Avian Monitoring in the Lassen and Plumas National Forest

2008 Annual Report

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Executive Summary

PRBO Conservation Science (PRBO) has been conducting songbird monitoring in the Northern Sierra since 1997. In this report we present results from monitoring efforts of forest management activities within the Herger Feinstein Quincy Library Group (HFQLG) project area.

Chapter one investigates the short-term response of the avian community to a suite of HFQLG treatments across the Plumas and Lassen National Forests. The response to the different treatments varied among species with some showing positive effects and others negative to most treatments. Prescribed fire had positive effects on the greatest number of species while mastication and pre-commercial thinning affected the most negatively.

The second chapter discusses results from monitoring aspen habitat on the Lassen National Forest. Results show that treated aspen stands support greater total abundance of birds and abundance of key species such as Mountain Bluebird, Chipping Sparrow, and Red-breasted Sapsucker but these initial benefits may be short-lived for some species. Avian abundance and richness indices have been increasing in aspen habitat in the Lassen National Forest since 2005.

In Chapter three we discuss Pileated Woodpecker monitoring on the Lassen National Forest. This project was focused on developing an effective monitoring plan and spatially explicit habitat suitability model for this uncommon and elusive species. We used a new landscape modeling technique (MaxEnt) to predict suitable habitat for this species and targeted those areas for sampling using call back surveys. Results show a far greater detection rate than from previous monitoring in the region and elucidate key habitat components for the species. Our results suggest that suitable habitat for this species occurs in areas with moderate to dense canopy closure and areas with large tree components. We developed an interactive living GIS layer to help managers use up-to-date information on detections of these species on the Lassen National Forest in project planning.

In the fourth chapter we present results from monitoring of meadows in the Almanor Ranger District of the Lassen National Forest from 2004 – 2008. We compared results between sites and across years. Results suggest ARD meadows support diverse and abundant bird populations including several species of conservation concern. Meadow bird populations at these sites have been relatively stable from year to year and across the five year period.

Acknowledgements

PRBO's work in the Northern Sierra Nevada is a multi-project program with several funding sources. Funding is provided by Region Five of the USFS through the Pacific Southwest Research Station, Sierra Nevada Research Center as well as the National Fire Plan. Additional funding is provided by the Lassen National Forest and directly through Herger Feinstein Quincy Library Group Forest Recovery Act monitoring funds. We wish to thank Peter Stine for his leadership and guidance with the Plumas-Lassen Study and staff of the Lassen and Plumas National Forest who support and continue to advocate for our work, especially Mark Williams, Tom Rickman, Coye Robbins, Tom Frolli, and Bobette Jones of the Lassen National Forest. We are indebted to our hard working field crews who have spent the long hours in the field collecting the massive amount of data required to produce such a report. The 2008 crew included crew leaders Tim Guida and Paul Taillie and crew members Juan Caicedo, Pedro Costa, and Ulla Kail. Diana Humple edited chapter's 2 and 4 of this report.

Management Recommendations

General/Fuel Treatments

- Manage for forest heterogeneity and diversity of habitat types and conditions placing priority on those that exist in small quantities, have been significantly reduced in quality or extent, or are disproportionately important to wildlife and ecosystem function (e.g. aspen, shrub, pine-hardwood, meadows, late successional forest).
- Restrict all activities that may disturb breeding bird habitat (e.g. timber harvesting, grazing, burning, herbicide treatments, shrub treatments) to the non-breeding season (August - April).
- Maximize snag retention in all projects, including old snags ready to topple. Where priority snags do not occur in high densities save senescing trees and shorter or smaller snags than are currently in snag retention guidelines. Snags as small as eight inches DBH and two meters tall are used by several species of cavity nesting birds (e.g. White-headed Woodpecker). Snags ready to topple are the next generation of down wood, important for many species including Pileated Woodpecker and Oregon Junco.
- Manage coniferous habitat for uneven aged stands with structural diversity including multiple canopy layers and openings that supports shrub and herbaceous understory.
- Focus DFPZ and other forest thinning in dense white fir dominated size class 3 stands to develop more forest heterogeneity that is positively correlated with many avian species.
- Promote more late successional open forests conditions that support shrub and herbaceous understory plant communities. Forests with large trees and 20-30% canopy cover such as the shelter woods on the Swain Experimental forests support an abundant and diverse bird community including declining species such as Olive-sided Flycatcher and Chipping Sparrow.
- Promote the development of forests with old-growth characteristics. Treatments in these areas should focus on ensuring their persistence on the landscape and avoiding impacts that alter their suitability for species such as Pileated Woodpecker.
- Use prescribed fire and wildland fire use to achieve fuel reduction goals.

Aspen

- Aspen habitat enhancement and expansion should be among the highest priorities as aspen is rare on the landscape and the single most species rich avian habitat in the Northern Sierra.
- Promote aspen regeneration to increase overall aspen cover and an understory aspen component. Aspen in the understory size classes were highly correlated with several key bird indices in the ELRD.
- Manage aspen habitat for multiple age and cover classes. Early successional open canopy aspen habitat support a number of bird species of interest (e.g. Mountain Bluebird, Chipping Sparrow).
- Develop strategies for treating Aspen within riparian areas that support, or will support, willows, alders, and other deciduous riparian vegetation. Aspen habitat with

these components, harbor a greater diversity and abundance of breeding birds than any other habitat in the Northern Sierra.
- Retain all snags over eight inch DBH in aspen treatments regardless of species, though highest priority should be given to retaining aspen snags.
- Reduce or eliminate over-browsing/grazing in regenerating Aspen stands through fencing or removal of livestock from the area of concern to ensure long-term continued regeneration and structurally diverse aspen stands.
- Consider the potential negative impacts grazing adjacent to aspen treatments has on the abundance of cowbirds and the potential ramifications on open cup nesting birds.

Pine Hardwood

- Prioritize an inventory and delineation of all potential areas for pine-hardwood enhancement at the district level.
- Maximize snag retention focusing on retaining multiple decay classes. Retain all oak and pine snags and where hazard trees are found top them to retain higher densities of snags.
- As both structural diversity and foliage volume are key avian habitat features, restoring both should be a management priority for pine-hardwood enhancement. Suckering of oaks would provide more mid-story foliage volume an important foraging component for many insectivorous birds.
- It is imperative to manage for understory habitat structure - including dense patches of shrubs and herbaceous plant species - in pine-hardwood habitat enhancement projects. Designing treatments that will create a mosaic of varying canopy covers (e.g. 10 – 60%) across stands in combination with prescribed burning should promote the establishment and enhance existing understory plant communities.
- Develop Pine-Oak treatments to create greater mosaics of canopy cover than was implemented at Brown's Ravine. 40% canopy cover can be achieved across a stand by creating dense clumps of conifers interspersed with semi-open pine-oak patches and open canopies areas dominated by shrubs and regenerating oak and pine.

Montane Shrub

- Consider the ecological value of shrubs within forested habitats and especially where they occur in shrub fields in project planning and design and consider the long-term viability of shrub habitats under the SNFPA.
- Manage a portion (e.g. 50%) of group selections for natural regeneration, including allowing for shrub communities to dominate some sites.
- Allow some areas to regenerate naturally following stand replacing fire events rather than salvaging, masticating, and re-planting for quick development of conifers. This should promote greater diversity in habitat structure on the landscape, uneven aged stands, and shrub and snag habitat for numerous avian and other wildlife species.
- Prioritize sites that are, or have the potential to regenerate, mixed species shrub fields (e.g. whitethorn, Manzanita, chinquapin, gooseberry, etc.). Mixed species shrub habitats have higher diversity and abundance of shrub nesting bird species than monotypic stands (e.g. Manzanita fields).

- Retain high snag densities in group selections as snags in open areas are readily used by numerous cavity nesting species (e.g. woodpeckers, bluebirds, swallows). Several shrub study plots support up to five species of woodpecker within a 10 hectare area, including Pileated, Hairy, White-headed, and Red-breasted Sapsucker.
- Replant conifers in group selections not slated for natural regeneration in a clumped design in order to create a mosaic with a semi-open canopy that invigorates shrub development in the openings and reduces the need to re-enter sites for thinning in 10 - 20 years.
- Design DFPZ plantation treatments and other thinning projects to create structural diversity by thinning to create some open patches with little canopy cover. In these openings promote lush and dense shrub communities.
- Apply prescribed fire treatments in decadent shrub fields where growth and live vegetative cover is now reduced. Manage these areas for regeneration of a newly invigorated shrub community.
- Greatly expand the use of under burns in thinning and group selection treatments to allow herbaceous and shrub seeds access to mineral soils to promote their regeneration.

Meadows

- Manage for wet meadows with functional hydrology and long-term resiliency in the face of changing climate patterns.
- Foster partnerships with local government, state agencies, and non-profit organizations to ensure meadow protection, enhancement, and long-term management
- Promote dense clumps of riparian deciduous shrubs and trees interspersed with tall lush herbaceous vegetation.
- Minimize non-natural disturbance such as livestock grazing and off-highway vehicle use.
- Manage for both low and high elevation meadows as they support different avian assemblages.

Presentations

Using Birds to Guide National Forest Management in the Sierra Nevada – oral presentation – International Partner's in Flight Conference – 2/16/08 – McAllen, TX.

Listening to the Birds: An Ecosystem Approach to Sierra Nevada Management – invited oral presentation – Society of American Foresters – California Chapter Annual Meeting – 1/31/2009 - Sacramento, CA.

Avian Monitoring in the HFQLG Area – 2007. Plumas-Lassen Study Symposium – 3/28/2008 - Quincy, CA.

Outreach

"Birds in the Park" – presentation on managing coniferous forest for birds and bird banding demonstration in collaboration with Lassen Volcanic National Park – over 200 park visitors participated 7/20/08.

Sierra Institute Bird Field Tour – Lead field tour to discuss the importance of meadows to Sierra Nevada birds including presentation and banding demonstration. – 6/28/2008.

Bird Banding Field Trip – coordinated outreach field trips with the Lassen National Forest to view bird banding and discuss the use of birds as indicators in forest management, PLAS study, and PRBO –7/16/2008.

Participated in several Forest Service Field Trips on the Almanor and Eagle Lake Ranger Districts.

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

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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.

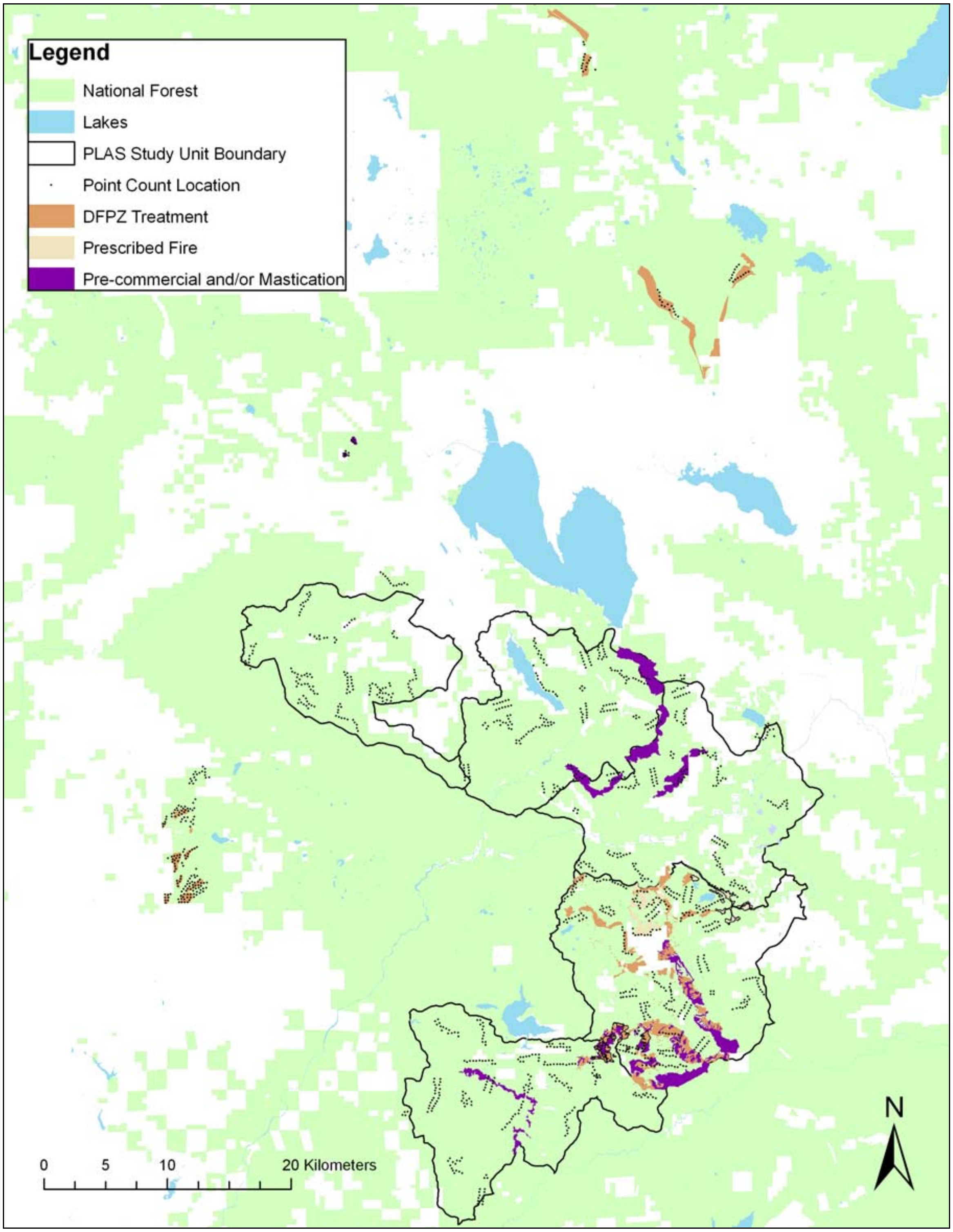
Other variables calculated from GIS layers for each study site included elevation, slope, annual solar radiation, vegetation type (California Wildlife Habitat Relationships classification from the US Forest Service CalVeg layer), and presence of a riparian habitat conservation area.

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).

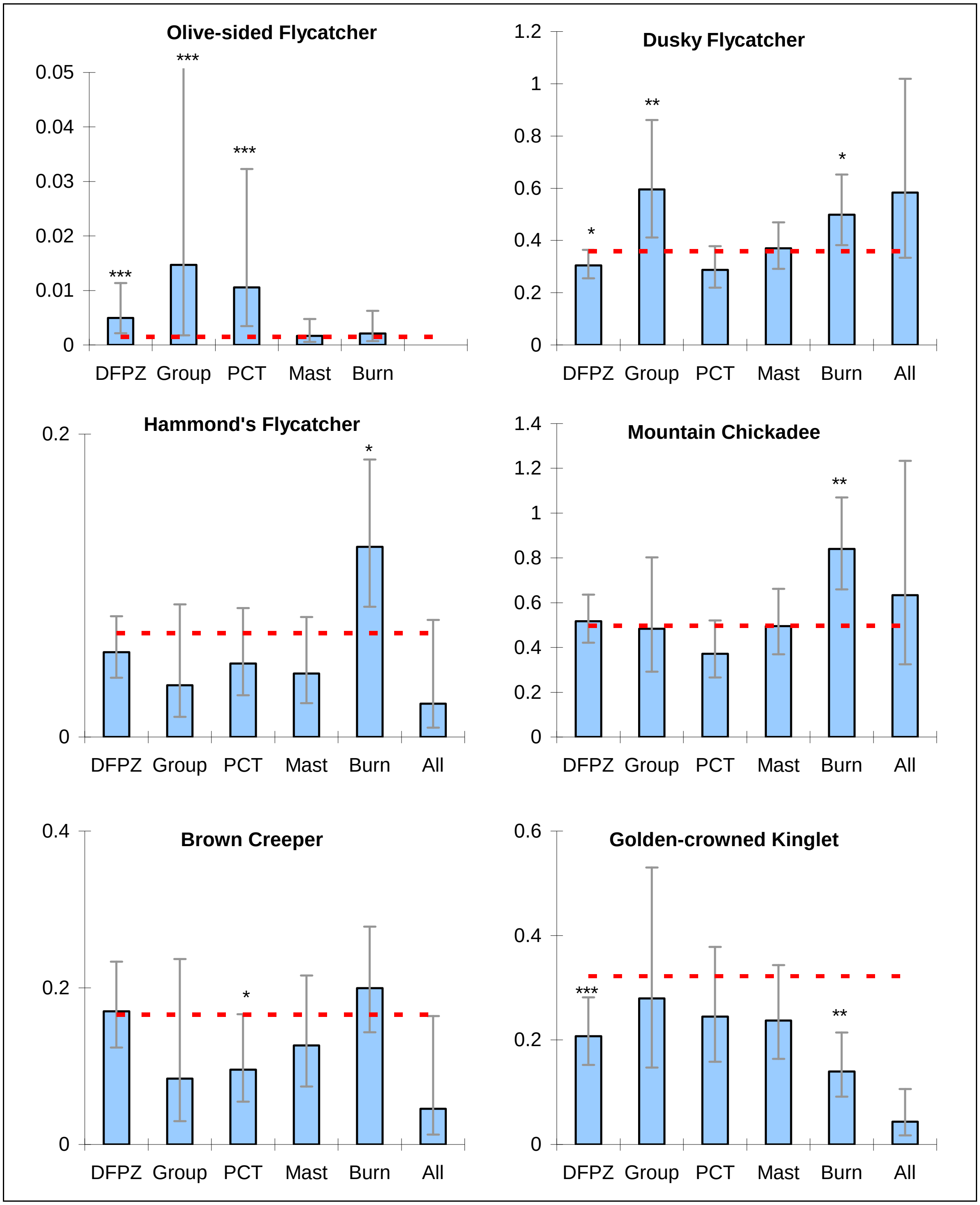
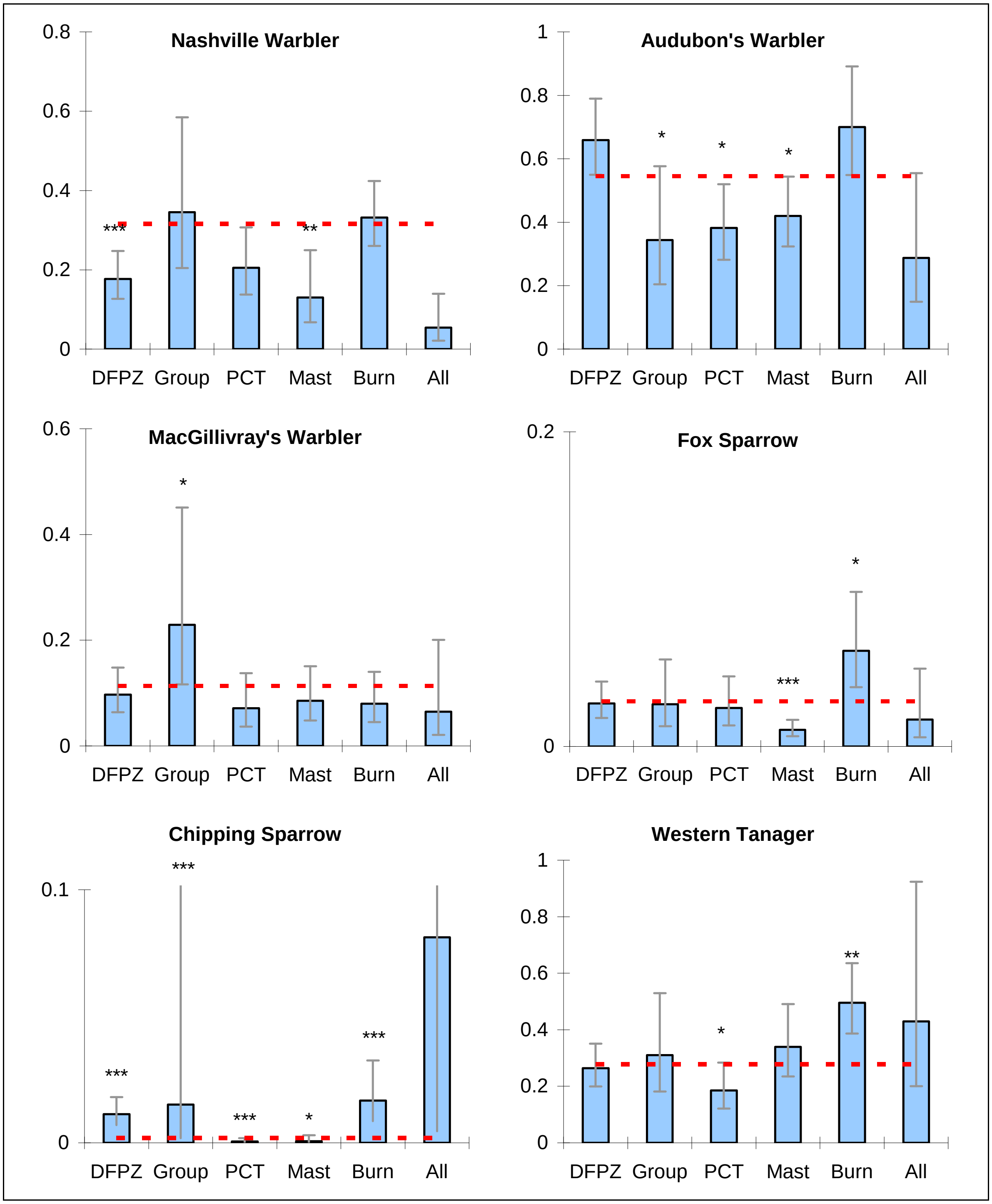


Figure 2. continued



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.

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Chapter 2. Resident and Neotropical Migratory Bird Response to Aspen Enhancement on the Lassen National Forest

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Background and Introduction

Declines in numerous songbird populations throughout North America have been well documented, particularly among Neotropical migrants – those species that breed in the U.S. and Canada and migrate to Mexico or Central or South America (see Finch and Stangel 1993). The Lassen area supports populations of many of these declining and threatened species, including Warbling Vireo, Swainson's Thrush, Willow Flycatcher, Olive-sided Flycatcher, and Yellow Warbler. The area is home to 9 of the 14 Riparian Focal Species and at least 12 of the 13 Coniferous Forest Focal Species listed by California Partners in Flight (RHJV 2004, CalPIF 2002), as well as all of the species of landbirds identified as declining or likely declining by the Sierra Nevada Ecosystem Project Report (SNEP 1996).

The composition and structure of western North American forests have been altered by fire-suppression, timber harvesting, grazing, and other forest management policies (see Hejl 1994, SNEP 1996, and Siegel & DeSante 1999). Human mediated shifts in the competitive balance of these vast and complex systems can result in permanent loss of habitat types or conditions if steps are not taken to mitigate these impacts.

In the Sierra Nevada, with extensive livestock grazing and the absence of regular fire, aspen are often out-competed by conifers (Mueggler 1985). As a result, the health of aspen has deteriorated and its extent throughout western North America has been reduced by at least 50 and up to 96% (Bartos and Campbell 2001). In 2000, the Eagle Lake Ranger District (ELRD) of the Lassen National Forest (LNF) began an aspen habitat inventory and risk assessment project. This effort documented that nearly 80% of all of the remaining stands had a high or highest risk rating, indicating that without immediate action the future of aspen in the district was endangered. Henceforth, they began a district-wide strategy to enhance and save aspen habitat by implementing conifer removal and erecting grazing exclosures at all remaining stands (Jones et al. 2005). While the study of birds in aspen habitat in the Sierra Nevada has only recently been a focus of ornithological research, evidence from point count data from the Almanor Ranger District of the LNF (Burnett and Humple 2003), the Mono Basin (Heath and Ballard 2003), and the Lake Tahoe Basin (Richardson and Heath 2005), show that aspen habitat supports an extremely rich and abundant avian community that includes several species of conservation concern, such as Warbling Vireo and Red-breasted Sapsucker (Gardali et al. 2000, Rich et al. 2004).

The avian community in the Lassen National Forest occupies a diverse range of niches with its members associated with a broad range of habitat types and features (Siegel and DeSante 1999, Burnett and Humple 2003). Birds are relatively high on the food chain and have been shown to be sensitive to environmental change. Using one inexpensive standardized method, it is possible to acquire data on an entire community of organisms. Thus, birds are an ideal candidate for use as ecosystem indicators as bird monitoring can provide the necessary feedback at the appropriate breadth and scale (Temple and Wiens 1989, Hutto 1998) to be a valuable tool to land managers.

In 2004, PRBO began monitoring bird response to aspen treatments on the Eagle Lake Ranger District of the Lassen National Forest. With the recent attention the Forest Service has place on monitoring and adaptive management (SNFPA 2004), this project will provide the necessary data to evaluate the efficacy of aspen treatments and provide feedback to support and/or improve future aspen projects in the ELRD and throughout western North America.

Project Area

All avian survey work was conducted on the Lassen National Forest in the Eagle Lake and Almanor Ranger Districts at the junction of the Sierra Nevada and Cascade Mountains of California (Lat 40^0 N, Long 120^0 W). Sites ranged in elevation from approximately 1500 – 2000 meters (Figure 1).

Methods

Aspen Sampling Design

For all aspen sites we used GIS layers containing polygons of known aspen stands based upon aspen inventories conducted by Forest Service staff.

In the Eagle Lake Ranger District we selected sites non-randomly that represent the range of conditions in which aspen are found throughout the District. We limited our selection to areas that could be covered by one observer in a four hour morning count window and that contained enough acres of aspen habitat to fit a minimum of 4 point count stations with at least 220 meter spacing between points. We attempted to maximize the number of post-treatment sites, which were limited in number, as they could provide us with information on bird response to aspen treatments that were already five to nine years old.

In the Almanor Ranger District we selected sites that were within proposed aspen enhancement projects (e.g., Minnow, Creeks II, Brown's Ravine, and Feather), and one additional site that has been proposed for treatment (Robber's Creek).

On both districts we attempted to maximize the number of points within the delineated aspen stands in the areas selected. In some areas where stands were not in high densities, we limited transect size to allow for the extra time to walk between stands in order to allow for completion within the limited morning hours allowed by the standardized protocol. Generally, the first stand chosen was the one closest to the nearest road. Once the first stand was chosen, the next closest stand that was at least 200 meters from the previous was selected, and so on. All sites were selected without previous knowledge of the local micro habitat attributes.

Survey Protocol

Standardized five minute fixed radius multiple distance band point count censuses (Ralph et al. 1993, Buckland et al. 1993) were conducted at 181 stations along 18 transects in 2008 (Table 1, Figure 1, and Appendix 1). Detections were placed within one of six categories based on the initial detection distance from observer: less than 10 meters, 10-20 meters, 20-30 meters, 30-50 meters, 50-100 meters, and greater than 100 meters. Birds flying over the study area but not observed landing were recorded separately. The method of initial detection (song, visual or call) for each individual was recorded. Counts began around local sunrise and were completed within four hours. All birds detected at each station during the five-minute survey were recorded. Each transect was surveyed twice between 15 May and 1 July in each year, including 2008 (Table 1). An electronic range finder was used to assist with distance estimation at each point count station.

Table 1. Aspen point count transects, ranger district, number of stations, and dates surveyed in 2008.

Site	# of Stations	Ranger District	Date, 1st Survey	Date, 2nd Survey
Brown's Ravine Aspen	4	Almanor	5/30/2008	6/23/2008
Coon Hollow Aspen	14	Almanor	6/5/2008	NS
Philbrook Aspen	10	Almanor	6/5/2008	6/23/2008
Robber's Creek Aspen	16	Almanor	5/28/2008	6/16/2008
West Dusty Aspen 1	10	Almanor	5/26/2008	6/12/2008
West Dusty Aspen 2	6	Almanor	5/25/2008	6/27/2008
West Dusty Aspen 3	8	Almanor	5/26/2008	6/26/2008
West Dusty Aspen 4	8	Almanor	6/03/2008	6/27/2008
Willow Creek Aspen	9	Almanor	6/03/2008	6/21/2008
Butte Creek Aspen	8	Eagle Lake	6/06/2008	6/27/2008
Crazy Harry Aspen	7	Eagle Lake	5/29/2008	6/21/2008
Feather Lake Aspen	5	Eagle Lake	5/29/2008	6/21/2008
Harvey Valley Aspen	15	Eagle Lake	5/28/2008	6/20/2008
Lower Pine Creek Aspen	12	Eagle Lake	6/6/2008	6/20/2008
Martin Creek Aspen	11	Eagle Lake	5/30/2008	6/18/2008
Pine Creek Aspen	14	Eagle Lake	5/28/2008	6/20/2008
Ruffa Aspen	12	Almanor	6/8/2008	6/23/2008
Susan River Aspen	12	Eagle Lake	6/5/2008	6/27/2008

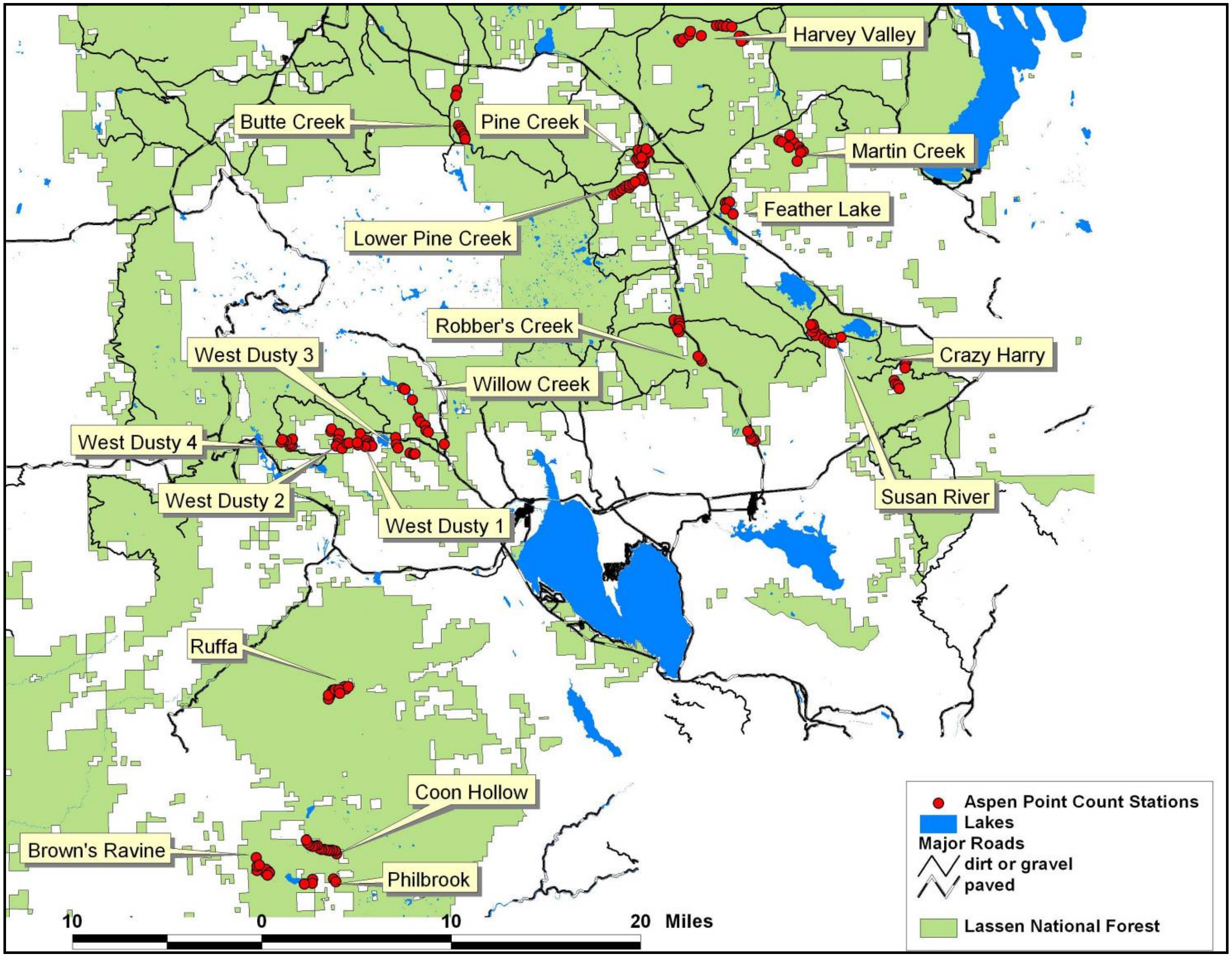
Analyses

Avian community point count analysis was restricted to a subset of the species encountered. We excluded species that do not breed in the study area as well as those that are not adequately sampled using the point count method (e.g., waterfowl, kingfisher, and raptors). We also excluded European Starling and Brown-headed Cowbird from analysis of species richness and total bird abundance because they are invasive species regarded as having a negative influence on the native bird community. However, we did investigate the abundance of these two species separately.

Species richness

We define species richness is the average number of species detected within 50 meters per point across visits within a year of species adequately sampled using the point count method.

Figure 1. Location of PRBO Aspen point count stations in the Lassen National Forest surveyed in 2007.



Total Bird Abundance

The index of total bird abundance is the mean number of individuals detected per station per visit. This number is obtained by dividing the total number of detections within 50 meters by the number of stations and the number of visits.

Relative Abundance of Species

The relative abundance of species is the total detections of a given species per point summed across the two visits within a year. We used total detections instead of detections per visit to allow for use of negative binomial regression – which requires raw count data – to compare differences. For analysis that compare multiple years we summed the total detections across years and divided by the number of years. Thus, multiple-year analyses are directly comparable to those comparing single years.

Trends in Richness and Abundance

I investigated trends in species richness and total bird abundance at treated and untreated aspen stands in the ELRD from 2004 – 2008. We included all sites surveyed on the ELRD, and since treatment occurred at a number of sites during this four year period, they may have been included in the untreated sample in one or more years and the treated sample in later years.

Statistical Tests

I employed a suite of statistical tests in comparing treated aspen to untreated aspen. Negative binomial regression was used to test for differences in indices of abundance of individual species between treated and untreated aspen stands; while I used linear regression to compare the community indices of species richness and total bird abundance. The test statistic (F for linear & Likelihood Ratio for negative binomial) and p-values are presented. For the analysis of trends I used linear regression with year as the independent variable. To test the significance between the treated and untreated trends I used a likelihood ratio test to compare linear regression models with and without a year x treatment interaction. The likelihood ratio χ^2 statistic and p-value from these tests are presented. For all tests significance was assumed at an $\alpha = 0.05$ level. Stata statistical software was used to conduct all statistical analysis (Stata Corp 2008).

Results

In 2008, total bird abundance ranged from a high of 8.00 at Feather Lake to a low of 1.29 at Crazy Harry, and species richness ranged from 8.42 at Ruffa Ranch to 2.25 at Susan River (Table 2). The average total bird abundance by transect in 2008 was 4.42 while species richness was 6.08.

We compared the total bird abundance and species richness at untreated aspen sites in the ARD to untreated aspen sites in the ELRD in 2008. Species richness was 6.07

in the ARD and 5.54 in the ELRD. Total bird abundance in the ARD was 4.14 compared to 3.49 in the ELRD (Figure 2); neither of these differences was statistically significant. When sites in the ELRD that have been treated were included, ELRD mean per point species richness increased to 6.32 while total bird abundance increased to 4.45.

Total bird abundance and species richness were higher at treated sites compared to untreated sites in the ELRD between 2006 and 2008 (Figure 3). Across this three year period, total bird abundance averaged 5.98 at treated sites and 4.50 at untreated sites ($F=29.40$, $p<0.01$). Species richness at treated sites averaged 7.28 compared to 6.33 at untreated sites ($F=9.70$; $p<0.01$).

Table 2. Mean per point total bird abundance (detections/point/visit) and species richness (within 50 m of observers) at aspen sites surveyed in the Lassen National Forest from 2004 – 2008. Sites not surveyed are represented by double dashes. Coon Hollow and Philbrook transects were surveyed only once in 2008 due to fire access restrictions, thus they were not included in 2008 figures.

Station	Total Bird Abundance					Species Richness				
	2004	**2005**	**2006**	**2007**	**2008**	**2004**	**2005**	**2006**	**2007**	**2008**
Ruffa Aspen	5.72	7.11	5.92	6.88	6.33	7.56	7.33	7.50	8.92	8.42
Brown's Ravine	2.38	3.25	4.13	3.75	2.75	2.75	5.25	6.25	5.00	4.25
Butte Creek	4.63	5.81	7.31	5.69	5.50	5.75	8.00	9.63	8.38	7.75
Coon Hollow	--	--	--	4.75	--	--	--	--	6.71	
Crazy Harry	4.50	4.00	5.43	3.64	3.57	6.43	5.43	8.00	5.85	5.71
Feather Lake	4.60	7.40	5.30	9.50	8.00	6.40	7.20	5.80	7.80	7.80
Harvey Valley	3.47	3.03	5.93	4.17	2.43	4.93	4.47	6.93	4.67	3.47
Lower Pine	4.00	2.67	4.04	4.67	3.96	5.75	4.42	5.92	6.83	6.17
Martin Creek	3.78	4.18	3.91	6.32	5.86	5.09	5.45	5.27	8.00	8.36
Philbrook Aspen	--	--	--	3.65	--	--	--	--	5.30	--
Pine Creek	4.60	4.57	5.90	5.04	4.71	5.93	6.43	7.21	7.00	6.86
Robber's Creek	--	--	5.72	5.78	5.09	--	--	7.63	7.31	7.63
Susan River	3.67	3.13	3.09	4.92	1.29	4.75	5.00	4.50	6.5	2.25
West Dusty 1	--	--	3.75	4.30	3.00	--	--	5.5	6.80	5.00
West Dusty 2	--	--	3.33	3.67	4.08	--	--	4.00	3.67	5.67
West Dusty 3	--	--	3.63	3.81	3.19	--	--	5.50	5.63	5.38
West Dusty 4	--	--	4.75	5.25	4.56	--	--	6.75	7.88	5.75
Willow Creek	--	--	4.28	5.44	4.61	--	--	5.33	7.22	6.78
Total	**4.16**	**4.67**	**5.36**	**5.32**	**4.42**	**5.53**	**5.90**	**6.68**	**6.79**	**6.08**

Species richness at treated sites has been increasing at a rate of 6.2% ($f= 7.83$, $p=0.01$) per year between 2004 and 2008 while at untreated sites it was increasing at 4.6% ($f=10.91$, $p=<0.01$) per year (Figure 4). The rate of increase in treated stands was not significantly greater than that in untreated stands (LR $\chi^2= 0.65$, $p=0.65$). Total bird abundance from 2004 through 2008 at treated sites was increasing at a rate of 5.2% ($f=3.27$, $p=0.07$) per year while at untreated sites it was increasing at a rate of 3.2% ($f=3.57$, $p=0.06$) per year (Figure 5). The difference in the trends between treated and untreated was not significant (LR $\chi^2= 0.27$, $p=0.60$).

Figure 2. Mean per point species richness and total bird abundance (mean per visit) based on detections within 50 meters of observers at untreated Aspen sites in the Almanor and Eagle Lake Ranger Districts in 2008 with standard error bars (excluding Coon Hollow and Philbrook).

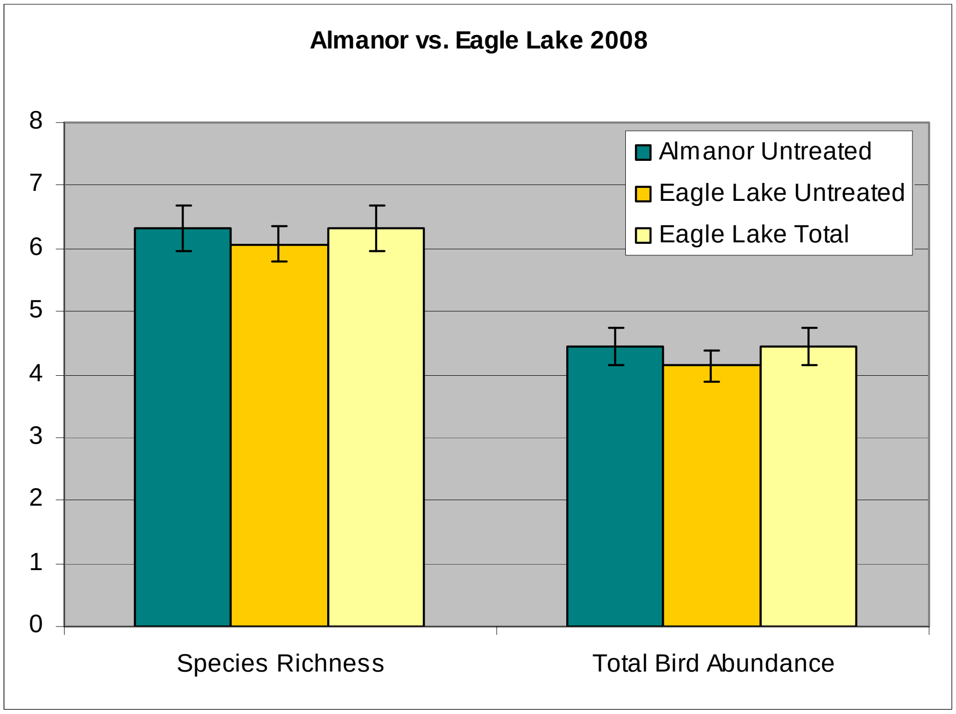
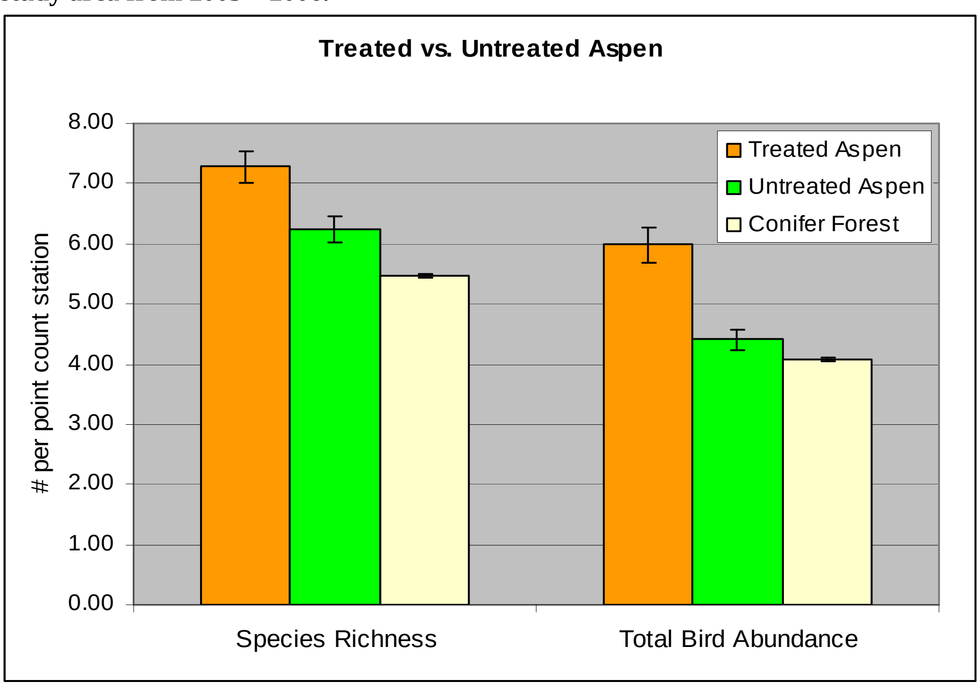


Figure 3. Mean per point species richness and total bird abundance at treated and untreated aspen in the Eagle Lake Ranger District from 2006 – 2008 compared to coniferous forest in the Plumas-Lassen study area from 2003 – 2006.



We investigated an index of the abundance of ten of the twelve previously identified aspen focal species (Burnett *in press*), at treated aspen, untreated aspen, and conifer forest. We also included Mountain Chickadee, another potential focal species. There were not adequate detections of Swainson's Thrush and Olive-sided Flycatcher – the remaining two focal species – to include them in the analysis.

Seven of the ten species were significantly more abundant in treated aspen than untreated aspen each of these seven were also significantly more abundant in aspen of any kind compared to coniferous forest in the region (Table 3, figure 6). Red-breasted Sapsucker, Hairy Woodpecker, Warbling Vireo, Mountain Bluebird, Tree Swallow, Mountain Chickadee and Chipping Sparrow were all significantly more abundant in treated aspen than untreated aspen. Additionally, total bird abundance and species richness were significantly greater in treated stands compared to untreated stands. Western-Wood Pewee, showed a small non-significant difference between treated and untreated aspen though it was far more abundant in either treated or untreated aspen than conifer forest. Only two focal species, Dusky Flycatcher and MacGillivray's Warbler, remained more abundant in untreated than treated aspen. The difference was marginally significant for Dusky Flycatcher and was not significant for MacGillivray's Warbler.

Table 3. Species Richness, total bird abundance, and the detections per point count visit for ten aspen focal species at treated and untreated aspen sites across the Lassen National Forest from 2006 -2008. P-value is from linear (species richness) or negative binomial regression (all other metrics) comparing treated to untreated aspen. Means from conifer forest in the Plumas-Lassen Administrative study area from 2003-2006 are also presented for comparison.

	Treated Aspen	Untreated Aspen	P	Conifer Forest
Species Richness	7.28	6.32	<0.01	5.47
Total Bird Abundance	5.98	4.50	<0.01	4.08
Red-breasted Sapsucker	0.24	0.15	0.03	0.03
Hairy Woodpecker	0.20	0.09	0.01	0.03
Western Wood-Pewee	0.18	0.16	0.59	0.02
Dusky Flycatcher	0.13	0.20	0.06	0.26
Warbling Vireo	0.59	0.45	0.04	0.09
Tree Swallow	0.48	0.03	<0.01	0.01
Mountain Bluebird	0.19	0.00	<0.01	0.00
Oregon Junco	0.55	0.45	0.14	0.36
Chipping Sparrow	0.21	0.09	<0.01	0.01
MacGillivray's Warbler	0.10	0.12	0.38	0.11

Figure 4. Mean per point species richness (with standard error) at treated and untreated aspen sites from 2004 -2008 in the Lassen National Forest with fitted linear trend lines.

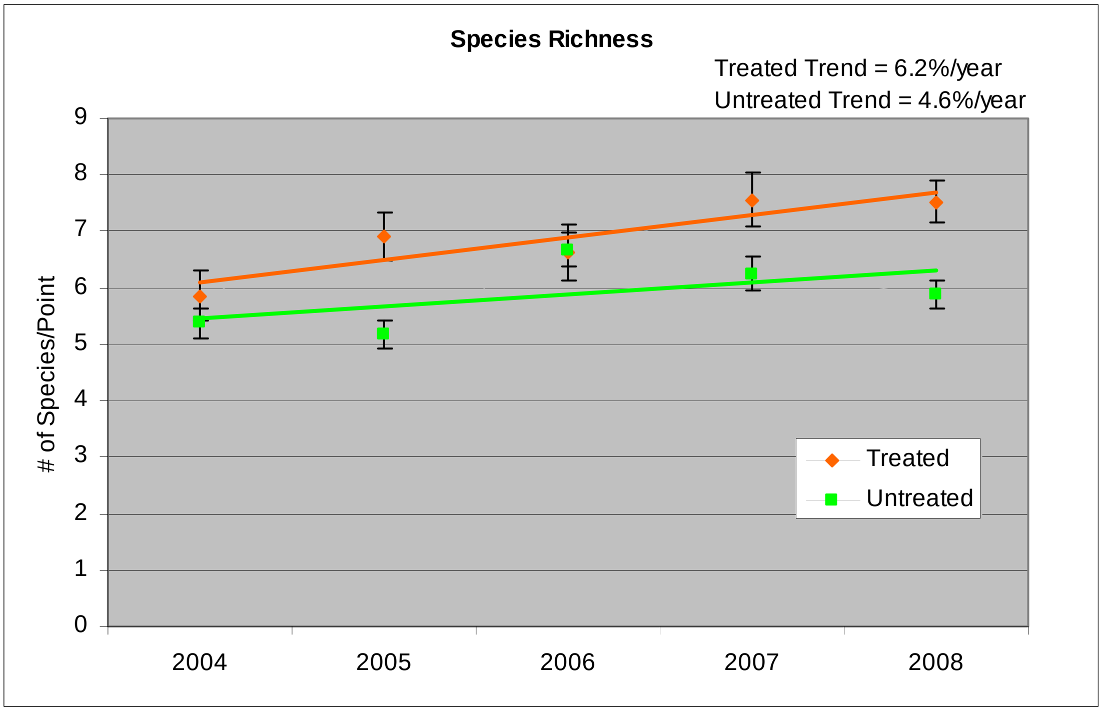


Figure 5. Total bird abundance per point count visit (with standard error) by year at treated and untreated aspen sites from 2004 -2008 in the Lassen National Forest with fitted linear trends.

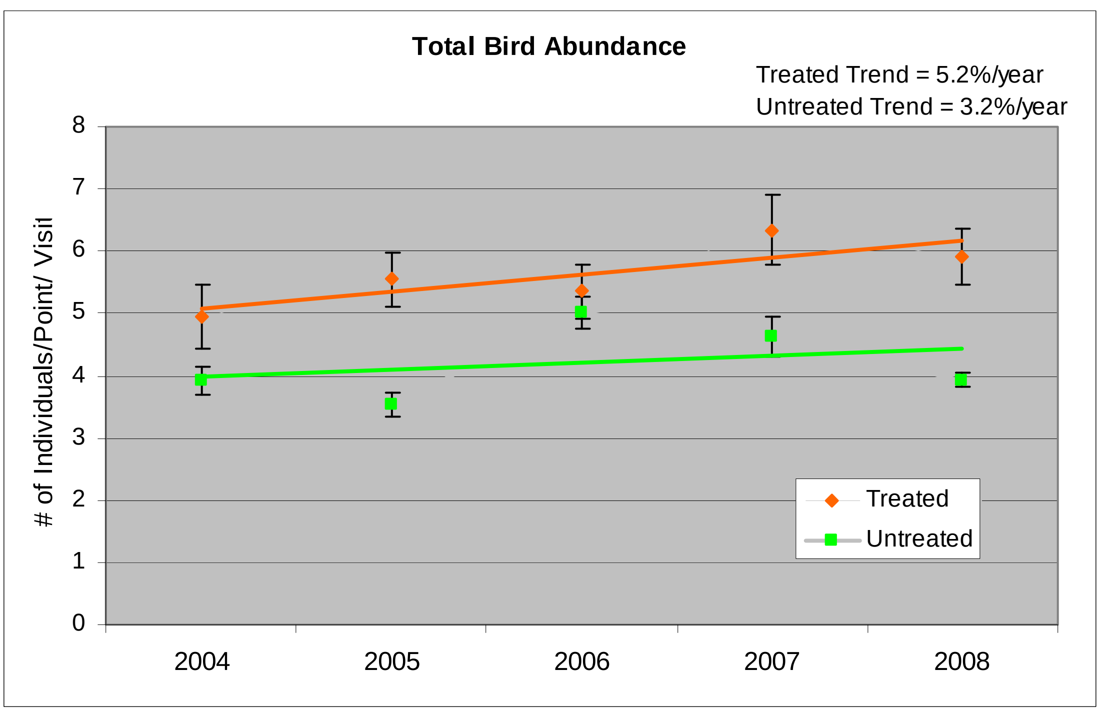
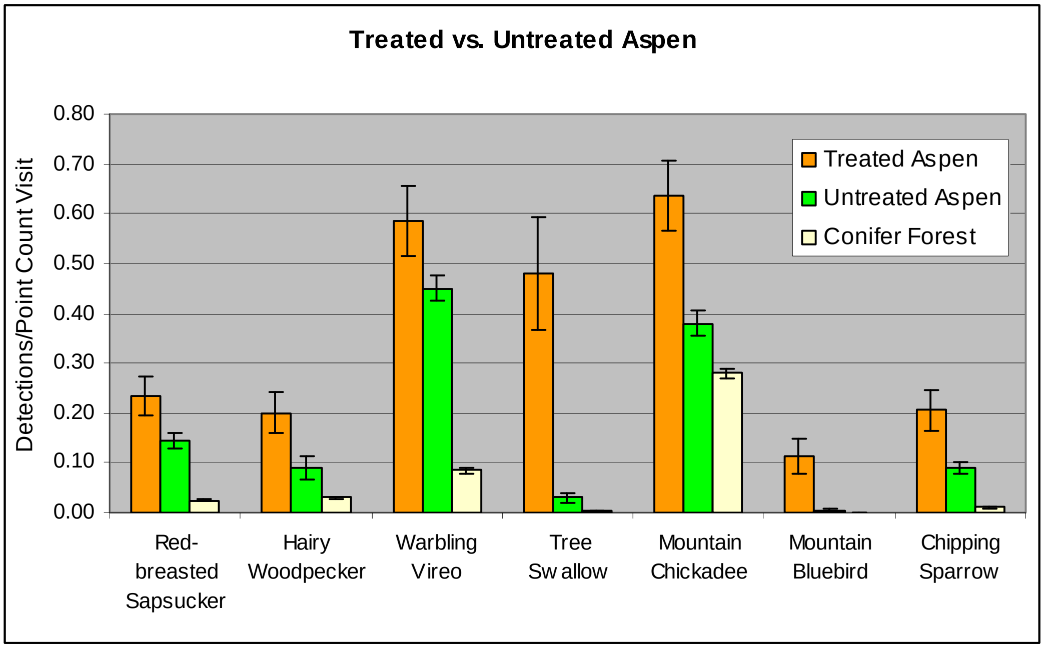


Figure 6. Abundance per point count visit (with standard error) for the seven aspen focal species with a significant difference in abundance (p<0.05) between treated and untreated aspen across the Lassen National Forest from 2006-2008. Conifer habitat indices are shown for comparison using data from the Plumas-Lassen Admin Study area from 2003 – 2006.



We investigated the effect of time since treatment on total bird abundance and species richness for all aspen sites on the Lassen National Forest while controlling for year. When all treated and untreated sites are included (with those that have not been treated coded as zero) there is a significant positive effect ($F=18.5$, $p<0.01$) of time since treatment (Figure 7). When untreated sites were not included there was no effect of time since treatment ($F=1.68$, $p=0.19$) on total bird abundance. For species richness the effect of time since treatment was positive and significant when untreated sites were included ($F=14.26$, $p<0.01$) but was not when they were excluded ($F=1.74$, $p=0.19$; Figure 8).

The time since aspen stands had been treated had a significant effect on the abundance of six of the ten focal species (Figure 9). For Red-breasted Sapsucker and Chipping Sparrow the effect was positive and the best fit was linear. For each of the other five species the effect was more complex. For Hairy Woodpecker, Tree Swallow, Mountain Bluebird, and Dusky Flycatcher, the best fit model was one with a quadratic effect of treatment. For all of these except Dusky Flycatcher there was an increasing trend peaking in the four to five year post treatment period followed by a significant decrease after that. Dusky Flycatcher was the only species to show a negative effect of time since treatment. It decreased in the years immediately following treatment but showed an increase in abundance in the longest time since treatment interval.

Figure 7. The effect of time since treatment on total bird abundance in aspen habitat on the Lassen National Forest from 2004 – 2008. The black line is the predicted values including all sites that have not been treated as zero years post treatment. The green line represents the predicted values if only sites that have been treated are included. Within a year multiple identical values are only represented with a single data point.

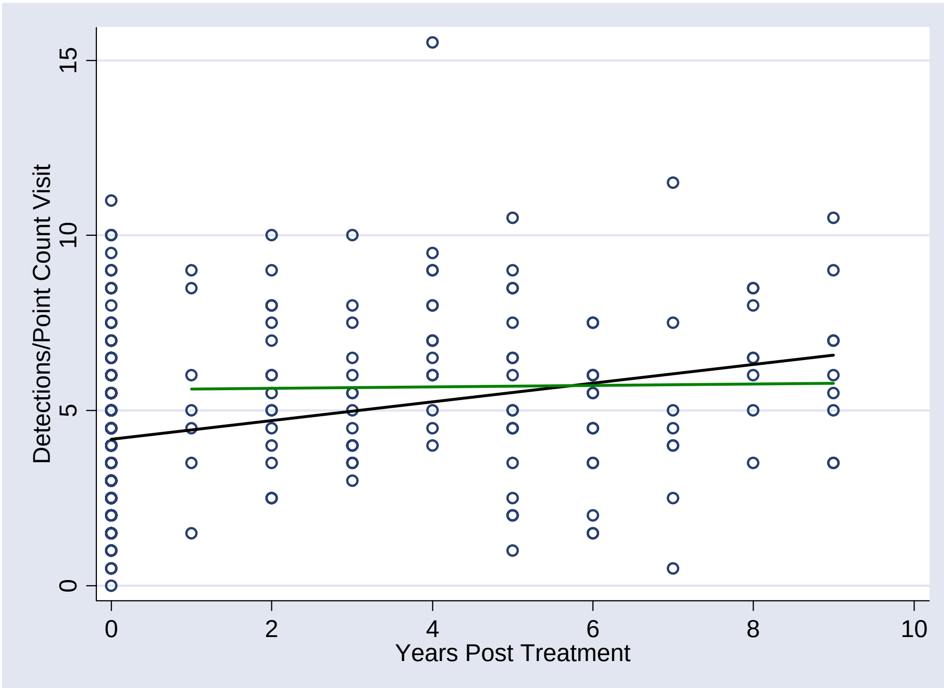


Figure 8. The effect of time since treatment on avian species richness in aspen habitat on the Lassen National Forest from 2004 – 2008. The black line is the predicted values including all sites that have not been treated as zero years post treatment. The green line represents the predicted values if only sites that have been treated are included. Within a year multiple identical values are only represented with a single data point.

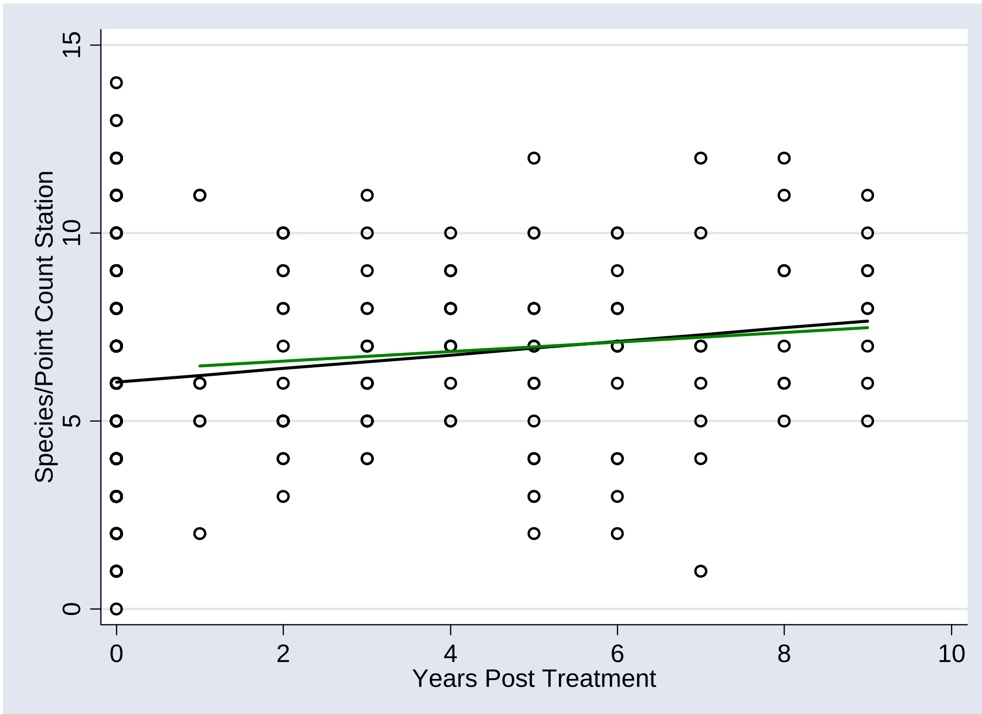
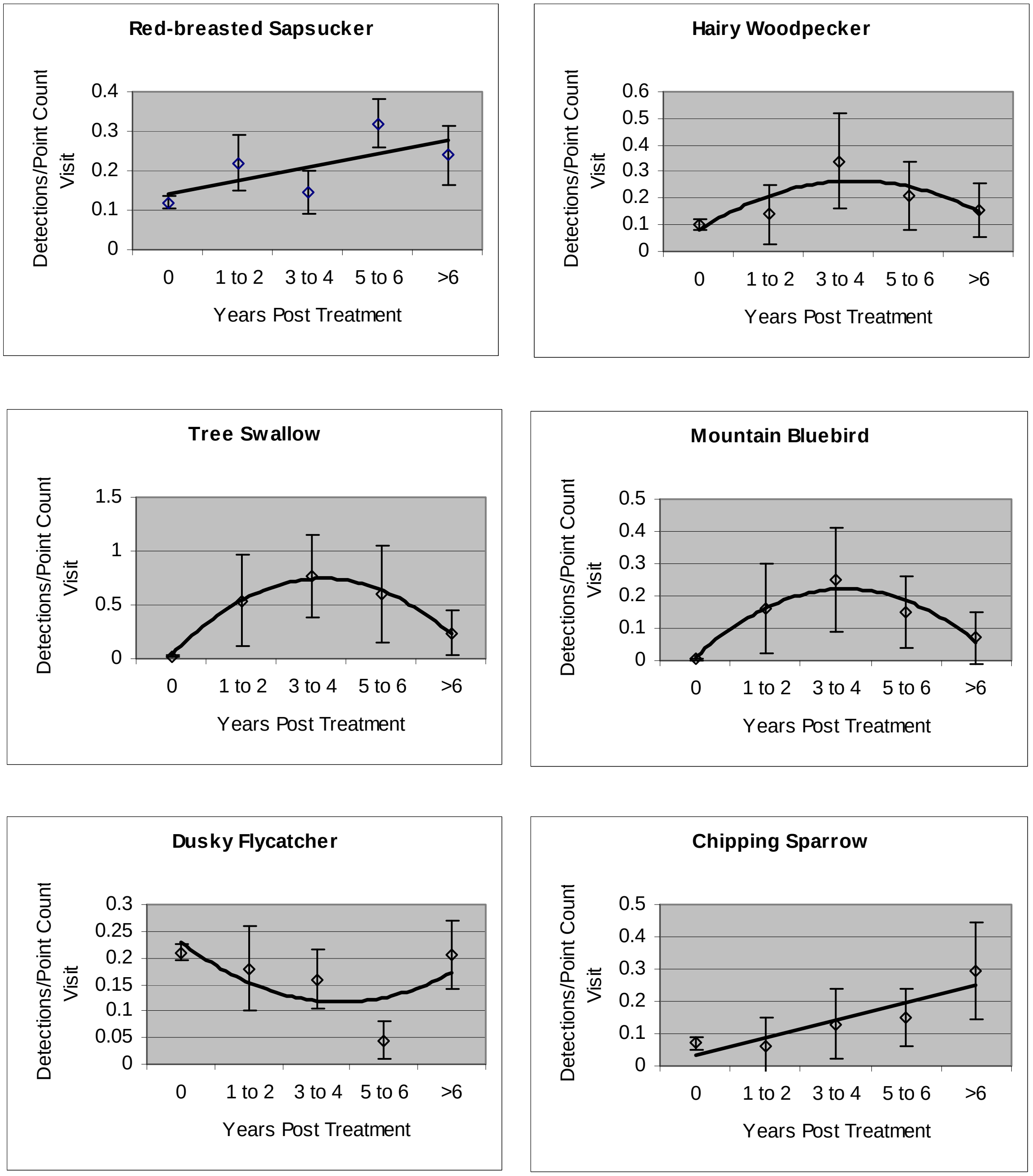


Figure 9. The mean abundance per point count visit with standard error and predicted values for the six focal species showing a significant effect of time since treatment from 2004 - 2008. Graphs show time since treatment in intervals for illustrative purposes but regression was conducted with all data. All aspen sites surveyed on the Lassen National Forest are included. All untreated sites were coded as zero years post treatment.



Discussion

Aspen habitat on the Lassen National Forest harbors greater total bird abundance, species richness, and abundance of almost all of the aspen focal species compared to conifer-dominated forest in the region. On average, aspen habitat on the Almanor and Eagle Lake Ranger Districts have comparable avian community indices though across both districts there is considerable site to site variation in these indices as well as in the abundance of individual species. In general, community indices at all sites were lower in 2008 than in 2007 a pattern that was expected following record high avian indices across habitats in the northern sierra in 2007 (PRBO data). The largest decrease from 2007 to 2008 was observed at Harvey Valley, a site where half of the stations we sampled had been treated over the last winter. This decrease immediately following treatment appears contrary to the majority of our results investigating the effects of aspen treatments on the avian community. We did not include Harvey Valley in the following analyses of treatment effects because it was only partially treated in 2008 and piles of logs were still stacked within our sampling area.

Treated vs. Untreated

In the ELRD the short term response of the avian community to aspen treatments has been decidedly positive. Over the five year period of monitoring bird populations in aspen habitat on the ELRD, there have been significant increases in species richness and a marginally significant increase in total bird abundance at both treated and untreated aspen. We have not observed similar patterns in conifer forest during this period (Burnett and Nur 2007). While the difference in the rate of increase between treated and untreated aspen was not significant, the rate was greater in treated aspen for both species richness and total bird abundance. It is not clear what would be leading to an increase in these metrics at untreated aspen sites; however, we have several hypotheses. First, over this time period we added new sites to our sample – particularly on the Almanor Ranger District where untreated aspen sites have shown slightly higher levels of these two indices. Second, recovery of habitat following the removal of grazing can result in significant increases in the majority of aspen associated birds in the west (Earnst et al. 2006). Many of the aspen sites have seen a reduction or cessation of grazing over the last five to 15 years which may be allowing for some improvement in aspen bird habitat.

Aspen treatments appear to be benefiting passerine species that are rare, declining, or both. All of the seven focal species that were significantly more abundant in treated aspen compared to untreated aspen were all also significantly more abundant in treated aspen than conifer forest. Chipping Sparrow has shown a consistent increasing trend as treated aspen sites mature. It has been significantly declining at a rate of 3.4% per year from 1968-2007 in the Sierra Nevada (Sauer et al. 2008); however, they are increasing significantly in treated aspen stands. This species often nests in understory trees in areas with a substantial herbaceous layer where it forages on insects and seeds (Middleton 1998). Thus, treated aspen stands appear to be ideal habitat for this species that is very rare in conifer dominated forest in the region. Likewise, Mountain Bluebird and Tree Swallow are all but absent from conifer forest and untreated aspen but are fairly common to abundant (respectively) in treated aspen. Mountain Bluebird has been declining over the past 40 years at a rate of 2.5% per year, though due to their rarity this trend is not significant (Sauer et al. 2008).

Warbling Vireo, which from 2004-2005 was more abundant in untreated aspen, continued to increase in treated aspen where it is now significantly more abundant than in untreated aspen. Treated sites such as Butte Creek and Martin Creek with two to three meter tall aspen regeneration are being used by this species for foraging as well as nesting. As total aspen cover was the best predictor of this species abundance (Burnett et al. 2005), we should expect to see a continued increase in this species in treated stands as they mature; a positive sign for a species that may be declining in at least part of its range in the west (Gardali et al. 2000).

Aspen habitat often supports a diverse and abundant guild of cavity nesting species, with many studies showing cavity nesters disproportionately select aspen trees for nesting (Li and Martin 1991, Dobkin et al. 1995, Martin and Eadie 1999, Martin et al. 2004). While aspen often contain relatively high numbers of natural cavities, secondary cavity nesting species have been found to nest predominantly in woodpecker created holes in both live aspen and aspen snags (Li and Martin 1991, Dobkin et al. 1995, Martin and Eadie 1999). At numerous treated aspen - including those at Feather Lake, Butte Creek, Pine Creek, and Martin Creek - we confirmed active woodpecker nest cavities within treated stands, and a myriad of previously excavated cavities. Removing encroaching conifers from within and surrounding aspen stands, resulting in the expansion of stands and increased density of large diameter aspen stems over time, should increase habitat for woodpeckers. There is little doubt that aspen supports far greater abundance of woodpeckers than coniferous forest and that treating aspen results in even greater increases in these species of management interest. In turn, woodpeckers are a critical component of the aspen community as the source of cavities for an abundant and diverse group of secondary cavity nesting birds, many of which use these aspen areas in relatively high numbers (e.g., Mountain Bluebird, Tree Swallow, and Mountain Chickadee).

Time Since Treatment

The time since aspen stands had been treated had a generally positive but complex effect on many of the focal species. The best fit models for four of the six species showing a significant effect of time since treatment included a quadratic term. For three of these species their abundance peaked in the three to four years post-treatment time period and then declined in the following time intervals. For Dusky Flycatcher, the only species showing an overall negative effect of time since treatment, its abundance decreased through the five to six year post treatment period and then showed a marked increase at sites that were treated more than six years prior. For the remaining two species the effect of time since treatment was best represented by a linear increase.

It is important to remember that that the post-treatment sample is relatively small (28 sites in 2008) and any inherent biases in how sites were chosen for treatment could easily be magnified. Furthermore, the sites that have been the longest time since treatment were treated using a hand thin prescription that left a greater number of conifers than the more recent prescriptions. Thus, this pattern may be at least partially a result of the different prescriptions utilized in older compared to younger treatments. With those cautions in mind, these results should not be entirely dismissed.

These patterns suggest that no one aspen condition or post-treatment time period is ideal for all species, that the habitat conditions created in the first four years following treatment are important for a number of bird species, and for several species the benefits of aspen treatments may be rather short lived. The conditions created immediately following aspen treatments may be mimicking the structure found in natural post-disturbance habitat that often supports greater numbers of some of these species (Raphael 1987). Though Hairy Woodpecker, Tree Swallow, and Mountain Bluebird showed marked declines at sites over four years post-treatment each was more abundant in these older sites than they were in untreated aspen. These results continue to support the notion that management of aspen habitat should consider the importance of disturbance and the early successional habitat it results in.

Conclusions

Our results from 2008 continue to suggest that aspen treatments employed on the ELRD are having a positive effect on the aspen breeding bird community. Key species such as Red-breasted Sapsucker, Mountain Bluebird, and Chipping Sparrow all appear to have had a short-term positive response to treatment. Based on these and previous results we believe that treatments that increase the size and health of aspen stands will be highly beneficial to key breeding bird species in the Lassen National Forest and should be a top priority of land managers here. We also recognize the value of continuing the monitoring of landbird communities in treated aspen habitat in order to better understand the complex patterns we have started to see as time since treatment increases.

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Appendix 1. GPS coordinates (UTM NAD 27) for all aspen point count locations surveyed in the Lassen National Forest in 2007 & 2008.

STATION	CODE	SITE	X_COORDINATE	Y_COORDINATE
Ruffa Aspen	ASPN	1	634087	4447622
Ruffa Aspen	ASPN	2	633993	4447459
Ruffa Aspen	ASPN	3	633909	4447283
Ruffa Aspen	ASPN	4	633842	4447102
Ruffa Aspen	ASPN	5	633746	4446885
Ruffa Aspen	ASPN	6	633746	4447193
Ruffa Aspen	ASPN	7	635118	4447923
Ruffa Aspen	ASPN	8	635203	4447725
Ruffa Aspen	ASPN	9	635411	4447925
Ruffa Aspen	ASPN	10	634306	4447661
Ruffa Aspen	ASPN	11	634612	4447680
Ruffa Aspen	ASPN	12	634683	4447371
Butte Creek Aspen	BCA	1	644638	4498553
Butte Creek Aspen	BCA	2	644550	4498065
Butte Creek Aspen	BCA	3	644760	4495527
Butte Creek Aspen	BCA	4	644952	4495285
Butte Creek Aspen	BCA	5	645027	4495074
Butte Creek Aspen	BCA	6	645194	4494831
Butte Creek Aspen	BCA	7	645272	4494654
Butte Creek Aspen	BCA	8	645346	4494398
Brown’s Ravine Aspen	BRAS	1	628386	4432142
Brown’s Ravine Aspen	BRAS	2	628624	4432262
Brown’s Ravine Aspen	BRAS	3	627589	4433429
Brown’s Ravine Aspen	BRAS	4	628428	4432429
Coon Hollow Aspen	COHO	1	634428	4433745
Coon Hollow Aspen	COHO	2	634323	4433988
Coon Hollow Aspen	COHO	3	634065	4434058
Coon Hollow Aspen	COHO	4	633839	4434016
Coon Hollow Aspen	COHO	5	633622	4434061
Coon Hollow Aspen	COHO	6	633412	4434120
Coon Hollow Aspen	COHO	7	633149	4434111
Coon Hollow Aspen	COHO	8	632946	4434228
Coon Hollow Aspen	COHO	9	632771	4434429
Coon Hollow Aspen	COHO	10	632562	4434400
Coon Hollow Aspen	COHO	11	632367	4434376
Coon Hollow Aspen	COHO	12	632123	4434511
Coon Hollow Aspen	COHO	13	631951	4434663
Coon Hollow Aspen	COHO	14	631864	4434894
Crazy Harry Aspen	CHA	1	682820	4475480
Crazy Harry Aspen	CHA	2	682688	4475240
Crazy Harry Aspen	CHA	3	682703	4474972
Crazy Harry Aspen	CHA	4	681773	4473900
Crazy Harry Aspen	CHA	5	681857	4473575
Crazy Harry Aspen	CHA	6	682098	4473532
Crazy Harry Aspen	CHA	7	682189	4473220
Feather Lake Aspen	FLA	1	667437	4488993
Feather Lake Aspen	FLA	2	667620	4488996

Feather Lake Aspen	FLA	3	667803	4489035
Feather Lake Aspen	FLA	4	667477	4488439
Feather Lake Aspen	FLA	5	668080	4488016
Harvey Valley Aspen	HVA	1	663482	4502834
Harvey Valley Aspen	HVA	2	663608	4502617
Harvey Valley Aspen	HVA	3	663820	4502901
Harvey Valley Aspen	HVA	4	664353	4503212
Harvey Valley Aspen	HVA	5	664447	4503537
Harvey Valley Aspen	HVA	6	665382	4503145
Harvey Valley Aspen	HVA	7	666678	4504026
Harvey Valley Aspen	HVA	8	666994	4504055
Harvey Valley Aspen	HVA	9	667246	4503973
Harvey Valley Aspen	HVA	10	667540	4503942
Harvey Valley Aspen	HVA	11	667974	4503901
Harvey Valley Aspen	HVA	12	669088	4502928
Harvey Valley Aspen	HVA	13	668861	4503100
Harvey Valley Aspen	HVA	14	668631	4503130
Harvey Valley Aspen	HVA	15	668785	4502703
Lower Pine Creek Aspen	LPA	1	660456	4490845
Lower Pine Creek Aspen	LPA	2	660334	4491146
Lower Pine Creek Aspen	LPA	3	660216	4490936
Lower Pine Creek Aspen	LPA	4	657955	4489672
Lower Pine Creek Aspen	LPA	5	658237	4489822
Lower Pine Creek Aspen	LPA	6	658449	4489995
Lower Pine Creek Aspen	LPA	7	658711	4490186
Lower Pine Creek Aspen	LPA	8	658995	4490395
Lower Pine Creek Aspen	LPA	9	659287	4490252
Lower Pine Creek Aspen	LPA	10	659286	4490494
Lower Pine Creek Aspen	LPA	11	659595	4490602
Lower Pine Creek Aspen	LPA	12	659793	4490770
Martin Creek Aspen	MCA	1	672919	4494467
Martin Creek Aspen	MCA	2	673274	4494078
Martin Creek Aspen	MCA	3	673697	4493728
Martin Creek Aspen	MCA	4	673905	4493440
Martin Creek Aspen	MCA	5	674067	4493319
Martin Creek Aspen	MCA	6	673832	4493247
Martin Creek Aspen	MCA	7	671981	4494288
Martin Creek Aspen	MCA	8	672235	4494142
Martin Creek Aspen	MCA	9	673517	4492496
Martin Creek Aspen	MCA	10	672833	4493680
Martin Creek Aspen	MCA	11	672888	4494725
Philbrook Aspen	PHAS	1	627678	4432335
Philbrook Aspen	PHAS	2	627656	4432684
Philbrook Aspen	PHAS	3	627857	4432784
Philbrook Aspen	PHAS	4	628732	4432132
Philbrook Aspen	PHAS	5	628544	4431953
Philbrook Aspen	PHAS	6	632371	4431587
Philbrook Aspen	PHAS	7	632352	4431246
Philbrook Aspen	PHAS	8	631700	4431187
Philbrook Aspen	PHAS	9	634153	4431618

Philbrook Aspen	PHAS	10	634369	4431371
Pine Creek Aspen	PCA	1	660374	4492311
Pine Creek Aspen	PCA	2	660524	4492546
Pine Creek Aspen	PCA	3	660297	4492538
Pine Creek Aspen	PCA	4	660175	4492348
Pine Creek Aspen	PCA	5	659873	4492702
Pine Creek Aspen	PCA	6	660075	4492809
Pine Creek Aspen	PCA	7	660132	4493134
Pine Creek Aspen	PCA	8	659993	4493476
Pine Creek Aspen	PCA	9	660365	4493446
Pine Creek Aspen	PCA	10	660627	4493377
Pine Creek Aspen	PCA	11	660746	4493133
Pine Creek Aspen	PCA	12	660931	4493315
Pine Creek Aspen	PCA	13	660698	4493566
Pine Creek Aspen	PCA	14	660328	4492835
Robber’s Creek Aspen	ROCA	1	669942	4468779
Robber’s Creek Aspen	ROCA	2	669793	4468956
Robber’s Creek Aspen	ROCA	3	669593	4468975
Robber’s Creek Aspen	ROCA	4	669486	4469442
Robber’s Creek Aspen	ROCA	5	669344	4469591
Robber’s Creek Aspen	ROCA	6	665405	4475553
Robber’s Creek Aspen	ROCA	7	665306	4475774
Robber’s Creek Aspen	ROCA	8	665115	4475967
Robber’s Creek Aspen	ROCA	9	663507	4478021
Robber’s Creek Aspen	ROCA	10	663373	4478266
Robber’s Creek Aspen	ROCA	11	663310	4478598
Robber’s Creek Aspen	ROCA	12	663106	4478822
Robber’s Creek Aspen	ROCA	13	663091	4479042
Robber’s Creek Aspen	ROCA	14	663513	4478985
Robber’s Creek Aspen	ROCA	15	663540	4478747
Robber’s Creek Aspen	ROCA	16	663579	4478488
Susan River Aspen	SRA	1	677245	4477578
Susan River Aspen	SRA	2	675682	4477640
Susan River Aspen	SRA	3	675445	4477816
Susan River Aspen	SRA	4	675110	4477746
Susan River Aspen	SRA	5	674827	4478047
Susan River Aspen	SRA	6	674932	4478384
Susan River Aspen	SRA	7	674883	4478663
Susan River Aspen	SRA	8	674697	4478626
Susan River Aspen	SRA	9	675795	4477426
Susan River Aspen	SRA	10	676097	4477220
Susan River Aspen	SRA	11	676339	4477123
Susan River Aspen	SRA	12	676609	4477077
West Dusty Aspen 1	WDA1	1	634004	4469806
West Dusty Aspen 1	WDA1	2	633923	4469600
West Dusty Aspen 1	WDA1	3	634639	4469394
West Dusty Aspen 1	WDA1	4	634539	4468874
West Dusty Aspen 1	WDA1	5	634497	4468542
West Dusty Aspen 1	WDA1	6	634387	4468347
West Dusty Aspen 1	WDA1	7	634873	4468129

West Dusty Aspen 1	WDA1	8	635297	4468584
West Dusty Aspen 1	WDA1	9	635469	4468617
West Dusty Aspen 1	WDA1	10	636174	4468629
West Dusty Aspen 2	WDA2	1	639420	4469076
West Dusty Aspen 2	WDA2	2	639502	4468483
West Dusty Aspen 2	WDA2	3	639619	4468179
West Dusty Aspen 2	WDA2	4	640654	4467742
West Dusty Aspen 2	WDA2	5	640951	4467632
West Dusty Aspen 2	WDA2	6	641089	4467671
West Dusty Aspen 3	WDA3	1	636449	4469388
West Dusty Aspen 3	WDA3	2	637197	4468745
West Dusty Aspen 3	WDA3	3	636961	4468828
West Dusty Aspen 3	WDA3	4	637049	4468527
West Dusty Aspen 3	WDA3	5	637181	4468351
West Dusty Aspen 3	WDA3	6	637412	4468346
West Dusty Aspen 3	WDA3	7	636864	4468309
West Dusty Aspen 3	WDA3	8	636248	4468425
West Dusty Aspen 4	WDA4	1	630461	4468307
West Dusty Aspen 4	WDA4	2	630615	4468421
West Dusty Aspen 4	WDA4	3	630501	4468560
West Dusty Aspen 4	WDA4	4	630663	4468939
West Dusty Aspen 4	WDA4	5	630154	4468780
West Dusty Aspen 4	WDA4	6	629921	4468724
West Dusty Aspen 4	WDA4	7	629708	4468657
West Dusty Aspen 4	WDA4	8	629797	4468887
Willow Creek Aspen	WICA	1	640030	4473252
Willow Creek Aspen	WICA	2	640219	4473149
Willow Creek Aspen	WICA	3	640837	4472266
Willow Creek Aspen	WICA	4	641354	4470754
Willow Creek Aspen	WICA	5	641541	4470368
Willow Creek Aspen	WICA	6	641956	4470077
Willow Creek Aspen	WICA	7	641999	4469674
Willow Creek Aspen	WICA	8	642215	4469538
Willow Creek Aspen	WICA	9	643562	4468519

Chapter 3. Pileated Woodpecker Monitoring on the Lassen National Forest

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Background and Introduction

The National Forest Management Act (NFMA) of 1976 was created to help guide management of National Forest lands in the United States. In 1982 planning regulations were adopted that guided the establishment of Management Indicator Species (MIS) under NFMA. The MIS approach was adopted in order to use a suite of species that can elucidate the most appropriate management approaches by guiding resource management plan revisions and forest plan project implementation. As part of this process the Lassen National Forest identified Pileated Woodpecker (among other species) as a MIS (LRMP 1992).

Pileated Woodpecker is the largest extant woodpecker in United States (Bull and Jackson 1995). While its distribution includes a variety of forested habitats across the eastern United States, in the west it is associated almost exclusively with mid- to late seral conifer-dominated forests (Mellen et al. 1992, Bull and Holthausen 1993). Its home range size is large and extremely variable compared to other North American woodpeckers, with a reported range from 53 to 1,056 hectares (Bull and Jackson 1995). In the Western U.S., studies in Oregon found average home range sizes between 407- 478 hectares (Bull and Holthausen 1993, Mellen et al. 1992).

Due to their retiring nature, habitat specialization, and large territory sizes, standard bird monitoring techniques such as point counts (Ralph et al. 1995) are unlikely to detect sufficient numbers of this species for meaningful analysis of population trends. In 2007 PRBO began a comprehensive forest wide monitoring program for Pileated Woodpecker with four primary objectives:

1. Determine its spatial distribution across the forest
2. Provide baseline data for determining long-term trends
3. Identify key habitat features
4. Develop an appropriate monitoring protocol for the species in the Sierra Nevada.

In order to adequately sample this species, we developed a GIS-based predictive model of suitable habitat in the Lassen National Forest (LNF) using existing point-count data. In 2007 we used this model to identify survey locations and conducted standard point counts followed by call playbacks if no individuals were detected. Compared with previous Plumas-Lassen random surveys, the 2007 surveys had significantly more detections of Pileated Woodpeckers when looking at unlimited-distance point counts *before* playbacks (Burnett et al. 2008), suggesting that targeting survey areas based on distribution model predictions could be an effective way to locate suitable habitat. When no individuals were detected, call playbacks resulted in a 37% increase in detections above point counts alone, suggesting this method could be an effective way to increase detections. However, some findings were inconclusive: Comparing point count detection rates prior to call playbacks at distances of 100 m and 50 m, the Plumas-Lassen random sampling actually had higher detection rates than the 2007 MIS surveys. Also, several survey locations failed to detect any Pileated Woodpeckers despite being located within very suitable habitat as identified by the model. Finally, we found that detection rates during our playback surveys may have been inflated as a result of individual birds following observers and thus being detected at two or more consecutive survey points. Thus there was room for improvement of both the distribution modeling and survey techniques.

Evaluating the performance of a model is crucial to assessing a model's usefulness and effectiveness, especially when tested within a real-world application (Pearce and Ferrier 2000, Vaughan and Ormerod 2005). So in conjunction with a new model and survey method we created an entirely new set of transects designed to provide a sufficient sample size to assess model performance while representing the anticipated use of the model. We discuss the implications of our results on the use of distributional modeling as a tool to focus monitoring efforts and inform management decisions.

Methods

Predictive Model

In order to maximize detections of Pileated Woodpeckers we developed a new model to predict areas most likely to support this species prior to selecting sites to monitor in 2008 (Figure 1). We used a powerful machine learning algorithm called Maxent (Phillips et al. 2006) to predict Pileated Woodpecker distributions based on presence and absence data from PRBO's Northern Sierra point count survey database. Maxent is based on the principle of maximum entropy, and uses information about a known set of species occurrence points, compared with environmental background data, to develop parsimonious models of species occurrence.

Although Maxent is typically used with presence-only data, we incorporated species absence data in place of random environmental background data to constrain the models to the environmental space that was sampled. Including absence data can serve to improve the model by providing information on where the species does not occur (Brotons et al. 2004).

In 2008 we developed a set of bioclimatic variables (Hijmans 2008) which are thought to influence species distributions and are used widely in such modeling exercises. These variables were derived from the monthly temperature and precipitation average values used in our previous models. Using survey data collected from 1997-2007, we updated our distribution model using these bioclimatic variables as well as a variety of classified vegetation types from USDA Forest Service CALVEG vegetation shapefiles that we converted to grids at a 50m resolution (http://www.fs.fed.us/r5/rsl/clearinghouse/gettiles.shtml). Vegetation data were manipulated to create local and several landscape scale variables of hypothesized importance for Pileated Woodpecker (Table 1). By including these new bioclimatic variables and results from the 2007 surveys, the 2008 model outperformed the 2007 model. Thus, we used this new model to inform our selection of survey sites in 2008.

Model Testing

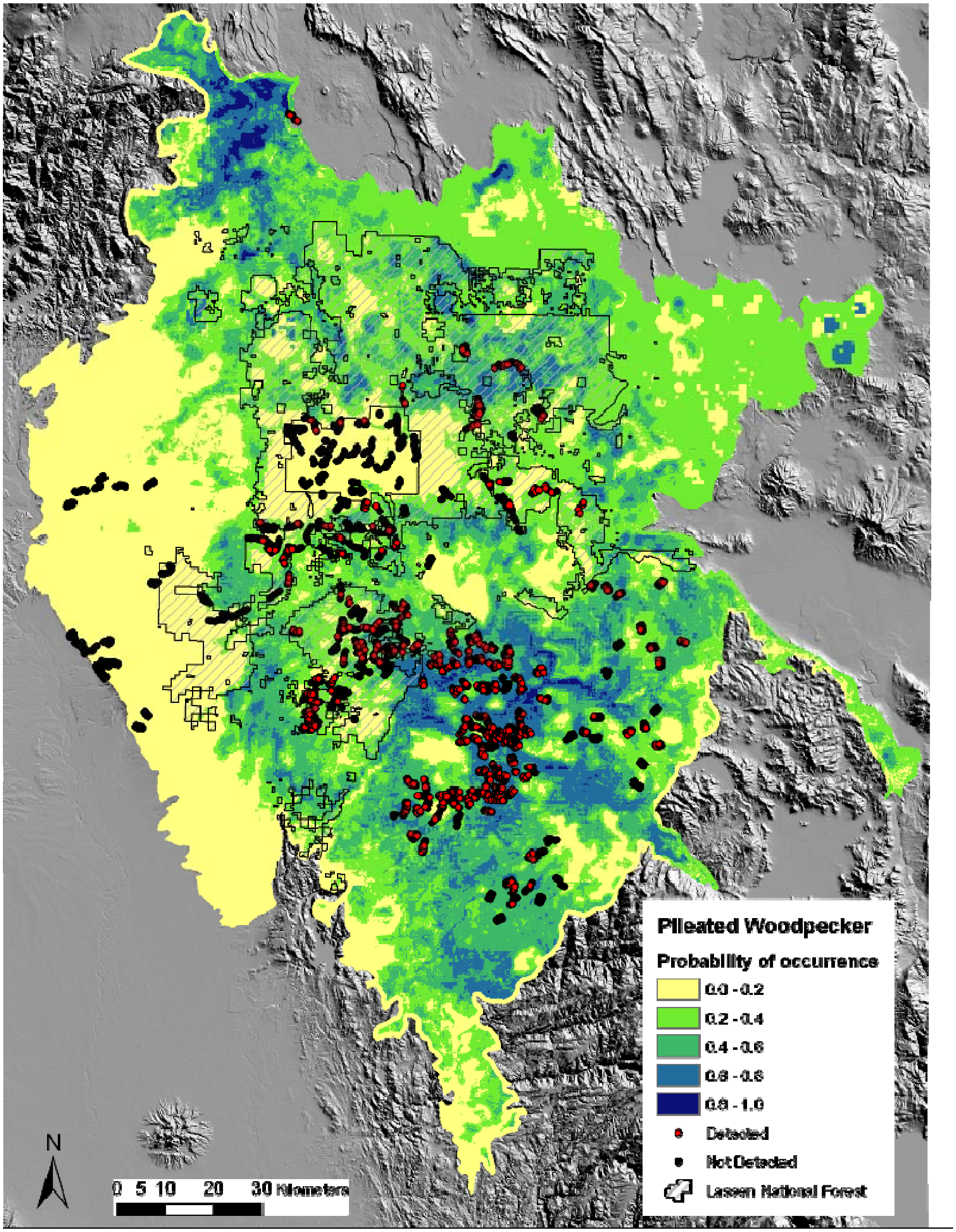
Model performance was assessed using the area under the curve (AUC) of receiver operating characteristic (ROC) plots (Fielding and Bell 1997). AUC values represent the predictive ability of a distribution model and are derived from a plot of true positive against false positive fractions for a given model. Models using presence only were tested using true positive against random background data points. Higher values (up to 1.0) characterize higher accuracy models. An AUC value of 0.5 is the equivalent of a random prediction. As a general guideline, AUC values of 0.6 – 0.7 indicate poor accuracy, 0.7 – 0.8 is fair, 0.8 - 0.9 is good, and values greater than 0.9 represent excellent accuracy (Swets 1988).

Table 1. GIS-based environmental predictors of species distribution. Habitat types, size classes, and density classes are California Wildlife Habitat Relationship classifications (Mayer and Laudenslayer 1988).

Variable Name	Description
Red fir	Percent red fir habitat within a 1km radius
Sierran Mixed Conifer	Percent mixed conifer forest within a 1km radius
White fir	Percent white fir vegetation within a 1km radius
Point Vegetation	Vegetation type at point count location
Size class 4 and 5	Vegetation size classes within a 1 km radius. Class 4 equals 11.0" – 23.9" DBH. Class 5 equals >24.0" DBH and was combined with class 6 (large trees multi-storied)
High Density Forest	Calculated within a 1km radius. Combines class M (40 – 59.9 % canopy closure) and Class D (>60% canopy closure).
Bio_1	Annual mean temperature (˚C)
Bio_2	Mean diurnal range (˚C) (mean of monthly (max temp - min temp))
Bio_3	Isothermality ((Bio_2/Bio_7) * 100)
Bio_4	Temperature seasonality (standard deviation *100)
Bio_10	Mean temperature of warmest quarter (˚C)
Bio_12	Annual precipitation (mm * 10)
Bio_15	Precipitation seasonality (coefficient of variation)
Bio_17	Precipitation of driest quarter (mm * 10)

The model prediction was cross-validated using a subset of the data points (25%) selected at random by the Maxent program. While this cross-validation technique is considered to be a robust method of model testing, unbiased estimates of a model's performance are best attained when tested against data that are independent of the data used to build the model (Fielding and Bell 1997). New surveys can provide an independent dataset because they differ from the training data in several ways. These include different collection methods, different geographic space, and different time periods (Vaughan and Ormerod 2005). Testing with independent data can help identify potential problems and provides a good assessment of a models ability to predict suitable Pileated Woodpecker habitat into areas outside of those used to build the model (Araújo et al. 2005). Testing a group of models allows us to identify more specifically how our models can be improved.

Figure 1. Map of model predicted probability of occurrence for Pileated Woodpecker. Presence and absence points used to build the model are shown as is the boundary of the Lassen National Forest.



We followed a basic framework to create a set of models and tested their performance using new survey data collected in 2008. We hypothesized that lower test scores could be caused by a model overfitting the results due to a high number of variables. We tested this by creating two sets of models with fewer variables (vegetation only and climate only). We also hypothesized that the absence data used to inform the model could be unreliable due to the natural history of this species. Thus, each set of variables was also used to run models using only presence data. This resulted in 5 total models, in addition to the original model used to select survey locations in 2008.

Site Selection

Because one of our objectives was to locate areas with Pileated Woodpecker within the LNF, we did not select transect starting points naively. We used spatially explicit model output from previous point count and call back surveys for this species in the LNF to select transect starting points (Burnett et al. 2008). We clipped the distribution model output to the LNF boundary and filtered the data to show only those areas considered to have a greater than 47% probability of occurrence for this species. This percentage was chosen because it represented a threshold that maximized the models true positive and true negative predictions based on our presence/absence data. A random point generator was used to create 60 starting points within this filtered boundary. We then randomly selected among starting points and established transects using a GIS road layer and LNF atlas to establish 19 additional points. We only allowed a maximum of eight transects in any of the three ranger districts to ensure adequate coverage of each administrative unit (Table 2). Thus, once this limit was reached if a subsequent starting point was selected that fell within that district we rejected it and moved on to the next random point. Additionally, a few starting points initially selected were rejected if the surrounding terrain was not appropriate (large tracts of private land or non forested habitat surrounding a selected site) or if another transect had already been established within 1km. When given a choice between two otherwise equal transect routes to follow, we followed the one that lead further away from existing points, dead ends, and towards areas that had higher model prediction values. All points were spaced approximately 500m apart, twice the normal distance between point counts to minimize the chances that an woodpecker near one point could hear the playback at the next nearest point. All transects were established on secondary unpaved roads (Figure 2).

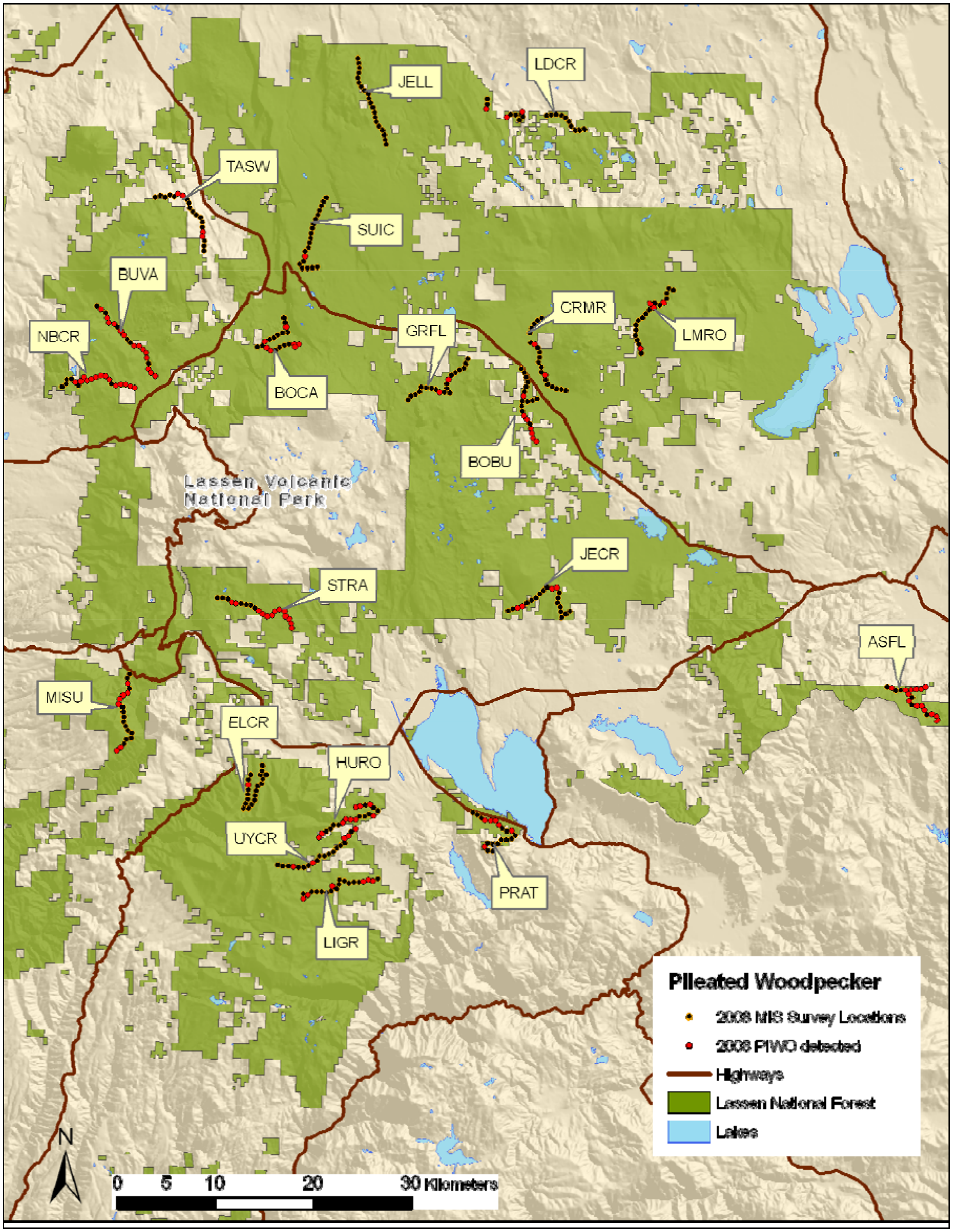
Table 2. Pileated Woodpecker playback survey transects, transect codes, ranger district and dates surveys conducted on the Lassen National Forest in 2008.

Transect Name	Transect Code	Ranger District	1st Survey	2nd Survey
Aspen Flat	ASFL	Eagle Lake	6/11/2008	7/01/2008
Bogard Buttes	BOBU	Eagle Lake	6/09/2008	6/26/2008
Box Canyon	BOCA	Hat Creek	6/10/2008	6/27/2008
Bunchgrass Valley	BUVA	Hat Creek	6/12/2008	6/30/2008
Crater Mountain Road	CRMR	Eagle Lake	6/06/2008	6/26/2008
Elam Creek	ELCR	Almanor	6/08/2008	-
Grey's Flat	GRFL	Eagle Lake	6/07/2008	6/26/2008
Humboldt Road	HURO	Almanor	6/17/2008	7/01/2008
Jennie Creek	JECR	Almanor	6/10/2008	6/27/2008
Jellico	JELL	Hat Creek	6/14/2008	-
Little Davis Creek	LDCR	Hat Creek	6/13/2008	-
Little Grizzly	LIGR	Almanor	6/06/2008	7/1/2008
Logan Mountain Road	LMRO	Eagle Lake	6/08/2008	7/02/2008
Mineral Summit	MISU	Almanor	6/07/2008	7/02/2008
North Battle Creek	NBCR	Hat Creek	6/16/2008	6/30/2008
Pratville	PRAT	Almanor	6/07/2008	6/26/2008
Stump Ranch	STRA	Almanor	6/07/2008	6/26/2008
Suicide Cabin	SUIC	Hat Creek	6/09/2008	6/30/2008
Tamarack Swale	TASW	Hat Creek	6/11/2008	6/30/2008
Upper Yellow Creek	UYCR	Almanor	6/06/2008	7/01/2008

Survey Protocol

Survey methods differed in 2008 in that call playbacks were conducted at each survey point immediately upon arrival. This differed from 2007 surveys where call playbacks were conducted only if a standard point count survey failed to detect any individuals. This change was designed to more efficiently determine the presence of an individual and allow for the greater number of points covered within each transect. We used a digital audio recording of a series of Pileated Woodpecker calls and drumming broadcast over a Radioshack® "Power Horn" blaster at full volume. Based on several field tests, our call playbacks could be detected from between 150 and 250 meters, depending on field conditions (e.g. slope, tree density), by our observers. The call playback survey was three minutes long and consisted of three 30 second call playbacks each followed by a 30 second listening period. The direction the blaster was directed was rotated 120 degrees from the previous broadcast position for each subsequent playback. If at any point during the survey a Pileated Woodpecker was detected we ceased the playback, recorded the type of detection (drumming, visual, or call), compass bearing, and distance from the observer, and moved on to the next survey location. Any incidental Pileated Woodpecker observations that occurred between points were also recorded but not included in any analysis. All transects were surveyed twice during the breeding season with the exception of three that we were unable to survey a second time due to wildfire related travel restrictions in late June through mid July (Table 2). Surveys for each transect were conducted at least two weeks apart.

Figure 2. The location of Pileated Woodpecker survey transects in 2008 in the Lassen National Forest. Four letter transect codes are defined in Table 2.



Results

Surveys

Pileated Woodpecker were detected on 19 of the 20 transects that were surveyed in 2008 with 17 transects having detections at more than one point (Table 3). Jellico, within the HCRD was the only transect that did not have any detections. However, we could only survey this site once in the season due to the wildfire related travel restrictions. They were detected at 124 out of the 400 survey points (30%). They were detected within 100 meters of the observer on 7 of the 20 transects (35%).

Table 3. Pileated Woodpecker call back survey transects where the species was detected within the Lassen National Forest in 2008.

Transect Name	Transect Code	Ranger District	Detected	Detected < 100 meters from survey point
Aspen Flat	ASFL	Eagle Lake	X	X
Bogard Buttes	BOBU	Eagle Lake	X	X
Box Canyon	BOCA	Hat Creek	X	
Bunchgrass Valley	BUVA	Hat Creek	X	X
Crater Mountain Road	CRMR	Eagle Lake	X	
Elam Creek	ELCR	Almanor	X	
Grey's Flat	GRFL	Eagle Lake	X	
Humboldt Road	HURO	Almanor	X	X
Jennie Creek	JECR	Almanor	X	
Jellico	JELL	Hat Creek		
Little Davis Creek	LDCR	Hat Creek	X	
Little Grizzly	LIGR	Almanor	X	
Logan Mountain Road	LMRO	Eagle Lake	X	
Mineral Summit	MISU	Almanor	X	X
North Battle Creek	NBCR	Hat Creek	X	X
Pratville	PRAT	Almanor	X	X
Stump Ranch	STRA	Almanor	X	
Suicide Cabin	SUIC	Hat Creek	X	
Tamarack Swale	TASW	Hat Creek	X	
Upper Yellow Creek	UYCR	Almanor	X	

We compared detection rates for the 2008 MIS surveys, 2007 MIS surveys, and 2007-2008 Plumas-Lassen passive point-count surveys (Table 4). The detection rates (detections per point per visit) in 2008 were slightly lower than for the 2007 MIS surveys, though these difference were not statistically significant (p>0.10). Both MIS surveys (that incorporated callbacks) had significantly higher detection rates than the Plumas-Lassen point counts for all detections and <50m. Detections at <100 m were equal for the 2008 MIS and Plumas-Lassen point counts and higher for the 2007 MIS survey.

Table 4. Pileated woodpecker detections per point per visit by year for three separate survey efforts in the Northern Sierra Nevada. Detections are shown for three detection distance bins with standard error.

Distance to detection	2008 MIS	2007 MIS	2007-2008 Plumas-Lassen
All detections	0.21± 0.03	0.23 ± 0.045	0.12 ± 0.02
<100 m	0.03 ± 0.01	0.05 ± 0.021	0.03 ± 0.008
<50 m	0.02 ± 0.01	0.03 ± 0.017	0.005 ± 0.004

Model Performance

The predictive performance of our six models ranged from fair to excellent (0.7< AUC <1.0) when tested against a 25% subset of the data. Our original full presence/absence model had a good performance AUC value at 0.841. However, when tested against 2008 survey results (our independent data), this dropped to 0.621 AUC (Table 5) indicating poor predictive performance. Both the presence/absence vegetation only and climate only models had lower test scores than the full model, thus rejecting the hypothesis that fewer environmental variables would improve the model. The full presence only model (excluding absence data) had a test score of 0.928 indicating excellent performance. This was the best performing model overall. Its test value dropped to 0.763 AUC, indicating fair model performance against the independent data set. Although some loss in performance against independent data is expected, the full presence only model was the only one that did not have poor test results against the independent data.

Table 5. Test AUC values for models built with presence/absence data as well as presence only data. Each model was tested with a 25% subset of the data used to build the model and also with independent data.

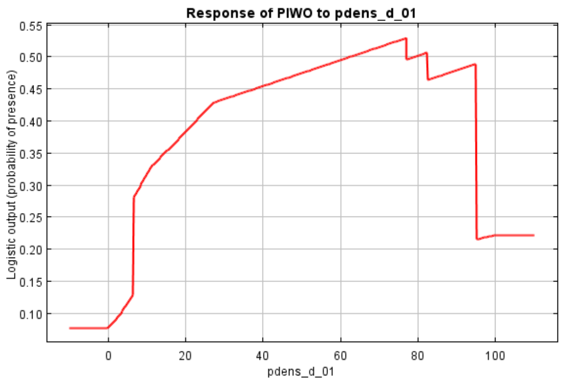
Presence/Absence Model		Presence Only Model	
25% subset test	Independent data	25% subset test	Independent data
0.841	0.621	0.928	0.763

Habitat Variables influencing Pileated Woodpecker Occurrence

The Maxent output includes a summary of how each environmental variable affects a given model. We analyzed this output across all of the models and assessed the relative contributions of each variable to the modeled occurrence probabilities of Pileated Woodpeckers. The relative contribution each variable made to the Maxent algorithms varied between the different models. The most consistent effects was for the percent of the area comprised of moderate to dense tree cover (>40%) which had a strong positive relationship with predicted suitability but become negative at high percentages (>80%).

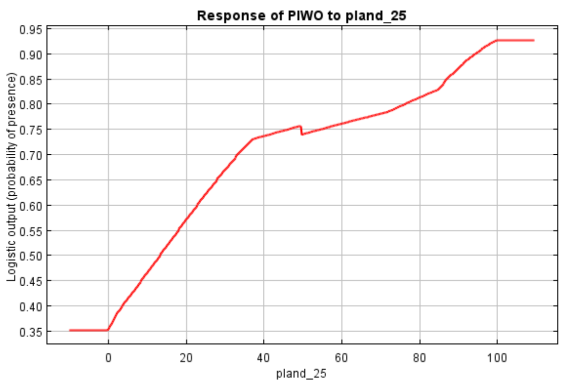
For the presence/absence models it provided the greatest contribution for the vegetation only model (35.1%) and the greatest contribution of any vegetation variable to the full model (12.1%). For the presence only models, the amount of habitat in the large tree size (>24.0" DBH) and the moderate to dense tree cover categories were the second and fourth highest contributors (22.1% and 14.1%) respectively. The effect of the amount of habitat in large tree size class was positive until it reached approximately 60% and then the effect weakened. The percent of Sierran mixed conifer and percent of white fir also had positive relationships with suitability, while percent red fir had a mostly negative relationship (Figure 3). These patterns held true when each variable was looked at in isolation from other the variables.

Figure 3. Model response curves for selected habitat variables for the presence only model, the best performing model. These curves show how model prediction values changes (y-axis) for each variable, keeping all other variables at their average sampled value.

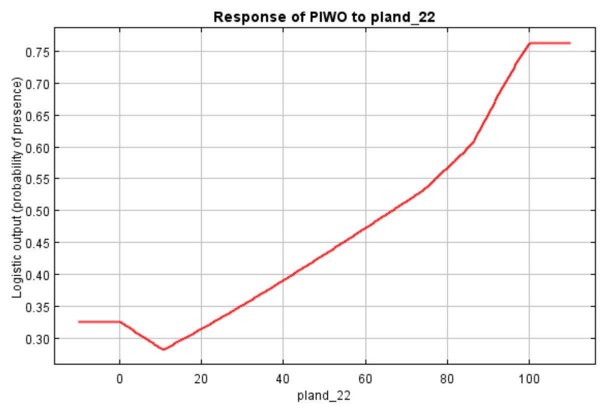


% dense tree cover (>60% closure)

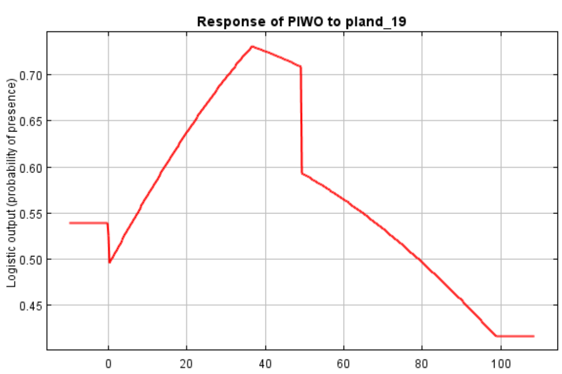
% large tree size (>7.27m crown diameter)



% Sierran mixed conifer (within 1km radius)



% white fir (within 1km radius



% red fir (within 1km radius)

Discussion

The final spatially explicit model predicting suitable Pileated Woodpecker habitat performs well and is an improvement over a similar model developed using just point count data prior to the 2007 surveys. The receiver operating characteristic from the final models show that the final models predicted areas are much more likely to contain Pileated Woodpecker compared to previous models.

Although 2008 MIS surveys that employed this model had slightly lower detection rates than the 2007 MIS surveys with that used the older model, the detection rates are not directly comparable and, in fact, we would expect the 2007 surveys to have higher detection rates fore several reasons. We selected transect starting locations within areas of high suitability for both years, but we did not constrain the rest of the survey points to these same high-suitability areas. Transects in 2008 consisted of 20 points compared to 6 points in 2007 and therefore covered much more ground. As our model shows (Figure 1), suitable habitat is not evenly spaced throughout the forest; but instead is clumped. Thus, since the surveys in 2008 covered approximately 10 km and the 2007 surveys only covered 2.5 it is clear that more of our survey locations were likely to occur in areas of lower suitability than in 2007. Additionally, by covering more ground in 2008 the number of stations where we detected the same individual woodpecker would be less than in 2007. In 2007 within our 2.5km transect it was possible, based on published home range sizes, that a single woodpecker could span the entire transect. This experience of "dragging" a territorial bird from point to point with playbacks is one of the reasons we decided to use road based surveys in 2008 as they allowed us to cover much more ground and be confident that birds detected at the beginning of the transect were indeed different than those detected in the middle or end (>5km apart).

We found a significant increase in Pileated Woodpecker detections when comparing both 2007 and 2008 MIS surveys to Plumas-Lassen point count surveys at unlimited distances and within 50m of observers. With our study design it is not possible to determine how much of the increase in detection rates is due to playbacks and how much is due to the use of the models informing transect starting locations. The Plumas-Lassen point count locations surveyed in 2007 and 2008 are in areas that have much higher predicted suitability for Pileated Woodpecker than the Lassen National Forest. As the majority of sites in the Plumas-Lassen are in mixed conifer and white fir dominated habitats on the Mt. Hough Ranger District which appears to be more suitable habitat than some of the east side pine and higher elevation red fir forest which is a major component of the Lassen (Figure 1). Thus we believe without playbacks and the use of the model to select areas to survey the detection rates on the Lassen would be much lower than those for the Plumas-Lassen study.

Placing surveys along roads allowed for far greater coverage of potential Pileated habitat than would have been possible with normal off road foot based surveys. We were able to cover almost twice as many total survey points in fewer days compared to the 2007 off road foot based surveys. We suggest any Pileated Woodpecker survey protocol should employ playbacks and, assuming a broad network of roads occurring in moderate to high density is present, road based surveys should be considered. When available the use of existing survey data to develop habitat suitability models may also greatly increase detection rates for this species, especially if every survey locations are only placed within high and moderate suitability categories (not just starting points).

Based on the model output and results from analysis of local vegetation features in 2007 (Burnett et al. 2008) several clear patterns emerge with respect to the habitat components that are important for this species in the Northern Sierra Nevada. Our results suggest this species is more likely to occur in areas with high canopy closure and large trees. These results are also consistent with findings from Oregon. Nelson (1988), found this species density was greater in forests over 80 years old, and old growth stands with >60% canopy closure were important for nesting and roosting, while mid-seral forests (>40 years) were preferred for foraging (Bull et al. 1992, Mellen et al. 1992).

Testing distribution models in "real-world" applications is an important component of evaluating a model's suitability for its intended use (Vaughan and Ormerod 2005). Our results indicate that testing with non-independent data can provide optimistic performance assessments for independent data. More importantly, results show that a presence/absence model may be limited in its usefulness when applied outside of the environment used to build the model. Although our presence/absence model tested well with a subset of the original model-building data, it subsequently performed poorly when tested against independent data. By comparison, the presence model resulted in an excellent AUC score when tested with a subset of the data and a fairly good score was achieved when it was tested against independent data. Even though playback surveys clearly reduced our errors of omission, other factors can lead to faulty absence information being used in the models thus reducing their performance compared to presence only models.

Several factors may have contributed to the poorer performance of the model that included absence data. First, we tested the models against passive point count data with no playback surveys which we know results in relatively high errors of omission. Additionally, we suspect this resident species that breeds in cavities begins breeding earlier in spring than many other birds and thus detectability may be greater earlier in the spring when most sites are inaccessible due to snow cover. Even with playbacks, due to the size of their home ranges, Pileated Woodpeckers may not always be within hearing range of call playbacks or human ears even though the observer is within an occupied area. There may also be individual variation of the vigor with which this species responds to playbacks. Indeed, only 7% of our 2008 MIS survey points had a consistently positive detection from one survey to the next. This is not surprising given this species shyness and large home range size. Additionally, population dynamics may result in areas of suitable habitat being unoccupied by this species, resulting in unreliable absence information (Hirzel et al. 2001). Such a scenario can cause a survey point to be correctly classified as an absence point while incorrectly informing the model that the point falls within unsuitable habitat. Long-term surveys may help to reduce these errors, but we recommend that for this species, models using only presence data are likely to outperform those that include absence data.

We might also be able to improve model performance by including more accurate, specific, and local habitat variables. As our results from 2007 showed, habitat features such as the number and size of snags, amount of downed woody debris, canopy height, and basal area are important predictors for this species (Burnett et al. 2007). Unfortunately, more detailed spatially explicit habitat data is not readily available for the entire Lassen National Forest. While emerging remote-sensing techniques such as LIDAR (Lefsky et al. 2002) can capture more specific habitat data, this type of information cannot always be practically captured and included in large scale species distribution models. At the landscape level, examination of how this species responds to resources at varying scales may be another way to help refine our models and our understanding of this species and its needs.

Conclusions

Our results from 2007 and 2008 suggest the Pileated Woodpecker is more abundant in the Lassen National forest than we suspected based on previous point count results. Our habitat models though they could benefit from additional information provide a spatially explicit tool for land mangers to determine the suitability of habitat across the entire Lassen National Forest for this species. With results from local habitat analysis in 2007 and model outputs in 2008 this effort has resulted in significantly more information to help guide management for this species on the Lassen.

Based on our results and two years of experience implementing Pileated Woodpecker monitoring in the field we believe the most appropriate approach for this species should employ active playbacks and should seriously consider a road based survey that employs vehicles to move quickly between distant survey points.

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Chapter 4. Resident and Neotropical Migratory Bird Monitoring in Mountain Meadows on the Almanor Ranger District

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PRBO Conservation Science

Background and Introduction

Mountain meadows are among the most important habitats for birds in California (Siegel and DeSante 1999, Burnett and Humple 2003, Burnett et al. 2005); they support several rare and declining species and are utilized at some point during the year by almost every bird species that breeds in or migrates through the Sierra Nevada. Meadows also perform a vital role as watershed wetlands that store and purify drinking water for millions of Californians. And yet, most of these meadows are in a degraded state and their value as wetlands and as critical habitat for birds and other wildlife has been dramatically reduced.

Mountain meadows have mostly been lost or heavily degraded by human activities over the past century (SNEP 1996, Siegel and DeSante 1999). The meadows that remain are owned by a diverse set of interests including private industry, state and federal agencies, and private landowners. Most mountain meadows in the Northern Sierra, including the largest meadows, are privately owned.

The Lassen area supports populations of many declining and threatened riparian meadow bird species, including Sandhill Crane, Swainson's Thrush, Yellow Warbler, and Willow Flycatcher. The area supports breeding populations of 12 of the 17 California Partners in Flight Riparian Focal Species, 10 of which breed in meadows within the Almanor Ranger District (Humple and Burnett 2004, RHJV 2004). With its large diversity and abundance of meadow bird species, including the largest population of Willow Flycatcher in the Sierra Nevada region (Humple and Burnett 2004), the Lassen region is a conservation hotspot for meadow birds.

Meadow conservation and management in the Lassen region and throughout the Sierra Nevada will require a collaborative effort between different land management agencies and private landowners. Many of the largest meadows in the area are not owned or managed by the Forest Service. Sites such as Battle Creek Meadow, Childs Meadow, Humbug Valley, West Shore Lake Almanor, and Warner Valley are non-Forest Service private holdings within the Almanor Ranger District (ARD). The majority of the breeding bird species, especially Neotropical migrants, in the ARD use these and other meadows during some portion of their annual cycle. In order to manage for breeding bird populations, especially meadow dependent species such as Willow Flycatcher and Sandhill Crane, the ARD must work collaboratively with the other meadow landowners in the area in order to ensure for the long-term viability of these and other bird species.

In this chapter we summarize point count data from meadow monitoring on the Almanor Ranger District from 2004 – 2008. We use a suite of meadow focal species to compare abundance and richness metrics between meadows and change over time.

Methods

Site Selection

Several considerations went into selecting meadow sites we sampled. Following an inventory of 16 meadows in the ARD area between 2000 and 2001 we selected a subset of those sites to continue long-term meadow monitoring within. We were interested in surveying sites that supported a riparian deciduous shrub (willows/alders) bird community and especially those sites that had recently undergone management changes (e.g. active restoration and/or removal of grazing). With these two considerations in mind we attempted to choose sites that represented a range of elevations and habitat conditions. With this strategy, we believe the sites selected are not representative of the meadow conditions in the ARD area but represent some of the higher quality riparian meadow bird habitat in the area.

Point Count Censuses

Point count data allow us to measure secondary population parameters such as relative abundance of individual bird species and species richness. This method is useful for making comparisons of bird communities across time, locations, habitats, and land-use treatments.

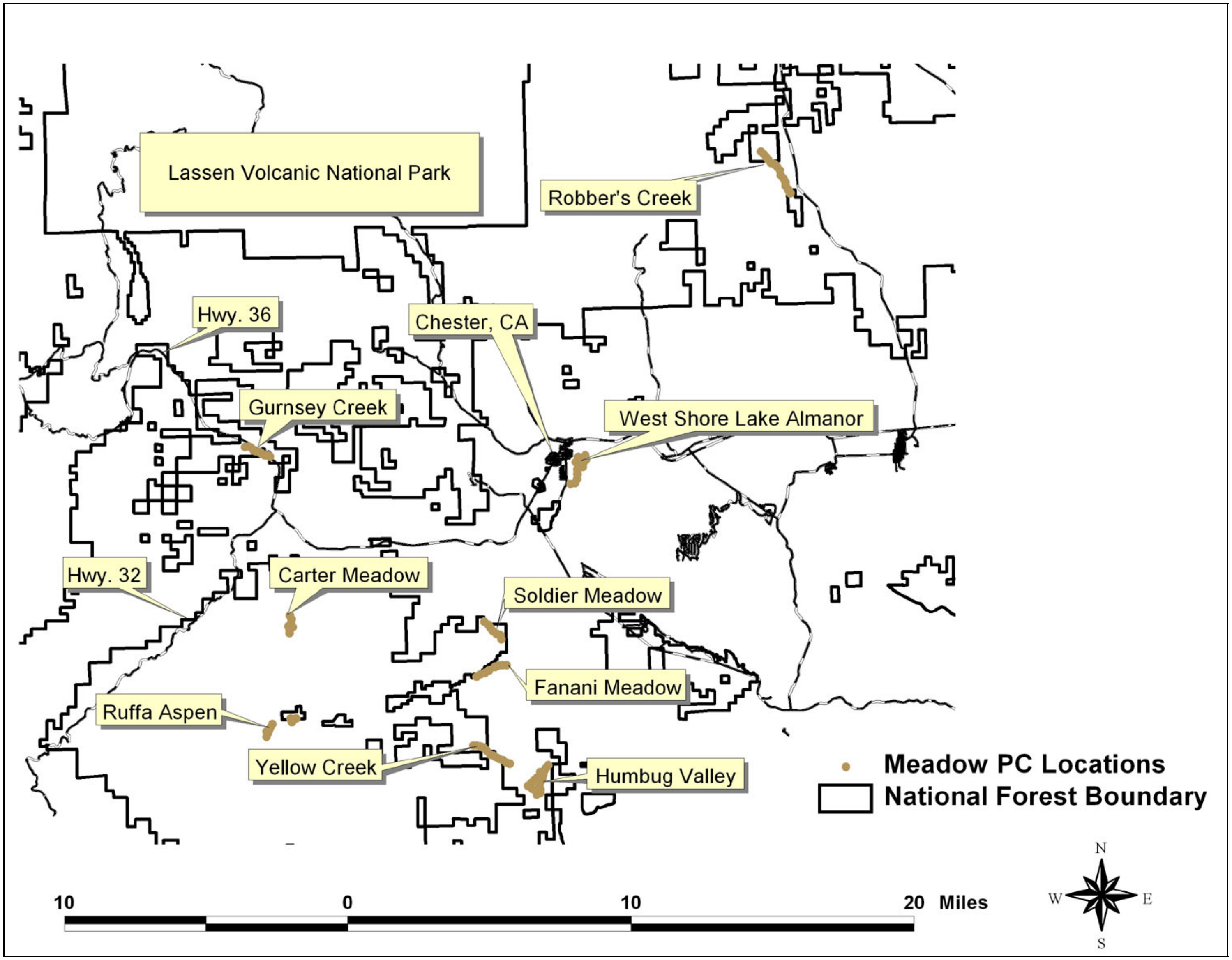
Standardized five-minute multiple distance band point count censuses (Buckland et al. 1993, Ralph et al. 1995) were conducted at each of 88 stations along eight transects in 2005 within the greater ARD area (Table 1). Each of the eight transects are located in riparian meadow habitat (Figure 1). Point count stations were a minimum of 50 meters from meadow edges where feasible; if the riparian corridor was less than 100 meters wide, points were placed equidistant from each edge. At each site points were placed at 200 to 250 meter intervals and were configured in a manner that maximized spatial coverage of the site.

Table 1. ARD area meadow and riparian point count transects surveyed by PRBO in 2008.

Transect	Code	# of points	Year established	2008 1st Visit	2008 2nd Visit
Carter Meadow	CAME	7	2004	June 10	NS
Fanani Meadow	FAME	8	2003	June 2	June 16
Gurnsey Creek	GUCR	10	1997	June 5	June 24
Humbug Valley	HUVA	17	2003	June 3	June 18
Robber's Creek	ROCR	14	2004	June 6	June 20
Soldier Meadow	SOME	7	2001	June 2	June 16
West Shore Lake Almanor	WSLA	13	2004	May 31	June 14
Yellow Creek Riparian	YCRI	12	2001	May 29	June 17

All birds detected at each station during the five-minute survey were recorded. Detections were placed within one of six categories based on the initial detection distance from observer: less than 10 meters, 10-20 meters, 20-30 meters, 30-50 meters, 50-100 meters, and greater than 100 meters. Birds flying over the study area but not observed using the habitat were recorded separately, and excluded from all analyses. The method of initial detection (song, visual or call) for each individual was also recorded. Counts began around local sunrise and were completed within four hours. Each transect was visited twice each year between late May and the end of June, except Carter Meadow which was only visited once in 2008 as a result of access restrictions due to wildfire (Table 1). All surveys were conducted by the author who has been conducting point counts in the Sierra Nevada since 2000. An electronic range finder was used to assist with distance estimation at each point count station.

Figure 1. PRBO meadow point count sites in the ARD area of Lassen National Forest, 2005.



Meadow Area Search and Territory Delineation

At each meadow an area search was conducted to note the presence and number of territories for three of the rarest meadow breeders in the Sierra Nevada: Sandhill Crane, Willow Flycatcher, and Swainson's Thrush. Care was taken to delineate territories during point counting and area searches, in transit between count stations, and then after completion of the point counts. No more than one hour was spent searching after completion of counts at any one site.

Point Count Vegetation Assessment

Vegetation at each point count station was assessed using a relevé method, based on the concepts summarized in Ralph et al. (1993). A 50-meter radius plot centered on each census station was used. General habitat characteristics of the site were recorded (canopy shrub, and herbaceous cover, riparian width, etc.) and the cover, abundance, and height of each vegetation stratum (tree, shrub, herb, and ground) were estimated. Within each stratum, the species composition was determined and each species' relative cover recorded, as a percentage of total cover for that stratum.

Statistical Analysis

Point count analysis was restricted to a subset of the species encountered. We excluded species that do not breed in the study area as well as those species that are not adequately sampled using the point count method (e.g., shorebirds, waterfowl, raptors, and swallows). For a number of the analyses we used a suite of meadow focal species (Table 2).

Table 2. Avian focal species (listed in taxonomic order) for meadow monitoring in the ARD and their conservation status. California Partners in Flight Riparian Focal species are noted in bold (RHJV 2004).

Species	Conservation Status
Sandhill Crane	State Threatened
Red-breasted Sapsucker	Declining in the Sierra[1]; NTMB
Willow Flycatcher	State Endangered, USFS Sensitive, NTMB
Warbling Vireo	NTMB
Swainson's Thrush	USFS Priority Land Bird Species, NTMB
Black-headed Grosbeak	NTMB
Yellow Warbler	State Species of Special Concern, NTMB
MacGillivray's Warbler	NTMB
Wilson's Warbler	Significant Decline in Sierra[1], NTMB
Song Sparrow	None
Lincoln's Sparrow	NTMB

[1] = from Sauer et al. 2008. NTMB = Neotropical Migratory Bird

Species richness

The species richness index I used is the sum of species detected per point per year and focal richness is the total number of focal species detected per point per year. Thus the species richness (or focal richness) for a meadow is the total number of species detected at each point in a year averaged across all the points in the transect. Presenting the mean species richness, as is done herein, allows for comparisons between transects or habitats consisting of different numbers of point count stations.

Indices of Abundance

I define the index of total bird abundance as the mean number of individuals detected per station per visit. This number is obtained by dividing the total number of detections within 50 meters by the number of stations and the number of visits. The same method was employed for creating abundance indices for focal species combined and individual species.

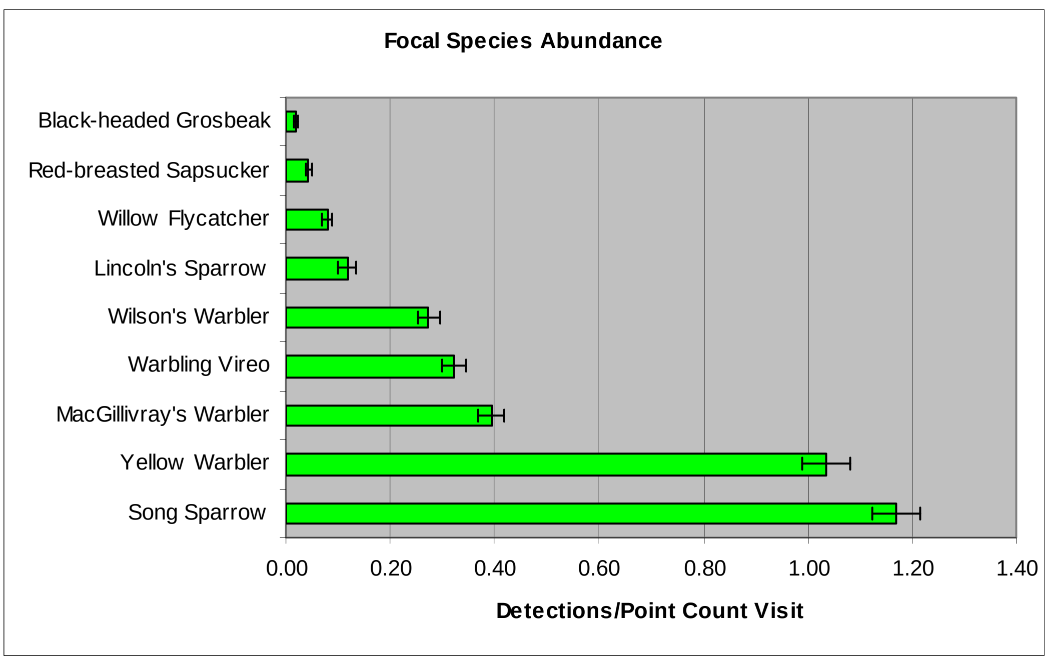
Trends

We used liner regression using Stata statistical software (Stata Corp 2005), to determine trends in species richness and bird abundance indices. We assumed statistical significance at the $p<0.05$ level.

Results

Song Sparrow was the most abundant meadow bird focal species detected from 2004 – 2008 in ARD meadows with and index of abundance of 1.17, followed by Yellow Warbler at 1.04 (Figure 2). Willow Flycatcher, a forest service sensitive species, had an index of abundance of 0.08 while Black-headed Grosbeak was the least abundant focal species at 0.01.

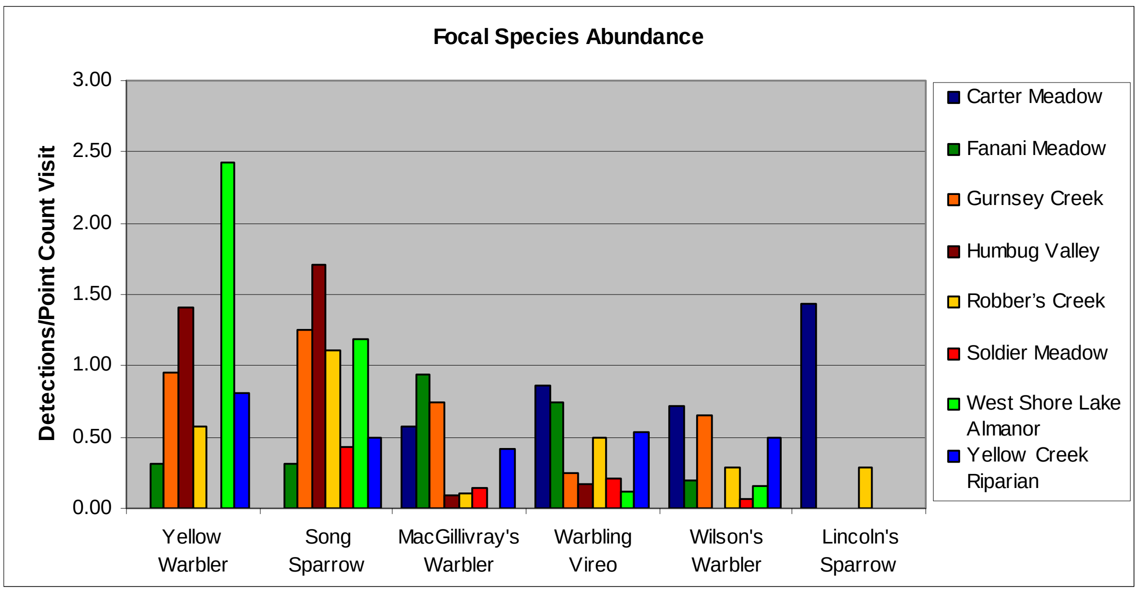
Figure 2. The mean abundance (+/- standard error) of nine meadow focal species per point count visit from 2004 – 2008 all sites combined in wet riparian meadows in the Almanor Ranger District.



Meadow Comparison

Warbling Vireo was the only species that was detected at each of the eight meadows; Swainson's Thrush was the least ubiquitous occurring at only at Humbug Valley. We are only aware of three locations in the greater Almanor Ranger District where this species breeds, Warner Valley, Ruffa Aspen, and Humbug Valley. Since 2004, Lincoln's Sparrow were detected only at two sites, Carter Meadow – where they are very abundant – and Robber's Creek. This species appears limited in the Almanor area to sites that are over 5000 feet. Sandhill Crane were detected at West Shore Lake Almanor, Robber's Creek, and Humbug Valley. Yellow Warbler was detected at six sites and each of the remaining focal species was detected at exactly seven sites (Figure 3).

Figure 3. Index of abundance (detections per point per visit within 50m of observers) for six meadow focal species at eight sites in the Almanor Range District in 2008. Note that Carter Meadow was only surveyed once in 2008 all other sites were visited twice.



In 2008, Yellow Warbler was most abundant at West Shore Lake Almanor where the index of abundance was 2.43 per point, followed by Humbug Valley at 1.41. Yellow Warbler was not detected at Carter Meadow or Soldier Meadow in 2008. Song Sparrow was most abundant in 2008 at Humbug Valley with an abundance index of 1.71 followed by Gurnsey Creek at 1.25 and West Shore Lake Almanor at 1.19. Song Sparrow was detected at every site except Carter Meadow. MacGillivray's Warbler was most abundant at Fanani Meadow in 2008 with an abundance index of 0.94, followed by Gurnsey Creek at 0.75. Warbling Vireo was most abundant at Carter Meadow with an abundance index of 0.86 followed by Fanani Meadow at 0.75. Wilson's Warbler was most abundant at Carter Meadow with and index of 0.72 followed by Gurnsey Creek with 0.65 and Yellow Creek Riparian with 0.50. Lincoln's Sparrow was most abundant at Carter Meadow with an index of 1.43 followed by Robber's Creek with 0.29, the only other point count site where this species was detected.

Temporal Patterns

Between 2004 and 2008 there was an increasing trend of 1.1% for species richness in ARD meadows and a 0.1% increasing trend for meadow focal species richness (Figure 4). Total bird abundance was increasing at 0.1% as was focal species abundance (Figure 5). None of these trends was statistically significant. Combined focal species abundance and richness were relatively consistent year to year. Focal species richness ranged from 2.74 in 2004 to a high of 3.06 in 2007. Focal species abundance ranged from 3.37 in 2008 to 3.80 in 2007.

Figure 4. Mean avian species richness and focal species richness across all Almanor Ranger District meadows surveyed from 2004 through 2008 with standard error and predicted trend line. Neither trend was statistically significant.

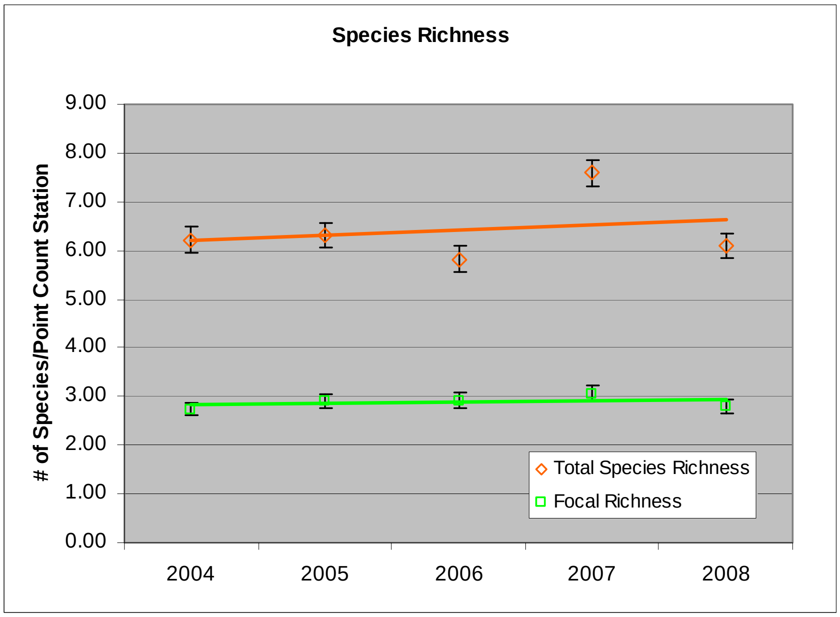
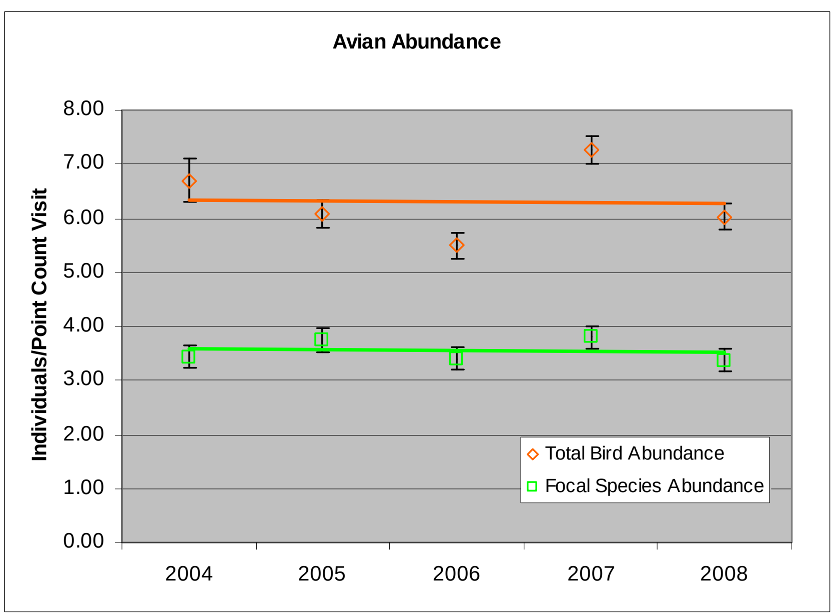
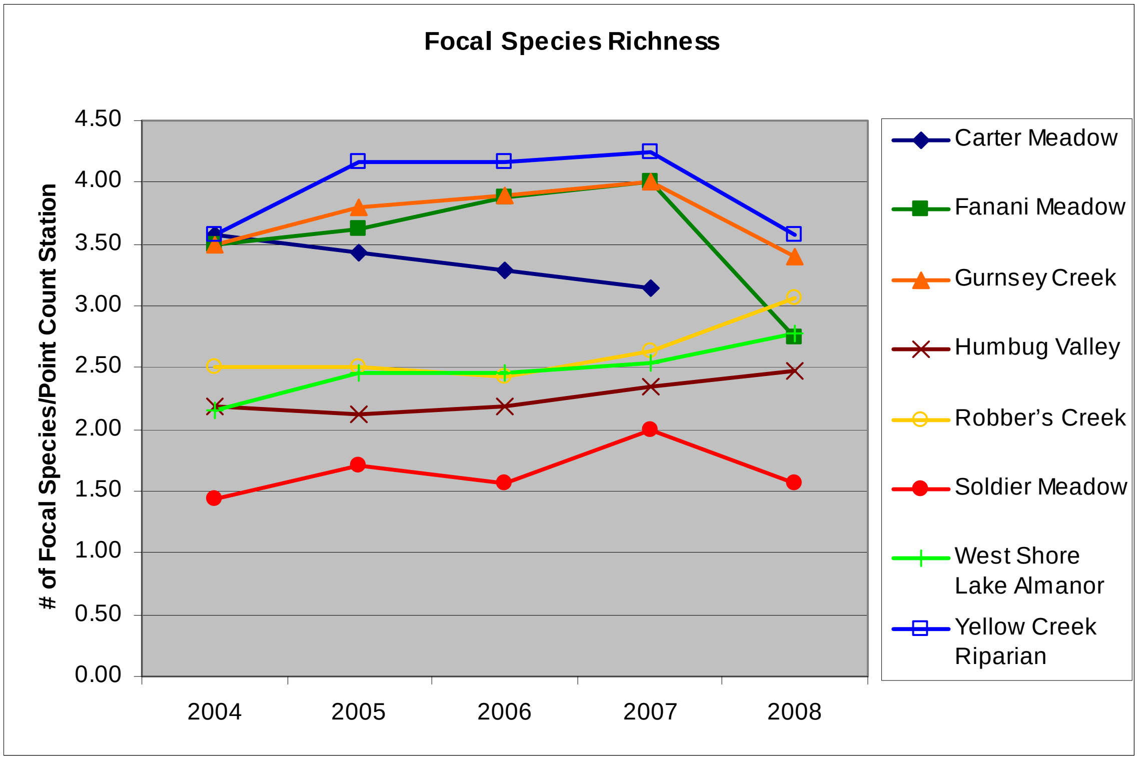


Figure 5. Mean total bird abundance and total focal species abundance across all Almanor Ranger District meadows surveyed from 2004 – 2008 with standard error and predicted trend line. Neither trend was statistically significant.



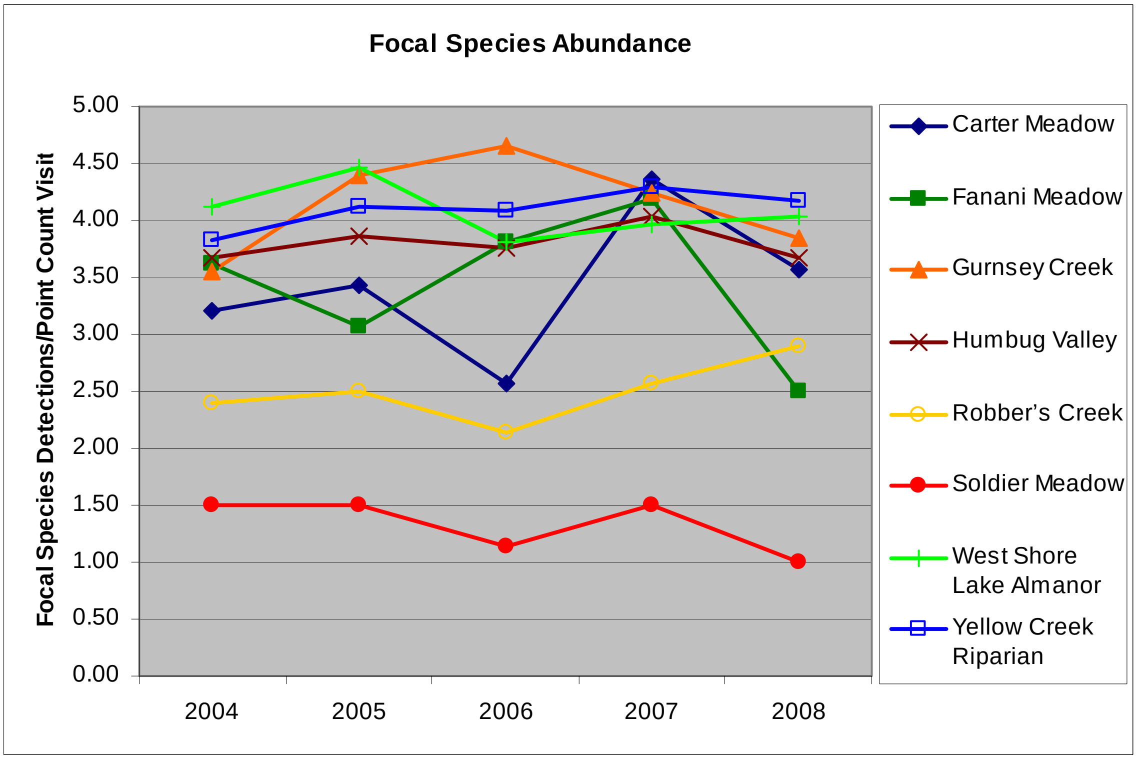
Yellow Creek Riparian had the highest focal species richness each year with a peak of 4.25 in 2007 (Figure 6). Focal richness at Gurnsey Creek, Fanani Meadow, and Carter Meadow were also relatively high. Focal richness was lowest each year at Soldier Meadow with a peak there of 2.0 in 2007. It was also relatively low each year at West Shore Lake Almanor, Humbug Valley, and Robber's Creek. However, with a marked drop in richness at Fanani Meadow in 2008, both Robber's Creek and West Shore Lake Almanor were higher than this site this year.

Figure 6. Mean meadow bird focal species richness at each of eight meadow sites in the Almanor Ranger District from 2004 to 2008.



Focal species abundance showed a different pattern than focal species richness (Figure 7). Focal abundance was highest at West Shore Lake Almanor in 2004 and 2005, Gurnsey Creek in 2006, Carter Meadow in 2007, and Yellow Creek Riparian in 2008. However, as with focal richness, focal abundance was markedly the lowest each year at Soldier Meadow. Humbug Valley and West Shore Lake Almanor which were among the least rich in terms of focal species had among the highest total abundance of focal species.

Figure 7. Mean meadow focal bird species combined abundance at each of eight meadow sites in the Almanor Ranger District from 2004 to 2008.



Rare Meadow Breeder Inventory

Willow Flycatcher's were detected at five of the eight meadows surveyed between 2004 and 2008 (Table 3), though they were only detected at West Shore Lake Almanor, Humbug Valley, and Robber's Creek in each of the five years. One bird was detected singing in Soldier Meadow in 2007 and its mate was subsequently found building a nest. In 2005 we documented three males that had established territories at Fanani Meadow and at least two territories were still occupied as of 2007; however none were detected here in 2008. The Willow Flycatcher populations on the West Shore Lake Almanor site appears to be the most stable with 12-14 territories documented in our survey area each year. The area north of the causeway has only been surveyed twice since 2003 and both times six additional territories were counted in this area. The vast majority of the Willow Flycatcher territories at this site are on PG&E property with only 1 to 2 on Forest Service land near the southern terminus of First Avenue in Chester.

Both West Shore Lake Almanor and the Humbug Valley-Yellow Creek Riparian area had two pairs of Sandhill Crane in 2008 (Table 3). No colts were observed at either site in 2008 but we did document a nest and subsequent adults with a colt above the causeway at Lake Almanor in 2007. We have observed a pair of Sandhill Crane in Swain Meadows at the terminus of the Robber's Creek transect on two occasions since 2005 though we did not see them here in 2008 and have not documented them breeding here in any year.

In 2007, a single Swainson's Thrush was detected along Miller Creek adjacent to Humbug Valley and in 2008 a singing male in the same location as 2007 as well as one within the valley were detected. A single bird was detected south of Ruffa Ranch on Forest Service property in an aspen/mountain alder stand was detected in 2008, the same location where one was detected in 2005. Warner Valley is the only other location I am aware of that this species breeds at in the Lassen National Forest.

Table 3. Total number of rare riparian bird species territories detected from area searches at each meadow site, 2008. Transect codes are presented in Table 1. An area search of meadow habitat around the Ruffa Aspen site was conducted in 2008 to include in the rare species inventory but data from that point count transect is now included in our aspen dataset (see Chapter 2).

Site Species	ASPN	CAME	GUCR	FAME	HUVA*	ROCR	SOME	WSLA	YCRI
Willow Flycatcher	3	0	0	0	8	1	0	13	0
Sandhill Crane	0	0	0	0	2	0	0	2	0
Swainson's Thrush	1	0	0	0	2	0	0	0	0

* **Includes Miller Creek area east of the valley proper.**

Discussion

Wet Meadows with extensive riparian deciduous vegetation support rich and abundant bird populations, they are used extensively following the breeding season by the majority of upland breeding species, and they are the preferred habitat of several species of conservation interest. Since wet meadows represent less than 1% of National Forest land in the Sierra Nevada, and have been heavily degraded over the past century, meadow restoration and conservation should be among the highest priorities of land mangers in the Sierra Nevada.

Our meadow monitoring in the ARD has been restricted to areas with riparian deciduous vegetation. While many of these sites have been altered – or undergoing passive restoration following cessation of grazing in the last 15 years - they should be viewed as among the best riparian meadow bird sites in the greater Almanor Ranger District area. Outside of these eight sites there are very few meadows in the ARD area that support large and diverse populations of riparian meadow dependent bird species. Nearly all of the largest meadows are privately owned and have been severely degraded by a century of excessive livestock grazing as well as other mismanagement (roads, culverts, and dams). Sites such as Battle Creek Meadows, Childs Meadows, Swain Meadow, and Mountain Meadows (including upper Goodrich Creek) are nearly devoid of riparian vegetation. Though we have not conducted formal bird monitoring surveys at these sites it is unlikely they support riparian meadow dependent bird populations at all similar to the eight sites we have surveyed.

The ARD area meadows support higher bird abundance than any other habitat type in the Lassen region we have surveyed. Only aspen habitat (see Chapter 2) has slightly higher species richness. Meadows in the greater ARD area are among the most important for meadow birds in the Sierra Nevada. Yellow Warbler, a California Bird Species of special concern, reaches its greatest reported density in the state here (RHJV 2004, Heath 2008). The area also harbors more Willow Flycatcher than any other similarly sized area of the Sierra Nevada and a breeding population of the state threatened Greater Sandhill Crane. With a wealth of mountain meadows and many in a degraded state, the Lassen area should be considered an ideal location to focus restoration actions to benefit these and other meadow dependent bird species.

The populations of meadow-dependent focal bird species appear to be stable across the sites we monitored in the ARD area since 2004. While this may be considered a positive sign, as many of these species have shown declines in the Sierra Nevada, it also suggests that many of the sites that have been recovering following grazing removal (and some active restoration) are not rapidly increasing their capacity for meadow-dependent birds. It appears that many of these sites could benefit from some additional restoration actions. For many of the sites, removal of encroaching conifers (Robber's Creek, Gurnsey Creek, Soldier Meadow) and/or planting of willows could greatly increase the value of the habitat here (Soldier Meadow, Swain Meadow below Robber's Creek). Both Humbug Valley and Yellow Creek have sections of stream channel that have been isolated from their floodplains and may benefit from more significant restoration actions that restore a wet meadow condition. An increase in riparian deciduous vegetation (e.g. *Salix*, *Populus*, *and Alnus* spp.) at many of these sites would greatly enhance their value to meadow birds.

A priority for meadow conservation in the ARD and surrounding areas should be protecting and enhancing the largest wet meadows, especially for Sandhill Crane and Willow Flycatcher. However, our results also show that species such as Lincoln's Sparrow, Wilson's Warbler, and Warbling Vireo are much more abundant in the smaller and higher elevation meadows, such as Carter. Several other higher elevation meadow sites Robber's Creek, Hay Meadow, and Spenser Meadow (where we have conducted post-breeding banding), also support breeding Lincoln's Sparrow. Unlike Carter, each of these meadows also have breeding Song Sparrows co-occurring with Lincoln's Sparrow. Other researchers have suggested Song Sparrow expanded its elevation range upwards in the last 75 years in the Sierra Nevada (Siegel and DeSante 1999, Moritz 2007). It is not clear how this possible invasion of higher elevation meadows by Song Sparrows will impact the more diminutive Lincoln's Sparrow but higher elevation sites should be considered a unique and valuable resource for certain meadow dependent birds. Thus, we recommend managing the larger meadow complexes at lower elevations (3500 – 5000 feet) for species such as Sandhill Crane and Willow Flycatcher (Childs Meadow, Battle Creek Meadow, Deer Creek Meadow, Humbug Valley, West Shore Lake Almanor) while also protecting and, where necessary, enhancing higher elevation sites to support species such as Lincoln's Sparrow and Wilson's Warbler.

Conclusions

With the loss and degradation of riparian meadow habitat and it disproportionate importance to birds, restoration and prudent management of meadows in the Lassen region should be among the highest priorities of land mangers here. Increasing the function and resiliency of wet willow-filled meadows should be a high priority.

The ARD meadows support dense populations of riparian and meadow species, including the largest population of Willow Flycatcher in the Sierra Nevada. It is necessary to protect both lower elevation meadows and higher elevation meadows in order to sustain populations of all meadow-dependent birds, as very few meadows are good for all meadow species. Meadow restoration in the Lassen region will require partnerships between the U.S. Forest Service, local government agencies (e.g. Plumas Corp.), watershed groups, and non-profit organizations (e.g. TNC and PRBO). Working together these groups have the potential to dramatically increase the value of meadow habitats for birds in this region.

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