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Avian Monitoring in the Lassen and Plumas National Forests

2007 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 project area.

The first 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. Our results also highlight the relative importance of aspen habitat to the avian community compared to coniferous forest.

In Chapter Two we discuss a new project: monitoring Management Indicator woodpecker species in the Lassen National Forest. This project was focused on developing an effective monitoring plan for the rare and elusive Pileated Woodpecker. We used a new landscape modeling technique (MaxEnt) to predict suitable habitat for this species and targeted those areas for sampling with point counts and 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. Pileated Woodpeckers were detected in areas with significantly greater canopy cover, basal area, snags, and downed logs than sites with no detections. 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. Our approach not only provided information about these two species but also, with minimal extra effort, provided information on a whole suite of landbird species. We suggest this approach is a model for implementing effective single- and multi-species monitoring in the region.

In the third chapter we present results from a project designed to reduce fuels while enhancing pine and black oak habitat on the Almanor Ranger District of the Lassen National Forest. We investigated the short-term response of a suite of pine-oak focal species to treatments implemented in 2005 and 2006. Results suggest there was little effect thus far of treatments on a suite of focal bird species, overall avian diversity, or species richness. The only metric that showed an effect was total bird abundance, which

increased after sites were treated. Continued monitoring of this project will be necessary to determine the effects of treatment and successional processes to pine-oak associated bird species.

The fourth chapter discusses result from landscape based habitat modeling of a suite of breeding bird species in the Plumas-Lassen study area. We used maximum entropy (MaxEnt), a powerful new modeling technique that can predict species distributions at a landscape scale. We modeled nine species in this effort and present results and discuss key findings pertinent to land managers. These results suggested the importance of habitat and stand structure heterogeneity to a number of landbird species, including those associated with mature forest. The maps derived from this modeling are ideal tools for use by managers planning projects in the Plumas-Lassen study area.

Acknowledgements

PRBO's work in the Northern Sierra's is a multi-project program with several funding sources. Funding is provided by the regional office of 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, 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 2007 crew included crew leaders Dennis Jongsomjit, Tana Ellis, and Jarred Wolfe and crew members Tim Guida, Paul Taillie, and Lishka Arata.

Management Recommendations

General

- 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, mixed chaparral, 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 the avian community has evolved to exploit.

- Create more 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 integrity. Manage size class four forest to enhance structural diversity and ensure the full range of old-growth forest conditions will be present on the landscape in the future (e.g. open pine stands, dense close canopy stands).

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 reseeding for quick development of conifers. This should promote greater diversity in habitat structure on the landscape, uneven aged stands, and shrub 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, especially woodpeckers. 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 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 avoid shrub removal to create the attributes of structural diversity that are positively correlated with the bird community.

- 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 projects to allow herbaceous and shrub seeds access to mineral soils to allow for regeneration in newly opened canopies.

Chapter 1. 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 the Mexico, 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 nearby 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 Geupel 2001). 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 contained enough stands or acres 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 are limited in number, because they could immediately 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 in the past (Robber's Creek).

On both districts we attempted to maximize the number of points within the delineated aspen stands in an area. In some areas where stands were not in high densities, we limited transect size 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 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 2007 (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 2007 (Table 1).

Table 1. Aspen point count transects, ranger district, number of stations, and dates surveyed in 2007.

Site	# of Stations	Ranger District	Date, 1st Survey	Date, 2nd Survey
Ruffa Aspen	12	Almanor	6/8/2007	6/28/2007
Brown's Ravine Aspen	4	Almanor	5/20/2007	6/12 & 6/20/2007
Butte Creek Aspen	8	Eagle Lake	5/23/2007	6/29/2007
Crazy Harry Aspen	7	Eagle Lake	5/24/2007	6/26/2007
Coon Hollow Aspen	14	Almanor	6/4/2007	6/28/2007
Feather Lake Aspen	5	Eagle Lake	5/22/2007	6/24/2007
Harvey Valley Aspen	15	Eagle Lake	6/1/2007	6/21/2007
Lower Pine Creek Aspen	12	Eagle Lake	5/21 & 5/22/2007	6/15/2007
Martin Creek Aspen	11	Eagle Lake	5/25/2007	6/30/2007
Philbrook Aspen	10	Almanor	6/4 & 6/12/2007	6/28/2007
Pine Creek Aspen	14	Eagle Lake	5/21/2007	6/15/2007
Robber's Creek Aspen	16	Almanor	5/22 & 5/23/2007	6/19/2007
Susan River Aspen	12	Eagle Lake	5/24 & 5/31/2007	6/26/2007
West Dusty Aspen 1	10	Almanor	5/29/2007	6/27/2007
West Dusty Aspen 2	6	Almanor	5/27/2007	6/29/2007
West Dusty Aspen 3	8	Almanor	5/29/2007	6/29/2007
West Dusty Aspen 4	8	Almanor	5/30/2007	6/27/2007
Willow Creek Aspen	9	Almanor	5/25/2007	6/24/2007

Habitat Assessment

Habitat characteristics were assessed at all sites using a modified relevé protocol (see Appendix 2 for habitat assessment protocol description). We assessed all sites in the ELRD in 2004 and re-surveyed in 2006 all sites that had been treated since 2004. Habitat assessments were conducted at all aspen sites on the Almanor Ranger District in either 2006 or 2007.

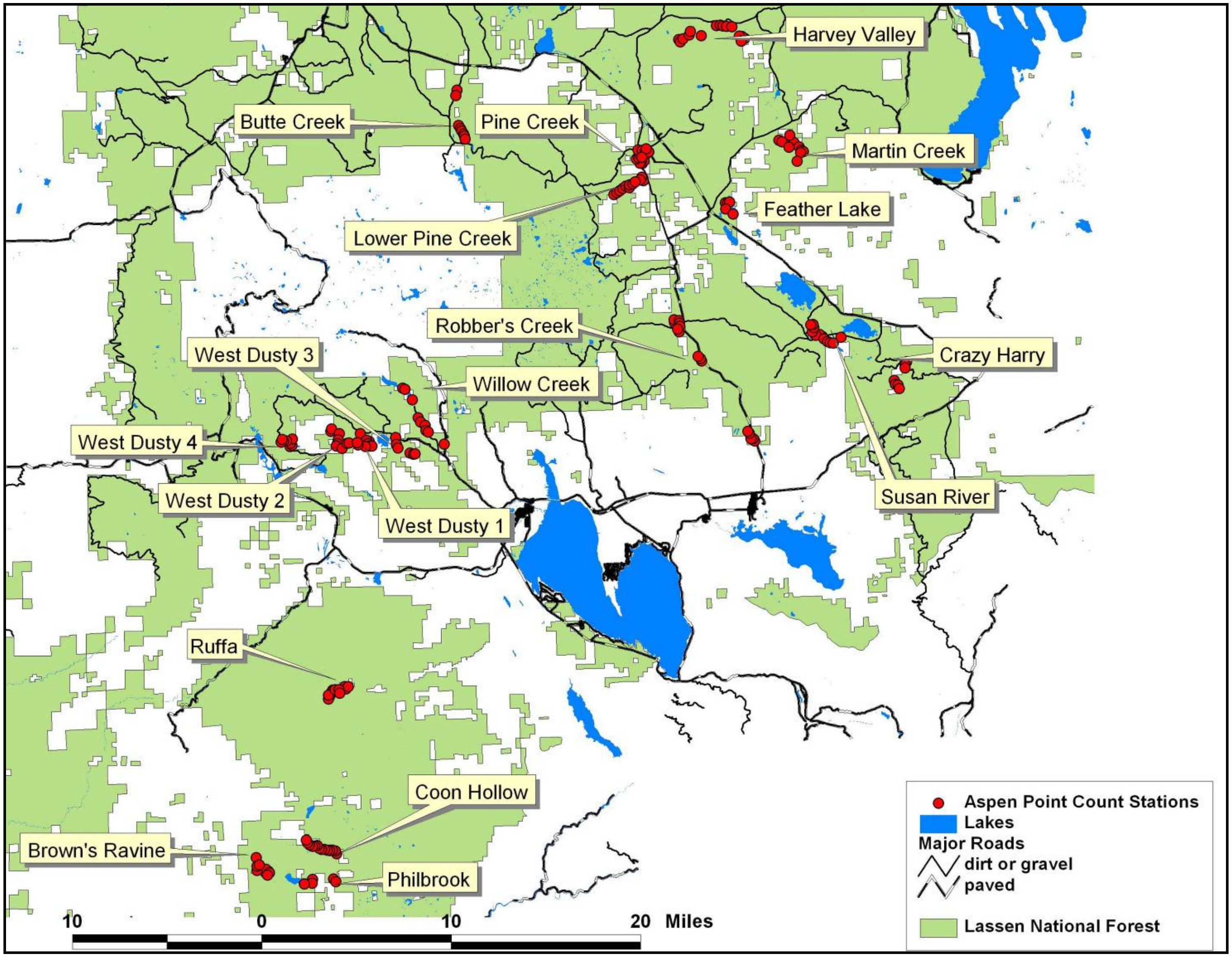
Analyses

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. We did investigate the abundance of these two species separately and report on them herein.

Species richness

Species richness is the total number of species detected within 50 meters per point across visits within a year.

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



Total Bird Abundance

We 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.

Relative Abundance of Species

We define the relative abundance of species as the total detections of that 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

We investigated trends in species richness and total bird abundance at treated and untreated aspen stands in the ELRD from 2004 – 2007. 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

We employed a suite of statistical tests in comparing treated aspen to untreated aspen. Negative binomial regression was used to test for differences in total bird abundance and relative abundance of individual species between treated and untreated aspen stands; while we used linear regression with species richness. We present the p-values from the associated F-test (linear) or Likelihood Ratio Test (negative binomial). For the analysis of trends we used general linear models with year as the independent variable and included transect as a categorical variable for both the treated and untreated samples. We present the test statistic and p-value from the F-test. We then tested to determine if the fitted trend lines between treated and untreated aspen were significantly different from each other. For both species richness and total bird abundance we added a binomial treatment term and an interaction between treatment and year to the model. We then compared the model with the treatment term to the same model but without the interaction using a likelihood ratio test. We present the likelihood ratio χ^2 statistic and p-value from these tests. For all tests we assumed significance at an $\alpha = 0.05$ level, however we considered α levels between 0.05 and 0.10 as marginally significant, and include them in discussion. Stata statistical software was used to conduct all statistical tests (Stata Corp 2005).

Results

Community and Species-specific Indices

Eleven of the 16 aspen transects surveyed in both 2006 and 2007 had greater total bird abundance in 2007, while species richness was higher at nine of 16 sites. In 2007, total bird abundance ranged from a high of 9.50 at Feather Lake to a low of 3.64 at Crazy Harry. Species richness ranged from 8.92 at Ruffa Ranch to 3.67 at West Dusty 2. The mean total bird abundance in 2007 for all sites combined was 5.11 while species richness was 6.67. Seven of the eleven sites showing increases in total bird abundance and five of the nine showing increases in species richness were on the Almanor Ranger District (ARD). Sites on the ELRD showing increases included Feather Lake, Martin Creek, Lower Pine Creek, and Susan River.

We compared the total bird abundance and species richness at untreated aspen sites in the ARD to untreated aspen sites in the ELRD in 2007. Species richness was 6.73 in the ARD and 6.38 in the ELRD. Total bird abundance in the ARD was 4.95 compared to 4.70 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 6.70 while total bird abundance increased to 5.19.

Total bird abundance and species richness were higher at treated sites compared to untreated sites in the ELRD across 2006 and 2007, though the difference was only significant with total bird abundance (Table 3, Figures 3, 4, and 5). Total bird abundance was 6.29 at treated sites and 4.70 at untreated sites ($F=8.63$, $p<0.01$). Species richness at treated sites was 7.42 compared to 6.38 at untreated sites ($F=1.64$; $p=0.20$).

Table 2. Mean per point total bird abundance and species richness (within 50 m of observers) at aspen sites surveyed in the Lassen National Forest from 2004 – 2007. Site not surveyed are represented by double dashes.

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

Species richness and total bird abundance from 2004 through 2007 were significantly increasing. In treated stands species richness from 2004 to 2007 increased at a rate of 8.9% per year (p=0.01), while untreated stands increased at 5.2% per year (p=0.06). The rate of increase in treated stands was not significantly greater than that in untreated stands (LR χ^2= 1.37, p<0.24). Total bird abundance in treated stands increased at a rate of 8.6% per year (p=0.02) while untreated stands increased at 5.6% per year (p=0.08). The difference in the rate of change between treated and untreated was not significant (LR χ^2= 1.32, p=0.25).

Figure 2. Mean per point species richness and total bird abundance based on detections within 50 meters of observers at Aspen sites in the Almanor and Eagle Lake Ranger Districts in 2007 with standard error bars.

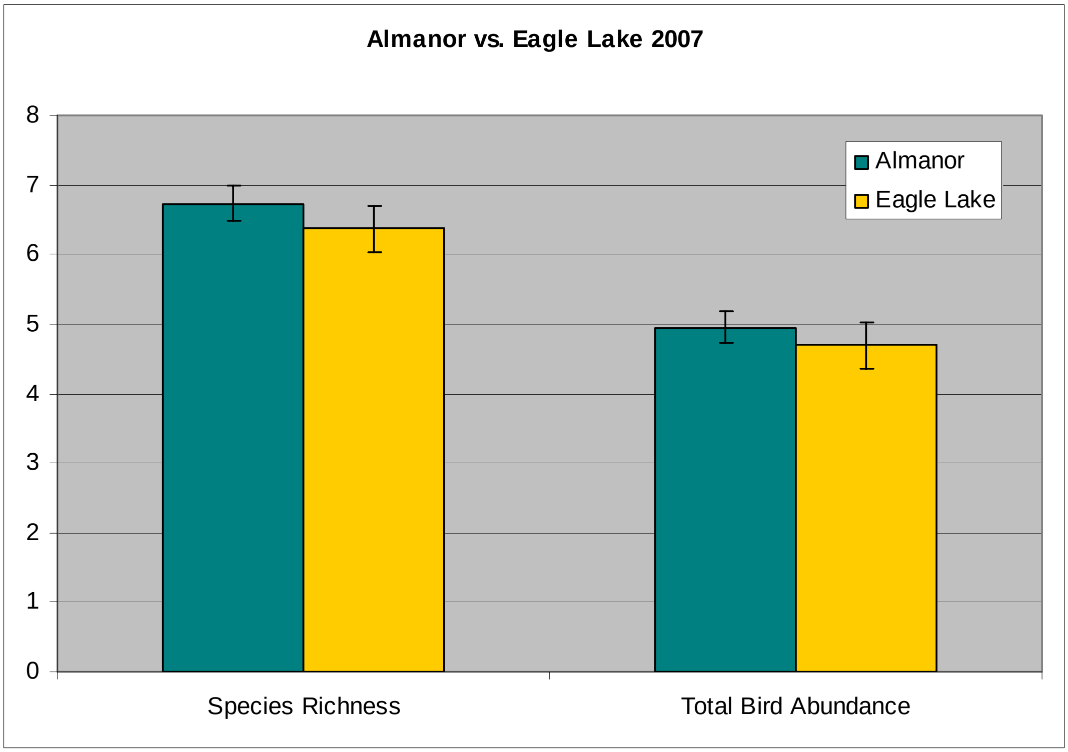


Figure 3. Mean per point species richness and total bird abundance at treated aspen and untreated aspen in the Eagle Lake Ranger District from 2006 – 2007 compared to coniferous forest in the Plumas-Lassen study area from 2003 – 2006.

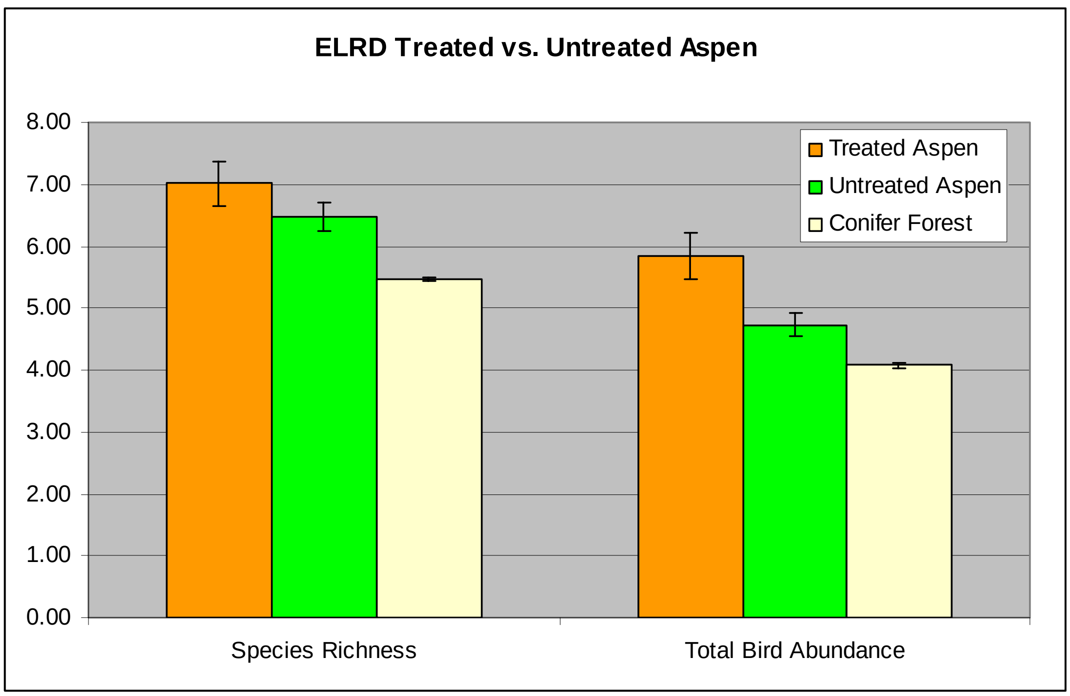


Figure 4. Annual per point species richness (with standard error) at treated and untreated aspen sites from 2004 -2007 in the Lassen National Forest with fitted linear trend.

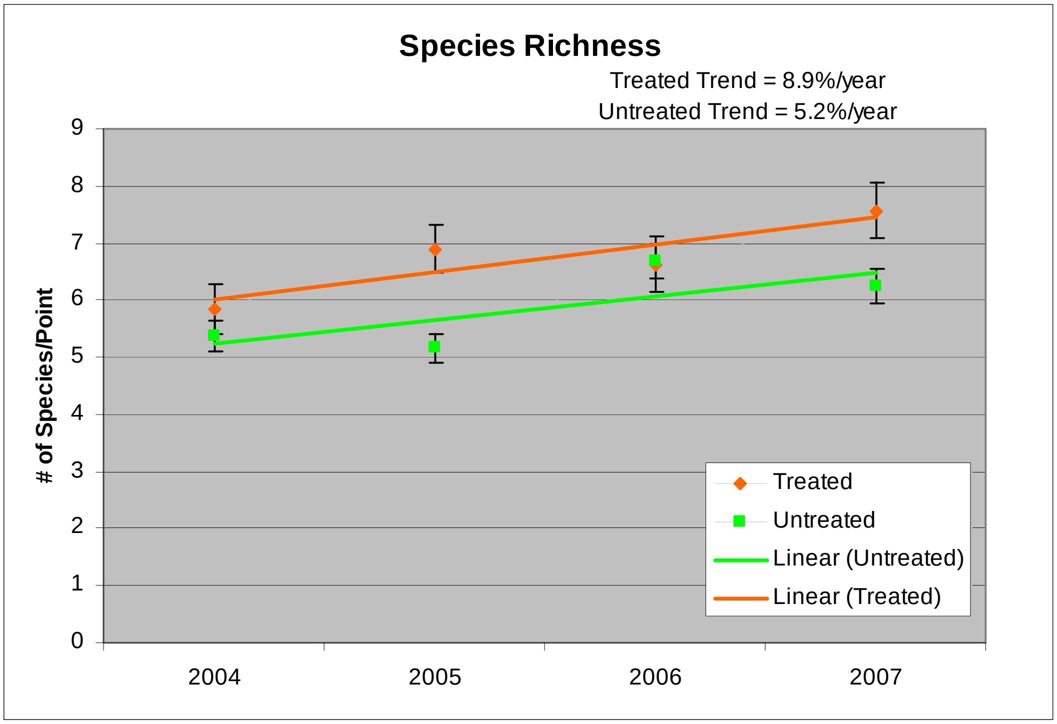
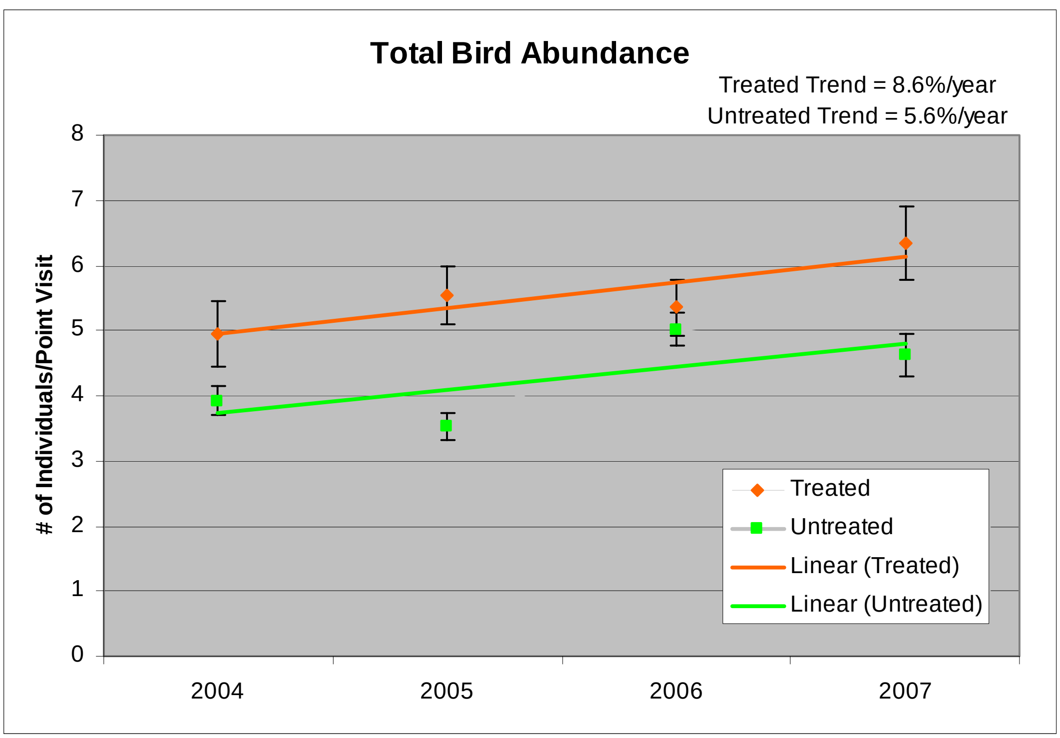


Figure 5. Annual per point visit total bird abundance (with standard error) at treated and untreated aspen sites from 2004 -2007 in the Lassen National Forest with fitted linear trend.



We investigated the relative abundance of ten of the twelve previously identified aspen focal species (Burnett *in press*), at treated aspen, untreated aspen, and conifer forest. There were not adequate detections of Swainson's Thrush and Olive-sided Flycatcher – the remaining two focal species – to include them in the analysis. Olive-sided Flycatcher were detected at 11 of the 18 transects but only one of those detections was within 50 meters of the observer. A total of five Swainson's Thrush were detected, two each at Ruffa Aspen and Coon Hollow, and one at Crazy Harry, the latter is our first detection of this species on the ELRD.

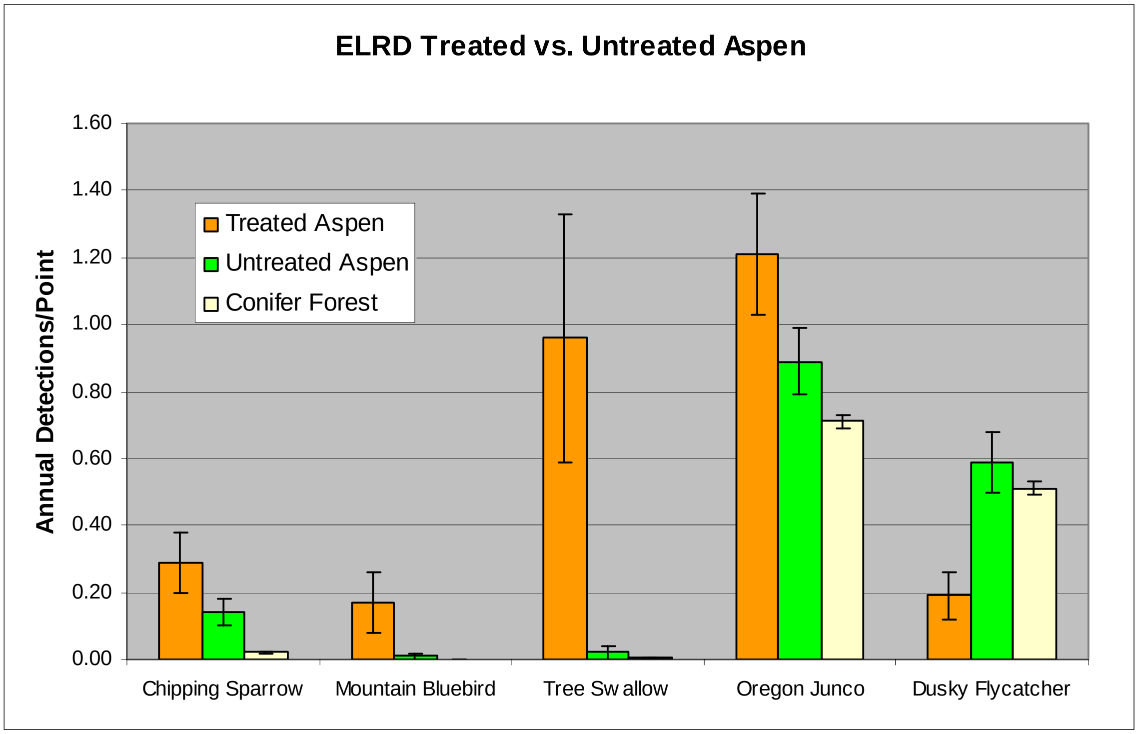
Six of the ten species were more abundant in treated aspen than untreated aspen and coniferous forest (Table 3) with the difference in abundance significant or marginally significant (Figure 6). Red-breasted Sapsucker, Hairy Woodpecker, Mountain Bluebird, Tree Swallow, Oregon Junco and Chipping Sparrow were all significantly or marginally significantly more abundant in treated aspen than untreated aspen. Additionally, total bird abundance was significantly greater in treated stands compared to untreated stands. Of the ten focal species examined, only Dusky Flycatcher was significantly more abundant in untreated aspen than treated aspen.

Table 3. Species Richness, total bird abundance, and the total detections of ten aspen focal species at treated and untreated aspen sites from 2006 and 2007. P-value is from negative binomial regression 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	7.02	6.47	0.20	5.47
Total Bird Abundance	5.85	4.73	<0.01	4.08
Red-breasted Sapsucker	0.50	0.28	0.07	0.05
Hairy Woodpecker	0.40	0.22	0.05	0.06
Western Wood-Pewee	0.35	0.28	0.49	0.03
Dusky Flycatcher	0.19	0.59	0.01	0.51
Warbling Vireo	1.08	1.04	0.86	0.17
Tree Swallow	0.96	0.02	<0.01	0.01
Mountain Bluebird	0.17	0.01	0.00	0.00
Oregon Junco	1.21	0.89	0.10	0.71
Chipping Sparrow	0.29	0.14	0.08	0.02
MacGillivray's Warbler	0.15	0.16	0.99	0.22

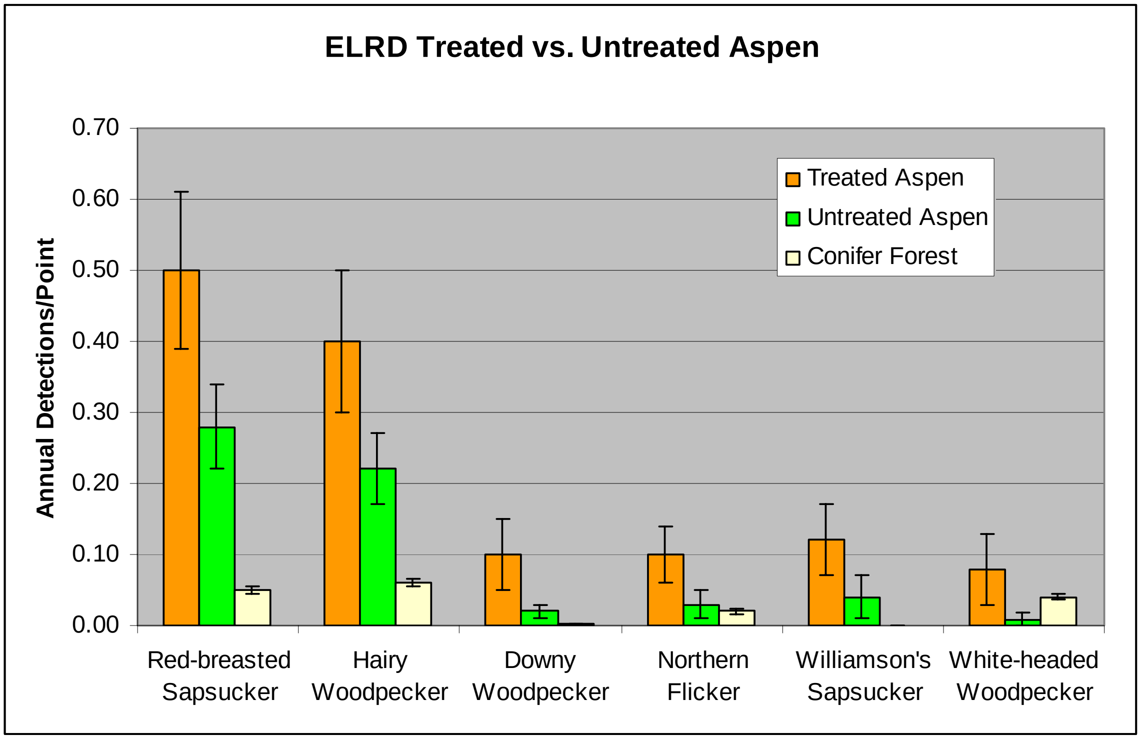
Each of the six species that were more abundant in treated than untreated aspen was also far more abundant in aspen of either type than conifer forest. Two other species, Western Wood-Pewee and Warbling Vireo, were also far more abundant in aspen of either type than conifer forest (Table 3). Of our focal species, only MacGillivray's Warbler and Olive-sided Flycatcher were more abundant in conifer forest than aspen, although Dusky Flycatchers were more abundant in conifer habitat than treated aspen.

Figure 6. Detections per point (with standard error) for seven aspen focal species in treated and untreated aspen in the ELRD from 206-2007 compared to conifer habitat in the Plumas-Lassen Admin Study area from 2003 - 2006.



All six of the most common woodpeckers were more abundant in treated aspen than untreated aspen (Figure 7; Table 3). Hairy Woodpecker relative abundance in treated aspen was 0.40 compared to 0.22 in treated aspen (p=0.06). Red-breasted Sapsucker abundance in treated aspen was 0.50 compared to 0.28 in untreated aspen (p=0.05). Williamson's Sapsucker abundance in treated was 0.12 compared to 0.04 in untreated (p=0.06) and Downy Woodpecker abundance in treated was 0.10 compared to 0.02 in untreated (p=0.05). Compared to coniferous forest, abundance in treated aspen was 6.7 times greater for Hairy Woodpecker, 10 times greater for Red-breasted Sapsucker, and five times greater for Northern Flicker. Furthermore, Downy Woodpecker and Williamson's Sapsucker were not detected within 50 meters of observers from over 4000 point count visits in conifer forest from the Plumas-Lassen study area, while they were fairly common in treated aspen.

Figure 7. Detections per point (with standard error) for the six most abundant woodpeckers at treated and untreated aspen stands in the ELRD from 2006- 2007 compared conifer habitat in the Plumas-Lassen Administrative Study area from 2003 – 2006.



Brown-headed Cowbird and European Starling

In both 2006 and 2007, the European Starling was not detected from point count surveys of Aspen sites in the Lassen National Forest. The mean per point Brown-headed Cowbird abundance was 0.11 for all sites combined. In the ELRD, cowbird abundance at treated sites was 0.08 compared to 0.19 at untreated sites.

Discussion

Overview

In both districts, aspen habitat harbors greater total bird abundance and species richness than conifer forest and far greater abundance of aspen focal species, highlighting the importance of aspen habitat for birds in the region. Untreated aspen habitat on the ELRD and ARD harbor similar abundance and richness of birds, with ARD indices slightly higher. When treated sites are included – which as of 2007 are exclusively on the ELRD – ELRD indices are equal to or higher than those on the ARD. Though we focus the remainder of the discussion on results from treated aspen on the ELRD we believe the results are directly applicable to the ARD and aspen habitat throughout the Northern Sierra.

Treated vs. Untreated Aspen

In the ELRD the short term response to aspen treatments on total bird abundance and species richness has been positive. Total bird abundance was significantly higher at treated sites (24% greater) and species richness, though a lesser effect and not significant, was also higher (9% greater). We would not necessarily have predicted an increase in species richness at sites that had been treated within one to eight years, as treatments remove the vast majority of encroaching conifers. While these conifers are a threat to the health of the aspen community, they do provide suitable conditions for a suite of conifer-associated birds. When these conifers are removed and aspen regeneration has not had the time to develop the structural diversity and habitat complexity lost in the middle story and canopy, one might expect to see a short term drop in species richness. However, the open habitat conditions created through treatment have attracted a new suite of species such as Tree Swallow, Chipping Sparrow, and Mountain Bluebird, which are almost completely absent from untreated aspen. However, it appears that the flush of young aspen shoots three to five years post treatment, as well as a response from the herbaceous layer, more than compensates for any habitat loss from conifer removal. In fact, understory aspen – the first new habitat condition to develop in treated aspen – is the strongest predictor of species richness in aspen habitat on the ELRD (Burnett et al. 2006).

Over the four year period of monitoring bird populations in aspen habitat on the ELRD, there have been significant increases in species richness and total bird abundance in treated and untreated aspen. These same patterns have not been evident from conifer forest over the same time frame (Burnett and Nur 2007). While the difference in the rate of increase between treated and untreated aspen was not significant, the rate is greater in treated aspen for both species richness and total bird abundance. It appears that the initial action of opening up overstocked stands has an immediate benefit to the avian community and that benefit is increasing over time. Thus, there have been significant short term benefits to the avian community from aspen treatments and those benefits appear to be increasing with time. Total aspen cover and especially understory aspen should increase significantly at treated sites in the coming years (Jones et al. 2005). Thus, based on current results already showing significant increases at treated sites, and habitat associations showing the importance of understory aspen, aspen foliage volume, structural diversity, and total aspen cover, we expect these trends will continue if not accelerate in the next five to ten years.

Our aim in selecting focal species to guide and evaluate aspen treatments was to focus on species we know to be far more abundant in aspen than conifer habitat, or that represent key aspen habitat attributes. The vast majority of our focal species were more abundant in treated aspen than untreated aspen, and all but MacGillivray's were indeed more abundant in one form of aspen (treated or untreated) than conifer forest.

MacGillivray's Warbler is an understory species that reaches its greatest abundance in meadow riparian with dense understory foliage (Burnett et al. 2006). As more of these riparian aspen areas are treated and the shade intolerant understory riparian plant community responds, this species should increase at aspen sites.

Dusky Flycatcher is another focal species that nests in the understory in aspen habitat (see cover photo of this chapter for an example of a typical nest location for this species in aspen). This flycatcher was the only species significantly more abundant in untreated aspen than treated aspen. Though they reach their greatest abundance in montane chaparral, we have found them nesting in dense lodgepole pine thickets throughout the Lassen region (pers. obs). This habitat component is largely removed during treatments, thus treated sites are likely to have a short-term negative impact on habitat suitability for this species. However, since treated aspen stands respond with a vigorous flush of new aspen stems (Jones et al. 2005), a dense understory of small trees should develop at most sites 5 to 10 years following treatment. As most treated sites are less than 5 years removed from treatment aspen clones have not had sufficient time to regenerate a dense understory aspen component suitable for nesting by this species. Additionally, a more extensive and vigorous shrub component in riparian aspen systems following conifer release should benefit this species. Regardless, Dusky Flycatcher is a good focal species for evaluating the quality of the understory aspen response following treatment, and we predict they will increase in treated aspen habitat as this study progresses and the number of years since treatment increases.

Aspen treatments appear to be benefiting passerine species that are rare, declining, or both. The four passerines that have shown the greatest positive short-term response to aspen treatments are Tree Swallow, Mountain Bluebird, Chipping Sparrow, and Oregon Junco. Not only are they far more abundant in treated aspen than untreated, they all seem to strongly prefer aspen over conifer habitat. Chipping Sparrow has been significantly declining at a rate of 4.0% per year from 1966-2005 in the Sierra Nevada (Sauer et al. 2007). This species often nests in understory trees in areas with a substantial herbaceous layer where it forages on insects and seeds. They are almost nonexistent in conifer forest in the region, but are among the ten most abundant species in treated aspen. 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 3.3% per year, though due to their rarity this trend is not significant (Sauer et al. 2007). The abundance of Oregon Junco, one of the most common species in conifer forest, is nearly double in treated aspen. It is another species, though common, that has experienced significant declines (2.4% per year) in the Sierra Nevada (Sauer et al. 2007).

Warbling Vireo, which from 2004-2005 was more abundant in untreated aspen, was slightly more abundant in treated aspen in 2006-2007. A Warbling Vireo nest was found in a two meter tall aspen at Butte Lake point count station 01 this year, anecdotally suggesting sites that have been the longest time since treatment are starting to provide habitat for this species.

Aspen habitat often supports a diverse and abundant guild of cavity nesting species, with many studies showing cavity nesters to 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 a 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). Thus, woodpeckers are of vital importance to the cavity nesting birds in aspen habitat.

Woodpeckers continued to be far more abundant in aspen habitat in the Lassen region than non-aspen forest, reaching their greatest abundance in treated aspen sites. Of special note is the case of Downy Woodpecker, a species declining at an alarming rate of 8.8% per year from 1980-2006 in the Sierra Nevada. As with all the other woodpeckers it was significantly more abundant in aspen than conifer forest and showed a preference for treated aspen. It is a riparian associated species, thus treatment of riparian aspen and cottonwood-dominated sites that have been encroached by conifers should benefit this species. The habitat conditions that result following treating aspen stands likely mimic natural disturbances such as fire and blow-down that woodpeckers often associated with. However, the ecological benefits of fire may not be fully realized by just treating aspen stands. It would be necessary to monitor demographic parameters. As it is possible that they are "tricked" by the treatment as food availability may not be any greater. However, we have no solid reason to believe treated aspen are not providing high quality habitat for woodpeckers.

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, Mountain Chickadee).

Brown-headed Cowbird

Brown-headed Cowbirds were present at a number of aspen sites, especially in the ELRD. However, treated aspen sites contained less than half the number of cowbirds than untreated sites. The distribution and abundance of cowbirds is most likely tied to the proximity of grazing allotments and the number of cows, and possibly less to treatment effect. Nineteen of the 33 cowbird detections in 2006 and 2007 were at Harvey Valley, an actively grazed area. As Harvey Valley is to be treated in 2008, measures beyond just fencing aspen may be necessary to alleviate the negative impacts of grazing on the aspen bird community here. In addition, permanent exclusion of grazing from aspen stands may be necessary to avoid significant detrimental impacts to a number of aspen-associated species (Earnst et al. 2005).

Conclusions

Our results from 2006 and 2007 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 determine how they change as time since treatment progresses.

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

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
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
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

Appendix 2. PRBO Northern Sierra Aspen Habitat assessment protocol.

All data is collected within a 50 meter radius circle centered on the point count station.

1st Section General Information:

Station = 3 or 4 letter code (e.g. PCA)

Point # = the actual point number of the PC.

Habitat 1 = general classifications (MCF, MCP, MCEA, ASP)

Habitat 2 = only record this if there is a distinct habitat edge (i.e. point is bisected by a clear cut/forest edge)

Date = the date you are collecting this data.

Aspect = the direction of the slope given in degrees (the direction a drop water would flow if poured onto the point). Collect magnetic direction.

Slope = the average slope of the plot with 90 degrees being vertical and 0 degrees being flat, from the highest point to the lowest (i.e., if it drops 10 meters over the 100 meter plot, slope is 10 %.)

Water = true or false is there any water in the plot running or standing.

Snags<10 = total number of the snags in the plot less than 10cm DBH (this includes things that still have dead branches on it but it must be appear to be completely dead, leaning snags that are uprooted but not on the ground or almost on the ground count).

Snags30>10 = the number of snags greater than 10 cm DBH but less than 30 cm DBH (see above for more details).

Snags >30 = the total number of snags greater than 30 cm DBH.

Logs = any downed trees or limbs greater than 8cm DBH and greater than 2m long. Must still have shape of log, rotted decomposed stuff that is really falling apart should not be counted.
Cover Layers
These are divided up into 6 layers (Tree, Tree Shrub, Real Shrub, Total Shrub, and Herbaceous)

Tree – this is defined by height category alone. Any plant species whose upper bounds (highest point) is greater than 5 meters tall is included in this category (a 6 m tall Manzanita would be included in this category, however a 4m tall White Fir would not be).

Tree Shrub – this is all tree species that are less than 5 meters tall regardless of height, this means a 25cm tall White Fir counts in this category. Tree species are the conifers, black oak, maple, white alder, canyon oak, etc. Do not count aspen in this category.

Real Shrub - this is the true shrub species as well as a few shrubby trees that rarely get above 5 meters tall (Dogwood, Mountain Alder, ARPA, CHCA, CECO, CEIN, etc.), record the total cover of these species regardless of height.

Total Shrub - this is the total cover of all vegetation whose maximum height is between 0.5 and 5 meters (the original relevé way of doing it). It may be just the sum of real shrub and true shrub but overlap and tall real shrubs may lead to differences.

Aspen – record the cover of all aspen and the low and high heights regardless of height category.

Herbaceous Layer – this is the total cover of all non-woody vegetation, regardless of height.

Note: the maximum cover theoretically is 100% for all of these categories but practically that would be impossible to achieve.

Height Bounds
High - estimate is to the nearest ½ to 1 meter of the average height of the upper bounds of the vegetation layer (tree, tree shrub, real shrub). This is not the tallest outlier it is the average high of the tallest plants in that layer (e.g., of the tallest trees in the plot what is the average high height).

Low – the average (as defined in the high) of the lowest living branches of the tree and tree shrub and real shrub do not record this for total shrub or herbaceous.

Lower and Upper Species – record the plant species that dominates the lower and upper bounds for all of the categories you collected low and high height data for, if you think there is absolute equal representation of these than good for you! Flip and coin and stop wasting your time and my money and move on to the next measurement.

DBH = estimate the minimum and maximum DBH of any tree within 50 meters, and record what species it is. Do not record this for the shrub layers.

Species List
Record these as T1 (tree layer), TS (true shrub), RS (real shrub), S1 (total shrub) and H1 (herbaceous)

Record for each of these layers the % each species comprises of the total (this number should add up to 100% regardless of the % total cover). List as many species as can easily be recorded in a timely manner. Chasing down that lone shrub off in the corner of the plot is not worth the effort. However, we are interested in hardwood species so if they are present in small numbers recording them even if they are less than 5% is worth the effort, also recording a single large tree as 5% or less is probably also worth it.

DBH Classes
Place each tree in the plot with a DBH (i.e. greater than 1.5 meters tall) into the four DBH classes on the bottom of the page. Note that the DBH tape may be in inches so you need to divide by 2.54. If there are more several hundred trees by all means make a good estimate do not go around taping every tree.

Aspen Density Transects
Using permanently (orange rebar) marked transects lay 50 meter tape out from center of point to one end point (transects are east and south unless an un-crossable barrier is met then chose the bearing 180 degrees from the un-crossable). Record all aspen stems that are within 3 feet of the tape (either side). For each Aspen hit place it within one of 4 categories as listed on the bottom of the sheet (0-1.5’, 1.5’-4.5’, 4.5-1” DBH, and >1” DBH). Subtotal all of these at the 100 ft mark (30.5 meters) and then a grand total for the entire 50 meters. Conduct this for both 50 meter transects.

Canopy Cover
Using same transect as Aspen density above record the hit/no hit along the transect every 10 feet (~3 meters) using the densitometer. For each hit record the species and subtotal these at 100 feet (30.5 meters) and then a grand total for all 50 meters. Repeat for the second transect. Note: It is vital that time is spent to lay out the tape accurately and taught so that transects are as repeatable as possible.

Chapter 2. Management Indicator Species Woodpecker Monitoring in the Lassen National Forest

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Background and Introduction

In order to help guide management of National Forest lands in the United States, the National Forest Management Act (NFMA) was passed in 1976. In 1982 planning regulations were implemented 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 and Hairy Woodpeckers (among other species) as 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). Their home range size is large and extremely variable compared to other North American woodpeckers with the literature reporting a range in western populations from 660 – 2600 acres (Bull and Jackson 1995). In Oregon, average home range size was between 1000 and 1200 acres (Bull and Holthausen 1993, Mellen et al. 1992). Due to their retiring nature, habitat specialization, and large territory sizes, standard bird monitoring techniques (e.g. point counts) are unlikely to detect sufficient numbers of this species for meaningful analysis of population trends. Thus, in order to adequately sample this species we developed a GIS-based predictive model of suitable habitat in the Lassen National Forest and followed up point count surveys with broadcasting of drumming and calls.

Hairy Woodpecker is a habitat generalist that occurs throughout a wide range of habitats in North America (Jackson et al. 2002). It is the most abundant (based on point count detections) woodpecker on National Forest land in the northern Sierra Nevada (PRBO unpublished data) and occurs across a range of elevations and habitat conditions here. Due to its generalist nature, it is difficult to determine key habitat attributes for this species, though based on its natural history we know that snags are important for foraging, roost, and nest sites. We have found this species reaches its greatest abundance in burned coniferous forest with large quantities of standing burned trees and in treated aspen stands (see chapter 1). We present information from detections of this species on the new MIS transects but also guide those interested to other chapters of this report or reports from previous years results for more discussion of this species in the Lassen National Forest (e.g. Burnett et al. 2006, Burnett and Nur 2007).

PRBO has been monitoring landbirds in the Lassen National Forest since 1997, focused primarily on the Almanor Ranger District. In 2007 PRBO began a comprehensive forest wide monitoring program for these two woodpecker species. We identified four objectives for our MIS woodpecker monitoring project:

1. Determine the distribution of these species across the forest
2. Provide baseline data for determining long-term trends of these species
3. Identify key habitat features for Pileated Woodpecker
4. Determine a valid approach to monitoring Pileated Woodpecker in the Sierra Nevada.

As a companion to this chapter we created two GIS layers, one is the output from the model predicting suitable Pileated Woodpecker habitat and the second is the detections of all woodpeckers from all sites surveyed by PRBO since 1997 in the Northern Sierra.

Methods

Predictive Model

In order to maximize detections of Pileated Woodpeckers we developed a model to predict areas most likely to support this species. We used a powerful machine learning algorithm called Maxent (Phillips et al. 2006) to predict Pileated Woodpecker distributions based on occurrence data and GIS-based environmental data layers. 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. The method accommodates several different types of non-linear relationships and is similar to generalized additive models (Hastie and Tibshirani 1990) in its outputs and interpretation.

Species occurrence data came from PRBO’s Northern Sierra projects point count survey database, which spanned from 1997-2006 and included over 2600 locations. PRBO point count survey data also contains species absence information, which was used for the Maxent modeling. Any location at which the species was detected at least once at any distance was considered a presence location.

Predictors of species distributions were GIS-based environmental data layers (50-m by 50-m pixels, Table 1). A variety of vegetation, climate, hydrology, and land use data layers were manipulated to create input data layers of hypothesized importance for Pileated Woodpecker (Table 2). Manipulation of input data was performed using ArcGIS 9.2 (ESRI 2006) and Fragstats 3.3 (McGarigal and Marks 1995). Resulting metrics included moving window averages (average pixel value within a circle of a given radius), linear densities (i.e., stream density), and Euclidean distances (i.e., distance to nearest stream or lake). Climate parameters were obtained from PRISM 800-m grid cell climate datasets (http://prism.oregonstate.edu/); vegetation parameters were based on USDA Forest Service CALVEG vegetation tiles converted to grid format at a 50m resolution (http://www.fs.fed.us/r5/rsl/clearinghouse/gettiles.shtml); topographic and hydrologic parameters were derived from the USGS's national elevation dataset (http://ned.usgs.gov/) and national hydrographic dataset (http://nhd.usgs.gov/), respectively.

Model predictions were cross-validated using a subset of the data points (25%) selected at random by the Maxent program. Model performance was assessed using the area under the curve (AUC) of receiver operating characteristic (ROC) plots (Fielding and Bell 1997).

Model validation statistics (ROC AUC) indicated good model performance. 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. 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

Environmental Variable	Description	Original Source
Habitat		
Wildlife habitat types	Categorical and combined vegetation types derived from CALVEG types using the California Wildlife Habitat Relationships (CWHR) classification scheme.	U.S. Forest Service CALVEG Eveg tiles (2000 or 2004)
WHR size classes	Tree size classifications on a 1-6 scale. Classes 5 and 6 were combined (6 being a combination of large and mid size trees)	U.S. Forest Service CALVEG Eveg tiles (2000 or 2004)
WHR density classes	Canopy cover ranging from sparse to dense.	U.S. Forest Service CALVEG Eveg tiles (2000 or 2004)
Weather		
Temperature monthly minimum/maximum	Average monthly minimum and maximum temperatures for Jan, March, June, Oct.	Oregon State University (PRISM climate mapping system)
Precipitation monthly average	Average monthly precipitation for Jan, March, June, Oct.	Oregon State University (PRISM climate mapping system)
Bioclimatic variables	Climate variables derived from monthly min, max, and average temperature and precipitation values	Derived from Oregon State University (PRISM climate mapping system) after Nix (1986)
Topography		
Elevation	Elevation at point in meters.	U.S. Geological Survey (Teale GIS Solutions Group)
Slope	Slope at point derived from elevation data.	U.S. Geological Survey (Teale GIS Solutions Group)
Perennial and intermittent stream density	Stream density (km/km^2) within 1 km radius.	U.S. Geological Survey (National Hydrography Dataset)

Table 2. Habitat variables selected for input into Pileated Woodpecker habitat model.

Variable	Description
Red fir	Percent shrub 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
All vegetation types	Vegetation type at point count location
Precipitation	Average precipitation in Jan, Mar, Jun, Oct
Temperature	Minimum and maximum temperatures in Jan, Mar, Jun, Oct
Size class 4 and 5	Vegetation size classes within a 1 km radius
Density class 1 and 2	Tree density within a 1km radius (cwhr class O & M+D)
Slope	Slope at point count location
Elevation	Elevation at point count location

Site Selection

In a GIS environment we clipped model outputs to the Lassen Forest boundary. We then queried the data to show only those sites considered to have greater than 40% likelihood that the habitat conditions that best predict this species occurrence were present. We then used a random point generator to select 70 potential starting points, which was double the number of transects we intended to establish. We then randomly selected among the starting points and attempted to establish transects within the polygons or several adjacent polygons. We attempted to place at least eleven transects in each district regardless of the amount of habitat the model suggested the district had (Table 3). If a random point fell within a polygon where an existing transect was located we used that transect (1 on ELRD and 7 on ARD).

Each transect was six points long with 500 meters between each point. We doubled the normal distance between point count stations in order to survey more area and to limit multiple surveys within the same woodpecker's territory.

Survey Protocol

At each station upon arrival we conducted a standardized five minute – multiple distance band fixed radius point count. The same survey technique used at all other PRBO northern Sierra point count stations. If a Pileated Woodpecker was detected during the point count census after the five minute survey we moved on to the next station.

If a Pileated Woodpecker was not detected during the five minute point count we conducted a playback survey that was up to three minutes in duration. 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 callback could be detected from between 150 and 250 meters by our observers based on field conditions (e.g. slope, tree density). The callback survey consisted of three 30 second callback surveys each separated 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) and distance from the observer, and moved on to the next survey location.

Table 3. MIS point count/Pileated Woodpecker callback survey transects, transect codes, Ranger District, and dates surveyed in the Lassen National Forest in 2007.

Transect Name	Transect Code	Ranger District	1st Survey	2nd Survey
114	114	Almanor	5/23/2007	6/7/2007
Cottonwood Creek	COCR	Almanor	6/7/2007	6/23/2007
D102	D102	Almanor	5/24/2007	6/11/2007
D108	D108	Almanor	5/24/2007	6/11/2007
D111	D111	Almanor	5/22/2007	6/10/2007
D112	D112	Almanor	5/23/2007	6/7/2007
Louse Creek	LOCR	Almanor	6/5/2007	6/30/2007
Peacock Point	PEPO	Almanor	6/4/2007	6/23/2007
Rattle Snake	RASN	Almanor	5/25/2007	6/12/2007
Rocky Point	ROPO	Almanor	5/25/2007	6/10/2007
Snag Lake	SNLA	Almanor	6/4/2007	6/21/2007
Upper Mill Creek Trail	UMCT	Almanor	5/26/2007	6/13/2007
Bear	BEAR	Eagle Lake	6/12/2007	7/1/2007
Crater Mountain	CRMO	Eagle Lake	5/26/2007	6/14/2007
Dixie Springs	DISP	Eagle Lake	5/29/2007	6/15/2007
Dow Flat	DOFL	Eagle Lake	5/30/2007	6/16/2007
Harvey Valley DFPZ	HVD	Eagle Lake	6/2/2007	6/21/2007
Harvey Valley Reference	HVR	Eagle Lake	6/2/2007	6/21/2007
Lodgepole	LODG	Eagle Lake	5/31/2007	6/13/2007
Logan Mountain	LOMO	Eagle Lake	5/31/2007	6/29/2007
Pine Creek	PINE	Eagle Lake	5/28/2007	6/14/2007
Squaw Valley	SQVA	Eagle Lake	5/29/2007	6/15/2007
Swain's Hole	SWHO	Eagle Lake	6/1/2007	6/18/2007
Ashpan Butte	ASBU	Hat Creek	6/6/2007	6/27/2007
Bald Mountain	BALD	Hat Creek	6/8/2007	6/25/2007
Crag	CRAG	Hat Creek	6/9/2007	6/30/2007
Devil's Rock	DERO	Hat Creek	6/8/2007	6/27/2007
Freaner Peak	FRPE	Hat Creek	6/9/2007	6/28/2007
Horse Heaven	HOHE	Hat Creek	6/9/2007	6/28/2007
Ice Cave	ICCA	Hat Creek	5/30/2007	6/16/2007
Lost Creek	LOST	Hat Creek	6/5/2007	6/19/2007
Moon Springs	MOON	Hat Creek	6/8/2007	6/25/2007
Plum Valley	PLUM	Hat Creek	6/2/2007	6/19/2007
Potato Butte	POBU	Hat Creek	6/9/2007	6/29/2007
Signal Butte	SIBU	Hat Creek	6/1/2007	6/18/2007

Vegetation sampling protocol

At each survey station a modified relevé protocol was used to asses habitat conditions (Ralph et al. 1993). A detailed description of the data collected and methods are presented in Appendix 1. Key information collected included: basal area, canopy closure, number of snags by size category, tree richness, average canopy height, and absolute cover of each tree and shrub species.

Analysis

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, an invasive species that is generally regarded as having a negative influence on the native bird community.

Species Richness and Total Bird Abundance

Species richness is defined as the total number of species detected within 50 meters. Presenting the mean species richness, as we do herein, allows for comparisons between transects or habitats consisting of different numbers of point count stations. We define 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.

For comparison of total bird abundance and species richness at Pileated Woodpecker sites compared to sites where they were not detected we tested for significant using logistic regression. For all analyses we present untransformed arithmetic means along with standard error of that mean.

Habitat Comparisons

We chose seven habitat variables that we believed may be important to Pileated Woodpeckers and compared them at sites where we detected Pileated Woodpecker and at sites where they were not detected in 2007. We considered site to have a positive detection if the species was detected at any distance and by any means (e.g. point count, call back, and incidental). We tested for significance using two-tailed student t-tests and considered significance at the $\alpha = 0.05$ level. We then entered each of the variables found to be significantly different into a reverse stepwise logistic regression model, with the level of significance set at $\alpha = 0.10$. We repeated this for Hairy Woodpecker, but we only used detections from point counts, as we did not conduct playbacks for this species. We also included all seven habitat variables (see Table 6) we believed were potentially important for the species into the stepwise model. All statistical analysis was conducted using Stata statistical software (Stata Corp 2006).

Results

Pileated Woodpecker

Pileated Woodpecker were detected on 21 of the 35 transects and within 100 meters of observers at 15 of the 21 transects in 2007. They were detected at nine of the twelve transects in the ARD, six of the eleven transects in the ELRD, and six of the twelve transects on the HCRD. Pileated Woodpecker were detected at 82 of the 234 stations (35% of sites) by way of point count or call back survey, 22% from point count surveys and 13% from call backs. Of the sites where they were confirmed, 63% were by way of point count surveys while 37% were from callbacks. Pileated Woodpecker were detected within 100 meters of observers at 9% of the stations (n=22), with all but three of those detections from call back surveys. They were detected at an additional nine stations from incidental observations before or after the surveys were conducted.

Figure 1. Locations of MIS survey transects in the Lassen National Forest in 2007 with detections of Pileated Woodpecker and areas predicted to have high suitability for Pileated Woodpecker from Maximum entropy landscape based model.

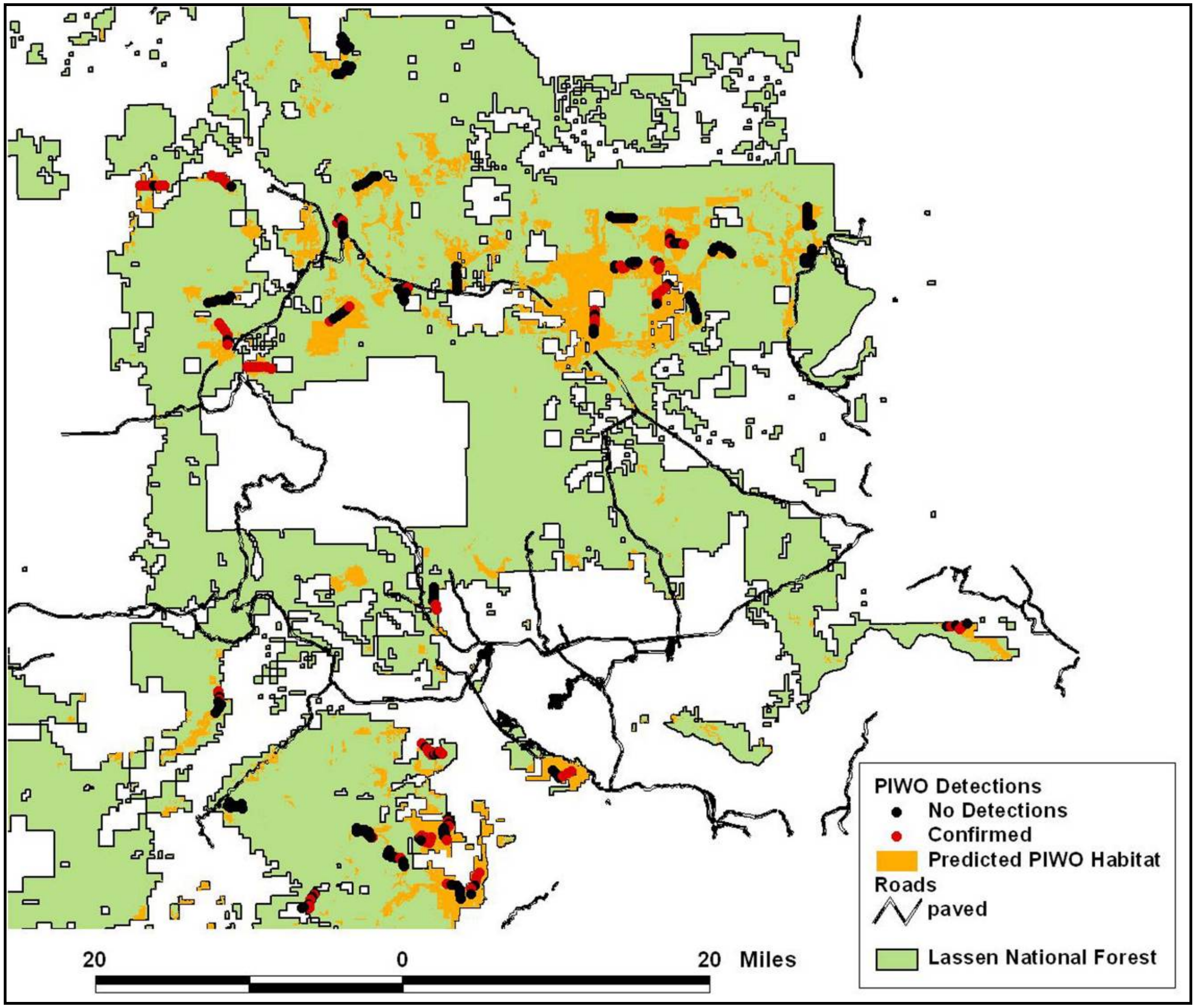


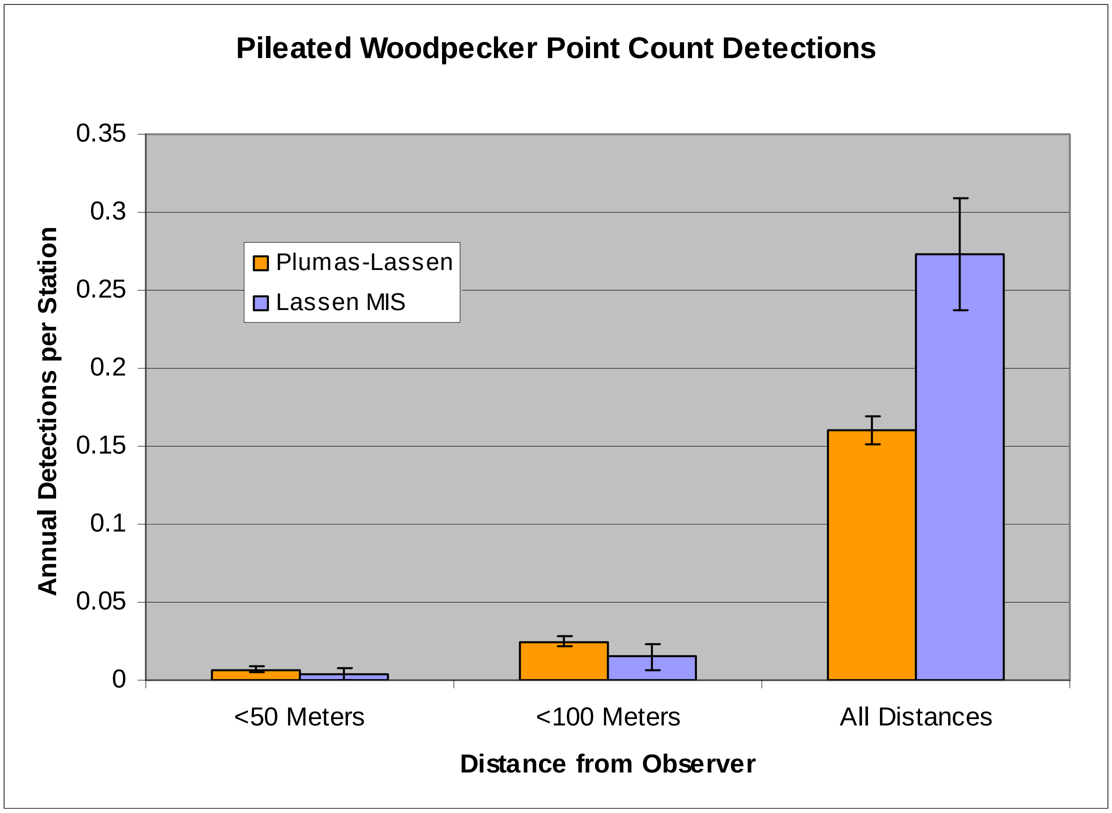
Table 4. MIS transects where Pileated Woodpecker were encountered in the Lassen National Forest in 2007 based on all detections from point counts, call back surveys, and incidental detections before or after surveys.

Transect Name	Ranger District	Pileated Detected	Pileated < 100 meters from survey point
114	Almanor	X	X
Cottonwood Creek	Almanor	X	X
D102	Almanor		
D108	Almanor	X	
D111	Almanor	X	X
D112	Almanor	X	X
Louse Creek	Almanor	X	X
Peacock Point	Almanor		
Rattlesnake	Almanor		
Rocky Point	Almanor	X	
Snag Lake	Almanor	X	X
Upper Mill Creek Trail	Almanor	X	
Bear	Eagle Lake	X	X
Crater Mountain	Eagle Lake	X	X
Dixie Springs	Eagle Lake		
Dow Flat	Eagle Lake		
Harvey Valley DFPZ	Eagle Lake	X	
Harvey Valley Reference	Eagle Lake	X	
Lodgepole	Eagle Lake	X	X
Logan Mountain	Eagle Lake		
Pine Creek	Eagle Lake		
Squaw Valley	Eagle Lake	X	X
Swain's Hole	Eagle Lake		
Ashpan Butte	Hat Creek	X	X
Bald Mountain	Hat Creek		
Crag	Hat Creek	X	X
Devil's Rock	Hat Creek		
Freaner Peak	Hat Creek	X	X
Horse Heaven	Hat Creek	X	X
Ice Cave	Hat Creek		
Lost Creek	Hat Creek		
Moon Springs	Hat Creek		
Plum Valley	Hat Creek	X	X
Potato Butte	Hat Creek	X	
Signal Butte	Hat Creek		

We compared detection rates of Pileated Woodpeckers at point count surveys on the Lassen MIS transects to those from the Plumas Lassen study area (Figure 2). Mean detections per point within 50 meters of observers was 0.004 for MIS and 0.007 for Plumas-Lassen. For detections within 100 meters of observers it was 0.015 for MIS and

0.025 for Plumas-Lassen; for all detections MIS was 0.27 compared to 0.16 for Plumas-Lassen.

Figure 2. Pileated Woodpecker total detections per point count station, with standard error, by distance from observer at MIS woodpecker point count stations in the Lassen National Forest in 2007 compared to point count stations in the Plumas Lassen study area in 2005 and 2006.



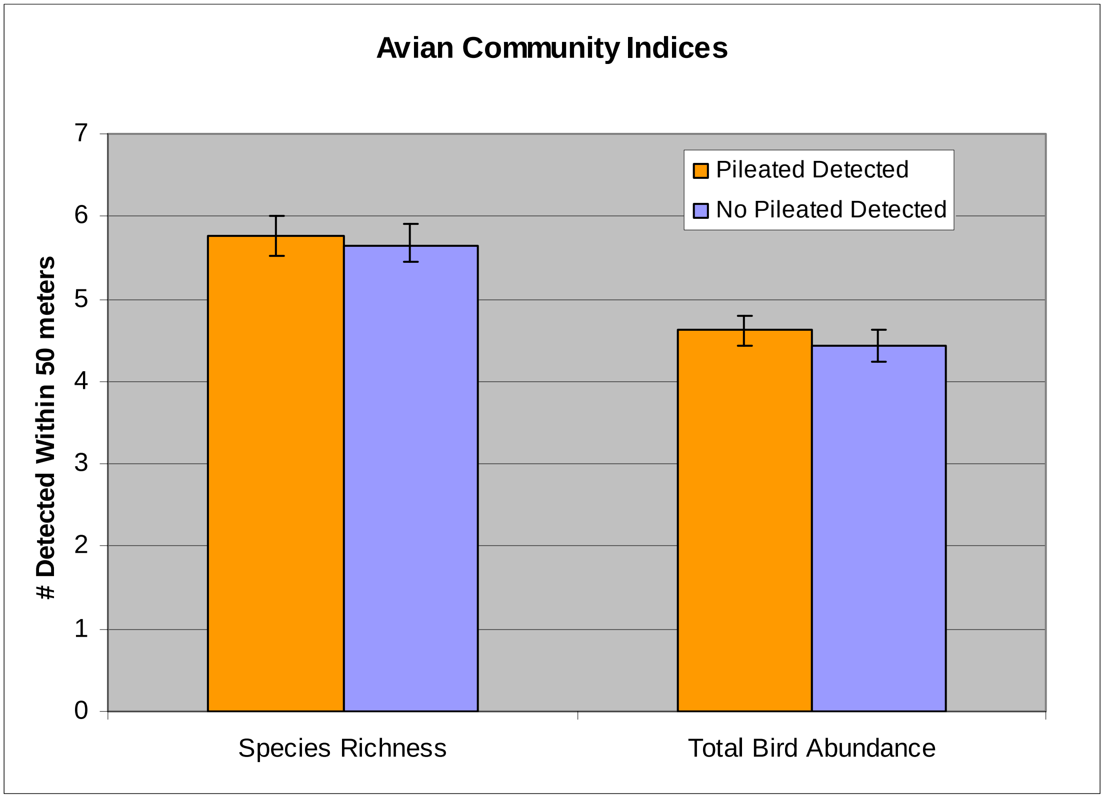
Species richness and total bird abundance for all sites combined in 2007 was 5.70 and 4.46 respectively in 2007 (Table 5). Species richness ranged from a high of 8.50 at Dixie Springs to a low of 3.17 at Moon Springs. Total bird abundance ranged from a high of 8.25 at Dixie Springs to a low of 2.25 at Moon Springs. In comparison, the average from 2003 – 2006 in the Plumas Lassen study was 5.68 for species richness and 4.31 for total bird abundance (Burnett and Nur 2007).

Species richness at sites where Pileated Woodpecker were detected was 5.76 compared to 5.65 at sites were they were not detected (Figure 3). Total bird abundance was 4.61 at detected sites compared to 4.44 at sites they were not detected; neither difference was statistically significant.

Table 5. Avian community indices at Pileated Woodpecker survey sites in 2007 in the Lassen National Forest.

Station	Species Richness	Total Bird Abundance
114	7.83	7.71
Ashpan Butte	4.33	3.00
Bald Mountain	7.33	7.50
Bear	7.00	6.33
Cottonwood Creek	6.50	4.25
Crag	4.17	3.25
Crater Mountain	6.17	5.08
D102	5.67	4.00
D108	7.58	6.33
D111	4.83	3.46
D112	5.75	4.42
Devil's Rock	4.83	3.50
Dixie Springs	8.50	8.25
Dow Flat	5.67	4.08
Freaner Peak	6.33	4.50
Horse Heaven	7.50	5.83
Harvey Valley DFPZ	5.14	3.36
Harvey Valley Reference	4.29	3.14
Ice Cave	5.50	3.58
Louse Creek	5.17	4.25
Lodgepole	4.33	3.83
Logan Mountain	6.17	4.25
Lost Creek	5.67	4.25
Moon Springs	3.17	2.25
Peacock Point	4.83	3.58
Pine Creek	6.67	5.50
Plum Valley	5.33	3.92
Potato Butte	6.17	3.75
Rattle Snake	5.08	3.83
Rocky Point	5.67	5.08
Signal Butte	3.83	2.50
Snag Lake	5.17	3.54
Squaw Valley	5.83	4.50
Swain's Hole	5.67	4.83
Upper Mill Creek Trail	5.92	4.67
Average	**5.70**	**4.46**

Figure 3. Avian community indices at sites where Pileated Woodpecker were detected compared to sites where they were not detected in the Lassen National Forest in 2007.



Habitat Variables at Pileated Woodpecker Sites

We chose seven habitat variables we predicted might be important for Pileated Woodpeckers (Table 6). We then compared these variables at sites were Pileated were detected and at sites were there were no detections. As described in the methods, this included only sites where Pileated Woodpeckers were predicted to occur, so differences might be greater if compared to all forest sites where they did not occur. We tested for significance using a one tailed t-test as our hypothesis was that each of these variables would be greater at Pileated Woodpecker occupied sites. Six of the seven variables were significantly or marginally significantly greater at occupied sites. Only maximum tree diameter (the diameter of the largest tree in the plot) was not significantly different. There were significantly greater basal area, canopy closure, canopy height, snags, and logs at sites were Pileated were detected compared to sites were they were not (Table 6, Figures 4 – 6). Basal area averaged 170.40 sq. ft at occupied sites compared to 117.40 at unoccupied sites, and canopy closure was 49% compared to 37%.

Table 6. Comparison of seven key habitat variables at sites were Pileated Woodpecker were detected and sites where they were not detected (including only sites where they were predicted to occur; not forest-wide), with standard error (SE) and p-value from one-tailed t-tests (Stata Corp 2005).

Habitat Variable	Pileated Detected	SE	No Pileated Detected	SE	P
Snags > 60 cm DBH	2.06	0.31	1.03	0.17	<0.01
Snags >30 cm DBH	8.03	0.96	4.83	0.62	<0.01
Logs	45.88	3.07	37.45	3.33	0.04
Canopy Height (m)	28.66	0.71	25.63	0.82	<0.01
Maximum Tree DBH (cm)	99.78	3.09	91.72	7.04	0.19
Basal Area (sq.ft./acre)	170.40	2.0	117.40	8.0	<0.01
Canopy Closure	0.49	0.02	0.37	0.02	<0.01

The average canopy height was 28.66 meters at occupied sites compared to 25.63 at unoccupied sites. There were 2.06 large snags at occupied sites compared to 1.03 at unoccupied sites. Likewise, there were 8.03 snags over 30 cm (11.81 inches) compared to 4.83 at unoccupied sites. There were 45.88 logs at occupied sites and 37.45 and unoccupied sites.

Figure 4. Mean canopy closure (with standard error) at sites where Pileated Woodpecker were detected compared to sites where they were not in the Lassen National Forest in 2007. Canopy closure was measured at 16 points along four transects within 50 meters of survey point.

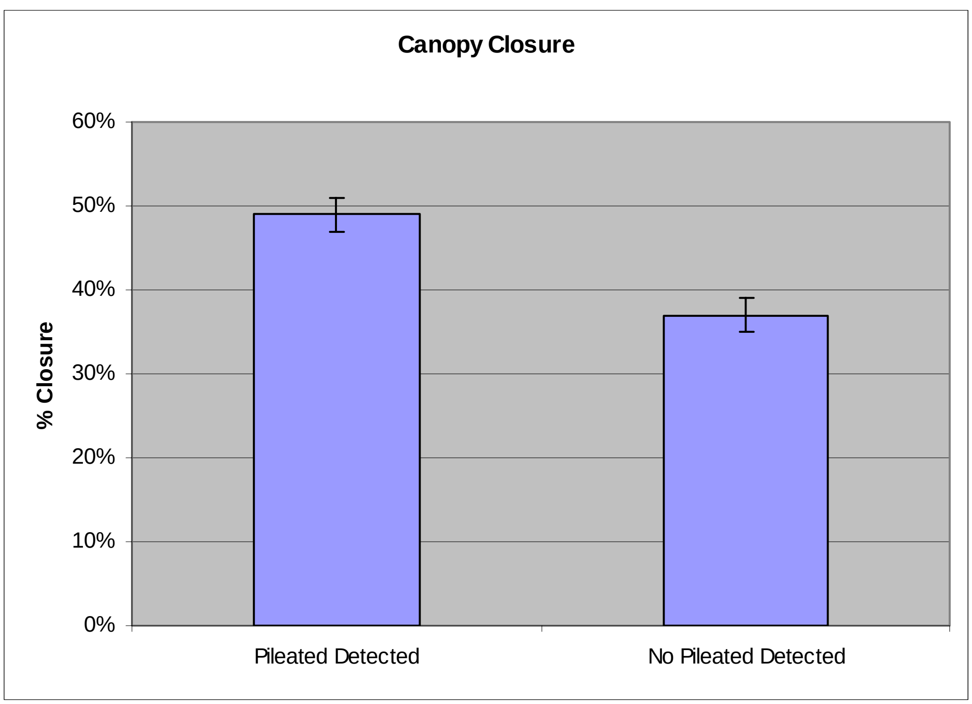


Figure 5. Mean canopy height (with standard error) at sites where Pileated Woodpecker were detected compared to sites where they were not in the Lassen National Forest in 2007. Canopy height is the average height of the tallest trees within a 50 meter radius circle around the survey point.

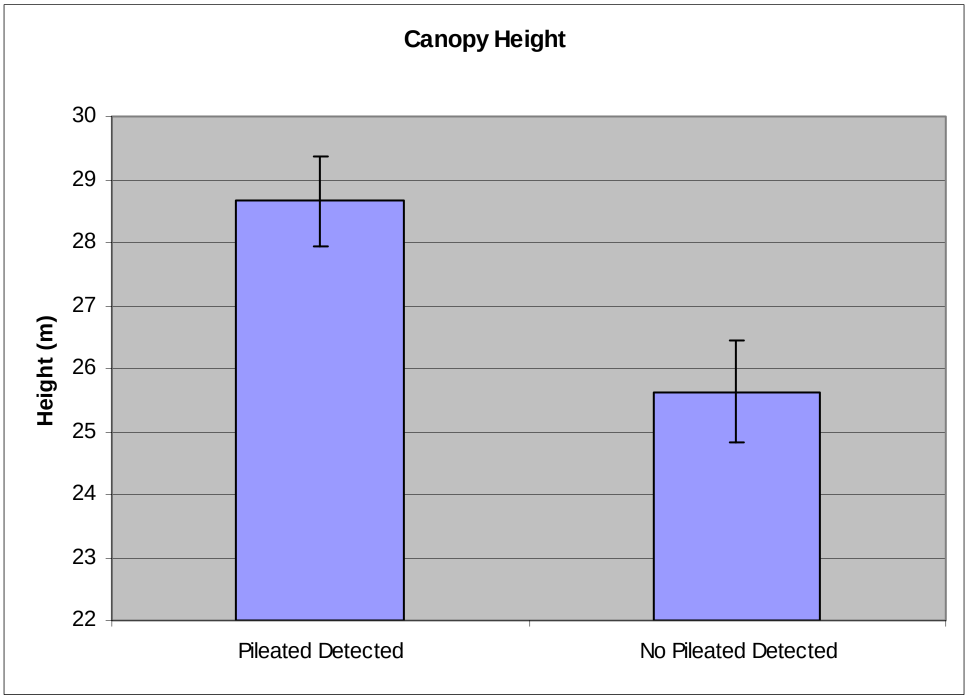
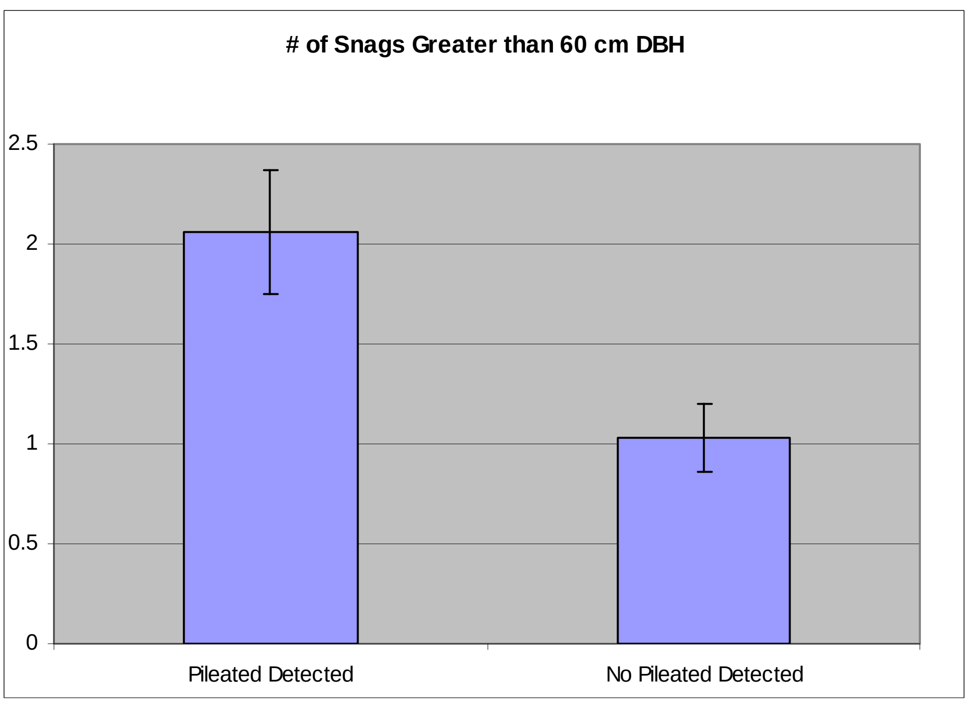


Figure 6. Mean number of snags greater than 60 cm DBH (with standard error) at sites where Pileated Woodpecker were detected compared to sites where they were not in the Lassen National Forest in 2007. Snags were counted within a 50 meter radius circle around the survey point center.



Of these habitat variables the single best predictor of the presence of Pileated Woodpecker, and the only variable to remain in the stepwise logistic regression model, was canopy closure (r^2 =0.08, p<0.001).

Hairy Woodpecker

Hairy Woodpecker were detected by way of point count survey (no callbacks were done for this species) at 28 of the 35 transects. There were a total of 83 Hairy detections, 44 of which were within 100 meters of observers. The mean per point Hairy Woodpecker abundance within 100 meters of observers was 0.17. Using the same seven variables listed above for Pileated Woodpecker (Table 6), canopy closure was the only significant predictor of Hairy Woodpecker abundance; and it was a negative association (r^2= 0.05, p=0.02).

Discussion

Pileated Woodpecker

Survey Approach

Pileated Woodpeckers were detected at far greater percentage of points and transects from the Lassen MIS surveys in 2007 than from the random sampling conducted in the Plumas-Lassen study from 2003 -2006. There were two primary differences between these two sampling schemes. The Lassen MIS surveys employed habitat modeling outputs to help select survey sites, and used call back surveys broadcast following each point count; this resulted in 37% increase in sites with detections over point counts alone. It is important to remember that call back surveys were only conducted after a point count survey failed to detect them, thus the 37% increase is the true increase over conducting point counts alone.

Using the maximum entropy model to predict sites that were likely to support habitat for Pileated Woodpecker appears to have increased the rate of Pileated detections as well. The total detections per point count station were 69% higher from the Lassen MIS than the Plumas-Lassen. However, this result was not consistent across detections at all distances, with detection rates within 50 and 100 meters of observers greater at Plumas-Lassen sites. Additionally, our call back surveys at previous points may have resulted in birds following observers to the next point or increasing their likelihood of vocalizing after being aroused up by previous call backs. However, on other transects we only detected them from a single point. Due to large territory size of Pileated's it is difficult to determine absolute numbers from point count and call back type surveys. We spaced points twice the normal point count spacing of 250 meters to limit multiple detections of the same birds but we have little doubt that we detected the same birds at multiple points within a transect.

Though it is not totally clear the value of using the model to target areas to survey, in order to increase detection rates, errors of omission, and reduce costs, we suggest sampling targeted areas with moderate to high habitat suitability be used along with call back surveys to monitor this species. The most prudent metric for measuring change over time for this species is probably detections at the transect level.

District Level Differences

We hypothesized prior to implementing this monitoring program that the majority of Pileated Woodpecker habitat and detections would be from the ARD, which contains large amounts of mixed conifer and fir forest. The amount of habitat predicted to support Pileated Woodpecker was similar among the districts with the greatest on the ELRD. However, Pileated were detected from a greatest portion of transects in the ARD. This may be due to a true difference, or may be an artifact of the majority of data used to build the model coming from the ARD and our sampling including some of those sites. The results do show that the species occurs across the entire forest and suitable habitat exists in relatively large quantities compared to our predictions. However, when one considers that the species was detected at a little more than half of the areas predicted, the amount of suitable habitat may be considerably less than our model output suggest. Though, these errors of commission may be ameliorated by errors of omission. We have developed a new Pileated Woodpecker model for the Plumas-Lassen study area (see Chapter 4).

Pileated Woodpeckers and the Avian Community

Comparing species richness and total bird abundance, we found no statistical difference between sites where Pileated Woodpecker were or were not detected. However, it is important to note that the sampling area is not the forest as a whole, but areas where the model predicted they would occur. For example, the sample did not include habitat such as meadows or shrub fields. Pileated Woodpecker were found to be significantly more abundant in Spotted Owl Core areas than outside these areas, while species richness and total bird abundance were both significantly lower in Core areas (Burnett and Nur 2007).

Habitat Conditions

Though our model limited the habitat we were sampling to those areas believed to have the conditions suitable for Pileated Woodpecker, we still found significant differences in a number of habitat measures between sites with and without detections. The differences would likely be considerably more marked if we compared sites with detections to the forest as a whole. Regardless, these results still paint a picture of the fairly specialized habitat conditions that this species occupies in the Northern Sierra: areas that contain large number of snags, high canopy closure and height, and relatively high basal area with downed woody debris.

<u>Canopy Closure</u>

The closure of the canopy – as measured by densitometer – was the single best predictor of Pileated Woodpecker presence in the Lassen National Forest. High canopy cover – a different but correlated measurement to canopy closure – has been identified as an important habitat condition for this species. In Oregon, roost trees were located in unlogged forest with greater than 60% canopy cover (Bull et al. 1992). The average canopy closure at sites Pileated Woodpecker were detected in our study was 49%. However, they may require or at least prefer higher canopy closure in nest and roost stands than foraging areas (Mellen et al. 1992), so this result does not necessarily suggest that they are occupying areas with less canopy cover in the Northern Sierras than in Oregon. Habitat preferences appear closely aligned with other late seral species of management concern in the region such as Pine Marten, Spotted Owl, and Northern Goshawk. In fact, Pileated Woodpeckers were significantly more abundant inside of 1000 acre California Spotted Owl Core areas than outside of Core areas (Burnett and Nur 2007).

Snags and Cavities

Large snags, as well as large trees that will be the next generation of large snags, are critical to managing habitat for this species. They are used for foraging, nesting, and roosting. A number of studies from the Pacific Northwest have shown that the majority of nests are in large snags. Based on four studies in Washington and Oregon, the average nest tree DBH was 94 cm and mean tree height was 33 meters (reviewed in Bull and Jackson 1995). The need for a large supply of suitable substrate for cavities is accentuated by the fact that cavities are rarely re-used between years and upwards of eleven roost cavities are used within a year by individual birds (Bull et al. 1992). Rotting snags and live trees, which are most likely to be removed as hazards during timber harvest, appear crucial; one study showed 95% of roost cavities had a hollow interior created by decay rather than excavation (Bull et al. 1992).

Of note, is a report of this species using large aspen for nesting (Grinnell and Miller 1944). We have documented this species in Aspen habitat along Pine Creek in the ELRD and Ruffa Ranch on the ARD. In both circumstances the canopy cover was well below 50%, though there were large conifers and snags and higher canopy cover in the vicinity.

Downed Wood Debris

There were more logs at sites we detected Pileated Woodpecker than sites where we did not, though the difference was only marginally significant. However, the way we defined and counted logs may not be totally appropriate to capture the needs of this species. Logs were sampled in the standardized point count releve method with any downed wood over two meters in length with a DBH over eight cm counted. Thus a ten meter long log with a 60cm DBH would be counted as equal to one that was two meters long and ten centimeter DBH. In future years we will modify our log sampling technique to more adequately quantify differences at a scale more likely to be meaningful to this species as it appears to be an important habitat component. A study in Oregon found that 38% of foraging was on logs and that they selected for logs with a diameter greater than 38cm with extensive decay (Bull and Holthausen 1993, Torgersen and Bull 1995). This species is known to forage extensively on carpenter ants *(Camponotus spp.*), which are prevalent in decaying downed woody material in coniferous forests of the west (Bull and Jackson 1995).

<u>Canopy Height</u>

Another key habitat component found to be significantly greater at sites where Pileated Woodpeckers were detected was canopy height. Though little information exists in the literature on canopy height within territories, at roost and nest sites trees averaged between 27 and 41 meters. Multiple studies also identified old-growth or late seral forest as being important for the species (reviewed in Bull and Jackson 1995).

Prescribed Fire and Pileated Woodpecker

Prescribed fire may have negative short-term impacts on Pileated Woodpecker. Prescribed has been shown to reduce down wood and may directly kill the ants that Pileated Woodpecker forage on (Bull et al. 2005). While prescribed fire is an important tool for land managers its potential negative impacts to Pileated Woodpecker habitat should be considered when determining the most prudent locations for introducing fire. In this same study they found mechanical treatments also significantly reduced snags and down wood but still resulted in significantly more Pileated Woodpecker foraging activity than areas that were mechanically treated and then burned. Fuel treatments in Pileated Woodpecker habitat should concentrate on making stands more resilient to high intensity fire while maintaining large down wood, snags, and relatively high tree density.

Hairy Woodpecker

In contrast to Pileated's, Hairy Woodpeckers were fairly common in the areas we surveyed – and occupied a wide range of sites. They were detected on the majority of sites we surveyed as well as from our other monitoring in the region (Burnett et al. 2006).

They appear to reach their greatest abundance in disturbance-associated habitats, especially burned forest and treated aspen (see Chapter 1). The single best predictor of their abundance in the 2007 MIS monitoring was a negative association with canopy closure. Based on these results, we believe that the majority of fuel treatments, aspen and oak restoration project that maximize snag retention and maintain a large downed woody debris component should provide habitat that supports relatively high densities of this species. Leaving large patches of areas that stand-replaced in fire as open snag fields should also benefit this and many other woodpecker species such as Black-backed Woodpecker, Lewis' Woodpecker, Northern Flicker, and both sapsucker species (Red-breasted and Williamson's).

Management Recommendations for Pileated Woodpecker

For the majority of these recommendations, we suggest they only be prescribed in areas that our model predicts to have high habitat suitability (>40%) for the species our are otherwise considered suitable habitat for this species. However, we recommend the snag retention guidelines be employed in all projects across all habitats.

Basal Area Retention:

- **Monitoring Results:** 10 factor basal area averaged 142 sq. ft. at occupied sites and 104 at unoccupied sites. 20 factor basal area averaged 170 sq. ft at occupied sites and 117 at unoccupied sites. Both statistically significant. Averaging the results from these two factor calculations the average basal area at occupied sites is 156 sq. ft. compared to 111 at unoccupied.

- **Management Recommendation:** Retain basal area of approximately150 sq.ft.

Retention of Snags:

- **Monitoring Result:** There were 2 snags over 60cm dbh (24 inches), and 8 snags over 30cm dbh(12 inches) per 2 acre plot at Pileated Woodpecker occupied sites compared to 1 and 4 respectively in unoccupied sites - these differences were statistically significant.

- **Management Recommendation:** All snags over 18 inches should all be retained. Operations should be adjusted if any large snags are deemed hazards as every effort should be made to ensure there retention. These are the most likely nest and roost trees for this species. Retention of snags 12 – 18 inches may be important as foraging substrate and should be retained. If snags are deemed a hazard they should be felled and left as large woody debris; or, if they are tall snags, topping them to a reasonable height to reduce the hazard (15 – 25 feet tall) and leaving the topped portion as downed woody material is another preferred option.

Downed Woody Debris Retention:

- **Monitoring Result:** The number of logs (over 8 inch diameter and at least 2 meters long) at occupied sites was 46 compared to 37 at unoccupied sites (marginally significant).

- **Management Recommendation:** Retain all large downed logs – Pileated's forage on carpenter ants in downed wood. Retain as much downed wood over 15 inches diameter as is feasible while meeting fuel reduction objectives. Priority should be given to the largest diameter material in a range of decay classes.

Canopy Closure:

- **Monitoring Result:** Canopy closure - based on densitometer measurements - at Pileated Woodpecker occupied sites was 49% compared to 37% at unoccupied sites. This difference was statistically significant.

- **Management Recommendation:** Retain canopy closure at approximately 50%.

Limiting Disturbance:

- **Monitoring Result:** this species is shy and retiring and may be more sensitive than most species to chronic disturbance during the breeding season.

- **Limited Operating Periods:** Consider limiting timber harvest operations near known nesting sites or high concentrations of this species during the peak of the breeding season (April – June).

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Appendix 1. PRBO MIS Habitat Assessment Protocol.

All data is collected within a 50 meter radius circle centered on the point count station.

1st Section General Information:

Station = 4 letter code (e.g. MOON)

Point # = the actual point number of the station.

Habitat 1 = general classifications (MCF, MCP, MCO, Shrub)

Habitat 2 = only record this if there is a distinct habitat edge (i.e. point is bisected by a clear cut/forest edge)

Date = the date you are collecting this data.

Aspect = the direction of the slope given in degrees (the direction a drop water would flow if poured onto the point). Collect magnetic direction.

Slope = the average slope of the plot with 90 degrees being vertical and 0 degrees being flat, from the highest point to the lowest.

Water = true or false is there any water in the plot running or standing.

Snags30>10 = the number of snags greater than 10 cm DBH but less than 30 cm DBH (see above for more details).

Snags >30 -60 = the total number of snags greater than 30 cm and less than 61 cm DBH.

Snags > 60 = the total number of snags greater than 60cm DBH.

Logs = any downed trees or limbs greater than 8cm DBH and greater than 2m long. Must still have shape of log, rotted decomposed stuff that is really falling apart should not be counted.

Cover Layers
These are divided up into 6 layers (Tree, Tree Shrub, Real Shrub, Total Shrub, and Herbaceous)

Tree – this is defined by height category alone. Any plant species whose upper bounds (highest point) is greater than 5 meters tall is included in this category (a 6 m tall Manzanita would be included in this category, however a 4m tall White Fir would not be).

Tree Shrub – this is all tree species that are less than 5 meters tall regardless of height, this means a 25cm tall White Fir counts in this category. Tree species are the conifers, black oak, maple, white alder, canyon oak, etc.

Real Shrub - this is the true shrub species as well as a few shrubby trees that rarely get above 5 meters tall (Dogwood, Mountain Alder, ARPA, CHCA, CECO, CEIN, etc.), record the total cover of these species regardless of height.

Total Shrub - this is the total cover of all vegetation whose maximum height is between 0.5 and 5 meters (the original Relevé way of doing it). It may be just the sum of real shrub and true shrub but overlap and tall real shrubs may lead to differences.

Herbaceous Layer – this is the total cover of all non-woody vegetation, regardless of height.

Note: the maximum cover theoretically is 100% for all of these categories but practically that would be impossible to achieve.

Height Bounds
High - estimate is to the nearest ½ to 1 meter of the average height of the upper bounds of the vegetation layer (tree, tree shrub, real shrub). This is not the tallest outlier it is the average high of the tallest plants in that layer. (E.g. of the tallest trees in the plot what is the average high height).

Low – the average (as defined in the high) of the lowest living branches of the tree and tree shrub and real shrub do not record this for total shrub or herbaceous.

Lower and Upper Species – record the plant species that dominates the lower and upper bounds for all of the categories you collected low and high height data for, if you think there is absolute equal representation of these than good for you! Flip and coin and stop wasting your time and my money and move on to the next measurement.

Max Tree DBH = record the DBH of the largest single trees in the plot and record what species it is.

Species List
Record these as T1 (tree layer), TS (true shrub), RS (real shrub), S1 (total shrub) and H1 (herbaceous)

Record for each of these layers the % each species comprises of the total (this number should add up to 100% regardless of the % total cover). List as many species as can easily be recorded in a timely manner. Chasing down that lone shrub off in the corner of the plot is not worth the effort. However, we are interested in hardwood species so if they are present in small numbers recording them even if they are less than 5% is worth the effort, also recording a single large tree as 5% or less is probably also worth it.

Basal Area
Standing in the center of the plot using the Cruz-All place the end of the chain at your mouth and look through the key and record the number of trees by species that fill the opening (ie no light can be seen on either side of the cruz-all opening. Record this for the 5, 10, and 20 factor slots on the cruz all and record separately in the provided space on the form.

Canopy Closure
Canoy closure is measured every three meters at 16 points along each of four 48meter long transects (each of the cardinal directions). Starting at the 3 meter mark facing north record canopy hits using the densitometer. For each hit record the species. For each direction there will be total of 16 readings and thus 64 total readings for the plot. All hits above 5 meters height are counted.

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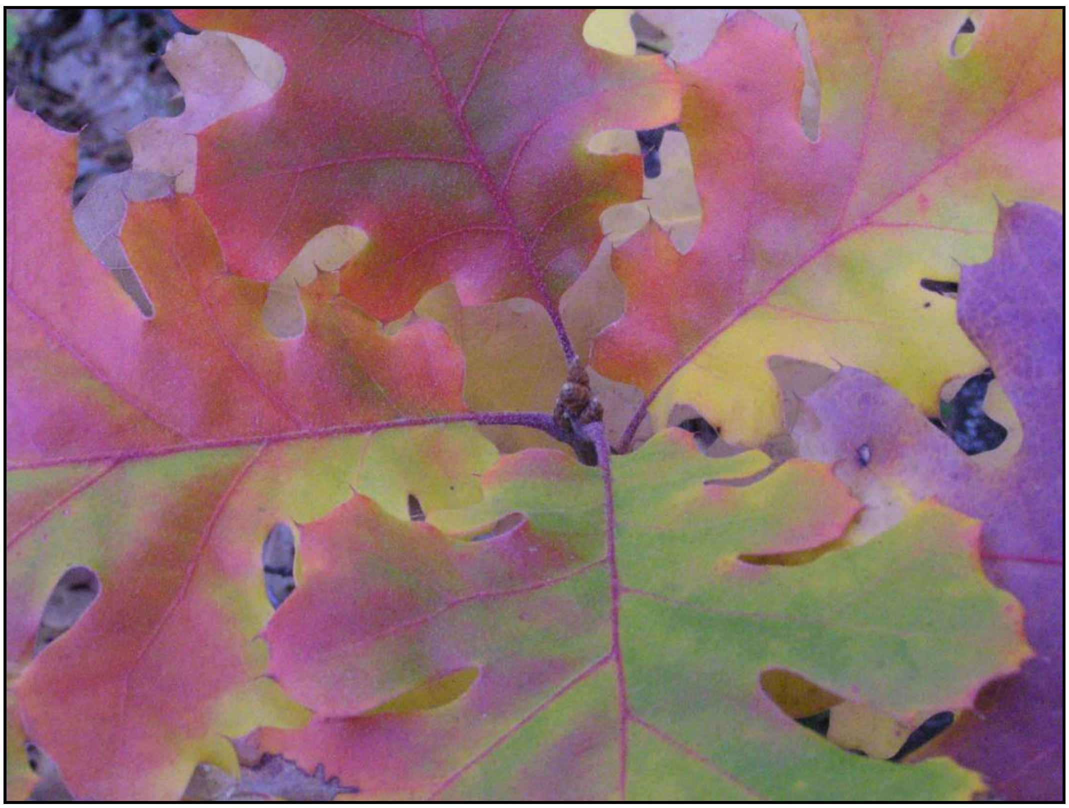
Chapter 3. Resident and Neotropical Migratory Bird Response to Fuel Treatments in Pine-Oak Habitat in the Almanor Ranger District



Ryan D. Burnett and Mark Herzog

PRBO Conservation Science

Background and Introduction

The species composition and structure of forests in western North America have been altered in the last century. The primary forces behind these changes are believed to be fire suppression and timber harvest practices (Minnich et al. 1995, Chang 1996, Stephenson 1999, Taylor 2000). Human-mediated shifts in the competitive balance of these vast and complex forest ecosystems can result in the widespread loss of unique and ecologically valuable habitat attributes upon which wildlife depend (Hejl 1994). In the mixed conifer forests that dominate the Sierra Nevada Mountains of California, these management practices have led to an increase in shade tolerant white fir (*Abies concolor*) and incense cedar (*Calocedrus deccurrens*), and to declines in shade intolerant pines (*Pinus ponderosa* and *Pinus lambertiana*) and hardwoods such as California black oak (*Quercus kelloggii*) (Vankat and Major 1978, Parsons and Benedetti 1979, Minnich et al. 1995).

In the Northern Sierra Nevada, pine-hardwood and mixed conifer hardwood plant communities are the dominant forest types in a confined elevation belt between roughly 3,500 and 5,500 feet on the western slope. The dominant hardwood in this habitat is California black oak with ponderosa pine the dominant conifer, at least historically (MacDonald 1990). Both Black Oak and Ponderosa Pine are shade intolerant species that require disturbances that open up forest canopies to ensure their health and long-term viability on the landscape (McDonald 1990, McDonald and Tappeiner 1996). Black Oak, with its limited maximum growth, is particularly susceptible to encroachment of conifers in a disturbance-limited ecological condition that exists as a result of fire suppression. As a result, without management intervention the health, extent, and eventually the long-term viability of the pine-oak forest in this region are threatened.

PRBO monitoring in the Almanor Ranger District (ARD) from 1997 – 2002 identified mixed conifer hardwood forest as among the most species rich avian habitats in the region. Many Neotropical migrant birds were positively associated with attributes of mixed conifer hardwood habitat (Burnett and Geupel 2001). In 2003, PRBO assisted the ARD in designing a pilot pine-oak enhancement project intended to promote the health and long-term viability of Pine-Hardwood habitat, based on the best available knowledge at the time. Specifically, the project was designed to reduce the overall amount of white fir, where feasible to establish pines as the dominant conifers, and to provide conditions that enhance existing black oak and increase its presence in the treated stands. The objective was to maintain a minimum cover of 30% oak and 30% conifer (averaged across the stand) with a maximum 10% overlap of canopies.

The U.S. Forest Service is emphasizing monitoring as part of an adaptive management ecological-based approach to forest management in the Sierra Nevada (SNFPA 2004). As pine-oak enhancement is a relatively new management practices in the region, monitoring and an adaptive management strategy are critical to providing managers with scientific results to help guide and evaluate such projects.

Avian monitoring is considered an excellent tool for providing feedback on the effects of land management actions (Temple and Wiens 1989, Hutto 1998, Burnett et al. 2005). Numerous avian species of management interest are associated with hardwood habitats in the Sierra Nevada and can provide information on the structure and function of ecological systems. These factors, along with concerns over widespread declines of Neotropical migratory birds (Finch and Stangel 1993), ensure that bird monitoring of forest management is exceedingly relevant.

Project Area

The project area is located west of Philbrook Lake in the vicinity of Fish Creek in the ARD of the Lassen National Forest. The Lassen National Forest is located in the Northern Sierra Nevada mountains of California (Lat 40^0 00'N, Long 120^0 22'W). Study sites range from 1400 – 1650 meters elevation. The total area being treated in this project is approximately 900 acres (Figure 1).

Methods

Sampling Design

Our adaptive management based monitoring plan is designed to investigate the effects of treatment on avian secondary population parameters of abundance, species richness, ecological diversity, and the abundance of individual species. Additionally, by collecting vegetation data at each point we will determine the factors influencing these metrics at pre-treatment sites and link observed changes in bird abundance to changes in habitat conditions following treatment.

Because this study is part of an adaptive management experiment employed on actively managed National Forest lands, our study design had to take into consideration limitations imposed by conducting such an experiment. The treatment implemented in each of the different units is based on pre-existing conditions in the unit and the stands are not of equal size; thus, the nine treatment units are not true replicates of each other. Once we have collected post-treatment data we will determine the most appropriate scale at which to analyze our data, based on plot effects and other potential interactions. We may then be able to reassign individual point counts into different strata based on pre-existing condition to create the most biologically appropriate replicates. For example, since the goal of treatment is to create one desired condition (30% oak, 30% conifer canopy cover), it may be appropriate to assign replicates at the treatment unit level by placing units and reference points into two or three mutually exclusive strata based on pre-existing condition (e.g., low oak high conifer, high oak low conifer, and high oak high conifer). This would give us between three and five replicates – depending on number of subgroups selected – in each pre-existing condition class.

In order to achieve this design, we placed point counts in each of 9 units scheduled for treatment and placed an equal number of points in adjacent reference stands (Table 1, Figure 1, Appendix 1). Points were laid out in a manner as to maximize sample size within treatment units using GIS coverage of the treatment boundaries provided by the Almanor Ranger District. Layout of treatment points was then conducted in an Arc View GIS environment (ESRI 2000). Point count stations were spaced at approximately 225 meter intervals throughout the treatment units and were a minimum of 100 meters from unit boundaries. However, due to changes in unit boundaries made by the Forest Service following the 2004 field season, a few points are now as close at 10 meters from treatment boundaries. For analysis of treatment effects we dropped all points within 25 meters of unit edges.

Reference sites were chosen that met two requirements: they were within 4 km of the nearest treated unit (almost all were within 2 km) and the site contained evidence of black oak (living oaks, oak snags, or oak logs). Since the presence of forest with a black oak component was limited in the surrounding forest and GIS vegetation layers did not adequately delineate mixed conifer forest with or without black oak, it was not possible to randomly select appropriate replicates for our treatment sites using GIS. Since we believed that habitat structure and composition were the primary factors influencing the avian community, we wanted to ensure our reference sites were a proportional representation of the habitat conditions in the treated stand sample. Thus, all reference sites were laid out in the field and were established after all treatment unit points had been established and classified into general habitat condition (Appendix 2). Reference point count stations are all a minimum of 100 meters from treatment boundaries and spaced at approximately 225 meter intervals.

Table 1. Point Count transects, number of stations, and dates surveyed in 2007 in the Brown's Ravine project area of the Almanor Ranger District of the Lassen National Forest.

Site	# of Stations	Dates, 1st Survey	Dates, 2nd Survey
LOKR	32	5/16 , 5/17/2007	6/18, 6/22, 6/25
MOKR	6	5/17, 5/20/2007	6/17, 6/22/2007
OAK1	7	5/16, 5/17/2007	6/18, 6/25/2007
OAK2	14	5/16/2007	6/25/2007
OAK3	10	5/17/2007	6/18/2007
OAK4	10	5/20/2007	6/17/2007
OAK5	7	5/17/2007	6/22/2007
OAK6	4	5/19/2007	6/12/2007
OAK7	8	5/19, 5/20/2007	6/12, 6/21/2007
OAK8	7	5/19/2007	6/21/2007
OAK9	6	5/16/2007	6/18/2007
UOKR	38	5/19, 5/20/2007	6/11, 6/12, 6/20, 6/21/2007

Survey Protocol

Standardized five minute fixed radius-multiple distance point count censuses (Ralph et al. 1993, Buckland et al. 1993) were conducted at 149 stations, 73 in stands that have or will be treated, and 76 in adjacent reference stands. Sites Oak 1, 2, and 3 were treated in the fall of 2005, while Oak4, 5, and 9 were treated in the fall of 2006. Oak 6, 7, and 8 had not been treated as of 2007. Point count 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 also recorded.

All birds detected at each station during the five-minute survey were recorded. Sites were surveyed from sunrise to 3.5 hours later. Each station was surveyed twice during the peak of the breeding season (May 15 – August 1).

Habitat Assessment

Habitat attributes were assessed over a 50 meter radius at all points in 2005 using a modified relevé protocol (Appendix 3). Additionally, vegetation was assessed more intensively at a subset of treatment points by the ARD staff in 2004 and 2005 using an 11.3 meter radius plot (C. Robbins pers. comm.). We will investigate the relationship of relevé measures of habitat characteristics to those collected in the more intensive 11 meter radius plots. Based on the results of this analysis we may use measures from both sampling scales to correlate with bird indices in 2006.

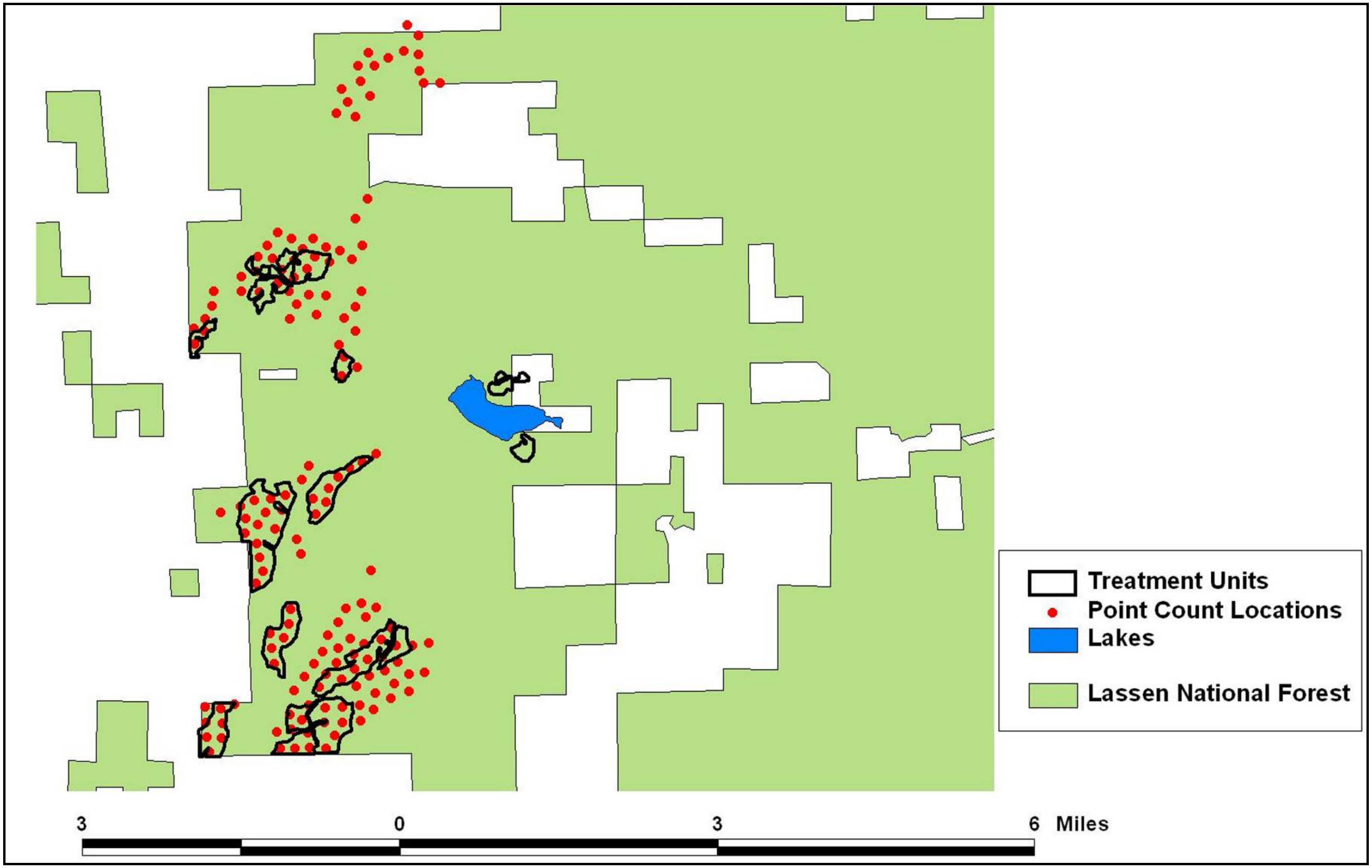
Analyses

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 species that are not adequately sampled using the point count method (e.g., waterfowl, kingfisher, and raptors). We also excluded European Starling, an invasive species that is generally regarded as having a negative influence on the native bird community. For community index analysis we present data based on treatment unit (Figure 1). For reference sites we used the general location of the points within the project area (Upper, Middle, or Lower).

Species richness

Species richness is defined as the total number of species detected within 50 meters of the observer. Richness can be presented as cumulative species richness (total number of species detected within a habitat or along a transect) or as mean species richness (average number of species detected per point within a habitat or transect). Presenting the mean species richness, as we do herein, allows for comparisons between transects or habitats consisting of different numbers of point count stations.

Figure 1. Location of PRBO Pine-Oak point count stations in the Almanor Ranger District and designation of treatment units in 2004.



Total Bird Abundance

We define 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.

Species Abundance

The abundance of individual species is defined as the total number of individuals detected within 50 meters across both visits.

Statistical Analysis

We used generalized linear mixed models with a negative binomial distribution with the "lmer" procedure in R, to analyze the effects of treatments on the relative abundance of focal species and community indices (RDCT 2008). We considered multiple hypotheses and tested them using an information theoretical approach with transect and site included as random effects (Burnham and Anderson 2002). We started with a year hypothesis – testing if the effect of year as a continuous variable was a predictor of each metric. We then created a variable for year since treatment and coded untreated sites as 0, sites treated the previous fall as one, and two for sites treated the year before. Additionally, we tested to see if there was an inherent difference in our control and treated sites by including a categorical variable which could be coded as control, treated 2005, or treated 2006. We also investigated the interaction of year and control impact to discern if any differences were found with these variables over time which would suggest the treatment resulted in difference (Table 2). Thus, we had two hypotheses, one which looked at treated sites before and after treatment and the other which looked to see if there were difference between control and impact over time.

For each species we developed predicted index of abundance using model averaged estimates from the final set of models with Akaike Information Criteria (AIC) scores within five points of the top model. We present AIC scores, ΔAIC, and model weights for each candidate model.

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Table 2. Variable codes and descriptions used in Akaike's Informaiton Criteria model selection for 12 focal species and three community indices assessing the effects of pine-hardwood enhancement fuel reduction project.

Variable Code	Variable Name
Intercept	Represents the null model where no effects were found
CI	Control/Impact (Possible categories = control, treated2005, treated 2006)
Year	Year, continuous from 2004- 2007
Yr.post.treat	Years since treatment 0 = untreated, 1 and 2 years post treatment
CI*Year	Interaction between Control/Impact and year

Results

We examined species richness and total bird abundance across nine treatment units and three groupings of reference points across all years surveyed (Table 3, Figure 2). In 2007 species richness ranged from 5.29 in Unit 4 to 7.57 in Unit 1. Total bird abundance ranged from 3.61 in Unit 4 to 5.64 in Unit 8. Species richness and total bird abundance were higher in 2007 than all other years at seven of the nine treatment stands but only one of the three reference areas. Relative abundance was also higher at seven of the nine treatment stands and all three of the reference areas in 2007.

Table 3. Mean (per point) ecological diversity, mean number of individuals detected (within 50m), and species richness at each sites surveyed in the Brown's Ravine Project area of the Almanor Ranger District, 2004-2007. NS = not surveyed.

Stand	Number of Points	Species Richness				Total Bird Abundance			
		2004	2005	2006	2007	2004	2005	2006	2007
1	7	4.29	4.86	5.86	7.57	3.36	3.5	4.14	5.36
2	14	4.07	4.77	5.71	5.79	2.79	3.35	4.14	4.25
3	10	2.6	4.8	5.50	6.70	1.60	3.10	3.75	4.65
4	10	3.2	5.00	5.86	5.29	2.35	3.39	4.64	3.61
5	7	4.43	5.57	4.57	6.71	3.64	4.43	3.14	4.86
6	4	4.75	4.50	5.33	6.00	3.88	3.08	3.83	3.83
7	8	4.89	3.88	4.38	6.25	3.69	3.06	3.00	4.31
8	7	3.71	3.00	5.14	6.43	2.86	1.93	3.79	5.64
9	6	NS	5.50	4.50	5.67	NS	4.25	3.75	4.83
LOKR	31	3.38	4.75	5.63	5.41	2.44	3.23	3.97	4.83
MOKR	6	3.00	7.00	4.67	6.67	1.83	5.08	4.00	4.67
UOKR	37	4.09	5.00	5.94	6.72	3.21	4.44	4.44	5.26

Investigating the effects of treatment, the model with the most support for each of the13 focal species was one with the intercept only. In other words we were unable to reject the null hypothesis that treatment had no effect on these metrics. However, for most species there was some support for other models (Table 4). Species for which the analysis suggested a positive effect of treatment include Audubon's Warbler, White-headed Woodpecker, Oregon Junco, and the community index of total bird abundance. The species with a possible negative effect of treatment were Cassin's Vireo and Hermit Warbler.

Table 4. List of models in order of their level of support for 12 pine-hardwood focal bird species with Akaike Information Criteria (AIC), the difference in AIC between a given model and the top model (ΔAIC$_{)}$, and model weights. Models with weights closest to 1 have the most support. A list of the variable codes included under model are presented in Table 2.

Species	Model	AIC	ΔAIC	Weight
Band-tailed Pigeon	Intercept only	62.41	0.00	0.48
	year	64.41	1.99	0.18
	yr.post.treat	65.19	2.78	0.12
	CI	65.25	2.84	0.12
	year + yr.post.treat	66.29	3.88	0.07
	CI + year	67.18	4.76	0.04
Hairy Woodpecker	Intercept only	157.57	0.00	0.24
	year	158.66	1.09	0.14
	yr.post.treat	158.69	1.12	0.14
	Control/Impact	159.63	2.06	0.09
	year + yr.post.treat	159.71	2.14	0.08
	CI + year	160.62	3.05	0.05
	CI + yr.post.treat	160.63	3.06	0.05
	CI*year	160.65	3.08	0.05
	year + CI *year	160.65	3.08	0.05
	CI*year + yr.post.treat	161.63	4.06	0.03
	year + CI*year + yr.post.treat	161.63	4.06	0.03
	CI + year + yr.post.treat	161.64	4.08	0.03
White-headed Woodpecker	Intercept only	116.96	0.00	0.43
	yr.post.treat	118.37	1.42	0.21
	year	118.86	1.90	0.17
	year + yr.post.treat	119.87	2.92	0.10
	CI	120.20	3.24	0.09

Table 4 continued.

Species	Model	AIC	∆AIC	Weight
Dusky Flycatcher	Intercept only	493.03	0.00	0.35
	year	493.50	0.47	0.28
	yr.post.treat	495.03	2.00	0.13
	year + yr.post.treat	495.47	2.44	0.10
	CI*year + yr.post.treat	496.30	3.27	0.07
	year + CI*year + yr.post.treat	496.30	3.27	0.07
Warbling Vireo	Intercept only	360.18	0.00	0.25
	year	360.23	0.05	0.24
	yr.post.treat	361.75	1.57	0.11
	year + yr.post.treat	361.75	1.57	0.11
	year + CI*year	363.48	3.30	0.05
	CI*year	363.48	3.30	0.05
	CI	363.88	3.70	0.04
	CI + year	363.93	3.75	0.04
	CI*year + yr.post.treat	364.50	4.32	0.03
	year + CI*year + yr.post.treat	364.50	4.32	0.03
	CI + yr.post.treat	364.56	4.38	0.03
	CI + year + yr.post.treat	364.97	4.79	0.02
Cassin's Vireo	Intercept only	293.00	0.00	0.29
	yr.post.treat	293.33	0.33	0.24
	year	294.74	1.74	0.12
	year + yr.post.treat	295.12	2.12	0.10
	CI	295.46	2.46	0.08
	CI + yr.post.treat	296.75	3.74	0.04
	year + CI*year	296.89	3.89	0.04
	CI*year	296.89	3.89	0.04
	CI + year	297.06	4.06	0.04
Red-breasted Nuthatch	Intercept only	557.42	0.00	0.73
	CI	560.22	2.79	0.18
	yr.post.tr	561.71	4.29	0.09
Nashville Warbler	Intercept only	449.94	0.00	0.63
	year	451.00	1.06	0.37
Hermit Warbler	Intercept only	442.55	0.00	0.51
	yr.post.treat	443.89	1.34	0.26
	year	444.91	2.35	0.16
	year + yr.post.treat	446.39	3.84	0.07

Table 4. continued

Species	Model	AIC	∆AIC	Weight
Audubon’s Warbler	Intercept only	654.18	0.00	0.48
	yr.post.treat	655.56	1.39	0.24
	CI	657.33	3.16	0.10
	CI + yr.post.treat	658.06	3.89	0.07
	CI + year	658.37	4.19	0.06
	year	658.40	4.22	0.06
MacGillivray’s Warbler	Intercept only	310.36	0.00	0.50
	year	311.38	1.02	0.30
	yr.post.treat	313.13	2.77	0.13
	year + yr.post.treat	314.15	3.79	0.08
Western Tanager	Intercept only	316.20	0.00	0.64
	year	317.31	1.11	0.36
Oregon Junco	Intercept only	564.45	0.00	0.28
	yr.post.treat	565.63	1.18	0.16
	year	566.07	1.62	0.12
	CI	566.61	2.16	0.10
	year + yr.post.treat	567.01	2.55	0.08
	CI + yr.post.treat	568.07	3.62	0.05
	year + CI:year	568.08	3.63	0.05
	CI*year	568.08	3.63	0.05
	CI + year	568.11	3.65	0.05
	year + CI*year + yr.post.treat	569.00	4.54	0.03
	CI*year + yr.post.treat	569.00	4.54	0.03
	CI + year + yr.post.treat	569.14	4.69	0.03

The model weight for the White-headed Woodpecker intercept only model was 0.43, followed by years post-treatment at 0.21, year only at 0.17, and a model with both year and years post-treatment at 0.10. The intercept only model for Cassin’s Vireo had a model weight of 0.29, followed closely by the year post-treatment model at 0.24. The next most supported model was the year only with a weight of 0.12. The intercept only model for Hermit Warbler had a model weight of 0.51, followed by years post-treatment at 0.26, and year only at 0.16. The intercept only model for Audubon’s Warbler had a model weight of 0.48, followed by years post-treatment at 0.24, and control/impact at 0.10. As with all of the other species the top model for Oregon Junco was the intercept only with a weight of 0.28, followed by the years post-treatment and year only models with weights of 0.16 and 0.12, respectively.

Table 5. List of models for community indices of species richness, ecological diversity, and total bird abundance with Akaike Information Criteria (AIC), the difference in AIC between a given model and the top model (ΔAIC), and model weights. Models with weights closest to 1 have the most support. A list of the variable codes included under model are presented in Table 2.

Index	Model	AIC	ΔAIC	Weight
Species Richness	Intercept only	498.66	0.00	0.18
	year + yr.post.treat	499.66	1.00	0.11
	year + CI*year	499.95	1.29	0.09
	CI*year	499.95	1.29	0.09
	CI*year + yr.post.tr	500.46	1.80	0.07
	year + CI*year + yr.post.treat	500.46	1.80	0.07
	CI + year	500.54	1.88	0.07
	CI + year + CI*year	500.54	1.88	0.07
	CI + CI*year	500.54	1.88	0.07
	CI + year + CI*year + yr.post.treat	500.58	1.92	0.07
	CI + CI*year + yr.post.treat	500.58	1.92	0.07
	CI + year + yr.post.treat	501.49	2.83	0.04
Ecological Diversity	year	437.84	0.00	0.21
	year + yr.post.treat	438.84	1.00	0.13
	year + CI*year	439.49	1.65	0.09
	CI*year	439.50	1.66	0.09
	CI + year	439.74	1.90	0.08
	year + CI*year + yr.post.treat	440.02	2.18	0.07
	CI*year + yr.post.treat	440.02	2.18	0.07
	CI + year + yr.post.treat	440.70	2.86	0.05
	CI + CI*year + yr.post.treat	440.72	2.89	0.05
	CI + year + CI*year + yr.post.treat	440.73	2.89	0.05
	CI + year + CI*year	440.79	2.96	0.05
	CI + CI*year	440.79	2.96	0.05
Total Bird Abundance	yr.post.treat	619.71	0.00	0.39
	year	620.04	0.33	0.33
	year + yr.post.treat	622.23	2.52	0.11
	CI + year	624.02	4.31	0.05
	CI*year	624.12	4.41	0.04
	year + CI*year	624.12	4.41	0.04
	Intercept only	624.40	4.69	0.04

Community index model results are shown in Table 5. For species richness the intercept only model had the strongest support with a model weight of 0.18, followed by the model with both year and years post-treatment at 0.11. The model with the greatest support for the Shannon Wiener index of diversity was the year only model with a weight of 0.21, followed by the model with both year and years post-treatment at 0.13. The top model for total bird abundance was years post-treatment with a model weight of 0.39, followed by the year only model at 0.33, and the model with both year and years post-treatment at 0.11.

Predicted annual indices of abundance for the five species that showed some evidence of an effect of treatment are shown in Figures 3-7. For each of these species the predicted value at treated sites changed trajectory following implementation of treatment while controls did not.

Figure 2. Predicted annual index of abundance for White-headed Woodpecker from generalized linear mixed effect model. Predictions are model averaged estimates using all models within five AIC points of the top model. Dashed lines represent the 95% confidence interval surrounding the estimate.

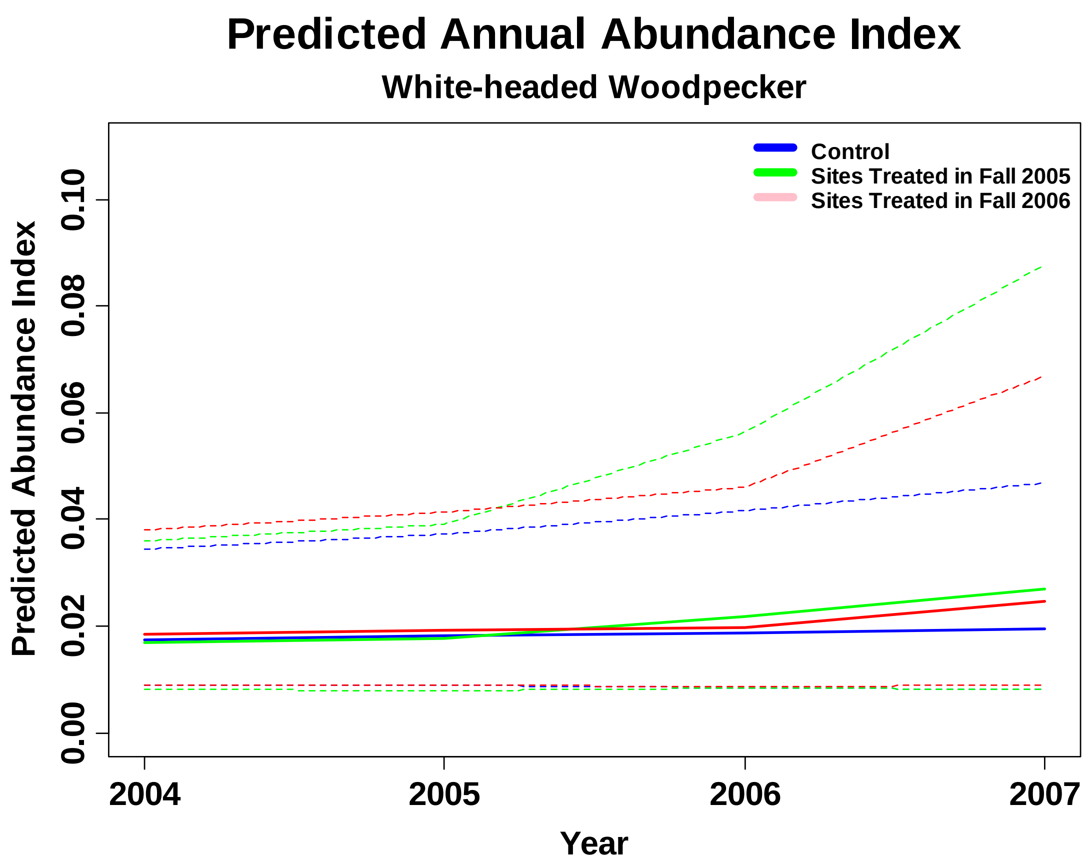


Figure 3. Predicted annual index of abundance for Audubon's Warbler from generalized linear mixed effect model. Predictions are model averaged estimates using all models within five AIC points of the top model. Dashed lines represent the 95% confidence interval surrounding the estimate.

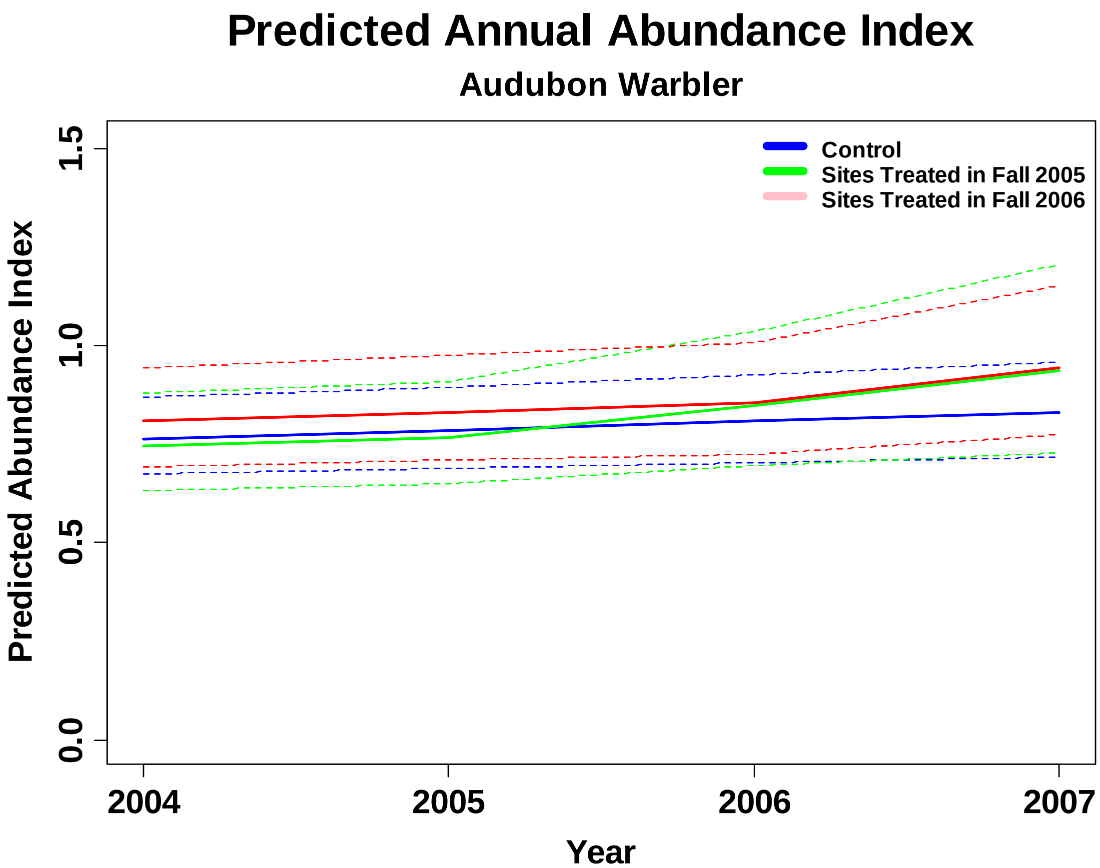


Figure 4. Predicted annual index of abundance for Oregon Junco from generalized linear mixed effect model. Predictions are model averaged estimates using all models within five AIC points of the top model. Dashed lines represent the 95% confidence interval surrounding the estimate.

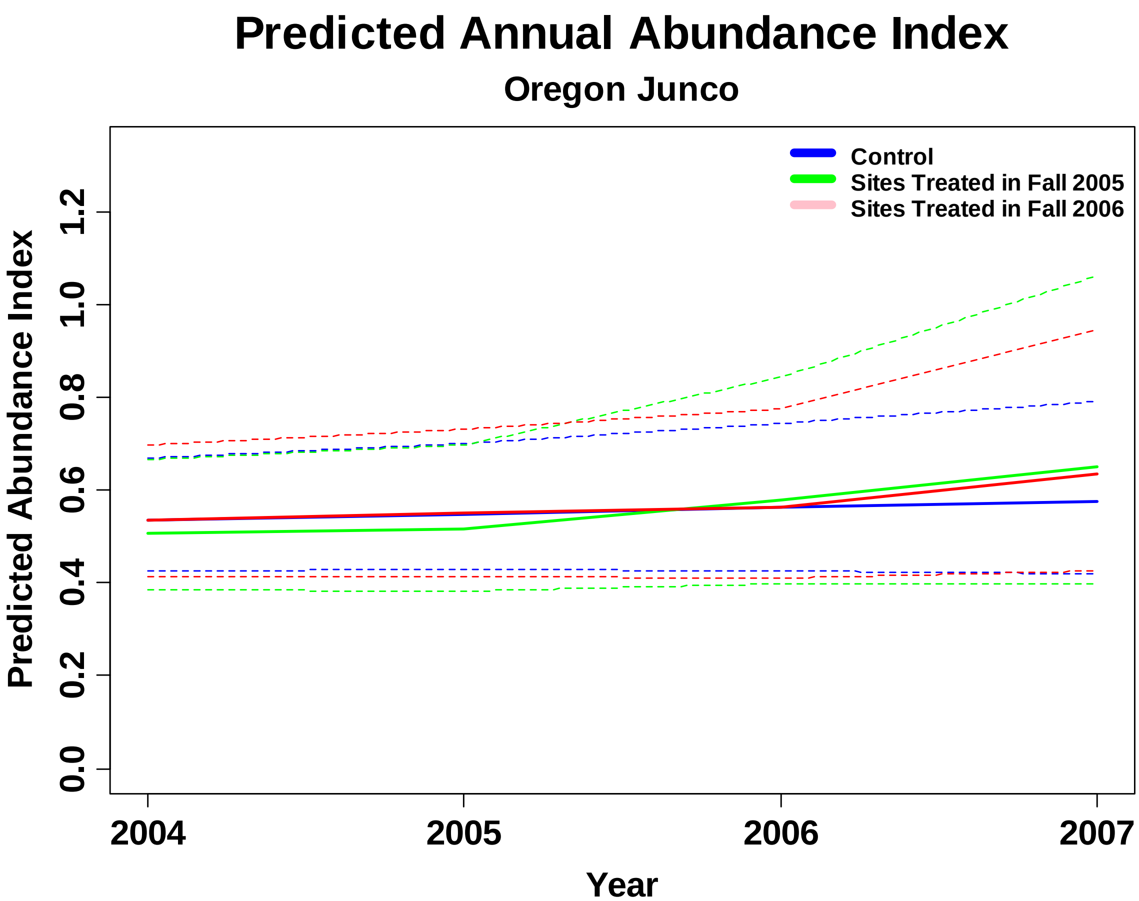


Figure 5. Predicted annual index of abundance for Cassin's Vireo from generalized linear mixed effect model. Predictions are model averaged estimates using all models within five AIC points of the top model. Dashed lines represent the 95% confidence interval surrounding the estimate.

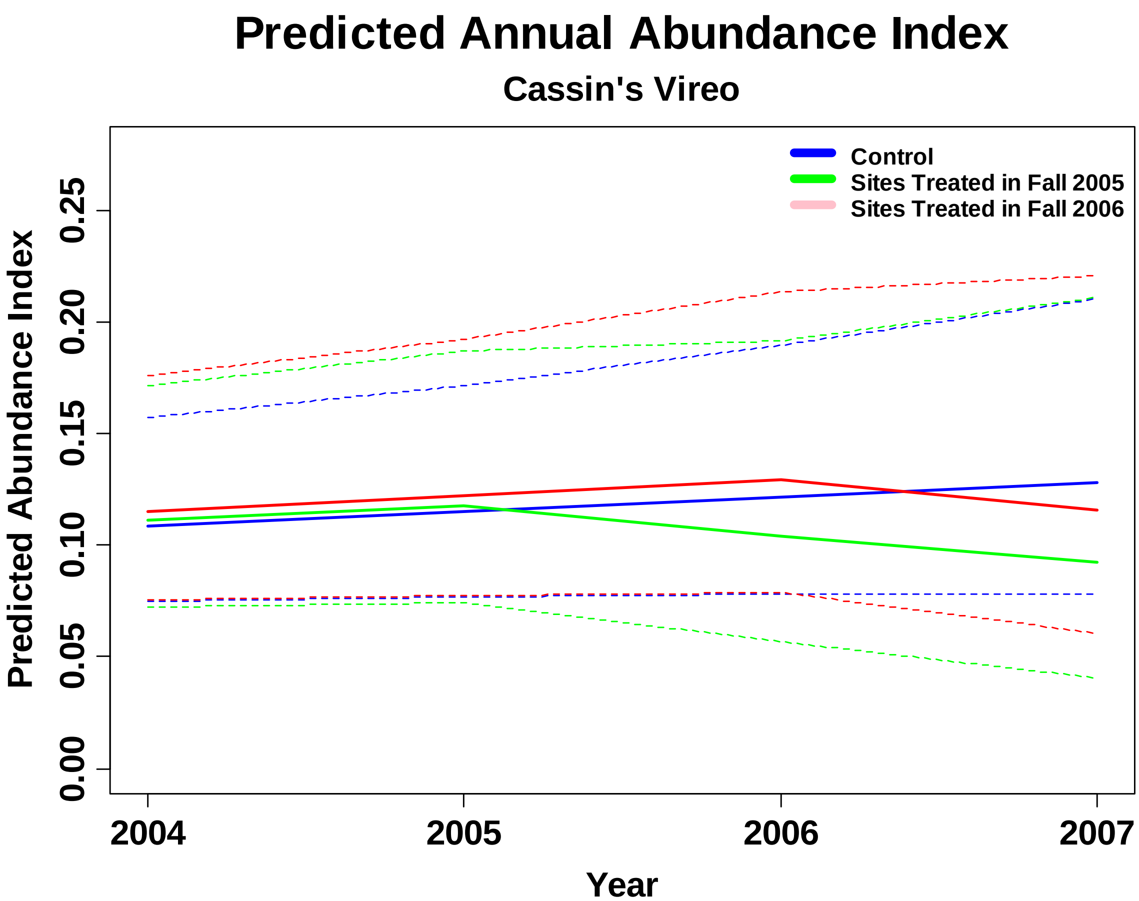


Figure 6. Predicted annual index of abundance for Hermit Warbler from generalized linear mixed effect model. Predictions are model averaged estimates using all models within five AIC points of the top model. Dashed lines represent the 95% confidence interval surrounding the estimate.

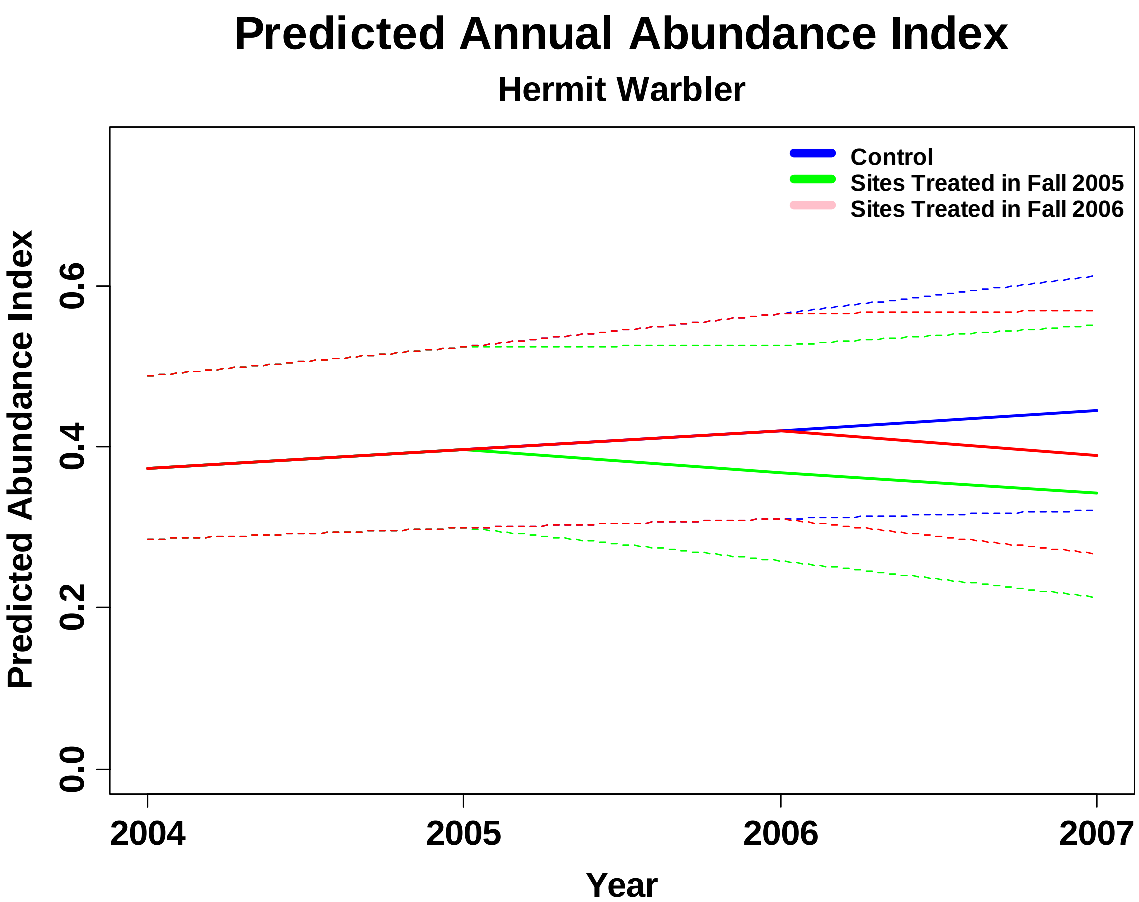
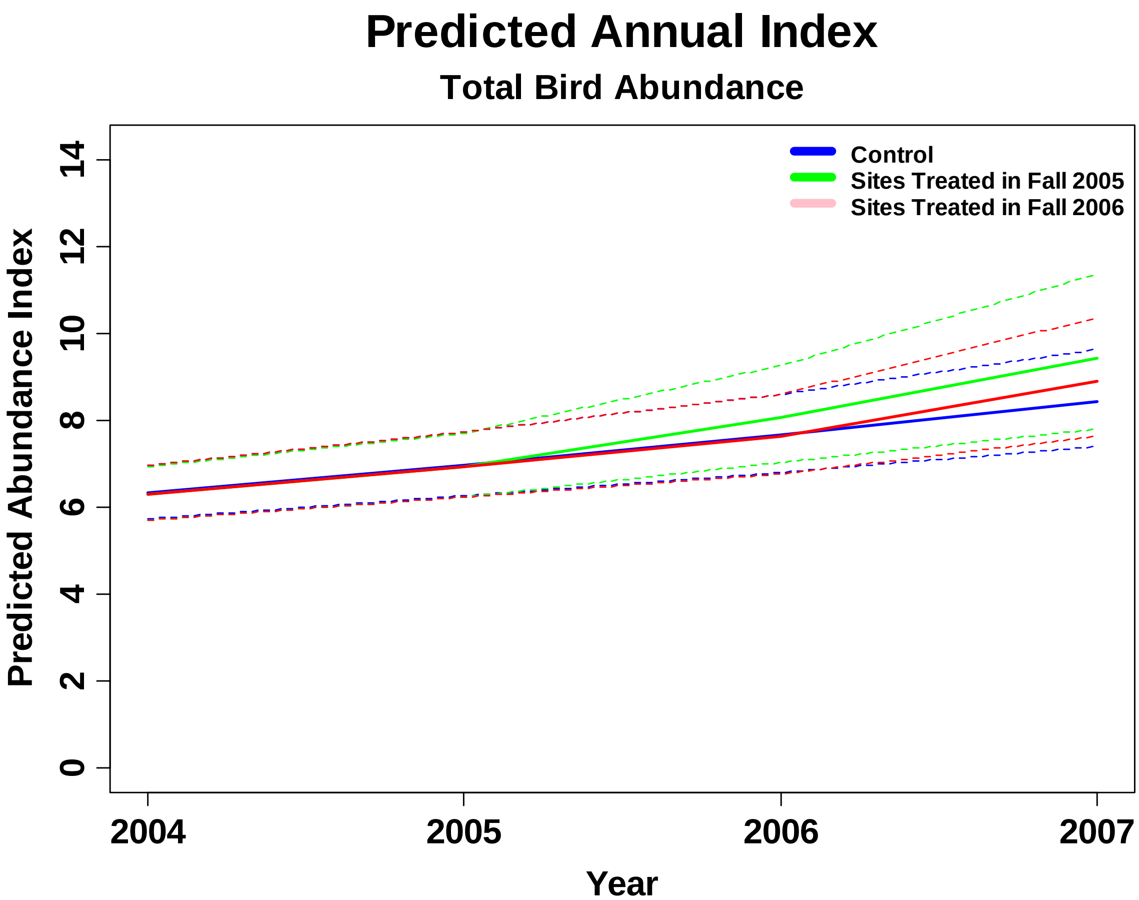


Figure 7. Predicted annual index for total bird abundance from generalized linear mixed effect model. Predictions are model averaged estimates using all models within five AIC points of the top model. Dashed lines represent the 95% confidence interval surrounding the estimate.



Discussion

Overview

Our top model for each species led us to the conclusion that we failed to reject the null hypothesis that there was no discernible effect of treatment. The variability within our dataset was equal to or greater than the variation that could be attributed to any treatments, and may have overwhelmed any true impact of treatment on these sites. A larger sample of treated sites and several more years of post-treatment data in the coming years should increase the ability to detect effects. Though data power was likely an issue in detecting effects, the relatively small differences in species abundance at sites before and after treatment does suggest the treatments have yet to have any major effects on the abundance of the majority of focal species. However, for several species there was fairly good support for the hypothesis that treatment did have an effect (Figures 2 – 7). Several species showed signs of a modest positive response, while several others showed a modest negative response.

Species Response to Treatments

Cassin's Vireo and Hermit Warbler were the two species that showed the most support for a negative effect of treatment. Cassin's Vireo has a strong preference for foraging in black oak in the Sierra Nevada and they most often forage within ten meters of the ground (Airola and Barret 1985). The project removed a number of black oak stems and favored retention of the largest oaks with the fullest crowns. This reduction, coupled with the removal of dense understory white fir, may have reduced the middlestory foliage volume which is not only used by this species for foraging but also nesting (Goguen and Curson 2002, Siegel and DeSante 2003). In our opinion, immediately following treatment the stands were less structural diverse than prior to treatment. In the long term, the reduction of canopy cover, removal of dense pockets of young white fir, and cutting of oaks may result in an increase in under and middle-story oak foliage volume as oaks re-sprout and respond to increased sunlight. Thus, the long-term effects of treatment may have a net benefit to Cassin's Vireo and other species with similar foraging niches such as Western Tanager and Nashville Warbler. The other species that may have been negatively affected by treatments is Hermit Warbler. This species is associated with stands of relatively large trees in mixed conifer forest in the Lassen region. The reduction in canopy cover coupled with a lack of structural diversity may have resulted in short-term negative effect to this species. However, they seem to show a preference for true mixed conifer forest with a diversity of tree species (Burnett and Humple 2003; also see Chapter 4). If treated sites respond with an increase in oak, pine, and increased structural diversity, the long-term effects of treatment may be neutral to beneficial to this species. Future treatments that use more of a mosaic design, instead of the relatively even spacing of these treatments, may reduce any negative short-term effects to Hermit Warbler and increase the long-term benefits.

Audubon's Warbler and Oregon Junco are among the most common breeding birds in the Lassen region (Burnett et al. 2005). There was some support for treatments having a positive effect on both of them. Oregon Junco, though still common, has been experiencing a significant population decline in the Sierra Nevada of 2.4% per year ($p = 0.03$), over the past 40 years (Sauer et al. 2006). They nest on the ground in a wide range of habitat conditions, including relatively dense stands of conifer. However, they also eat seeds and may benefit from increased herbaceous cover of grasses and forbs. In general they seem to prefer open habitats and habitat edges, which is the likely explanation for their positive response immediately following treatments. Audubon's Warbler also occur across a relatively broad range of habitats though they seem to prefer more open conifer conditions. They show a preference for pine dominated conifer forest over the dense white fir encroached stands that existed in the project area prior to treatments. While they are foliage gleaners, like the other warblers, they are also accomplished at fly catching. The more open spaces created through thinning may provide better conditions for aerial foraging.

Structural Diversity

Much of the white fir encroached pine-hardwood habitat in the ARD is lacking both under and middle story foliage volume and overall structural diversity. As canopy closure increases in the absence of natural disturbance, suitable conditions for vigor and reproduction of understory plant assemblages is lost. Shrubs, herbs, and grasses are replaced with seedling and sapling white fir and incense cedar (*Calocedrus decurrens*).

Tree species, especially black oak, drop understory branches, and without fire little oak sprouting occurs. As both structural diversity and foliage volume are key avian habitat features, restoring both should be a management priority for pine-hardwood enhancement.

Species such as Dusky Flycatcher, Nashville Warbler and MacGillivray's Warbler are all strongly associated with shrub habitat (Burnett and Humple 2003, Siegel and DeSante 2003). In the Lassen region shrub nesting species are more abundant in thinned forest that supports greater shrub cover than unthinned forest (Siegel and DeSante 2003). A vigorous understory – including dense patches of shrubs and herbaceous plant species – should be a desired condition in pine-hardwood habitat enhancement projects. Designing treatments that will create a mosaic of varying canopy covers (e.g. 10 – 70%) across stands in combination with prescribed burning and wildland fire use, should promote the establishment and enhance existing understory plant communities.

Snags

Though the effects of treatments were opposite and inconclusive for Hairy and White-headed Woodpeckers, the value of snags to birds and other wildlife is well established (e.g., Laudenslayer et al. 2002). Five of the twenty-one most abundant species in the project area are obligate cavity nesters (Burnett et al. 2006). While the woodpeckers excavate their own cavities, species such as Red-breasted Nuthatch rely to some degree on abandoned woodpecker cavities or natural cavities for nest sites. Furthermore, dead and dying trees are an important food source for many avian species, especially bark gleaners such as woodpeckers and nuthatches. Timber harvest operations can result in unintended loss of snags and dying trees due to logistical issues during harvest operations. A group selection Black Oak enhancement project in the El Dorado National Forest resulted in a significant decrease in snag density following treatment (Garrison et al. 2005). Snag retention and ensuring long-term healthy snag dynamics are important management considerations for pine-hardwood enhancement. Topping hazard trees and some dead and dying trees to a maximum allowable height (to meet safety needs) – even as low as two meters above ground – would maintain or increase this important habitat component.

Band-tailed Pigeon

Band-tailed Pigeon, another species occurring in low numbers in the project area, has been declining in the Sierra Nevada (-3.0%/year, p=0.17), over the past 40 years (Sauer et al. 2006). Our results suggest they have shown a slight increase in treated stands while their numbers have remained stable in untreated stands. As they occur at low densities and are highly nomadic, it is difficult to monitor this species that is so closely tied to black oak in the study area. Little is known about the specific habitat features influencing its abundance and productivity in the Sierra Nevada. One of its primary food sources is acorns; thus, increasing oak health and habitat extent on the landscape, including mast production and reliability, should benefit this declining species.

Conclusions

The results of our analysis of the effects of pine-oak habitat enhancement are inconclusive. Due to large annual variation in bird abundance across the study area and relatively small sample and number of years of post-treatment data for most species, there has been no strong effect of treatments.

Based on the results from this analysis, our previously developed habitat associations, and information gleaned from the literature, we have developed specific recommendations for managing key habitat attributes in pine-hardwood forest in the Lassen region (listed in the beginning of this report following the executive summary). We suggest that the Lassen National Forest continues to design pine-hardwood enhancement projects that incorporate these recommendations within an adaptive management framework. They then can then be tested and refined in order to maximize the ecological benefit of projects to birds and other wildlife.

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Appendix 1. GPS coordinates (UTM Zone 10 NAD 27) for all point count locations surveyed in the Brown's Ravine Pine-Hardwood Enhancement Project in the ARD, 2005.

Station Name	Latitude	Longitude	Station Name	Latitude	Longitude
LOKR00	4427104.89	626315.74	MOKR01	4430559.57	627788.29
LOKR01	4427350.45	627671.53	MOKR02	4430768.63	627884.31
LOKR02	4427566.64	627820.95	MOKR04	4430953.99	628909.56
LOKR03	4427760.19	627968.16	MOKR05	4429652.72	627708.98
LOKR04	4427944.69	628104.98	MOKR06	4429426.03	627774.42
LOKR05	4428187.47	628174.90	MOKR07	4430059.68	626552.66
LOKR06	4428388.57	628339.10	OAK101	4426869.71	626325.54
LOKR07	4428593.41	628454.72	OAK102	4427090.71	628135.31
LOKR08	4428678.79	628692.18	OAK103	4426414.03	626371.27
LOKR09	4429174.91	628841.49	OAK104	4426629.62	626567.25
LOKR10	4428609.05	628919.34	OAK105	4426856.65	626575.43
LOKR11	4428474.07	628755.61	OAK106	4427078.77	626546.03
LOKR12	4426718.16	627406.67	OAK107	4427135.94	626763.25
LOKR13	4428078.12	629718.88	OAK208	4426464.68	627453.45
LOKR14	4428032.04	629471.53	OAK209	4426476.64	627680.74
LOKR15	4427790.85	629247.45	OAK210	4426480.63	627900.04
LOKR16	4427654.03	629046.27	OAK211	4426707.92	627872.14
LOKR17	4427576.40	628808.08	OAK212	4426755.77	627628.90
LOKR18	4427413.92	628609.02	OAK213	4426987.04	627600.99
LOKR19	4426896.08	628672.78	OAK214	4427126.60	627888.09
LOKR20	4427132.55	628669.42	OAK215	4426899.32	627788.39
LOKR21	4427058.77	628876.58	OAK216	4426476.64	628151.26
LOKR22	4427313.82	628895.53	OAK217	4426664.05	628286.84
LOKR23	4427227.42	629134.62	OAK218	4426859.44	628402.48
LOKR24	4427457.57	629194.23	OAK219	4427102.68	628402.47
LOKR25	4427596.22	629412.55	OAK220	4426637.79	626335.32
LOKR26	4427333.03	629410.88	OAK221	4426859.44	628127.33
LOKR27	4427633.64	629654.87	OAK322	4427400.99	628042.85
LOKR28	4427767.40	628312.91	OAK323	4427597.51	628157.37
LOKR29	4427997.12	628339.24	OAK324	4427525.72	628382.31
LOKR30	4428138.30	628516.32	OAK329	4427899.01	628568.95

Station Name	Latitude	Longitude	Station Name	Latitude	Longitude
LOKR31	4428061.73	628729.28	OAK330	4427681.26	628590.50
OAK331	4427824.83	628777.14	OAK768	4433916.95	627337.91
OAK332	4427865.53	629011.07	OAK869	4433752.48	627475.92
OAK333	4428131.13	628992.49	OAK870	4433637.16	627663.08
OAK334	4428293.84	629148.04	OAK871	4433769.50	627869.15
OAK335	4428033.01	629219.81	OAK872	4433898.05	627670.63
OAK437	4429869.26	627110.74	OAK873	4433868.63	628197.99
OAK438	4429737.29	626922.20	UOKR01	4433007.48	627593.71
OAK439	4429803.28	627378.45	UOKR02	4433221.68	627699.54
OAK440	4430155.84	626852.44	UOKR03	4433955.81	627979.38
OAK441	4430244.45	627061.71	UOKR04	4434069.51	627798.15
OAK442	4430274.61	627304.92	UOKR05	4434222.78	627626.97
OAK443	4430327.40	627529.28	UOKR06	4434313.31	627415.23
OAK444	4430095.51	627476.49	UOKR07	4434231.55	627949.64
OAK445	4430065.34	627227.62	UOKR08	4434088.60	628147.42
OAK446	4429965.42	626931.63	UOKR09	4434041.80	628359.00
OAK547	4430032.16	628000.44	UOKR10	4433916.57	628548.30
OAK548	4430273.79	627948.20	UOKR11	4434114.48	628701.57
OAK549	4430210.12	628157.17	UOKR12	4434533.79	628597.95
OAK550	4430425.62	628193.09	UOKR13	4434834.55	628777.88
OAK551	4430592.14	628331.86	UOKR14	4432825.69	628596.86
OAK552	4430747.24	628501.64	UOKR15	4433010.78	628430.81
OAK553	4430818.85	628709.55	UOKR16	4433185.72	628604.22
OAK656	4432859.46	626140.28	UOKR17	4433420.53	628692.53
OAK657	4432998.50	626315.20	UOKR18	4433063.74	628011.14
OAK658	4433206.32	626416.87	UOKR19	4433352.05	628147.90
OAK659	4433427.59	626446.77	UOKR20	4433369.88	627893.04
OAK760	4433415.97	627143.18	UOKR21	4436397.39	628815.70
OAK762	4433548.31	627419.20	UOKR22	4436857.27	628890.04
OAK763	4433417.86	626859.61	UOKR23	4436968.80	629099.00
OAK764	4433650.39	626865.27	UOKR24	4437048.81	628793.99
OAK765	4433727.90	627080.80	UOKR25	4436857.80	628643.00
OAK766	4433952.88	627112.94	UOKR26	4436619.79	628679.00

Station Name	Latitude	Longitude	Station Name	Latitude	Longitude
OAK767	4434123.03	627264.18	UOKR27	4436494.80	628389.00
UOKR28	4436299.80	628485.00			
UOKR29	4436084.80	628593.00			
UOKR30	4436129.80	628312.00			
UOKR31	4436587.80	629634.99			
UOKR32	4436590.80	629884.99			
UOKR33	4436777.80	629566.00			
UOKR34	4437028.80	629555.00			
UOKR35	4437308.79	629555.00			
UOKR36	4437073.81	629331.99			
UOKR37	4437476.80	629389.00			

Appendix 2. PRBO Pine-Oak habitat assessment protocol.

All data is collected within a 50 meter radius circle centered on the point count station.

1st Section General Information:

Station = 3 letter code (e.g. OAK1)

Point # = the actual point number of the station.

Habitat 1 = general classifications (MCF, MCP, MCO, Shrub)

Habitat 2 = only record this if there is a distinct habitat edge (i.e. point is bisected by a clear cut/forest edge)

Date = the date you are collecting this data.

Aspect = the direction of the slope given in degrees (the direction a drop water would flow if poured onto the point). Collect magnetic direction.

Slope = the average slope of the plot with 90 degrees being vertical and 0 degrees being flat, from the highest point to the lowest. (If it drops 10 meters over the 100 meter plot slope is 10 %.)

Water = true or false is there any water in the plot running or standing.

Snags<10 = total number of the snags in the plot less than 10cm DBH (this includes things that still have dead branches on it but it must be appear to be completely dead, leaning snags that are uprooted but not on the ground or almost on the ground count).

Snags30>10 = the number of snags greater than 10 cm DBH but less than 30 cm DBH (see above for more details).

Snags >30 = the total number of snags greater than 30 cm DBH.

Logs = any downed trees or limbs greater than 8cm DBH and greater than 2m long. Must still have shape of log, rotted decomposed stuff that is really falling apart should not be counted.

Cover Layers
These are divided up into 6 layers (Tree, Tree Shrub, Real Shrub, Total Shrub, and Herbaceous)

Tree – this is defined by height category alone. Any plant species whose upper bounds (highest point) is greater than 5 meters tall is included in this category (a 6 m tall Manzanita would be included in this category, however a 4m tall White Fir would not be).

Tree Shrub – this is all tree species that are less than 5 meters tall regardless of height, this means a 25cm tall White Fir counts in this category. Tree species are the conifers, black oak, maple, white alder, canyon oak, etc.

Real Shrub - this is the true shrub species as well as a few shrubby trees that rarely get above 5 meters tall (Dogwood, Mountain Alder, ARPA, CHCA, CECO, CEIN, etc.), record the total cover of these species regardless of height.

Total Shrub - this is the total cover of all vegetation whose maximum height is between 0.5 and 5 meters (the original Relevé way of doing it). It may be just the sum of real shrub and true shrub but overlap and tall real shrubs may lead to differences.

Black Oak – record the cover of all Black Oak regardless of height in the plot.

Herbaceous Layer – this is the total cover of all non-woody vegetation, regardless of height.

Note: the maximum cover theoretically is 100% for all of these categories but practically that would be impossible to achieve.

Height Bounds
High - estimate is to the nearest ½ to 1 meter of the average height of the upper bounds of the vegetation layer (tree, tree shrub, real shrub). This is not the tallest outlier it is the average high of the tallest plants in that layer. (E.g. of the tallest trees in the plot what is the average high height).

Low – the average (as defined in the high) of the lowest living branches of the tree and tree shrub and real shrub do not record this for total shrub or herbaceous.

Lower and Upper Species – record the plant species that dominates the lower and upper bounds for all of the categories you collected low and high height data for, if you think there is absolute equal representation of these than good for you! Flip and coin and stop wasting your time and my money and move on to the next measurement.

DBH = estimate the minimum and maximum DBH of any tree within 50 meters, and record what species it is. Do not record this for the shrub layers.

Species List
Record these as T1 (tree layer), TS (true shrub), RS (real shrub), S1 (total shrub) and H1 (herbaceous)

Record for each of these layers the % each species comprises of the total (this number should add up to 100% regardless of the % total cover). List as many species as can easily be recorded in a timely manner. Chasing down that lone shrub off in the corner of the plot is not worth the effort. However, we are interested in hardwood species so if they are present in small numbers recording them even if they are less than 5% is worth the effort, also recording a single large tree as 5% or less is probably also worth it.

DBH Classes
Place each tree in the plot with a DBH (i.e. greater than 1.5 meters tall) into the four DBH classes on the bottom of the page. Note that the DBH tape may be in inches so you need to divide by 2.54. If there are more several hundred trees by all means make a good estimate do not go around taping every tree.

Oak Density Transects
Using permanently (orange rebar) marked transects lay 50 meter tape out from center of point to one end point (transects are east and south unless an un-crossable barrier is met then chose the bearing 180 degrees from the un-crossable). Record all black oak stems that are within 3 feet of the tape (either side). For each hit place it within one of 4 categories as listed on the bottom of the sheet (0-3', 3'-6', 6-12" DBH, and >1' DBH). Subtotal all of these at the 100 ft mark (30.5 meters) and then a grand total for the entire 50 meters. Conduct this for both 50 meter transects.

Canopy Cover
Using same transect as the Oak density above record the hit/no hit along the transect every 10 feet (~3 meters) using the densitometer. For each hit record the species and subtotal these at 100 feet (30.5 meters) and then a grand total for all 50 meters. Repeat for the second transect. Note: It is vital that time is spent to lay out the tape accurately and taught so that transects are as repeatable as possible.

Chapter 4. Landscape-scale Predictive Models for Northern Sierra Landbirds

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Introduction

Forest Service mangers are tasked with making important decisions, often with limited scientific information. These decisions are often complex and involve consideration of multiple potentially competing objectives at various spatial scales. In order to be successful, managers need decision support tools in the form of scientifically-based, appropriately scaled syntheses of available information.

There are currently several such tools available to National Forest land managers in the Sierra Nevada, including the California Department of Fish & Game's (DFG) Wildlife Habitat Relationship (WHR) system (http://www.dfg.ca.gov/whdab/html/cwhr.html). The WHR allows the user to select general habitat types including some characteristics of those habitats (e.g., small trees) within various predefined areas (e.g., USDA Ecoregions) with an output of predicted species occurrence lists. With appropriate GIS-based habitat layers, WHR predictions can also be made spatially explicit, and can provide reasonably accurate predictions for conservation planning at the ecoregional scale (Edwards et al. 1996). For North American birds, the U. S. Geological Survey (USGS) has developed an online tool (http://umesc-ims01.er.usgs.gov/website/new_bird/viewer.htm) that summarizes both land cover and bird survey data at a variety of spatial scales. California Partners in Flight (CalPIF) also has a tool available online that provides site-specific bird lists (http://cain.nbii.gov/prbo/calpifmap/livemaps/). While these are all good systems, they do not provide the kind of detailed information at the appropriate spatial scales for project, ranger district, or even Forest level decision making. WHR is based on expert opinion compiled across species' ranges; the USGS system is based on Breeding Bird Survey (BBS) routes, of which there are only twenty nine across the entire Sierra Nevada; and the CalPIF system is only site-specific for where monitoring has occurred and is not extrapolated out to a regional scale.

When adequate survey data are available, spatial models of species habitat associations and spatial predictions of species occurrence ("species distribution models" or "habitat occupancy models") can serve as useful decision support tools for managers to identify and rank potential habitat areas in order to guide management decisions. While GIS-based, empirical species distribution models have been developed at broad spatial scales for over a decade (Lindenmayer et al. 1991, Pereira and Itami 1991, Aspinall and Veitch 1993), the recent availability of high-resolution aerial photography and satellite imagery, and resulting detailed vegetation classification maps, have improved our ability to develop fine-scale models of species occurrence for local and regional conservation purposes (Ozesmi and Mitsch 1997, Loyn et al. 2001, Gibson et al. 2004). At the landscape scale, species distribution models are generally based on habitat variables such as vegetation cover type/structure, and local topographic and climatic variations, rather than general land cover classes and broad-scale climate. Thus they can provide significant improvements in predictive power over a simple habitat suitability index (HSI) or wildlife habitat relationship (WHR) model.

The objective of this analysis was to provide the necessary tools to help managers make informed decisions using landbirds as indicators for ecologically based management. In order to do so we developed spatially explicit landscape based predictive models for nine bird species across the Plumas-Lassen study area using our existing avian survey data and existing vegetation and climatic landscape based datasets.

Methods

Study Area

The Plumas-Lassen study area is located in the extreme Northern Sierra Nevada and Southern Cascade Mountains in Plumas, Butte, and Tehama counties of California (Figure 1). We used the area encompassed by the 2002 GIS based vegetation maps developed as part of the Plumas-Lassen Administrative Study (PLAS) to define our study area boundary. The study area encompasses approximately 1,100,000 acres ranging in elevation from 600 to 2500 meters and encompassing a broad range of habitat types, size and canopy cover classes.

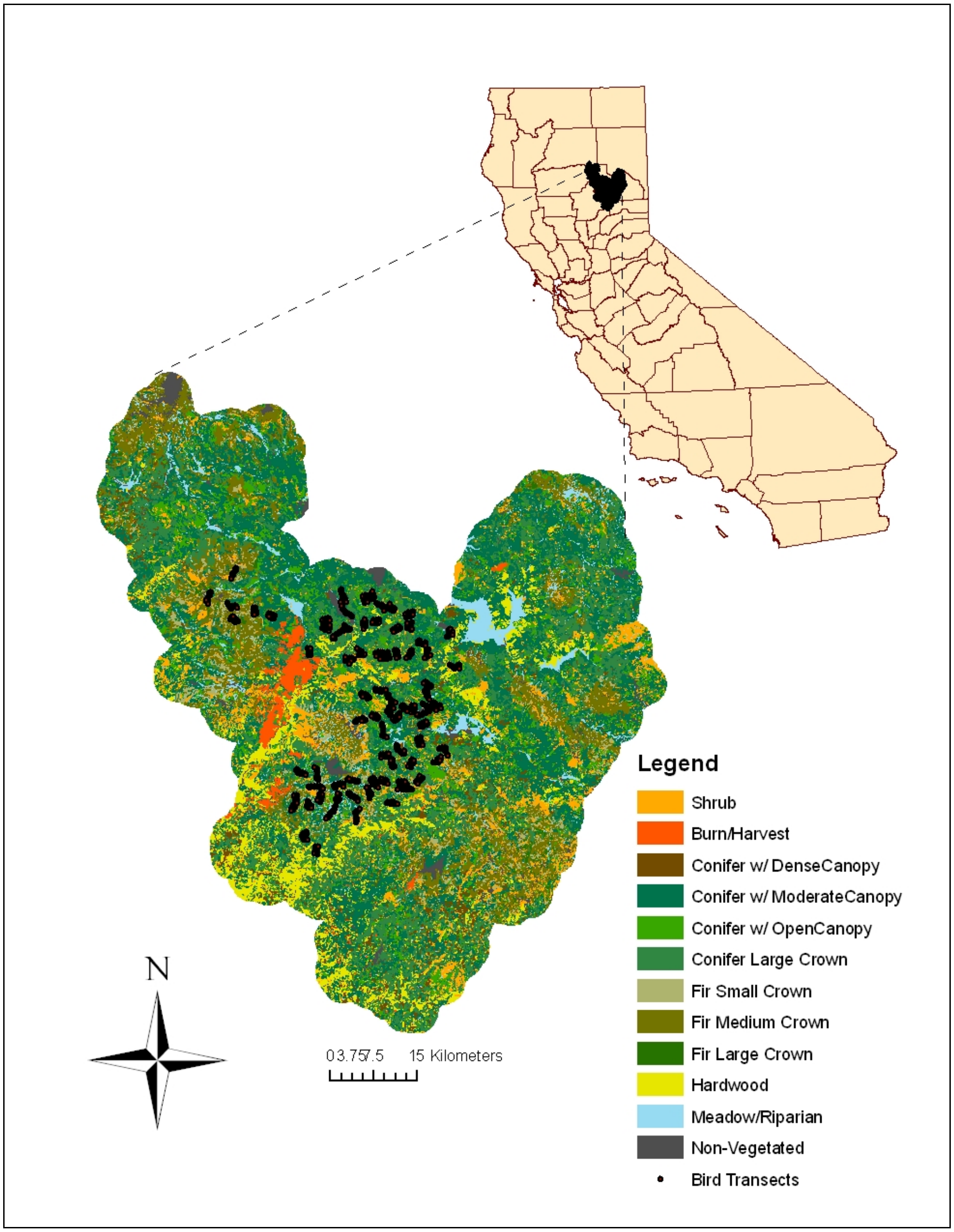
Point Count Methods

We used variable radius point counts to sample landbirds (Buckland et al. 1993, Ralph et al. 1993, Thomas et al. 2003). Point counts at each point within a transect were conducted for 5 minutes, with each individual bird recorded. Each transect was visited twice in each year it was surveyed. Surveys were conducted by observers well versed in the identification of species encountered. Counts were conducted starting just after local sunrise up to four hours and were not conducted in inclement weather (e.g. wind over 10mph, rain, dense fog). We used all detections from all distances from observers to input into the models. We included point count data from all untreated sites in our study area from 2003-2006, which included between six to eight visits at each of over 1000 points across all years. Treated sites were not included in these models.

Site Selection

Point count transect selection was carried out from 2002-2004, using slightly different techniques employed 2003 and 2004 than in 2002. In 2002, a set of randomly selected transect starting points were generated in ArcView GIS (ESRI 2000) for each of the proposed eleven treatment units (roughly 50,000 in size) on the basis of accessibility from roads and stratification by forest stand characteristics (average crown closure and tree size). There were 3 tree size categories based on crown diameter (<12’, 12-24’, and >24’ or two-storied) and 2 tree crown closure categories (30-50% and 60-80%), resulting in 6 combinations by which to stratify sampling. These classes were derived from the complete Forest Service classifications. Starting points placed in these categories were also constrained to be at least 100 m, but not more than 250 m, from a road; and at least 50 m from a planned or proposed Defensible Fire Protection Zones (DFPZs). In ArcView GIS (ESRI 2000), points were placed randomly within polygons that met these requirements, on the basis of information in data layers provided by the US Forest Service. Ten potential starting points were generated for each of the 6 strata, resulting in 60 points per treatment unit, even though only one starting point per stratum was needed.

Figure 1. Location of the Plumas-Lassen study area within California, major vegetation types within study area, and avian sampling transects.



Using GIS layers representing ownership, slope, and habitat we attempted to fit U-shaped transects using a random heading determined by spinning a compass. If a transect could not be established after four compass spins – due to topography (slopes >30%), bodies of water, or other constraints (e.g. private property) – the next point in the list was attempted, and so on until a satisfactory location was found for that particular stratum. The transect was then established by placing 6 points along the random compass bearing at 250 m intervals, turning 90 degrees from original bearing 500 meters to point 7, then returning 180 degrees from original bearing back towards starting point until 12 points were established.

Analysis from GIS layers and field classification of all points established in 2002 revealed that points were distributed across the six different structural strata proportionate to their frequency across the entire study area (Burnett et al. 2003). We believe this was due to the amount of area a transect covers combined with the extreme heterogeneity (in size and canopy closure) across the study area. Since only the first point was stratified; the remaining eleven points were laid out in a U-shape across the landscape and thus allowed to fall into any structural category.

In 2003 and 2004, following changes to the study plan mandated by changes in direction from the Plumas and Lassen National Forests, it was necessary to reassess our original study design. Thus, we modified our design to place three transects in each individual CalWater Planning Watershed (CalWater 1999) within the previously defined treatment units 2, 3, 4, and 5. Based on our finding that stratifying points by habitat structure resulted in a distribution of points no different than would have been expected by non-stratified random points, and the logistical difficulties in placing transects in 2002 using this method, we decided not to stratify random starting points in 2003 or 2004 by structural class. Other than not stratifying points by cover and size class, in 2003 and 2004 our site selection methodology was very similar.

Species Selection

We developed spatial models for nine avian species (Table 1). We included all species proposed as Management Indicator Species (MIS) by the Forest Service (MIS DEIS 2007), as well as those currently identified as focal species in the Lassen National Forest (the Plumas National Forest does not specifically list any landbird species). Additionally, we included several focal species identified by the California Partner's in Flight Coniferous Forest Bird Conservation Plan (CalPIF 2002). We also chose Hermit Warbler as it was the most abundant songbird detected in our study area, though it is not on either the MIS or focal species lists. Together we believe these species represent the range of habitat requirements utilized by birds in the study areas.

Table 1. Species selected for modeling in the Plumas-Lassen study area, status as a current or proposed Management Indicator Species (MIS DEIS 2007), and status on the California Partner's in Flight Coniferous Forest Bird Conservation Plan focal species list (CalPIF 2002).

Species	MIS	CalPIF Focal Species
Hairy Woodpecker	X	
Pileated Woodpecker	X	X
Olive-sided flycatcher	X	X
Dusky Flycatcher		
Brown Creeper	X	X
Nashville Warbler	X	
Hermit Warbler		
MacGillivray's Warbler		X
Fox Sparrow	X	X

Modeling Approach

We employed a powerful machine learning algorithm called Maxent (Phillips et al. 2006) to predict species distributions based on species occurrence locations and GIS-based environmental data layers in the PLAS. 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. The method accommodates several different types of non-linear relationships and is similar to generalized additive models (Hastie and Tibshirani 1990) in its outputs and interpretation. Because point count surveys produce absence as well as presence data, we used this information in our models. We used environmental data from just our survey locations, rather than the entire study area, as "background" for the models. Spatial predictions (maps) of species occurrence were generated for each management indicator species.

Model predictions were cross-validated using a subset of the data points (25%) selected at random by the Maxent program. Model performance was assessed using the area under the curve (AUC) of receiver operating characteristic (ROC) plots (Fielding and Bell 1997), a threshold-independent measure of model accuracy (i.e., a measure of model accuracy that does not depend on a particular probability cut-off to distinguish between presence and absence). 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. The larger the area under the curve (AUC), the higher the rate of correct classification for both presence and absence values, across a range of cut-off probabilities (because predictions are expressed as probabilities of occurrence, rather than strict presence or absence). The value of the AUC is always between 0.5 and 1.0. A value of 0.5 indicates a chance model performance while a value of 1.0 indicates perfect performance. A value of 0.8 means that 80% of the time a random selection from the presence group will have a higher probability of occurrence than a random selection from the absence group. 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).

We also evaluated the importance of each variable in the final model, as well as by itself, by assessing the difference in model performance (training gain) as measured by the Maxent program. For final model variables, we evaluated partial response curves produced by Maxent to interpret relationships between the occurrence of each species and each environmental variable. Because these curves were based on models containing other, potentially correlated, variables, they may differ from univariate relationships, and may not accurately reflect the functional response of a species to a particular environmental variable. Furthermore, these relationships should only be considered relevant for the area surveyed.

We reclassified habitat types in the Vestra vegetation map by combining similar habitats in order to limit the total possible variables (Table 2). For each species we selected a suite of variables that we believed might be important in explaining its distribution at the landscape scale (Appendix B). Additionally, we selected eight climatic variables that were included in each species' model (Table 3).

Table 2. Habitat types, size classes, and canopy density classes used in Maxent landscape models with CWHR classes and codes included in each type or classification.

Vegetation Type	CWHR Classes	CWHR Codes
Shrub	Brush, Plantation, Burned-Harvested	CX, FBX, FXC
Riparian or Meadow	Meadow, Riparian, Aspen, Pasture	GM, HA, RIP, GP
Hardwoods	Black Oak, Live Oak, Tanoak	HB, HL, HT
Ponderosa Pine Forest	Ponderosa Pine	PP
Mixed Conifer Forest	Douglas Fir & Ponderosa Pine Mixed Conifer and Mixed Conifer	DMC, PMC, MC
White Fir Forest	White Fir Mixed Conifer & True Fir	WMC, TF
Red Fir Forest	Red Fir	RF
Unvegetated	Water, Urban, Rock, Bare	NW, NU, NR, NB
Tree Size Classes		**CWHR Size Class**
Saplings	Saplings	Size 2
Poles	Less than 12 ft. crown diameter	Size 3
Small Trees	12 – 24 ft. crown diameter	Size 4
Medium/Large Trees	>24 ft. crown diameter	Size 5 & 6
Canopy Densities Classes		**CWHR Density Classes**
Open Canopy	Sparse and Open	S & P
Mostly Closed Canopy	Moderate	M
Closed Canopy	Dense	D

Table 3. Variable codes and descriptions for variables used in maximum entropy modeling of nine landbird species in the Plumas-Lassen study area. Metrics were calculated using moving window averages within the given radius. Temperature is expressed in degrees Celsius multiplied by 10 and precipitation is expressed in centimeters.

Variable codes	Description
an_mn_temp	Annual mean temperature
an_precip	Annual precipitation
precip_dry_qtr	Total precipitation in the driest quarter of the year
mn_diurn_range	Mean diurnal temperature range (Mean of (monthly maximum temperature - minimum temperature))
isotherm	Isothermality ((Mean diurnal range/Annual temperature range)*100)
temp_seasonality	Temperature seasonality (Standard deviation of mean temperature)*100
mx_temp_wm_mnth	Maximum temperature of the warmest month
mn_tmp_wm_qtr	Mean temperature of the warmest quarter

Results

Model validation statistics (ROC AUC) indicated fair to excellent model performance for the nine species investigated, with scores ranging from 0.70 to 0.93 (Table 4). Graphs depicting the nature of the relationship between each species and the chosen environmental variable, as well as graphs showing the relative importance of the most influential variables for each species, are presented (Figures 2 - 10). The species with the best performing models were Hermit Warbler at 0.93, Nashville Warbler at 0.90, and Dusky Flycatcher at 0.87. The species with the poorest performing models were Hairy Woodpecker at 0.70 followed by Brown Creeper at 0.74. Maps of predicted species distributions for the PLAS study area are presented in Appendix A.

Table 4. Area under the curve (AUC) receiver operating characteristics (ROC) and qualitative model performance for each of nine species in the Plumas-Lassen Study area from Maxent landscape based habitat modeling.

Species	ROC AUC	Model Performance
Hairy Woodpecker	0.70	Fair
Pileated Woodpecker	0.80	Good
Olive-sided Flycatcher	0.82	Good
Dusky Flycatcher	0.87	Good
Brown Creeper	0.74	Fair
Nashville Warbler	0.90	Excellent
Hermit Warbler	0.93	Excellent
MacGillivray's Warbler	0.78	Fair
Fox Sparrow	0.85	Good

Hairy Woodpecker

Model performance was fair for Hairy Woodpecker with an AUC of 0.70 (Table 4). The percent of white fir-dominated forest contributed most to the model. The response to this variable was curvilinear, peaking at approximately 25%. There was a negative relationship with the amount of size class four forest, and a mostly positive, though complex, response to the percent of open canopy forest (Figure 2). Vegetation at the point count location was also among the most influential habitat variables as positive associations with burn and red fir forest were of note. Annual precipitation and annual mean temperature were among the most influential climatic variables, both positive associations.

Pileated Woodpecker

Model performance for Pileated Woodpecker was good, with an AUC of 0.80 (Table 4). A relatively large number of variables were important contributors to explaining this species presence in the study area (Figure 3). The habitat variables with the strongest influence were the amount of mixed conifer, red fir, white fir forest, and size class two forest. The effect of red fir and size class two forest was negative, while white fir was positive. The effect of mixed conifer forest was more complex. Among the most influential climatic variables were the mean diurnal range in temperature, precipitation in the driest quarter, and mean annual temperature. The effect of precipitation in the driest quarter was negative while the other two had a positive effect.

Olive-sided Flycatcher

Model performance for Olive-sided Flycatcher was good with an AUC of 0.82 (Table 4). The habitat variables with the greatest contribution to the model were the amount of white fir forest, open canopy forest, edge between forest and non-forested habitats, and shrub habitat (Figure 4). Each of these four variables had a positive effect on the likelihood of this species being present at a site. However, the relationship with white fir forest appears to have a threshold; around 90% at which point the relationship turned negative. The climatic variables with the greatest influence were mean diurnal temperature range and temperature seasonality. The effect of diurnal temperature range was negative while that of temperature seasonality was more complex, being moderately positive at lower values but strongly negative at the highest levels.

Dusky Flycatcher

The overall model performance for Dusky Flycatcher was good, with an AUC of 0.87 (Table 4). The habitat variables with the greatest model contribution were the percent of hardwood forest, percent of ponderosa pine forest, and habitat conditions at the point count station (Figure 5). The relationship with both hardwoods and ponderosa pine was negative. The habitat conditions at the point with the greatest influence were negative associations with hardwoods and burn. The two most influential climatic variables were mean diurnal temperature range, which had a positive effect, and annual precipitation, which showed a complicated pattern.

Brown Creeper

The model performance for Brown Creeper was fair with an AUC of 0.74 (Table 4). By far the most influential habitat variables was a negative relationship with the percent of the 500 meter radius circle comprised of size class two forest (Figure 6). Though substantially less influential than the amount of size class 2 forest, the cohesion of high density forest and the amount of mixed conifer forest were the next most important habitat variables for this species. Cohesion of dense forest had a curvilinear effect: positive at lower levels and negative as it increased. The habitat at the point count station was also among the most influential habitat variables for this species with a strong negative influence of size class 2.

Nashville Warbler

Model performance for Nashville Warbler was excellent with an AUC of 0.90 (Table 4). The percent of mixed conifer forest contributed far more to the model than any other habitat variable, with its effect strongly positive (Figure 7). A number of climatic variables appeared important including dry quarter precipitation, mean temperature in the warmest quarter of the year, and mean annual temperature. Annual mean temperature was positive while the other two showed more complex non-linear effects.

Hermit Warbler

Model performance for Hermit Warbler was excellent with an AUC of 0.93, the best performing of the nine models (Table 4). The habitat variables that contributed the most to the model were the percent of hardwood, followed by the percent of size class two and percent of moderate density forest (Figure 8). The effect of hardwood habitat and size class two forest were negative while the response to moderate density forest was curvilinear (positive at lower levels and then turning negative as moderate density forest became dominant). Overall climatic variables were less predictive for this species than for others. The most influential ones were mean annual temperature and mean warm quarter temperature, both of which had a positive effects.

MacGillivray's Warbler

Model performance for MacGillivray's Warbler was fair with an AUC of 0.78 (Table 4). The habitat variables that contributed the most to the model were the amount of size class five forest, followed by the percent of ponderosa pine and mixed conifer forest (Figure 9). The effect of size class five forest was positive while those of ponderosa pine and mixed conifer forests were negative. The most predictive climatic variables included mean diurnal range, mean warm quarter temperature, and dry quarter precipitation. The effects of all three were generally negative, though for both dry quarter precipitation and mean warm quarter temperature the effects were more complex.

Fox Sparrow

Model performance for Fox Sparrow was good with an AUC of 0.85 (Table 4). The habitat variables that contributed the most to the model were the percents of size class five forest, shrub habitat, and open canopy forest (Figure 10). The relationship with each of these variables was non-linear, showing positive effects at lower levels and as each increased they reached a threshold where the effect turned negative. The three most influential climatic variables were mean diurnal range, dry quarter precipitation, and annual precipitation. The effect of annual precipitation was positive and near linear while mean diurnal range was mostly negative and dry quarter precipitation was curvilinear, with a peak in the middle.

Figure 2. Partial response curves and jackknife estimates of individual variable contribution from Maxent landscape model for Hairy Woodpecker. Variable codes are defined in Appendix C and D.

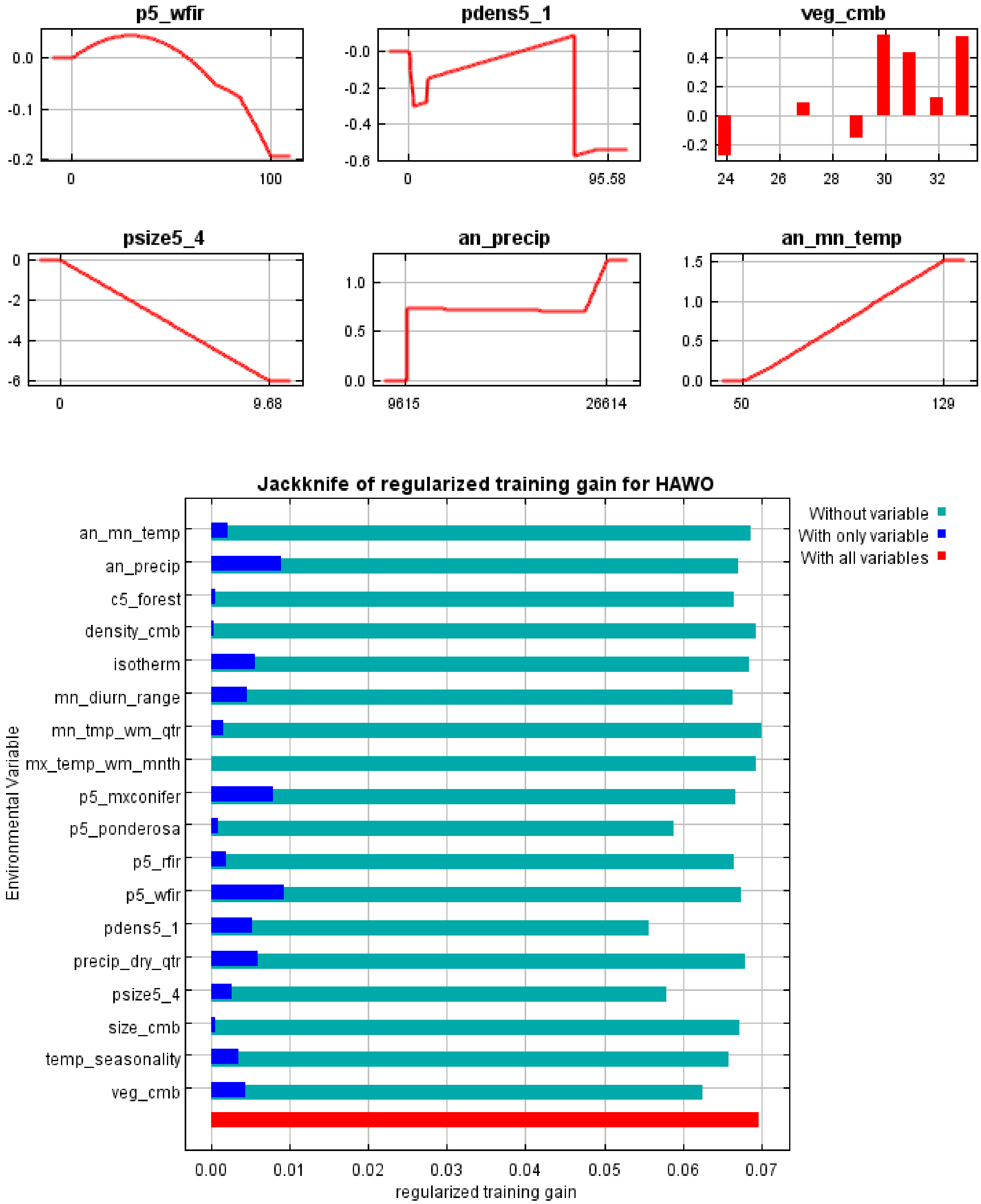


Figure 3. Partial response curves and jacknife estimates of individual variable contribution from Maxent landscape model for Pileated Woodpecker. Variable codes are defined in Appendix C and D.

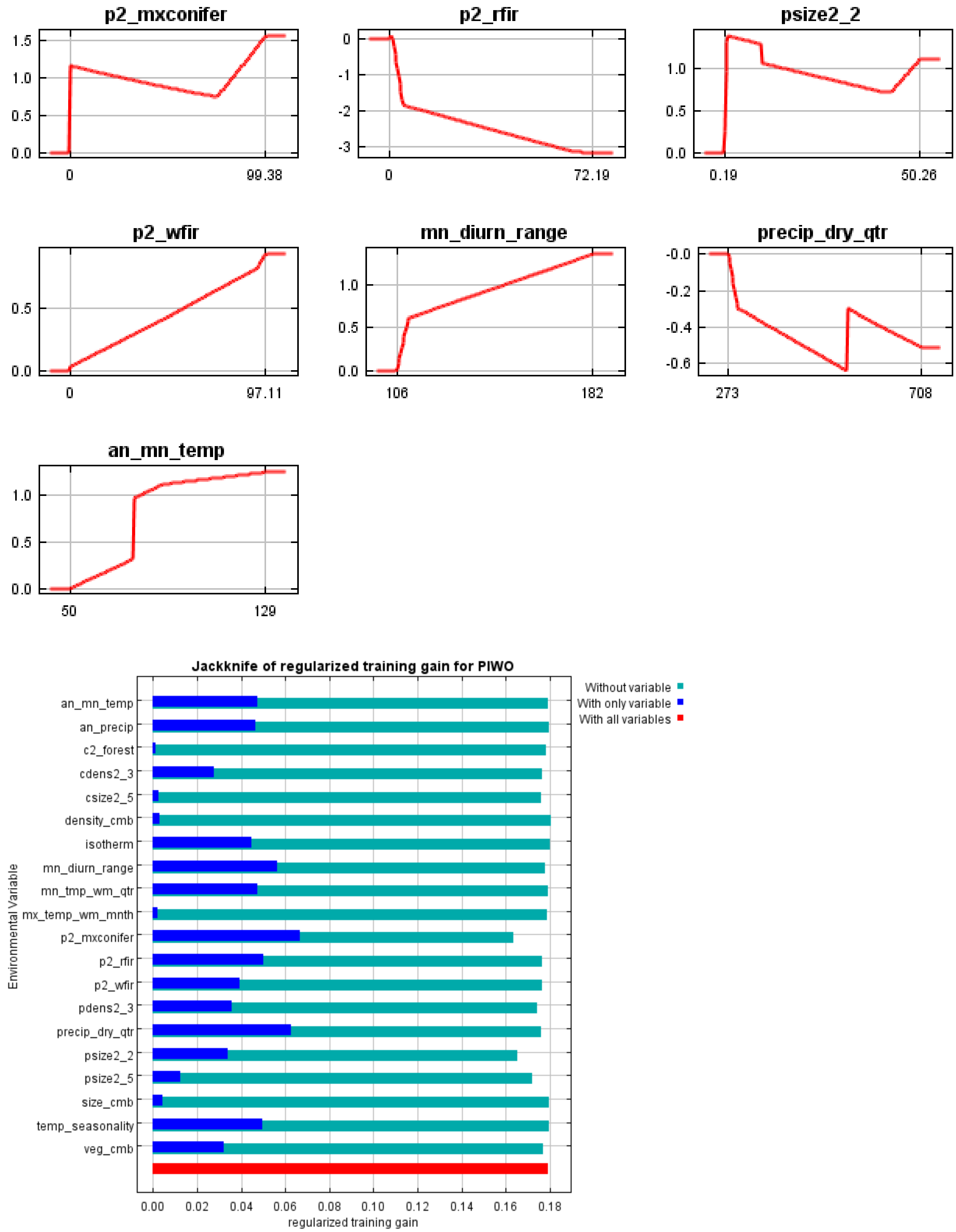


Figure 4. Partial response curves and jacknife estimates of individual variable contribution from Maxent landscape model for Olive-sided Flycatcher. Variable codes are defined in Appendix C and D.

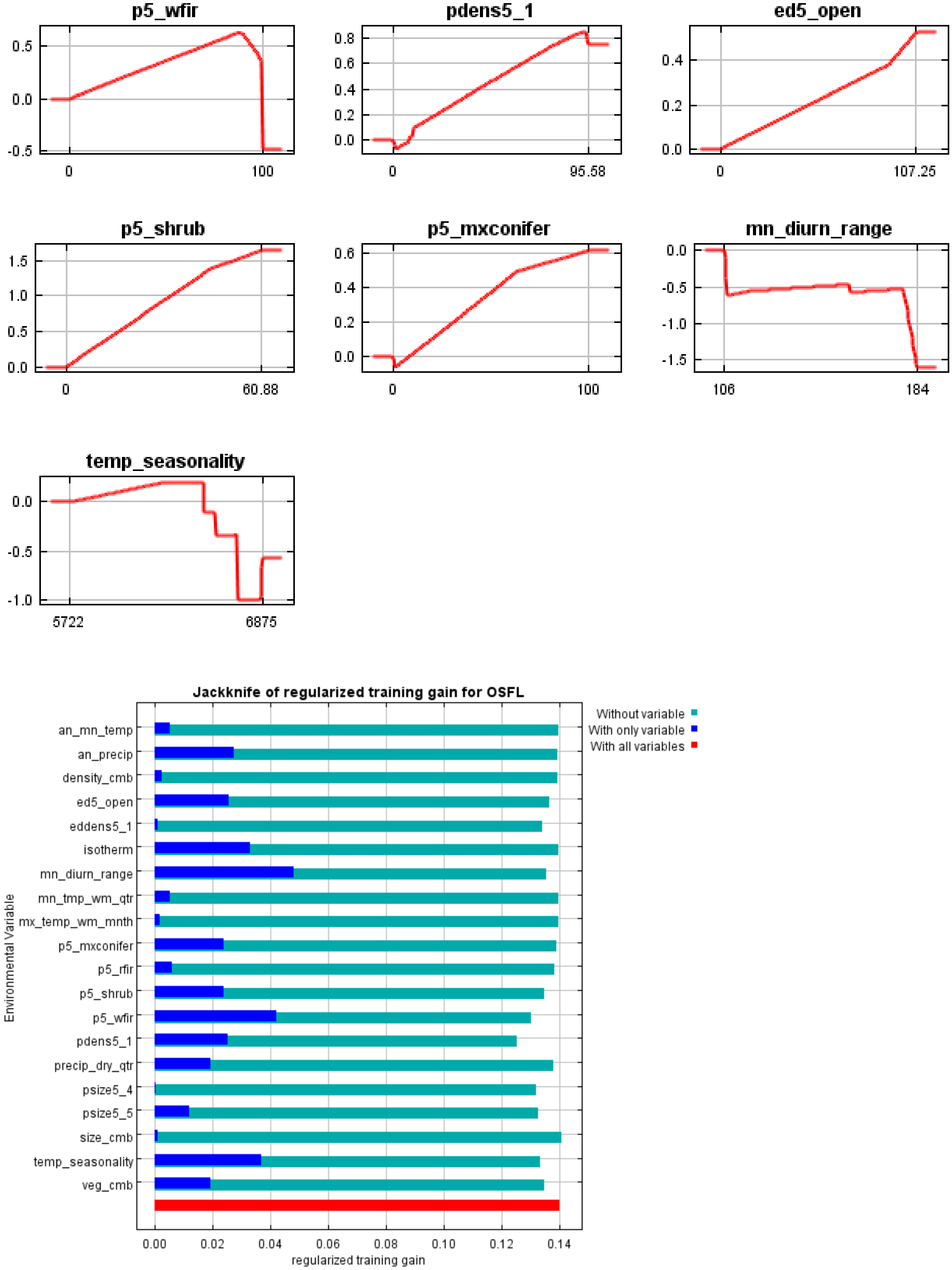


Figure 5. Partial response curves and jacknife estimates of individual variable contribution from Maxent landscape model for Dusky Flycatcher. Variable codes are defined in Appendix C and D.

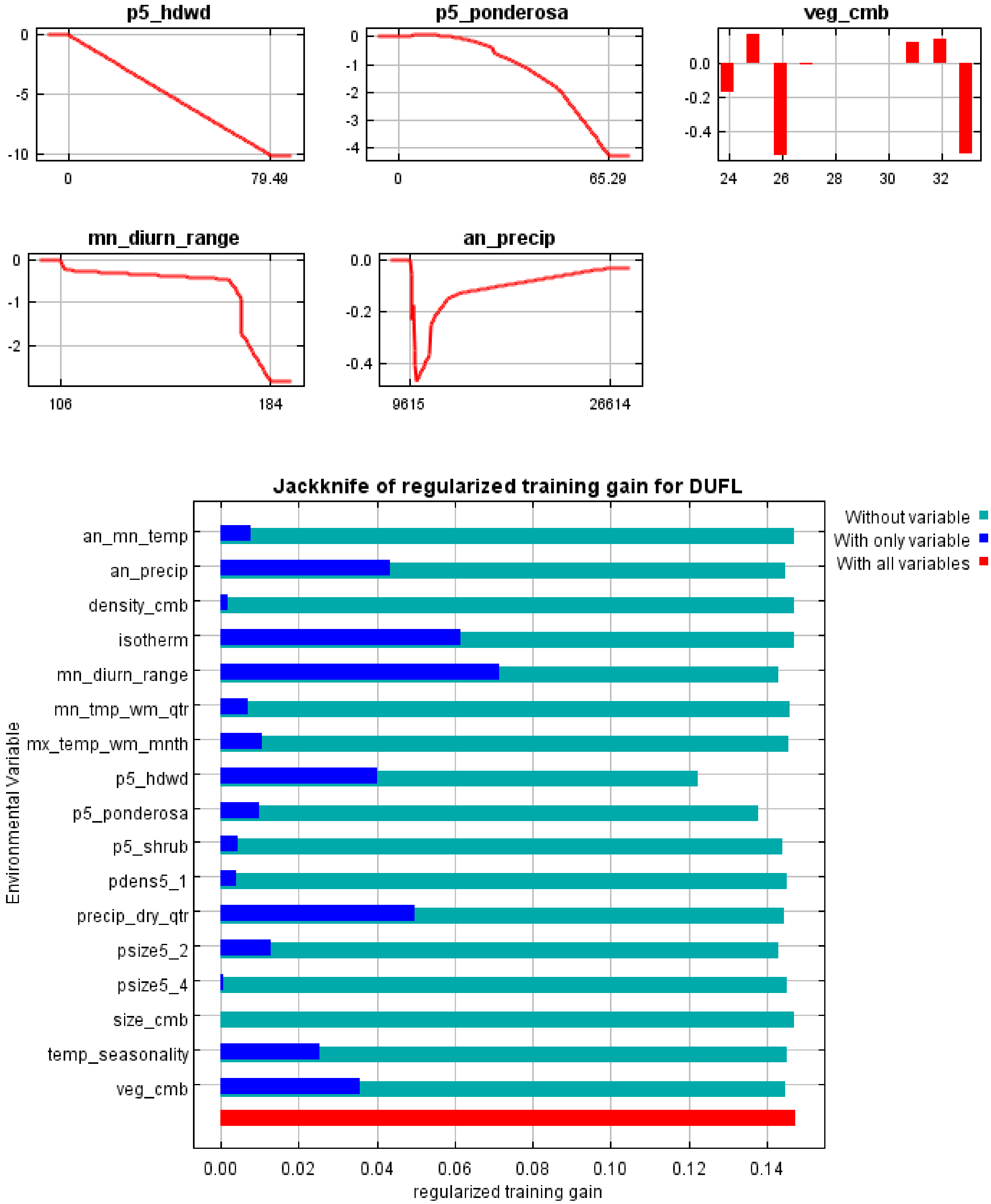


Figure 6. Partial response curves and jacknife estimates of individual variable contribution from Maxent landscape model for Brown Creeper. Variable codes are defined in Appendix C and D.

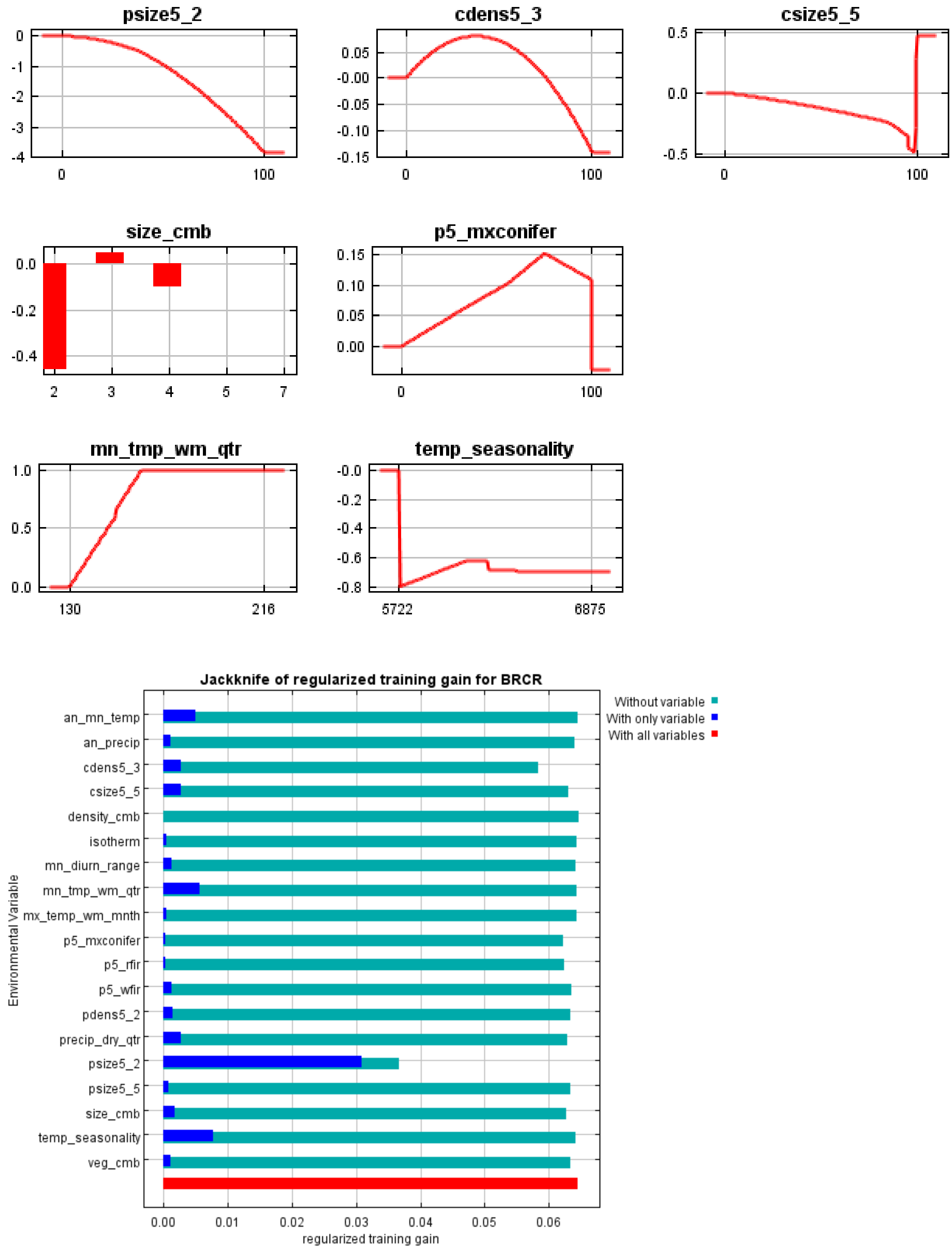
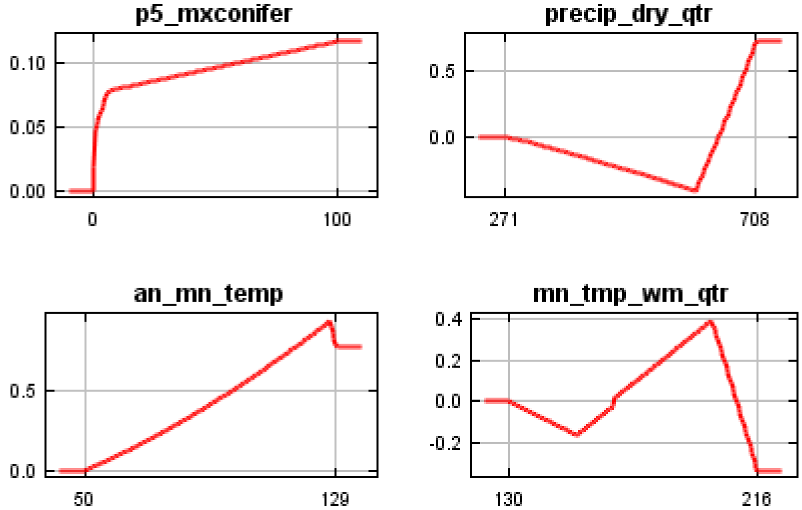


Figure 7. Partial response curves and jacknife estimates of individual variable contribution from Maxent landscape model for Nashville Warbler. Variable codes are defined in Appendix C and D.



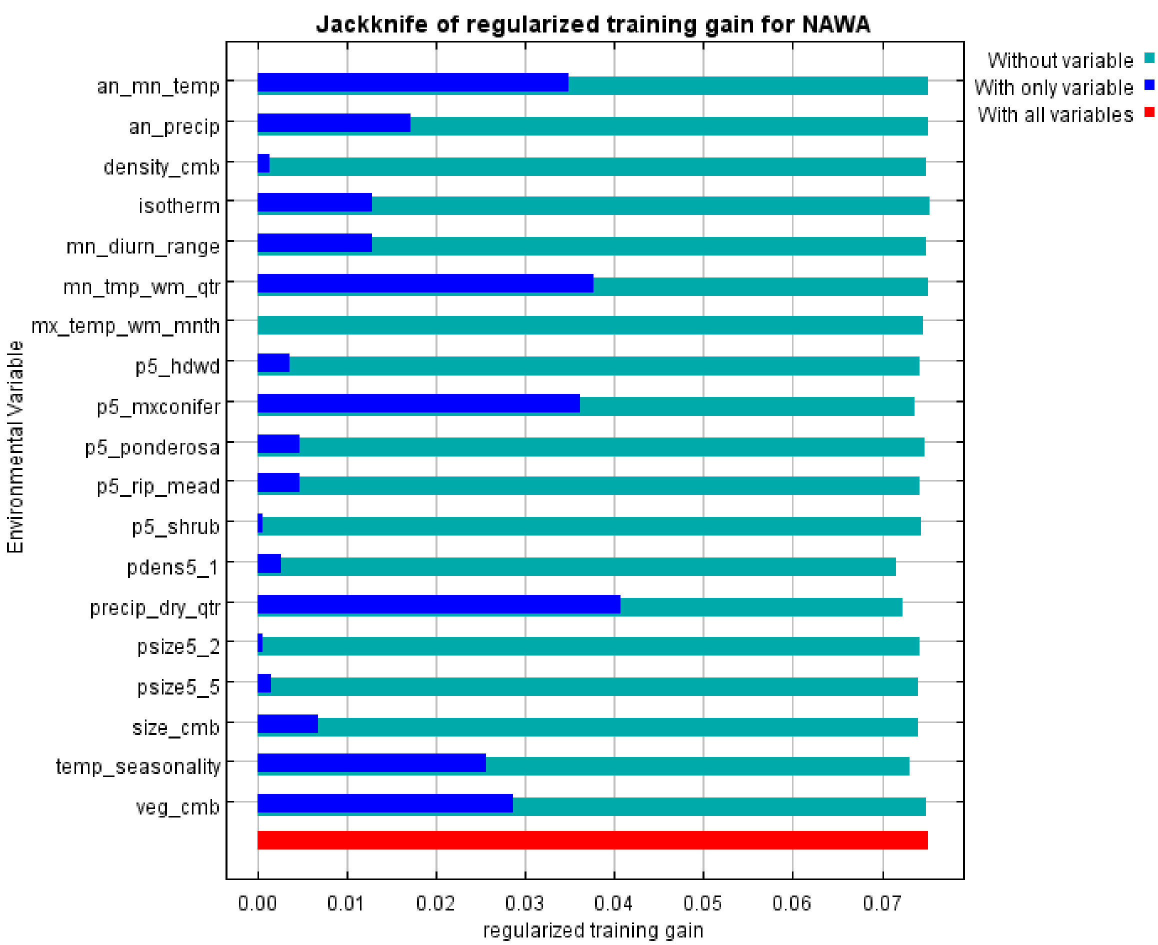


Figure 8. Partial response curves and jacknife estimates of individual variable contribution from Maxent landscape model for Hermit Warbler. Variable codes are defined in Appendix C and D.

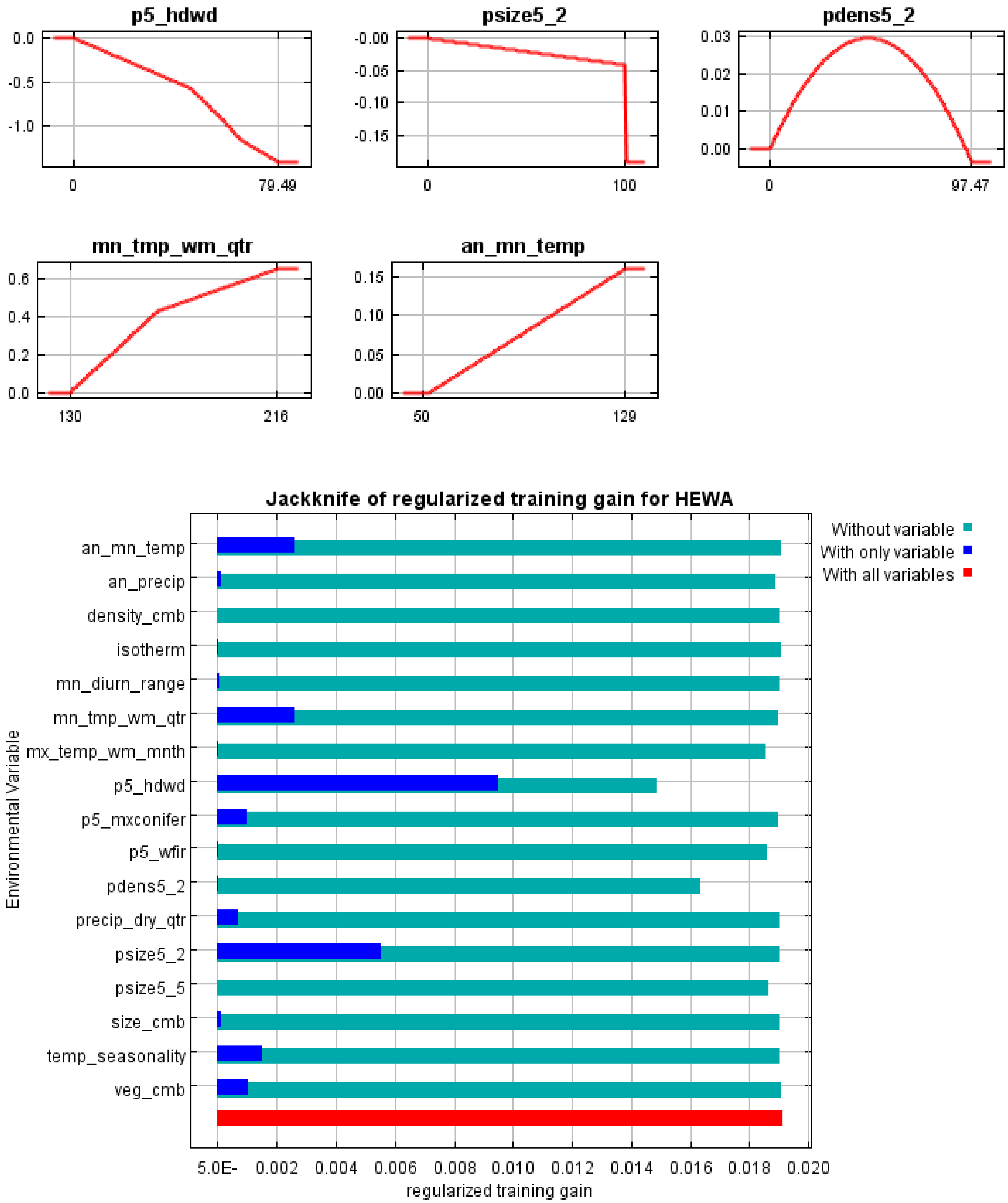


Figure 9. Partial response curves and jacknife estimates of individual variable contribution from Maxent landscape model for MacGillivray's Warbler. Variable codes are defined in Appendix C and D.

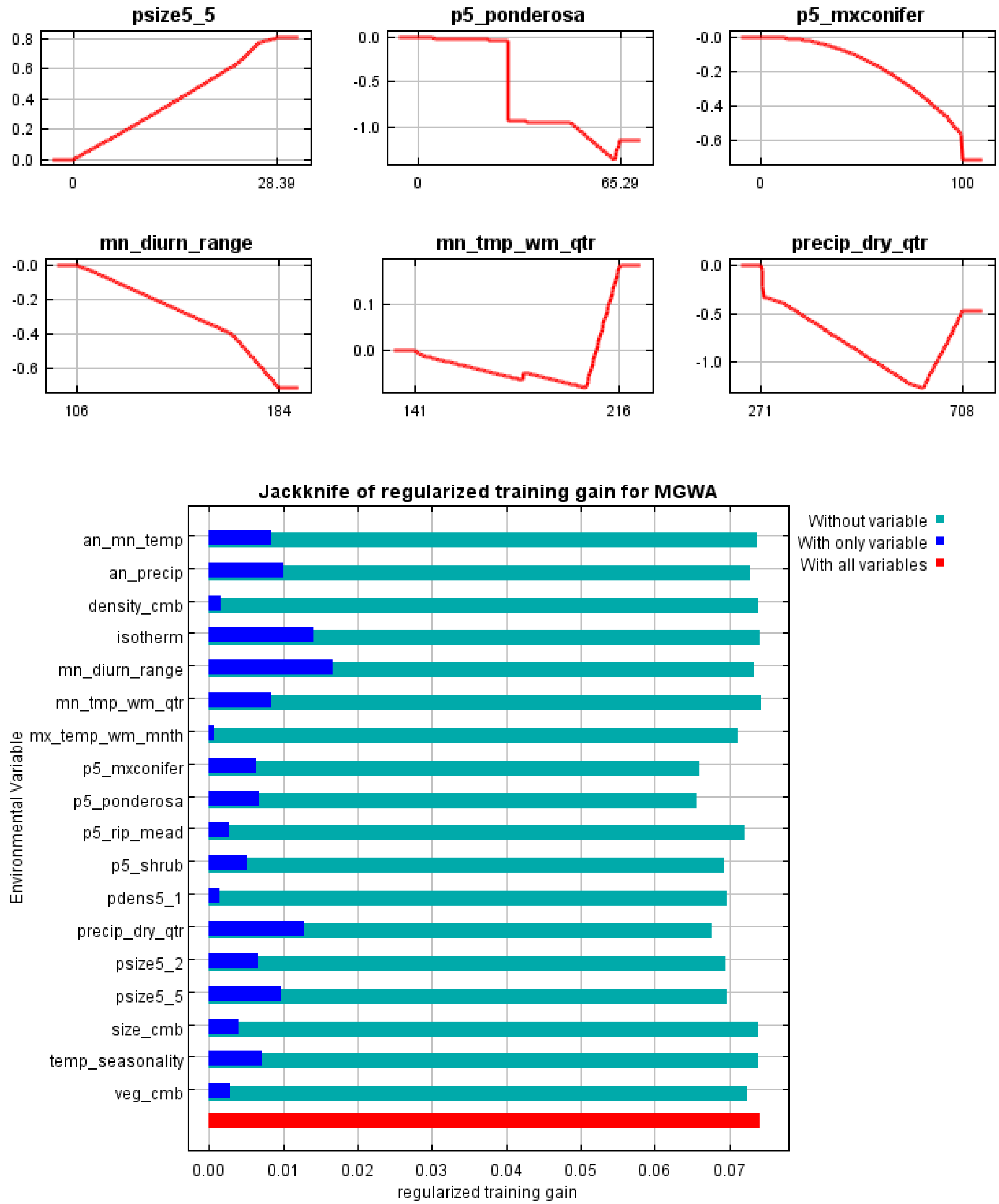
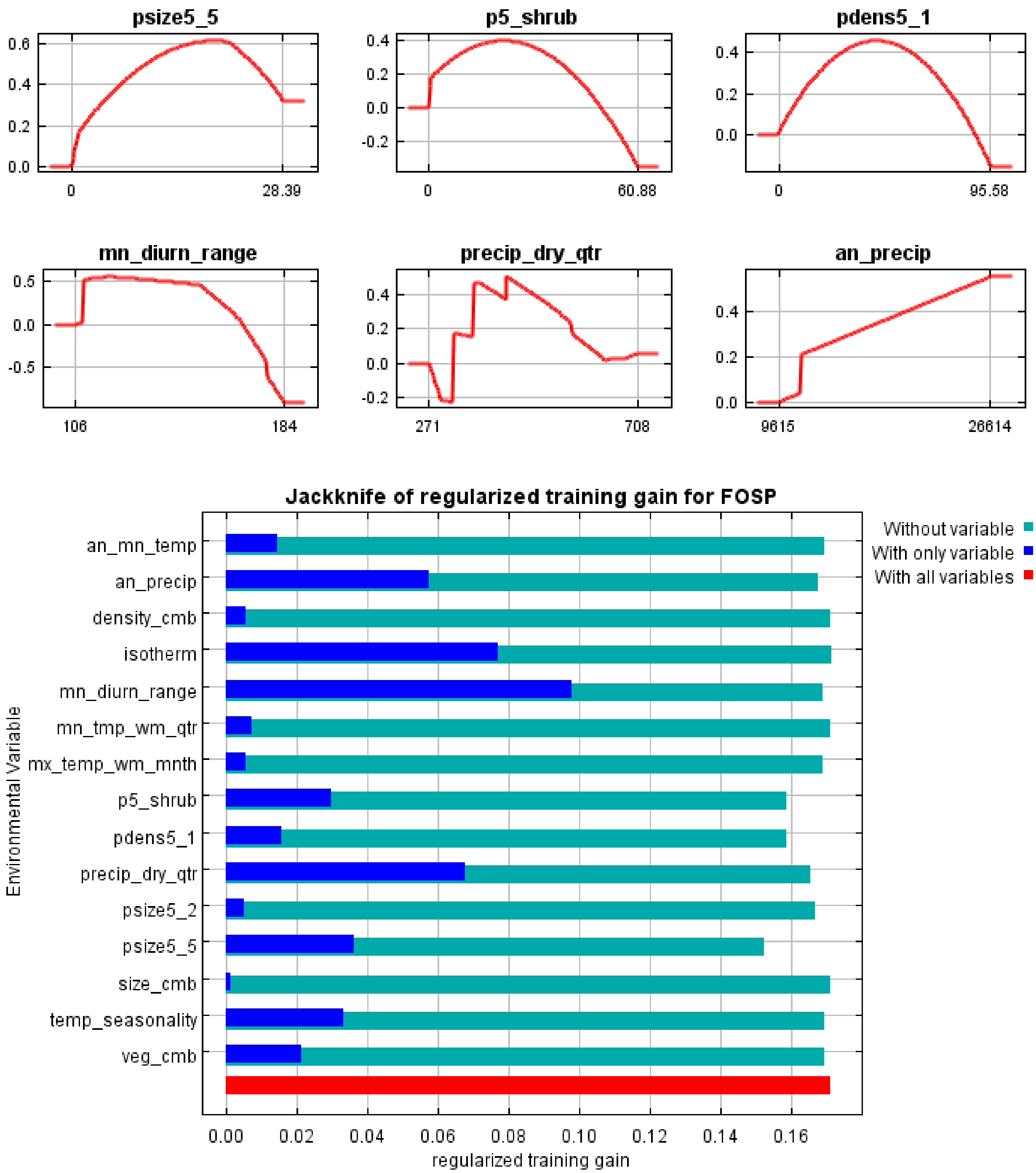


Figure 10. Partial response curves and jacknife estimates of individual variable contribution from Maxent landscape model for Fox Sparrow. Variable codes are defined in Appendix C and D.



Discussion

Models as Planning Tools

The spatially explicit distribution maps developed from this analysis can readily be used in land management and planning decisions. They should, however, be used with an understanding of their limitations. Models are simplifications of complex ecological systems and, as a result, no prediction is perfect. They are best estimates based on the best available data. Distribution models do not tell us about the processes that drive population change, and hence simply prioritizing specific areas may not lead to the project's desired outcome. Furthermore, we did not equally sample the entire area for which the predictions were made. Thus, model performance may be poorer in areas where the habitat and climate vary considerably from the areas that were sampled; such as in east side pine and the highest elevations.

The model predictions presented herein may be used to address management questions at a variety of different spatial scales. However, because the models do not include site-specific habitat characteristics, they should be used primarily as a coarse filter to help guide project planning. Thus said, they have a number of useful applications. Models may be used to evaluate potential landbird impacts of small-scale projects such as plantation management or a larger scale network of DFPZ's and group selections. Additionally, these models can be used to analyze the potential impacts of a proposed action to a species in the context of the surrounding landscape. Another key benefit of using landbird models is that planning can be based on multiple species that represent a diverse array of habitats, life history strategies, and ecosystem processes. Further, many of the metrics presented here are based on common species; thus their use in management decisions constitutes a proactive ecosystem approach to management and preservation of biodiversity.

Habitat Variables

Across the species and metrics examined, we found that landscape-level vegetation characteristics (within a 500-m radius, or 2000-m radius for Pileated Woodpecker) were generally more important predictors than vegetation type at the survey location. Furthermore, the landscape metrics of edge density and cohesion were important for Olive-sided Flycatcher, and Brown Creeper suggesting habitat configuration and pattern are key components influencing the distribution of species across the landscape. It is important to note that this analysis only investigated broad habitat types at the local level and did not consider the influence of more detailed quantifications of local habitat conditions that clearly are important for determining habitat suitability for landbirds in the Sierra Nevada.

We intentionally selected species that we felt occupied a broad range of habitat types and conditions in the study area. Thus, it is not surprising to find that cumulatively these species are associated with a diverse and often contrasting set of variables. However, within this variation we did find a few consistent patterns.

Canopy cover and Tree density

Open canopy forest was among the most important variables for three species: Hairy Woodpecker, Olive-sided Flycatcher, and Fox Sparrow. All of which had a positive association with this condition. Open canopy forest exists in the study area as a climax condition where spacing is created by competition, often in areas with poor soil and moisture conditions. It also exists throughout the forest in areas that burn often enough to regularly eliminate understory trees and in early successional stands following more intense fire. However, fire intervals have been lengthened (Taylor and Skinner 2003), and acreage affected by wildfire today in California is only a fraction of what it was historically (Stephens et al. 2007). Though the total number of acres affected by high severity fire are surely fewer, within individual fires the percent of the area that burns at high intensity has increased in the last 50 years (H. Safford pers. comm.). As a result, fire's role in creating and maintaining early successional shrub dominated habitats has been altered as well as its role in creating structural diverse mature forest. The lack of pyrodiversity is likely resulting in a loss of structural and floristic diversity at a landscape scale. These factors are likely to manifest in loss of habitat for a large number of disturbance-dependent species including Olive-sided Flycatcher, Dusky Flycatcher, MacGillivray's Warbler, and Fox Sparrow.

Heterogeneity

The Maxent modeling approach that we used provided insight regarding the non-linear relationships between the indicator species and landscape habitat patterns. Most modeled bird responses to landscape variables were not linear or even monotonic. In many cases, the optimal condition was an intermediate one, even among forest-associated species, suggesting that landscape heterogeneity is important.

The Olive-sided Flycatcher, more than any other bird species, requires heterogeneity in the form of edges at the union of distinctly different habitat types (McGarigal and McComb 1995, Howell and Burnett *in prep*). They occur most often where mature forest meets high intensity burn, shrub fields, and meadows (Altman and Sallabanks 2000). It is one of the fastest declining species over the past 40 years in the Sierra Nevada, and the rate of decline appears to be accelerating in recent years (Sauer et al. 2006). Though some of the reasons for its decline may be due to issues on its wintering grounds (Siegel and Desante 1999), there is little doubt that current trends towards a more homogenous fire-suppressed forest will negatively impact this species (Hutto 1995).

Presence of mixed conifer forest had a positive effect on four species: Pileated Woodpecker, Olive-sided Flycatcher, Nashville Warbler, and Hermit Warbler. For this habitat designation we did not include white fir dominated mixed conifer, as under current conditions this habitat type often reaches near homogenous stands of white fir in the study area. Thus, this association is with what may have historically been the more common mixed conifer forest types dominated by either pine, Douglas fir, or an equal representation of multiple species. It is our experience that within these heterogeneous mixed conifer types, hardwoods are more likely to be present than in ones dominated by white fir. In fact, Nashville Warbler is rarely found away from hardwoods, especially Black Oak, and Hermit Warbler is associated with arboreally diverse mixed conifer forest in the study area (Burnett and Humple 2003). The conversion of true mixed conifer forest to more homogenous white fir dominated forest may result in negative impacts to these species. In contrast, Pileated Woodpecker and Olive-sided Flycatcher were both positively associated with both mixed conifer and white fir forest types, and lack the association with hardwood trees found in the above species.

MacGillivray's Warbler, a shrub nesting species, was positively associated with size class five forest. Unlike Fox Sparrow, MacGillivray's Warbler can occur in relatively small forest gaps dominated by shrub cover. Within size class five forests there may be more natural gaps and increased heights to live crowns, allowing more sunlight to reach the forest floor. These conditions are more likely to support a shrub understory resulting in habitat suitable for this species. However, forest dominated by larger trees may directly benefit this species as well.

The importance of forest gaps should be considered key to this and other species. Management actions that increase the amount of structurally diverse size class five forest on the landscape will likely benefit a number of bird species: mechanical treatments that significantly reduce canopy cover or create forest gaps have been shown to benefit MacGillivray's Warbler and other open forest and shrub associated species (Siegel and DeSante 2003, Hagar et al. 2004). Additionally, many forest associated birds are likely to benefit from small gaps in mature forest as they utilize the unique resources available therein (Vitz and Rodewald 2006).

Heterogeneity in the Sierra Nevada is not only important for providing diverse habitat types occupied by a diverse range of birds, but the heterogeneity itself – the juxtaposition of distinct habitat types and structures – appears key to maintenance of avian diversity (McGarigal and McComb 1995). With the role of wildfire greatly reduced in shaping forest structure, mechanical treatments, wildland fire use, prescribed burning, and most importantly a re-evaluation of the importance of stand replacing fire and management thereafter will be necessary to ensure structural diversity and the full range of forest types and conditions are represented on the landscape.

Mature Forest Patch Size

Hermit Warbler, Pileated Woodpecker, and Brown Creeper all showed a negative response to the amount of the surrounding landscape in the smallest size class forest, suggesting there are benefits to limiting the fragmentation of habitat dominated by large trees. These results are in contrast to those for many of the other species and highlight the importance of a balanced approach to ecosystem management that ensures patches of mature forest are available for these species. With management focused on providing relatively large patches of intact mature forest for species such as Spotted Owl and Pine Marten, the needs of these forest-dwelling birds are likely to be met. In fact, Hermit Warbler is currently the most abundant bird in the Plumas-Lassen study area.

Using Birds a Management Indicators

Pileated and Hairy Woodpeckers are management indicator species on the Lassen National Forest. Pileated Woodpeckers show a strong aversion to red fir forest and appear to avoid higher elevations all together (see Chapter 2). The habitat needs of this species should be managed for in the mixed conifer and white fir dominated forest of the middle elevations. The habitat associations of Hairy Woodpecker were in direct contrast to those of Pileated Woodpecker. Hairy Woodpeckers were negatively associated with white fir, were associated with burn and red fir at the local level, and were more likely to occur as the amount of open canopy forest increased. Thus, management actions that benefit one of these species is likely to negatively impact the other. These species illustrate the need to avoid treating management indicators as if they are endangered species but use them as tools to help inform a more balanced approach that ensures the needs of all species are being met. Using tools such as these models, it is possible to prioritize planned treatments or other actions in the most effective locations to ensure both species needs are being met.

Climate and Sierra Birds

Climate variables are likely correlated with vegetation variables, but at a large landscape scale they provide more insight to help refine models as they incorporate additional information that is not represented by vegetation types alone. However, when interpreting the relative contribution of different variables to the final models it is important to consider these variables are all interacting, which can confound the importance or change the direction of their effect.

For a number of species, climate variables were among the most important variables even when habitat was included in the model, suggesting that climactic factors – beyond their role in defining and shaping habitats – play an important role in determining the distribution of avian species in the Sierra. Indeed, other studies have highlighted the importance of climate to bird distributions (Root 1988). Climate may be important to birds in numerous ways including its influence on the timing and intensity of insect outbreaks, thermoregulation of eggs and nestlings, and adult overwinter survival. At a smaller microhabitat scale, climate has also been shown to affect bird distribution and even abundance through its effect on nest site selection (Martin 2001). The climate variables that were included in the models represent both extremes and averages that may likely define the physiological boundaries and requirements of birds. As we continue into an era of increased climatic variability it will be critical to better understand its potential role in shaping habitat types as well as ecosystem processes.

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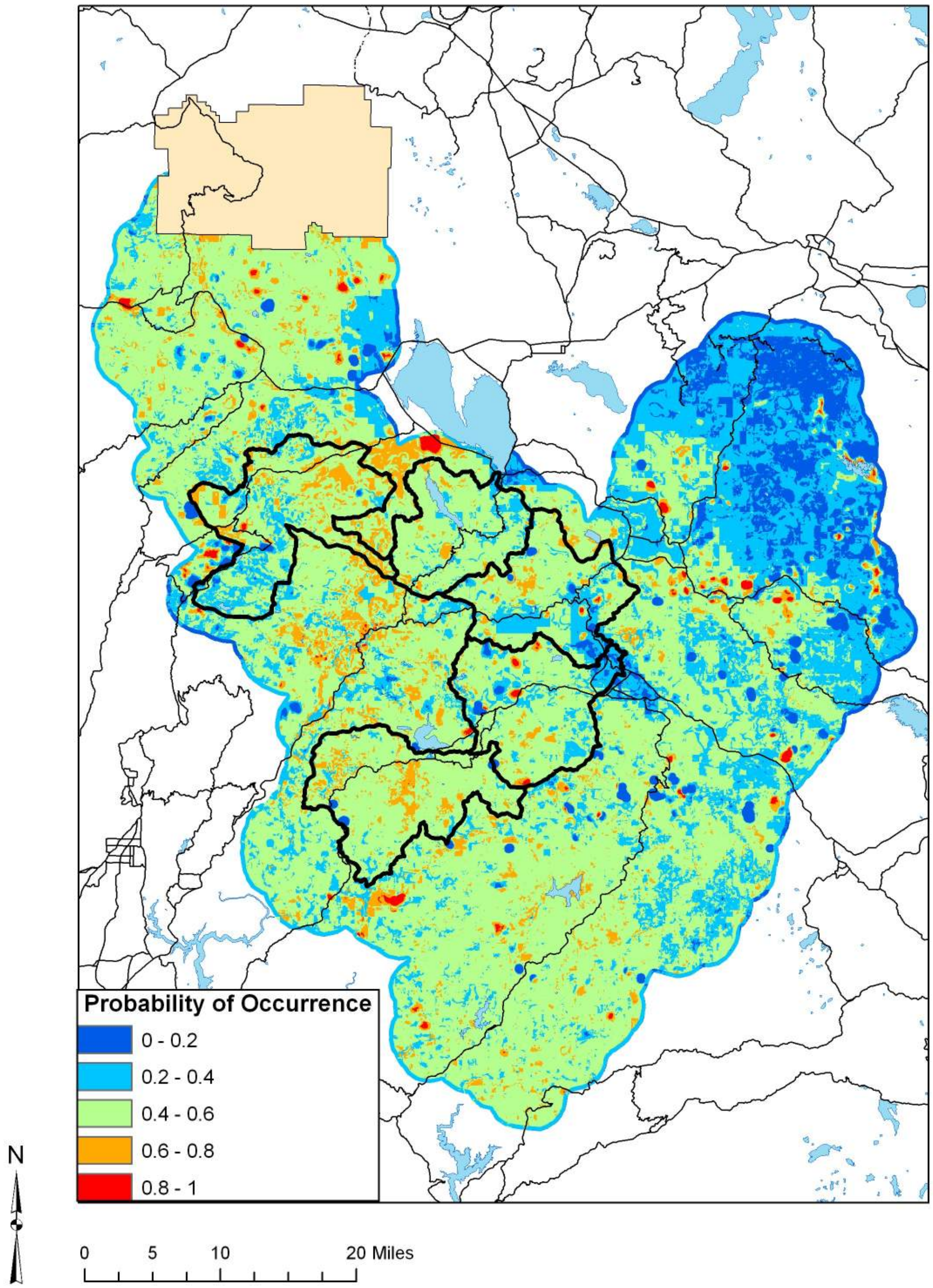
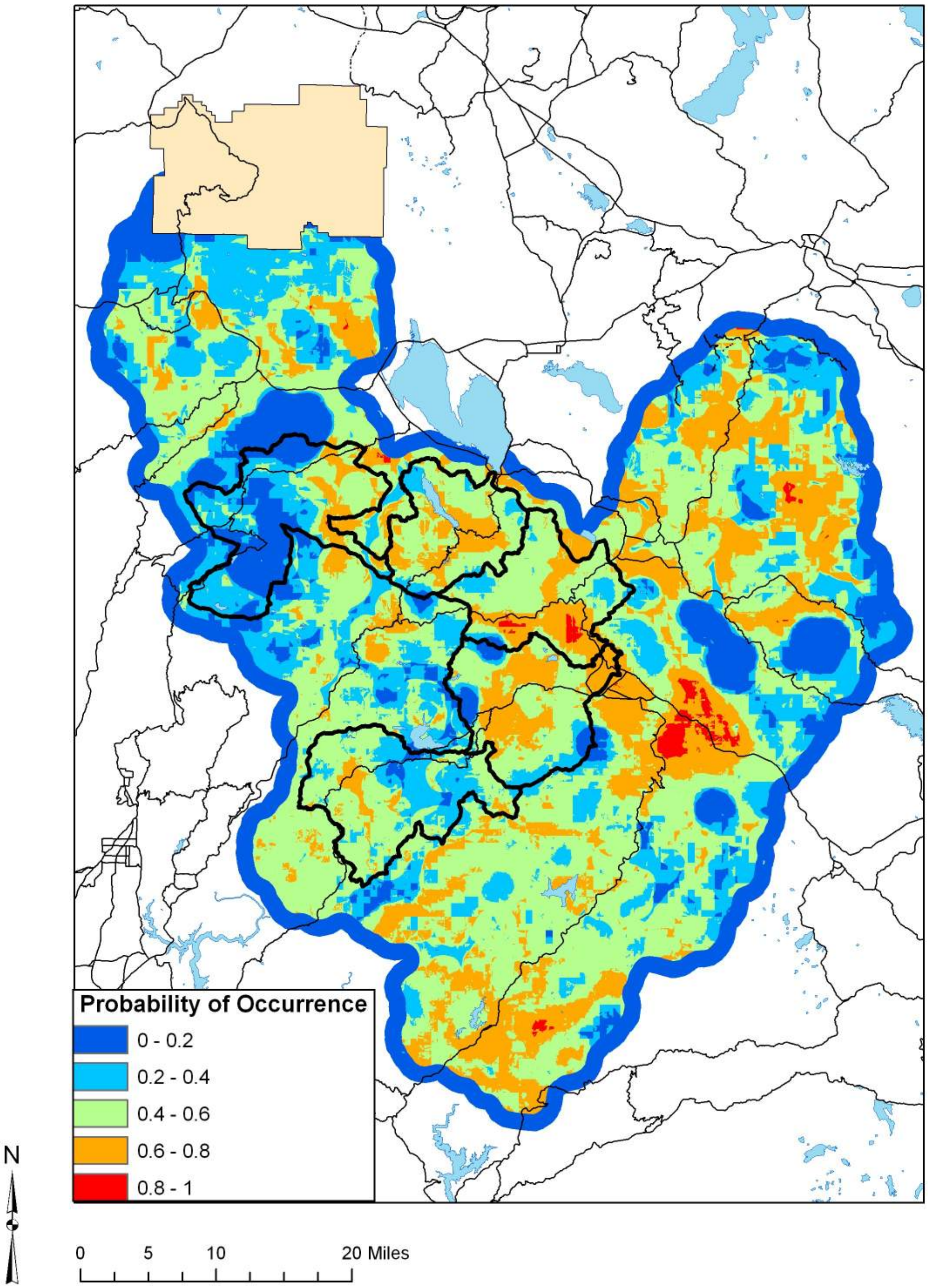
Appendix A. Predicted probabilities of occurrence for nine species in the Plumas-Lassen study area based on MaxEnt landscape habitat modeling. The black outlined polygons in the center of the map are the former administrative study treatment units. Lassen National Park is depicted in beige in the north portion of the maps.

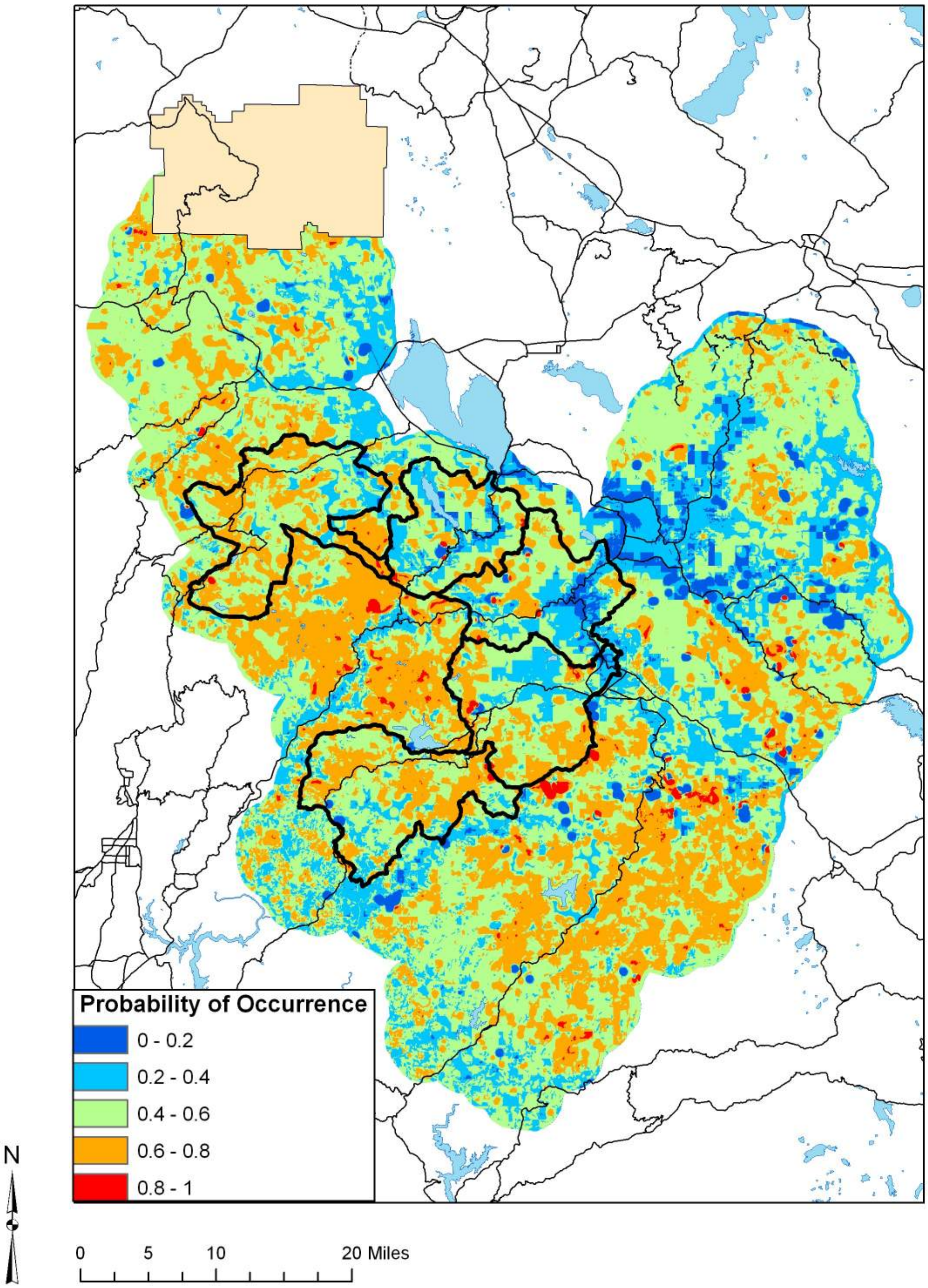
Hairy Woodpecker



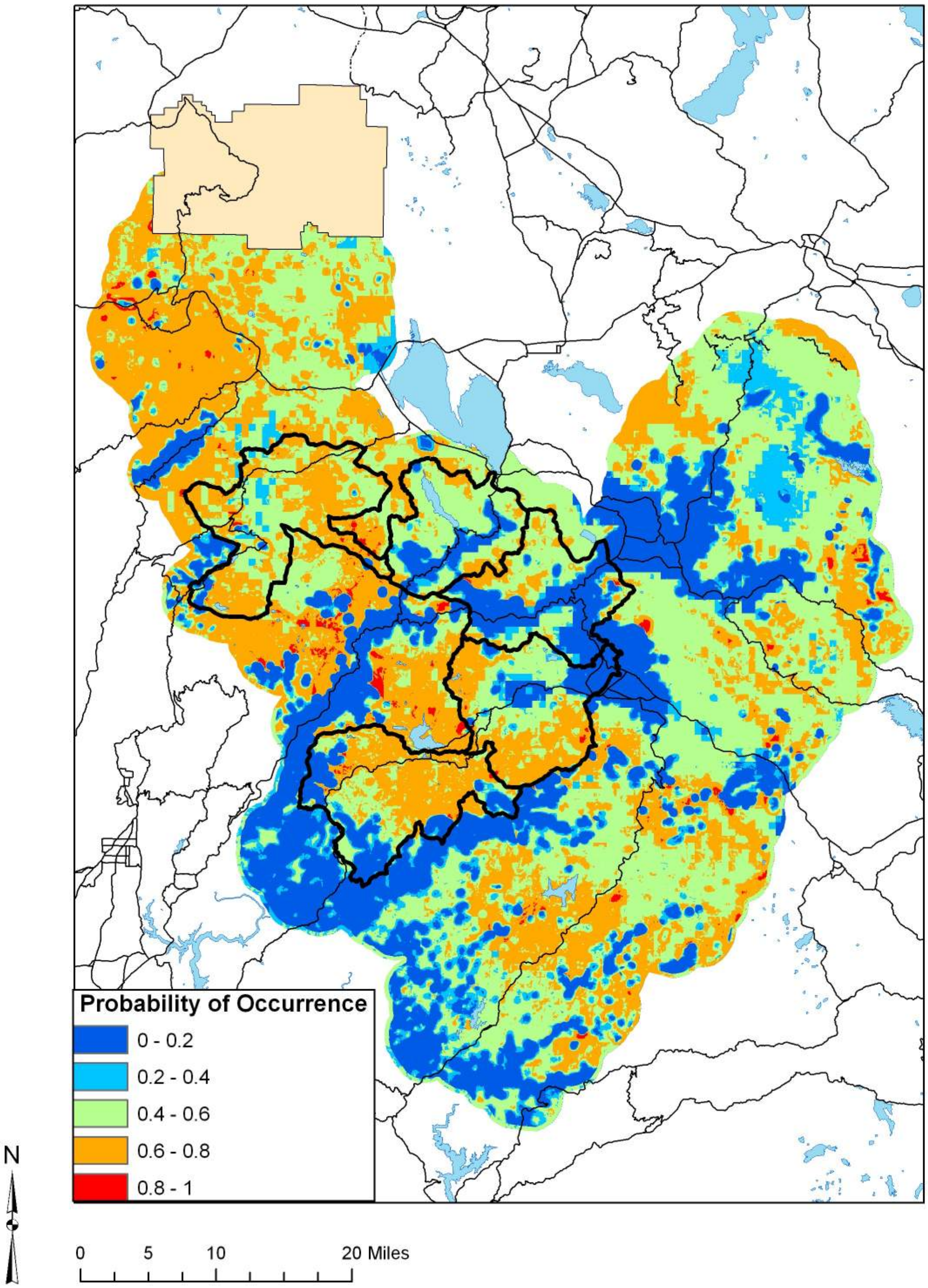
Pileated Woodpecker



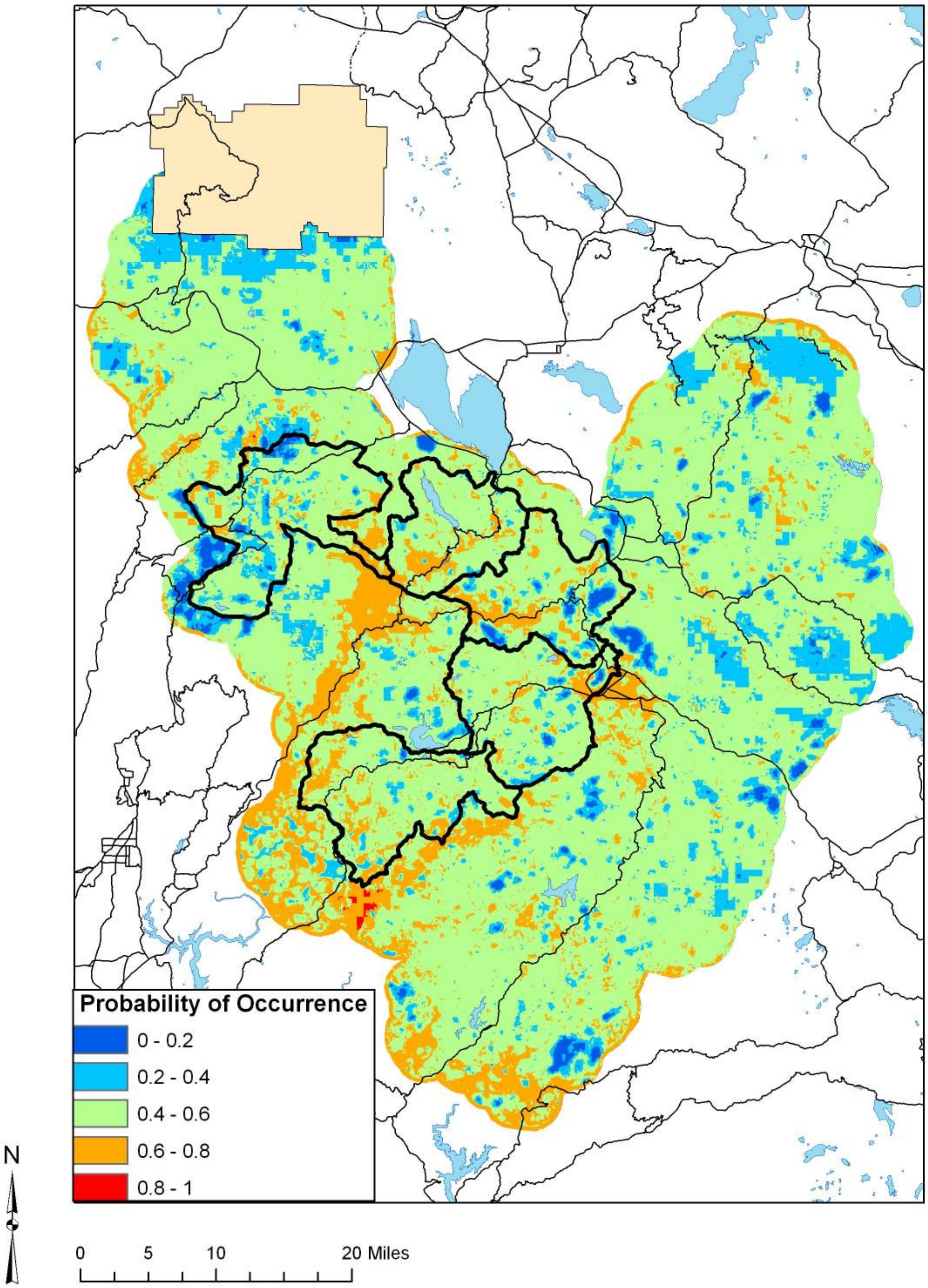
Olive-sided Flycatcher



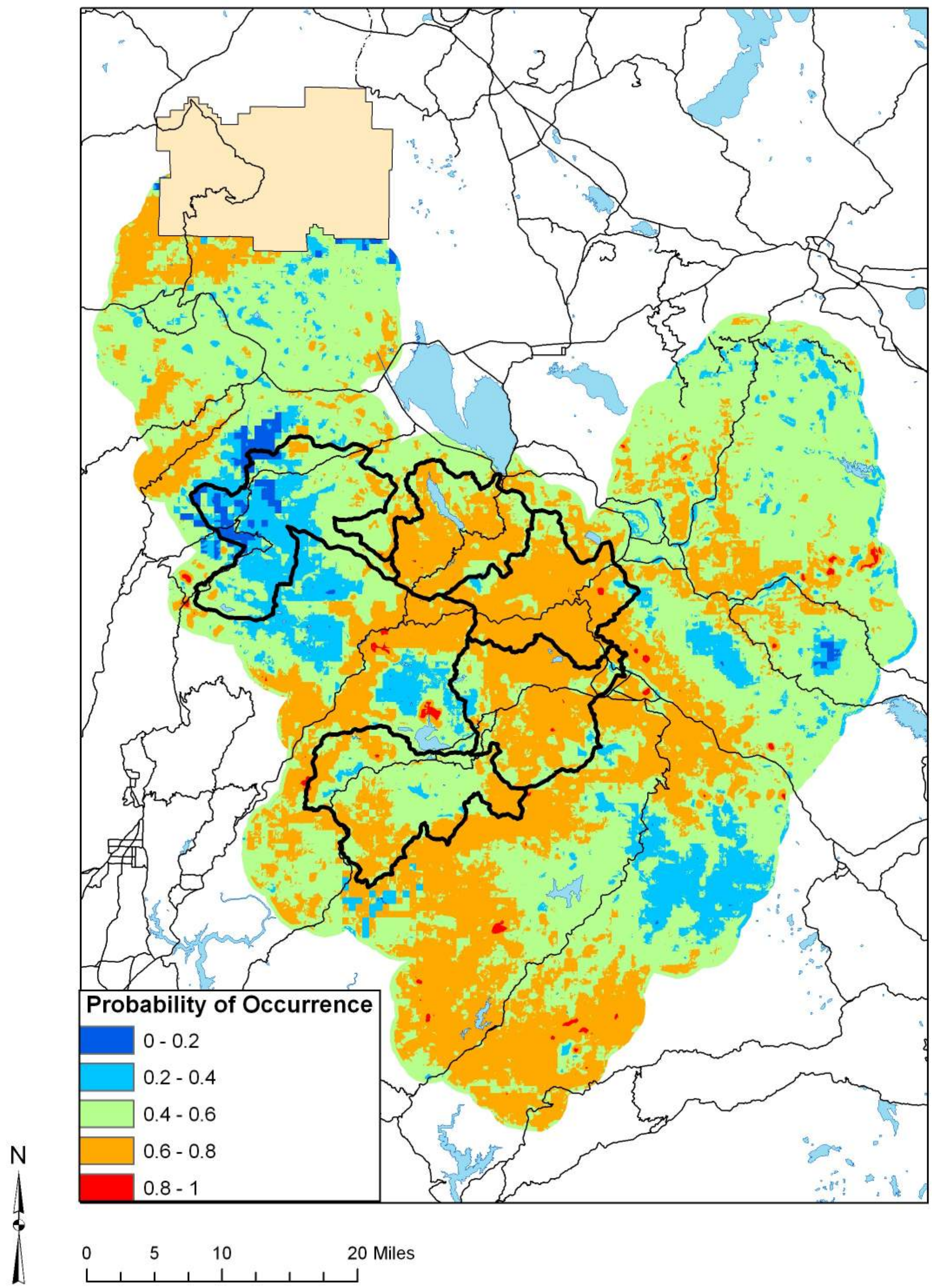
Dusky Flycatcher



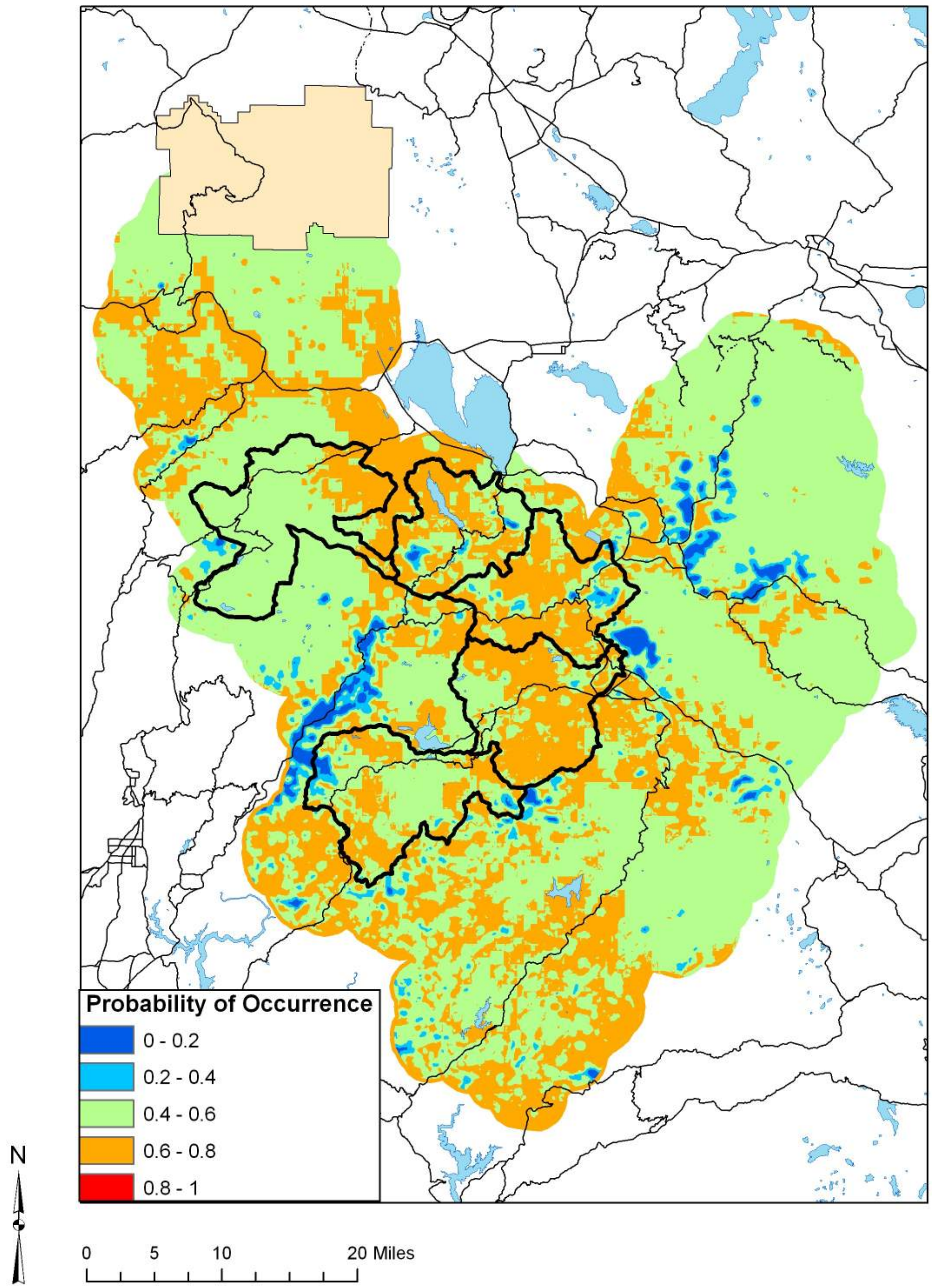
Brown Creeper



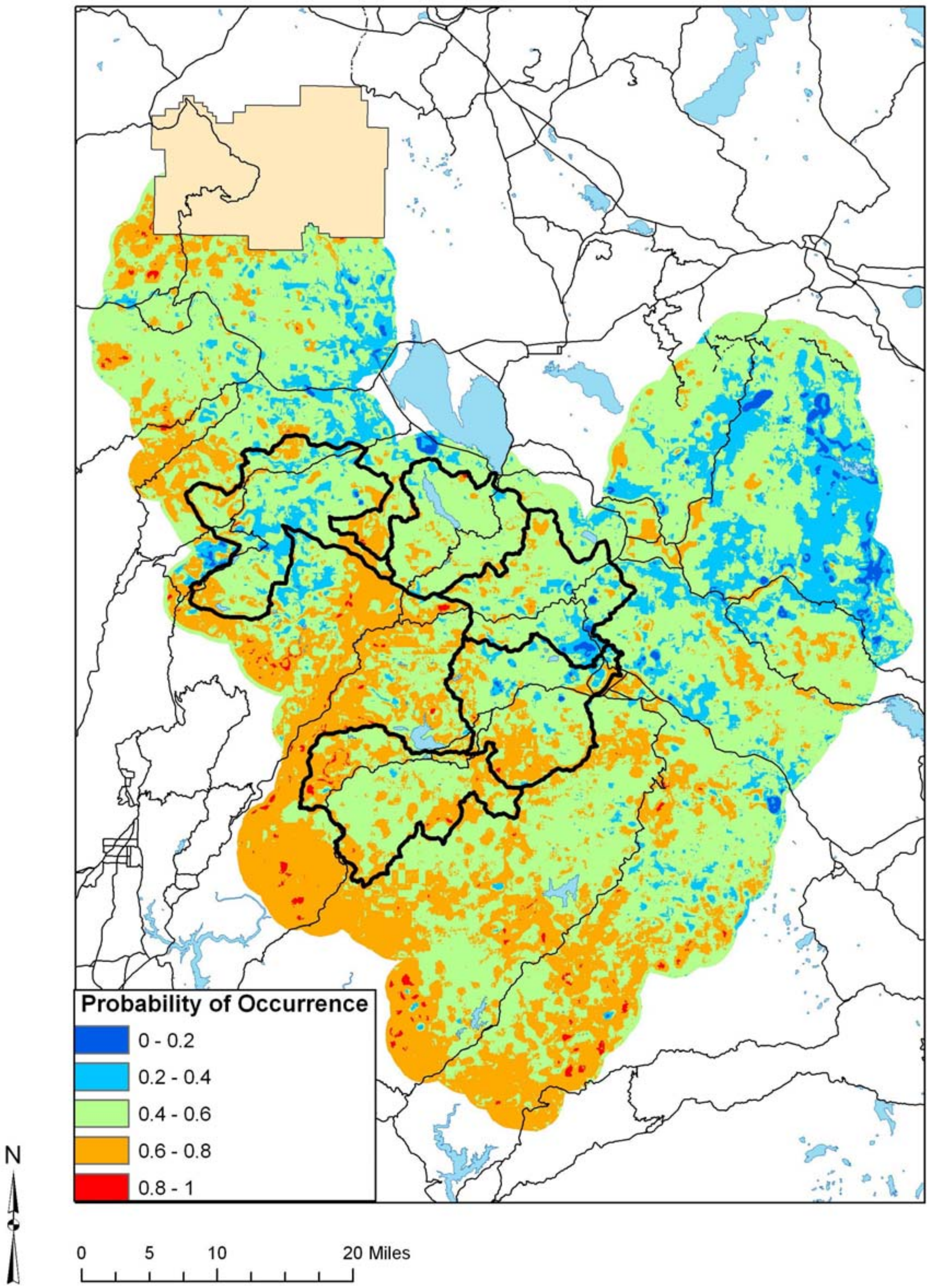
Nashville Warbler



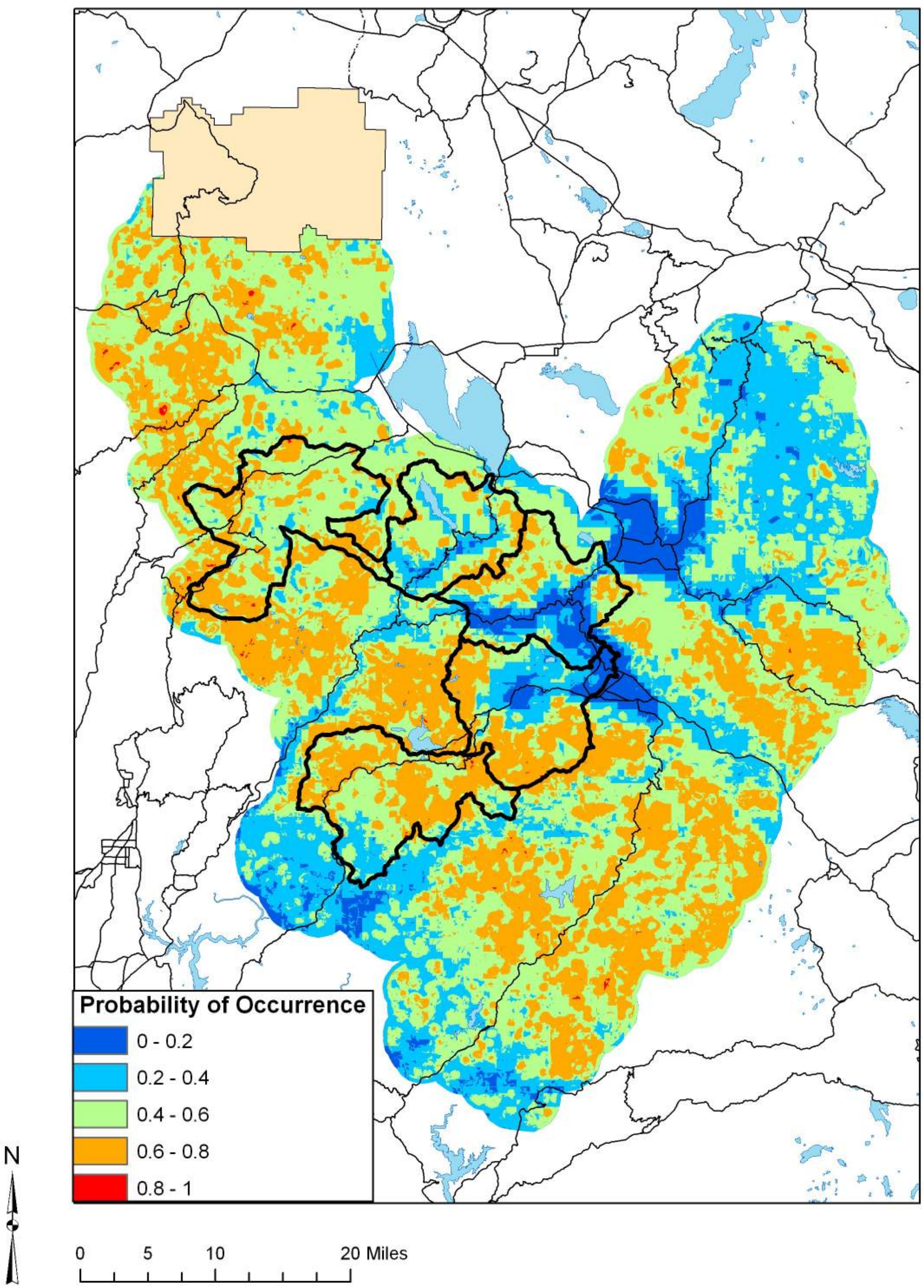
Hermit Warbler



MacGillivray's Warbler



Fox Sparrow


Probability of Occurrence
0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1
N
0
5
10
20 Miles

Appendix B. Habitat variables used as input for modeling the presence of each species in the Plumas-Lassen Study area. Codes are defined in Tables 2 – 5 in this report.

Species	Variables at 500m and 2km	Density class	Size class	Cohesion	Edge Density
PIWO	cover class D, size classes 2 and 5, RF, WFD, MC	3	2 & 5	fortype35, dens3 & size5	
HAWO	Burn, cover class P, MC, WFD, PPD, RF, size class 4	1	4		
OSFL	cover class P, size class 4 and 5, RF, MC, WFD, Burned, SHB	1	4 & 5		fortype36 & dens1
DUFL	SHB, HDWD, PPD, density class P, size class 2 and 4	1	2 & 4		
BRCR	size classes 2 and 5, cover class M, MC, WFD, RF	2	2 & 5	dens3 & size5	
NAWA	HDWD, SHB, PPD, MC, RIP/MDW, size 2, size 5, cover class P	1	2 & 5		
HEWA	HDWD, MC, WFD, size class 4 and 5, density class M	2	2 & 5		
MGWA	SHB, RIP/MDW, PPD, MCD, density class P, Size 2 and 5	1	2 & 5		
FOSP	Shrub, size class 2 and 5, cover class P, Burn	1	2 & 5		

Appendix C. Variable codes and descriptions of habitat metrics used in maximum entropy modeling of nine landbird species in the Plumas-Lassen study area. Metrics were calculated using moving window averages within the given radiusf (2000 meters for Pileated Woodpecker and 500 meters for all other species).

Habitat Variable Code	Description
Shrub	Percent shrub vegetation class within the given radius
rip_mead	Percent riparian and meadow vegetation class within given radius
Hdwd	Percent hardwood vegetation class within the given radius
Ponderosa	Percent ponderosa pine vegetation class within the given radius
Mxconifer	Percent mixed conifer vegetation class within the given radius
Wfir	Percent white fir vegetation class within the given radius
Rfir	Percent red fir vegetation class within the given radius
Unveg	Percent unvegetated class within the given radius
veg_cmb	Vegetation class at the point count station
size_cmb	Size class at the point count station
density_cmb	Density class at the point count station
pdens (classes 1, 2, or 3)	Percent of CWHR forest density class within the given radius.
psize (classes 2, 3, 4, or 5)	Percent CWHR forest size class within the given radius.
cdens class 2 or 3	Cohesion index for given density class within the given radius
csize class 4 or 5	Cohesion index for given size class within the given radius
cforest	Cohesion index for combined forest types (red fir, white fir, mixed conifer, ponderosa pine dominated) within the given radius
ed5_open	Edge density of combined open vegetation types (shrub, riparian/meadow, burn, unvegetated) within 500 meters
eddens5_1	Edge density of CWHR density class 1 within 500 meters

Appendix D. PRBO codes, habitat types, and CHWR types by code used for defining habitat at the location of each point count station. Habitat at the point was derived from the Vestra GIS vegetation map.

Vegetation Codes	Habitat Type	CWHR Types Included
24	Shrub & Plantation	CX, FBX, FXC
25	Riparian or Meadow	GM, HA, RIP, GP
26	Hardwoods	HB, HL, HT
27	Ponderosa Pine Dominated	PP
28	Mixed Conifer Dominated	DMC, MC, PMC
29	White Fir Dominated	WMC, TF
30	Red Fir Dominated	RF
31	Unvegetated	NW, NU, NR, NB
33	Burned	FBX
36	Combined Open types	GM, HA, RIP, GP
35	Combined Forest types	RF,WFD,MC,PPD
32	other	LP, GP
Size Codes		**Size Types**
2	Small	Size 2
3	Medium-Small	Size 3
4	Medium- Large	Size 4
5	Large	Size 5 - 6
Density Codes		**Density Classes**
1	Open	P
2	Moderate	M
3	Dense	D

OUTREACH AND PUBLICATIONS

Publications in Prep

Landscape effects on songbird abundance in the Northern Sierra – submitted March 2008 – Journal of Wildlife Management.

Avian community composition in the context of Spotted Owl management in the Sierra Nevada – submitted April 2008 – Forest Ecology and Management.

Habitat use and productivity of two shrub dependent bird species in clear cut plantations in the Sierra Nevada – submitted spring 2008 – The Condor.

Short-term response of the avian community to Aspen enhancement timber harvest treatments – submitted summer 2008 – Restoration Ecology.

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.

Managing Disturbance Associated Habitats for Birds in the Sierra Nevada – invited oral presentation – Region 5 Forest Management Conference – 2/6/08 – Reno, NV.

Managing Aspen Habitat for Birds in the Sierra Nevada– invited oral presentation at: Aspen Delineation Project – Aspen Workshop – 9/12/2007 – Lassen National Forest.

Ecological Significance of Lake Almanor Meadows to Birds – oral presentation at Almanor Basin Watershed Advisory Committee Workshop on meadow management – 8/7/07 - Chester, CA.

Using Birds to Guide Forest Management in the HFQLG Area: Results from 2002 – 2006 – invited oral presentation – USFS Region 5 biologist conference – 5/23/07 - Sacramento, CA & PLAS symposium 3/2007.

Other 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 7/22/07.

Sierra Nevada Conservancy Field Trip – 5/1/2007 – Westwood, CA.

Aspen Workshop – invited to participate in the event co-sponsored by the Lassen National Forest, Aspen Delineation Project, and Sierra Forest Legacy – 9/13/2007.

Led Plumas Audubon Society Field Trip – 10/3/2007 – Chester, CA.

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 – 7/25/2007, 8/8/2007.

Integration with Management

We provided input to several important Forest Service projects in 2007 in an effort to integrate our results to help guide forest management in the Sierra Nevada. In addition we:

1. Updated the "Interactive GIS Project" with 2007 avian monitoring data. This product can be used by forest planners in the region to determine the presence/absence or abundance of all species detected in the study area.

2. Updated the Lassen National Forest interactive GIS CD with presence/absence data of each woodpecker species at every point count station ever surveyed by PRBO in the district. We also conducted a tutorial of its application and use with ARD biologist Mark Williams.

3. Continued distribution with positive feedback for our white papers integrating avian monitoring data into science based recommendations for managing four important Sierra habitat types for birds.