for the Black-backed Woodpecker, which is the agency's chosen "management indicator species" for snag forest, strongly

recommends no logging in the nesting season, to protect not only Black-backed Woodpecker chicks as snags are felled, but also the many other birds of Black-backed Woodpecker habitat (Bond et al. 2012). However, although many studies of birds and burned habitat have been published over the last decade, the Forest Service has not incorporated this recommendation into its plan governing Sierra Nevada national forests (USFS 2004, USFS 2014a-c).

Additional harm to species associated with post-fire shrub habitat is caused by planting of conifers, intended to short-circuit the chaparral stage of natural post-fire succession and substantially reduce the extent and duration of shrub cover. This suppression of shrubs is exacerbated by post-fire logging often being promoted as a means of generating revenue to fund artificial planting of conifers (USFS 2004). Thus current post-fire management practices represent a threat to species that nest in or under shrubs, like the Orange-crowned Warbler, which is associated with intermediate stages of succession of severely burned forest in the Pacific states and the northern Rockies (Hutto 1995, Fontaine et al. 2009) and which is declining in the Sierra Nevada.

While my results highlight conservation concern for snag-forest species, they do not suggest that there are no threats to any species in unburned forest in the Sierra Nevada, particularly those of specialized habitat within unburned forest. For example, one of the declining species of unburned forest, Wilson's Warbler, is associated with dense thickets of riparian shrubs and small trees, and livestock grazing has been identified as a substantial threat in this regard (Beedy and Pandolfino 2013). Also, dense, old conifer forest is disproportionately affected by intensive mechanical thinning, which under current management tends to remove most of the trees, many of which are mature and old (USFS 2004). The California Spotted Owl (*Strix occidentalis occidentalis*), which the Forest Service considers sensitive, tends to avoid such thinned areas (Gallagher 2010). Dense, old forest adjacent to unmanaged burned patches offers conditions optimal for this species, since the owls prefer the former for nesting and roosting, the latter for foraging (Bond et al. 2009). Under current management (USFS 2004), these conditions are being targeted by mechanical thinning of dense old forest and by post-fire logging (DellaSala et al. 2014), which tends to reduce occupancy (Lee et al. 2012). The California Spotted Owl is now experiencing a population decline, except in unmanaged forests protected on national park lands (Conner et al. 2013, Tempel and Gutiérrez 2013, Tempel 2014).

Thus a reevaluation of current policies for forest and fire management (i.e., fire suppression, forest thinning for fuel reduction, post-fire logging, shrub eradication, and conifer planting) is warranted, especially on federal public lands where most of the current and potential habitat for these species occurs. Furthermore, increased use of managed wildland fire, particularly in remote areas, to restore fire of mixed severity to these forests, would benefit many species.

ACKNOWLEDGMENTS

Thanks are due to all of the authors of the cited studies regarding snag-forest habitat for their intellectual curiosity about this unique forest type, and for their countless hours of field work in difficult terrain. I also thank the peer reviewers and *Western Birds*' editorial staff for numerous helpful suggestions that improved the manuscript.

LITERATURE CITED

Beedy, E. C., and Pandolfino, E. R. 2013. Birds of the Sierra Nevada: Their natural history, status, and distribution. Univ. of Calif. Press, Berkeley.

Bond, M. L., Lee, D. E., Siegel, R. B., and Ward, J. P., Jr. 2009. Habitat use and selection by California Spotted Owls in a postfire landscape. J. Wildlife Mgmt. 73:1116–1124.

Bond, M. L., Siegel, R. B., and Craig, D. L. 2012. A conservation strategy for the Black-backed Woodpecker (*Picoides arcticus*) in California, version 1.0. Report from the Institute for Bird Populations, Point Reyes Station, CA, to the U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

Burnett, R. D., Preston, M., and Seavy, N. 2012. Plumas Lassen study 2011 annual report. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

Conner, M. M., Keane, J. J., Gallagher, C. V., Jehle, G., Munton, T. E., Shaklee, P. A., and Gerrard, R. A. 2013. Realized population change for long-term monitoring: California Spotted Owl case study. J. Wildlife Mgmt. 77:1449–1458.

DellaSala, D. A., Bond, M. L., Hanson, C. T., Hutto, R. L., and Odion, D. C. 2014. Complex early seral forests of the Sierra Nevada: What are they and how can they be managed for ecological integrity? Nat. Areas J. 34:310–324.

Fix, D., and Bezener, A. 2000. Birds of Northern California. Lone Pine Publishing, Renton, WA.

Fontaine, J. B., Donato, D. C., Robinson, W. D., Law, B. E., and Kauffman, J. B. 2009. Bird communities following high-severity fire: Response to single and repeat fires in a mixed evergreen forest, Oregon, USA. Forest Ecol. Mgmt. 257:1496–1504.

Gallagher, C. V. 2010. Spotted Owl home range and foraging patterns following fuels-reduction treatments in the northern Sierra Nevada, California. M.S. thesis, Univ. of Calif., Davis.

Hanson, C. T. 2007. Post-fire management of snag forest habitat in the Sierra Nevada. Ph.D. dissertation, Univ. of Calif., Davis.

Hanson, C. T., and North, M. P. 2008. Postfire woodpecker foraging in salvage-logged and unlogged forests of the Sierra Nevada. Condor 110:777–782.

Hanson, C. T., and Odion, D. C. 2014. Is fire severity increasing in the Sierra Nevada mountains, California, USA? Int. J. Wildland Fire 23:1–8.

Hutto, R. L. 1995. Composition of bird communities following stand-replacement fires in northern Rocky Mountain (U.S.A.) conifer forests. Cons. Biol. 9:1041–1058.

Hutto, R. L. 2008. The ecological importance of severe wildfires: Some like it hot. Ecol. Appl. 18:1827–1834.

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

Mallek, C., Safford, H., Viers, J., and Miller, J. 2013. Modern departures in fire severity and area vary by forest type, Sierra Nevada and southern Cascades, USA. Ecosphere 4, article 153; http://www.esajournals.org/doi/full/10.1890/ES13-00217.1.

North, M. 2012. A desired future condition for Sierra Nevada forests, in Managing Sierra Nevada forests (M. North, ed.), pp. 165–176. Gen. Tech. Rep. PSW-GTR-237. U.S. Forest Service, Pacific Southwest Research Station. Albany, CA.

Odion, D. C., and Hanson, C. T. 2013. Projecting impacts of fire management on a biodiversity indicator in the Sierra Nevada and Cascades, USA: The Black-backed Woodpecker. Open Forest Sci. J. 6:14–23.

Odion, D. C., Hanson, C. T., Arsenault, A., Baker, W. L., DellaSala, D. A., Hutto, R. L., Klenner, W., Moritz, M. A., Sherriff, R. L., Veblen, T. T., and Williams, M. A. 2014. Examining historical and current mixed-severity fire regimes in ponderosa pine and mixed-conifer forests of western North America. PLoS One 9:e87852.

Peterson, R. T. 2010. Peterson Field Guide to Birds of Western North America. Houghton Mifflin Harcourt, New York.

Raphael, M. G., and White, M. 1984. Use of snags by cavity-nesting birds in the Sierra Nevada. Wildlife Monogr. 86.

Raphael, M. G., Morrison, M. L., and Yoder-Williams, M. P. 1987. Breeding bird populations during twenty-five years of postfire succession in the Sierra Nevada. Condor 89:614–626.

Robertson, B. A., and Hutto, R. L. 2007. Is selectively harvested forest an ecological trap for Olive-sided Flycatchers? Condor 109:109–121.

Rosner, B. A. 2000. Fundamentals of Biostatistics, 5th ed. Duxbury, Pacific Grove, CA.

Stephens, S. L., McIver, J. D., Boerner, R. E. J., Fettig, C. J., Fontaine, J. B., Hartsough, B. R., Kennedy, P. L., and Schwilk, D. W. 2012. The effects of forest fuel-reduction treatments in the United States. BioScience 62:549–560.

Swanson, M. E., Franklin, J. F., Beschta, R. L., Crisafulli, C. M., DellaSala, D. A., Hutto, R. L., Lindenmayer, D., and Swanson, F. J. 2011. The forgotten stage of forest succession: Early-successional ecosystems on forest sites. Frontiers Ecol. Env. 9:117–125.

Tempel, D. J. 2014. California Spotted Owl population dynamics in the central Sierra Nevada: An assessment using multiple types of data. Ph.D. dissertation, University of Minnesota.

Tempel, D. J., and Gutiérrez, R. J. 2013. Relation between occupancy and abundance for a territorial species, the California Spotted Owl. Cons. Biol. 27:1087–1095.

Traill, L. W., Bradshaw, C. J. A., and Brook, B. W. 2007. Minimum viable population size: A meta-analysis of 30 years of published estimates. Biol. Cons. 139:159–166.

U.S. Forest Service. 2004. Sierra Nevada forest plan amendment, final environmental impact statement and record of decision. U.S. Forest Service, Pacific Southwest Region, Vallejo, CA.

U.S. Forest Service. 2014a. Rim Fire recovery project, draft environmental impact statement. Stanislaus National Forest, Sonora, CA.

U.S. Forest Service. 2014b. Big Hope Fire salvage and restoration project, preliminary environmental assessment. Tahoe National Forest, Nevada City, CA.

U.S. Forest Service. 2014c. Aspen recovery and reforestation project, environmental assessment. Sierra National Forest, Clovis, CA.

White, A. M., Zipkin, E. F., Manley, P. N., and Schlesinger, M. D. 2013. Conservation of avian diversity in the Sierra Nevada: Moving beyond a single-species management focus. PLoS One 8:e63088.

Accepted 21 August 2014