Chapter 1. Short-term response of avian species to HFQLG fuel treatments in the Northern Sierra Nevada

Ryan D. Burnett and Diana Stralberg
PRBO Conservation Science

Background and Introduction

The Records of Decisions for the Sierra Nevada Forest Plan Amendment and Herger Feinstein Quincy Library Group Forest Recovery Act direct the Forest Service to maintain and restore old forest conditions that provide habitat for a number of plant and animal species (HFQLG 1999, SNFPA 2001, 2004). Simultaneously, the direct the Forest Service to take steps to reduce risks of large and severe fire by removing vegetation and reducing fuel loads in overstocked forests (HFQLG 1999, SNFPA 2004). Striking a balanced approach to achieving these potentially competing goals is a significant challenge to effectively accomplish the various desired outcomes of forest management (NFMA 1976).

Historically, fire was the primary force responsible for creating and maintaining habitat diversity and landscape heterogeneity in the Sierra Nevada (Skinner and Chang 1996). Over the past century, fire return intervals have been lengthened and the area affected by wildfire annually has been dramatically reduced in the interior mountains of California (Taylor 2000, Taylor and Skinner 2003, Stephens et al. 2007). Thus, there is little doubt fires role in influencing the composition of the Sierra Nevada landscape has been reduced (Skinner and Chang 1996).

Fire suppression in concert with past silvicultural practices has resulted in increased stand densities, loss of landscape heterogeneity, and increased fuel loads in Sierra Nevada Forests (Vankat and Major 1978, Parsons and DeBenedetti 1979, McKelvey and Johnston 1992, Minnich et al. 1995, Taylor and Skinner 2003). While the ways in which these changes affect fire patterns and vegetation dynamics are frequently discussed, they also undoubtedly impact the wildlife species that inhabit these forests. In fact, many of the avian species now believed to be declining in the Sierra Nevada are those associated with disturbance dependent habitat types and structure (Burnett et al. *in review*).

Mechanical silvicultural treatments have the potential to fill some of fire's historic role in maintaining disturbance dependent habitats (Weatherspoon 1996, Arno and Fiedler 2005). There has been considerable study of silvicultural treatments and their effects on landbirds in eastern North American forests (Anand and Thompson 1997, King et al. 2001, Fink et al. 2006, Askins et al. 2007) and the Cascades (Hansen et al. 1995, Hagar et al. 2004, Chambers et al. 2007), but little published information exists on the effects of mechanical fuel treatments on the avian community in the Sierra Nevada (but see Siegel and DeSante 2003 and Garrison et al. 2006).

Forest Service management practices, primarily in the form of fuel reduction treatments, are resulting in changes in habitat composition and structure across the HFQLG area. By monitoring the populations of a suite of landbird species we can measure the effectiveness of management actions in achieving a sustainable and ecologically functional forest ecosystem. Specifically, we are interested in determining the responses of landbirds to management practices intended to produce forests with larger trees and high canopy cover along with more open-canopy, smaller size class forest with reduced ladder and ground fuels.

In this chapter we investigate how a broad range of avian species respond to changes in vegetation structure and composition that occur when forests are managed to reduce fuels and generate timber products under the Herger Feinstein Quincy Library Group Forest Recovery Act Pilot Project (HFQLG 1999). We investigated the short-term response of 17 breeding landbird species (e.g. passerines, woodpeckers) to a suite of HFQLG treatments in the Lassen and Plumas National Forests between 2002 and 2008.

Methods

Study Location

The study occurred in the Lassen and Plumas National Forests within the boundaries of the Herger-Feinstein Quincy Library Group Forest Recovery Act Pilot Project (HFQLG). The study sites encompassed portions of Butte, Lassen, and Plumas Counties at the intersection of the Sierra Nevada and Cascade mountains of Northeastern California, USA (Figure 1). Survey sites ranged in elevation from 956m to 1896m within the mixed conifer, true fir, and yellow pine zones.

Site Selection

We combined data across multiple projects on the Almanor and Eagle Lake Ranger Districts of the Lassen National Forest and the Mt. Hough Ranger District of the Plumas National Forest to investigate the effects of HFQLG treatments on landbirds

(Table 2). For the Plumas-Lassen study, three transects were established in each planning watershed, (CalWater 1999), using a random starting point generated in a GIS environment (ArcView 3.2a). For each transect, 11 additional points were added using a random compass bearing from the starting point and spaced at approximately 250 m intervals. If transects could not be established along a random bearing due to inaccessible areas being encountered (e.g. private property, steep topography) we attempted a non-random bearing; if they still could not be established we placed the transect on or adjacent to the secondary road nearest the starting point. A total of 876 stations along 73 transects were established in this manner across the 24 planning watersheds in the study area.

Table 1. Forest treatment types in the Northern Sierra Nevada for which the response of landbirds was investigated.

Treatment	Description
Defensible Fuel Profile Zones	Shaded Fuel Break, generally linear in shape, affects more acres than any treatments in our study area
Group Selection	Removal of all overstory trees in 0.5 – 2 acre area, often embedded within a DFPZ network
Pre-commercial Thinning	Removal of understory trees and shrubs, often conducted prior to removal of overstory trees but also used extensively as independent treatment in Meadow Valley (e.g. Waters project)
Mastication	Mechanical shredding of shrubs that sometimes uproots shrubs but often leaves plant alive below ground that regenerate.
Prescribed Fire	Generally low intensity human ignited burning. Generally consumes understory fuels and some middle story trees

A number of the sites that were intended to be part of the untreated sample were treated either immediately before or during the course of this study (2002 – 2008) as part of projects were unknown to us, or due to changes in treatment locations during the planning process. We also established additional transects in areas slated to be treated as part of the Meadow Valley project. For a more detailed description of site selection for the Plumas-Lassen study see Stine et al. (2005).

DFPZ treatments monitored on the Eagle Lake Ranger District were established in 2004 after consulting ranger district staff and available GIS layers. We selected 6 sites that were slated for treatment in the next several years. At each treatment area we established between 5 to 7 point counts inside of treatment boundaries and 5 to 8 sites in similar habitat at least 100m outside the treatment but within 500m of the treated area (see Burnett et al. 2004).

A similar protocol was used for the Brown's Ravine Black Oak enhancement DFPZ project in the Almanor Ranger District of the Lassen. In this project, treatment units were larger so we filled each unit with points spaced 220m apart. Each unit contained between 5 and 14 points. Control sites were established in adjacent units where no treatment was planned (Burnett et al. 2004).

Survey Protocol

We used a standardized five-minute multiple distance band circular plot point count census (Buckland et al. 1993, Ralph et al. 1993, Ralph et al. 1995) to sample the avian community in the study area. In this method, points are clustered in transects, but data were only collected from fixed stations, not along the entire transect.

All birds detected at each station during the five-minute survey were recorded according to their initial distance from the observer. These detections were placed within one of six categories: within 10 meters, 10-20 meters, 20-30 meters, 30-50 meters, 50-100 meters, and greater than 100 meters. The method of initial detection (song, visual, or call) for each individual was also recorded. All observers underwent intensive 14 day training in bird identification and distance estimation prior to conducting surveys. Laser rangefinders were used to assist in distance estimation at every survey point.

Counts began around local sunrise, were completed within four hours, and did not occur in inclement weather. Each transect was visited twice during the peak of the breeding season from mid May through the first week of July in each year.

Analysis

Annual per-point species abundance and diversity metrics were summarized for 1,194 point-count locations surveyed between 2002 and 2008. For this analysis we excluded detections beyond 50 m, as well as single surveys that were not repeated within a season, resulting in a total sample size of 5,826 point-visits (Table 2). For each point-year combination, the total number of detections for each of 17 species was calculated by summing across two visits (each point was surveyed exactly twice). The 17 species were comprised of all of the Coniferous Forest Focal species, (CALPIF 2002), for which we had adequate detections to conduct meaningful analysis as well as eight additional species that represented a range of habitat preferences and were relatively common in the study area (Table 3). We also calculated overall species richness, conifer focal species richness (CALPIF 2002), and Shannon and Simpson diversity metrics, for each point in each year.

For each point-count location, we identified the treatment history with respect to five distinct treatment types (Table 1). A given treatment was only considered to occur at a point if the point fell inside the treatment polygon. An exception was made for group selection treatments, due to their small size and their relatively extreme effects (removal of all trees); a point was considered inside a group selection treatment if it was within a group or was outside a group but within 25 m of the treatment edge. Of the 1194 points, 249 were treated in one or more ways; the remaining points were considered control sites. For each point in each year, we then calculated the number of years since treatment for each of the five treatments types. Since we did not have site specific historical treatment and fire data we assigned all untreated sites an estimating average time since treatment or fire. Pre-treatment and control sites were considered to be 35 years since timber removal treatments, and 75 years since fire, based on estimates of fire exclusion in mixed conifer habitat in the Sierra Nevada (Skinner and Chang 1996). The minimum time since treatment was 1 year, as most treatments were implemented in the fall, after the the point count survey season. If a treatment was performed in the spring (i.e., before survey season), it was considered to have occurred the previous year (time = 1). If a site was treated in the middle of the survey season, the surveys from that year were excluded from analysis, as we were unable to determine whether surveys were conducted before or after the treatment.

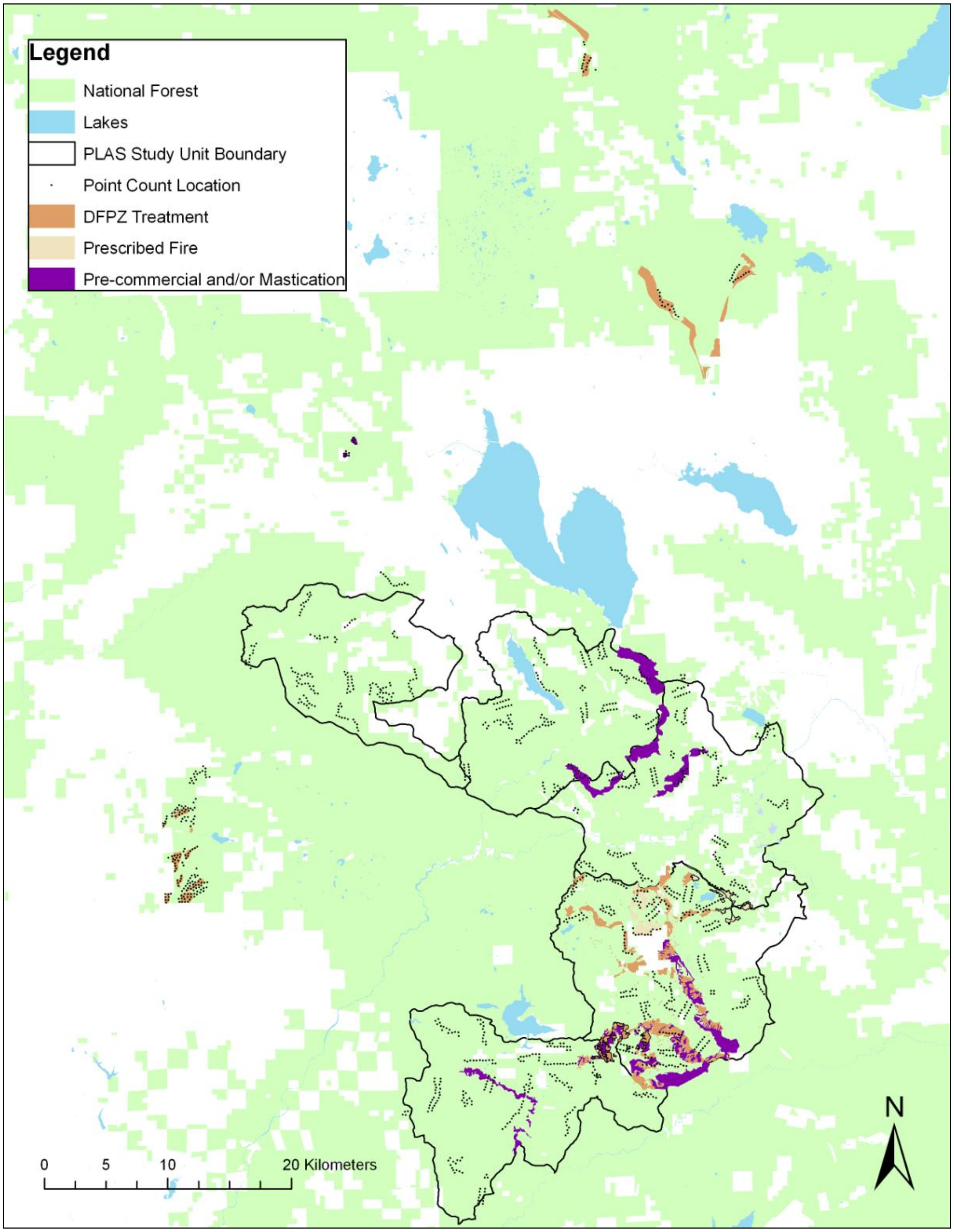
Other variables calculated from GIS layers for each study site included elevation, slope, annual solar radiation, vegetation type (California Wildlife Habitat Relationships classification from the US Forest Service CalVeg layer), and presence of a riparian habitat conservation area.

Table 2. The number of point count stations and total surveys conducted by treatment type in each ranger district in PRBO's Northern Sierra study area. Each point was visited twice in each year it was surveyed.

Treatment Type		Almanor	Eagle Lake	Mt. Hough
Total	Number of points	165	71	958
	Number of point visits	787	264	4775
DFPZ	Number of points	57	29	30
	Number of post-treatment point visits	284	112	148
Group Selection	Number of points	0	0	19
	Number of post-treatment point visits	0	0	78
Pre-commercial Thin	Number of points	26	0	24
	Number of post-treatment point visits	52	0	208
Mastication	Number of points	4	0	32
	Number of post-treatment point visits	8	0	242
Prescribed Burn	Number of points	0	0	40
	Number of post-treatment point visits	0	0	344

For each species and diversity metric, we constructed a mixed-effects model including five treatment effects (time since each of the five treatment types), five covariates (described above, 1 categorical and 4 continuous), and a random site (point) effect to account for the lack of independence within a given site across multiple years. Models for species diversity metrics, which had nearly normal distributions, were specified as linear models with a Gaussian distribution using the 'nlme' package for R (R Development Core Team 2009). Individual species abundance, which were generally approximated by the negative binomial distribution, were specified as generalized linear models with a negative binomial distribution using a penalized quasi-likelihood approach with the 'MASS' page for R. The dispersion parameters for the negative binomial mixed models were estimated using a standard generalized linear model ('glm.nb' function) and provided as inputs to the mixed models.

Figure 1. Location of HFQLG treatment projects where landbirds were monitored in the Lassen and Plumas National Forests with the Plumas-Lassen (PLAS) study units, treatment types, and point count locations shown.



The significance of treatment effects and covariates were evaluated at a 95% confidence level (P<0.05). Model-predicted focal species abundance and species richness were calculated for each of the five treatment types, as well as for the combined effect of all treatments. For each of the treatment predictions, all other continuous model variables were held constant at their mean values; vegetation type was assigned to Sierran Mixed Conifer, the most common vegetation type in the dataset (occurring at 666 points). The value of the treatment effect was set at one to indicate one year post-treatment.

Results

The mean abundance per point count station for the 17 species we investigated ranged from 1.02 for Hermit Warbler to 0.03 for Olive-sided Flycatcher (Table 3). Fox Sparrow and Hairy Woodpecker, the two new Management Indicator Species for the Forest Service in the Sierra Nevada had an abundance of 0.33 and 0.06 respectively in our study area.

Table 3. Common and scientific names of the 17 species investigated for effects of fuel treatments in the Northern Sierra Nevada with the mean abundance per point count station per year (summed across 2 visits) and standard deviation. California Partner's in Flight Coniferous Forest Focal Species are in bold.

Common Name	Scientific Name	Mean	SD
Hermit Warbler	*Dendroica occidentalis*	1.02	1.26
Oregon Junco	***Junco hyemalis oreganus***	0.71	0.96
Dusky Flycatcher	*Empidonax oberholseri*	0.66	1.02
Audubon's Warbler	*Dendroica auduboni*	0.63	0.88
Mountain Chickadee	***Poecile gambeli***	0.62	0.95
Nashville Warbler	*Vermivora ruficapilla*	0.59	0.98
Golden-crowned Kinglet	***Regulus satrapa***	0.44	0.77
Red-breasted Nuthatch	***Sitta canadensis***	0.39	0.73
Western Tanager	***Piranga ludoviciana***	0.35	0.64
Fox Sparrow	***Passerella iliaca***	0.33	0.85
Hammond's Flycatcher	*Empidonax hammondii*	0.23	0.58
Brown Creeper	***Certhia americana***	0.23	0.51
MacGillivray's Warbler	***Oporornis tolmiei***	0.20	0.53
Steller's Jay	*Cyanocitta stelleri*	0.12	0.41
Hairy Woodpecker	*Picoides villosus*	0.06	0.26
Chipping Sparrow	*Spizella passerina*	0.04	0.26
Olive-sided Flycatcher	***Contopus cooperi***	0.03	0.19

Of the 17 species we investigated, 14 showed a significant association with at least one treatment type (Table 4, Figure 2). Seven species showed significant effects of DFPZs, 5 of group selections, 6 of pre-commercial thinning, 5 of mastication, and 7 of prescribed burning. Chipping Sparrow was the only species that had a significant effect with each of the five treatments; no other species had more than three. Three species, Olive-sided Flycatcher, Audubon's Warbler, and Chipping Sparrow all increased in abundance following DFPZ treatment. Contrastingly, Dusky Flycatcher, Golden-crowned Kinglet, Nashville Warbler, and Hermit Warbler showed negative responses. Of the five species with significant responses to group selection, Olive-sided Flycatcher, Dusky Flycatcher, MacGillivray's Warbler, and Chipping Sparrow responded positively, while Hammond's Flycatcher had a negative response. Hairy Woodpecker, Brown Creeper, Audubon's Warbler, Chipping Sparrow, and Western Tanager all showed a negative relationship with pre-commercial thinning, while only Olive-sided Flycatcher responded positively to this treatment. Hairy Woodpecker, Nashville Warbler, Audubon's Warbler, Fox Sparrow, and Chipping Sparrow all had negative associations with mastication while no species showed a positive effect of this treatment. Of the 7 species that had a significant relationship with prescribed fire treatments, only Golden-crowned Kinglet's was negative. Hairy Woodpecker, Dusky Flycatcher, Mountain Chickadee, Fox Sparrow, Chipping Sparrow, and Western Tanager all responded positively to prescribed fire.

For the four measures of species diversity examined, only the treatments of pre-commercial thinning and mastication had significant effects. Pre-commercial thinning had a negative effect on all four measures and mastication negatively affected all but conifer focal species richness (Table 4).

Table 4. The effect of time since five separate treatments on the abundance of 17 species, and four diversity metrics in the Herger Feinstein Quincy Library Group Pilot Project area. Negative coefficients represent negative associations with time since treatment, which means there was a positive response to the treatment. DFPZ = Defensible Fuel Profile Zone, Group = Group Selection, PCThin = Pre-commercial Thin, Mast = Mechanical Mastication, and Burn = Prescribed Burn. ELEV = elevation, VegType = California Wildlife Habitat Relationship Habitat Type, SolRAD = Solar Radiation Index, RHCA = Riparian Habitat Conservation Area.

Metric	DFPZ	Group	PCThin	Mast	Burn	Other significant effects
Focal Species Richness	-0.0025	0.0005	0.0135**	0.0079	-0.0047	Elev (+), VegType
Species Richness	0.0033	-0.0131	0.0283***	0.0175*	-0.0086	Elev (+), VegType
Shannon Diversity	0.0003	-0.0037	0.0069***	0.0039*	-0.0017	Elev (+), VegType
Simpson Diversity	0.0002	-0.0014	0.0024***	0.0012*	-0.0005	Elev (+), VegType
Hairy Woodpecker	0.0054	0.7535	0.0254*	0.0415***	-0.0129**	Elev (+)
Olive-sided Flycatcher	-0.0373***	-0.0666***	-0.0576***	-0.0024	-0.0032	Elev (+)
Dusky Flycatcher	0.0050*	-0.0150**	0.0066	-0.0009	-0.0046*	Elev (+), Slope (-), RHCA (+), VegType
Hammond's Flycatcher	0.0066	0.0207*	0.0104	0.0148	-0.0062	Elev (+), Slope (-), VegType
Steller's Jay	-0.0044	0.0009	-0.0070	-0.0087	0.0011	Elev (-), Slope (+), RHCA (-), VegType
Mountain Chickadee	-0.0013	0.0008	0.0087	0.0001	-0.0054**	Elev (+), VegType
Red-breasted Nuthatch	-0.0035	0.0016	0.0048	-0.0007	0.0018	Elev (+), VegType
Brown Creeper	-0.0008	0.0201	0.0166*	0.0082	-0.0019	Elev (-), VegType
Golden-crowned Kinglet	0.0142***	0.0042	0.0082	0.0092	0.0086**	Elev (+), VegType
Nashville Warbler	0.0260***	-0.0030	0.0061	0.0392**	0.0048	Elev (-), SolRad (+), VegType
Audubon's Warbler	-0.0061*	0.0137	0.0106*	0.0079*	-0.0026	Elev (+), VegType
Hermit Warbler	0.0159***	-0.0060	0.0078	-0.0039	0.0006	Elev (-), VegType
MacGillivray's Warbler	0.0050	-0.0208*	0.0140	0.0086	0.0037	Elev (+), VegType
Fox Sparrow	0.0015	0.0020	0.0048	0.0301***	-0.0078*	Elev (+)
Chipping Sparrow	-0.0555***	-0.0620***	0.0385***	0.0310*	-0.0306***	Slope (-), SolRad (+), VegType
Oregon Junco	-0.0010	-0.0013	0.0028	-0.0054	-0.0027	SolRad (+)
Western Tanager	0.0016	-0.0033	0.0121*	-0.0061	-0.0060**	Elev (-), SolRad (+), VegType

*** = P<0.05, ** = P<0.005, *** = P<0.0005**

Figure 2. Predicted species abundance in the year following each of five treatments, as well as a hypothetical combination of all five treatments ("all"). Predicted abundance (sum over two visits) for each treatment was modeled for t=1 year since treatment, and all other variables were held constant at their mean values (except VegType, which was assigned "Sierran Mixed Conifer" type). Predicted values that were significantly different from the mean at untreated sites (dashed red line) are indicated with asterisks. Treatments included Defensible Fuel Profile Zones (DFPZ), group selections (Group), pre-commercial thin (PCT), mastication (Mast), and prescribed fire (Burn).

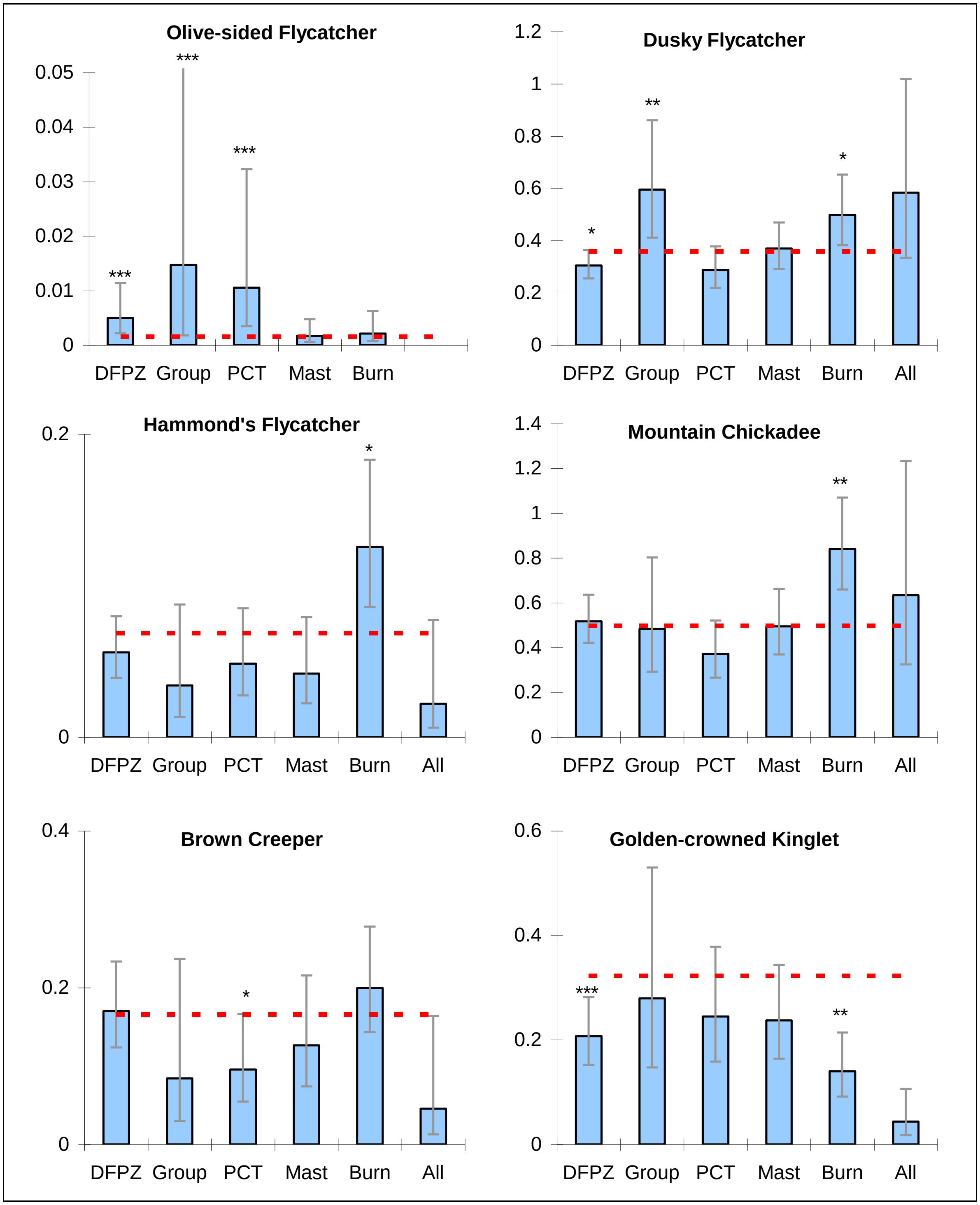
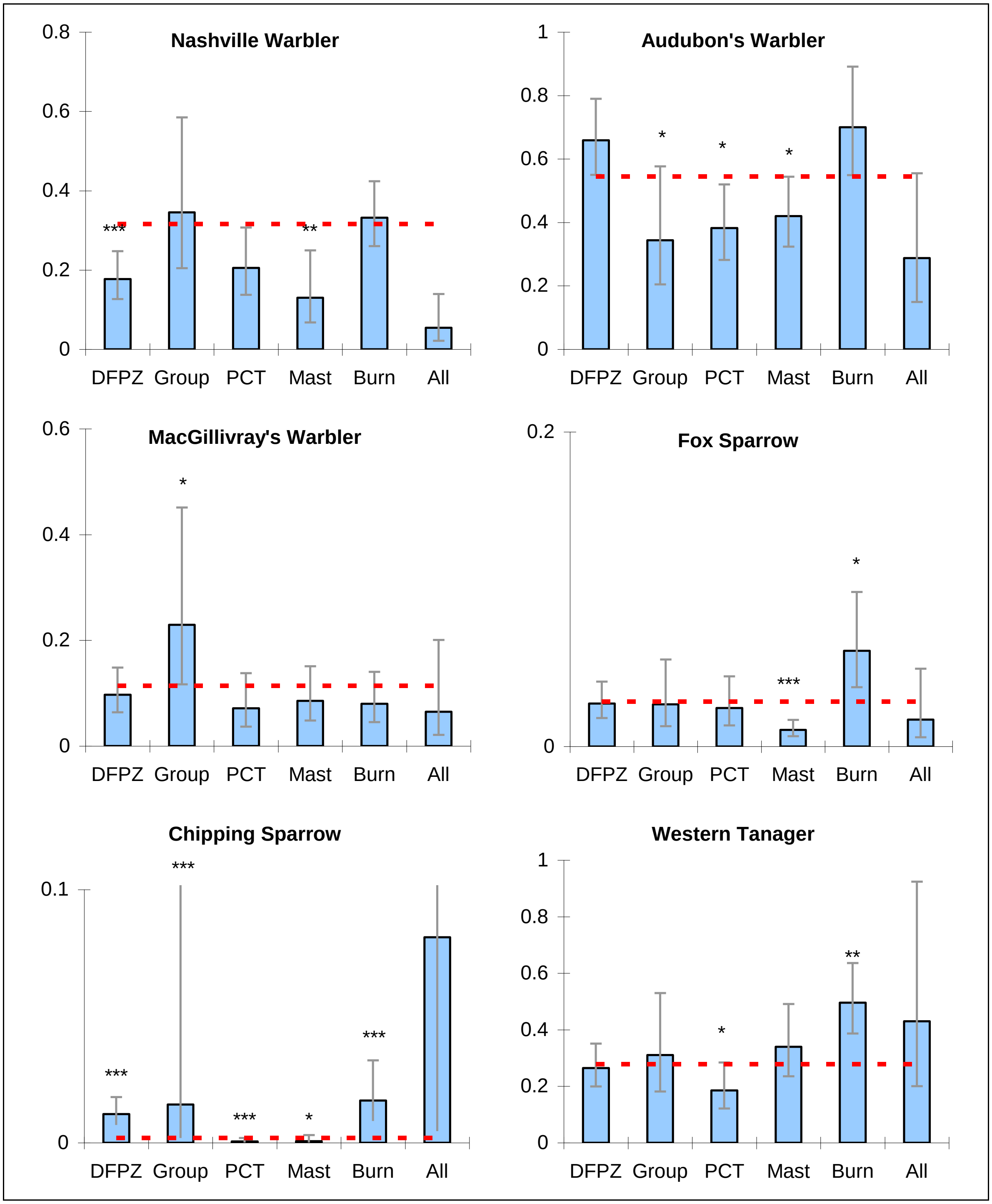


Figure 2. continued



Discussion

Overview

Fuel reduction treatments in our study area significantly influenced the abundance of most of the species we investigated, with both positive and negative effects detected. However, our results suggest prescribed fire benefits the greatest number of species while negatively impacting the fewest while mastication and pre-commercial thinning benefited the fewest species and had negative impacts on the most. Though there are several limitations to this analysis, with its relatively large sample size and geographic scope it fills a gap in information about the effects of fuel treatments on wildlife species in the Sierra Nevada. Mechanical silvicultural treatments appear capable of providing habitat for some disturbance dependent bird species but also may reduce the suitability for species associated with higher canopy cover and later successional forests. Management decisions should be made in the context of current trends in forest structure and disturbance patterns in order to strike a balance that ensure the needs of the greatest number of species are being met.

Limitations and Caveats

This study investigated the short-term effects (1 – 6 years post-treatment) of fuel reduction activities, and thus provides an incomplete picture of treatment effects on breeding landbirds. Post-treatment successional processes may result in considerable change at these sites over longer time periods, though recent evidence suggests at least DFPZ sites change little in vegetative structure in the first 15 years following treatment (S. Stephens pers. comm.).

The results of this study should also be considered in the context of the conditions that existed in the study area prior to implementation of these treatments. After over a century of resource extraction and fire suppression, these forests should not be considered natural as untreated sites have all been subjected to past timber harvest and a century of fire suppression. We attempted to account for this in our estimates of time since treatment at control sites (35 years for mechanical treatments and 100 years for burns), although models would likely have been improved with site specific information about historic timber management practices and fire occurrence.

Our analysis was focused primarily on species that are fairly common to abundant. The species that are most sensitive to silvicultural treatments may already be quite rare in these forests, which have been actively managed for over a century. However, other studies in western forests have shown that few if any landbird species appear to be negatively affected by fragmentation or habitat edges (McGarigal and McCombs 1995, Scheick et al. 1995, Tewskbury et al. 1998, 2006, George and Dobkin, 2002).

Our analysis of pre-commercial thinning was limited to sites that received no overstory treatment (e.g., DFPZ or group). Many of the group selection and DFPZ treatments underwent pre-commercial thinning at the same time as these overstory treatments were implemented. As a result we were unable to isolate the relative effects of pre-commercial components within these treatments.

Finally, it is important to consider that this study only investigated the abundance patterns of species and not demographic parameters (productivity or survival). Abundance (or density), may not always be a good estimate of the suitability of habitat for a species (VanHorne 1983, Bock and Jones 2004).

DFPZ and Group Selection: Promoting Heterogeneity

Group selection treatments, which are basically 0.5 – 2 acre clear cuts, had predominantly positive short-term effects on the landbird species we investigated. Only Hammond's Flycatcher, a species associated with shaded mature forest, showed a negative response. Similarly, Hagar et al. (2004) found evidence of this species being sensitive to high intensity treatments in the Pacific Northwest.

Two species that have undoubtedly been declining in the Sierra Nevada for many years, Olive-sided Flycatcher and Chipping Sparrow, both responded positively to group selections. Given the Olive-sided Flycatcher's strong associations with forest heterogeneity and contrasting edges (McGarigal and McCombs 1995, Howell and Burnett *In review*, Meehan and George 2003), group selection type treatments are likely creating habitat for this species. However, mechanical silvicultural treatments that mimic natural disturbance may be an ecological trap for this species as predation rates may be higher and food availability lower in mechanically treated areas compared to those that have burned (Robertson and Hutto 2007). Further investigation of the demographic parameters of this declining species in mechanically- and naturally-created (e.g., wind-throw, wildfire) edges is warranted. Chipping Sparrow, the only species to have a significant response to all five treatments were significantly more abundant in Group Selections.

Forest openings that promote herbaceous vegetation and open ground for foraging are likely to benefit this species.

Two shrub associated species, MacGillivray's Warbler and Dusky Flycatcher also responded positively to group selections. Unlike Fox Sparrow, which requires relatively large patches of open shrub-dominated habitat (Howell & Burnett *In review*), these two species readily occupy small shrub filled forest gaps. Thus it seems appropriate that they would benefit from group selection treatments. The increased light and presumably soil moisture within group selections may facilitate rapid establishment and growth of shrub habitat preferred by these species. Further analysis of the changes in vegetation following treatment will be necessary to conclusive link habitat changes to the observed effects of treatments.

DFPZs, the treatments affecting the greatest number of acres in our study area, had mixed effects on the avian species we investigated. Not surprisingly, several of the species associated with more mature higher canopy-cover forest (Hermit Warbler and Golden-crowned Kinglet) showed a negative response to this treatment, as did the ground-nesting and middlestory-foraging Nashville Warbler. The Hermit Warbler is the most abundant breeding landbird in our study area (Table 3). The increased canopy cover and densification of white fir dominated forest has probably increased the available habitat for Hermit Warbler and Golden-crowned Kinglet. Though the Golden-crowned Kinglet is also quite abundant in our study area, unlike the Hermit Warbler, this species has been declining in the Sierra Nevada according the Breeding Bird Survey (Sauer et al. 2008). Another declining species, Nashville Warbler, showed a strong negative association with DFPZ and mastication. This species nests on the ground in dense patches of vegetation with heavy leaf litter and forages in the middlestory (Williams 1996). The short-term negative effects of DFPZ and mastication for this species may be a result of the reduction in these habitat components within these treatments. However, because they are closely allied with black oak (*Quercus kelloggii*) in our study area, (Burnett and Geupel 2002, Burnett and Howell in review), DFPZ treatments that retain oak and reduce canopy cover to increase oak vigor and regeneration are likely to have long-term positive effect on this species.

Mechanical treatments that significantly reduce canopy cover and create canopy gaps can result in increased abundance of middle and understory associated landbirds in western forests and overall avian diversity (Hansen et al. 1995, Siegel and DeSante 2003, Hagar et al. 2004). Additionally, many forest interior associated birds may benefit from small gaps in mature forest as they utilize the unique resources they provide such as fruit and nectar (Thompson et al. 1992, Vitz and Rodewald 2006, Greenberg et al. 2007).

None of the shrub dependent species we investigated showed a positive response to DFPZ treatments. This is likely due to our analysis being limited to the short-term response of treatments. However, based on our experience with most of these treated areas, the retention of over 40% canopy cover is unlikely to allow for understory foliage volume, especially of shade intolerant shrubs. In order to more effectively mimic the mosaic patterns created through natural disturbance and benefit a greater number of species dependent upon disturbance we suggest - where appropriate - DFPZ treatments consider a greater reduction in canopy cover (Chambers et al. 1999). A mosaic pattern with areas with reduced canopy cover can enhance shade intolerant understory plant assemblages and promote landscape heterogeneity (McGarigal and McCombs 1995, Siegel and DeSante 2003).

Prescribed Fire vs. Mechanical Understory Treatments: Understory Structure

The importance of forest structural diversity for landbirds in western forests is well established (Beedy 1981, Verner and Larson 1989, Wilson and Comet 1996). Thus fuel treatments that remove and inhibit understory habitat structure can have negative impacts on a number of avian species while benefiting relatively few (Rodewald and Smith 1998).

For landbirds in our study area, prescribed fire treatments had a far greater positive effect than mastication or pre-commercial thinning. The effects of mastication and pre-commercial thinning had almost unanimously negative effects on the avian community while burning was almost always positive. While all three treatments are primarily designed to reduce understory fuels, it is quite clear that their impacts on birds are disparate.

Many of the factors believed to be driving the increased abundance of bird species in burned habitat, such as high densities of snags, increased abundance of some insect populations, and increased seed availability, may not be facilitated through mechanical treatments alone. Prescribed fire in the Sierra Nevada generally results in a reduction in surface fuels while mechanical treatments without fire generally increase surface fuels (Stephens & Moghaddas 2005, Stephens et al. 2009). Reduction in surface fuels and release of nutrients can promote an increase in herbaceous vegetation following prescribed fire (Wayman and North 2007). Combining mechanical treatment with prescribed fire can result in similar surface fuel loads and vegetative response as burn only treatments (Collins et al. 2007). However, fire may be more beneficial than mechanical treatments for shrub dependent birds as it often results in greater retention of shrub cover than mastication treatments (Collins et al. 2007, Wayman and North 2007). Our results suggest a reevaluation of the benefits of pre-commercial thinning and mastication treatments as they clearly have negative impacts on a number of avian species including a number that are declining in the Sierra Nevada.

Prescribed fire as well as mechanical treatments during the bird breeding season can result in direct loss of nests and dependent young. All of the burns we monitored were in the Mt. Hough Ranger District, with the majority carried out in April or after July thus avoiding the peak of the bird breeding season. However, each of the other treatment types was carried out at least in part during the middle of the bird breeding season (May – July).

Conclusions

Fuel reduction treatments varied in their effects on landbirds in our study area. Group selection and prescribed fire benefited the greatest number of species while negatively impacting the least. Mechanical mastication and pre-commercial thinning benefited the least while negatively impacting the greatest. However, the goal of land management may not always be to maximize the number of species that benefit from a treatment while minimizing those that do not. This approach may lead to more homogenization of the landscape. We suggest a more landscape based ecological approach is prudent. Promoting an increase in late successional habitat in some locations while prescribing greater reductions in canopy cover that mimic natural disturbance patterns in areas where biological diversity is relatively low (e.g. closed canopy size class 3 and 4 white fir stands). Under current management strategies being implemented on National Forest lands in the Sierra Nevada, the loss of late seral forest, landscape heterogeneity, and fire-dependent habitats appear to be the greatest threat to biodiversity here. A balanced approach using a full range of management tools and prescriptions is advisable to ensure biodiversity is sustained.

Literature Cited

Beedy, E.C. 1981. Bird communities and forest structure in the Sierra Nevada of California. The Condor 83: 97-105.

Bock C.E. and Z.F. Jones. 2004. Avian habitat evaluation: should counting birds count? Frontiers Ecol Environ 2:403–410

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London.

Burnett, R.D. and D.L. Humple. 2003. Songbird monitoring in the Lassen National Forest: results from the 2002 field season with summaries of 6 years of data. A PRBO report to the U.S. Forest Service. Contribution # 1069.

Burnett, R.D., D.Humple, T.Gardali, and M.Rogner. 2004. Avian Monitoring in the Lassen National Forest. A PRBO report to the USFS. Contribution # 1242.

Burnett, R.D. and N. Nur. 2007. Plumas-Lassen Area Study module on landbird abundance, distribution, and habitat relationships: 2006 annual report. A PRBO Report to the U.S. Forest Service. Contribution # 1550.

Burnett, R.D., N.Nur, and C.A.Howell. *In review*. Implications of spotted owl management for landbirds in the Sierra Nevada, CA, USA. Forest Ecology and Management.

CALPIF (California Partners in Flight). 2002. Version 1.0. The draft coniferous forest bird conservation plan: a strategy for protecting and managing coniferous forest habitats and associated birds in California (J. Robinson and J. Alexander, lead authors). Point Reyes Bird Observatory, Stinson Beach, CA. http://www.prbo.org/calpif/plans.html.

CalWater (The California Interagency Watershed Mapping Committee). 1999. California Watersheds Version 2.2. (available at www.ca.nrcs.usda.gov/features/calwater/)

Chambers, C.L., W.C. McComb, and J.C. Tappeiner II. 1999. Breeding bird responses to three silvicultural treatments in the Oregon Coast Range. Ecological Applications 9: 171-185.

Collins, B.M., J.J. Moghaddas, and S.L. Stephens. 2007. Initial changes in forest structure and understory plant communities following fuel reduction activities in a Sierra Nevada mixed conifer forest. Forest Ecology and Management 239: 102-111.

ESRI 2000. Arc View GIS 3.2a. Environmental Systems Research Institute. Redlands, CA.

George, T.L, and D.S. Dobkin (eds.). 2002. Effects of habitat fragmentation on birds in western landscapes: Contrasts with paradigms from the eastern U.S. Studies in Avian Biology 25, 270p.

Greenberg, C.H., A.L. Tomcho, J.D. Lanham, T.A. Waldrop, J. Tomcho, R.J. Phillips, and D. Simon. 2007. Short-term effects of fire and other fuel reduction treatments on breeding birds in a Southern Appalachian upland hardwood forest. The Journal of Wildlife Management 71: 1906-1916.

Hagar, J., S. Howlin, and L.Ganio. 2004. Short-term response of songbirds to experimental thinning of young Douglas-fir forests in the Oregon Cascades. Forest Ecology and Management 199: 333-347.

Hansen, A.J., W.C. McComb, R. Vega, M.G. Raphael, and M. Hunter. 1995. Bird habitat relationships in natural and managed forests in the west cascades of Oregon. Ecological Applications 5: 555-569.

HFQLG (Herger-Feinstein Quincy Library Group Forest Recovery Act) 1999. Final Environmental Impact Statement, U.S. Department of Agriculture, Forest Service, Pacific Southwest Region, Vallejo, CA. http://www.fs.fed.us/r5/hfqlg/publications/1999_feis/TOC.htm

Howell, C.A. and R.D. Burnett. *In review*. Landscape effects on songbird abundance in the Northern Sierra Nevada, USA. Forest Ecology and Management.

King, D.I., R.M. Degraaf, and C.R. Griffin. 2001. Productivity of early successional shrubland birds in clearcuts and groupcuts in an eastern deciduous forest. Journal of Wildlife Management 65: 345-350.

McGarigal, K., and W.C. McComb. 1995. Relationships between landscape structure and breeding birds in the Oregon Coast Range. Ecological Monographs 65: 235-260.

Meehan, T.D. and T.L. George. 2003. Short-term effects of moderate to high-severity wildfire on a disturbance-dependent flycatcher in northwest California. Auk 120: 1102-1113.

Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin, and D.F. DeSante 1993. Field Methods for Monitoring Landbirds. U.S. Department of Agriculture, Forest Service, General Technical Report PSW-144.

Ralph, C.J., S. Droege, and J.R. Sauer. 1995. Managing and monitoring birds using point counts: standards and applications. In C. J. Ralph, J. R. Sauer and S. Droege (eds.), Monitoring Bird Populations by Point Counts. USDA Forest Service Publication, Gen. Tech. Rep. PSW-GTR-149, Albany, CA .

Roberston, B.A. and R.L. Hutto. 2007. Is selectively harvested forest an ecological trap for olive-sided flycatchers? The Condor 109: 109-121.

Rodewald, P.G. and K.G. Smith. 1998. Short-term effects of understory and overstory management on breeding birds in Arkansas oak-hickory forests. The Journal of Wildlife Management 62: 1411-1417.

Sauer, J. R., J. E. Hines, and J. Fallon. 2008. The North American Breeding Bird Survey, Results and Analysis 1966 - 2007. Version 5.15.2008. USGS Patuxent Wildlife Research Center, Laurel, MD

Schieck, J.K., B. Lertzman, B., Nyberg, and R.Page. 1995. Effects of patch size on birds in old-growth montane forests. Conservation Biology 9: 1072-1084.

Siegel, R.B. and D.F. DeSante. 2003. Bird communities in thinned versus unthinned sierran mixed conifer stands. Wilson Bulletin 115: 155-165.

Skinner, C.N. and C.Chang. 1996. Fire regimes, past and present. Sierra Nevada Ecosystem Project: Final Report to Congress. Vol. 2, Assessments and scientific basis for management options, pp. 1041-1069. University of California Centers for Water and Wildland Resources, Davis, CA, USA.

SNFPA 2001. Sierra Nevada Forest Plan Amendment Final Environmental Impact Statement, Record of Decision. United States Department of Agriculture, Forest Service, Pacific Southwest Region, Vallejo, CA.
http://www.fs.fed.us/r5/snfpa/library/archives/rod/rod.pdf

SNFPA 2004. Sierra Nevada Forest Plan Amendment, Final Supplemental Environmental Impact Statement, Record of Decision. United States Department of Agriculture, Forest Service, Pacific Southwest Region, Vallejo, CA. http://www.fs.fed.us/r5/snfpa/final-seis/rod/

Stine, P., Landram, M., Keane, J., Lee, D., Laudenslayer, B., Weatherspoon, P., and Baldwin, J. 2002. Fire and fuels management, landscape dynamics, and fish and wildlife resources: An integrated research plan for the Herger-Feinstein Quincy Library Group Pilot Study Area.
http://www.fs.fed.us/psw/programs/snrc/forest_health/plas_studyplan.pdf

Stephens, S.L. and J.J. Moghaddas. 2005. Experimental fuel treatment impacts on forest structure, potential fire behavior, and predicted tree mortality in a California mixed conifer forest. Forest Ecology and Management 215: 21-36.

Stephens, S.L., J.J. Moghaddas, C. Edminster, C.E. Fiedler, S. Haase, M.Harrington, J.E. Keeley, E.E. Knapp, J.D. McIver, K. Metlen, C.N. Skinner, and A. Youngblood. 2009. Fire treatment effects on vegetation structure, fuels, and potential fire severity in western U.S. forests. Ecological Applications 19: 305-320.

Stephens, R.E. Martin, and N.E. Clinton. 2007. Prehistoric fire area and emissions from California forests, woodlands, shrublands, and grasslands. Forest Ecology and Management 251: 205-216.

Tewksbury, J.J., S.J. Hejl, and T.E. Martin. 1998. Fragmentation in a western landscape: forest fragmentation does not reduce nesting success. Ecology 79: 2890-2903.

Thompson, F.R., W.D. Dijak, T.G. Kulowiec, and D.A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. The Journal of Wildlife Management 56: 23-30.

Van Horne, B. 1983. Density as a misleading estimate of habitat quality. The Journal of Wildlife Management 47: 893-901.

Verner, J. and T.A. Larson. 1989. Richness of breeding birds species in mixed-conifer forests of the Sierra Nevada, California. The Auk 106: 447-463.

Vitz, A.C. and A.D. Rodewald. 2006. Can regenerating clearcuts benefit mature-forest songbirds? An examination of post-breeding ecology. Biological Conservation 127: 477-486.

Wayman R.B. and M. North. 2007. Initial response of a mixed-conifer understory plant community to burning and thinning restoration treatments. Forest Ecology and Management 239: 32-44.

Williams, Janet Mci. 1996. Nashville Warbler (Vermivora ruficapilla), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/205

Wilson, M..F. and T.A. Comet. 1996. Bird communities of northern forests: ecological correlates of diversity and abundance in the understory. The Condor 98: 350-362.