Plumas-Lassen Area Study Module on Landbird Abundance, Distribution, and Habitat Relationships

2006 Annual Report

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EXECUTIVE SUMMARY

In this document we report on the avian module of the Plumas-Lassen Area Study (PLAS). In 2006 we conducted our fifth year of monitoring. Information presented herein includes updated species richness and total bird abundance for all sites surveyed, final results from our analysis of avian community composition within several measures of Spotted Owl (SPOW) habitat, and analysis of population trends for 25 species in the study area from 2003 – 2006.

Species richness and total bird abundance in 2006 – when pooled across all sites – was the second lowest recorded between 2002 and 2006 and was similar to the lowest year for these indices, recorded in 2004. In contrast, in 2005 we recorded the highest richness and abundance indices of the five years.

Analysis of avian community composition in relation to SPOW habitat showed avian species richness and total bird abundance significantly higher outside of SPOW Core Areas. Nineteen of 25 species analyzed had a statistically significant relationship with at least one of the three measures of SPOW habitat. Thirteen of these were negative and six were positive. Five of the thirteen species were negative with all three measures and two of the six were positive with all three measures. The majority of those negatively associated with SPOW habitat areas are shrub or open forest dependent species.

Analysis of population trends from 2003 – 2006 showed that 14 of the 25 species analyzed were decreasing while eleven were increasing. Of these, six decreasing and four increasing trends were statistically significant. Four of the six species with significant declining population trends had a significant negative association with at least one measure of SPOW habitat. Decreasing species included: Hammond's Flycatcher, Mountain Chickadee, Red-breasted Nuthatch, Fox Sparrow, and Spotted Towhee. Three of the four species with increasing trends had a significant positive association with at least one measure of SPOW habitat. Increasing species included: Dusky Flycatcher, Golden-crowned Kinglet, Brown Creeper, and Hermit Warbler. The species with the largest per year population decline was the Pileated Woodpecker – a species strongly correlated with SPOW habitat. However, due to very small sample sizes this trend was not significant.

In 2006, we increased our outreach efforts and integrating with forest managers. We presented results at several conferences, created white papers on managing important Sierra Nevada habitats for birds, and worked on several forest service efforts to provide data for the new management indicator species direction. We have also updated our interactive GIS tool – for use by forest managers – with 2006 data.

INTRODUCTION

The Sierra Nevada is one of the most important ecosystems for birds in California (Siegel and DeSante 1999, CalPIF 2002). A century of intensive resource extraction and forest management practices here have put at risk the ecological stability and continued functionality of the system as a whole (SNEP 1996). Loss of habitat to intensive logging operations and human development, lack of replacement of old-growth stands due to harvest rotations of insufficient duration, changes in forest structure and species composition due to fire suppression, and removal of snags and dead trees are among the most detrimental impacts (SNEP 1996, CalPIF 2002). Birds and other wildlife populations have subsequently been altered by such changes; significant population declines have been observed in a number of species, some of which are now afforded special status at the federal or state level.

The Record of Decision (ROD) for the Sierra Nevada Forest Plan Amendment (SNFPA) and subsequent supplemental ROD (SNFPA 2001, SNFPA 2004) direct the Forest Service to maintain and restore old forest conditions that provide crucial habitat for a number of plant and animal species. The decision focuses attention and directs actions towards both protecting and creating habitat with old forest attributes, while providing substantial amount of harvestable timber. Simultaneously, the Forest Service is taking steps to reduce risks of catastrophic fire by reducing fuel loads in overstocked forests. Achieving all of these potentially competing goals will, at the very least, be a challenging task.

Here we report on the landbird study module of the Administrative Study, one of an integrated series of research efforts intended to evaluate land management strategies designed to reduce wildland fire hazard, promote forest health, and provide economic benefits within the area covered by the Herger-Feinstein Quincy Library Group Forest Recovery Act Pilot Project (HFQLG Pilot Project; see Stine et al. 2004).

Valuable feedback can be gained by determining how the full complement of the avian community responds to different forest management regimes, particularly at the landscape scale. If forest management practices encourage old forest development and forests across landscapes trend towards larger trees and higher canopy cover, how will birds other than the SPOW respond to these conditions?

The primary objective of the landbird module is to assess the impact of forest management practices in sustaining a long-term ecologically stable forest ecosystem at the local and landscape scales. We know, *a priori*, that the avian community is comprised of species that are associated with a wide range of forest seral stages, vegetative composition, and structures (SNEP 12996, CALPIF 2002, Burnett and Humple 2003). This habitat, and hence avian diversity, is due in large part to the natural ecological dynamics of these forest systems. Though humans have altered these systems, they continue to undergo non-human mediated changes through biological, geological, and stochastic processes. Therefore, it is imperative for managers to consider how these changes influence management actions temporally and spatially, and how ecological balance can be achieved in an inherently dynamic system.

In order to meet our primary objective of assessing the impacts of forest management practices on landbirds at local and landscape scales, we are addressing the following:

(1) Determine landbird habitat associations at the local scale.

(2) Determine landscape effects on bird habitat associations.

(3) Based on the results of objectives 1 and 2, develop predictive bird models to forecast how individual species may respond to forest management, particularly those planned as part of the HFQLG Pilot Project.

(4) Quantitatively assess the impacts of forest management treatments on avian abundance and species diversity.

(5) Identify population trends for landbirds to determine if populations are changing temporally.

(6) Evaluate population trends to assess factors responsible for observed trends.

This multiple-objective approach will allow us to interpret both the effects of specific management practices, the extent to which they influence the greater landscape (in the short-term), and the integrated effects of treatments and natural processes over time.

In addition to this study, PRBO has been monitoring songbird populations in the Northern Sierra Nevada since 1997. Since 2001, these efforts have aimed to complement the avian research of the Administrative Study within the HFQLG area. Specifically, these efforts have focused on avian response to meadow restoration and cessation of grazing, the viability of clear-cut regenerations in providing habitat for shrub dependent bird species, and avian response to aspen and black oak habitat enhancement (see Burnett et al. 2005a). Working closely with the project planners from Forest Service ranger district staff, these studies are being implemented as adaptive management experiments. This work should be seen as not only providing valuable data to guide forest management but also as models of effective collaboration between science and managers in administering public lands in the Sierra Nevada and beyond (Burnett *in press*).

METHODS

Avian Surveys

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

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

All birds detected at each station during the five-minute survey are recorded according to their initial distance from the observer. These detections are placed within one of six categories: within 10 meters, 10-20 meters, 20-30 meters, 30-50 meters, 50-100 meters, and greater than 100 meters. The method of initial detection (song, visual, or call) for each individual is also recorded. Using a variable radius point count allows us to conduct distance sampling. Distance sampling should enable us to provide more precise estimates of density and detectability of individual birds as well as account for some of the observer variability inherent in the point count sampling method (Buckland et al. 1993).

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

Treatment Unit and Transect Nomenclature

In this report we use the former treatment units (TUs) – those defined in the original Administrative Study plan – as functional units to analyze bird indices across aggregations of watersheds (see Appendices 1-7). These aggregations of watersheds no longer have any planned treatment in common; they are simply used here as a tool to describe geographically linked portions of the study area.

Transect naming protocols were different in 2002 than in 2003 and 2004. Transects established in 2002 under the previous study design are numbered transects (e.g., 222). The first number is the TU and the second and third numbers are the cover and size class, respectively, of the randomly-generated starting point (e.g. 214 is in TU-2, ands starts in forest designated as having cover class 1, and size class 4. In 2003 and 2004, under the existing study plan, new transects were named after the CalWater Planning Watershed (CalWater 1999). For example, SNK1 is in the Snake Lake watershed and is the first transect established there, while CHG3 is in the China Gulch watershed and was the third transect established there. The numeric ending is simply for designating between the different transects in the same watershed and does not have any additional significance.

2006 Survey Effort

In 2006 we surveyed 92 transects of 12 points each as well as the 72 additional owl territory points for a total of 1176 points (Table 1). Each site was surveyed twice for a total of 2352 point visits. All 72 owl points were surveyed in both 2005 and 2006. Of the remaining 1104 points, 348 have been surveyed consecutively since 2004, and 756 have been surveyed consecutively since 2003.

Field Crew Training

Point count crew members all have had previous experience conducting avian fieldwork and undergo extensive training onsite for two weeks prior to conducting surveys. Training consists of long hours in the field studying bird identification and conducting simultaneous practice point counts with expert observers. Each crew member is given an audio compact disc with the songs and calls of all of the local avifauna two months prior to their arrival at the study site to begin the training process early. Each person uses the CD to study the local birds and is then given quizzes each evening designed to test their knowledge of the songs and calls of the local birds. All observers must pass these tests and be 95% accurate on double observer point counts (compared to R. Burnett) before being allowed to begin surveying alone. Significant time is also given to calibrating each person in distance estimation. In addition each observer uses a laser range finder to calibrate distances at each point before starting an actual survey. Distance and bird identification calibration continues throughout the field season.

Statistical Analysis

We present the mean by point (average per point per visit) index for all analyses presented herein. For community indices we used a restricted list of species that excluded those that do not breed in the study area (Rufous Hummingbird, House Wren, Orange-crowned Warbler) or are not accurately censused using the point count method (e.g., raptors, waterfowl, grouse, nightjars, swallows, crows, ravens).

Species Richness

We define species richness as the total number of species detected within 50 meters of each point in a year divided by the number of visits to the site (two in all cases).

Diversity

We define species diversity as the mean number of species detected within 50 meters (species richness) weighted by the mean number of individuals of each species. A high diversity score indicates high ecological (species) diversity, or a more equal representation of the species. Species diversity was measured using a modification of the Shannon-Wiener index (Krebs 1989). We used a transformation of the usual Shannon-Weiner index (symbolized H′), which reflects species richness and equal distribution of the species. This transformed index, introduced by MacArthur (1965), is N_1, where $N_1 = 2^{H'}$. The advantage of N_1 over the original Shannon-Weiner metric (H′) is that N_1 is measured in terms of species instead of bits of information, and thus is more easily interpretable (Nur et al. 1999).

Abundance

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

Table 1. Extensive and DFPZ point count transects surveyed in the Plumas – Lassen Study in 2006.

Treatment Unit	Watershed	Code	Extensive Survey Points	DFPZ Survey Points	Owl Nest Stand Points
5	Grizzly Forebay	GRZ	41	0	2
5	Frazier Creek	FRC	45	0	4
5	China Gulch	CHG	36	0	0
5	Bear Gulch	BEG	41	0	5
5	Haskins Valley	HAV	38	0	2
5	Red Ridge	RED	31	5	0
5	**Unit Total**		**232**	**5**	**13**
4	Silver Lake	SIL	49	10	2
4	Meadow Valley Creek	MVY	47	3	2
4	Deanes Valley	DVY	36	4	4
4	Snake Lake	SNK	37	11	0
4	Miller Fork	MIL	39	25	4
4	Lower Knox Flat	LKF	36	0	2
4	Pineleaf Creek	PLC	31	12	0
4	**Unit Total**		**283**	**65**	**14**
3	Soda Creek	SOD	36	0	0
3	Rush Creek	RUS	50	5	12
3	Halsted Flat	HAL	36	0	0
3	Lower Spanish Creek	SPC	31	5	0
3	Black Hawk Creek	BLH	24	0	0
3	Indian Creek	IND	12	0	3
3	**Unit Total**		**189**	**0**	**15**
2	Mosquito Creek	MSQ	43	0	6
2	Butt Valley Reservoir	BVR	36	0	0
2	Ohio Creek	OHC	39	3	1
2	Seneca	SEN	57	5	8
2	Caribou	CAR	25	10	0
2	**Unit Total**		**200**	**18**	**15**
1	Upper Yellow Creek	UYC	24	22	7
1	Grizzly Creek	GCR	29	19	5
1	Butt Creek	BCR	24	13	3
1	Soldier Creek	SCR	0	12	0
1	**Unit Total**		**77**	**66**	**15**
	Grand Total		**959**	**145**	**72**

Spotted Owl Habitat Avian Community Analysis

Using the full set of point count locations – where treatment has not yet occurred – we compared the abundance of 25 avian species and several measures of avian community with three measures of SPOW habitat. The three measures of SPOW habitat were: inside vs. outside of Core Areas (Core), inside of Protected Activity Centers (PACs) vs. outside of Core, and direct line distance from the nearest known owl nest. For the purposes of this analysis and discussion we define the Core as the 1000-acre protected area around the nest, which includes the 300-acre PAC and the additional 700 acre Core. We used existing digitized PAC, Core, and SPOW nests locations - provided by the Plumas and Lassen National Forest - in a GIS environment to delineate each of our point count locations as being inside or outside of PAC and/or Core and to calculate distance from nests (ESRI 2000). We only used known SPOW nest locations from 2002 – 2004 in the PLAS study area as documented by the Plumas Lassen SPOW admin study and the Lassen Demography Study.

Dependent variables included the twenty most abundant species in the study area (based on point count detections), five uncommon to rare species of special interest, species richness, Shannon-Weiner index of diversity, total bird abundance, and the total abundance of individuals within each of the three primary nesting guilds (tree, shrub, and cavity; see table 2). Ground nesting species were not included in the nesting guild analysis.

Table 2. The abundance of the twenty most abundant species (based on per point detections) and five species of special interest and their respective nesting location in the PLAS study area in 2005 and 2006 (mean per point per year across visits).

Species	Mean Abundance Per Point	Nesting Guild
Hermit Warbler	1.34	Tree
Oregon Junco	0.72	Ground
Nashville Warbler	0.62	Ground
Audubon's Warbler	0.61	Tree
Dusky Flycatcher	0.60	Shrub
Mountain Chickadee	0.57	Cavity
Golden-crowned Kinglet	0.55	Tree
Western Tanager	0.42	Tree
Fox Sparrow	0.29	Shrub
Red-breasted Nuthatch	0.29	Cavity
Brown Creeper	0.26	Cavity
Hammond's Flycatcher	0.25	Tree
Cassin's Vireo	0.19	Tree
Warbling Vireo	0.18	Tree
MacGillivray's Warbler	0.17	Shrub
Stellar's Jay	0.13	Tree
American Robin	0.11	Tree
Black-headed Grosbeak	0.10	Tree
Spotted Towhee	0.09	Shrub/Ground
Calliope Hummingbird	0.08	Shrub
Species of Special Interest		
Red-breasted Sapsucker	0.04	Cavity
Olive-sided Flycatcher	0.04	Tree
Western Wood - Pewee	0.03	Tree/Snag
Chipping Sparrow	0.03	Tree/Shrub
Pileated Woodpecker	0.01	Cavity

We used 2005 and 2006 raw point count detections from within 50 meters of the observer for analysis of both community indices and the 20 most abundant species. For the five species of management concern, we used detections within 100 meters to increase power to detect differences. Using detections within 100 meters increased mean per point abundances for each of these five species to 0.10 – approximately the same as the mean per point abundance of the least common of our 20 most abundant species.

We examined the relationship between each dependent variable with three measures of SPOW habitat using negative binomial regression (Stata Corp 2005). This procedure can be used to model count data when Poisson estimation is inappropriate due to overdispersion (Cameron and Trivedi 1998). Negative binomial regression was preferred over Poisson regression based on a Poisson Goodness of Fit test for all but one species, Pileated Woodpecker (Stata Corp. 2005).

We examined interactions with year by including a year term in each model and then comparing those to models with only the main effect using a Likelihood Ratio test (Stata Corp 2005). We found significant interactions with year for a number of species, however, in each case the relationship with the independent variable (measure of SPOW habitat) was significant in the same direction in both years with only the magnitude of the relationship (i.e. slope of the line) being different. Thus we felt it was appropriate to consider both years together. For community indices we used linear regression instead of negative binomial and then followed the same procedure listed above.

Comparing SPOW PAC and Core to outside of Core we generated a binomial response variable coded (1 for inside of PAC or Core and 0 for outside of PAC and Core). For the analysis of distance from known SPOW nest we used a transformed index of continuous distance from known nest – the natural log of the inverse distance [$\ln(1 \div \text{distance})$]. Since negative binomial regression log transforms dependent variables we log transformed distance from known nest to make them comparable scales. Graphs of all significant relationships are presented with mean per distance interval and best fit line. Probability statistics presented on graphs are those generated from negative binomial regression. In several cases we fit trends using second or third order polynomials as they better represented the apparent relationship with abundance and distance from nest for those species. Note that graphs show mean abundance per distance bin and that not all bins are of equal distance intervals. We assumed statistical significance at the 0.05 alpha level for all analyses though for PAC and Core analyses we presented the probability statistic for all values of alpha <0.15; all other values are represented as NS (non-significant).

Four Year Trend Analysis

We analyzed annual linear trends (annual rate of change) for the twenty most abundant species (based on point count detections) and the five species of special interest discussed above. We generated estimates of annual rate of change using the incident rate ratio option with negative binomial regression (Stata Corp. 2005). Statistical significance was assumed at an alpha level of 0.05. For all species showing a significant trend, graphs of estimated trend lines are presented. While several trends appear to deviate from linear (non-constant rate of change), with only four years of data, we did not attempt to fit higher order models for these species even if the data appeared to support one. Each graph also contains the mean abundance per year (summed across visits) with standard error bars.

RESULTS

Overview

We determined breeding bird species richness and abundance at all sites surveyed in 2006 (Table 3), and included indices for these same transects from all previous years they were surveyed (2002-2005). For the location of each transect we refer you to the supplemental GIS project available on compact disc from the authors. In 2006, total bird abundance ranged from 1.54 on the 422 transect to 6.46 on RED 2. Species richness ranged from 2.17 on the D409 transect to 8.83 on the RED 2 transect. Mean species richness and total bird abundance for all extensive transects combined in 2006 was 5.09 and 3.60, respectively. Overall total bird abundance and species richness across all years (2003 – 2006) was highly correlated (r^2= 0.76, p<0.001).

Table 3. Mean abundance and species richness for all point count transects surveyed by PRBO in the Plumas/Lassen area study, 2002-2006. NS stands for not surveyed. Locations of all transects can be obtained in the CD supplement.

Transect	Unit	Abundance					Richness				
Extensive		**2006**	**2005**	**2004**	**2003**	**2002**	**2006**	**2005**	**2004**	**2003**	**2002**
114	1	3.54	6.38	5.67	3.58	7.63	4.67	6.50	6.00	4.58	8.42
BCR1	1	3.63	4.54	2.41	NS	NS	5.33	6.33	3.73	NS	NS
UYC1	1	2.71	3.58	5.18	NS	NS	4.25	5.41	6.33	NS	NS
GCR1	1	3.67	5.00	2.75	NS	NS	5.67	5.83	4.17	NS	NS
GCR2	1	2.83	3.71	3.71	NS	NS	4.17	5.58	4.92	NS	NS
HSRF	1	2.92	6.00	3.88	NS	NS	4.67	8.16	5.75	NS	NS
Subtotal	**1**	**3.22**	**4.87**	**3.93**			**4.79**	**6.30**	**5.06**		
213	2	3.88	4.54	2.38	5.13	1.89	5.00	6.17	2.92	6.17	2.29
214	2	2.21	4.71	1.42	1.63	3.92	3.50	6.42	2.08	2.25	5.58
222	2	3.88	3.95	3.50	5.25	4.46	5.50	5.25	5.17	7.58	6.08
223	2	5.54	5.83	3.63	6.29	6.04	6.25	6.25	4.50	7.33	8.58
224	2	2.50	3.92	2.67	3.21	4.50	3.50	4.83	4.17	4.33	6.08
MSQ1	2	3.17	4.75	2.17	2.79	NS	4.83	5.58	3.16	4.08	NS
MSQ2	2	4.13	3.67	2.17	2.75	NS	4.92	4.50	3.33	3.50	NS
BVR1	2	4.67	4.83	4.08	5.17	NS	6.17	6.50	5.42	5.42	NS
BVR2	2	4.25	5.96	5.96	3.63	NS	6.25	7.33	7.17	5.33	NS
BVR3	2	2.71	4.92	3.54	4.67	NS	4.08	6.25	4.75	6.25	NS
OHC1	2	4.38	6.88	3.17	3.00	NS	5.92	7.67	4.00	4.33	NS
OHC2	2	2.38	4.13	1.64	4.08	NS	4.08	6.33	2.55	5.58	NS
SEN1	2	2.92	2.88	2.25	3.00	NS	3.92	4.08	3.75	4.08	NS
CAR1	2	3.46	5.75	4.17	3.42	NS	4.08	6.50	5.67	4.42	NS
CAR2	2	3.54	5.54	3.63	2.50	NS	5.17	7.00	5.33	3.83	NS
CAR3	2	1.88	4.17	1.91	NS	NS	2.58	4.50	2.82	NS	NS
Subtotal	**2**	**3.47**	**4.78**	**3.02**	**3.77**		**4.73**	**5.95**	**4.17**	**4.97**	
313	3	5.75	5.50	6.08	7.58	3.67	8.42	7.50	8.25	10.00	5.08
314	3	2.67	5.17	3.88	4.42	4.08	4.00	6.50	5.50	6.42	3.75
322	3	4.83	5.25	5.58	3.38	4.63	6.58	7.67	7.00	5.17	6.58
323	3	2.79	3.92	2.46	2.79	5.33	4.08	5.67	4.00	4.67	7.92
324	3	3.29	5.21	4.63	3.83	4.54	4.92	6.00	5.25	5.17	6.83
BLH1	3	3.00	3.92	2.09	2.42	NS	3.42	5.08	3.36	3.25	NS
BLH2	3	2.25	2.71	3.55	NS	NS	3.58	4.00	4.73	NS	NS

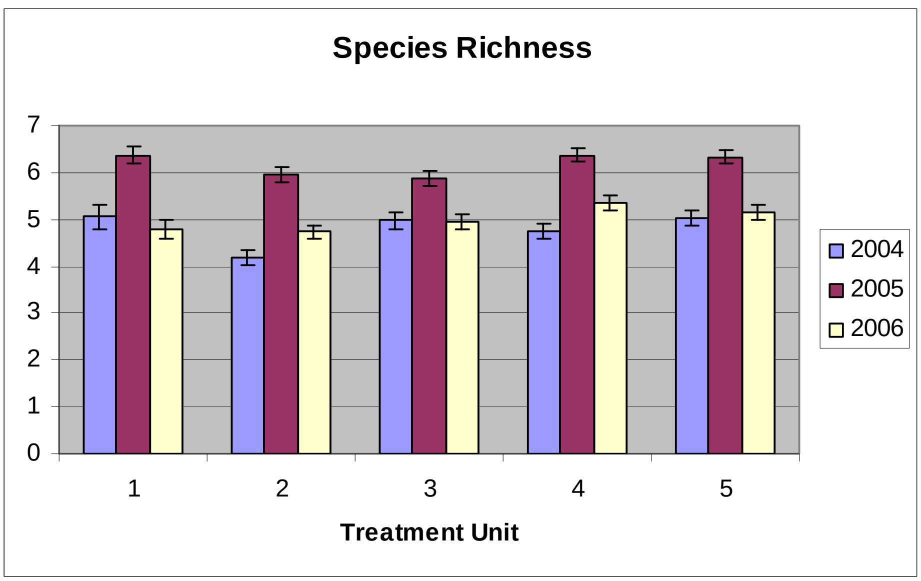
HAL1	3	3.67	4.08	2.50	3.46	NS	5.67	5.83	3.92	5.58	NS
HAL2	3	5.00	4.50	3.00	3.92	NS	5.58	5.08	3.58	5.17	NS
HAL3	3	2.96	7.33	3.25	6.96	NS	4.83	8.17	4.67	7.67	NS
IND1	3	2.29	4.96	2.83	4.13	NS	3.83	6.83	4.50	5.50	NS
RUS1	3	4.00	5.04	5.79	5.83	NS	5.75	6.42	6.92	7.75	NS
SOD1	3	2.63	3.67	3.92	NS	NS	4.25	4.83	5.75	NS	NS
SOD2	3	5.17	4.04	2.75	NS	NS	6.67	6.58	4.17	NS	NS
SOD3	3	2.42	1.38	0.63	NS	NS	3.83	2.16	1.17	NS	NS
SPC1	3	3.42	3.79	3.13	3.29	NS	4.58	5.08	4.33	4.75	NS
SPC2	3	3.33	5.04	2.21	4.25	NS	4.25	6.00	3.50	5.75	NS
Subtotal	**3**	**3.50**	**4.47**	**3.43**	**4.33**		**4.96**	**5.88**	**4.74**	**5.91**	
413	4	5.21	5.29	4.83	2.83	5.83	7.17	6.83	6.33	2.58	7.83
414	4	6.13	4.42	4.75	4.38	6.79	7.17	6.25	6.08	6.50	8.58
422	4	1.54	5.36	3.71	4.54	4.29	2.50	6.42	4.58	5.42	5.92
423	4	4.88	5.04	3.58	3.29	4.58	6.33	5.92	4.92	4.50	6.75
424	4	4.96	4.25	3.54	5.46	5.75	6.75	5.75	5.33	7.42	8.00
MIF1	4	4.17	5.79	3.29	4.00	NS	6.08	6.75	4.25	5.50	NS
MIF2	4	6.25	5.50	3.00	5.67	NS	8.67	7.50	4.25	7.42	NS
MIF3	4	4.33	7.21	3.54	5.21	NS	5.42	7.25	4.50	6.17	NS
D404	4	4.21	5.00	3.35	6.50	4.96	5.67	6.25	5.00	8.33	7.08
D405	4	4.21	4.67	3.35	4.79	4.46	6.17	6.50	4.90	7.00	6.50
LKF1	4	4.54	5.04	2.96	NS	NS	6.50	6.58	3.42	NS	NS
LKF2	4	1.67	3.42	3.83	NS	NS	2.75	4.50	4.92	NS	NS
LKF3	4	3.25	4.21	5.13	NS	NS	5.00	5.58	6.75	NS	NS
MVY1	4	3.13	6.08	3.29	4.75	NS	4.50	7.42	4.33	6.92	NS
MVY2	4	4.00	5.92	3.79	5.58	NS	5.83	6.83	5.17	7.08	NS
PLC1	4	3.21	5.46	3.71	NS	NS	4.83	7.25	5.67	NS	NS
SIL1	4	5.79	6.96	3.08	5.17	NS	7.50	8.00	4.42	6.67	NS
SIL2	4	2.92	6.04	6.83	5.13	NS	3.75	7.17	7.08	7.17	NS
SIL3	4	2.00	3.25	2.46	2.29	NS	2.75	4.25	3.17	3.75	NS
SNK1	4	4.25	5.04	2.38	4.25	NS	4.92	6.58	3.75	5.50	NS
SNK2	4	3.04	4.08	2.33	4.54	NS	4.58	5.17	3.33	6.33	NS
SNK3	4	2.63	5.25	1.71	NS	NS	4.08	6.17	2.67	NS	NS
Subtotal	**4**	**3.92**	**5.15**	**3.57**	**4.61**		**5.41**	**6.41**	**4.77**	**6.13**	
513	5	3.63	4.79	6.79	3.00	5.38	4.25	6.58	7.67	4.33	6.92
514	5	3.71	4.38	4.08	5.75	2.46	5.58	6.58	5.58	5.17	4.25
522	5	2.29	5.25	3.17	5.63	5.50	3.50	6.00	4.42	7.25	7.67
523	5	2.29	5.50	2.42	3.33	3.54	3.92	7.00	4.00	5.75	5.25
524	5	3.75	5.17	3.04	2.79	4.42	5.58	6.33	4.92	4.08	6.42
BEG1	5	2.04	4.21	1.96	3.42	NS	3.17	5.75	3.25	4.42	NS
CHG1	5	4.00	3.58	2.46	3.46	NS	6.08	4.92	3.58	5.08	NS
CHG2	5	4.38	4.88	3.17	6.67	NS	6.08	6.08	4.33	8.25	NS
CHG3	5	2.58	4.38	5.79	3.54	NS	4.00	6.00	7.25	5.17	NS
FRC1	5	4.00	4.88	2.96	5.25	NS	6.25	6.50	4.67	7.08	NS
GRZ1	5	2.33	3.29	2.58	3.92	NS	3.50	4.25	3.50	4.92	NS
GRZ2	5	3.88	4.25	3.96	3.58	NS	5.33	5.75	5.75	5.67	NS
GRZ3	5	3.21	6.96	3.38	4.71	NS	4.83	6.00	5.08	7.08	NS
RED1	5	3.50	4.96	4.42	4.75	NS	5.00	6.83	5.67	5.92	NS
RED2	5	6.46	5.58	3.38	3.00	NS	8.83	7.50	4.92	5.08	NS
RED3	5	4.17	4.71	3.92	4.13	NS	6.75	7.00	5.83	6.25	NS

D501	5	4.96	5.50	2.35	4.21	NS	7.08	6.67	3.40	5.75	NS
HAV1	5	2.96	5.17	3.42	5.75	NS	5.00	7.00	4.92	7.67	NS
HAV2	5	3.38	4.33	3.42	4.92	NS	4.92	6.92	5.08	7.25	NS
Subtotal	**5**	**3.55**	**4.83**	**3.51**	**4.31**		**5.24**	**6.30**	**4.94**	**5.90**	
Extensive Total		**3.60**	**4.83**	**3.50**	**4.25**		**5.09**	**6.17**	**4.77**	**5.73**	
DFPZ											
D102	1	3.29	5.08	2.42	3.54	5.29	4.92	6.42	2.75	5.00	5.92
D107	1	5.63	5.83	3.63	3.50	4.25	7.25	6.92	5.50	5.25	6.17
D108	1	2.67	5.25	6.09	NS	5.89	4.42	6.83	7.25	NS	4.67
D110	1	4.63	4.63	2.79	NS	NS	7.00	6.25	4.08	NS	NS
D111	1	4.29	4.88	3.42	NS	NS	5.75	6.58	5.33	NS	NS
D112	1	3.92	4.58	5.46	NS	NS	4.50	5.67	7.08	NS	NS
Subtotal	**1**	**4.07**	**5.04**	**3.97**	**3.52**	**5.14**	**5.64**	**6.45**	**5.33**	**5.13**	**5.59**
D401	4	4.58	6.04	2.30	4.21	6.79	6.58	7.67	3.33	5.00	8.75
D402	4	4.63	4.26	3.05	4.13	4.71	7.08	5.83	4.50	5.58	6.75
D403	4	5.13	4.21	1.85	3.79	3.71	7.25	5.75	2.45	5.58	5.42
D407	4	4.25	6.04	3.00	3.46	4.42	6.58	7.75	4.83	5.33	6.33
D408	4	3.63	4.67	3.70	5.88	4.50	5.42	6.08	5.08	7.58	6.75
D409	4	1.79	3.38	2.00	1.92	NS	2.17	4.42	2.73	3.00	NS
DFPZ	**4**	**4.00**	**4.77**	**2.65**	**3.90**	**4.83**	**5.85**	**6.25**	**3.82**	**5.35**	**6.80**

Species Richness by Treatment Unit

We compared species richness between treatment units and years (Figure 1). In 2006 richness ranged from 4.73 species detected per point in Unit Two to 5.35 in Unit Four.

Figure 1. Avian species richness (mean per point per visit) by treatment unit in 2004 – 2006 in the Plumas Lassen Study Area (+ standard error).



All five units showed a significant decrease (p<0.05) in mean richness between 2005 and 2006. However, richness was not significantly lower in any unit in 2006 compared to 2004, though it was significantly higher in Unit Two. Richness declined 25% in Unit One between 2005 and 2006; the largest decline of any of the five units.

Four Year Trends in Species Abundance

Of the 25 species for which we analyzed linear trends in abundance from 2003 to 2006, 14 had a decreasing trend while 11 were increasing (Table 4). Six of the 14 decreasing trends and three of the 11 increasing trends were statistically significant (p<0.05). Three additional species, two positive and one negative, had trends significant at the alpha = 0.10 level. Species with significant negative trends (p<0.05) from 2003 – 2006 were: Hammond's Flycatcher, Mountain Chickadee, Red-breasted Nuthatch, Audubon's Yellow-rumped Warbler, Spotted Towhee, and Fox Sparrow. Species with significant increasing trends were: Dusky Flycatcher, Golden-crowned Kinglet, Brown Creeper, and Hermit Warbler.

Table 4. Estimated annual linear trends in abundance for the twenty five species in the Plumas Lassen Study area from 2002 – 2006. Species are listed in taxonomic order (AOU 2006).

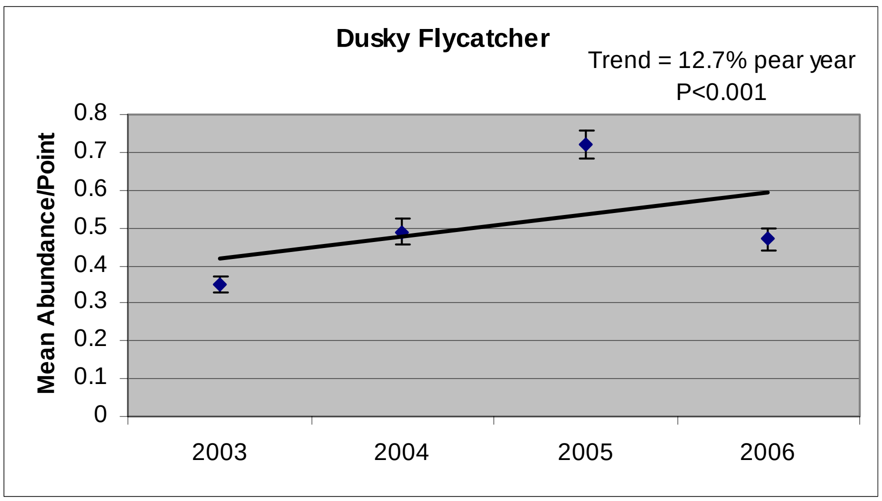
		95% Confidence Interval	
Species	**Trend (%)**	**Low**	**High**
Hairy Woodpecker	-10.1	-22.8	4.7
Red-breasted Sapsucker	-6.6	-20.6	9.8
Pileated Woodpecker	-26.2+	-45.9	0.8
Hammond's Flycatcher	-19.4***	-25.8	-12.5
Dusky Flycatcher	12.7***	6.2	19.6
Western Wood-Pewee	10.8	-9.7	35.9
Olive-sided Flycatcher	-8.8	-23.7	8.9
Cassin's Vireo	2.6	-5.2	11.0
Warbling Vireo	2.4	-7.2	13.1
Steller's Jay	0.2	-10.1	11.7
Mountain Chickadee	-9.2***	-14.0	-4.1
Red-breasted Nuthatch	-19.9***	-25.1	-14.3
Brown Creeper	6.4+	-0.6	13.9
Golden-crowned Kinglet	10.3***	5.6	16.3
American Robin	-1.1	-10.1	10.0
Nashville Warbler	4.2	-1.4	10.0
Audubon's Warbler	-7.4***	-11.6	-3.1
Hermit Warbler	11.7***	6.5	15.0
MacGillivray's Warbler	-4.4	-11.9	7.7
Western Tanager	-0.6	-6.0	5.2
Spotted Towhee	-14.0*	-23.8	-2.9
Chipping Sparrow	27.8+	-4.06	70.0
Fox Sparrow	-10.5**	-17.7	-2.8
Oregon Junco	2.7	-1.8	7.4
Black-headed Grosbeak	-4.2	-14.7	7.5

***** = p<0.05, ** = p<0.01, *** = p<0.001, + = p<0.1

Of the five species of special interest included here, two showed an increasing trend (Chipping Sparrow, Western Wood-Pewee) and three a decreasing trend (Pileated Woodpecker, Red-breasted Sapsucker, and Olive-sided Flycatcher).

Annual rate of change (% per year) ranged from -26.2% for Pileated Woodpecker to +27.8% for Chipping Sparrow; due to low sample sizes – for both these species – their trends were only significant at the alpha = 0.10 level. For species with significant trends, it ranged from a -19.9% decline for Red-breasted Nuthatch, to 11.8% increase for Hermit Warbler (Table 4 and Figures 2 & 3). Abundance of all decreasing species was lower in 2006 than any of the previous three years; for several species - Hammond's Flycatcher, Red-breasted Nuthatch, and Mountain Chickadee - 2006 was solely responsible for the decreasing population trend (Figure 3).

Figure 2. Linear trends for species with significant ($p < 0.05$) population increases in the PLAS study area from 2003 – 2006.



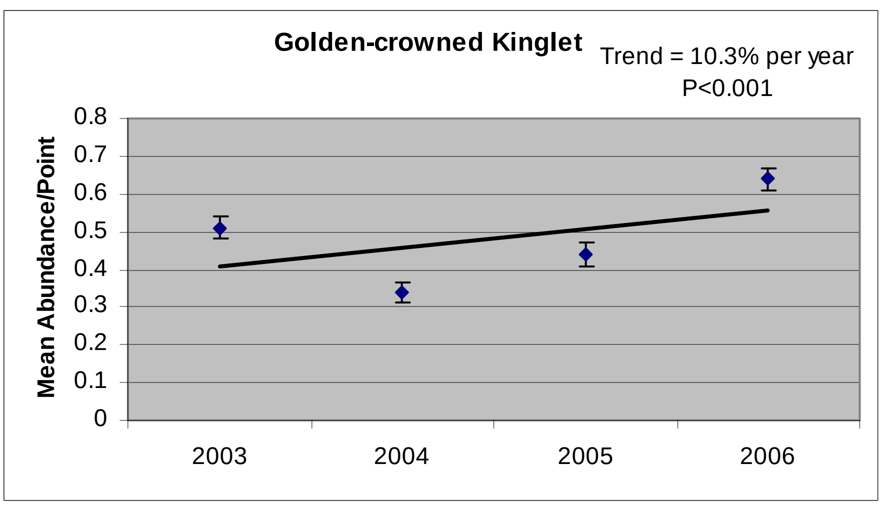
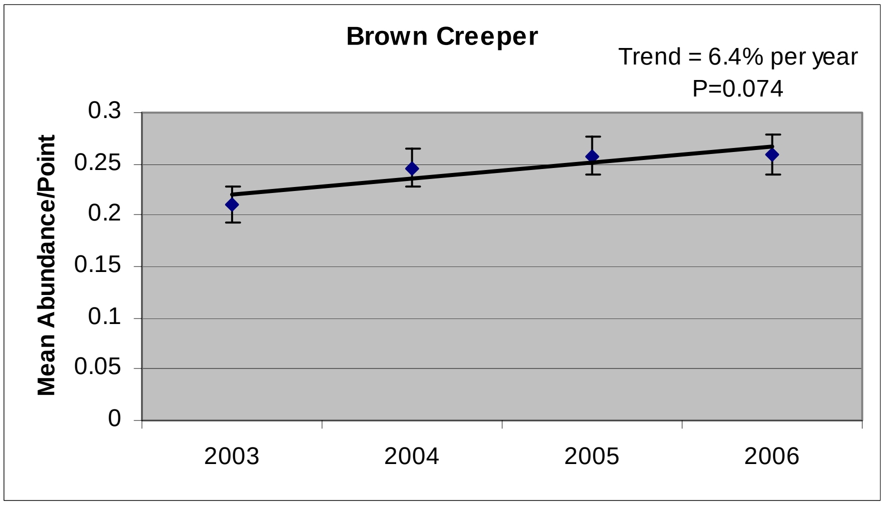


Figure 2. continued.



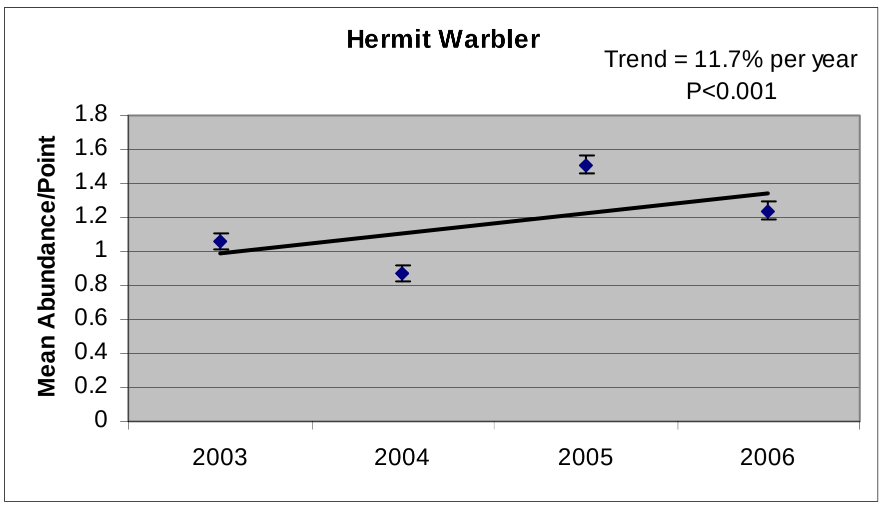
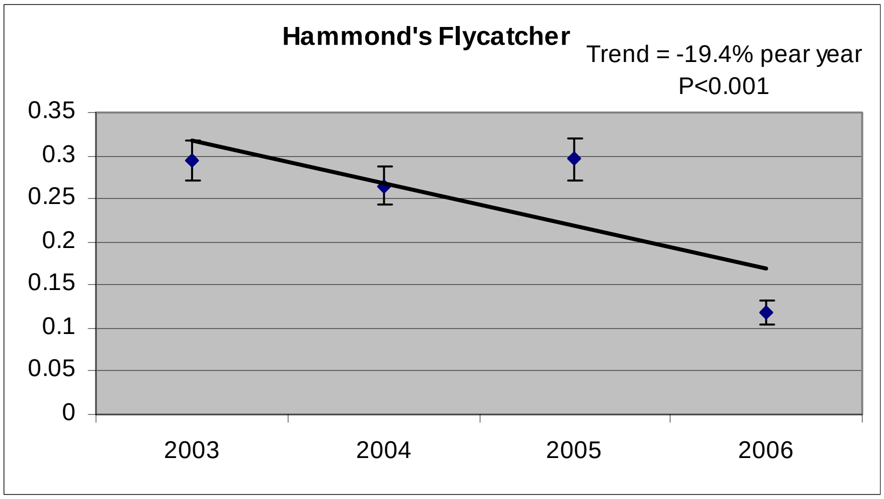
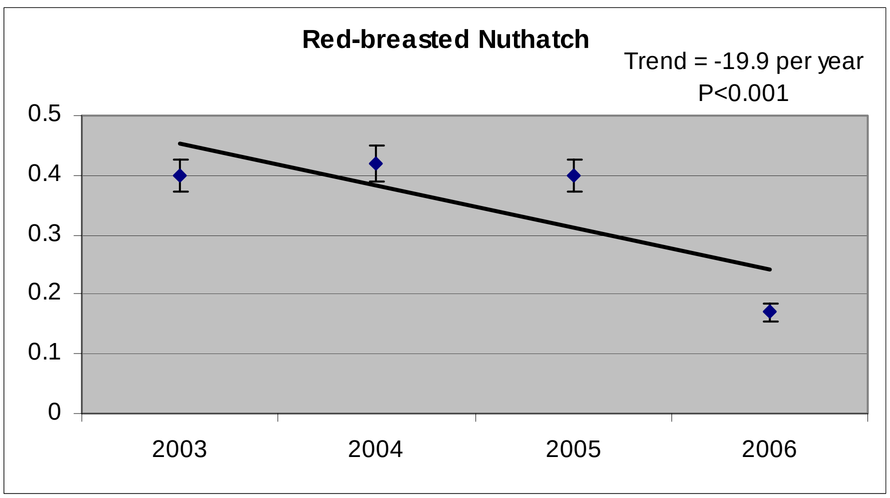


Figure 3. Linear trends of species showing significant (p< 0.05) population declines in the PLAS study area from 2003 – 2006.





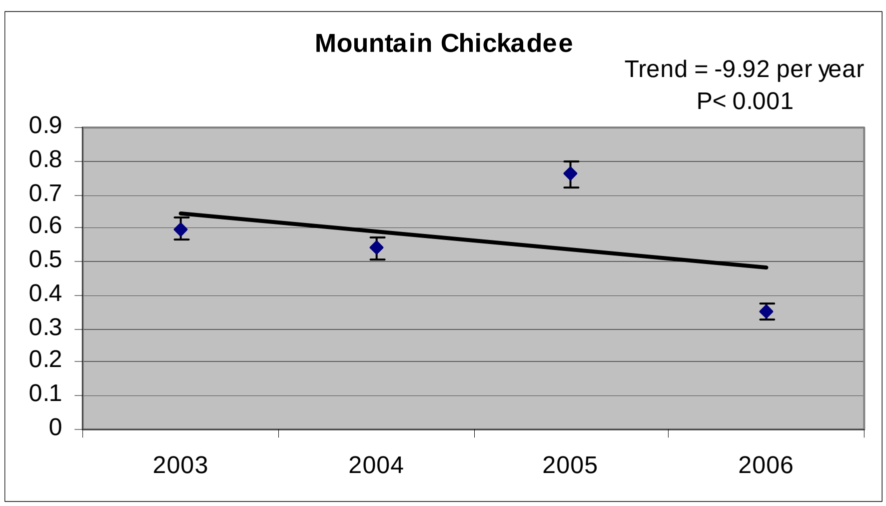
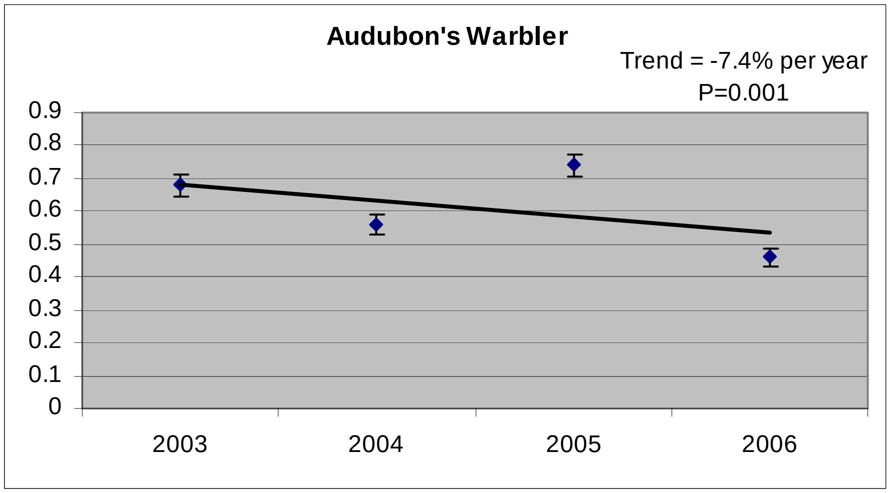
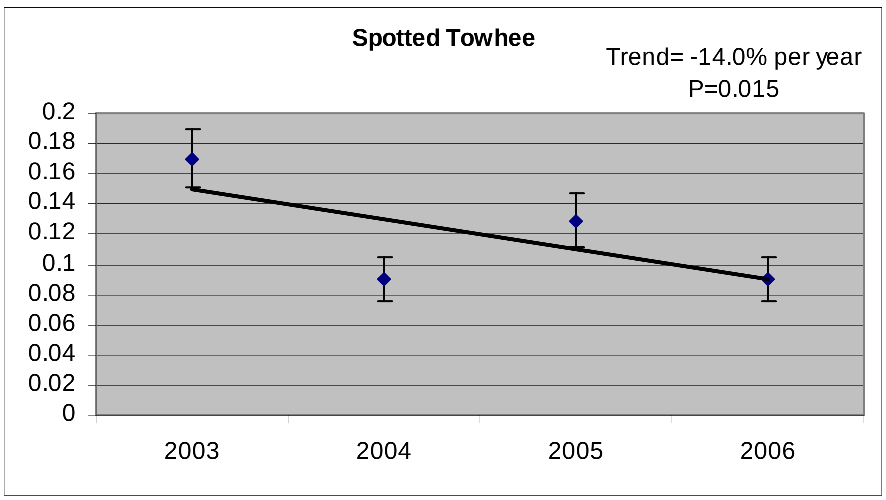
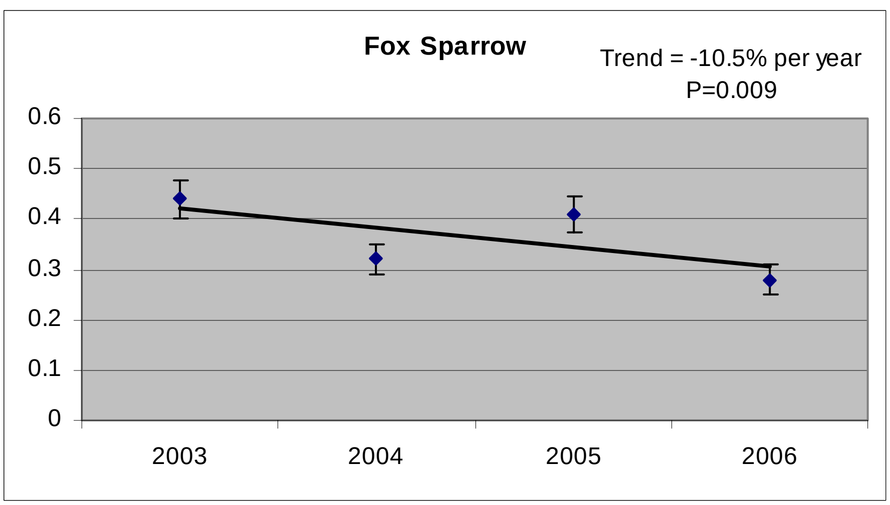


Figure 3 continued.







Avian Community Composition in Relation to Spotted Owl Habitat

Overview

19 of the 25 species and all six community indices analyzed showed a statistically significant relationship with at least one measure of SPOW habitat. Thirteen species had a negative association while six were positive. Five species were negative with all three measures, while two were positive with all three. All six community indices were significantly different with at least one measure of SPOW habitat, five negative and one positive.

Community Indices

Avian species richness, Shannon-Wiener index of diversity, and total bird abundance were all significantly higher outside of SPOW Core (see definition of Core in methods). Comparing the abundance of birds in each of three nesting guilds, the abundance of members of the tree nesting guild were significantly higher inside of Core while both shrub and cavity nesters were significantly more abundant outside (Table 5).

Comparing outside of Core to inside of PAC, species richness, diversity, total bird abundance, and abundance of cavity nesters were similar (ratios $\leq$ 1.04) with no statistically significant differences. Shrub nesters were still significantly more abundant outside of Core than inside PAC and tree nesters were still significantly more abundant inside of PAC, with ratios of 2.07 and 1.30 respectively.

Table 5. Six avian community indices in relation to Spotted Owl Core Areas in the PLAS study area in 2005 and 2006.

Index	Outside Core	Inside Core	Ratio	P
Species Richness	5.85	5.47	1.07	<0.001
Shannon Index of Diversity	5.36	4.99	1.07	<0.001
Total Bird Abundance	8.70	8.20	1.06	0.001
Shrub Nesters	1.79	0.86	2.08	<0.001
Cavity Nesters	1.37	1.24	1.10	0.026
Tree Nesters	3.90	4.63	0.84	<0.001

Species Abundance related to Pac and Core

Nine species were significantly more abundant outside of Core Areas than inside Core Areas (Table 6). Eight of these nine species showed the same relationship when comparing outside Core to inside PAC only (Table 7). Six species were significantly more abundant inside of Core; these same six species were also significantly more abundant inside of PAC. The highest ratios (abundance outside:inside) for species negatively associated with Core were: Fox Sparrow (4.18), Calliope Hummingbird (2.80), and Spotted Towhee (2.76). The highest ratios for species positively associated with Core (inside:outside) were: Hammond's Flycatcher (1.69), Hermit Warbler (1.64), Brown Creeper, and Pileated Woodpecker (both 1.59). Of the five species of special interest, three (Olive-sided Flycatcher, Western Wood-Pewee, and Chipping Sparrow) were negatively associated with Core, while Pileated Woodpecker was the only one with a positive association. The fifth species, Red-breasted Sapsucker, was equally abundant inside and outside of Core.

Table 6. The mean abundance per point per year of 25 avian species inside and outside of 1000 acre Spotted Owl Core Areas in the PLAS study area in 2005 & 2006. Ratios are the higher abundance divided by the lower abundance.

More Abundant Outside	Outside Core	Inside Core	Ratio	P
Fox Sparrow	0.460	0.110	4.18	<0.001
Calliope Hummingbird	0.112	0.040	2.80	<0.001
Spotted Towhee	0.127	0.046	2.76	<0.001
Olive-sided Flycatcher	0.208	0.103	2.02	<0.001
Dusky Flycatcher	0.769	0.411	1.87	0.001
Western Wood-Pewee	0.137	0.079	1.73	<0.001
MacGillivray's Warbler	0.202	0.130	1.55	<0.001
Mountain Chickadee	0.671	0.452	1.48	<0.001
Chipping Sparrow	0.099	0.074	1.34	0.076
Western Tanager	0.456	0.388	1.18	0.014
American Robin	0.118	0.105	1.12	NS
Audubon's Warbler	0.638	0.577	1.11	0.080
Steller's Jay	0.137	0.123	1.11	NS
Nashville Warbler	0.639	0.595	1.07	NS
Red-breasted Sapsucker	0.100	0.090	1.11	NS
Oregon Junco	0.740	0.695	1.06	NS
Red-breasted Nuthatch	0.294	0.289	1.02	NS
More Abundant Inside				
Pileated Woodpecker	0.022	0.035	1.59	0.023
Hammond's Flycatcher	0.185	0.313	1.69	<0.001
Hermit Warbler	1.028	1.682	1.64	<0.001
Brown Creeper	0.202	0.322	1.59	<0.001
Golden-crowned Kinglet	0.473	0.626	1.32	<0.001
Cassin's Vireo	0.177	0.214	1.21	0.002
Black-headed Grosbeak	0.091	0.110	1.21	NS
Warbling Vireo	0.172	0.179	1.04	NS

The analysis examining the differences between inside PAC vs. outside Core produced similar results to the inside versus outside of Core. For almost all species the difference in abundance was greater when we limited the measure of owl habitat to just the PAC. For example, Fox Sparrow went from 4.18 to 5.06 times more abundant outside while Pileated Woodpecker went from 1.59 to 2.17 times more abundant inside.

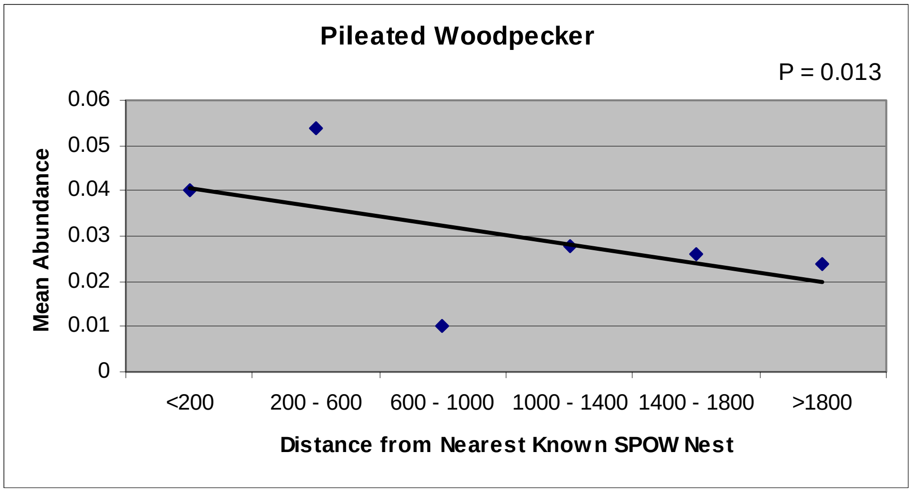
Table 7. The mean abundance per point per year of 25 avian species inside of 300 acre Spotted Owl Protected Activity Centers vs. outside of 1000 acre Core Areas in the PLAS study area in 2005 & 2006. Ratios are the higher abundance divided by the lower abundance.

More Abundant Outside	Outside Core	Inside Pac	Ratio	P
Fox Sparrow	0.460	0.091	5.06	<0.001
Spotted Towhee	0.127	0.030	4.23	<0.001
Calliope Hummingbird	0.112	0.048	2.33	0.001
Western Wood-Pewee	0.137	0.063	2.18	<0.001
Olive-sided Flycatcher	0.208	0.123	1.69	<0.001
Dusky Flycatcher	0.769	0.461	1.67	<0.001
American Robin	0.118	0.078	1.51	0.045
MacGillivray's Warbler	0.202	0.136	1.49	0.012
Mountain Chickadee	0.671	0.452	1.49	<0.001
Chipping Sparrow	0.099	0.067	1.48	0.117
Steller's Jay	0.137	0.102	1.34	0.130
Western Tanager	0.456	0.407	1.12	NS
Oregon Junco	0.740	0.669	1.11	NS
Nashville Warbler	0.639	0.597	1.07	NS
Audubon's Warbler	0.638	0.610	1.05	NS
Red-breasted Nuthatch	0.289	0.289	1.00	NS
More abundant inside				
Pileated Woodpecker	0.018	0.039	2.17	0.016
Hammond's Flycatcher	0.185	0.346	1.87	<0.001
Hermit Warbler	1.028	1.910	1.86	<0.001
Brown Creeper	0.202	0.396	1.96	<0.001
Golden-crowned Kinglet	0.473	0.688	1.46	<0.001
Cassin's Vireo	0.177	0.260	1.47	<0.001
Black-headed Grosbeak	0.091	0.123	1.35	NS
Warbling Vireo	0.172	0.199	1.16	NS
Red-breasted Sapsucker	0.100	0.106	1.06	NS

Distance from Known Spotted Owl Nests

Fewer species were significantly associated with distance from known SPOW nests than with either of the two measures of SPOW habitat discussed above (Figures 4 & 5). Two species, Pileated Woodpecker and Hermit Warbler, increased in abundance as you approached the nearest nest site, while the abundance of eight species significantly decreased. For four species – Olive-sided Flycatcher, Western Wood-Pewee, Chipping Sparrow, and Fox Sparrow – the relationship with distance appeared to be driven by a large increase in abundance beyond 1800 meters from nests (Figure 5). For all other species a linear relationship appeared to accurately portray the relationship.

Figure 4. Mean abundance per point count station across five distance intervals from SPOW nests, and fitted line of predicted values for species whose abundance significantly increases (p<0.05) as you approach SPOW nest sites in the PLAS study area in 2005 & 2006.



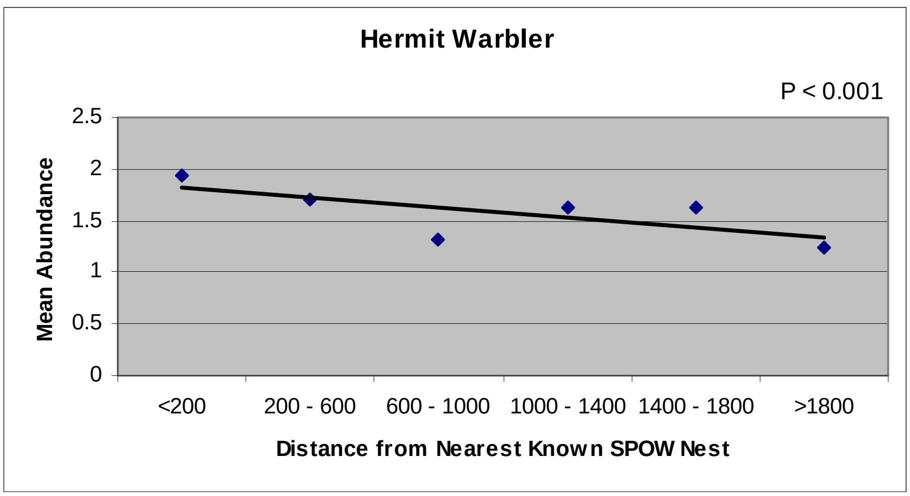
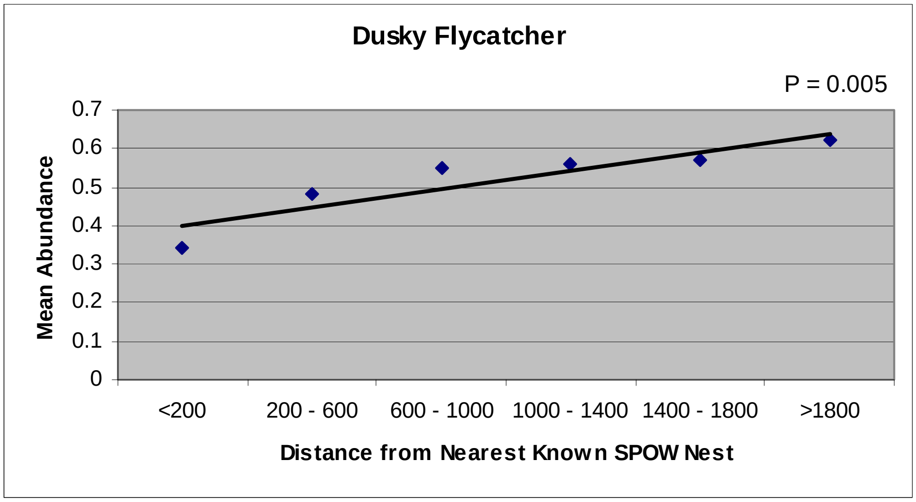
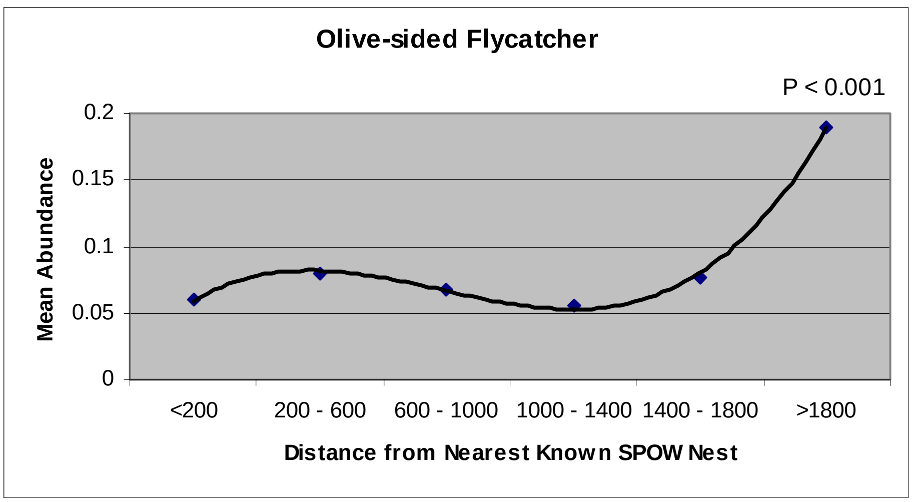
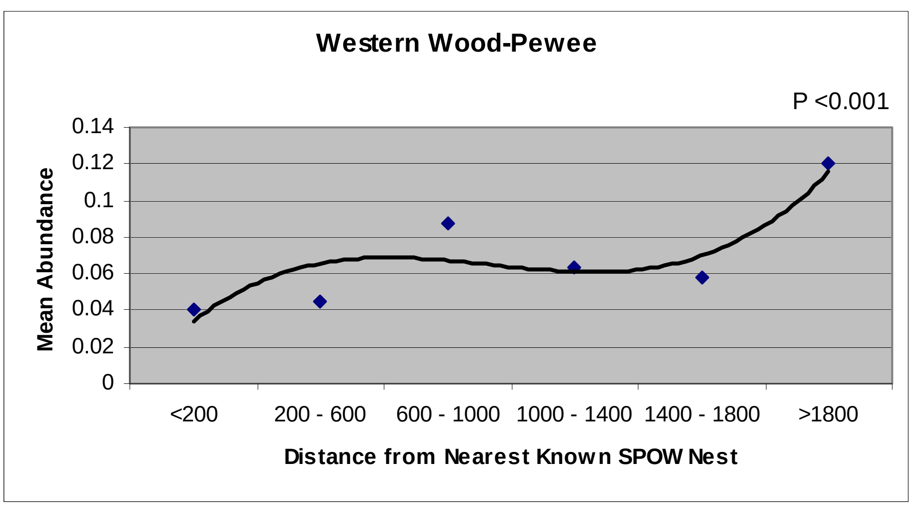


Figure 5. Mean abundance per point count station across five distance intervals, from SPOW nests, and fitted line of predicted values for species whose abundance significantly increases (p<0.05) as you move away from SPOW nest sites in the PLAS study area in 2005 & 2006.







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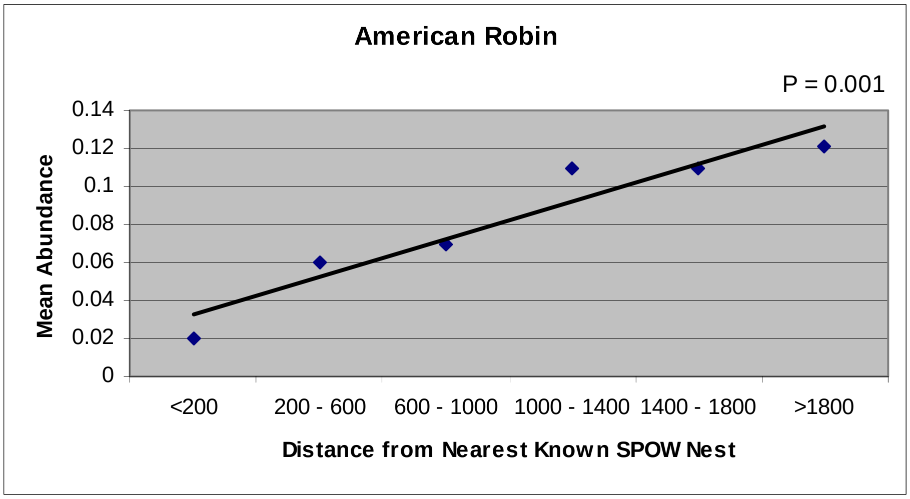

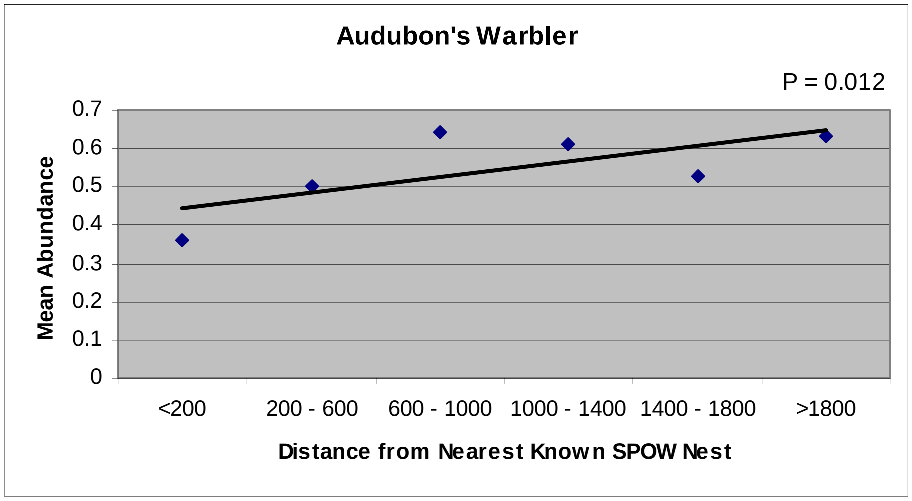

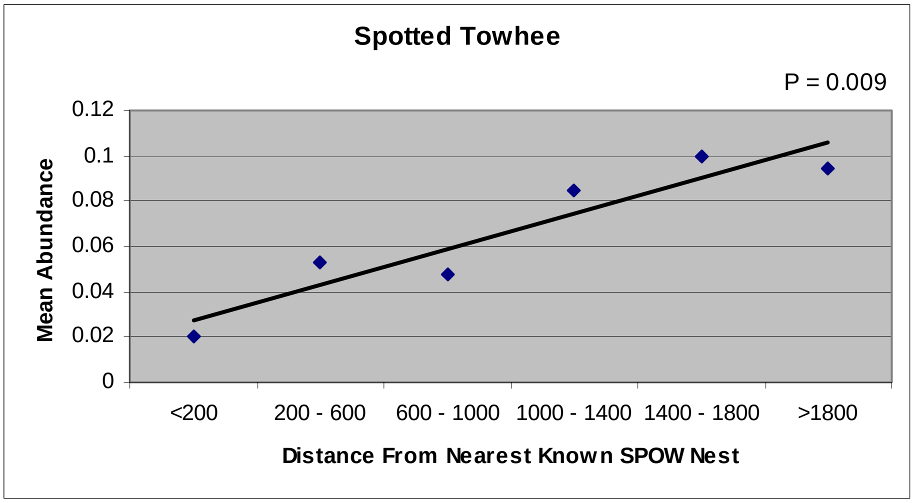

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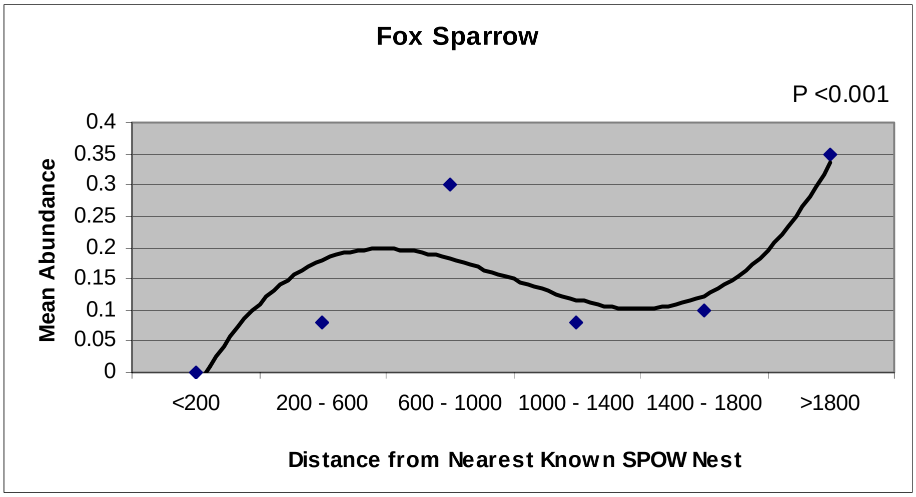
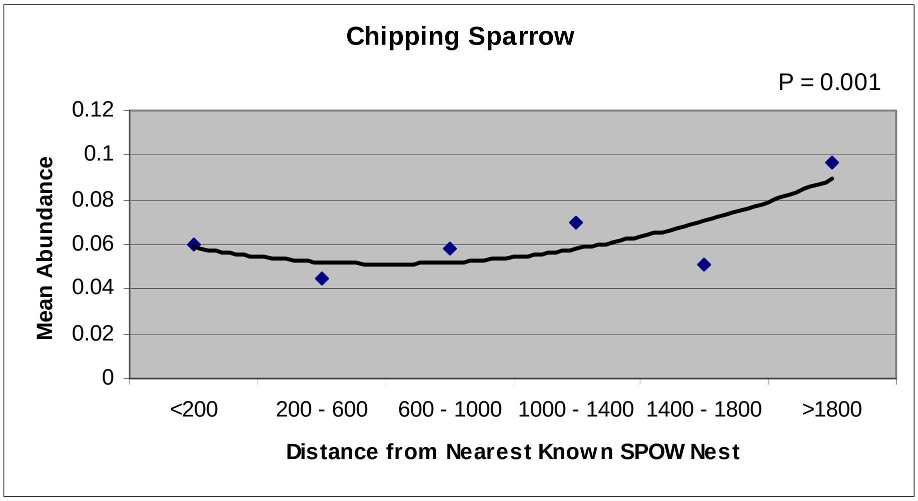
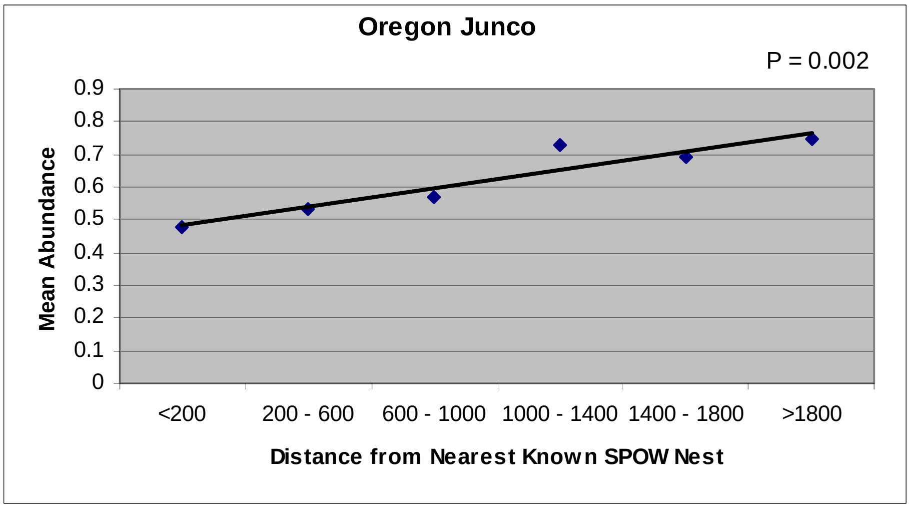
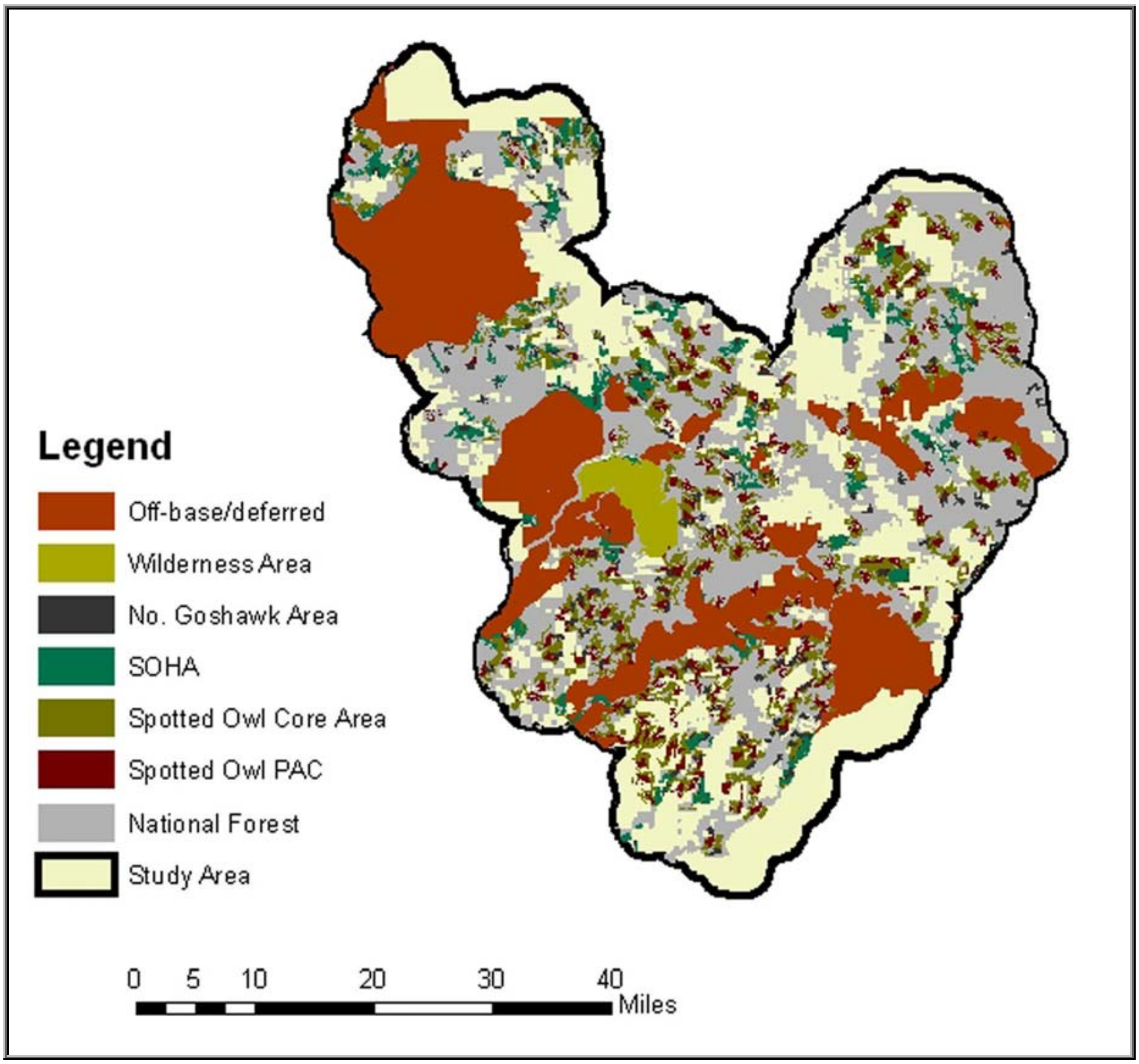






Management Land Allocations in the PLAS Study Area
In order to understand the significance of the analysis of avian species composition associated with SPOW habitat we investigated land allocations in the PLAS study area. We identified six separate allocations that have restrictions on timber harvest, fuel reductions, and other significant forest management activities that would result in canopy reductions or change towards younger seral stages (Figure 6).

Figure 6. Land allocations with restrictions on timber harvest activities on National Forest lands in the PLAS study area as of 2005.



Eleven and a half percent of the National Forest land in the PLAS study area is currently designated as SPOW PACs, with an additional 19.95% in Core Areas, and 9.62% in Spotted Owl Habitat Areas. In the HFQLG project area the 700 additional acres of Core surrounding the PAC is no longer a recognized allocation (though few Core Areas have been treated under this direction). However, unlike the rest of the Sierra Nevada Spotted Owl Habitat areas are recognized here (HFQLG FEIS 1999). Additional land allocations with restricted activities include: Northern Goshawk PACs – 3.07%; Wilderness Areas – 2.31%; and the HFQLG recognized Off-base and Deferred that encompass 28.42% of the landscape (HFQLG FEIS 1999). Accounting for non-duplication where these designations overlap, a total of 56.62% of the National Forest land in the study area is set aside in these restricted areas. If Core Areas are subtracted from this total (since the HFQLG does not recognize them), the total is 44.13% of the total study area (Table 8).

Table 8. Total acres and percent of National Forest lands in each of six conservation land allocations in the PLAS study area as of 2005.

Land Allocation	Acres of USFS Land in Study Area	% of total USFS Land in Study Area
Spotted Owl PAC	117,966	11.49
Spotted Owl Core	204,939	19.95
Spotted Owl Habitat Areas	98,812	9.62
Northern Goshawk PAC	31,481	3.07
Wilderness	23,738	2.31
Off-base/Deferred	291,884	28.42
Total - overlap	581,459	56.62
Total - Core	453,185	44.13

GIS Project for Creating Species Maps

We updated the interactive GIS project incorporating all bird data collected from 2003-2006 (CD Supplement A). This tool can be used by land managers to generate distribution maps for all species breeding within the PLAS study area (see Appendices 9 and 10 for examples). In addition the project can be queried to produce avian species richness, total bird abundance, and the abundance of any species by point. These data are then presented on a map with relevant habitat and treatment layers. Appendix 11 outlines directions for creating additional maps for any species of interest or for bird community indices, and describes all aspects of this GIS project and associated database tables. In future years we will continue to update this project to incorporate the most current and relevant information on the distribution and abundance of birds in the study area. If you do not have a copy of the GIS project CD and would like one please contact the author at rburnett@prbo.org.

DISCUSSION

Species Richness and Total Bird Abundance

Total bird abundance is highly correlated with species richness in our study area, thus in years with fewer total birds; species richness is likely to decline as well. It may be that in years with ample resources, or following a highly productive year, species will occupy sub-optimal habitat. In years with scarcer resources, or following a poor reproductive year it is likely only the highest quality sites are occupied. Thus, statistically significant annual fluctuations in species richness and total bird abundance across the entire study area are likely a result of population fluctuations not directly tied to changes in available habitat between years. However, it is critical to identify the key habitat features for each species that are instrumental in a site providing high quality habitat. Using a suite of avian species as management indicators, we can develop habitat models to determine the most important habitat features, monitoring their population trends over time, and determine their response to treatments. With this information one can then understand what species – or, more importantly, what habitat types and features – are underrepresented and then modify direction to ensure a balanced approach to future forest management.

Avian Community Composition in Relation to Spotted Owl Habitat
In the Sierra Nevada, considerable attention – and now management direction – is being influenced by the California SPOW (e.g., HFQLG FEIS 1999, SNFPA 2001). With this management direction the need exists to understand how these changes in forest management will impact the rest of the avian community. Understanding the composition and abundance of the avian community inside and outside of the key management areas for SPOW in the Sierra Nevada may allow managers to take a proactive ecosystem based approach to future management direction.

The California SPOW is a habitat specialist in the Sierra Nevada (Gutierrez et al. 1992). Due to these specific habitat requirements, it appears to be a poor candidate as an umbrella species, for more than a handful of avian species, in this habitat diverse ecosystem. Avian species richness and total bird abundance were significantly lower inside of Core Areas and substantially more of the twenty most abundant species were significantly less abundant inside of both PAC and Core Areas than outside. However, it should be noted that the disparity in species richness, total bird abundance, and diversity was mitigated when comparing outside Core to PACs alone. PACs appear to support more total birds and a greater diversity of species than the surrounding 700 acres of the Core, however PACs have significantly lower abundance for most shrub and open forest dependent species.

Five of the nine species significantly more abundant outside of PAC and Core Areas are shrub dependent birds, while two others, are known to have strong affinities for open forest and edge habitats conditions. The Large-billed subspecies of Fox Sparrow is unique to the mountains of southern Oregon and interior California (Rising & Beadle 1996, Weckstein et al. 2002). Evidence suggest that this subspecies is in fact one of four distinct species of Fox Sparrow (Zink & Kessen 1999). With the Sierra Nevada comprising the majority of this subspecies (or species) range managing, for its needs here is vital to its existence. Fox Sparrows were five times less abundant inside of Pac and Core areas than they were outside. This species may be the most at risk from a management strategy that will result in significant increases in SPOW like habitats.

The Olive-sided Flycatcher, another species negatively correlated with all three measures of SPOW habitat, is a Forest Service sensitive species in California. According to the Breeding Bird Survey, it has experienced a nearly 4% per year decline in the Sierra Nevada over the past 40 years (Sauer et al. 2005). This Neotropical migrant flycatcher is quite uncommon in the study area with 0.04 detected within 50 meters of observers per point count station between 2002 and 2006. For comparison, the most abundant species in the study area – Hermit Warbler – averaged 1.17 detections within 50 meters. Olive-sided Flycatcher has also experienced an 8.8% per year decline in the study area over the past four years – though this trend was not significant due to our small sample size. This species has strong affinities for forest edges, burned habitat, and snags (Altman and Sallabanks 2000). If forests continue to trend towards more homogenous

PAC-like habitat, the Olive-sided Flycatcher's decline in the Sierra will likely continue if not accelerate in coming decades.

Trending towards a PAC-like Forest

Approximately 50% of National Forest lands in the PLAS study area are currently set aside in areas where little if any forest treatments will occur. In a fire suppression dominated management regime, tree size and densities will continue to increase, in areas where no forest treatments occur. Furthermore, many forest treatments now being planned – including Defensible Fuel Profile Zones (DFPZ) and Strategically Placed Area Thinnings – are retaining a minimum of 40% canopy cover in order to minimize potential impacts to late seral associated species (HFQLG FEIS 1999, SNFPA 2001). With half the forest in restricted areas and the other half being managed for high canopy retention and larger trees, it appears inevitable that the majority of the Northern Sierra forests will become Core like habitat. In fact, analysis conducted for each of the two current management strategies for the Northern Sierra forests – SNFPA and HFQLG Pilot Project – predicted significant increases in canopy cover and tree sizes in the coming decades (HFQLG FEIS 1999, SNFPA 2001).

DFPZ treatments may not only be ineffective in creating open forest and shrub dominated habitats but they are likely having a detrimental effect on shrub nesting bird species. At least in Treatment Unit Four, managers appear to be targeting shrub dominated sites for DFPZ placement. Pre-treatment DFPZs in Unit Four had significantly higher abundance of Dusky Flycatcher and Fox Sparrow – two shrub-dependent birds that were negatively associated with SPOW habitat – compared to non-DFPZ sites (Burnett et al. 2006). The three species significantly less abundant within proposed DFPZs were Hermit Warbler, Brown Creeper, and Hammond's Flycatcher – three species strongly correlated with SPOW habitat. Based on our observations over the past four years, treatments in shrub dominated areas involves partial to wholesale mastication of shrubs. The majority of shrub nesting bird species select for sites with very high shrub cover. In the Lassen National Forest, four shrub-dependent species (including Fox Sparrow and Dusky Flycatcher) nesting in 15 to 20 year old plantations – with shrub cover averaging 50% – chose nest sites with significantly higher shrub cover than random sites (Burnett et al. 2005a). For each of these species, shrub cover within five meters of nests averaged over 60%. Thus, it is not likely that shrub-dominated habitats treated under fuel reduction projects will support these shrub-nesting species.

In the HFQLG area of the Northern Sierra, group selections are being used as an additional management tool. Groups involve removal of almost all of the overstory and therefore are a potential source of open forest and shrub dominated habitat. However, group selection treatments as they are prescribed under HFQLG are two acres or less in size (HFQLG FEIS 1999). Densities of shrub nesting birds in the Lassen National Forest; including Dusky Flycatcher, MacGillivray's Warbler, Green-tailed Towhee, and Fox Sparrow averaged over two acres per territory (PRBO unpublished data). Thus even the largest groups – if they were managed for dense shrub cover – are too small to support a single shrub nesting bird territory.

Private lands are a potential source of early succesional open forest habitat in the Sierra Nevada. Timber harvest practices on these lands are often more intensive resulting in larger forest openings with suitable conditions for shrub establishment. However, based on our observations in the Northern Sierra, many of these sites are densely replanted with conifers and shrubs are actively inhibited or removed through mastication and herbicide treatments. The resulting early succesional habitat is unlikely to support species such as Dusky Flycatcher, Fox Sparrow, MacGillivray's Warbler, or Spotted and Green-tailed Towhee.

It is evident that managing for an increase in PAC- and Core-like habitat may result in significant changes to the avian community in the Northern Sierra Nevada. While it is important to manage for SPOW and other late seral associated species, it is essential to strike a balance with the needs of all the other species dependent upon this system. Our analysis of avian community composition in relation to SPOW habitat has led us to ask several questions: Should late seral habitat be emphasized in all forest treatments? Are Sierra Nevada forests limited in the amount of high canopy cover forest or the amount of high quality late seral habitat? The current approach to forest management appears to be focused on converting more of the forest to closed canopy to meet the needs of late seral species. While this approach may or may not benefit late seral species in the coming years it is fairly clear that it will negatively impact a number of other Sierra Nevada birds and undoubtedly other organisms. Shrub-dominated and open forest habitat conditions are a critical component of the Sierra Nevada ecosystem and are likely to decline under a late seral dominated management regime.

Four Year Trends in Species Abundance

It is important to note that four years is not enough time to confidently ascertain long-term trends in avian populations. However, analyzing trends over this timeframe can provide meaningful information on the status of avian populations and alert one to species that may be in need of more management attention.

We found an interesting correlation between species with significant population trends from 2003 – 2006, and the association of those species with SPOW habitat. Three of the four species significantly increasing were positively correlated with SPOW habitat, while four of six declining were negatively associated with SPOW habitat. Brown Creeper, Golden-crowned Kinglet, and Hermit Warbler were all positively correlated with at least two of the three measures of SPOW habitat. The fourth significantly increasing species, Dusky Flycatcher, was negatively associated with all three measures of SPOW habitat. Two of the species showing declines – the shrub-dependent Spotted Towhee and Fox Sparrow – showed strong negative associations with all three measures of SPOW habitat. The Mountain Chickadee was significantly more abundant outside of Core and PACs and Audubon's Warbler's abundance increased away from SPOW nests. Hammond's Flycatcher, on the other hand, was significantly more abundant inside of Pac and Core. The Red-breasted Nuthatch showed no affinity for or against any of the three measures of SPOW habitat.

The only two species that did not fit the correlation of increasing species being positively associated with SPOW habitat and decliners being negatively associated were Hammond's and Dusky Flycatcher. Dusky Flycatcher is an early seral shrub dependent species (Sedgwick 1993). It was negatively associated with owl habitat areas and showed a significant increasing trend. Hammond's Flycatcher is a late seral closed canopy associated species (Sedgwick 1994) that was positively correlated with owl habitat areas and showed a significant population decline. These two species are very difficult to separate in the field during point count surveys. In some years observers were more conservative and many birds were only identified to the species pair, while in other years almost all individuals were identified to the species. For our analysis purposes we had to discard these unidentified detections. For the analysis of abundance associated with SPOW habitat this is probably not an issue, for analysis of population trends this may be a confounding factor. The number of unidentified flycatcher detections in 2006 was higher than any of the previous three years. It may be many of these detections were Hammond's Flycatcher thus explaining the precipitous decline observed in this species in 2006. However, it does not explain the significant increasing trend in Dusky Flycatcher. It is important to be aware of these potential confounding factors when analyzing data of these two species.

Population trends for avian species can be influenced by factors other than available breeding habitat or habitat quality. These species may be limited by wintering habitat or other factors such as widespread disease (e.g. West Nile Virus, Avian Influenza). However, the list of species showing significant population trends have a wide range of life history strategies and includes, permanent residents (e.g. Mountain Chickadee and Golden Crowned-Kinglet), short-distance migrants (Oregon Junco, Audubon's Warbler), and neotropical migrants (Hermit Warbler and Dusky Flycatcher). In fact, all of the declining species are either permanent residence or short-distance migrants, suggesting declines are at least in part due to factors on the breeding grounds. The strongest and most plausible link between these species appears to be their relationship to SPOW habitat.

Results from the four year trend analysis highlight the need to continue to collect data for several more years to conclusively determine the true magnitude of these population rates. Should the Forest Service be focusing more management actions on the needs of Fox Sparrow and Red-breasted Nuthatch? Should we be unconcerned with Hermit Warblers and Golden-crowned Kinglets? Will these trends change as more treatments are implemented?

CONCLUSION

Long-term, landscape-based ecological monitoring will be critical to determining when an acceptable balance has been struck with the full compliment of habitat conditions. Avian monitoring is one of the only practical tools capable of providing the necessary feedback to make these complex and difficult decisions before the scale has been tipped too far and regulatory hurdles significantly limit management options. In the last century, fire suppression and timber harvest practices (among others) have tipped the balance of these systems towards overstocked forests with small to medium sized shade tolerant trees. In response to this, current management direction has emphasized retaining and creating more late-seral habitat. However, results presented in this report highlight the need to balance the requirements of the whole suite of species and ecological conditions that exist in the Sierra Nevada in order to avoid significant impacts to a number of avian species.

OUTREACH AND PUBLICATIONS

Accepted Publications

Integrating Avian Monitoring into Forest Management: Pine-Hardwood and Aspen Enhancement on the Lassen National Forest. Accepted as part of a PSW General Technical Report.

Presentations

Avian Community Composition in the Context of Spotted Owl Management in the Sierra Nevada – oral presentation at:

Plumas Lassen Study Symposium in Quincy, California 3/31/06.
The Western Section of the Wildlife Society in Monterey, California 2/2/07.

Integrating Avian Monitoring into Forest Management on the Lassen and Plumas National Forests – oral presentation at:

Forest Forum in Westwood, California 1/19/2006.

Pine-Oak Habitat Enhancement on the Lassen National Forest – poster presented at:

The 6th California Oak Symposium in Rohnert Park, California 10/10/06.

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 7/23/06.

Pine-Oak Habitat Enhancement Field Trip – invited to participate on Lassen National Forest tour of QLG Pine-Oak project in the Almanor Ranger District. Gave a presentation on our monitoring results and produced a "white paper" handout summarizing our results. 7/14/06.

Mono Lake Bird Chataqua – led a field trip on bird identification and overview of Plumas-Lassen Study and all of PRBO's work in the Northern Sierra. 6/19/2006

We have been in regular contact with several members of the Quincy Library Group and the Plumas Audubon Society.

Integration with Management

We provided input to several important Forest Service projects in 2006 in an effort to integrate our results to help guide forest management in the Sierra Nevada:

1. Updated the "Interactive GIS Project" with 2006 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. Created an interactive GIS CD for the Almanor Ranger District (ARD) 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. Provided data from all PRBO avian survey sites from across all National Forest lands in the Sierra Nevada in coordination with Diana Craig in the Region 5 office for use in MIS analysis.

4. Provided input on Sierra National Forests Kings River Project Biological Evaluation, including reviewing the pilot analysis using the new MIS direction from Region 5. A collaboration between PRBO, John Robinson of On My Mountain, and the Sierra National Forest.

5. Produced and distributed four white papers integrating avian monitoring data into science based recommendations for managing four important Sierra habitat types for birds. These papers have now been distributed to all QLG area forest service staffs, the QLG, private timber companies in the Northern Sierra, and other interested parties.

PERSONNEL

This project is coordinated and supervised by PRBO staff biologist Ryan Burnett. Eric Wood was the field crew supervisor in 2006. Field work in 2006 was conducted by those listed above as well as Jeff Birek, Jeremy Russell, Elizabeth Summers, Alyson Webber, and Jared Wolfe. Computer programs used to manage and summarize data were created by PRBO staff biologists Grant Ballard and Diana Humple. Diana Humple and Nadav Nur provided helpful editing and statistical advice respectively. The study is carried out under the guidance of PRBO Terrestrial Ecology Division Director Geoffrey R. Geupel.

ACKNOWLEDGEMENTS

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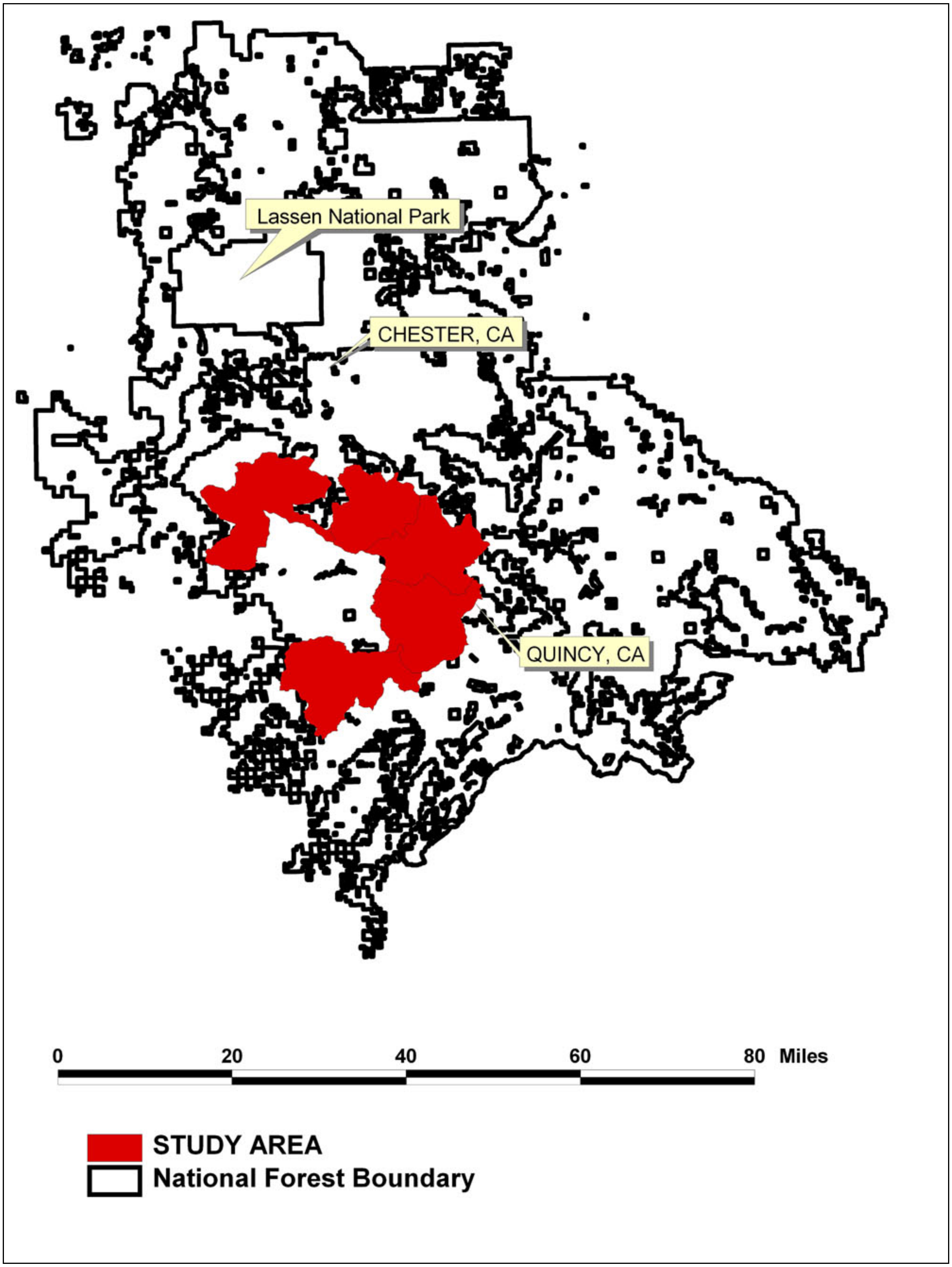
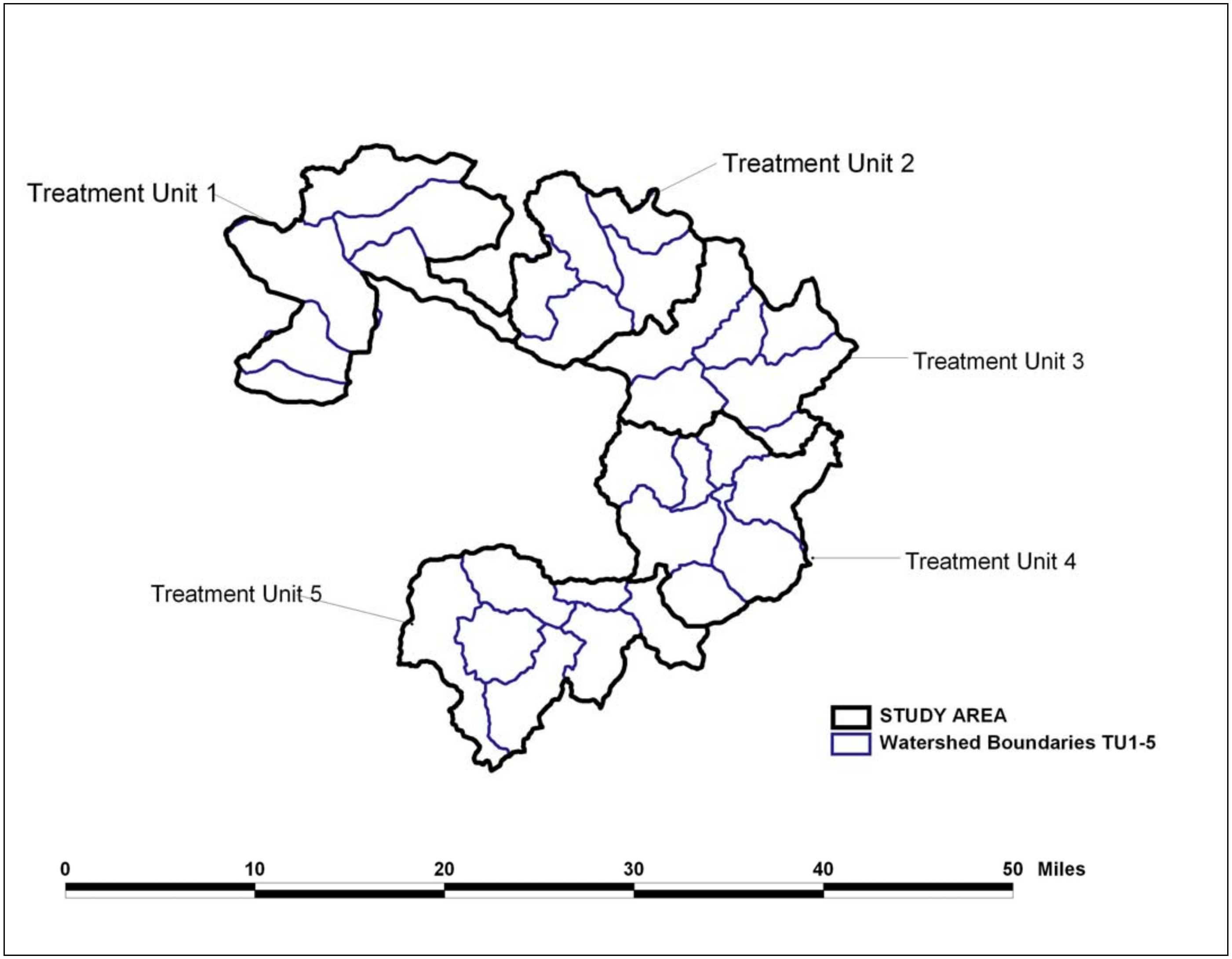
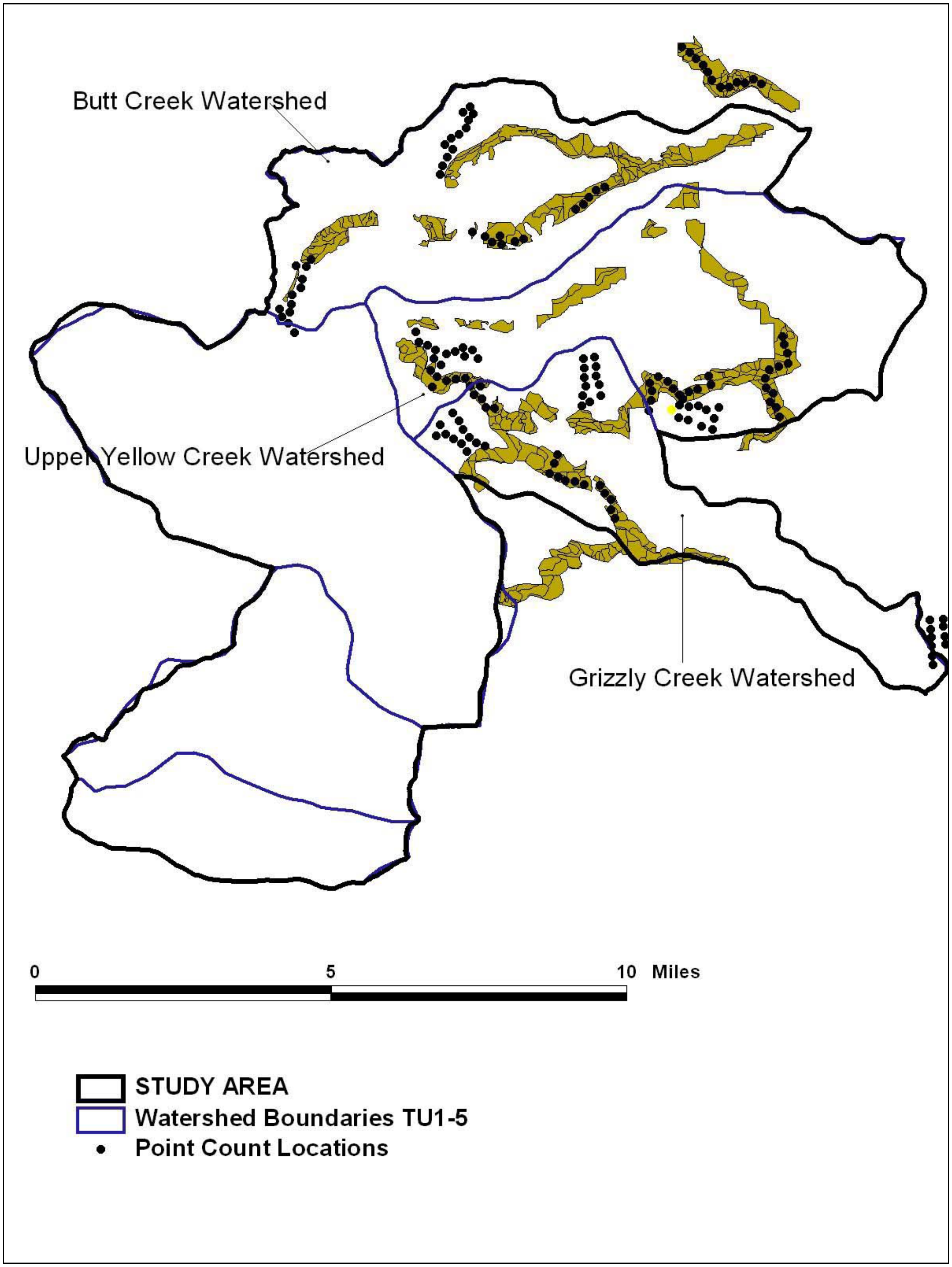
Appendix 1. Study area overview map of the PRBO Plumas-Lassen module of the Administrative Study.



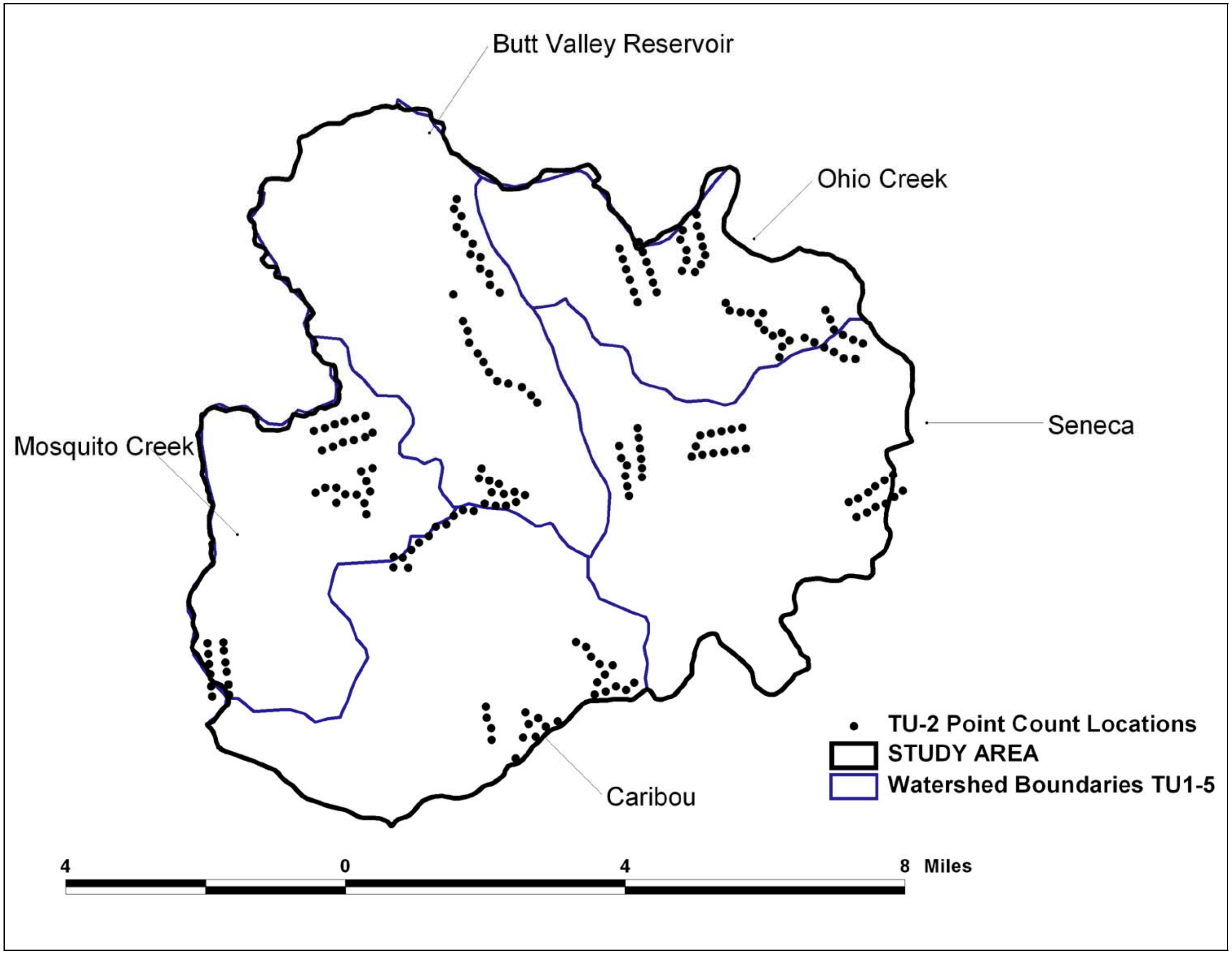
Appendix 2. Treatment Units and Watershed boundaries of the PRBO Plumas-Lassen Avian Study Area.



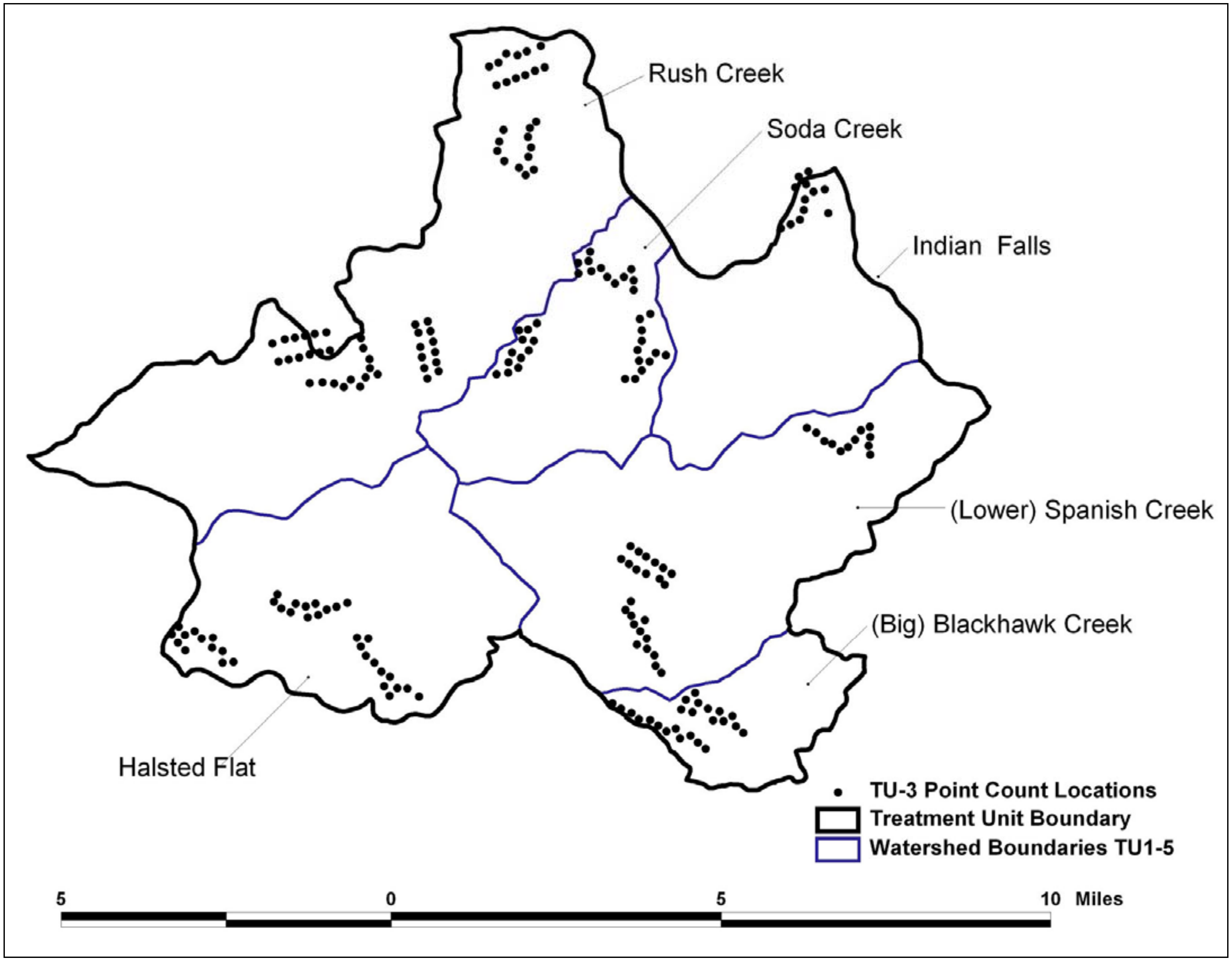
Appendix 3. Treatment Unit 1 Map with watersheds, DFPZ outlines, and locations of point count transects surveyed in 2006 for the PRBO Plumas-Lassen Administrative Study.



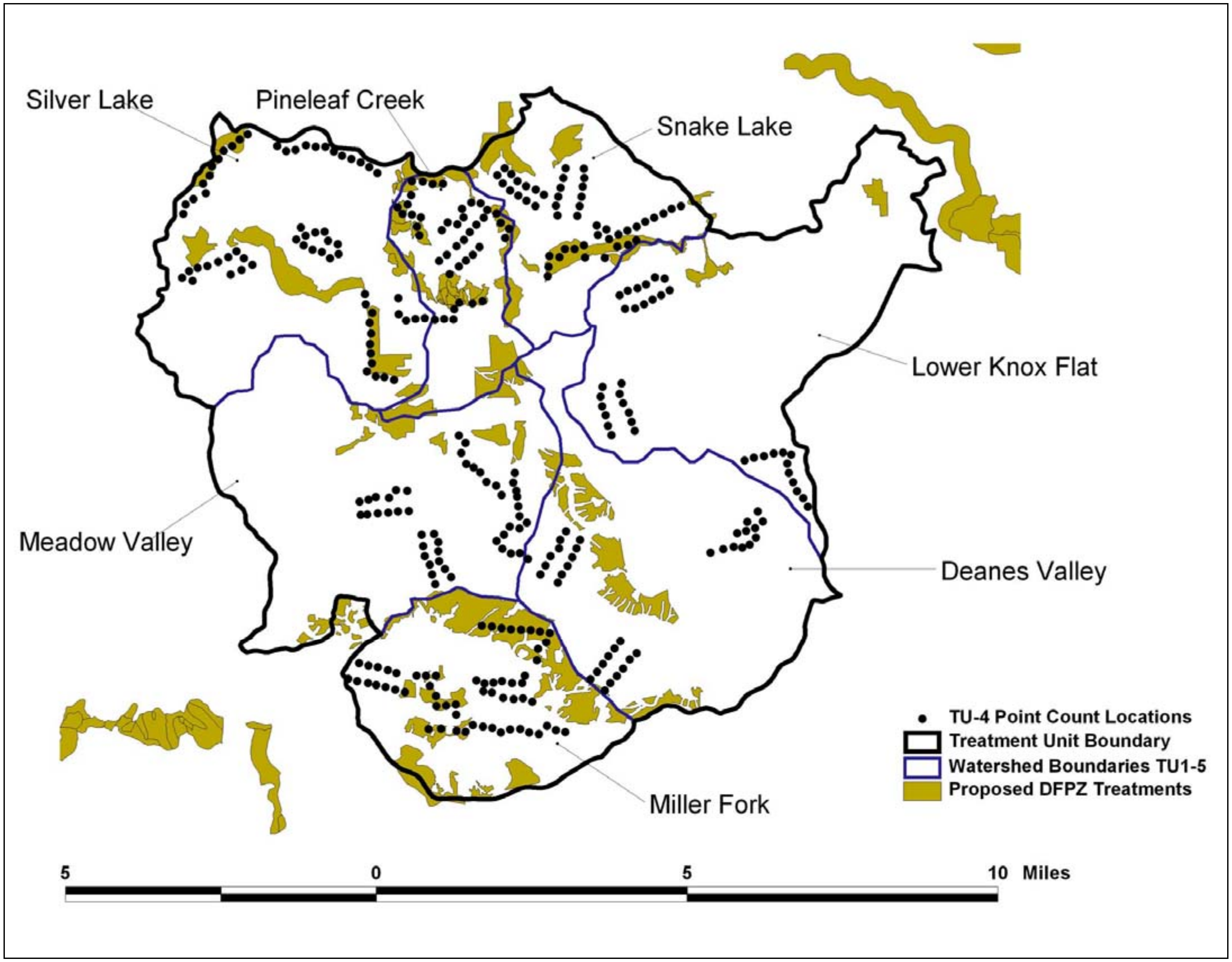
Appendix 4. Treatment Unit 2 map with watersheds, DFPZ outlines, and locations of point count transects surveyed in 2006 for the PRBO Plumas-Lassen Administrative Study.



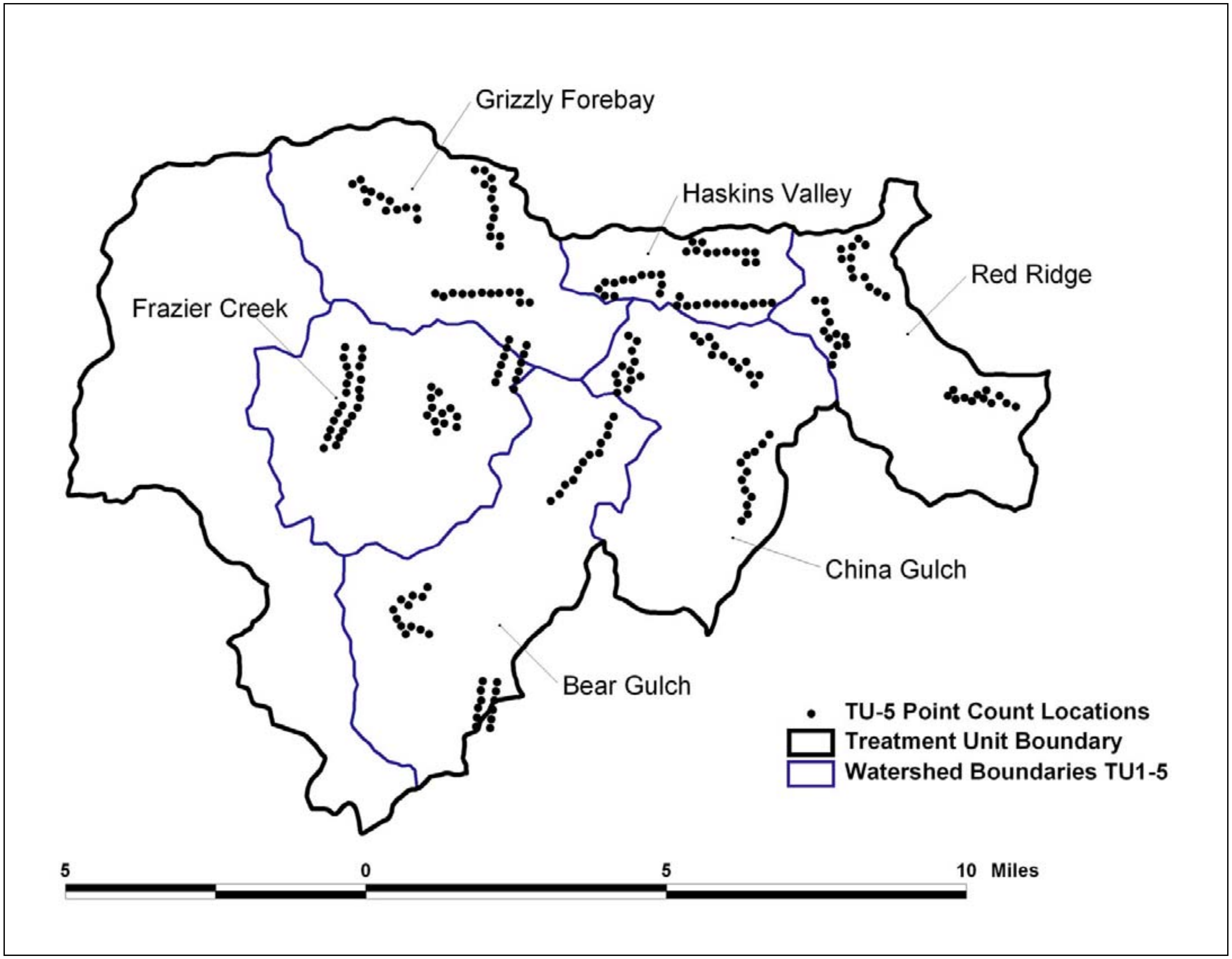
Appendix 5. Treatment Unit 3 map with delineating watersheds and locations of point count transects surveyed in 2006 for the PRBO Plumas-Lassen Administrative Study.



Appendix 6. Treatment Unit 4 map delineating watersheds, DFPZ outlines, and locations of point count transects surveyed in 2006 for the PRBO Plumas-Lassen Administrative Study.



Appendix 7. Treatment Unit 5 map delineating watersheds and locations of point count transects surveyed in 2006 for the PRBO Plumas-Lassen Administrative Study.



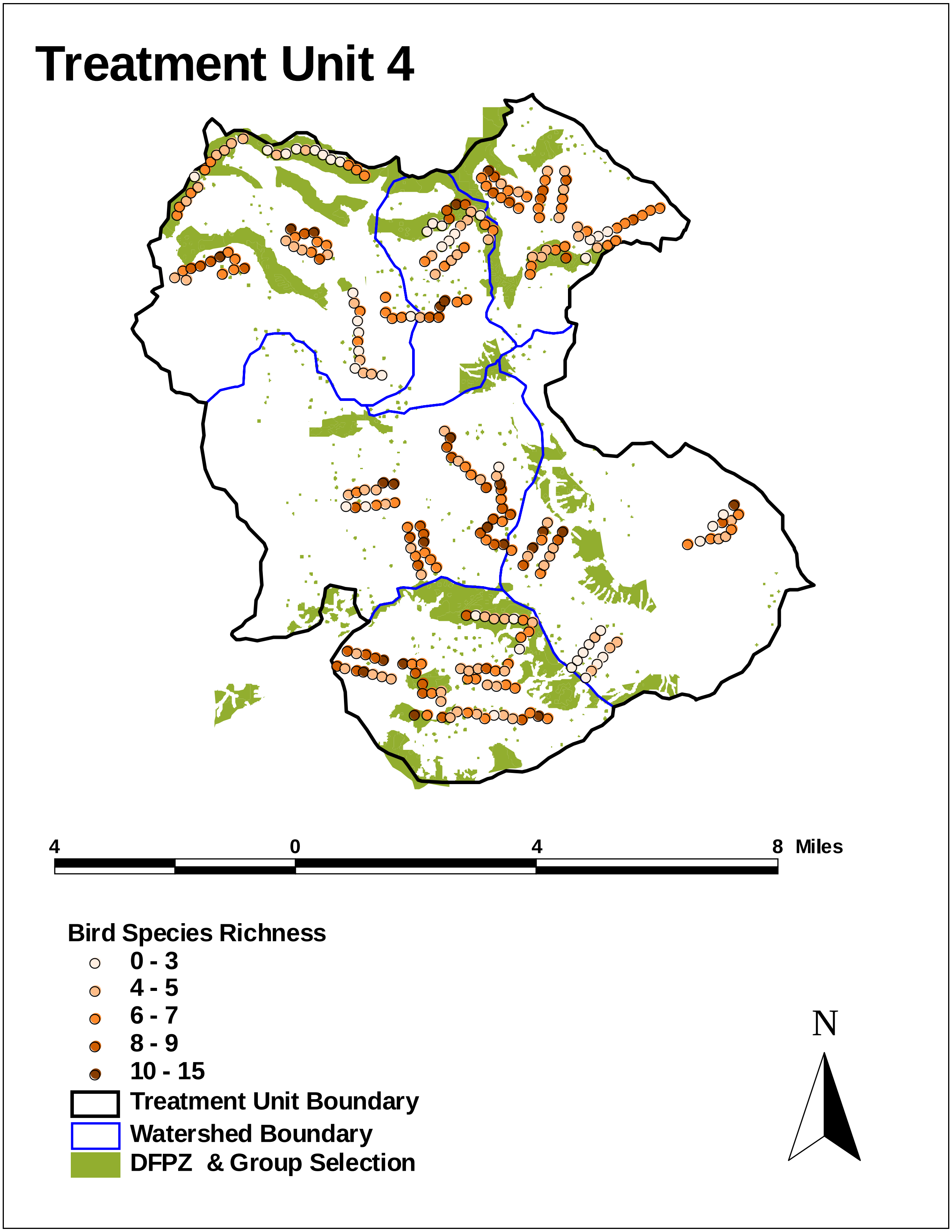
Appendix 8. List of all bird species detected by PRBO on point count surveys (common, AOU code, scientific name) in the PLAS in 2002-2006.

Common Name	AOU Code	Scientific Name
Acorn Woodpecker	ACWO	*Melanerpes formicivorus*
American Crow	AMCR	*Corvus brachyrhynchos*
American Dipper	AMDI	*Cinclus mexicanus*
American Kestrel	AMKE	*Falco sparverius*
American Robin	AMRO	*Turdus migratorius*
Anna's Hummingbird	ANHU	*Calypte anna*
Audubon’s Warbler	AUWA	*Dendroica coronata audubonii*
Bald Eagle	BAEA	*Haliaeetus leucocephalus*
Band-tailed Pigeon	BTPI	*Columba fasciata*
Belted Kingfisher	BEKI	*Ceryle alcyon*
Bewick’s Wren	BEWR	*Thryomanes bewickii*
Black Phoebe	BLPH	*Sayornis nigricans*
Black-backed Woodpecker	BBWO	*Picoides arcticus*
Black-headed Grosbeak	BHGR	*Pheucticus melanocephalus*
Black-throated Gray Warbler	BTYW	*Dendroica nigrescens*
Blue Grouse	BGSE	*Dendragapus obscurus*
Blue-gray Gnatcatcher	BGGN	*Polioptila caerulea*
Brewer’s Blackbird	BRBL	*Eupphagus cyanocephalus*
Brewer’s Sparrow	BRSP	*Spizella breweri*
Brown Creeper	BRCR	*Certhia Americana*
Brown-headed Cowbird	BHCO	*Molothrus ater*
Bushtit	BUSH	*Psaltriparus minimus*
California Quail	CAQU	*Callipepla californica*
Calliope Hummingbird	CAHU	*Stellula calliope*
Canada Goose	CAGO	*Branta Canadensis*
Cassin's Finch	CAFI	*Carpodacus cassinii*
Cassin's Vireo	CAVI	*Vireo casinii*
Cedar Waxwing	CEDW	*Bombycilla cedrorum*
Chestnut-backed Chickadee	CBCH	*Parus rufescens*
Chipping Sparrow	CHSP	*Spizella passerine*
Clark’s Nutcracker	CLNU	*Nucifraga Columbiana*
Common Nighthawk	CONI	*Chordeiles minor*
Common Raven	CORA	*Corvus corax*
Cooper’s Hawk	COHA	*Accipiter cooperii*
Downy Woodpecker	DOWO	*Picoides pubescens*
Dusky Flycatcher	DUFL	*Empidonax oberholseri*
European Starling	EUST	*Sturns vulgaris*
Evening Grosbeak	EVGR	*Coccothraustes vespertinus*
Fox Sparrow	FOSP	*Passerella iliaca*
Golden-crowned Kinglet	GCKI	*Regulus satrapa*
Gray Flycatcher	GRFL	*Empidonax wrightii*
Gray Jay	GRJA	*Perisoreus Canadensis*
Great Blue Heron	GTBH	*Ardea herodias*

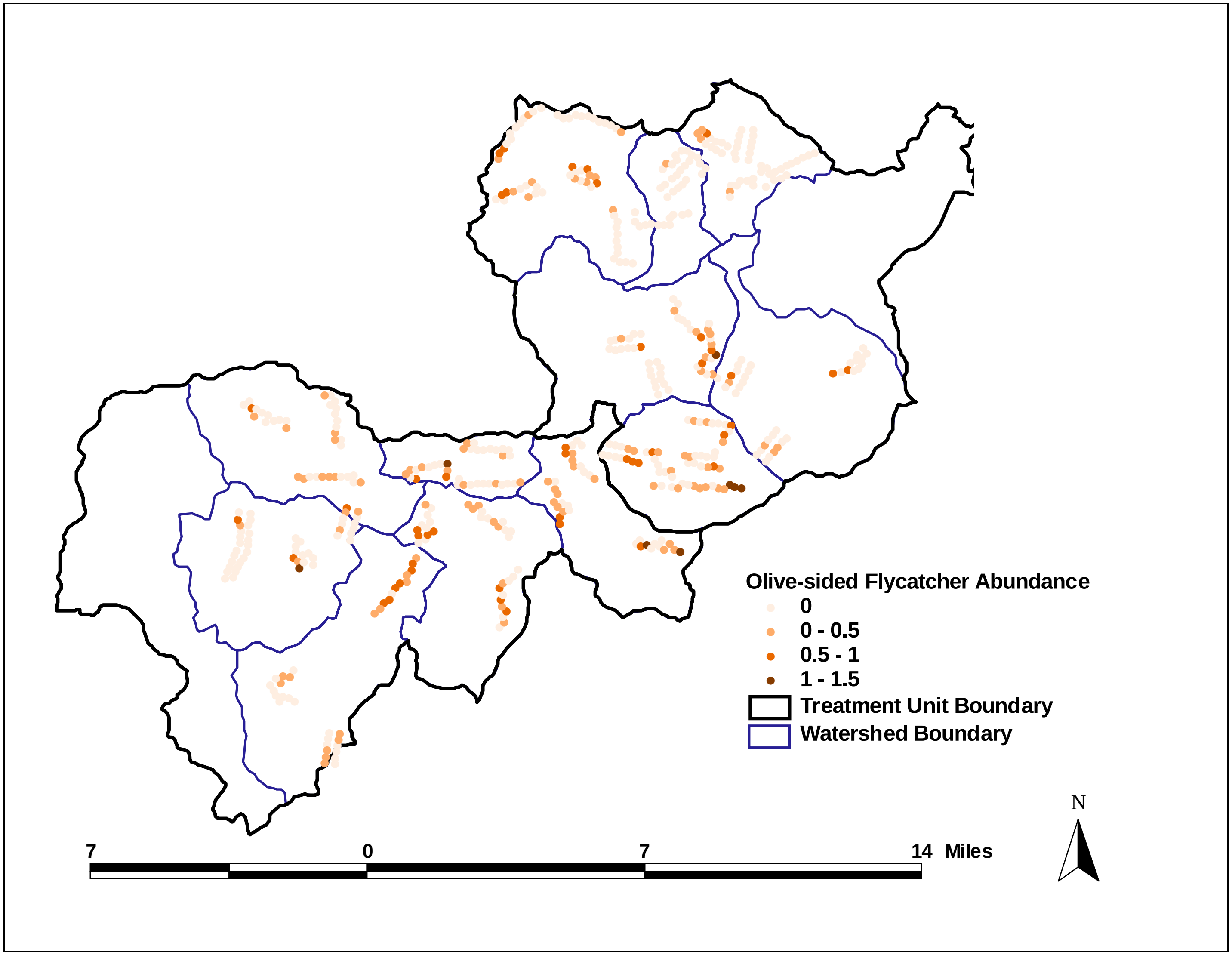
Common Name	AOU Code	Scientific Name
Green Heron	GRHE	*Butorides virescens*
Green-tailed Towhee	GTTO	*Pipilo chlorurus*
Hairy Woodpecker	HAWO	*Picoides villosus*
Hammond's Flycatcher	HAFL	*Empidonax hammondii*
Hermit Thrush	HETH	*Catharus guttatus*
Hermit Warbler	HEWA	*Dendroica occidentalis*
House Wren	HOWR	*Troglodytes aedon*
Hutton’s Vireo	HUVI	*Vireo huttoni*
Lazuli Bunting	LAZB	*Passerina amoena*
Lesser Goldfinch	LEGO	*Carduelis psaltria*
Lewis’s Woodpecker	LEWO	*Melanerpes lewis*
Lincoln’s Sparrow	LISP	*Melospiza lincolnii*
MacGillivray's Warbler	MGWA	*Oporornis tolmiei*
Mallard	MALL	*Anas platyrhynchos*
Mountain Bluebird	MOBL	*Sialia currucoides*
Mountain Chickadee	MOCH	*Poecile gambeli*
Mountain Quail	MOQU	*Oreotyx pictus*
Mourning Dove	MODO	*Zenaida macroura*
Nashville Warbler	NAWA	*Vermivora ruficapilla*
Northern Goshawk	NOGO	*Accipiter gentiles*
Northern Pygmy-Owl	NPOW	*Glaucidium gnoma*
Northern Saw-whet Owl	NOSO	*Aegolius acadicus*
Olive-sided Flycatcher	OSFL	*Contopus cooperi*
Orange-crowned Warbler	OCWA	*Vermivora celata*
Oregon Junco	ORJU	*Junco hyemalis*
Osprey	OSPR	*Pandion haliaetus*
Pacific-slope Flycatcher	PSFL	*Empidonax difficilis*
Pileated Woodpecker	PIWO	*Dryocopus pileatus*
Pine Siskin	PISI	*Carduelis pinus*
Purple Finch	PUFI	*Carpodacus purpureus*
Red Crossbill	RECR	*Loxia curvirostra*
Red-breasted Nuthatch	RBNU	*Sitta Canadensis*
Red-breasted Sapsucker	RBSA	*Sphyrapicus rubber*
Red-shafted Flicker	RSFL	*Colaptes auratus*
Red-tailed Hawk	RTHA	*Buteo jamaicensis*
Red-winged Blackbird	RWBL	*Agelaius phoeniceus*
Rock Wren	ROWR	*Salpinctes obloletus*
Rufous Hummingbird	RUHU	*Selasphorus rufus*
Sandhill Crane	SACR	*Grus Canadensis*
Sage Thrasher	SATH	*Oreoscoptes montanus*
Sharp-shinned Hawk	SSHA	*Accipiter striatus*
Song Sparrow	SOSP	*Melospiza melodia*
Spotted Owl	SPOW	*Strix occidentalis*
Spotted Towhee	SPTO	*Pipilo maculates*
Steller's Jay	STJA	*Cyanocitta stelleri*

Common Name	AOU Code	Scientific Name
Swainson's Thrush	SWTH	*Catharus ustulatus*
Townsend's Solitaire	TOSO	*Myadestes townsendi*
Townsend's Warbler	TOWA	*Dendroica towsendi*
Tree Swallow	TRES	*Tachycineta bicolor*
Turkey Vulture	TUVU	*Cathartes aura*
Vaux's Swift	VASW	*Chaetura vauxi*
Violet-green Swallow	VGSW	*Tachycineta thalassina*
Warbling Vireo	WAVI	*Vireo gilvus*
Western Bluebird	WEBL	*Sialia mexicana*
Western Scrub-Jay	WESJ	*Aphelocoma californica*
Western Tanager	WETA	*Piranga ludoviciana*
Western Wood-Pewee	WEWP	*Contopus sordidulus*
White-breasted Nuthatch	WBNU	*Sitta carolinensis*
White-headed Woodpecker	WHWO	*Picoides albolarvatus*
Williamson's Sapsucker	WISA	*Sphyrapicus thyroideus*
Wilson's Warbler	WIWA	*Wilsonia pusilla*
Winter Wren	WIWR	*Troglodytes troglodytes*
Wrentit	WREN	*Chamea fasciata*
Yellow Warbler	YWAR	*Dendroica petechia*

Appendix 9. Sample map from GIS CD supplement of bird species richness in treatment unit 4 of the PLAS study area in 2003.



Appendix 10. Sample Map from GIS CD Supplement of Olive-sided Flycatcher Abundance (all detections) in Treatment Units 4 and 5 in the PLAS study area in 2003.



Appendix 11. Details on GIS CD Supplement Project for building species maps

I. Summary

With this GIS project and these tables, additional maps can be generated (e.g., abundance maps for individual species showing where they are most and least common; maps showing differences in diversity, richness or overall abundance; and maps showing presence/absence of species of interest that are not well surveyed with this method, but encountered during point counts) for 2003, 2004 and 2005 data. Included in the ArcView project (see below for details) are examples of such maps: abundances of Hammond's Flycatchers within 50 meters of every point in 2003 and 2004; abundances of Band-tailed Pigeons detected at each of the points in 2004; abundances of Black-backed Woodpeckers at each of the points in 2004; and species richness at each of the points in 2003. The directions and metadata below will allow the user to create such maps for any species or index in either of the two years.

II. PRIMARY ARCVIEW FILES

PRBO_PSWreportsupplement06.apr – ArcView project file. Double click this file to open the project.

PLASabsum06_allGIS.dbf – table which contains one line of data per point with all associated bird data from the 2006 point count season, including diversity, species richness, and abundance of all species combined, as well as abundance of individual species. Only includes data within 50m and for restricted species only (breeders in area and species well surveyed by the point count method; see *Methods*) This has been imported into an ArcView project file. It means "Point count abundance summary for birds less than 50 m from the observer in 2005".

PLASabsum06_l50GIS.dbf – table which contains one line of data per point with all associated bird data from the 2005 point count season, includes ALL data (birds within 50m, birds greater than 50m, and flyovers, combined) and is for all species, including non-breeders as well as species not well surveyed with the point count method. Has been imported into ArcView project file. It means "Point count abundance summary for birds of all detections in 2005."

PLASabsum05_l50GIS.dbf – same as above (less than 50 m) but for 2005 point count data.

PLASabsum05_allGIS.dbf – same as above (for all data) but for 2005 point count data

PLASabsum04_l50GIS.dbf – same as above (less than 50 m) but for 2004 point count data.

PLASabsum04_allGIS.dbf – same as above (for all data) but for 2004 point count data.

PLASabsum03l50.dbf – same as above (less than 50 m) but for 2003 point count data.

PLASabsum03all – same as above (for all data) but for 2003 point count data.

III. GIS DATABASE FIELDS EXPLAINED

Below are the definitions for each field within the pcabsuml50.dbf and pcabsumall.dbf (see above) tables.

YEAR = year that data was collected

STATION = abbreviated point count transect name (4-letters)

SITE = point count station number within a given transect

X_COORD = latitude in UTMs for the point

Y_COORD = longitude in UTMs for the point

VISITS (2003 database) = number of total point count visits done per point; all sites where this is not detailed were visited 2 times.

SW = bird diversity at that point (see *Methods: Statistical Analysis*)

SPECRICH = bird species richness at that point (see *Methods: Statistical Analysis*)

ABUNDANCE = average number of individuals detected at that point per visit (total individuals/number of visits; see *Methods: Statistical Analysis*)
"SPEC"AB = multiple fields, detailing number of individuals of each species at each point (averaged across visits). Uses AOU 4-letter codes for each bird species, combined with "AB" for abundance (e.g., Audubon's Warbler abundance is delineated as *AUWAAB*). See Appendix 8 for explanation of all 4-letter bird species codes. This is done for 61 species within 50 meters (PLASabsum03L50.dbf) and 92 species when including all detections (PLASabsum03all.dbf).

IV. HOW TO GENERATE ABUNDANCE MAPS BY SPECIES

1. Save all files on the CD onto hard drive
2. Open **PRBO_PSWreportsupplement06.apr** in ArcView
3. Since it has been moved, you will have to direct ArcView to each file location (all wherever you have saved them) for the first time, and then save the project so you won't need to do so again.
4. Open view 1.
5. Once inside view 1 click on VIEW on the pull down menu and choose "add event theme"
6. Choose table you want to take data from (PLASabsum06L50.dbf, PLASabsum06all.dbf, or 2003/2004/2005 tables); click OK.
7. Double click on the newly created event theme in left margin
8. Under legend subfolder inside the project folder choose ***speciesabundance.avl*** if you are going to create a map for individual species abundance; or **choose richdivab_legend.avl** if you are going to create a map of community indices. This way all the legends for all species are identical, and done to the same scale.
9. Then under *load legend: field* pick the species abundance you wish to map (i.e., choose *wiwrab* if making a map of Winter Wren abundance based on point count stations) and click OK.
10. Hit APPLY (and close legend window).
11. While that event theme is still selected, under *theme*, click on *properties.* You can then modify the theme name here (e.g., *Winter Wren <50 m*)
12. You will likely choose to make each species map a *layout* if you wish to print them out with a legend (View → layout)

Appendix 12. Poster presented at 6th Oak Symposium in collaboration with the Lassen National Forest.