Plumas/Lassen Study
2004 Annual Report
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Introduction

The Pacific Southwest Region and the Pacific Southwest Research Station agreed in 2002 to jointly develop and fund an administrative study to fill management information needs concerning the relationship between management-caused changes in vegetation and their effects on spotted owl habitat and population dynamics. The original impetus for this study is in the Record of Decision (ROD), dated January 12, 2001, for the Sierra Nevada Forest Plan Amendment (SNFPA), Final Environmental Impact Statement (FEIS). In this document the Regional Forester presented his decision to amend the Pacific Southwest Regional Guide, the Intermountain Regional Guide and land and resource management plans (LRMPs) for national forests in the Sierra Nevada and Modoc Plateau. Among the elements of this decision was a commitment to develop in collaboration with PSW, a Study that would examine the relationship between management-caused changes in vegetation and their effects on spotted owl habitat and population dynamics. The Regional Forester specifically stated in the ROD:

> "Under the procedures of the adaptive management strategy in this decision, the Forest Service will cooperate with the Pacific Southwest Research Station to design and implement an administrative study to examine the relationship between management-caused changes in vegetation and their effects on spotted owl habitat and population dynamics. I would expect group selection provisions of the HFQLG pilot project as well as other treatments to be used in carrying out this study. The administrative study is intended to investigate the response of the California spotted owl and its habitat, particularly populations of prey species features of their habitats, to various silvicultural treatments."

This intent was reaffirmed in the January 2004 ROD for the Final Supplemental EIS. However, the focus of this work has changed from the original intent expressed in the 2001 ROD to what is now intended by the 2004 ROD. This is discussed below but in short, the work being done now is oriented towards understanding the response of an array of key forest elements to the set of management activities prescribed for in the HFQLG pilot project.

Purpose of the Study

This study is interdisciplinary, examining at least five groups of response variables (spotted owls, small mammals, terrestrial birds, vegetation, and fuels conditions) through collaboration between researchers of the USDA Forest Service Pacific Southwest Research Station (PSW) and cooperators from the Universities of California, Berkeley and Davis, and the Point Reyes Bird Observatory. The study addresses some of the most significant uncertainties that confound management decisions in the Sierra Nevada today, including in the HFQLG Pilot Project Area. How do old-forest-dependent species respond to vegetation management over space and time? Do fuels management approaches effectively address fuels loadings without negatively affecting species viability? How effective are landscape level fuels management strategies in modifying fire behavior and reducing the extent and severity of wildland fire? These and related questions are the focus of the work being done in this study.

Objectives of Study

The original overarching objective of this proposed research was to address an array of related ecological questions in a coordinated, integrated effort, thereby providing empirical data to inform future management decisions. The landscape scale of this design was both the driving force addressing the key questions as well as the largest impediment to successful construction of a scientifically credible experimental design. Our research team believes that assessing many of the key elements of forest ecosystems should be done over larger spatial and temporal scales than has typically been investigated in past research. The important difference we are investigating is the response to changes in forest structure and composition over space and time rather than simply site specific and immediate response. We believe this difference is especially relevant to forest management practices that are designed for large landscapes, executed over relatively long time frames, such as landscape level fuels treatment strategies.

The proposed research program is designed to address the three principal issues described below. These issues are specifically addressed through research questions and attending hypotheses for five different research components of this research program. These specific questions, and our ability (or lack thereof) to address these questions in an experimental manner, are detailed in the individual study plans for each module. Here we simply highlight the main objectives of the integrated research program and summarize the primary research questions that we plan to pursue.

- ***Wildland Fire Behavior and Protection.*** How do landscape level fuels and silvicultural treatments affect potential fire behavior and effects? Are specific combinations of defensible fuel profile zones (DFPZs) and subsequent individual tree selection or area treatments to thin the matrix effective in reducing the extent and severity of wildland fires? Are realized fire management benefits consistent with hypothesized results in reducing fire risk and altering fire behavior?

- ***Landscape Dynamics.*** How do combinations of DFPZs, subsequent individual tree selection or area treatments to thin the matrix, group selection, riparian protection standards, and species-specific protection measures affect landscape dynamics such as forest structure, composition, and succession at multiple scales of space and time?

- ***Species Viability.*** Induced by a forest management regime, how will old-forest-dependent species, particularly the California spotted owl and its prey base comprised of various species of small mammals, respond to changes in vegetation composition, structure, and distribution over space and time? How is response to treatments manifested at the individual and population levels of biological organization?

These issues are all encompassed in a dynamic forest ecosystem that is subject to natural processes of growth and mortality as well as vegetation manipulation through management and uncontrollable forces of fire, weather, and sporadic infestations of insects and pathogens. All components of a forest respond to the dynamic nature of a forest ecosystem (both natural processes and human-induced changes) through continual adaptation across the landscape over space and time. Forest ecosystems and their component species have evolved to cope with change. The question we pose is how does contemporary forest conditions (structure, composition, etc.) combined with forest management strategies influence forest ecosystem response? Are these new combinations of change within the bounds of historical variation that forest elements are capable of coping with? Will the changes lead to re-establishment of a resilient forest?

Similarly, addressing each major issue requires addressing multiple component issues or questions. For example, the issue of DFPZ efficacy can be addressed by considering such questions as initial treatment levels, maintenance, or location in the landscape. These are constituent questions that are limited to the area directly within the DFPZs. A complete understanding of DFPZ efficacy, however, requires a larger view that encompasses fuel conditions across the broader landscape, prevalent weather conditions, potential ignition sources, and the placement of other DFPZs. Adding to the complexity is the simple fact that no two DFPZs are identical; each is an artifact of individual design requirements under which it is constructed and maintained, and the unique properties and history of its location. Thus we need to devise our work in a manner that can enable understanding of how forests respond to treatments at multiple spatial scales and over long time periods. We believe this is important to better appreciate the complete and long-term effects, both potentially positive or negative, that will result from treatments.

Below we provide brief summary statements that capture the essence of the questions we are pursuing under this new research agenda. These questions are similar to the original research agenda developed by the research team for the Plumas Lassen study; however, due to changes in management direction our work now is largely observational, oriented around examining a series of case studies where treatments are planned under the HFQLG Pilot Project. We also have included some more experimental work at smaller spatial scales, where the opportunity has presented itself. We are still interested in, and pursuing, work that allows a better understanding of ecological response at as large a spatial scale as possible, albeit with a diminished strength of inference due to necessary adjustments in study design. Nevertheless, we are confident that the results from this work will add important new scientific insights on key management questions.

The specific management questions that are being addressed within the five different research components are:

Fuels and Fire Module

1) How do current fuels conditions affect potential fire behavior and effects?
  - What are current fuel loads and ladder fuel conditions prior to treatment?
  - What is the range of potential fire behavior given current conditions?
  - What are likely effects of fire behavior on these landscapes as determined by simulation models?

2) How will fuels treatments (i.e. DFPZs and other management applications) change fire behavior and effects?
  - How does the installation of Defensible Fuel Profile Zones (DFPZs) affect fuel loading?
  - How does the placement of DFPZs affect potential fire behavior? Do they reduce the risk of catastrophic fire under extreme weather conditions? What effect would DFPZs have on resulting fire effects? Would the reduction in total fire extent and intensity reduce the severity and extent of canopy fires?
  - What is the spatial efficiency of DFPZs for fire suppression and how do other spatially-allocated strategies compare?

3) What are the links between changes to landscape vegetation (treatment, fire) and associated spotted owl habitat? (in collaboration with the Owl Module)

Vegetation Module

1) What are the effects of canopy reduction due to thinning treatments on understory microclimate and shrub cover? How do we accurately measure changes in canopy cover to meet management prescriptions?

2) What are the appropriate ecological conditions to induce regeneration of shade-intolerant conifer species?

3) What is the influence of group selection openings on abiotic factors that guide plant community development?

Small Mammal Module

1) What are the habitat associations of the different taxa of small mammals found in coniferous forests in the northern Sierra Nevada (objective of developing refined yet functional models of habitat associations)? What is the relative abundance and distribution of these taxa with respect to forest structure and composition?

2) Estimate values of the demographic parameters (for example, population size, reproductive output, survivorship, and mortality rates) of these taxa.

3) Estimate values for spatial patterns (for example, home range area and configuration) for these taxa.

Bird Community Module

1) Do current forest management practices promote an ecologically balanced forest ecosystem that supports sustainable populations of the breeding bird community over time?

2) What are the critical local-scale habitat components and landscape-scale composition elements that should be managed for in order to sustain the avian community over time (20 to 50 years)? Can we predict species composition, abundance, and distribution in response to future landscape treatments?

3) How do, or will, a suite of avian species that are associated with a wide range of forest conditions respond to fuels treatments, at the local and landscape scales in the short (one to five years) and long term (five to 20 years)?

4) Do Spotted Owl protected activity centers provide high quality habitat for the broader avian community? What are the differences in the avian community composition within owl territories compared to the surrounding landscape?

California Spotted Owl Module

1) What are the associations among landscape fuels treatments and CSO density, distribution, population trends and habitat suitability at the landscape-scale?

2) What are the associations among landscape fuels treatments and CSO reproduction, survival, and habitat fitness potential at the core area/home range scales?

3) What are the associations among landscape fuels treatments and CSO habitat use and home range configuration at the core area/home range scale?

4) What is the population trend for CSOs in the northern Sierra Nevada and what factors account for variation in population trend?

5) Are barred owls increasing in the northern Sierra Nevada, what factors are associated with their distribution and abundance, and are they associated with reduced CSO territory occupancy?

6) Does West Nile Virus affect the survival, distribution and abundance of California spotted owls in the study area?

Summary

This work represents some significant scientific study that has occurred over the last three years and is expected to continue over the next five years within the HFQLG Pilot Project area. At the conclusion of the pilot project the HFQLG Act requires the Forest Service to commission a team of scientists to evaluate the pilot project and provide the Forest Service with guidance on the efficacy of the work and what were the environmental consequences on the natural resources of the geographic region. The results of these studies are intended to provide valuable, objective scientific insights that managers will need to develop subsequent management direction for the Plumas and Lassen National Forests, as well as other National Forest lands in the northern Sierra Nevada such as the portions of the Tahoe National Forest that contain similar ecological conditions.

We cannot ignore or deny the fact that designing a credible and useful research program in this area has been challenging to say the least. We want to be clear to all interested parties that the Pacific Southwest Research Station was asked to become involved in this project and for the purposes stated in the introduction above and we responded with the intent to provide as much new scientific learning as would be possible. PSW knew that we would be entering into efforts that would have many more challenges than research projects typically encounter. Our goal was to contribute as much as we could to the better understanding of forest ecosystem response to fuels and other forest management practices as they are manifested at a landscape scale.

We understand there is some uncertainty and sometimes controversy over how various forest elements will respond to planned forest management practices. This is likely to be the case under any chosen management regime. The objective of PSW was to tackle the difficult scientific challenges derived from the salient management questions as best as we could. PSW, as a research organization, remains wholly objective in executing this charge. We have assembled an excellent team of scientists with the appropriate areas of expertise and we have done the best we can to design our work to address the important questions. Many of these questions present significant challenges to experimental design of field ecology experiments and management constraints further constrain our ability to test questions with traditional hypothesis testing approaches. Nevertheless, we have invested three years of effort to develop the research approach for this work and have moved forward in defining the scientific opportunities, as they are now described below and in the attending detailed study plans for each of the five modules. These detailed research plans are now available for anyone interested in more detail. We expect to make the most of these opportunities in advancing our scientific understanding of forest ecosystem response to management practices.

Appendix A

2004 Annual Report: Fuels and Fire at the Landscape Scale Plumas and Lassen Administrative Study (PLAS)

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Project Goals:

In this study, we are investigating how landscape-level fuels and silvicultural treatments affect potential fire behavior and fire effects across the forested landscape of the project area in the Plumas National Forest. This analysis is critical for assessing the potential of severe or extensive fire occurring on the landscape.

In addition, both fuels treatments and fire alter forest structure, pattern and composition and thereby modify wildlife habitat that depends on the vegetation. Our assessments of potential change to landscape-scale vegetation will be instrumental when coupled with assessments of wildlife habitat conducted by the owl research module. This linking of module research relies on an integrative analytical model developed by our team. That model is described here, as the last part of this study.

Objectives and Overview

Past management activities including fire suppression, timber harvesting, and livestock grazing have changed the structure and composition of many coniferous forests in the western United States, particularly those that once experienced frequent, low-moderate intensity fires (Biswell 1961; Hartesveldt and Harvey 1967; Parsons and Debenedetti 1979; Beesley 1995; Erman 1996; Menning 2003). These changes in vegetation have altered habitat for a variety of species. Correspondingly, changes in vegetation and fuel loading have changed the probability of fire spreading across the landscape.

The USDA Forest Service aims to actively manage vegetation with the goal of reducing the probability of large, intense, or severe fires while minimizing negative effects on wildlife habitat and ecosystem stability. Proposed treatments include group selections and defensible fuel profile zones (DFPZs). Group selection treatments involve the harvest of all trees smaller than 30” diameter at breast height (DBH) over a one to two acre area (Stine et al. 2002). DFPZs are areas with extensive forest thinning intended to reduce surface and canopy fuel loads. They are also known as shaded fuel breaks and are designed to allow access for active fire suppression. DFPZs are spatially-extensive, covering hundreds to thousands of hectares (Stine et al. 2002).

Currently, there is limited information on the effects of landscape fuels treatments on reducing severe fire behavior and effects, especially at the landscape scale (Erman 1996; Agee et al. 2000; Fites-Kaufman et al. 2001). Elsewhere in the Sierra Nevada, group selections have been shown to have little effect on the landscape-level behavior of fire (Stephens and Finney 2002); the proposed group selections in the Plumas, however, retain more large trees per acre than typical group selections. To date, the modeled effects of group selections with large tree retention have not been published for this forest type.

Assessing the effects of these vegetation management strategies—group selections and DFPZs—across the forested ecosystems of the Plumas and Lassen National Forests is the goal of the Plumas-Lassen Administrative Study (Stine et al. 2002). The study is composed of five research teams with distinct focuses: California spotted owls, small mammals, songbirds, fuels and fire, and vegetation. Due to practical considerations of a study as spatially extensive as this, we have to mix research with monitoring. The overall study does not comprise a formal scientific experiment in that the scientists involved have little control over actual treatments. The study amounts to far more than monitoring, however, in that we are independently assessing a large landscape and modeling changes to that landscape given a set of prescriptive treatments.

For the Fuels and Fire Module, which is the focus of this study plan, we aim to address the landscape-scale effects of the proposed forest treatments by answering a suite of questions: First, what are current conditions, in terms of fuel loads and vegetation, measured directly in the field? Second, what is the current potential fire behavior and effects given these measured fuel and vegetation conditions? Third, how would landscape fuels treatments affect vegetation condition and fire behavior and effects?

Fourth, in addition to these efforts to characterize fuels and fire relationships, it is essential to link results of our research with findings from the other research modules (figure 1). It is clear that any landscape-level fuels or forest management strategy will affect many interrelated components of forest ecosystems (Erman 1996; Bahro 2004). Therefore, it is important to understand the synergistic effects between potential treatments and various areas of concern—forest conditions, risks of severe or extensive fire, and habitat alteration. Our goal in answering this fourth question is to produce an analytical model in which we integrate maps of current conditions with models that project responses of fire behavior and effects given prescriptions of treatment and weather scenarios. The vegetation component of the current conditions maps would act simultaneously as input to the Spotted Owl Module's habit suitability models. By coupling these data layers and models between research modules we will model the likely effect of a landscape fuels strategy on both *fire* and *owl habitat* given various prescriptions and weather scenarios.

Taken together, these four research goals form the top level of a hierarchical set of research goals that may be best expressed in a table. Hence, we have shown these research objectives and their supporting details and questions in table 1. Details supporting the modeling efforts follow the table.

Fig 1: Ecosystem Relationships Examined in PLAS
(Topics addressed in this module emphasized in bold)

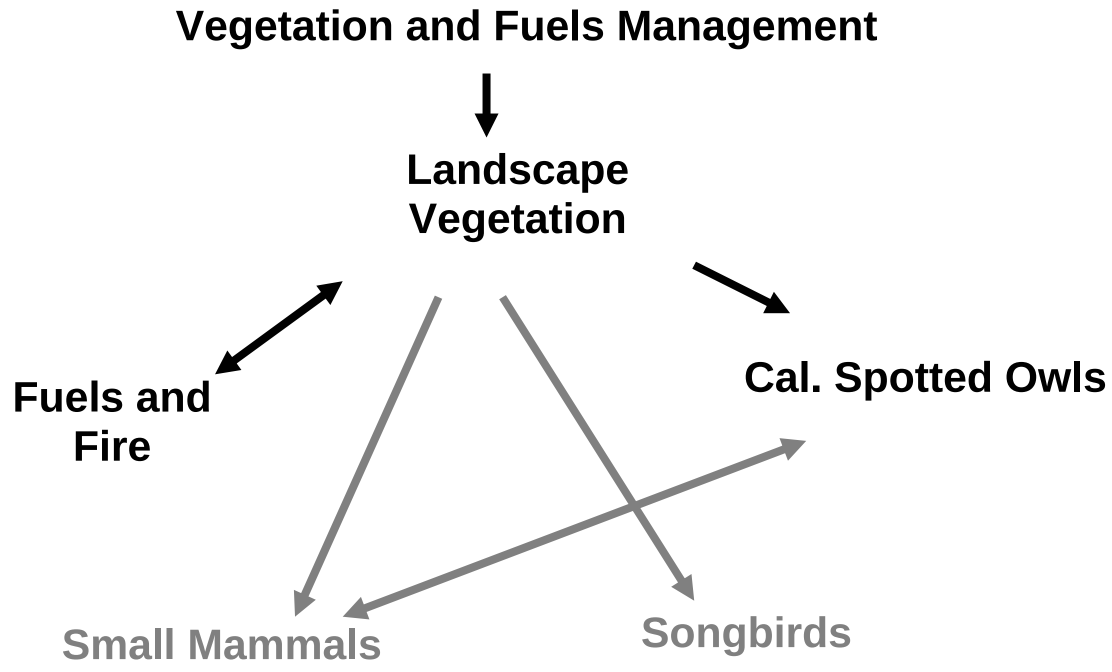


Table 1: Fuels and Fire Module: Summary of hierarchical arrangement of study topics

1.0 Current conditions: measurement of vegetation and fuels at the landscape scale
  1.1 Current vegetation: What are current vegetation conditions prior to treatment?
    1.1.1 Forest sampling in the field (forest plots)
    1.1.2 Remote sensing of forest conditions
      1.1.2.1 Forest and vegetation classification (LANDSAT imagery)
      1.1.2.2 Forest structural diversity analysis (IKONOS imagery)
  1.2 Current fuels: What are current fuel loads prior to treatment?
    1.2.1 Fuels sampling in the field (forest plots)
    1.2.2 Remote sensing of annual fine fuels production using LANDSAT
    1.2.3 Ladder fuels: probability of fire ascending forest canopy (LaFHA)
    1.2.4 Integration of data sources into a fuel model/map for the study area

2.0 Fire modeling: how might current conditions (above) affect fire *behavior* and *effects*?
  2.1 Fire *behavior*: What is the range of potential fire behavior given current conditions & a range of weather scenarios? (FARSITE & FlamMap models)
  2.2 What are likely *effects* of fire behavior on these landscapes as determined by simulation models? (Stephens approach using FARSITE & FlamMap outputs)

3.0 Effects of treatments: how might landscape-scale treatments change fire behavior and effects (using FlamMap)?
  3.1 Group Selections (GS) and Defensible Fuel Profile Zones (DFPZs)
    3.1.1 Measure: how does the installation of GSs & DFPZs affect fuel loads?
    3.1.2 Model: how does the placement of GSs & DFPZs affect potential fire behavior? Do they reduce the probability of catastrophic fire under extreme weather conditions?
    3.1.3 Modeling: how does the installation of GSs & DFPZs affect fire effects such as mortality to different species and size classes of trees? Would the reduction in fire extent and intensity reduce the severity of canopy fires?
  3.2 Spatial allocation and efficiency: DFPZs and Strategically Placed Landscape Area Treatments (SPLATs)
    3.2.1 How does the installation of alternative treatments affect fuel loading?
    3.2.2 How does the placement of alternative treatments affect potential fire behavior?
    3.2.3 How do different levels of management intensity (extent of treatment) affect the treatment's ability to reduce the size or intensity of fires?

        - 3.2.4 What effect would alternative treatments have on resulting fire *effects*?

- 4.0 Fire and habitat model integration
    - 4.1 Link current vegetation coverages to potential fire behavior & effects (as above)
    - 4.2 Provide link from vegetation coverage to Keane’s owl habitat assessment
    - 4.3 Model interaction between vegetation management and both fuels and fire, and owl habitat given current conditions, prescriptions and weather scenarios

Study Area

Our study area is a subset of the Plumas National Forest in Northern California, USA. The Plumas and Lassen National Forests cover hundreds of thousands of acres, and sampling an area this size with a limited field crew and small remote sensing budget is beyond our capacity. As a result, we have chosen to focus on the study area's treatment units (TU) 2, 3 and 4 (Stine et al. 2002), which present widely varying topographical conditions and contain a variety of owl habitat quality. The total area of these three TUs is about 60,000 ha (150,000 ac) (Keane 2004). Vegetation varies widely through this region, presenting a good opportunity to examine fire behavior and end effects across a spectrum of conditions. The town of Quincy lies directly eastward of TU 4 and would be immediately affected by fire in this area and the resulting smoke. In addition, TU 2 has been evaluated to have high quality spotted owl habitat while areas 3 and 4 have lower qualities (Keane 2004). As a result, these three treatment units present a good range of conditions in which to conduct this research and test our model integration.

Vegetative cover in this area is primarily mixed conifer forest. The mixed conifer forest community comprises a mix of three to six conifers and several hardwoods (Barbour and Major 1995; Holland and Keil 1995; Sawyer and Keeler-Wolf 1995). Common conifers include ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*P. jeffreyi*), sugar pine (*P. lambertiana*), incense-cedar (*Calocedrus decurrens*), Douglas fir (*Pseudotsuga menziesii)* and white fir (*Abies concolor*). Red fir (*Abies magnifica*) is common at higher elevations where it mixes with white fir (Holland and Keil 1995; Sawyer and Keeler-Wolf 1995). At mid to lower elevations, common hardwoods include

California black oak (*Quercus kelloggii*) and canyon live oak (*Q. chrysolepis*) (Rundel et al. 1995).

In addition, a number of species are found occasionally in or on the edge of the mixed conifer forest: western white pine (*P. monticola*) at higher elevations, lodgepole pine (*P. contorta*) in cold air pockets and riparian zones, western juniper (*Juniperus occidentalis*) on dry sites, California hazelnut (*Corylus cornuta*), dogwood (*Cornus spp.*) and willow (*Salix spp.*) in moister sites, California bay (*Umbellularia californica*) and California nutmeg (*Torreya californica*) in lower, drier areas (Griffen and Critchfield 1976; Holland and Keil 1995; Rundel et al. 1995).

A variety of vegetation types currently comprise the matrix of covers in which the mixed conifer forest is arrayed. Vegetation in the matrix ranges from chaparral on exposed, poorly watered south and west facing slopes to oak woodlands and riparian meadows. At higher elevations, particularly toward the Bucks Lake Wilderness, some red fir may be found in pure stands (personal experience).

Methods

This study is conducted under a passive adaptive management framework administered by the USDA Forest Service; we have no control over the implementation of the landscape fuels treatments. The HFQLG Act outlines the landscape fuels treatment strategies, and defines the types of timber harvest to be implemented. Decisions on the timing and placement of fuels treatments will be determined at a local level by the Plumas National Forest.

We do have control over the data collection and modeling aspects of the project. Our research topics (table 1) can be divided into several methodological groupings. Here, we present summaries of methodologies for field data collection, remote sensing, and model integration. Data are collected from a series of field plots (discontinuous data) as well as from satellites (continuous forest canopy data). Additional data products are derived through modeling.

Methods: Field data collection

Plot Layout and Design

Data on forest cover and fuels is being collected in 0.05ha (0.125 ac) plots 12.6m (41.3 ft) in radius (figure 2). Plot locations are established using a stratified-random approach. Strata of elevation, aspect and vegetation type were defined using the layers previously supplied by the contractor VESTRA (Stine et al. 2002). This process identified over 700 plot locations in treatment units 2, 3 and 4. In addition to the randomly-stratified plot locations described above, similar data will be collected at locations identified by the other modules: plots are located at each owl nesting site and mammal study grid in the three treatment units.

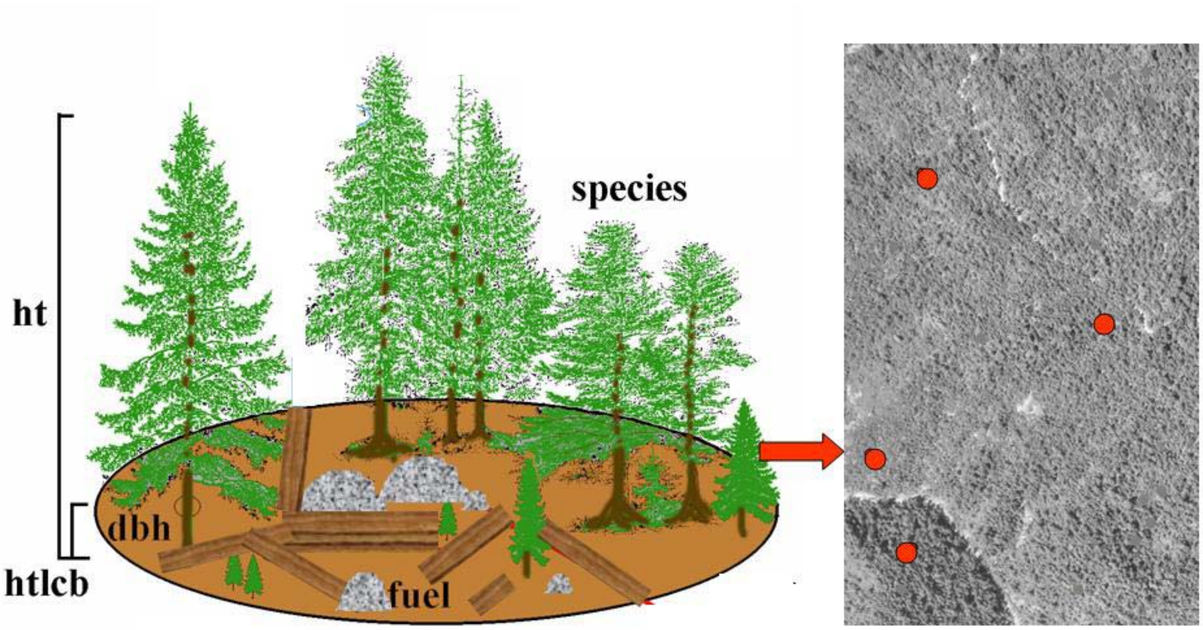
Forest Structure and Composition; Site Data

We collect data on tree species, diameter at breast height (DBH), categorical estimate of height, and height to lower crown (see Appendix A for sample data sheet). Site data collected include location (using high-precision GPS), slope, and aspect. Canopy cover is assessed at 24 points (every 1 meter) along two linear fuels transects (described below).

Ground based sampling of ladder, surface, and ground fuels

Surface and ground fuels are sampled in each plot using the line intercept method (Brown 1974; Brown et al. 1982). Ground and surface fuels are sampled along two transects radiating from plot center. The first transect is located along a random azimuth and the second falls 90 degrees clockwise from it. We sample 1 and 10 hour fuels from 10-12 meters along each transect, 100 hour fuels from 9-12 meters, and 1000 hour fuels

Figure 2: Data sources: field plots and satellite imagery
(plots shown scattered on landscape on satellite image to right)



data from 1-12 meters. Duff and litter depth (cm) are measured at 5 and 8 meters along each transect. Maximum litter height is additionally sampled at three locations from 7 to 8m (Brown 1974; Brown et al. 1982). Total fuel loads for the sites are occularly estimated using fuel photo series developed for the Northern Sierra Nevada and Southern Cascades (Blonski and Schramel 1993).

Ladder Fuel Hazard Assessment (LaFHA)

We have devised and implemented a mixed quantitative-expert system for assessing ladder fuels (Appendix B). The Ladder Fuel Hazard Assessment (LaFHA) requires a trained field crew member to rapidly assess the presence and continuity of fuel ladders in each of four quadrants in a plot using a flowchart (Appendix B). The first step is to determine the presence of low aerial fuels: the fuels that would create sufficient flame lengths to reach several meters from the forest floor. Sparse vegetation, or vegetation widely distributed, probably has too little fuel per volume of air to create and sustain large flames. Therefore, we define a clump of low aerial fuels to be brush or small trees covering an area of at least 4 square meters (2m x 2m) with gaps of less than 50cm. If it is particularly dense, or tall and brushy, a clump may cover a small area. A particularly dense clump may cover as little as $2m^2$ on the forest floor, for example. Branchy dead fuel or stems may be included in the assessment. The size and density of these clumps of fuel and vegetation are based upon personal experience (S. Stephens, K. Menning). If there is no clumping of low aerial fuels, the site would fall in the two lowest ladder fuel hazard categories (C, D); conversely, if there is a clumping of low aerial fuels, the site would fall in one of the two higher-risk categories (A, B). It is important to note that isolated clumps of low aerial fuels, well removed from any ladders, are discounted.

Letters (A, B, C, and D) are assigned to hazard ratings instead of numbers to prevent confusion: categories are not of interval or ratio quality (e.g., “Is category 4 twice as risky as category 2?” No, we would not know the quantitative relationship without a direct test).

The second step is to make a determination about the vertical continuity of the fuel ladder from the ground to the canopy. Gaps of more than 2m might be enough to prevent the spread of flames vertically (S. Stephens). Vegetation with gaps of less than 2m from the ground to the upper canopy may present a good ladder to conduct flames. Sparse vegetation lowers the probability and reduces the quality of the ladder. The technician is expected to look at the vegetation and determine whether there are gaps of 2m or more. If the maximum gap is less than 2m, then the site would be categorized as the higher hazard of the two options.

After placing the site in one of the four categories (A, B, C, or D), the technician records the minimum height to live crown (HTLCB) and the size of the maximum gap in the best ladder. These two values may later be used to help verify the classification is correct. The process is repeated for each of the four quadrants of the plot.

The effect of slope is not considered during the hazard evaluation in the field, slope data are used later, to modify the hazard rating. Because the effect of slope on flame length is non-linear (Rothermel 1972), the slope must have a non-linear multiplicative effect on the hazard rating. Final analysis of the plot is performed in the laboratory by combining the ratings of the four quadrants and applying a non-linear slope factor. A plot with one quadrant of high ladder fuel hazard and three low hazard ratings is certainly not as great a risk as a plot with continuous, high-risk ladders in each quadrant.

While this semi-quantitative, semi-qualitative process is experimental, and the exact numerical relationships between slope and hazard are yet to be determined, we feel the method has merit; importantly, the field crews report consistent ratings after training and repetition (K. Menning).

Methods: Remote sensing

Two different remote sensing methods are being implemented. First, high spatial resolution IKONOS provides information on continuous forest pattern, structure, cover and variability using methods developed by Menning (2003) including spectral entropy canopy diversity analysis (SpECDA—see appendix E of Fuel and Fire Study Plan). These data and analyses have the benefit of being linked to analyses of vegetation and wildlife habitat conducted by other researchers in the project (see model integration, below). In 2003, high-resolution (1-4m) IKONOS imagery of several treatments was collected covering treatment units 3 and 4. In 2004, IKONOS imagery covering TU 2 and 3—overlapping the data collected in 2003—was collected to provide additional coverage of the area with high owl population.

Second, an approach similar to that developed by van Wagtendonk and Root (2003) in Yosemite National Park is being used to provide information on vegetation and the annual cycle of fine fuel production. Two thematic mapper (TM) scenes are used to help differentiate the forest types. One TM scene is obtained in June and another over the same area from October. The two scenes are used to differentiate the vegetation types including forests, deciduous hardwoods, montane chaparral, wet meadows, and dry meadows. These are verified using data from the extensive network of field plots.

The spatial resolution of this second class of remotely sensed data is 30m by 30m. Bands 3 and 4 are being used from the TM data to calculate Normalized Difference Vegetation Index (NDVI). The result of this procedure will be a forest ecosystem map that will include rock, meadows (dry and wet), bare ground, montane chaparral, riparian areas over 30 m in width, and the three most common forest types (ponderosa pine, mixed conifer, white fir). Comparison of the pre- and post-summer growing season images will allow us to quantify the production of fine fuels in a variety of vegetation types. This will lead to more realistic inputs the fire modeling process.

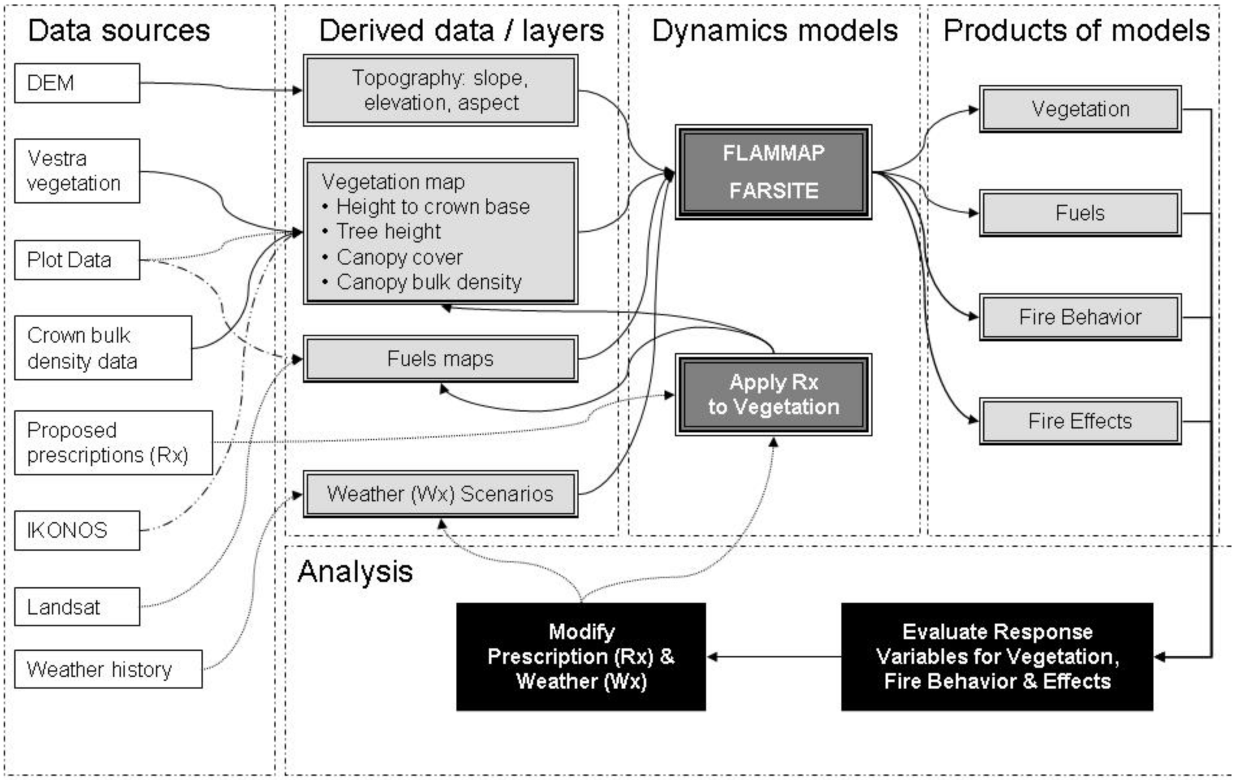
Methods: Data Processing, Analysis and Model Integration

Fire behavior models such as FARSITE require maps of vegetation, topography, and fuels, as well as weather scenarios, in order to model the spatial behavior of fire (figure 3). These data are integrated from a variety of different sources. Development of the vegetation map has been described above, in the remote sensing methodology. Topographic variables—slope, elevation and aspect—are mapped across the study area using pre-existing Digital Elevation Models (DEM) on a 30x30m grid. Assembling fuels maps requires that fuels be measured at select sites (a discontinuous set) and then extrapolated across the landscape where fire may burn (continuous coverage).

Calculation of Fuel Loads and Development of Fuel Models

Many fuel inventories done in the Sierra Nevada have assumed that the fuel particles being inventoried had similar properties to those found in the northern Rocky Mountains (Brown 1974) but Van Wagtendonk's work in quantifying Sierra Nevada surface and ground fuel properties allows custom fuel load equations to be developed for a site-specific project such as this. This methodology previously has been used to produce accurate estimates of fuel loads (Stephens 2001). Additional validation of these fuel load coefficients are provided by Menning's research in Sequoia National Park (Menning 2003). As tree species in the northern Sierra Nevada are the same as those sampled by Menning and van Wagtendonk, the data should be relevant to this study site.

Figure 3: PLAS Landscape Vegetation, Fuels and Fire



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Field measurements provide data on species mixes and fuel particle size distribution. Using these data, ground and surface fuel loads are calculated by using equations developed for Sierra Nevada forests (van Wagtendonk et al. 1996; van Wagtendonk and Sydoriak 1998; Menning 2003) as well as the production of fine fuels as determined by Landsat imagery analysis (van Wagtendonk and Root 2003). Coefficients required to calculate all surface and ground fuel loads are arithmetically weighted by the basal area fraction (percent of total basal area by species) that are collected in the plots.

Plot based fuel measurements are being used to create a set of customized and spatially-extensive fuel models for the study area (Burgan and Rothermel 1984) for this area. Fuel model development includes a stochastic element to more closely model actual field conditions that have a large amount of spatial heterogeneity. Stochastic fuel models are being produced for each stratum identified using van Wagtendonk and Root's methods (forest type, aspect, seral stage, etc.). Plot data provide crown cover, height to live crown base, and average tree height at each site. Canopy bulk density estimates are based on previous work by Stephens (Stephens 1998). All of these spatially-discontinuous data derived from plot-specific measurements are extrapolated across the landscape using the remote sensing imagery maps of vegetation.

Simulations: Potential fire behavior

Potential fire behavior is being estimated using a similar technique developed by Stephens (1998) but at much broader spatial scales. The effectiveness of the different restoration treatments will be assessed with computer models such as FARSITE (Finney 1996; Finney 1998; Finney 2000) and FlamMap (Finney 2003). FARSITE is a deterministic, spatial, and temporal fire behavior model that requires as inputs fuel measurements and models; topographic data, including slope, aspect, and elevation; forest structural data including canopy cover, tree height, height-to-live crown base, and canopy bulk density; and weather. A historic fire occurrence map is being produced to estimate the probability of ignitions in the study area. Data come from the Plumas National Forest archives and current GIS layers. This derived map will be used to generate an actual ignition point in each FARSITE simulation. FlamMap is similar to FARSITE but does not use a user-determined ignition but burns the entire landscape using one set of weather data. These models will be used to quantify the potential fire behavior of the different treatment approaches.

The duration of each simulation would be seven days, a period that approximates the duration of many landscape-scale wildfires in the Sierra Nevada before they are contained (Stephens, personal experience). Weather scenarios using data from the 50th (average) and 90th (extreme) percentile condition is being used and this data is being collected from local weather stations. Fire simulations would be constrained by suppression activities. Constrained simulations will use realistic suppression elements (15 person hand crews, aircraft, bulldozers, etc.; Stephens, personal experience).

Outputs from the fire simulation include GIS files of fire line intensity (kW/m), heat per unit area (kW/square meter), rate of spread (m/s)**,** area burned (ha), emissions (tons) and if spotting and crowning occurred. Scorch height (m) would be calculated from fireline intensity, air temperature, and wind speed. This information will be used to compare the effects of the different landscape level restoration treatments on altering fire behavior.

Simulation: Fire effects

After the fire has passed, the effects of the fire linger: trees die, exposed soils erode, and insects invade. Some fire effects such as tree mortality are being modeled using the GIS outputs from the FARSITE and FlamMap simulations coupled to previously-tested quantitative models that estimate tree mortality (Stephens and Finney

2001). In addition to the tree-mortality measure of fire severity, the amount of bare mineral soil exposed by the simulated fires is being estimated for each 30m by 30m pixel.

Analytical response variables for simulations

Landscape Fire Behavior

The differences in landscape-scale suppression efficiencies among fuels treatments is an essential aspect of this study (Agee et al. 2000; Bettinger et al. 2002). Defensible Fuel Profile Zones (DFPZs) should aid the ability of a wildfire suppression crew to successfully extinguish a fire during initial attack. FARSITE is being used with realistic suppression elements to determine if these landscape level fuel treatments will increase suppression efficiency when compared to the current untreated conditions. To test this efficiency in suppression, one landscape-scale fire response variable is the percentage of wildfires contained below 5 ha (12.5 ac) in size in one burning period before and after landscape fuel treatments.

Second, it is common for wildfires to be propagated by spotting and this can exponentially increase the size of the fire, particularly during the early periods such as the first 24 hours (Pyne et al. 1996). Treatments may reduce the spread of fire into a canopy where flaming brands may be carried into adjacent unburned areas(Pyne et al. 1996). Hence, the ability of a treatment to reduce the number of spot fires is an important measure of the treatment's ability to reduce fire severity or frequency. The number of spot fires is being estimated before and after treatments to determine if treatments reduce fire spread from spotting. Here, the second fire response variable is the percentage change in spot fire initiation before and after landscape level fuel treatments.

A third critical response variable focuses on escapements of fire across the landscape during a longer time period. We will report the probability of simulated fires escaping from or crossing DFPZs and spreading at least another 200 ha (500 ac). This probability will be defined as the percentage of fires given 90^{th} percentile fire conditions. This will be an important measure of the effectiveness of the DFPZs at reducing the chance of fire spreading across the landscape.

The total spatial extent of fire, given treated or untreated areas, is the fourth response variable. Simulated fires will be allowed to burn either until they burn out or are contained. The extent of forested area burned will be compared between treated and untreated areas.

Fifth, ground and canopy fires are dramatically different in behavior, severity, intensity and likelihood to spread across a forested landscape (Pyne et al. 1996). Ground fires are often beneficial, reducing fuel from the ground and surface, and reducing competition for small trees (Stephenson et al. 1991; Stephenson 2000). The fifth response variable, therefore, is a simple ratio of the area of canopy fire to total fire extent.

Analyzing Spatial Efficiency of the Placement of Landscape-Level Fuels Treatments

Location of fuel breaks can play a significant role in the efficiency of fire suppression (Finney 1999; Finney 2001). This is discussed more thoroughly in our Study Plan. SPLATs are passive in nature—no active suppression is performed—and thereby differ markedly from DFPZs which are meant to be the base of active suppression. The efficacy of SPLATs, however, will be tested the same way as the DFPZs, as previously described with the same response variables and over the same time periods. SPLATs, like DFPZs, would be placed on the landscape over a period of years rather than being applied all in the same time period. Performing this analysis with the same base data layers of vegetation and topography will allow us to analyze the efficiency of these different landscape-scale forest fuels management strategies.

We plan to test SPLATs at several spatial extents. The first set of SPLATs tested will have the same spatial extent as the proposed DFPZs. We will test increasing increments of landscape treated by SPLATs by 5% until we find the level of treatment that corresponds with similar degrees of suppression efficiency with the DFPZ network.

Further, we will try re-allocating the DFPZ treatment areas spatially to see if we can improve their efficiency for suppressing large or severe fires. A response variable here would be the percentage of the landscape burned given different configurations given the same weather scenarios and suppression efforts.

Landscape Vegetation and Habitat Response to Fire

A primary concern of this study is the effect of fires on forest structure, pattern and condition. Of particular concern are the older, late-successional forest remnants (Erman 1996). These provide essential habitat to the spotted owl. Wildfires in the Sierra Nevada are commonly low to moderate severity events with patches of high severity fire (Stephenson et al. 1991). Low severity fires may kill only the smallest pole or seedling size-class trees while moderate severity fire may kill both small and moderately sized trees. Fire in the high severity patches—or landscapes in the case of an extensive high severity fire—kills the majority of the small and medium sized and many of the large trees within the perimeter. High severity fire and the corresponding large tree mortality will significantly reduce canopy cover.

Many wildlife species such as California spotted owls prefer diverse forest structure for foraging and breeding and the presence of such variation may affect the success of reproduction (Hunsaker et al. 2002; Blakesley et al. In Press; Lee and Irwin. In press). Telemetry studies indicate that owls prefer to nest in areas with high canopy cover. Some areas of lower cover can also be included in the foraging habitat but this should probably only comprise a fraction of the area. Reduction of canopy cover may reduce the nesting habitat quality for the owl.

While there is a certain link between vegetation structure, pattern and composition and spotted owl core areas and home ranges (Keane and Blakesley 2005) exact measures of vegetation condition or change are not yet well defined. In addition, the link between different spatial scales of vegetation—extent and variation—and habitat selection is unknown. As a result, the definition of meaningful measures of vegetation condition and change, including appropriate scales of analysis from $30m^2$ to hundreds of hectares, will evolve along with the active analyses conducted in the Spotted Owl module (Keane and Blakesley 2005).

Fire and Habitat Model Integration

The final goal of the Fuels and Fire Module research is to coordinate with the Spotted Owl Module to produce a system in which an input of landscape-scale vegetation layers, weather scenarios, and fire events can be used to derive simultaneous assessments of fire and owl habitat (figure 4, appendix C). This effort requires separate but linked analyses by both our module and the Spotted Owl Module analysts (Keane and Blakesley 2005). The fuels and fire module will use inputs of IKONOS and LANDSAT imagery (described above, and in appendix E of Study Plan), extensive plot data, and pre-existing

VESTRA vegetation classification data to produce derived coverages, including base vegetation layers. These vegetation layers will be passed to both the Owl Module and the fire behavior and effects part of this module's study. Analysts in the Owl Module use the layers in their Akaike Information Criteria (AIC) and regression analyses to determine owl habitat suitability (Keane and Blakesley 2005).

These paired analytical efforts—fire and wildlife habitat—will yield results covering the same landscape at the same time given the same weather and treatments. Fire behavior and effects and habitat will be evaluated jointly. Revised prescriptions for landscape fuels treatments (such as DFPZs) will be drafted along with a defined set of potential weather scenarios. These prescriptions and scenarios will be used to update the base vegetation layer to a post-treatment condition. Then, the whole process is repeated, with emphasis on analysis of the results (figure 4, Appendix C).

Figure 4: PLAS Landscape Vegetation, Fire and Habitat Model Integration and Projection

Note: Vegetation, Fuels and Fire module diagram (left column) simplifed from Figure 4.

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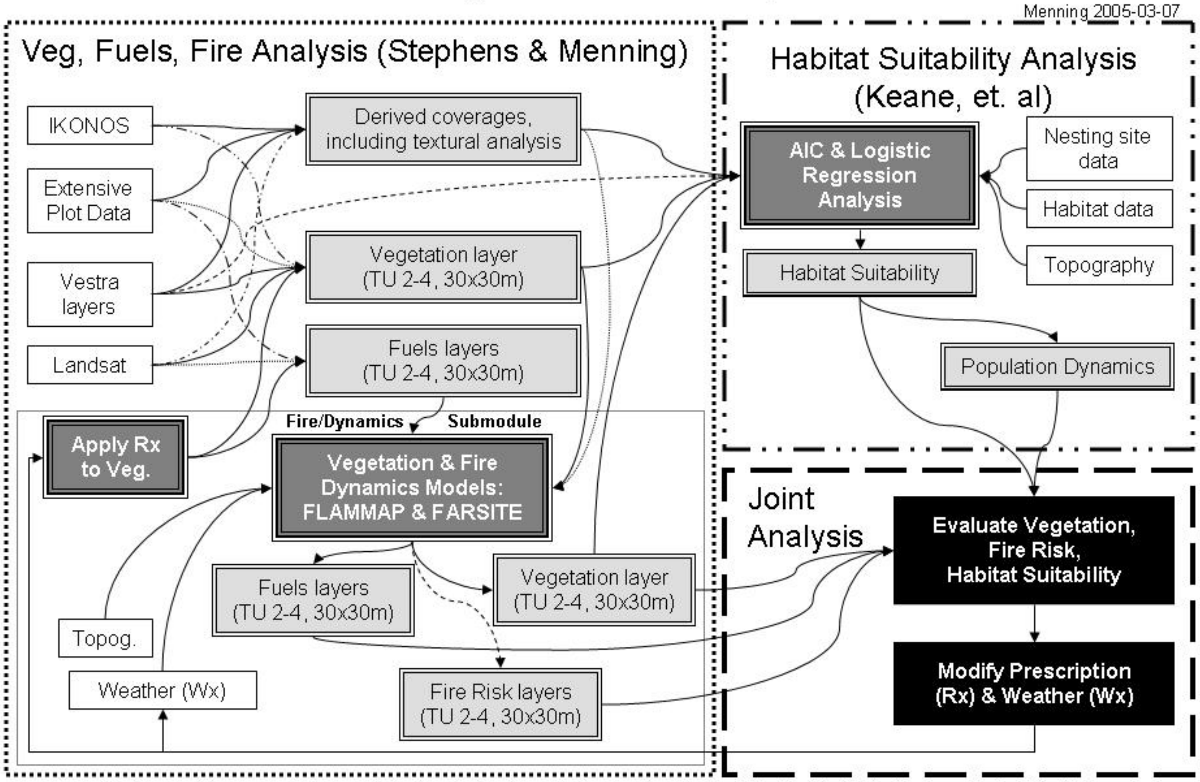


Key: white boxes = data sources; light grey = derived products or layers; dark grey = dynamics/analytical models; black = human evaluation & decision space

The net result of this collaborative effort will be an integrated analysis of the landscape-level effects of any potential fuels treatments and weather scenarios on both fire and owl habitat. We anticipate that other modules—Small Mammals and Songbird—may be able to develop habitat suitability analysis from vegetation layers that will enable them to integrate with this model, as well. As an interim step, we can probably crudely assess habitat of songbirds and small mammals using the California Wildlife Habitat Relationships system which links vegetation characteristics to the known habitat needs of different wildlife species. Eventually, empirical models derived from the research of the Songbird and Small Mammal Modules could supplant these coarser models.

Coordination with Interested Parties

We plan to work closely with Mark Finney, a fire-modeling expert in Missoula, Montana on FARSITE and FlamMap fire assessments. In addition, we anticipate close coordination with fire management offices at the Forest Service districts. In 2003, for example, we supplied forest structural data to the Plumas National Forest to use in its forest management planning.

Accomplishments in 2004

Field

In the summer of 2004, we put two field crew members—Randy Karels and James Graves—in the field with a part-time supervisor, Kurt Menning. The crew visited and inventoried 198 new plots in TUs 2 and 3. At each of these plots, the crew inventoried site conditions, fuel loads, and forest structure and composition, as per the methods described above. Combined with the 68 plots visited by the vegetation module crew, with which we coordinated on data collection in 2003, we have now collected data from 266 plots.

In addition to these core plot areas, additional data on fuel loads and forest structure are collected by the songbird module crews at their observation points. Each transect they run has twelve sites. At two of these observation sites the team collects plot data in a fashion similar to our module. At the other ten sites, the team rapidly assesses fuel loads using the fuel photo series (Blonski and Schramel 1993) and the LaFHA flowchart. These rapid assessments were conducted at 625 sites in 2004.

Initial analysis of the ladder fuel data from 240 field plots and 510 songbird observation sites (750 plots, 3000 total observations) are being analyzed. Initial analysis, before slope data are used to quantitatively modify the ratings, indicated that 17% of the observations were placed in the highest ladder fuel hazard category, 22% in the second, 25% in the third and 36% in the lowest. The best measure of these numbers will come first when the results are modeled to link them to fire behavior; and second, when the observations may be repeated after fuels treatments to gauge the reduction in ladder fuels.

Remote Sensing

In 2003, high-resolution IKONOS imagery was acquired for TUs 3 and 4. In 2004, we contracted the acquisition of this imagery covering TUs 2 and 3. The overlap in TU 3 will allow cross-calibration between the two years. TU 2 was added since that area has now been included in the core area of our analysis (TUs 2-4). Processing of this imagery is underway.

LANDSAT imagery, which does not require a special contract for acquisition, is available and will be purchased in 2005 for these areas covering the summer of 2004. These data will be processed during the 2005-2006 academic year.

Analytical

Much of the work to date has involved the transfer of data from datasheets and spreadsheets to databases. Raw field data, which come from discontinuous points on the ground, are processed and extrapolated across the landscape to form continuous coverages. These base layers are essential inputs to all fire and integrative habitat modeling efforts.

Goals for 2005

Field

In 2005, we plan to put another two-person field crew in place to continue sampling plots in TUs 2 through 4. We plan to add an additional 200 forest plots to the 266 already in place. The songbird module teams will be able to add more rapid observations of fuels at their sites, pushing the total of these sites well over 1000.

We hope to place one field crew supervisor at the site full-time during the summer. This individual would act as an on-site analyst, processing incoming data and developing base layers for the fire behavior and effects modeling. Whether we fill this position or not depends on availability of personnel.

Remote Sensing & Geographic Information Systems (GIS)

By this summer, we expect to have a fully-functioning GIS operational with our topographic data and remote sensing imagery. Integrating the processed imagery into the spatial database (GIS) is essential for completion of the base layers for modeling.

Whether we acquire new IKONOS imagery for the study area is dependent upon analysis of the existing imagery this spring. LANDSAT imagery will be acquired post-field season.

Analytical

Our primary analytical goal during the 2005 field season and following academic year is to finalize the base layers of fuels and vegetation for fire behavior and effects simulations in FARSITE and FlamMap. Once these layers are complete, and initial runs in the fire models have been completed, we can proceed with the initial integrated modeling runs with owl module. Key to this effort will be the processing of the remote imagery and performing the forest canopy spectral analysis that links our assessments of vegetation cover with the owl module's habitat analysis.

Additionally, we would like to find a setting in which we can begin testing and validating our LaFHA approach. We need to find an area—outside the study area—where prescribed fire is planned with potential escapes of flame into the canopy. Using the LaFHA method to assess ladder fuel hazards before fire and comparing the assessment with data on where fire actually reached the canopy can help us refine this model.

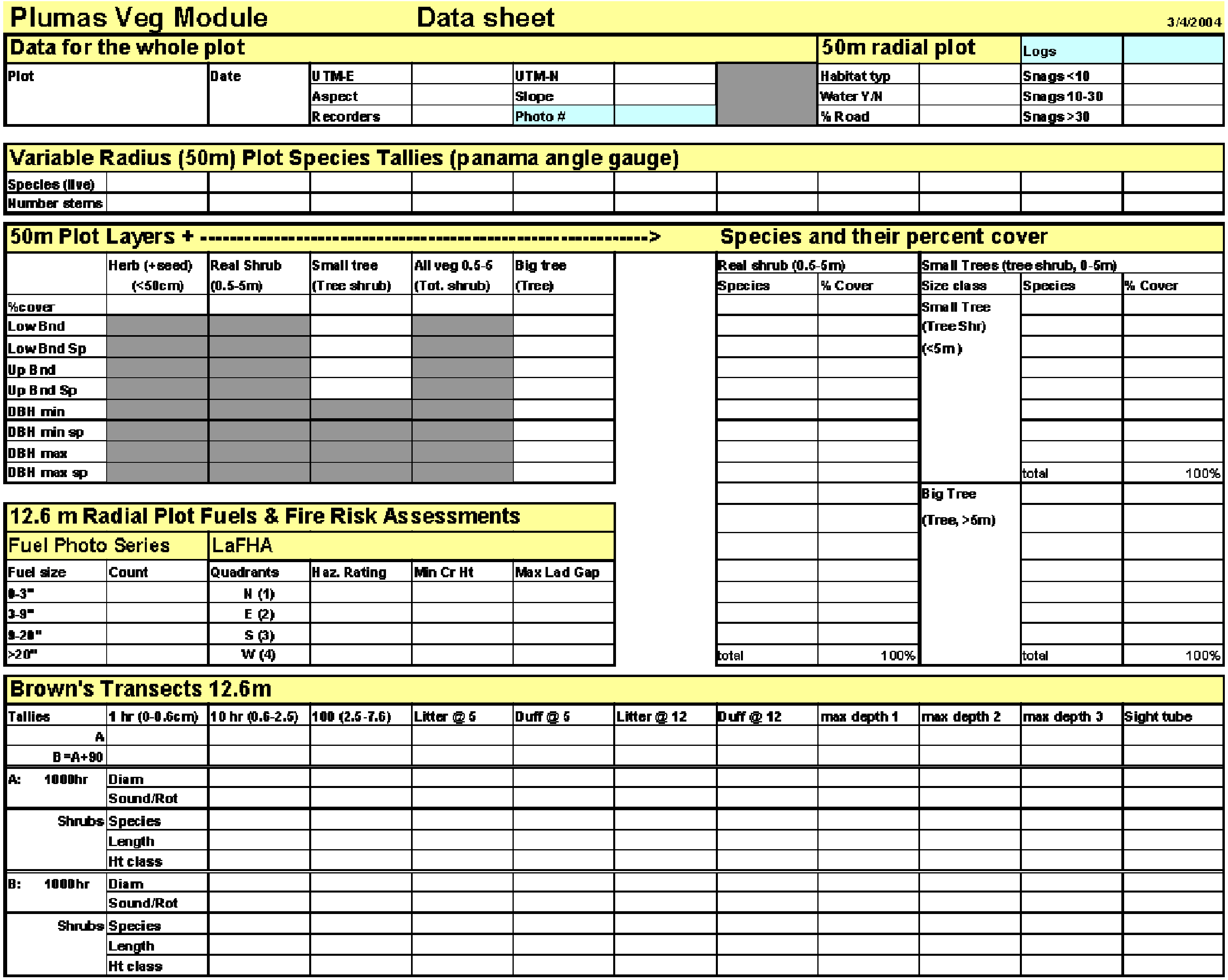
Expected Products (Deliverables)

Results will be published regularly in the Plumas-Lassen Administrative Study Annual Reports. We will present results directly, as they are derived, to interested parties. More formal scientific publications are targeted covering a variety of areas including the LaFHA approach being piloted in this study, SpECDA analyses of forest structure and its variability, fire behavior and effects, integrated model results with the Owl Module, and assessments of the efficiency of DFPZs and other treatments in moderating the landscape-level effects of fire. We plan to present initial results of the LaFHA approach at the Ecological Society of America meeting in August, 2005.

Data Management and Archiving

All data will be archived with the USDA Forest Service's Sierra Nevada Research Center (SNRC) in Davis, California, as well as the Fire Science Lab (Stephens Lab) at the University of California, Berkeley. Some derived products will be put on-line by the SNRC or Stephens Lab.

Appendix A1: Datasheet for field data collection, page 1 of 2



Plumas Veg Module **Data sheet** 3/4/2004

Data for the whole plot							50m radial plot		Logs	
Plot	Date	UTM-E		UTM-N			Habitat typ		Snags <10	
		Aspect		Slope			Water Y/N		Snags 10-30	
		Recorders		Photo #			% Road		Snags >30	

Variable Radius (50m) Plot Species Tallies (panama angle gauge)

Species (live)											
Number stems											

50m Plot Layers + -->

	Herb (+seed) (<50cm)	Real Shrub (0.5-5m)	Small tree (Tree shrub)	All veg 0.5-5 (Tot. shrub)	Big tree (Tree)
%cover					
Low Bnd					
Low Bnd Sp					
Up Bnd					
Up Bnd Sp					
DBH min					
DBH min sp					
DBH max					
DBH max sp					

Species and their percent cover

Real shrub (0.5-5m)		Small Trees (tree shrub, 0-5m)		
Species	% Cover	Size class	Species	% Cover
		Small Tree		
		(Tree Shr)		
		(<5m)		
			total	100%
		Big Tree		
		(Tree, >5m)		
total	100%		total	100%

12.6 m Radial Plot Fuels & Fire Risk Assessments

Fuel Photo Series		LaFHA			
Fuel size	Count	Quadrants	Haz. Rating	Min Cr Ht	Max Lad Gap
0-3"		N (1)			
3-9"		E (2)			
9-20"		S (3)			
>20"		W (4)			

Brown's Transects 12.6m

Tallies	1 hr (0-0.6cm)	10 hr (0.6-2.5)	100 (2.5-7.6)	Litter @ 5	Duff @ 5	Litter @ 12	Duff @ 12	max depth 1	max depth 2	max depth 3	Sight tube
A											
B=A+90											
A: 1000hr	Diam										
	Sound/Rot										
Shrubs	Species										
	Length										
	Ht class										
B: 1000hr	Diam										
	Sound/Rot										
Shrubs	Species										
	Length										
	Ht class										

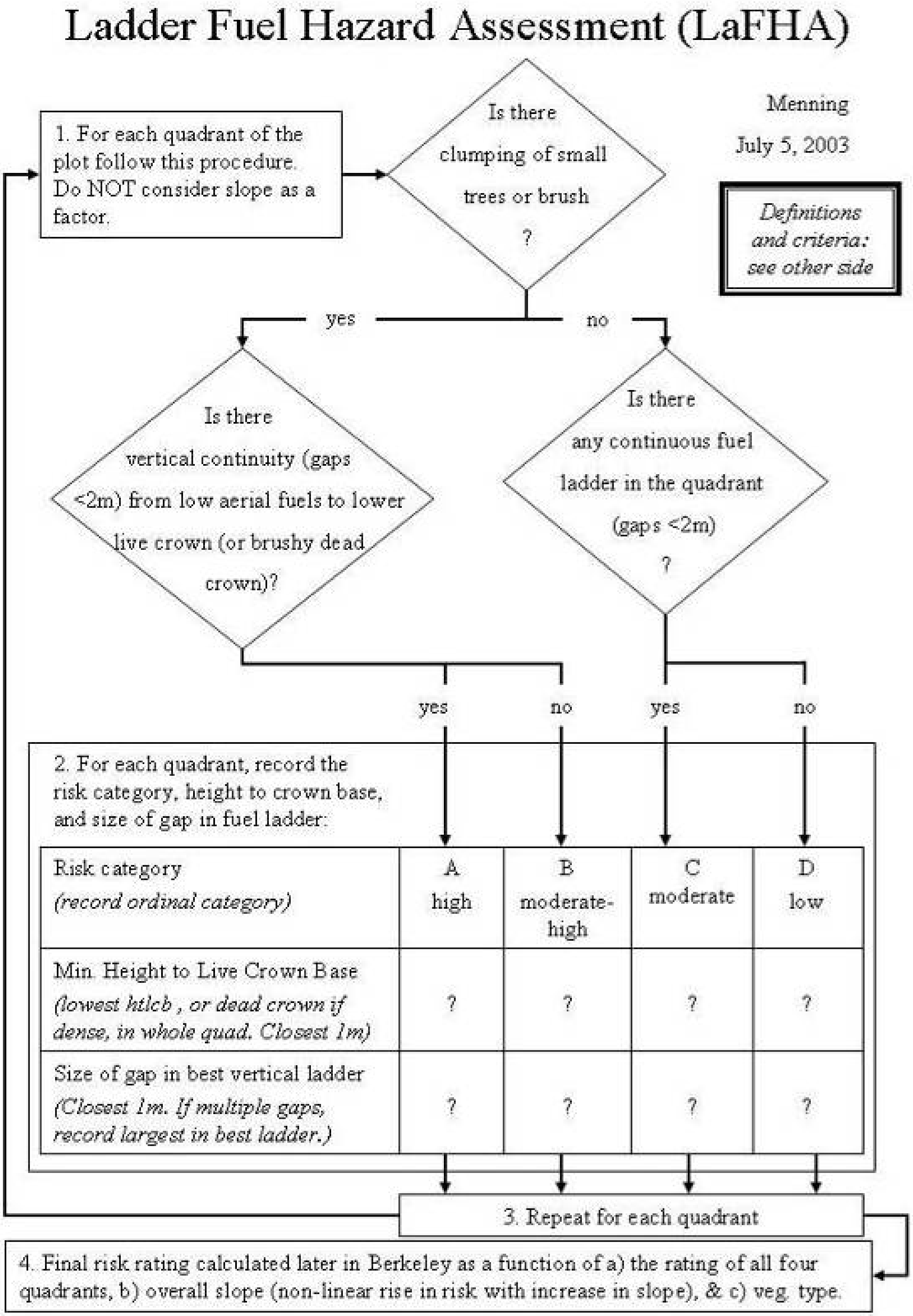
Plot

Sheet 2

Trees in 12.6m radius plot								Snags in 12.6m radius plot			
Species	DBH	Height	Ht. Low Cr.	Cr. Width	Shape	Mistletoe 0-6		DBH	Ht. Class	Decay class	Cav >10cm

Appendix A1 (continued): Datasheet for field data collection, page 2 of 2

Appendix A2: Ladder Fuel Hazard Assessment (LaFHA)



Risk category *(record ordinal category)*	A high	B moderate-high	C moderate	D low
Min. Height to Live Crown Base *(lowest htlcb , or dead crown if dense, in whole quad. Closest 1m)*	?	?	?	?
Size of gap in best vertical ladder *(Closest 1m. If multiple gaps, record largest in best ladder.)*	?	?	?	?

Appendix A2 (continued): LaFHA Definitions

Definitions

- **Division of plots**: Use a compass to quickly divide plots into four quadrants: northeast, southeast, southwest and northwest. Use trees for reference.
- **Clumping:** Brush or small trees covering an area of at least 4 square meters (2m x 2m) with gaps of less than 50cm. If it is particularly dense, or tall and brushy, a clump may cover a small area. A particularly dense clump may cover as little as 2m2 on the forest floor, for example. Branchy dead fuel or stems may be included in the assessment. Remember not to worry too much about definitions but to return to the question, "is this a dense clump of potential fuel?"
- **Risk categories** are given letters (A, B, C, and D) instead of numbers to prevent confusion: categories are not of interval or ratio quality ("Is category 4 twice as risky as category 2?" Probably not). Also, final ratings depend on additional information (see Step #4 at bottom of flowchart page).
- **HTLCB**: Height to live crown base: The live crown base is the lowest extent of the live canopy. Note: if the crowns of small trees are completely separate from the overhead canopy do not consider them. If they connect, or are close, do consider them.
- **Dead Crown** and when to consider it: Include dead branches in a tree's crown if they are particularly branchy or brushy. This will almost never happen in pines, but is common in white fir and Douglas-fir. If the branches radiate laterally and are well spaced (common with incense-cedar) do not consider them to be part of the ladder fuel matrix (live crown and brushy dead crown). In order to be considered part of a ladder, the branches should be dense and mostly vertical. Lichens, moss and needles increase the fuel hazard. Consider this in your assessment.
- **Ground and surface fuels**: do not adjust your assessment of the risk category by the presence or absence of ground or surface fuels (litter and duff with branches and cones mixed in). Consider only clumping and the presence of ladder fuels.
- **Canopy or No Canopy:** Consider only conifer and oak tree species as part of the canopy. Do not consider chaparral to have a canopy for this analysis. If there is no higher canopy, then record the gap as –99. This is important to distinguish from empty fields which may mean a datum was or was not recorded. A –99 value indicates that data were recorded and that the gap was infinite because there was no crown.

Appendix A3: Model integration with California Spotted Owl team (Keane)

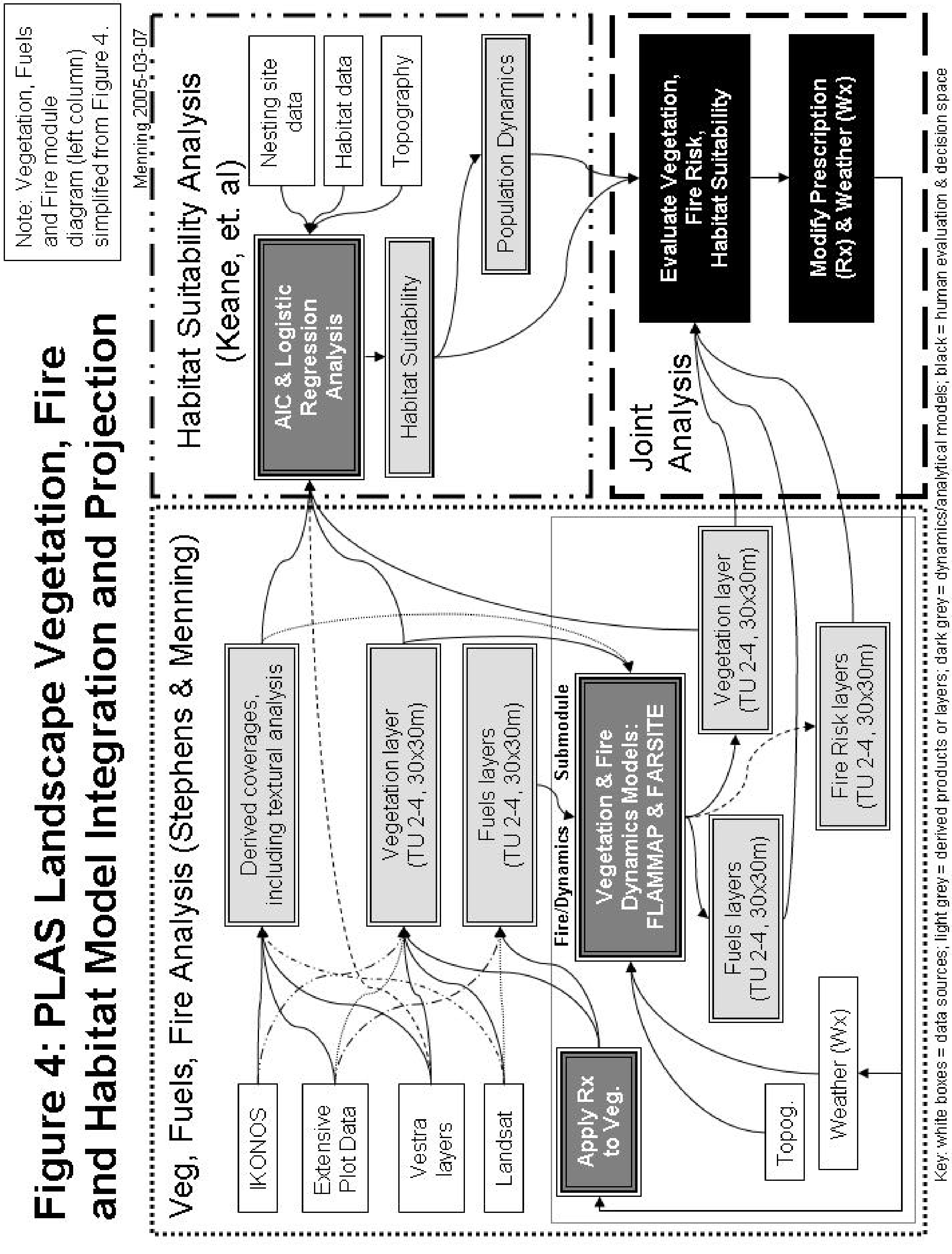


Figure 4: PLAS Landscape Vegetation, Fire and Habitat Model Integration and Projection

Note: Vegetation, Fuels and Fire module diagram (left column) simplifed from Figure 4.

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Key: white boxes = data sources; light grey = derived products or layers; dark grey = dynamics/analytical models; black = human evaluation & decision space

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Appendix B

Vegetation Module: Report of Activities during 2004

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Objectives

The vegetation module of the Plumas-Lassen Administrative study is focused on studying how changes in the forest canopy affect ecosystem functioning. Aspects of ecosystem function studied include understory microclimate and growth and competition of shrubs and juvenile trees, and understory diversity. The module objectives are the following:

1) determine the effects of reduction in tree canopy cover on microclimate, fuels dryness, and other factors contributing to flammability of the forest understory, and

2) determine effects of reduction in tree canopy cover on composition and growth of the understory plant community.

Research approaches include stand-level experimental manipulations, measurement of plant growth and survival along existing environmental gradients, and assessment of impacts of routine (i.e., non-experimental) forest management activities.

Research activities 2004

Field work in the 2004 season was aimed at gathering stand descriptive data prior to the experimental cuttings planned for the 2005 season. The experiment design was augmented with a group selection treatment (Fig. 1). A 1-hectare inventory plot, consistent with Forest Inventory and Analysis (FIA) protocol, was established in each of the 12 experimental management plots. These plots reveal basic elements of stand structure (e.g., stems per unit area, Fig. 2) and will provide for monitoring thinning effects on canopy structure over time. Dead fuels were measured in all plots with the protocol established by fuels researchers Scott Stephens and Kurt Menning, and a cross-walk was established to the FIA fuels measurement protocol.

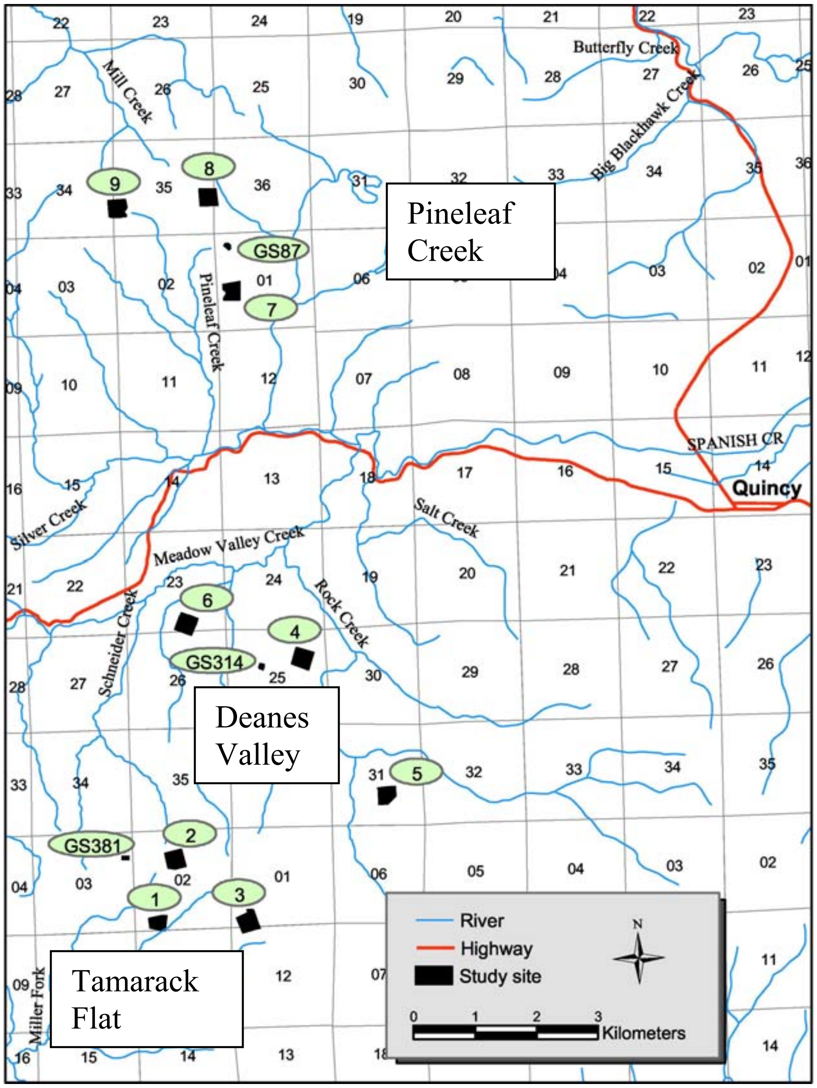

Fig. 1. Map of locations of experimental thinning and group selection plots in Meadow Valley area. Larger black squares are 22-acre thinning stands, and small black dots are planned groups.

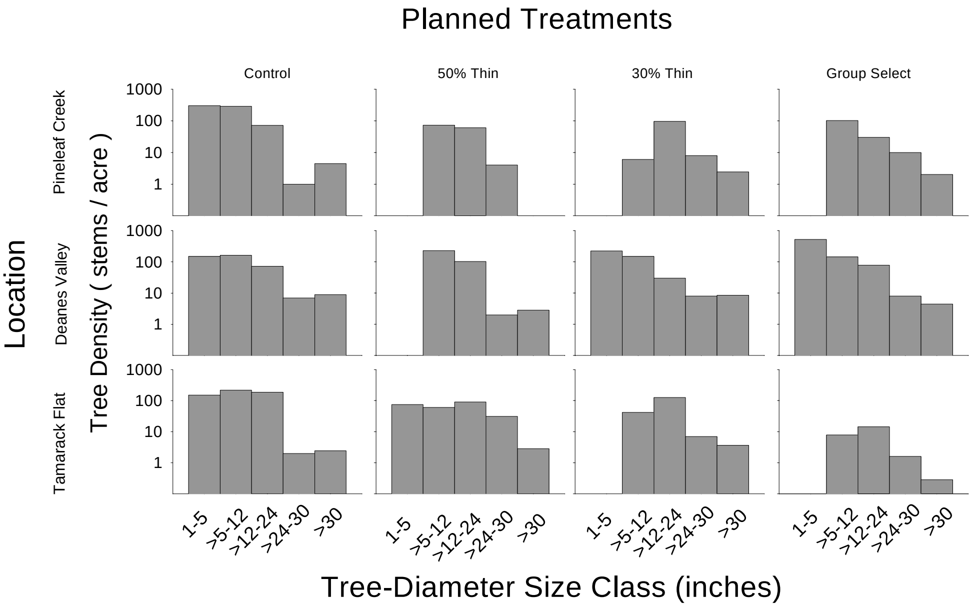

Fig. 2. Breast-height tree diameter distributions in plots slated for experimental silvicultural treatments. Note log scale for tree density.

Plant understory composition was assessed at 100 2-m radius circular plots within each experimental plot. Circular plots were centered on small-mammal trapping locations to enhance compatibility with data collected by small mammal researchers. Cover of six plant growth-forms was estimated visually (Fig. 3). The growth forms were graminoids (grass and grass-like plants), forbs (non-grass herbs), shrubs, shade-tolerant conifers, shade-intolerant conifers, and broad-leaved trees. The plant making the largest contribution to cover in each life-form was identified to species (Table 1). Only one non-native invasive species, *Silene noctiflora* or night-flowering catchfly, was detected.

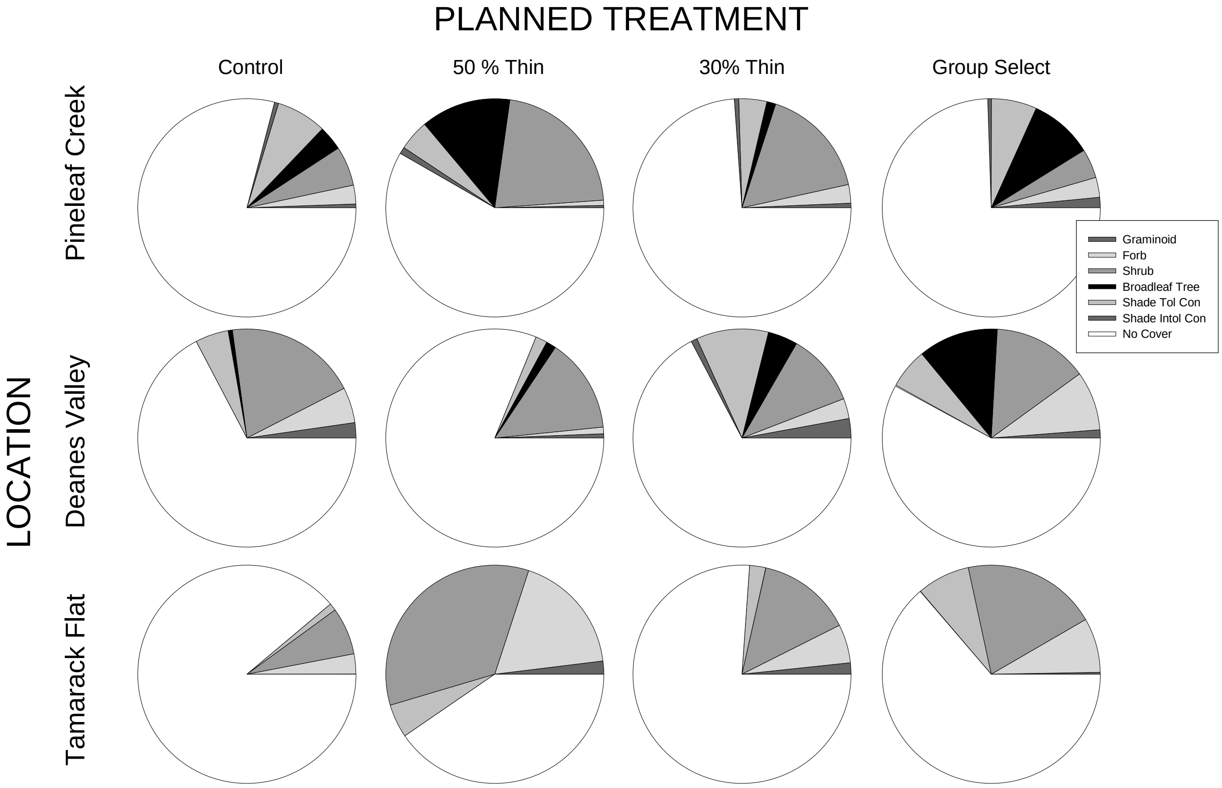

Fig. 3. Understory cover, by plant growth form, in plots planned for experimental thinning and group selection. Each pie chart presents averages from 100 2-m radius circular plots.

Table 1. Most common vascular plant species in understory vegetation composition plots.

Plant Species	Common Name	Plant Species	Common Name
Graminoids		**Forbs**	
Acnatherum lemmonii	Lemmon's Needlegrass	*Adenocaulon bicolor*	Trail Plant
Carex brainerdii	Brainerd's Sedge	*Allium sp.*	Wild Garlic
Carex multicaulis	Many-stemmed Sedge	*Apocynum canabanum*	Indian Hemp
Carex sp.	Sedge	*Arenaria sp.*	Sandwort
Festuca occidentalis	Western Fescue	*Aster radulinus*	Broadleaf Aster
		Calystegia malacophylla	Morning-glory
Shrubs		*Campanula prenanthoides*	Harebell
Amelanchier alnafolia	Serviceberry	*Castillea sp.*	Indian Paintbrush
Arctostaphylos patula	Greenleaf Manzanita	*Claytonia perfolata*	Miner's Lettuce
Arctostaphylos viscida	Whiteleaf Manzanita	*Claytonia rubra*	Spring Beauty
Ceanothus cordulatus	Whitethorn	*Clarkia sp.*	Clarkia
Ceanothus integerrimus	Deerbrush	*Corallorhiza maculate*	Spotted Coralroot
Ceanothus prostratus	Mahala Mat	*Corallorhiza striata*	Striped Coralroot
Chimaphila menziesii	Little Prince's Pine	*Corallorhiza sp.*	Coralroot
Chimaphila umbelata	Prince's Pine	*Cryptantha affinis*	Common Cryptantha
Chrysolepis sempervirens	Bush Chinquapin	*Cryptantha torreyana*	Torrey's Cryptantha
Garrya fremontii	Silk Tassel Bush	*Cynoglossum occidentale*	Hound's Tongue
Penstemon gracilentus	Slender Penstemon	*Disporum hookerii*	Hooker's Fairybells
Prunus emarginata	Bitter Cherry	*Gallium sp.*	Bedstraw
Quercus vaccinifolia	Huckleberry Oak	*Gayophytum sp.*	Groundsmoke
Rhamnus rubra	Sierra Coffeeberry	*Goodyearea oblongifolia*	Rattlesnake Plantain
Ribes roezlii	Sierra Gooseberry	*Hiracium albiflorum*	Hawkweed
Rosa sp.	Rose	*Iris hartwegii*	Iris
Rubus parvifolia	Thimbleberry	*Kelloggia galioides*	Kelloggia
Symphoricarpos sp.	Snowberry	*Chamaesaracha nana*	Dwarf Chamaesaracha
		Lilium sp.	Lily
Broadeaf Trees		*Lupinus latifolia*	Broadleaved Lupine
Cornus nuttallii	Pacific Dogwood	*Monardella odoratissima*	Pallid Mountain Wild Mint
Quercus kelloggii	California Black Oak	*Osmorhiza chilensis*	Mountain Sweet-cicely
Salix scouleriana	Scouler's Willow	*Penstemon personatus*	Close-throated Beardtongue
Sambucus sp.	Elderberry	*Phacelia sp.*	Phacelia
Sorbus californica	California Mountain Ash	*Piperia sp.*	Piperia
		Potentilla sp.	Cinquefoil
Shade Intolerant Conifers		*Pteridium aqualinum*	Bracken Fern
Pinus lambertiana	Sugar Pine	*Pyrola picta*	White-veined Wintergreen
Pinus ponderosa	Ponderosa Pine	*Sanicula graveolens*	Sierra Sanicle
		Silene noctiflora	Night-flowering Catchfly
Shade Tolerant Conifers		*Smilacina sp.*	False Solomon's Seal
Abies concolor	White Fir	*Stephanomeria lactucina*	Large-flowered Stephanomeria
Calocedrus decurrens	Incense Cedar	*Trifolium brewerii*	Forest Clover
Pseudotsuga menzeisii	Douglas-fir	*Trientalis latifolia*	Pacific Starflower
		Vicia americana	America Vetch
		Viola lobata	Pine Violet
		Viola sheltonii	Shelton's Violet
		Viola sp.	Violet
		Whitneya dealbata	Whitneya

Air temperature and humidity within the experimental plots were measured using a network of 36 stations, and measurements of moisture in soil, duff, and 10-, 100-, and 1000-hour fuels were made monthly at 108 sampling points (Fig. 4). Instrumentation for continuous monitoring of soil wetness, soil temperature, and wind velocity was installed at one location in each experimental plot; instrumentation for photosynthetically active radiation (PAR) measurement was installed in four plots.

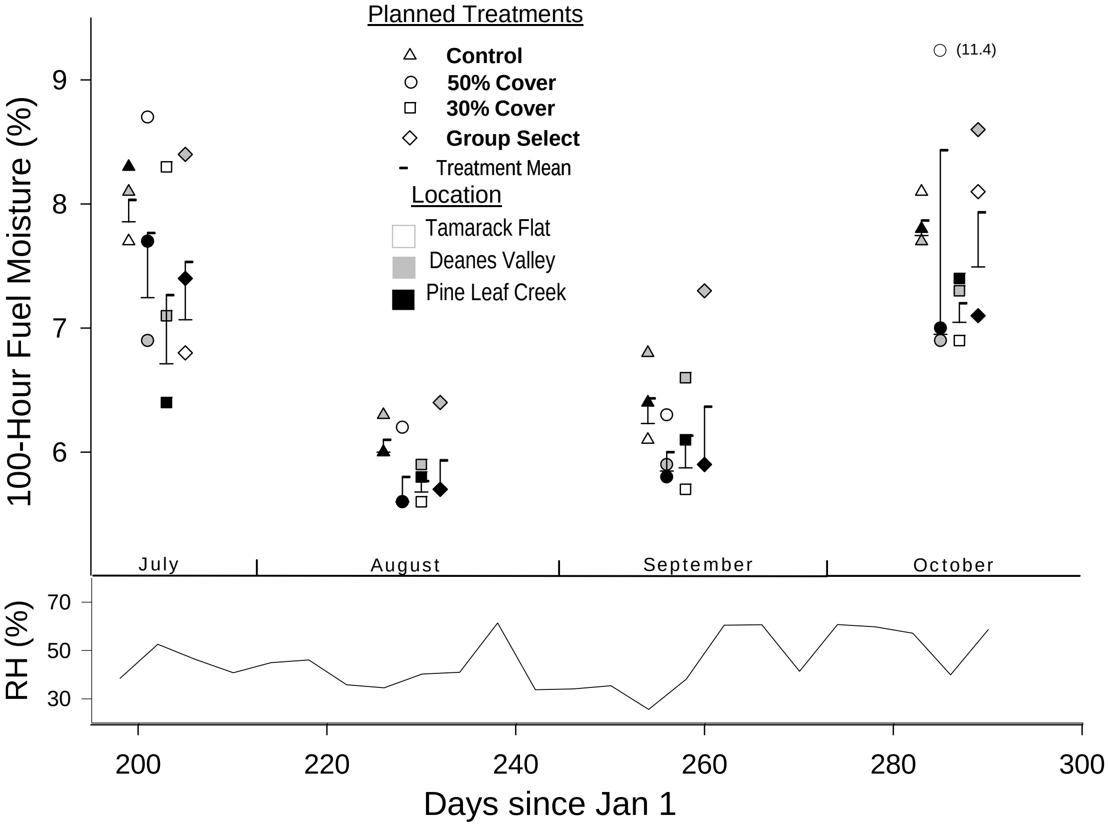

Fig. 4. Moisture in 100-hr fuels over the 2004 growing season. Each data point is a mean of nine samples per plot. Planned treatments are identified by symbol shape, and location is coded by shading. Short horizontal lines show means and standard deviation by planned treatment. Lower panel shows four-day running average of relative humidity of air.

During the 2004 season a long-term conifer seedling study was continued, and lab work was completed for the 2003 study of conifer sapling growth along soil moisture and nutrient gradients.

Outreach, Collaboration, Training, and Safety

Outreach

Vegetation module staff made presentations to the Quincy Library Group (April 2004), and the USFS Herger-Feinstein Quincy Library Group Steering Committee (July 2004). An all-day tour of the experimental plots was provided to the Quincy Library Group and other members of the interested public (Sept. 2004), and individual tours of the experimental plots were given to two members of the QLG. A presentation on the sapling growth study was made at the annual meeting of the Ecological Society of America (see reference).

Collaboration

The vegetation module staff collaborated closely with the Ecosystem Management staff of the Mount Hough Ranger District to plan the experimental silviculture treatments, and took a leadership role in preparing NEPA-process documents for the experiment. The field crew of the vegetation module devoted two months in Fall 2004 to assessing stand structure at owl activity sites. Dr. W. R. Horwath of the U. C. Davis Department of Land, Air, and Water Resources cooperated on the study of sapling performance along water and nutrient gradients.

Training and Personnel Development

Seth Bigelow completed a mandatory 40-hour course, Introduction to Supervision. Two members of the field crew participated in a two-week training course in FIA protocols in Oregon. Carl Salk attended the Ecological Society of America Annual Conference as part of his professional development, and completed a one-day course in snowmobile safety. The entire field crew attended a one-day orientation to the Mount Hough Ranger District.

The two seasonally employed GS-5 field technicians both made significant advances in professional development subsequent to their employment with the vegetation module. One enrolled in a Master's degree program in Natural Resource Management at Humboldt State University, and the other was hired for a permanent position with the Forest Service.

Safety

There were no serious accidents: a bee sting resulted in one lost day of work. The leased field vehicle was maintained in excellent condition and required no body work after the field season.

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Bigelow, S. W., M. P. North, and W. R. Horwath. 2004. Shade and drought tolerance in conifers of the Sierra Nevada, USA. Poster presentation at the 89th Annual Meeting of the Ecological Society of America, Portland OR.

Appendix C

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

Annual Report

January 2005

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INTRODUCTION

Small mammals provide critical food sources for many carnivores, including the American marten, California spotted owl, and Northern goshawk. As a result, changes in small mammal abundances could have affects on many species throughout the forest. Understanding the demographics, habitat requirements, and natural fluctuations of small mammals is critical to the management of Sierra Nevada forests. Alterations in habitat structure can directly affect small mammals by increasing habitat quality allowing greater small mammal density, higher reproduction, and increased survival. In addition, changes in the spatial distribution of habitat characteristics can lead to differences in small mammal distribution patterns (e.g. more clumping).

Determining which components of the habitat are important in structuring the dynamics of small mammal populations requires close monitoring of several independent populations through multiple years combined with measuring habitat characteristics. In addition, the requirements of key prey species (woodrats and flying squirrels) must be understood in detail. In particular, daily activity and habitat use of key prey species within specific habitat types is necessary to understand the link between small mammal and predator populations.

In addition to understanding small mammal population dynamics and habitat relationships, we will investigate links between physiology and population dynamics in a key diurnal prey species. Golden-mantled ground squirrels represent a primary prey species for diurnal predators, such as the Northern goshawk. Alterations to habitat structure may affect individual fitness of small mammals by altering their ability to build fat layers in anticipation of hibernation. We will quantify fat content of golden-mantled ground squirrels throughout the year and relate that to habitat structure. The results of this aspect of the study would provide a possible link between habitat structure and population dynamics of these important prey species.

Finally, we are establishing separate collaborations with independent researchers to investigate the phylogenetic relationship between the chipmunk species living in the study site. Several of the chipmunk species are virtually identical in appearance and can only be identified by skeletal differences. As a result, we hope to find simple molecular techniques to identify species using a small of ear tissue. This will allow proper identification of the species without killing individuals being studied.

OBJECTIVES

Research objectives for the small mammal unit are to evaluate small mammal responses to different forest management practices, and model these responses in terms of demography, spatial distribution, and habitat associations. Specifically we will investigate:

1. <u>Demographic profiles of small mammal populations inhabiting a variety of habitat types</u>. We established nine semi-permanent live-trapping grids for use as experimental plots. Three sets of three experimental grids were established throughout the treatment area with each set of three grids established in a cluster. The clustered grids

consist of two grids established in known DFPZ treatment zones and will be treated with a light (grid A) or heavy (grid B) thinning treatment, and a third, control, grid (grid C) will not be treated. All grids are located in white fir dominated forest with triplicate grids located in close proximity to each other.

2. Habitat associations of small mammal populations in the northern Sierra Nevada. This was investigated using multivariate techniques to identify key habitat characteristics used by individual species of small mammals. Nine additional grids were established in various representative habitats throughout the study site. Habitat grids were established in triplicate for each habitat, and did not necessarily need to be located near other grids in the same habitat type. We measured a number of macro- and microhabitat characteristics among the habitat grids for use in determining habitat associations among small mammals inhabiting the study area. In addition, we performed fall cone counts on all trapping grids to identify annual and seasonal pattern in cone production among the major conifer species inhabiting the study area.
3. Dynamics of key spotted owl prey: dusky-footed woodrat and northern flying squirrel. Dusky-footed woodrats (*Neotoma fuscipes*) and northern flying squirrels (*Glaucomys sabrinus*) are of particular concern to forest managers, as they comprise a major portion of California spotted owl diets. We will capture and radio-collar 20 dusky-footed woodrats and perform monthly radio-telemetry throughout the season. Through the use of radio-telemetry we will identify home ranges and nest locations for both sexes and various age classes. In addition, we will capture as many flying squirrels as we can and radio-collar them for use in home range analyses.
4. Fitness correlates to forest management. Some taxa may not exhibit numerical responses to forest treatments, but the quality of individuals as prey items may be altered, with important implications for spotted owls or northern goshawk. In particular, fat deposition is critical in ground squirrels that live off these stored reserves while hibernating. We will capture and radio-collar 12 female golden-mantled ground squirrels for use in the fat analysis study. Females will be randomly assigned to one of two groups. Group one will receive a high-fat supplementary diet during the months leading into hibernation, whereas group 2 will forage normally and act as a control group. All individuals will be captured and have their mass, body composition, and overall health measured. In addition, monthly home ranges will be calculated for each individual using monthly radio-triangulation. Offspring from these 12 experimental females will be captured, radio-collared, and followed to determine the effects of maternal body condition on offspring fitness, dispersal, and home range establishment.
5. Taxonomy and classification of Sierra Nevada chipmunks. Chipmunk species in the Plumas and Lassen National Forests display considerable overlap in habitat requirements, diet, and activity. Additionally, two

species (long-eared chipmunk (*Tamias quadrimaculatus*) and Allen's chipmunk (*Tamias senex*)) overlap in appearance to such an extent that they are virtually impossible to identify without using skeletal features. We will collect representative samples of chipmunks from throughout the study site to identify species through the use of pubic bines and collect tissue samples from these known chipmunk species to develop molecular markers for non-lethal identification of chipmunk species in the future. While this is not central to the present study, we have begun to establish collaborations with chipmunk taxonomists towards better understanding the nature and distribution of these species using outside funds.

METHODS – 2004 Field Season

Demographic profiles of small mammal populations inhabiting a variety of habitat types:

Small mammal populations were sampled monthly using established trap grids. We employed a nested grid system. Sherman live traps were established in a 10 x 10 grid with 10m spacing, nested within a larger (6 x 6, with 30 m spacing) grid of Tomahawk live traps (2 traps per station). All traps were opened in the late afternoon and checked the following morning. Both Sherman and Tomahawk traps were checked soon after sunrise (AM1 session). Animals captured during the AM1 session were worked up and released. Tomahawk traps were reset following release of any animals. All Sherman traps were closed following the AM1 session to prevent deaths from heat exposure. All Tomahawk traps were checked again approximately 2 hrs following the AM1 session (AM2). Animals captured during the AM2 session were worked up and released, and all traps were then closed. All traps remained closed from 11:00 – 15:00 to prevent deaths to animals due to heat exhaustion. All traps were baited with a mixture of rolled oats, peanut butter, and sunflower seeds.

All individuals captured were weighed and measured (e.g., ear length, hind foot length), and sex and reproductive condition noted. For males, testes may either be enlarged and scrotal or reduced and abdominal; for females, the vagina may be perforate (thereby receptive) or imperforate (not receptive), the vulva may either be swollen or not, and the nipples may be enlarged and/or reddened (reflecting nursing offspring), or not. All animals were individually marked with numbered ear tags, and released at the site of capture. Total processing time for an experienced technician is generally < 2 minutes.

Population demographics will be modeled by species using program MARK. Species that do not enough individuals to generate detailed capture history will be modeled using the minimum number known alive (MNKA) parameter. Monthly survival and population densities will be modeled for each species by habitat type using the Cormack-Jolly-Seber data type in program MARK. Suitable habitat parameters, such as cone production, will be incorporated into population models and can be used to identify habitat variables that are linked to population parameters using multivariate analyses.

Habitat associations of small mammal populations:

Measurement of habitat variables on each trap grid was stratified into macro- and microhabitat characteristics and measured during the 2003 field season. Macrohabitat variables were measured at alternate trap stations on each grid, whereas microhabitat variables were measured at all trap stations on each grid. Macrohabitat was defined by forest type. Overstory vegetation was quantified in July-August 2003 using point centered quarter sampling (Mueller-Dombois and Ellenberg 1974) at 18 predetermined, stratified Tomahawk trap stations per grid. Trees sampled had a diameter-at-breast height (1.4 m) of ≥ 10cm. All macrohabitat analyses used the first capture of an individual at a forest type (thus, repeat captures were not counted). Macrohabitat variables include the identity (species), DBH, height class, and distance to the nearest tree (> 10 cm DBH) in each of four quadrants, centered on the trap station.

Microhabitat characteristics were sampled during July-August 2003. All measurements were recorded within a 1m radius (3.14 m^2) circular plot centered at every trap station. Percent cover was visually estimated for 12 ground cover variables (e.g., rocks, bare ground, forbs and grasses, litter, downed wood, shrubs, saplings; Table 1). Canopy above breast height (1.4 m) was quantified by taking a single photograph with a hemispherical lens at every trap station, and calculating percent canopy openness using Gap Light Analyzer v2 (Simon Fraser University 1999). Aspect was measured with a compass by estimating the direction water would flow from the center of a trap station and was converted to North-South (e.g., $^{-}90^{\circ}$-$^{+}90^{\circ}$) and West-East ($^{-}90^{\circ}$-$^{+}90^{\circ}$) variables. Slope was measured with a clinometer as the general decline of the substrate within each circular plot. Substrate (ground) hardness was measured as kg/cm^2 using a soil penetrometer (Pocket penetrometer, Forestry Suppliers Inc.) at four random points (one per quadrat) within each circular plot; the four measurements were averaged for a hardness value per trap station. Very thick duff layers at ≥ 50% of trapping grids (up to 15cm) made digging for true soil measurements impractical and somewhat meaningless; therefore, this metric represents a measurement of substrate (ground surface) hardness rather than true soil hardness. A non-woody perennial category was created to include species that exhibited both shrub- and forb-like characteristics yet did not fall distinctly into either category; such non-woody species include bracken fern (*Pteridium aquilinum*), thimbleberry (*Rubus parviflorus*), Prince's pine (*Chimaphila umbellata*), and snowberry (*Symphoricarpos* sp.). Snowberry was by far the most frequently encountered of these species. Microhabitat vegetation (excluding canopy) was re-sampled in July 2004 at one fourth (n = 30) of all trap stations in six randomly chosen trapping grids representing all forest types; because no changes were documented in these metrics (paired t-tests; all $p > 0.01$), measurements recorded in 2003 were used in comparisons with small mammal data from both 2003 and 2004. All microhabitat analyses used the first capture of an individual at a given trap station (thus, repeat captures were not counted).

Total abundance (N), species richness (S) and species diversity (H') was calculated for each trapping grid. Small mammal species diversity was calculated using the Shannon-Wiener diversity index ($H' = -\sum p_i \log p_i$). We tested the null hypothesis that the mean of these metrics of community structure do not differ across forest types and sampling year using a repeated measures multivariate analysis of variance (rmMANOVA) and subsequent repeated measures analysis of variance tests (rmANOVA) on each metric. Abundance counts were square-root transformed to meet assumptions of normality. Variances were univariate homogeneous but were not examined at the multivariate level. Because variances were univariate homogeneous and the smallest cell size was > 50% the size of the largest cell (meaning sample sizes were not extraordinarily unbalanced; Scheiner 2001), we are confident that assumptions were met within reason. Nevertheless, Pillai's trace was used to test the null hypothesis as it is considered very robust to violations of assumptions (Scheiner 2001). *Post hoc* comparisons were conducted using Scheffé test (Day and Quinn 1989) and considered significant at $\alpha = 0.05$.

There were sufficient captures of *P. maniculatus* and *Neotamias* for parametric analyses of macrohabitat associations. The null hypothesis that abundance of *P. maniculatus* and *Neotamias* did not differ across forest type and year was tested using rmMANOVA and subsequent rmANOVAs on each species. Counts of *P. maniculatus* and *Neotamias* were square-root transformed to meet assumptions of normality. All assumptions were tested as for community metrics. Pillai's trace was used to test the null hypothesis and post hoc comparisons were conducted using Scheffé test ($\alpha = 0.05$) (Day and Quinn 1989).

Six taxa were captured at < 50% of sampling grids, precluding the use of parametric tests; these species included: *Glaucomys sabrinus*, *Microtus*, *Neotoma fuscipes* (dusky-footed woodrat), *Spermophilus beecheyi* (California ground squirrel), *Spermophilus lateralis,* and *Tamiasciurus douglasii* (Douglas squirrel). Because a Wilcoxin nonparametric test documented no significant differences in abundance of these species between sample years, a Kruskal-Wallis nonparametric test was applied to species counts pooled from 2003 and 2004 to evaluate differences in abundance of each species among forest types. All macrohabitat analyses were conducted using SAS v8 (SAS Institute Inc. 2000).

Repeated measures MANOVA and rmANOVAs were used to examine microhabitat associations of *Peromyscus* and *Neotamias* across microhabitat variables (n = 19) and between sample years. Counts were square-root transformed and all assumptions were addressed identically to those at the macro-scale. Again, Pillai's trace was used to test the null hypothesis that abundance did not differ across microhabitat characteristics or sample year.

Canonical correspondence analysis (CCA) using CANOCO v4.5 (ter Braak & Šmilauer 2002) was used to describe associations between abundance of small mammals (n = 8) pooled from 2003 and 2004 and all microhabitat variables. CCA is a constrained ordination that directly and simultaneously relates species composition to environmental variables, unlike unconstrained ordinations (e.g., Detrended Correspondence Analysis) that perform sequential analyses. CCA is an extension of multivariate multiple regression but is robust to moderate violations of normality assumptions (Palmer 1993, Lepš & Šmilauer 2003), performing well even with skewed species distributions (Palmer 1993). Small mammal counts were square-root transformed prior to ordination. Default options (e.g., biplot scaling focusing on inter-species distances) were used because they were appropriate for these analyses. Monte Carlo permutations (n = 500) were performed to test the significance of the contribution by each canonical axis to explanations of variation in small mammal abundance. Forward selection with unrestricted Monte Carlo permutations (n = 500) was used to determine the relative importance of each measured microhabitat variable to species abundance. Finally, the overall ordination results were qualitatively confirmed by inspecting species-specific contour plots that illustrate the fitted values of species abundance (using Loess linear regression) and microhabitat variables in CCA space.

Dynamics of spotted owl prey taxa:

Dusky-footed woodrat:

Two primary study areas, Oasis and Gulch, were used to supplement species habitat relationships. To supplement species habitat relationships obtained from Oasis and Shrub, vegetation data was collected at 2 other study areas: Gulch and Black Oak. These study areas are located within the Meadow Valley quadrangle in Plumas National Forest, Plumas County, California, approximately 5 km north of Meadow Valley at 1300 m elevation. The study areas are indicative of the Sierra Nevada mixed-conifer forest type, which is characterized by one tree deciduous species, California black oak (*Quercus kelloggii,* QUKE), and 5 dominant conifer species: white fir (*Abies concolor,* ABCO), sugar pine (*Pinus lambertiana,* PILA), Ponderosa pine (*P. ponderosa,* PIPO), Douglas fir (*Pseudotsuga menziesii,* PSME), and incense cedar (*Calocedrus decurrens,* CADE). The understory is dense and dominated by deer brush (*Ceanothus integerrimus*).

Individual woodrats were captured and fitted with radio-collars. These individuals were followed throughout the year as access was available to identify activity patterns and specific patterns of habitat use. We captured 85 (31 fitted with radio-collars) individual dusky-footed woodrats of various ages and sexes from the two main study areas (Oasis and Shrub) in the Plumas NF.

Live-trapping was used to obtain biological information for and attach radio-collars to individual woodrats. In addition, live-trapping data will be used to determine house use patterns by individual woodrats. Two trap sessions (Session 1: Apr-Jun, Session 2: July-August), consisting of 4 consecutive trap nights each were conducted with additional trapping performed when necessary. During trap sessions, 4 Sherman live-traps were placed within 1 m of the base of all houses within the study area. Traps were baited with raw oats and sunflower seeds coated in peanut butter, set prior to sunset, and checked at sunrise. All woodrats were given eartags for identification, weighed, sexed, and, if necessary, were fitted with radio-collars (Model PD-2C, Holohil Systems Ltd.). Woodrats were lightly sedated with ketamine HCl (100mg/ml) to facilitate application of radio-collars and allowed to recover from anesthesia before release. Radio-collared individuals were released at the point of capture, immediately after transmitters were attached and biological data was obtained.

Nocturnal radio-telemetry was conducted to determine movement patterns and estimate individual home ranges. In addition, diurnal radio-telemetry was used to locate houses, determine house use, and verify trap data accuracy. During nocturnal surveys, radiolocations were determined using triangulation methods, and occurred during 10 nights each month from June to October 2004. Bearings to radio-collared animals were obtained by bisecting the angle of signal drop-offs. Technicians worked in synchronized pairs to achieve 3 (or more) directional bearings within as short a time interval as possible. Triangulation systems were tested regularly using dummy collars to ensure the accuracy of the triangulation method. Radiolocations were obtained 2-3 times per night, a minimum of 3 hours apart to avoid location autocorrelation. The timing of nightly telemetry was varied to ensure heterogeneity in sampling effort.

Diurnal surveys utilized homing techniques. Diurnal locations for all radio-collared animals were determined once per day, 3 days per week from June to September 2004. Diurnal radiotelemetry locations were accurately (≤ 1 m) referenced using a Trimble GPS. Program *Locate II* will be used to calculate animal locations from bearing data obtained during triangulation. Animal locations were then be entered into an ArcView GIS database and plotted. Monthly minimum convex polygon (MCP) and adaptive kernel home ranges will be calculated for each individual using the animal movement extension of ArcView. We will compare home range size and overlap among sexes and age classes as well as temporally within each individual. We will also determine habitat use by these key prey species based on vegetation and forest maps obtained from the fire and vegetation modules.

Differences between the structure and composition of plants adjacent to woodrat houses and the surrounding habitat will be measured by using a matched-pair sampling design. A 4-m radius circular plot (0.005 ha) was placed around each house and random points. Random points were placed at a random distance (10-50 m) and directions (1-360°) from house center and a number of characteristics were measured: shrub density, tree and snag composition, stumps and logs, and rock and coarse woody debris cover. In addition, house-specific characteristics were measured including house length, width, height, shape, location (i.e. ground, tree), type (i.e. cavity, stick) and supporting structures.

Northern flying squirrel:

We trapped for northern flying squirrels using a combination of Sherman (Tallahasee, FL) and Tomahawk (Tomahawk, Tomahawk, WI) live traps placed on the ground or strapped to trees at a height of 1.5 m. Traps were baited with peanut butter or molasses coated rolled oats and checked in the morning. Polyfill fluff and a milk carton were provided for warmth during cold nights.

All captured individuals were weighed and measured (e.g., ear length, hind foot length), and sex and reproductive condition noted. For males, testes may either be enlarged and scrotal or reduced and abdominal; for females, the vagina may be perforate (thereby receptive) or imperforate (not receptive), the vulva may either be swollen or not, and the nipples may be enlarged and/or reddened (reflecting nursing offspring), or not. All animals were individually marked with numbered ear tags.

New individuals were anesthetized with isofluorane to facilitate the administration of a radio-collar. Following radio-collar attachment, individuals were allowed to recover form the anesthetic and were released at the site of capture. Individuals were monitored following release until they flew into a nest or cavity. The tree was marked as a potential nest tree and the animal was allowed to rest for 24-48 hrs before radio-telemetry began.

Individuals were radio-tracked during the day to find their nest trees. Each tree was marked and the location taken by GPS using UTM coordinates. Tree height, diameter at breast height (DBH), species, and condition (live, dead snag), and nest type (cavity or external nest) were measured for each nest tree.

Monthly radio-telemetry sessions were performed to determine individual location during each month. Individuals were located using the drop-off signal method of triangulation. Locations of all radio-collared individuals were determined at least three times per session for 5-8 sessions each month from May to October. Animal locations in UTM coordinates were calculated from triangulation data using program LOCATE and entered into an ArcView GIS database. The animal movement extension in ArcView was used to generate monthly home range estimates using the 95% minimum convex polygon for interspecific comparison with previously published flying squirrel home range sizes. Adaptive kernel home range analysis was also used to identify core usage for individuals during the entire field season.

Fitness correlates to forest management:

Twelve female golden-mantled ground squirrels were captured for use as experimental subjects in July of 2003 and fitted with radio-collars. Individuals were randomly assigned to control or supplemented diet treatments. Supplemental feeding began in September 2003 with all supplemental animals fed at the same date and time. Individuals in the control group were trapped at the same interval as the supplemental group, but were not provided extra food. We evaluated the effectiveness of food supplementation by comparing the slope of mass over time for control vs. supplemental groups.

Monthly measurements taken on female squirrels required that the radio-collars be removed. Immediately following anesthetization (using ketamine hydrochloride, 100 mg/ml) the rectal temperature was taken from each individual to monitor changes in body temperature. Total mass was measured to the nearest 0.1g using a portable electronic balance, and the head+body length recorded. Total body electrical conductivity (ToBEC) was measured using an EM-SCAN body composition analyzer. Following body composition analysis the radio-collar was reattached.

Locations of all females were determined at least three times per day for at least 5 days each month from July to September. Animal locations were determined using triangulation methods for radio-telemetry. Each sampling occasion was separated by 2 hours to ensure independence of samples. Three technicians were used to take 6 bearings to animal locations. Animal locations were calculated using program LOCATE (Nams 1990) and then entered into an ArcView GIS database. The animal movement extension in ArcView was used to generate monthly home range estimates using the minimum convex polygon (MCP) for interspecific comparisons with previously published home range sizes. Adaptive kernel home range analysis also was used to identify core usage for individuals during the entire field season. In addition to telemetry locations, known burrow locations were identified by homing to an individual's burrow during the late afternoon after they have settled into their burrows for the night. Locations of individuals in burrows were measured using a handheld GPS unit accurate to ca. 3m. Final burrow locations were noted to facilitate relocation of individuals following winter hibernation.

In the spring of 2004 we attempted to relocate and recapture all 12 females from the previous field season; however, only 7 were recaptured. The fate of the remaining 5 females is not known. The remaining 7 females were given new radio-collars and followed monthly until offspring became apparent in early July. Unfortunately, during the Fourth of

July weekend one of the remaining females was shot reducing our sample size to 6 females. The female was found dead on a rock with a bullet hole in its side.

Once offspring become available aboveground (mid July 2004) the remaining mothers were located early in the morning before they became active and traps were placed around the burrow. Traps were checked around 11:00 for the presence of the female squirrel and her offspring. Typically the female was captured along with a number of offspring within 2 hours of trap placement. A total of 9 offspring from 4 females were captured and used for the remainder of the experiment. Offspring were fitted with radio-collars and subjected to the same monthly cycle of measurements: overall mass, body condition, head+body length, and home range. Each offspring was marked as described above and tissue samples will be collected for possible maternity analyses. All subjects (i.e., offspring and mothers) were followed throughout the remainder of the 2004 field season (July-October) to determine home ranges; however all locations during the 2004 field season (offspring and mothers) were determined using homing and GPS position rather than triangulation. This allowed us to determine precise offspring locations and reduce the error associated with triangulation.

Van Vuren (1979) defined dispersal as "the process of leaving the natal home range before breeding and establishing a new home range." Following this definition, we measured dispersal using adaptive kernel home range estimators, as this produced two distinct home ranges for offspring, one encapsulating the burrow offspring were initially captured and one at the final place of residence before hibernation. No individuals will breed until after their first hibernation (Bartles and Thompson 1993) and so all location data for offspring is considered pre-reproductive. Dispersal distance was calculated as the linear distance between the point of initial capture (mother's burrow) and the final location for a particular individual (hibernation burrow). Dispersal direction was determined by setting all initial captures to the origin (0,0), adjusting the final location to reflect the new relative coordinates, and then solve for the angle of dispersal. Percent use by offspring of their new home range was calculated as the proportion of locations found within the new home range for each week following initial capture.

Taxonomy and classification of Sierra Nevada chipmunks:

We collected a sample of reference chipmunks from areas throughout the study site and brought them back to U. C. Davis for use in the phylogenetic study. Individuals collected were prepared as standard museum specimens (full skeleton plus skin) and tissues (e.g., liver, heart, muscle, kidney) collected for use in molecular analyses. All individuals were deposited in the Museum of Wildlife and Fish Biology at U. C. Davis.

We also collected small sections (< 1 cm) of ear pinna from all chipmunks trapped in this study to identify the distribution of closely related chipmunk species. Ear tissue was placed in cryovials containing 95% ethanol and stored in a refrigerator. Tissues from both reference and live chipmunks will be sent to the University of Idaho for molecular analysis to determine what molecular markers exist to identify chipmunk species. In addition, we will investigate whether hybridization is occurring between certain species, most notably *Tamias senex* and *T. quadrimaculatus*.

2004 FIELD SEASON PROGRESS AND RESULTS

The 2004 season began in February with the hiring of 8 technicians. Work began at the study site on 1 May and continued through October. Due to heavy snow, we were limited in the amount of area we could access at the beginning of the season. As a result, we began the field season by training the technicians on trapping and telemetry methods. We began trapping the grids that were established in 2003 as they became accessible. We continued pretreatment trapping of the nine experimental grids and continued a second season of trapping for the nine habitat grids. The nine experimental grids (Grids 1-9) were located in white fir dominated forests in the Snake Lake, Dean's Valley, and Waters districts. Each site was trapped on a monthly basis consisting of 5 consecutive days (4 nights) of trapping. Each night's effort comprised 100 Sherman trap-nights and 72 Tomahawk trap-nights (n = 172 trap-nights total), and each grid experienced 688 trapnights during each month of trapping. Similarly, the habitat grids were trapped on the same schedule.

Demographic profiles of small mammal populations inhabiting a variety of habitat types:

During the 2004 field season we captured and marked a total of 2,414 individuals across all species of small mammal and all sites (Table 1). A total of 123,840 trapnights were evenly distributed across all sites during two years of trapping. Predominant species in the study area include dusky-footed woodrat (*Neotoma fuscipes*), deer mice (*Peromyscus maniculatus*), long-eared and Allen's chipmunks (*Tamias quadrimaculatus* and *T. senex*), California and golden-mantled ground squirrels (*Spermophilus beecheyi* and *S. lateralis*), montane vole (*Microtus montanus*), Douglas squirrel (*Tamiasciurus douglasii*), and the northern flying squirrel (*Glaucomys sabrinus*). Incidental species captured during our trapping included shrews (*Sorex* spp.), snowshoe hare (*Lepus americanus*), long-tailed weasel (*Mustela frenata*), striped skunk (*Mephitis mephitis*), and spotted skunk (*Spilogale gracilis*).

White fir forests had the highest number of captures consisting of 1,084 unique individuals from 9 species. Red fir forests had 1,009 individuals from 8 species, and Douglas fir and ponderosa forests had 652 and 224 individuals from 9 and 6 species respectively. Species richness did not differ between white fir and Douglas fir forests and was only differentiated from red fir forests by the absence of woodrats in the red fir forest. Ponderosa pine forests, however, did not contain golden-mantled ground squirrels, Douglas squirrels, or flying squirrels.

Goodness-of-fit tests for individual encounter histories were performed by species using RELEASE and bootstrap simulation methods in program MARK. Goodness-of-fit tests were used to assess the assumption of capture homogeneity and survival. These tests indicated that significant deviations from the assumptions were found in all species. If individuals do not exhibit independence in trapability then estimated sampling variances will be underestimated, a situation called overdispersion. For example, individuals that occupy a home range centered within the trap grid will be more likely to be trapped than individuals living on the edge of the grid. This characteristic may violate the assumption of independence and will lead to overdispersion. Burnham et al. (1987)

suggested that estimation of overdispersion (c-hat) is calculated from the summation of tests 2 and 3 in the goodness-of-fit analysis. If the assumption of independence is violated, then a c-hat value of > 1.0 will be observed. Burnham et al (1987) gives a c-hat value of > 1.3 as evidence of significant overdispersion in the data. As a result, we used corrected values for c-hat to compensate for our observed overdispersion (Table 2).

Model selection identified top candidate models for each species (Table 2). A single model was chosen for both deer mice and golden mantled ground squirrels with the model for golden-mantled ground squirrel survival explained by month. Deer mouse survival was dependant on an interaction between habitat and month as well as over-winter survival and fall mean cone production (Table 2). Both species of chipmunk had survival vary by an interaction of habitat and month with over-winter survival.

Cone production varied within each forest type and between fall 2003 and fall 2004 (Figure 1). Cone production by Douglas fir did not vary greatly between the two fall cone counts and seemed to represent a constant source of seed. Production among the other tree species did differ between fall counts, however. Overall, cone production was greater in the fall of 2003 compared to fall 2004 (Figure 1). White fir cone production differed by season ($F_{2,360} = 37.49$, $P < 0.0001$) and within forest types ($F_{2,360} = 6.12$, $P = 0.002$). White fir cone production was higher in Fall 2003 (22.4 ± 2.2 cones/tree) compared to Fall 2004 (4.7 ± 1.0 cones/tree). Between forest types white fir cone production was lowest in white fir forests (9.5 ± 1.1 cones/tree), and increased in Douglas fir (26.0 ± 4.1 cones/tree) and ponderosa (43.0 ± 8.7 cones/tree) forest types. Red fir cone production also showed a seasonal effect with cone production higher in fall 2003 (71.4 ± 8.7 cones/tree) than fall 2004 (6.7 ± 6.0 cones/tree). Western white pines also produced more cones in fall 2003 (83.5 ± 11.2 cones/tree) than fall 2004 (37.1 ± 5.9 cones/tree). Sugar pines were the only species to show an interaction between season and forest type ($F_{4,335} = 3.03$, $P = 0.02$) with cone production within the Douglas fir and red fir forests being greater than those from ponderosa and white fir forests.

Ponderosa pines and Douglas firs both showed a season and forest type effect in cone production. Ponderosa pines produced cones in fall 2003 (10.2 ± 1.7 cones/tree) whereas there was virtually no cone production in fall 2004 (0.2 ± 0.1 cones/tree). Within forest types, ponderosa pines from white fir (4.8 ± 0.9 cones/tree) and ponderosa (3.8 ± 1.3 cones/tree) forest types produced similar amounts of cones, where ponderosa pines from Douglas fir forests only produced and average of 1.1 ± 0.4 cones/tree. The largest cone producer was the Douglas fir, producing 156.6 ± 15.9 cones/tree and 137.2 ± 14.5 cones/tree in fall of 2003 and 2004 respectively. Douglas fir cone production also varied by habitat ($F_{2,310} = 8.57$, $P = 0.0002$) with trees located in Douglas fir (174.5 ± 19.0 cones/tree) producing the most cones followed by those in white fir (123.6 ± 11.1 cones/tree) and ponderosa pine (73.4 ± 7.6 cones/tree) forests.

Mean monthly deer mouse densities varied both between years and between months within years (Figure 2a). Deer mouse densities were significantly lower during all of 2003 compared to 2004. A single peak was observed in deer mouse populations during 2004, suggesting a single reproductive episode. The reproductive peak occurred during June in all forest types except the Douglas fir forest which peaked in September (Figure 2a). Densities during 2003 remained below 10 individuals/ha on all sites, varying between 0.7 and 7.3 individuals/ha. However, in 2004 densities were much greater reaching maximum densities (individuals/ha) of 86.0, 112.7, 77.4 and 65.7 in red fir, Douglas fir, white fir, and ponderosa pine forests respectively.

Although golden-mantled ground squirrels were found in both red fir and Douglas fir forests, we only captured enough individuals to provide estimates for individuals from the red fir forest. Population densities increased following hibernation from a low in May or June, peaked in September, and declined in October (Figure 3).

Two chipmunk species were found in the study sites: long-eared (*Tamias quadrimaculatus*) and Allen's (*T. senex*) chipmunks. Both species occurred in white fir, Douglas fir, and red fir forests. In 2003, long-eared chipmunks reached higher densities in red fir and Douglas fir forests than in white fir forests (Figure 4a). Populations form all three forest types peaked in September. In 2004 population levels in all three forest types remained low. Population levels in July 2004 were not assessed in white fir and Douglas fir forests because trapping did not occur during this month. Allen's chipmunks remained at lower densities compared to long-eared chipmunks, except during September 2004 when populations of Allen's chipmunks reached high densities (Figure 4b). Although Allen's chipmunks peaked during September 2004, there was considerable variation among the densities.

Deer mouse survival varied by forest type with those inhabiting white fir forests remaining at moderate levels (0.48 – 0.71) until fall 2004 when survival decreased (Figure 2b). Deer mouse survival followed a similar pattern in the remaining three forest types. Survival decreased throughout 2003 reaching a low in September 2003. The best fit model used a single survival value for deer mice in all forest types indicating that the probability of survival did not differ by forest type during winter. However, following winter survival did differ. Deer mouse survival from white fir forests remained near 0.60 whereas deer mice from Douglas fir and ponderosa forests declined. Red fir forests were not trapped until June due to snow cover, but mice from this forest type also showed an initial decrease in survival (July and August 2004) followed by an increase in fall (September and October).

Golden-mantled ground squirrel survival was only measured in red fir forests. Survival remained near or above 0.50 throughout the study (Figure 3b). Survival rates followed similar patterns throughout both years, increasing from August to September before dropping again in October. Although survival was not estimated for June 2003, June 2004 showed the greatest survival rate (0.79).

Survival among long-eared chipmunks did not differ between forest types, and remained above 0.50 for all of 2003 (Figure 5a). Winter survival did not differ between forest types and was estimated to be 0.94. Survival rates returned to their previous vales following winter. Allen's chipmunk did not show a difference in survival by habitat type during 2003, however, chipmunks from Douglas fir forests and red fir forests had decreased survival during early summer (May and June; Figure 5b). Survival remained high in red fir forests, but decreased in chipmunks from Douglas fir and white fir forests during late fall 2004. Survival estimates could not be determined for July 2004 in either chipmunk species because trapping did not occur at that time.

Habitat associations of small mammal populations:

A total of 464 small mammals were captured 1201 times during July-September 2003. With equivalent trapping effort, 1647 small mammals were captured 4204 times during May-August 2004 representing a 355% and 350% increase in individuals and total captures, respectively. Chipmunks (*Neotamias*) comprised 49% of individuals in 2003 while deer mice (*Peromyscus maniculatus*) increased from 2003 by nearly nine-fold and comprised 69% of individuals in 2004. It was unclear if these abundance values represented unusually low numbers for 2003 or high counts for 2004. Studies of small mammals in similar Sierra habitats are rare but may suggest that small mammal abundance is similar to that found in 2004. For comparable trapping effort in the neighboring Lassen National Forest, Waters and Zabel (1998) captured similar counts of small mammals (n = 1700). However, unlike the small mammal fauna found in the Plumas National Forest, few deer mice (n = 70) contributed to their captures. Two late and severe winter storms in 2003 may have contributed to low capture success in that year. Incidental captures included Trowbridge's shrew (*Sorex trowbridgii*), snowshoe hare (*Lepus americanus*), long-tailed weasel (*Mustela frenata*), western spotted skunk (*Spilogale gracilis*), and striped skunk (*Mephitis mephitis*).

Forest Structure

Previous logging and fire history are not well documented for these trapping grids but the general vegetative structure indicated active fire suppression and silvicultural practices. For example, mixed fir, white fir, and mixed conifer forests generally were characterized by high tree density (440 m^2/ha, 512 m^2/ha and 645 m^2/ha, respectively), fairly closed canopies (mean openness 12%, 11%, and 11%, respectively), deep duff layers (up to 15cm), and heavy fuel and litter loads. Three of the five mixed fir sites had comparably more patchy canopies and heterogeneous understories characterized by high shrub cover and richness and highest cover of all forest types by non-woody perennials (i.e. *Symphoricarpos*). Pine-cedar and red fir forests generally had more open stand structure (178 m^2/ha and 166 m^2/ha, respectively) with comparably open canopies (mean openness 40% and 47%, respectively) and high cover by rocks, exposed soils, and live shrubs. However, shrubs in pine forests were spatially clumped whereas those in red fir comprised a ground cover. One trapping grid in pine-cedar forest likely experienced a fire in 1970 yet was structurally indistinguishable from other pine-cedar trapping grids.

Macrohabitat Associations

Small mammal abundance (N), species richness (S), and diversity (H') were significantly different across forest types (rmMANOVA; Pillai's trace = 1.06, $F_{12,78}$ = 3.58, $P = 0.0003$) and between sample years (rmMANOVA; Pillai's trace = 0.79, $F_{3,24}$ = 29.68, $P < 0.00001$). Overall, forest type and sample year explained 84% of the variation in mean abundance (rmANOVA; $F_{3,24}$ = 14.86, $P < 0.0001$), 49% of variation in mean species richness (rmANOVA; $F_{3,24}$ = 2.72, $P = 0.0223$), and 31% of variation in diversity (rmANOVA; $F_{3,24}$ = 1.32, $P = 0.2765$). Results of rmANOVAs revealed that mean abundance and richness differed significantly across forest types and abundance increased significantly between sample years. *A posteriori* multiple comparisons showed that red fir forests had significantly greater mean abundance of small mammals than any other forest type (Scheffé, $P < 0.05$; Figure 6a) and greater mean species richness than all types but mixed fir (Scheffé, $P < 0.05$; Figure 6b).

Abundance of *Peromyscus* and *Neotamias* differed significantly among forest types (rmMANOVA; Pillai's trace = 0.73, $F_{8,52}$ = 3.78, *P* = 0.0015) and between sample years (rmMANOVA; Pillai's trace=0.91, $F_{2,25}$ = 133.57, *P* < 0.0001). There was a strong trend towards a forest type x year interaction (rmMANOVA; Pillai's trace = 0.48, $F_{8,52}$ = 2.06, *P* = 0.0568) likely because of high captures of deer mice in 2004. Overall, forest type and sample year explained 93% of variation in abundance of *Peromyscus* (rmANOVA; F = 36.52, *P* < 0.0001) and 67% of variation in *Neotamias* (rmANOVA; F = 5.78, *P* = 0.0002). Results of rmANOVAs indicated that abundance of *Peromyscus* was influenced significantly by forest type, year, and forest type x year interaction and abundance of *Neotamias* was influenced significantly by forest type. *A posteriori* multiple comparisons revealed a clear preference by *Peromyscus* for red fir, white fir, and mixed fir sites over mixed conifer and pine-cedar forests (Scheffé, *P* < 0.05; Figure 6c). Macrohabitat affinities of *Neotamias* were similar to *Peromyscus* but more narrowly focused with preferences for red fir and white fir sites over all other types (Scheffé, *P* < 0.05; Figure 6d).

Kruskal-Wallis nonparametric analyses suggested that abundance for *G. sabrinus*, *Microtus, N. fuscipes, S. beecheyi,* and *S. lateralis* were significantly influenced by forest type (Figure 7). For example, *G. sabrinus* (χ^2_4 = 13.615, *P* = 0.0086), *Microtus* (χ^2_4 = 21.43, *P* = 0.0003) and *S. lateralis* (χ^2_4 = 28.04, P<0.0001) were found almost exclusively in red fir forests. In contrast, *N. fuscipes* (χ^2_4 = 11.61, *P* = 0.0205) and *S. beecheyi* (χ^2_4 = 16.62, *P* = 0.0023) were associated primarily with pine-cedar and mixed fir forests but only rarely in mixed conifer forests. *Tamiasciurus* abundance was low and not significantly different among forest types (χ^2_4 = 5.07, *P* = 0.28).

Microhabitat Associations

Results of rmMANOVA revealed that local abundance of *Peromyscus* and *Neotamias* differed significantly across 14 of 19 microhabitat variables. Overall, microhabitat variables and sample year explained 69% of variation in local (i.e. trap-scale) abundance of *Peromyscus* (rmANOVA; F_{2405} = 1.75, *P* < 0.0001) and 70% of variation in local abundance of *Neotamias* (rmANOVA; F_{2405} = 1.83, *P* < 0.0001).

CCA of microhabitat associations was based on 4503 individuals (samples) captured at 1424 trap stations (Figure 8). The first two canonical axes cumulatively explained a large proportion (71%) of the variation in local abundance of small mammals. The first canonical axis alone explained more variation (53%) than axes 2, 3, and 4 combined (37%) and was positively correlated with canopy openness, cover by live shrubs, and shrub species richness. Despite a significant amount of variation in small mammal local abundance explained by the first canonical axis (Monte Carlo Permutation test; F = 66.091, *P* = 0.002), axes two and three each also contributed significantly to explanations of community variation (Monte Carlo Permutation test; F = 22.216, *P* = 0.002 and F = 18.370, *P* = 0.002, respectively) but were comparably less correlated with microhabitat characteristics. Forward selection included the following variables (at *P* ≤ 0.05) in the final model explaining overall small mammal abundance: cover by rocks, bare ground, branches, large logs, live shrubs, and percent canopy openness, shrub richness, substrate hardness, slope, and south-facing aspects.

CCA described diverse microhabitat affinities for many species (Figure 8). For example, *G. sabrinus*, *S. lateralis*, and *Microtus* exhibited strong microhabitat preferences for open canopy, high cover by shrubs, bare ground, and rocks; these characteristics dominate the understories of red fir forests where the three species reached their highest abundance. *Neotamias* was captured across many microhabitats but affinities were best described by high shrub cover and richness, open canopies, bare ground, rocks, large logs and south-facing aspects, characteristics associated predominantly with red fir forests but also representative of mixed fir forest understories. Local captures of *N. fuscipes, S. beecheyi,* and *T. douglasii* were not restricted to narrow microhabitats; rather, these species exhibited broader affinities for similar microhabitat features. The location of *Peromyscus* in the center of CCA space likely is artifactual since this species was found at 99% of trap stations used in analyses and over half of all analyzed trap stations were located in closed canopy forests (left side of figure). Inspection of a species-specific contour plot reveals that while *Peromyscus* is associated with all measured microhabitat variables (no zero values); this species reached the highest abundance in traps characterized by open canopy and cover by live shrubs, rocks, and bare ground.

Dynamics of spotted owl prey taxa:

Dusky-footed woodrats:

In 2004, we captured and placed radio-collars on 31 individual woodrats, consisting of 18 females and 13 males. Of these, we recaptured 6 individuals from the 2003 field season. Work continued in the Oasis study area (where the 6 individuals were recaptured) and a second study site, Shrub, was established to replicate woodrat work. Both Shrub and Oasis were located in ponderosa pine forests. We captured 36 and 49 individuals in the Oasis (10 adult males, 11 juvenile males, 7 adult females, and 9 juvenile females) and Shrub (5 adult males, 15 juvenile males, 15 adult females, and 14 juvenile females) study sites. Telemetry began in late June and continued until the beginning of October.

We located 109 woodrat houses at Oasis and 104 at Shrub. Most woodrat houses were located on the ground (Oasis, 77%; Shrub 76%), but many were also located in tree and snag cavities or on the limbs of live trees (Oasis, 23%, Shrub, 24%). Woodrat houses were found in a variety of structures ranging from cavities in stumps and logs to stick houses constructed to heights of 2 m. Thirty-six percent and 54% of houses were utilized diurnally by radio-collared woodrats at Oasis and Shrub, respectively.

We will continue to analyze the location data obtained from 2004 telemetry and expect to generate a viable home range for most, if not all, woodrats studied during the 2004 field season. In addition, we will analyze the vegetation and woodrat house data to begin understanding the relationship between woodrat house use and availability and habitat preference for woodrats.

Northern flying squirrels:

We captured 6 northern flying squirrels consisting of 3 males and 3 females (Table 3). All individuals but two, M2 and F2, were of adult size and coloration. We attempted to place radio-collars on all individuals, however only 3 individuals (M1, M3, and F3) survived long enough to produce enough locations for use in calculating home ranges. Three other radiocollared flying squirrels were either predated within a week of release (M2), died from exposure to a night-time thunderstorm (F2), or died during handling (F1). Radio-tracking of M1 stopped after 7 July 2004 because the collar never moved from the top of a tree indicating the squirrel had lost its collar or had been predated. Squirrels M3 and F3 were tracked until October snowfall made it impossible to get to the study site.

Although telemetry could not be performed on all individuals, nest trees were located for 5 individuals (Table 4). Only 2 external nests were used by flying squirrels in this study area, with the remainder of nests consisting of cavities drilled by woodpeckers. Both external nests were found in live trees: one in a red fir (*Abies magnifica*) and one in a sugar pine (*Pinus lambertiana*). Of the cavity nests, one was in a live western white pine (*Pinus monticola*), four in solid, well formed snags, and one in a decayed snag. All snags consisted of the trunk of a dead red fir ranging from 6.4-19.3 m in height and a diameter at breast height (DBH) of 44.0-57.3 cm. The decayed snag was a small red fir 4.9 m in height with a DBH of 22.3 cm and was in an advanced stage of decay.

Three viable home ranges were generated from the data obtained from flying squirrels M1, M3 and F3 (Figure 9). The home ranges from these three individuals were located in the same general area (Taylor Rock). Minimum convex polygon home ranges were calculated from 95% of the locations and generated home ranges from 26.1 to 83.4 ha (Table 3). However, MCP home ranges can be inflated due to outlying points. As a result, 95% kernel home ranges were calculated to better reflect the actual usage of the home range (Figure 9). Kernel home ranges were calculated to be 23.0, 39.8, and 63.4 ha for flying squirrels M1, M3, and F3 respectively (Table 3). The home ranges of M3 and F3 showed considerable overlap. The only female captured had the largest home range, whereas the two males had similarly sized home ranges that were approximately half the size of the female.

Fitness correlates to forest management:

Maternal body mass decreased following emergence from hibernation until August when lactation was completed (Figure 10). Following August, both experimental groups increased in mass until females entered hibernation in early October. Supplemental feeding began on September 1, 2003, and was followed by a divergence in control and supplemental mean mass (Figure 10), although the proportion of fat found in females did not differ between treatment groups ($F_{4,27} = 0.76$, $P = 0.56$). The slopes of mass gain for August - October showed a strong trend towards distinct trajectories (control, $\beta = 14.56$; supplemental $\beta = 42.49$; $F_{1,18} = 3.25$, $P = 0.08$). No significant difference in total mass was observed between the two groups at the start of the experiment. Although supplemental females gained mass at a greater rate than control females, the rate at which both groups increased the proportion of fat did not differ (control $\beta = 4.8$; supplemental $\beta = 4.0$; $F_{1,18} = 1.83$, $P = 0.19$). Supplemental females exhibited less variation in the rate of mass gain ($r^2 = 0.73$) compared to control females ($r^2 = 0.11$). A similar, but less pronounced, trend was observed in the rate of body fat accumulation ($r^2 = 0.36$ control; $r^2 = 0.50$ supplemental).

As expected, maternal home range size for the two treatment groups did not differ during any of the months studied (Figure 11). Although supplemental feeding could induce a shift to a smaller home range in fed females, the timing of feeding coincided with the time of year when female home ranges already are at their smallest. However, we did detect a temporal change in maternal home ranges ($F_{4,31} = 3.89$, $P = 0.005$). In 2004, female home range size increased from emergence, peaking in July and then declined until females entered hibernation. Home range size was smallest during June and September, ranging from 0.64-0.86 ha, when females were emerging and entering hibernation respectively and were largest (1.49 – 2.22 ha) during July when energetic demands from lactation were greatest (Figure 11).

Offspring emerged from their natal burrows in mid- to late- July. Nine offspring (4 males, 5 females) from four mothers were radio-collared and released. Of these, one control female, likely was predated while the remainder survived the summer and entered hibernation. The predated female was found a considerable distance away with the collar showing signs of distress (i.e. chew marks).

Offspring from supplemental mothers grew at a significantly greater rate than those from control mothers (linear regression, slope 34.9 vs. 7.26 respectively; $F_{1,12} = 4.14$, $P = 0.06$; Figure 10). In addition, the rate of fat development also was greater for offspring from supplemental mothers (linear regression, slope 9.66 vs. 2.24 respectively; $F_{1,11} = 4.62$, $P = 0.05$; Figure 10). Mean percent fat that supplemental and control offspring reached before hibernation was 19.1% and 9.3% respectively.

Dispersing juveniles quickly established new home ranges at various distances from their natal home range. Dispersal distance was greater for supplemented males than control males ($F_{1,5} = 9.13$, $P = 0.03$; Figure 12). Although control females tended to disperse farther than supplemental females, this was not significantly different. Most dispersing offspring moved to the northwest. One supplemental male dispersed to the northeast while two females moved west. No clear pattern was observed with regard to treatment or sex differences in dispersal direction.

Offspring dispersal tended to follow one of two patterns. Some offspring conducted a few short forays into the new area before moving completely to the new home range, whereas others remained in their natal home range while making numerous forays to their new home range before finally moving; these patterns were not clearly related to gender or experimental treatment.

First-year home ranges consisted of two unique non-overlapping areas: a natal home range and a dispersed home range. The natal home range was centered around the natal burrow, whereas the dispersed home range was centered near the area where they entered hibernation. Although sample sizes were too small to allow comparisons between sex and treatment groups for both natal and dispersed home range size there was a trend for dispersed home ranges to be larger than natal home ranges for supplemental males and smaller for control males.

The proportion of usage between natal and dispersed home ranges was similar among both sexes and treatments so data were combined (Figure 13). Individuals remained close to their natal home range during the first 3 weeks following initial capture, and increased the amount of time spent in their dispersed home range during weeks 3 - 7. By week 8 (20 September to 4 October), all offspring had dispersed to their new home range and all individuals had entered hibernation by 11 October 2004.

Taxonomy and classification of Sierra Nevada chipmunks:

We have collected 241 (2003 field season) and 353 (2004 field season) tissue samples from live, free-living chipmunks in the study area, and have collected and prepared 5 reference chipmunks. All tissue samples have been labeled and sent to the University of Idaho for analysis.

COLLABORATION WITH OTHER MODULES

We have initiated collaborative efforts with the vegetation module as well as the fire and fuels module, and will establish collaborative efforts with the spotted owl module over the next year. We have completed rigorous vegetation sampling on all trap grids for use with small mammal habitat associations. Vegetation data were collected in conjunction with the vegetation and fire and fuels modules. The vegetation module has also established a number of weather stations within the mammal trap grids to coordinate specific climate data with our grids. In addition, we will benefit from the remote sensing analyses of the fire and fuels team. Finally, we will initiate a study of California spotted owl diet by working with the spotted owl crew to collect and analyze pellets collected from spotted owl nests throughout the year. Results of our woodrat study will directly benefit the spotted owl module in their development of prey models within the Sierra Nevada. The results of the small mammal study will be available for any of the other modules to use, and will be of particular benefit to the spotted owl team.

CONCLUISONS

The 2004 calendar year marked the second full year of data collection. We continued to trap all 18 grids that were trapped in 2003. We have now completed two years of pretreatment data on the nine experimental grids. We have also added a second year of trapping on the nine habitat grids. We anticipate that the thinning treatments will occur sometime in 2005 and allow us to trap for 2-5 years (2006-2010) of post treatment seasons. We have used the two years of habitat data to identify patterns in the demography of small mammals inhabiting the four habitat types we studied, and have generated a paper that will be published in a peer-review journal on this aspect of the project.

With the budget forecast for 2006, we plan to continue trapping on the nine experimental grids to obtain a third year of pretreatment data, or if the thinning treatments occur then we will begin post treatment data collection. Thinning on the treatment grids will begin as early as spring 2005, but is likely to not be done until fall 2005 or spring 2006. We will evaluate the need to keep the nine habitat grids over the winter of 2003-2004 and will establish new grids as deemed necessary. We will also reevaluate the need to continue trapping the nine habitat grids and may drop them from our study in order to allocate more resources to finding flying squirrels.

In an effort to increase our flying squirrel sample size we will change our workforce to include 6 technicians that will continue to monitor the normal set of trapping grids and perform woodrat telemetry, however for the 2005 field season we will hire 2 technicians, preferably with flying squirrel experience, to trap exclusively for flying squirrels and perform the needed telemetry on these animals. We will continue to trap and follow flying squirrels in various habitats throughout the Plumas National Forest.

We will return to the woodrat site and capture new and recapture woodrats from last field season to continue to monitor their activities and habitat use through a second year. We will also continue to study golden-mantled ground squirrel dispersal and home range establishment. We have enough tissue samples from chipmunks and will not continue collecting these from wild chipmunks. Additional studies may be added as opportunities present themselves and may include a descriptive study of the chipmunk species in the study area and the rate of fat development in chipmunks from different forest types.

Forest managers will benefit from these data in being able to more accurately predict the responses of small mammals to forest treatments, and to relate these to the population dynamics of important predator species such as northern goshawk, California spotted owl, and American marten. We have begun to publish the data obtained and expect to continue publishing through the next year. Articles have been submitted for publication to the following journals: Ecology Letters and Journal of Mammalogy (see publishing section below) and we expect to submit additional articles to the Journal of Mammalogy. We expect publication of data to continue into the 2005 field season and to include articles in peer-reviewed journals on the following subjects:

1. Habitat relationships of small mammals in the northern Sierra Nevada.
2. Northern flying squirrel home range size and structure.
3. Characteristics of woodrat house use.
4. Woodrat home range size and structure.
5. Genetic structure and hybridization of *Tamias* species in the Sierra/Cascade interface.

PUBLICATIONS

Wilson, J. A., D. A. Kelt, D, H, Van Vuren, and M. Johnson. Submitted. Effects of maternal body condition on offspring dispersal in Golden-Mantled Ground Squirrels (*Spermophilus lateralis*). Ecology Letters.

Wilson, J. A., D. A. Kelt, D, H, Van Vuren, and M. Johnson. Submitted. Population dynamics of small mammals inhabiting four forest types in the northern Sierra Nevada. Journal of Mammalogy.

Copetto, S. A. 2005. Habitat associations of small mammals at two spatial scales in the northern Sierra Nevada, California. M.S. Thesis, University of California, Davis.

PRESENTATIONS

Data from the 2003 – 2004 field seasons will be used in the development of 2-3 presentations to the 2005 annual meeting of the American Society of Mammmalogists in Springfield, Missouri. We anticipate giving presentations on 1. Population dynamics of small mammals in the Plumas NF, 2. Habitat associations of small mammals in the Plumas NF, 3. Woodrat home range structure and nest use, and 4. Golden-mantled ground squirrel body composition and offspring fitness. In addition, the golden-mantled ground squirrel presentation may also be given at the Ninth International Mammal Conference in Sapporo, Japan.

PERSONNEL

Fieldwork was coordinated by James A. Wilson, postdoctoral fellow at the University of California, Davis. Principal investigators for the small mammal module are Doug Kelt and Dirk VanVuren, Dept. of Wildlife, Fish, & Conservation Biology, University of California, Davis, and Mike Johnson, John Muir Institute of the Environment, University of California, Davis. Fieldwork in 2004 was conducted by James A. Wilson, Stephanie Coppeto, Robin Jenkins, Jolene Csakany, Geoffrey Palmer, Rebecca LeChalk, Regina Wassen, Sean Connelly, Devon DeJesus, Anna Derrick, and Jennifer Gold.

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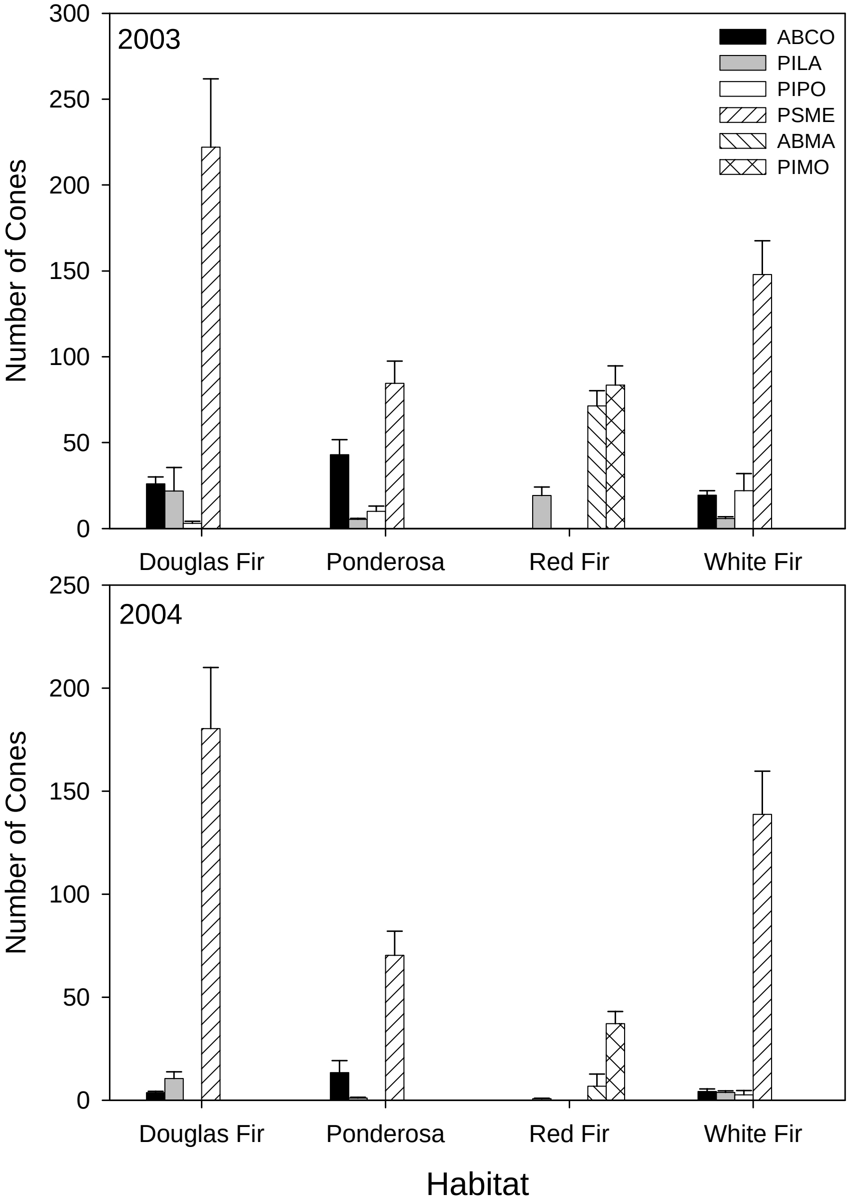


Figure 1. Mean cone production by species for fall 2003 and 2004. Tree species measured are white fir (*Abies concolor*; ABCO), sugar pine (*Pinus lambertiana*; PILA), ponderosa pine (*P. ponderosa*; PIPO), Douglas fir (*Pseudotsuga menziesii*; PSME). Red fir (*A. magnifica*; ABMA), and western white pine (*P. monticola*; PIMO).

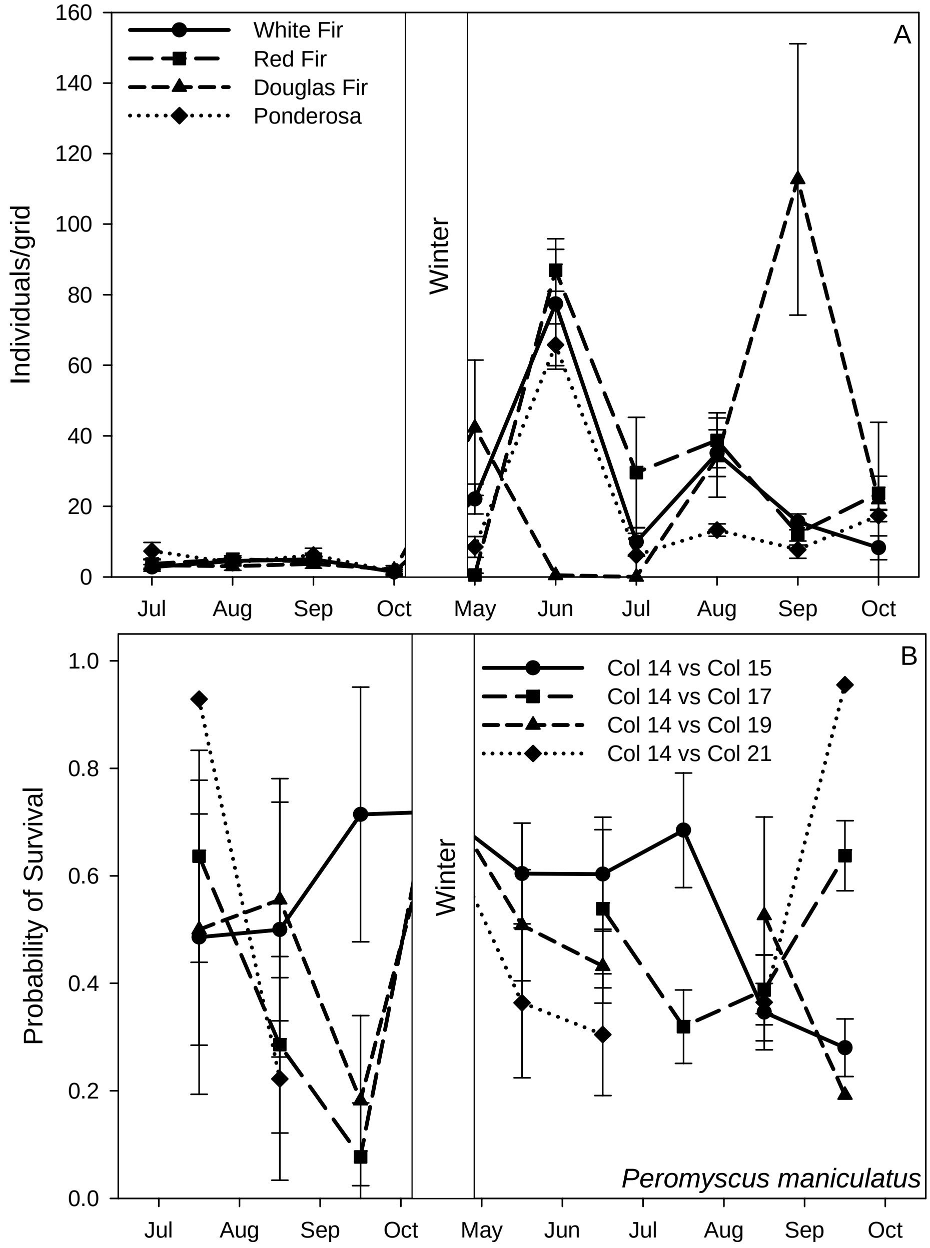


Figure 2. Mean monthly density (A) and survival (B) of deer mouse (*Peromyscus maniculatus*) populations inhabiting four forest types in the northern Sierra Nevada: white fir, Douglas fir, red fir, and Ponderosa pine. Population estimates were obtained using live recapture data and program MARK. Populations were monitored from June 2003 to October 2004.

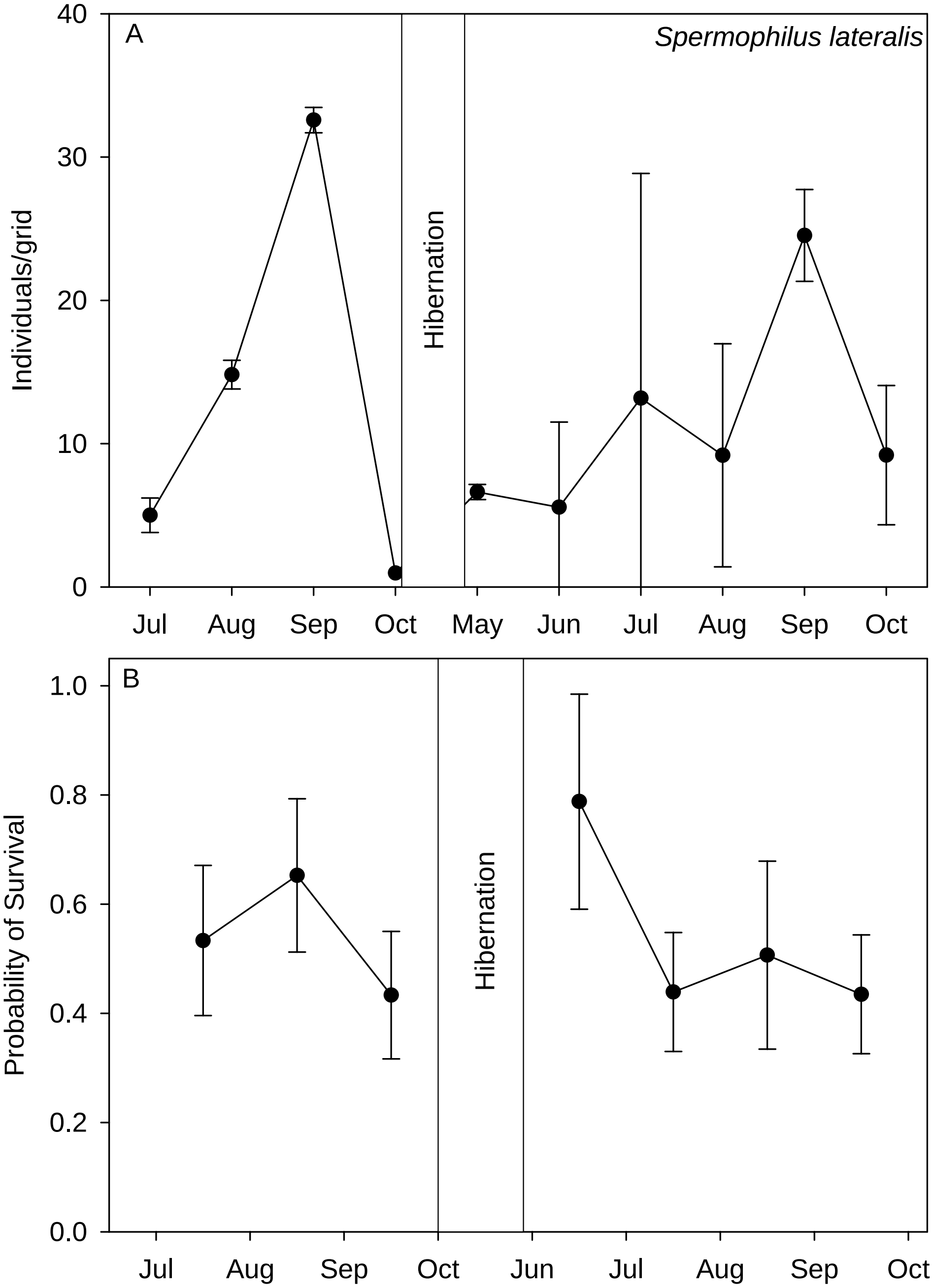


Figure 3. Mean monthly density (A) and survival (B) of golden-mantled ground squirrel (*Spermophilus lateralis*) populations inhabiting red fir forests in the northern Sierra Nevada. Population estimates were obtained using live recapture data and program MARK. Populations were monitored from June 2003 to October 2004.

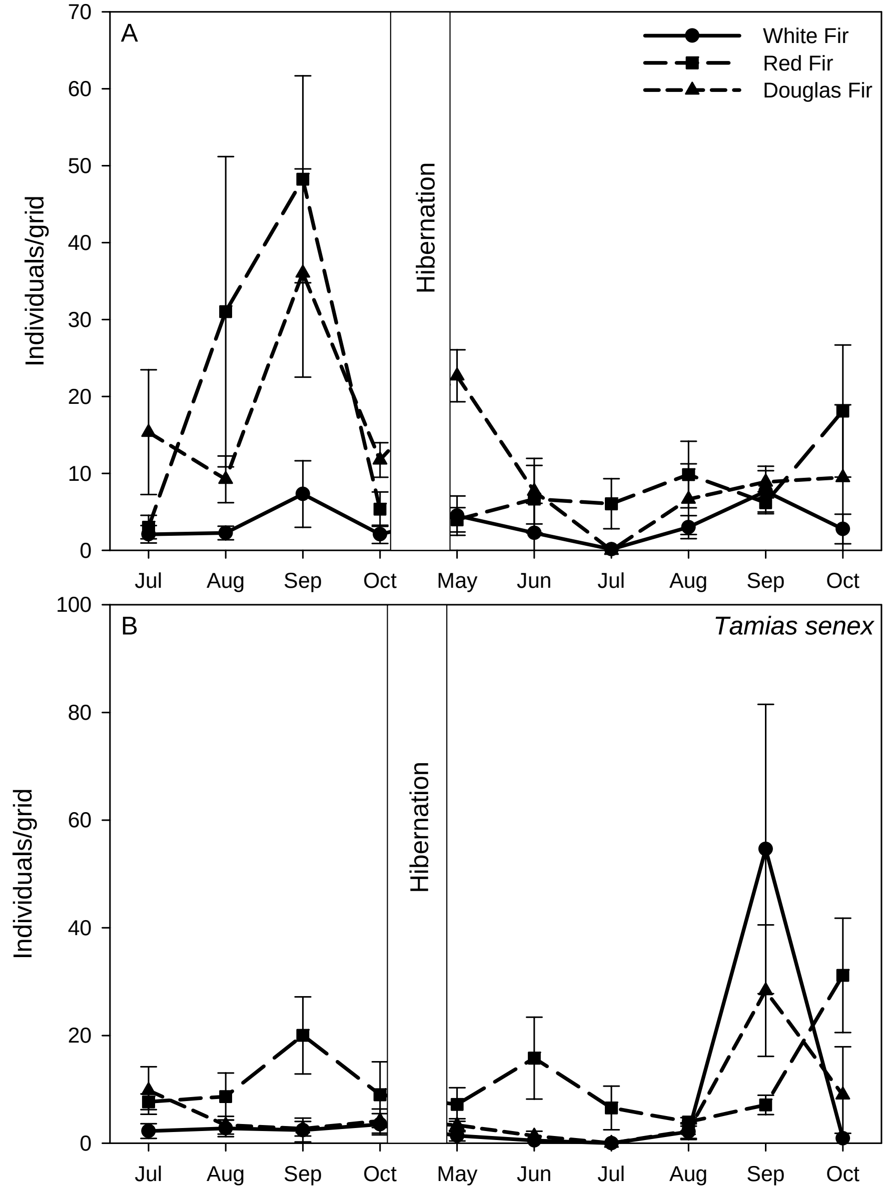


Figure 4. Mean monthly density of (A) long-eared chipmunk (*Neotamias quadrimaculatus*) and (B) Allen's chipmunk (*N. senex*) populations inhabiting three forest types in the northern Sierra Nevada: white fir, Douglas fir, and red fir. Population estimates were obtained using live recapture data and program MARK. Populations were monitored from June 2003 to October 2004.

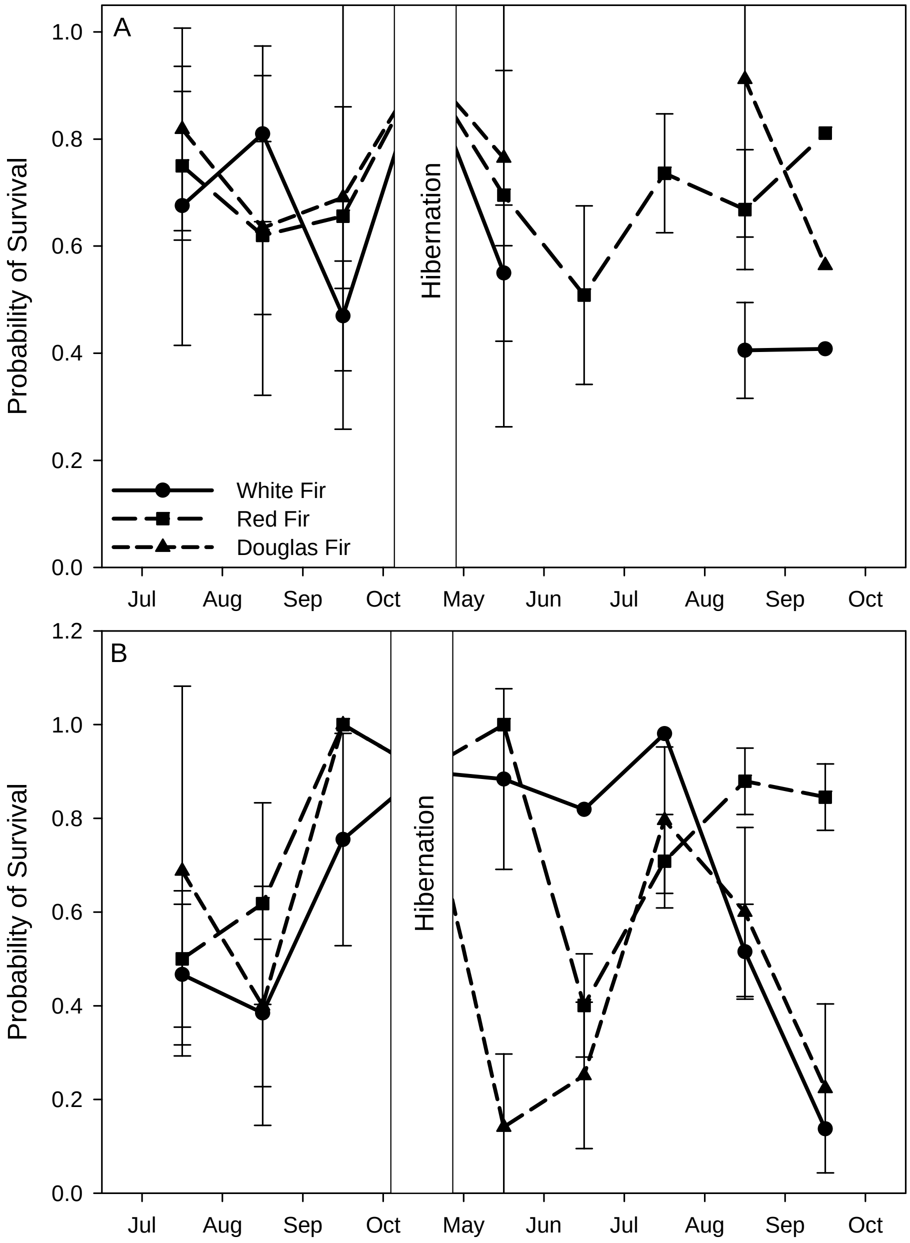


Figure 5. Mean monthly survival of (A) long-eared chipmunk (*Neotamias quadrimaculatus*) and (B) Allen's chipmunk (*N. senex*) populations inhabiting three forest types in the northern Sierra Nevada: white fir, Douglas fir, and red fir. Population estimates were obtained using live recapture data and program MARK. Populations were monitored from June 2003 to October 2004.

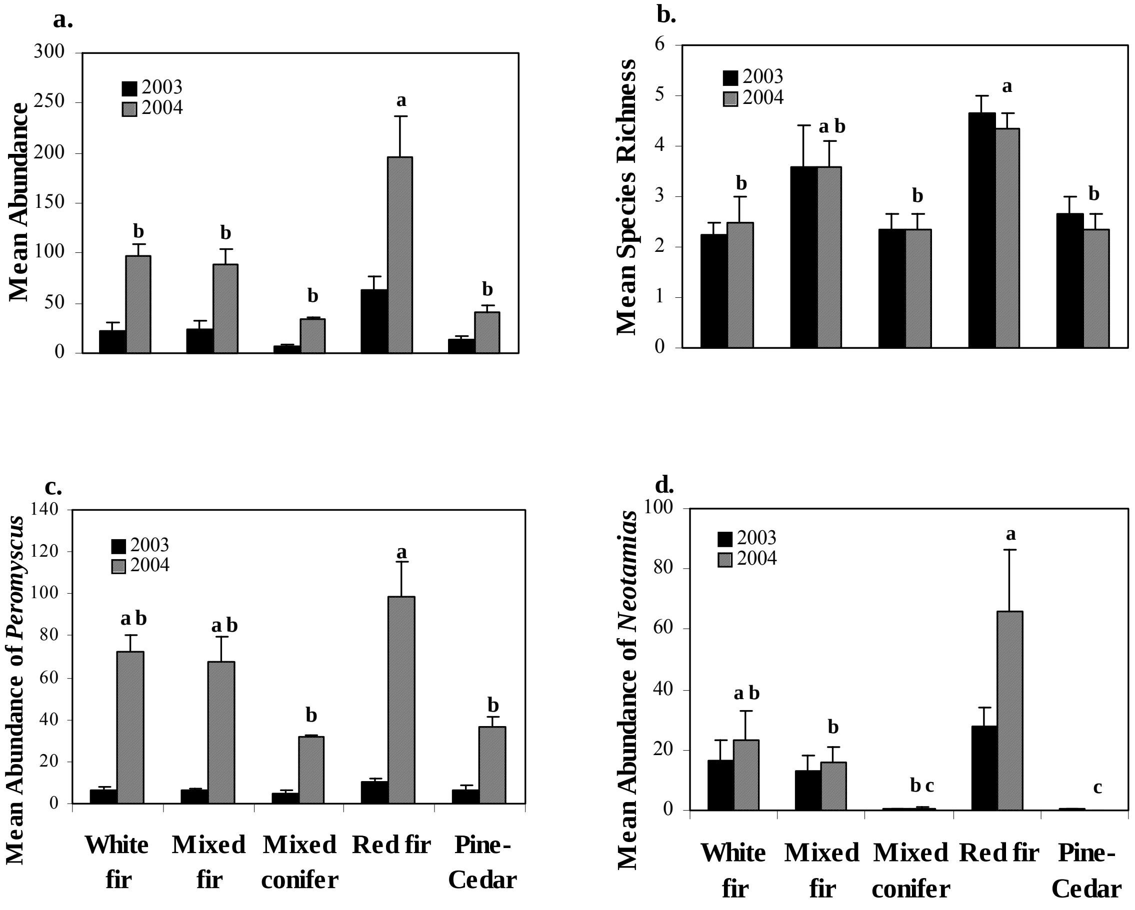


Figure 6. Differences in (A) mean abundance of all small mammals (N), (B) species richness (S), (C) abundance of *Peromyscus maniculatus* and (D) abundance of *Neotamias* among forest types in 2003 and 2004. Columns with the same letter are not significantly different (Scheffé, $P < 0.05$).

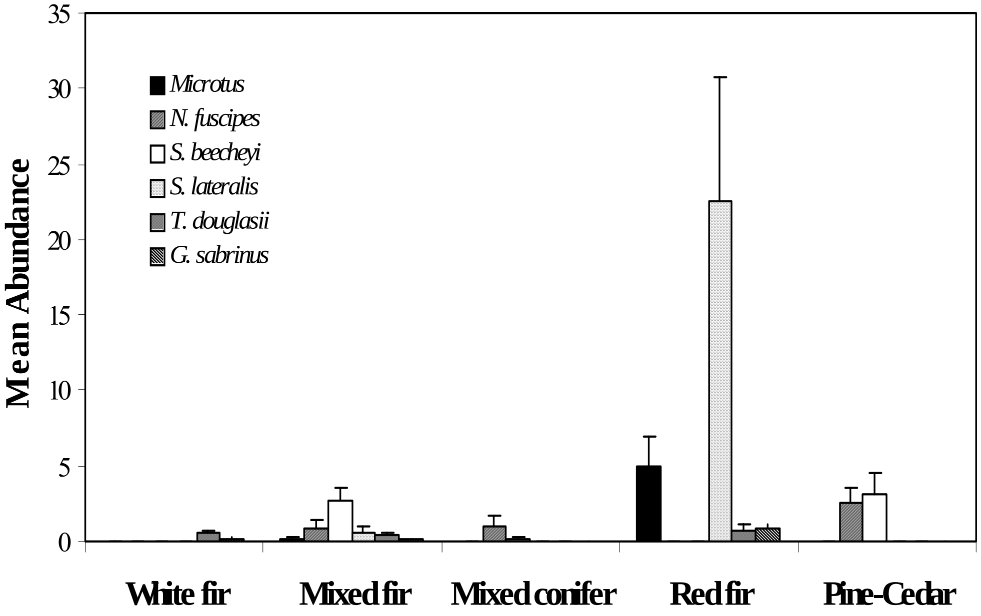
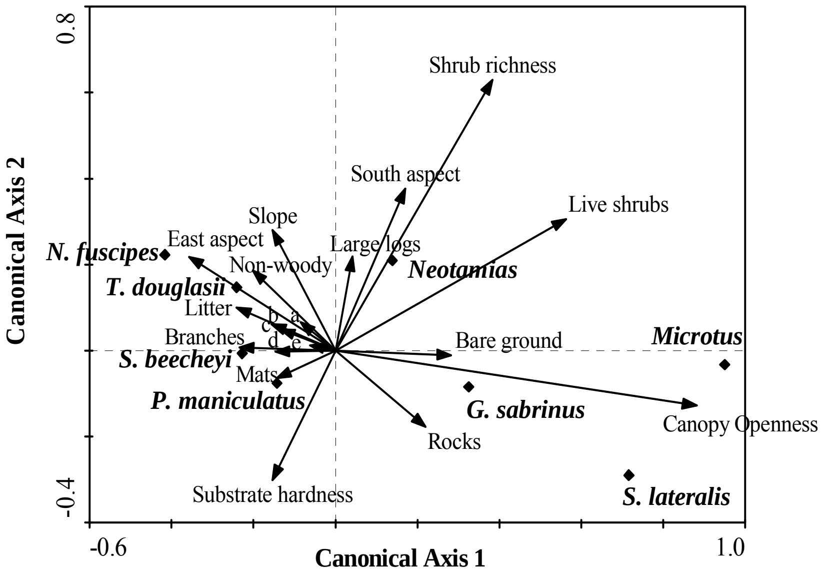


Figure 7. Mean abundance (for 2003 and 2004) of voles (*Microtus*), dusky-footed woodrats (*Neotoma fuscipes*), California ground squirrels (*Spermophilus beecheyi*), golden-mantled ground squirrels (*S. lateralis*), Douglas squirrels (*Tamiasciuris douglasii*), and northern flying squirrels (*Glaucomys sabrinus*) in five forest types (white fir, mixed fir, mixed conifer, red fir, pine-cedar).



a. Dead shrubs; b. Forbs and grasses; c. Saplings; d. Sapling richness; e. Small logs

Figure 8. Canonical correspondence analysis biplot of small mammal trap-scale abundances and microhabitat variables. Length of vector represents strength of correlation with canonical axes.

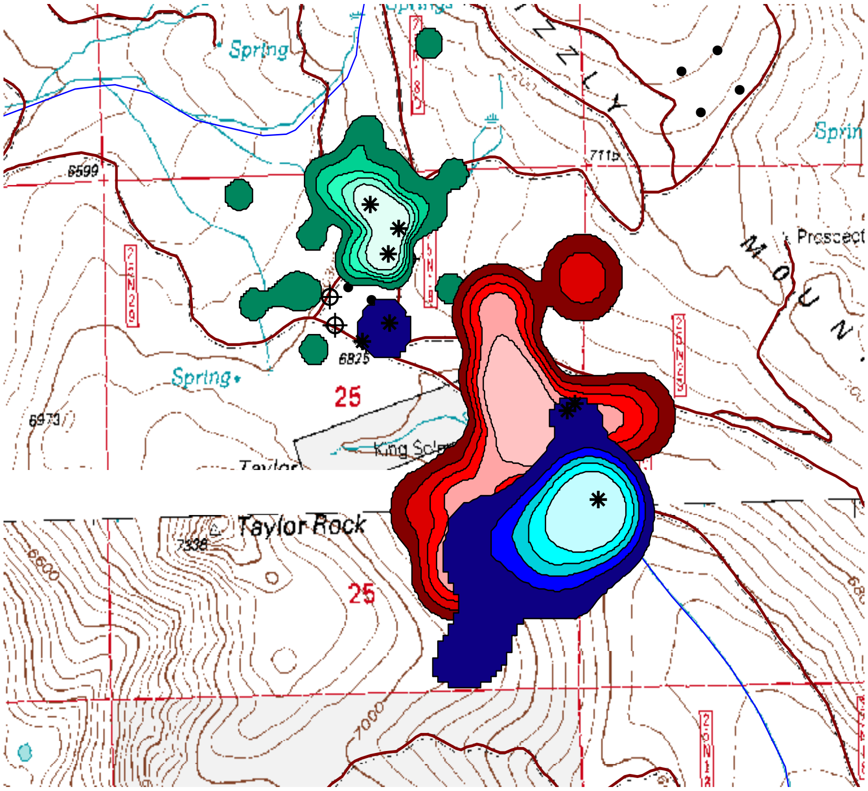


Figure 9. Home range of three (2 males, 1 female) individual northern flying squirrels (*Glaucomys sabrinus*) in red fir forests. Home ranges represent the results of adaptive kernel analyses and show frequency of use with lighter shades representing areas of higher use. Nest trees are shown by asterisks.

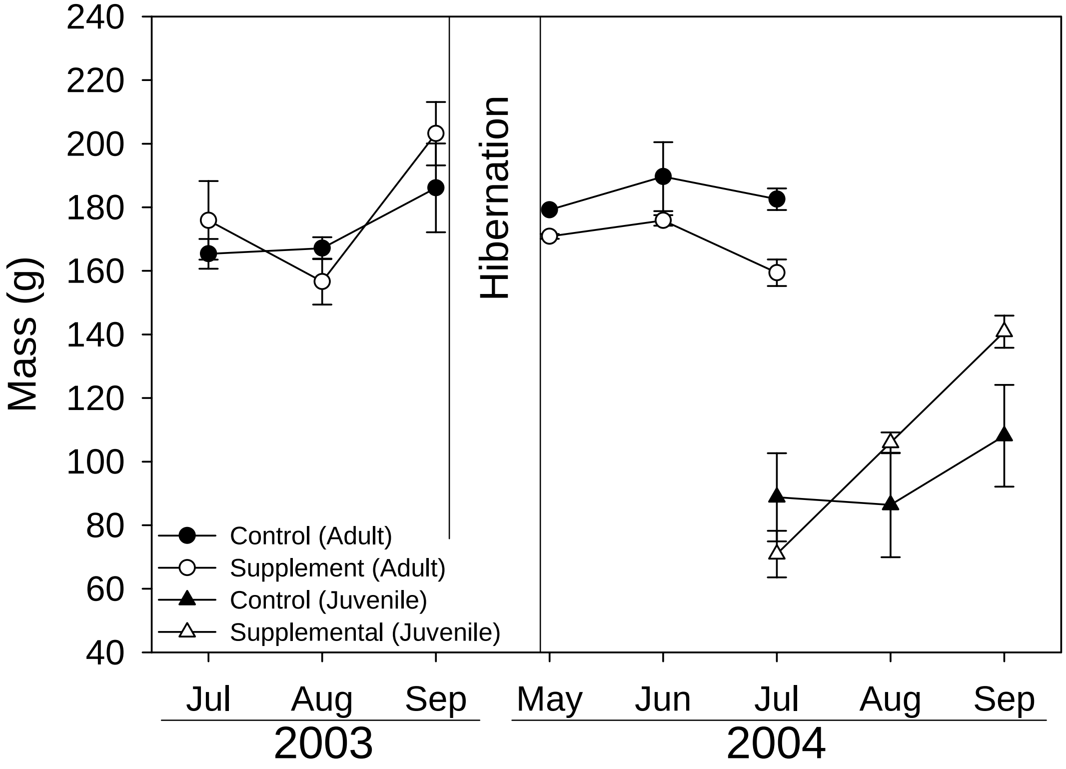


Figure 10. Mass of female (mother) golden-mantled ground squirrels and their offspring through the 2003 – 2004 field seasons. All squirrels enter hibernation during early October and Emerge following snowmelt in mid May.

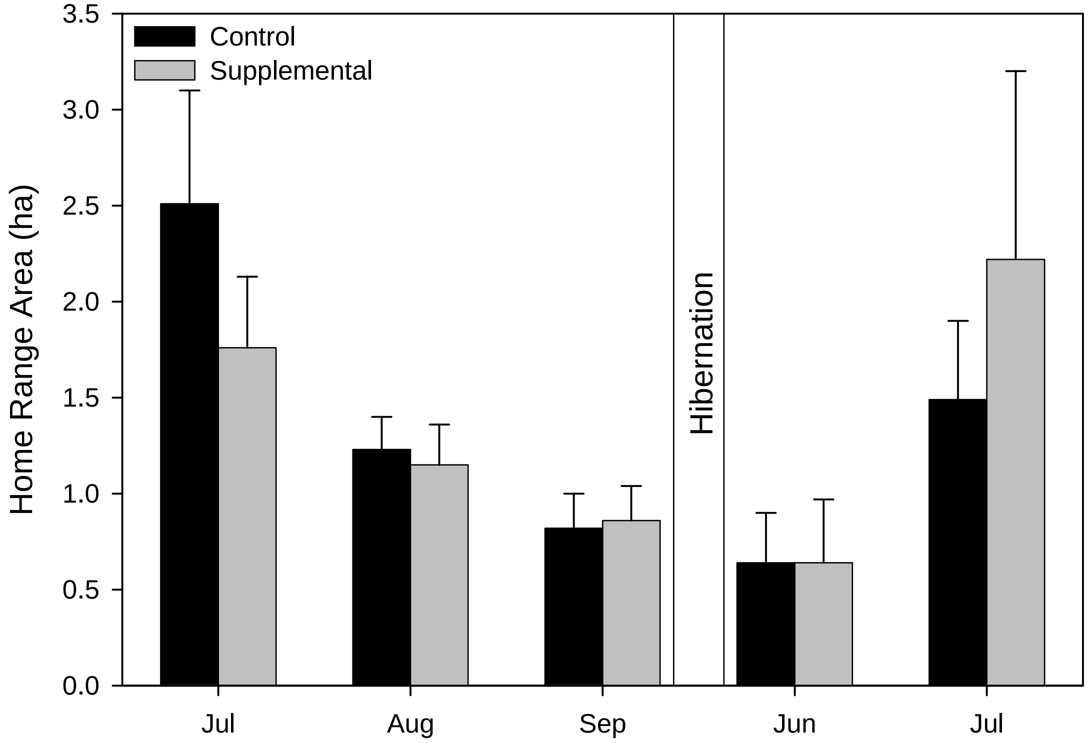


Figure 11. Maternal home range size (ha) measured using minimum convex polygon methods in ArcView. Error bars represent standard errors.

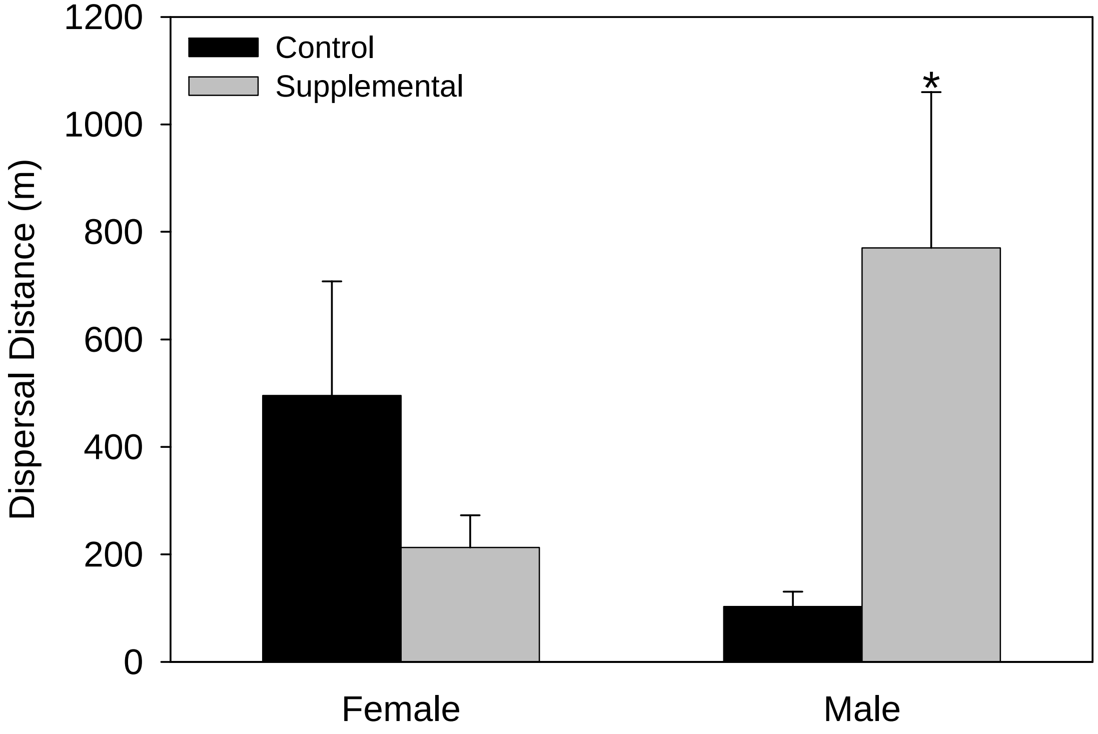


Figure 12. Dispersal distance (m), measured as the distance between location of first capture and location of hibernation, of male and female offspring from each treatment group. Treatments were applied to mothers only.

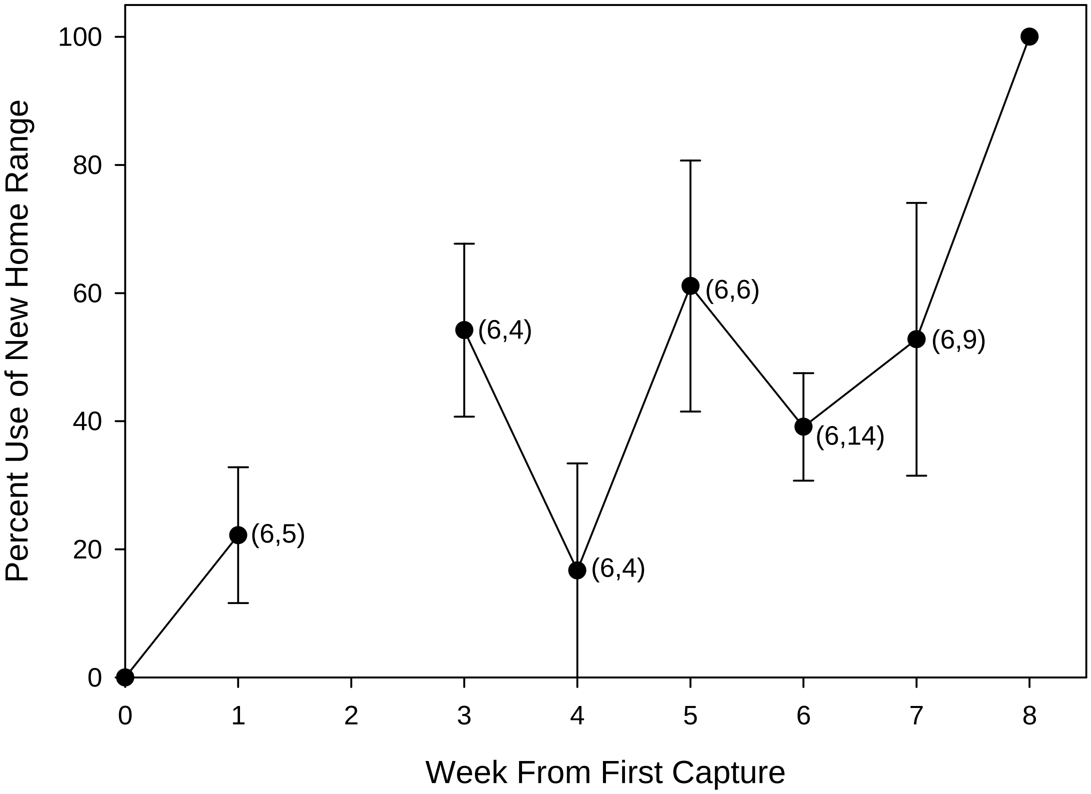


Figure 13. Proportion of use between the natal home range and the dispersed home range by offspring during the weeks following initial capture. Locations were not taken during week two. All offspring were captured between 26 July and 8 August 2004 and the initial capture date was counted as time zero. Numbers next to symbols represent number of (individuals, days) used to calculate percent use

Appendix D

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

2004 Annual Report

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EXECUTIVE SUMMARY

In this document we report on the avian module of the Plumas Lassen Area Study. 2004 was the third year of data collection, though in 2002 a different study was being carried out. While some of that data has been incorporated into this study 2004 was the second year under the current study design. As of the end of the 2004 bird breeding season, none of the proposed treatments have been implemented, thus everything we report on reflects pre-treatment conditions.

Analysis and discussion in this report are intended to provide background information on the pre-treatment status of the avian community, determine habitat associations of many of those species, while providing insight into the important habitat attributes to manage for to ensure a sustainable avian community.

Our analysis shows that for the most abundant species in the study area, at the level of the treatment unit (aggregation of 4 to 6 adjacent watersheds), the bird community is very similar. However, there are some significant differences between treatment units. Units 1 and 5 have the highest species richness and unit 2, the area with the highest density of Spotted Owls, has the lowest. Additionally, several species are markedly more abundant in some units than others (e.g. Nashville Warbler). Proposed treatment sites (DFPZ's) in Treatment Unit 1 have higher species richness than the surrounding landscape while in Treatment Unit 4, proposed DFPZ sites had lower species richness than the surrounding landscape.

Habitat associations showed that while predictive power of our models was relatively low, a broad range of habitat attributes were significantly positively correlated with the abundance of more than one bird species. Large snags, large DBH trees, and shrub cover were all positively correlated with multiple species while elevation and the amount of hardwood habitat within 3 km of points were negatively correlated with several different species. We found several species were only correlated with local habitat variables (Fox Sparrow, Golden-crowned Kinglet, and Nashville Warbler) while the majority were correlated with both local and landscape level habitat attributes.

INTRODUCTION

Coniferous forest is one of the most important habitat types for birds in California (CalPIF 2002). In the Sierra Nevada, a century of intensive resource extraction and forest management practices 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; declines and extirpations 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) directs 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). 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 Spotted Owl respond to these conditions?

Specifically, 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 (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 stability 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, this module will address 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) Determine population trends for landbirds to identify 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 (again over the short term).

In addition to this study PRBO has been monitoring songbird populations in the Northern Sierra since 1997. Since 2001, these efforts have aimed to complement the avian research of the Administrative Study by focusing on monitoring the non-coniferous habitats within the HFQLG area (Burnett and Humple 2003 and 2005, Humple and Burnett 2004). 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, as well as avian response to aspen and black oak habitat enhancement. Working closely with the project planners from Forest Service ranger district staff these studies are being implemented as adaptive management experiments. These efforts 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.

METHODS

Avian Surveys

We are using standardized five-minute variable circular plot (VCP) point count censuses (Buckland et al. 1993, Ralph et al. 1993) 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 begin around local sunrise and are completed within four hours. Each transect is visited twice during the peak of the breeding season.

Treatment Unit and Transect Nomenclature

In this report we use the former treatment units (TUs), those defined in the original Admin 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" that is consistent across them and are simply used here as a tool to describe geographical linked portions of the study area. Additionally, it is important to note that while we refer to DFPZ's as treated sites and others as untreated sites, no treatment has yet been implemented to date thus all data is pre-treatment.

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 class and size class of the randomly generated starting point respectively (e.g. 222 is in TU-2, cover class 2, and size class 2). In 2003 and 2004, under the existing study plan, transects are named after the CalWater Planning Watershed (CalWater 1999). For example, SNK1 is in the Snake Lake watershed and is the first transect established while CHG3 is in the China Gulch watershed and was the third transect established. The numeric ending is simply for designating between the different transects in the same watershed and does not have any additional significance.

2004 Survey Effort

In 2004 we established and surveyed 18 new permanent transects and continued surveying 75 transects that had been established in 2002 or 2003, for a total of 93 transects surveyed (Table 1). These transects consist of 12 points each for a total of 1116 point count locations surveyed in 2004 in the study area (TUs 1-5). Of these 1116 points, 971 are located in areas not-currently slated for DFPZ treatment (extensive sampling) with the remaining 145 located within DFPZ's scheduled for treatment. All of these DFPZ transects are located in TUs 1 and 4 (Table 1). As the location of additional DFPZ networks is solidified in (former) TUs 2, 3, and 5, and potentially elsewhere, we will add additional transects to those sites, as described in the study plan (Stine et al 2004).

Table 1. Extensive and DFPZ point count transects surveyed in the Plumas – Lassen Study in 2004.

Treatment Unit	Watershed	Code	Extensive Survey Points	DFPZ Survey Points
5	Grizzly Forebay	GRZ	39	0
5	Frazier Creek	FRC	45	0
5	China Gulch	CHG	36	0
5	Bear Gulch	BEG	36	0
5	Haskins Valley	HAV	36	0
5	Red Ridge	RED	36	0
5	**Unit Total**		**228**	**0**
4	Silver Lake	SIL	41	24
4	Meadow Valley Creek	MVY	51	0
4	Deanes Valley	DVY	36	0
4	Snake Lake	SNK	36	12
4	Miller Fork	MIL	36	24
4	Lower Knox Flat	LKF	36	0
4	Pineleaf Creek	PLC	31	12
4	**Unit Total**		**267**	**72**
3	Soda Creek	SOD	36	0
3	Rush Creek	RUS	64	0
3	Halsted Flat	HAL	36	0
3	Lower Spanish Creek	SPC	36	0
3	Black Hawk Creek	BLH	24	0
3	Indian Creek	IND	12	0
3	**Unit Total**		**208**	**0**
2	Mosquito Creek	MSQ	36	0
2	Butt Valley Reservoir	BVR	36	0
2	Ohio Creek	OHC	41	0
2	Seneca	SEN	47	0
2	Caribou	CAR	36	0
2	**Unit Total**		**196**	**0**
1	Upper Yellow Creek	UYC	24	31
1	Grizzly Creek	GCR	24	17
1	Butt Creek	BCR	24	13
1	Soldier Creek	SCR	0	12
1	**Total**		**72**	**73**
	Grand Total		**971**	**145**

Field Crew Training

Field crew members all have previous experience conducting avian fieldwork and undergo extensive training onsite for three weeks prior to conducting surveys. Training consists of long hours in the field birding 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, prior to their arrival at the study site. Each person uses the compact disc 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. 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 a survey.

Vegetation Sampling Methods

Vegetation is assessed using the relevé method, following procedures outlined in Ralph et al. (1993). In summary this method uses a 50-meter radius plot centered on each census station where general habitat characteristics of the site are recorded (canopy cover, slope, aspect, etc.) and the cover, abundance, and height of each vegetation stratum (tree, shrub, herb, and ground) are determined through ocular estimation. Within each vegetation stratum, the species composition is determined and each species' relative cover recorded, as a percentage of total cover for that stratum (see Ralph et al. 1993 for complete description).

Statistical Analysis

We analyzed point count data in order to create by-point community indices for each transect. Community indices were created using 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 surveyed using the point count method (e.g. raptors, waterfowl, grouse, nightjars, swallows, crows, ravens).

We present the mean by point (average per point per visit, per year, by transect) for the following three indices. This method allows for using the point as the individual sampling unit and therefore makes possible the stratification of points for analysis based on attributes other than the transect and comparison of uneven sample sizes.

Species Richness

Species richness is defined as the mean number of species detected within 50 meters of each point averaged across visits.

Diversity

Species diversity is defined as the mean number of species detected within 50 m (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-Wiener 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 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.

Landscape Statistics

Landscape statistics were calculated using the program FRAGSTATS (McGarigal et al. 2002). Landscape statistics were measured within a 3km radius circle centered on the geographic center of each of 32 transects using the most current Vestra GIS vegetation coverage. Landscape parameters included the following measures: (a) forPLAND, percent forest coverage where classification was binary (forested and non-forested), (b) forED, forest edge density as meters of edge per hectare (m/ha), (c) C1 percent of non-vegetated area (e.g. bare ground, rock, or urban areas), (d) C4 percent of hardwoods in landscape, (e) C13 percent of conifers in stand size class 3, (f) C14 percent of conifers in stand size class 4, (g) IJI interspersion and juxtaposition index (a measure of landscape heterogeneity) where landscape classification included seven landtype categories (see below), (h) SHDI (Shannon’s diversity index) increases as the number of different patch types increases and/or the proportional distribution of area among patch types becomes more equitable, and (i) CONTAG a contagion index with seven landtype categories which measures the extent to which landscape elements (patch types) are aggregated or clumped (i.e., dispersion); higher values of contagion may result from landscapes with a few large, contiguous patches, whereas lower values generally characterize landscapes with many small and dispersed patches. For the indices of contagion, interspersion, and diversity we considered seven land type categories: (i) no vegetation (C1), (ii) meadow/pasture (C2), (iii) shrub cover, burnt, or harvested areas (C3), (iv) hardwood cover (C4), (v), conifers of size class 2 (C12), (vi) conifers of size class 3 (C13), and (vii) conifers of size class 4 or 5 (C14).

A subset of extensive transects were used in the landscape analysis. We attempted to maximize our sample size without having any transects that the 3km circle, for which landscape attributes were quantified, overlapped. Thus the following point count transects were chosen:114, 213, 214, 222, 223, 224, 323, 413, 513, 514, BCR1, BEG1, BVR3,CHG1, GCR2, GRZ3, HAL2, HAV2, HSRF, IND1, LKF2, LKF3, MSQ2,MVY2, RED1, RUS1, SIL2, SIL3, SNK3, SOD3, and SPC2 (Table 1).

Local Habitat Variables

Detailed descriptions of the local vegetation variables used in the habitat association analysis are in Appendix 8 and are a modified version of the releve protocol described by Ralph et al. (1993). Of those variables collected at the “local” point count station, we used the following 22 in this analysis: slope, elevation (elev), basal area of all tree species combined (basal), shrub cover (realshrbco), cover of trees under 5 meters tall (treshrbcov), cover of trees less than 5 meters tall and shrubs combined (ttlshrbcov), snags 10-30cm dbh (snags1030), snags>30cm dbh (snagsg30), maximum tree dbh (maxtrdbh), minimum tree dbh (mintrdbh), high tree height (hitreeht), high shrub height (hirsht), White Fir basal area (abiconba), Black Oak basal area (quekelba), Sugar Pine basal area (pinlamba), Red Fir basal area (abimagba), Jeffrey Pine basal area (pinjefba); and the absolute cover of Sugar Pine (pinlamt1), White Fir (abicont1), Douglas Fir (psement1), Ponderosa Pine (pinpont1), and Incense Cedar (cedar).

Regression Procedure

The statistical package SAS (SAS Institute Inc. 1999) was used to perform various statistical tests described in Sokal and Rohlf (1981). A probability of Type I error of 0.05 or less was accepted as significant (unless otherwise noted) but greater values are shown for descriptive purposes. For this analysis we focused on 18 bird species which were detected consistently across the study area. We calculated species abundance as the average number of detections of each species at each census point for each year.

We used stepwise multiple regression models to determine which of the local and landscape variables accounted for the greatest amount of variation in species abundance for 18 of the breeding bird species following Howell et al. (2000). Stepwise multiple regression identifies which variables explain the greatest amount of variation in species abundance; the first variable to enter the stepwise model accounts for the greatest variability. We only included variables that explained at least 1.5% of the variance in the stepwise regression (partial $r^2 \geq 0.015$). A variable may be removed if variables are highly correlated, but this did not occur for variables with partial $r^2 \geq 0.015$. Only variables that made significant contributions to the overall model were kept ($P < 0.05$). Because the variable "basal" was a linear combination of the individual species tree basal areas (see Vegetation Variables above) there were potential problems with colinearity. Therefore for species where basal area was important, we ran the stepwise procedure separately for total basal area and for its separate components. After first employing the stepwise procedure to identify significant variables, we analyzed each overall model again using multiple regression.

RESULTS

A total of 93 species were detected during point count surveys in 2004, one more than was detected in 2003 (Burnett et al. 2004), for a total of 102 species detected across all 3 years of the study (Appendix 9). We determined breeding bird species richness and abundance at all sites surveyed in 2004 (Table 2), and included indices for these same transects from all previous years they were surveyed (i.e. 2002, 2003, or both). Abundance (the average number of individuals detected within 50 meters of each point per visit) ranged from a 0.63 on the SOD3 transect to 6.83 on the SIL2. Species richness ranged from 1.17 on the SOD3 transect to 8.25 on the 313 transect. For sites surveyed in both 2003 and 2004, the mean index of abundance was lower in 2004 for 57 of the 74 transects, while richness was lower for 58 of the 74 transects. The mean abundance for all of 74 transects was 3.50 in 2004 compared to 4.25 in 2003, while species richness was 4.77 in 2004 and 5.73 in 2003.

Of the DFPZ transect surveyed, the highest mean per point abundance in 2004, was recorded at D108 (6.09) while the lowest was at D403 (1.85). The highest per point mean species richness was recorded at D108 and D109 (both 7.25) while the lowest was at D403 (2.45). Both the abundance and species richness indices were considerably higher at TU-1 DFPZ transects than at TU-4 DFPZ transects (Table 2).

Table 2. Mean abundance, ecological diversity, and species richness for all point count transects surveyed by PRBO in the Plumas/Lassen area study in 2004 (including all data from all years they were surveyed).

		Abundance			Richness		
Transect	**Unit**	**2004**	**2003**	**2002**	**2004**	**2003**	**2002**
Extensive							
114	1	5.67	3.58	7.63	6.00	4.58	8.42
BCR1	1	2.41	NS	NS	3.73	NS	NS
UYC1	1	5.18	NS	NS	6.33	NS	NS
GCR1	1	2.75	NS	NS	4.17	NS	NS
GCR2	1	3.71	NS	NS	4.92	NS	NS
HSRF	1	3.88	NS	NS	5.75	NS	NS
Subtotal	**1**	**3.93**			**5.06**		
213	2	2.38	5.13	1.89	2.92	6.17	2.29
214	2	1.42	1.63	3.92	2.08	2.25	5.58
222	2	3.50	5.25	4.46	5.17	7.58	6.08
223	2	3.63	6.29	6.04	4.50	7.33	8.58
224	2	2.67	3.21	4.50	4.17	4.33	6.08
MSQ1	2	2.17	2.79	NS	3.16	4.08	NS
MSQ2	2	2.17	2.75	NS	3.33	3.50	NS
BVR1	2	4.08	5.17	NS	5.42	5.42	NS
BVR2	2	5.96	3.63	NS	7.17	5.33	NS
BVR3	2	3.54	4.67	NS	4.75	6.25	NS
OHC1	2	3.17	3.00	NS	4.00	4.33	NS
OHC2	2	1.64	4.08	NS	2.55	5.58	NS
SEN1	2	2.25	3.00	NS	3.75	4.08	NS
CAR1	2	4.17	3.42	NS	5.67	4.42	NS
CAR2	2	3.63	2.50	NS	5.33	3.83	NS
CAR3	2	1.91	NS	NS	2.82	NS	NS
Subtotal	**2**	**3.02**			**4.17**		
313	3	6.08	7.58	3.67	8.25	10.00	5.08
314	3	3.88	4.42	4.08	5.50	6.42	3.75
322	3	5.58	3.38	4.63	7.00	5.17	6.58
323	3	2.46	2.79	5.33	4.00	4.67	7.92
324	3	4.63	3.83	4.54	5.25	5.17	6.83
BLH1	3	2.09	2.42	NS	3.36	3.25	NS
BLH2	3	3.55	NS	NS	4.73	NS	NS
HAL1	3	2.50	3.46	NS	3.92	5.58	NS
HAL2	3	3.00	3.92	NS	3.58	5.17	NS
HAL3	3	3.25	6.96	NS	4.67	7.67	NS
IND1	3	2.83	4.13	NS	4.50	5.50	NS
RUS1	3	5.79	5.83	NS	6.92	7.75	NS
SOD1	3	3.92	NS	NS	5.75	NS	NS
SOD2	3	2.75	NS	NS	4.17	NS	NS
SOD3	3	0.63	NS	NS	1.17	NS	NS
SPC1	3	3.13	3.29	NS	4.33	4.75	NS
SPC2	3	2.21	4.25	NS	3.50	5.75	NS
Subtotal	**3**	**3.43**			**4.74**		
413	4	4.83	2.83	5.83	6.33	2.58	7.83
414	4	4.75	4.38	6.79	6.08	6.50	8.58

		Abundance			Richness		
Transect	**Unit**	**2004**	**2003**	**2002**	**2004**	**2003**	**2002**
422	4	3.71	4.54	4.29	4.58	5.42	5.92
423	4	3.58	3.29	4.58	4.92	4.50	6.75
424	4	3.54	5.46	5.75	5.33	7.42	8.00
MIF1	4	3.29	4.00	NS	4.25	5.50	NS
MIF2	4	3.00	5.67	NS	4.25	7.42	NS
MIF3	4	3.54	5.21	NS	4.50	6.17	NS
D404	4	3.35	6.50	4.96	5.00	8.33	7.08
D405	4	3.35	4.79	4.46	4.90	7.00	6.50
LKF1	4	2.96	NS	NS	3.42	NS	NS
LKF2	4	3.83	NS	NS	4.92	NS	NS
LKF3	4	5.13	NS	NS	6.75	NS	NS
MVY1	4	3.29	4.75	NS	4.33	6.92	NS
MVY2	4	3.79	5.58	NS	5.17	7.08	NS
PLC1	4	3.71	NS	NS	5.67	NS	NS
SIL1	4	3.08	5.17	NS	4.42	6.67	NS
SIL2	4	6.83	5.13	NS	7.08	7.17	NS
SIL3	4	2.46	2.29	NS	3.17	3.75	NS
SNK1	4	2.38	4.25	NS	3.75	5.50	NS
SNK2	4	2.33	4.54	NS	3.33	6.33	NS
SNK3	4	1.71	NS	NS	2.67	NS	NS
Subtotal	**4**	**3.57**			**4.77**		
513	5	6.79	3.00	5.38	7.67	4.33	6.92
514	5	4.08	5.75	2.46	5.58	5.17	4.25
522	5	3.17	5.63	5.50	4.42	7.25	7.67
523	5	2.42	3.33	3.54	4.00	5.75	5.25
524	5	3.04	2.79	4.42	4.92	4.08	6.42
BEG1	5	1.96	3.42	NS	3.25	4.42	NS
CHG1	5	2.46	3.46	NS	3.58	5.08	NS
CHG2	5	3.17	6.67	NS	4.33	8.25	NS
CHG3	5	5.79	3.54	NS	7.25	5.17	NS
FRC1	5	2.96	5.25	NS	4.67	7.08	NS
GRZ1	5	2.58	3.92	NS	3.50	4.92	NS
GRZ2	5	3.96	3.58	NS	5.75	5.67	NS
GRZ3	5	3.38	4.71	NS	5.08	7.08	NS
RED1	5	4.42	4.75	NS	5.67	5.92	NS
RED2	5	3.38	3.00	NS	4.92	5.08	NS
RED3	5	3.92	4.13	NS	5.83	6.25	NS
D501	5	2.35	4.21	NS	3.40	5.75	NS
HAV1	5	3.42	5.75	NS	4.92	7.67	NS
HAV2	5	3.42	4.92	NS	5.08	7.25	NS
Subtotal	**5**	**3.51**	**4.31**		**4.94**	**5.90**	
Extensive Total[1]	**1-5**	**3.50**	**4.25**		**4.77**	**5.73**	
DFPZ							
D102	1	2.42	3.54	5.29	2.75	5.00	5.92
D107	1	3.63	3.50	4.25	5.50	5.25	6.17
D108	1	6.09	NS	5.89	7.25	NS	4.67

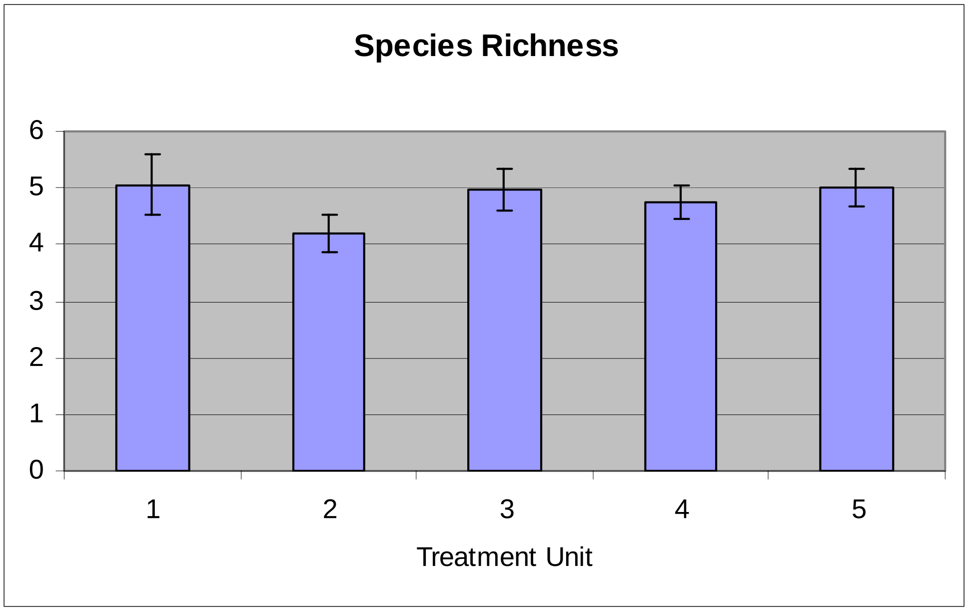
		Abundance			Richness		
Transect	**Unit**	**2004**	**2003**	**2002**	**2004**	**2003**	**2002**
D109	1	6.08	5.71	6.13	7.25	7.08	8.67
D110	1	2.79	NS	NS	4.08	NS	NS
D111	1	3.42	NS	NS	5.33	NS	NS
D112	1	5.46	NS	NS	7.08	NS	NS
Subtotal	**1**	**4.27**	**4.58**	**5.17**	**5.61**	**6.29**	**6.90**
D401	4	2.30	4.21	6.79	3.33	5.00	8.75
D402	4	3.05	4.13	4.71	4.50	5.58	6.75
D403	4	1.85	3.79	3.71	2.45	5.58	5.42
D407	4	3.00	3.46	4.42	4.83	5.33	6.33
D408	4	3.70	5.88	4.50	5.08	7.58	6.75
D409	4	2.00	1.92	NS	2.73	3.00	NS
Subtotal	**4**	**2.65**	**3.90**	**4.83**	**3.82**	**5.35**	**6.80**

[1] Only calculated for transects surveyed in both 2003 and 2004.

Species Abundance and Richness by Treatment Unit

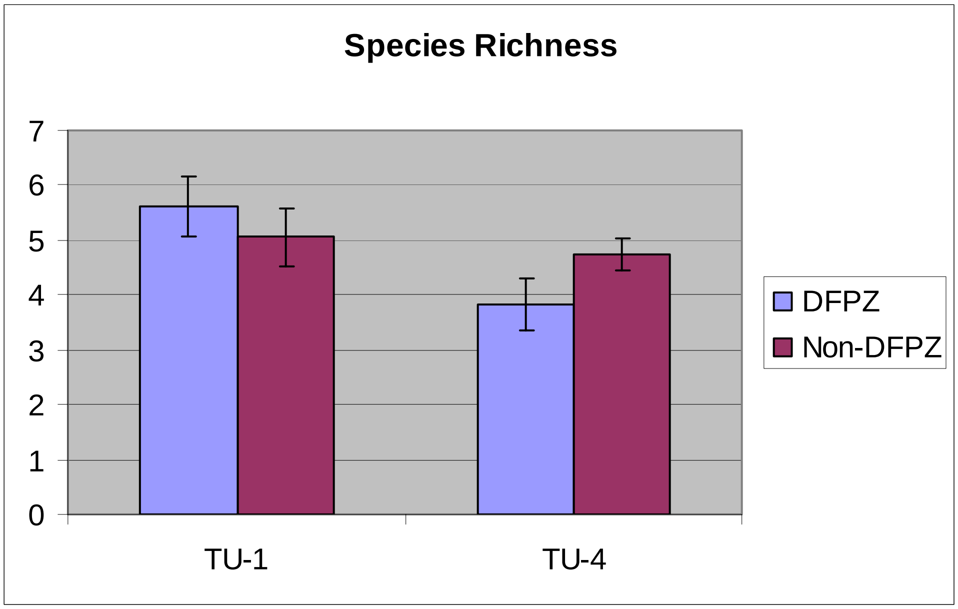
We compared the mean species richness for extensive transects (non-DFPZ) in each treatment unit in 2004 (Figure 1). Species richness ranged from a high of 5.05 in TU-1 to a low of 4.19 in TU-2. TU-2 mean richness per point was significantly ($p<0.05$) lower than TU-1, TU-3, and TU-5, with all other differences non-significant ($p>0.05$). Twenty-five percent (n=4) of transects in TU-2 averaged species richness below 3.00 (213, 214, OHC2, and CAR3), while only 12.5% (n=2) averaged per point richness over 5.50 (BVR 2 & CAR 1; Table 2). In contrast, 50% (n=3) of transects in TU-1, 29% (n=5) in TU-3, 23% (n=5) in TU-4, and 32% (n=6) in TU-5 averaged over 5.50 species per point. There were no transects in TU-1 and 5 that averaged below 3.00 species per point, and TUs 3 and 4 had one each (6% and 5% respectively).

Figure 1. Avian species richness per point average by treatment unit in 2004 in the Plumas Lassen Study, with 95% confidence intervals.



We compared species richness between pre-treatment DFPZ and extensive sites (non-DFPZ's) in TUs 1 and 4 (Figure 2). In TU-1 species richness was higher (non-significant $p>0.05$) in DFPZ's than at extensive sites (5.61 vs. 5.05), while in TU-4 DFPZ sites had significantly lower species richness than non-DFPZ sites (3.83 vs. 4.75; $p<0.05$). TU-4 DFPZ's were significantly lower than both TU-4 DFPZ and DFPZ and non-DFPZ sites in TU-1.

Figure 2. Avian species richness per point average comparing all DFPZ and Extensive point count stations in Treatment Units 1 and 4 with 95% confidence intervals.



We compared per point mean abundance of the ten most abundant species detected in TUs (2-5) from all extensive points surveyed in 2002 – 2004 (Table 3). We excluded TU-1 because most transects in that unit were only surveyed in 2004. A total of fourteen species comprised the ten most abundant species in the four units, though eight species were among the ten most abundant in each of the four units (Hermit Warbler, Audubon's Warbler, Oregon Junco, Mountain Chickadee, Western Tanager, Red-breasted Nuthatch, Dusky Flycatcher, and Fox Sparrow). TU-5 had the most unique species in its ten most abundant, with Hammond's Flycatcher and MacGillivray's Warbler not on any other units' most abundant species lists. TU-3 had one unique species, Cassin's Vireo, while units 2 and 4 did not have any unique species among their ten most abundant.

Hermit Warbler was the most abundant species in TUs 2, 3, and 4 (0.57, 0.45, and 0.62 respectively). In TU-4 where it was at its highest abundance per point, Hermit Warbler was nearly twice as abundant as Nashville Warbler (0.33), the next most abundant species. Audubon's Warbler was the most abundant species in TU-5 (0.41), followed closely by Oregon Junco (0.38), while Hermit Warbler was the fifth most abundant there with 0.28 detections per point.

Table 3. Mean avian abundance[1] (within 50 meters) per point with 95% confidence interval for the 10 most abundant species (including ties) in each treatment unit (non DFPZ transects) for the PLAS study area for 2002 – 2004 combined.

Treatment Unit 2 Species	Mean Abundance	Treatment Unit 3 Species	Mean Abundance
Hermit Warbler	0.57 ± 0.06	Hermit Warbler	0.45 ± 0.06
Audubon's Warbler	0.34 ± 0.04	Nashville Warbler	0.38 ± 0.06
Oregon Junco	0.32 ± 0.04	Oregon Junco	0.33 ± 0.04
Mountain Chickadee	0.29 ± 0.04	Mountain Chickadee	0.31 ± 0.04
Nashville Warbler	0.23 ± 0.04	Audubon's Warbler	0.22 ± 0.04
Western Tanager	0.19 ± 0.04	Red-breasted Nuthatch	0.21 ± 0.04
Red-breasted Nuthatch	0.18 ± 0.04	Dusky Flycatcher	0.21 ± 0.04
Golden-crowned Kinglet	0.17 ± 0.04	Fox Sparrow	0.19 ± 0.04
Dusky Flycatcher	0.15 ± 0.04	Western Tanager	0.18 ± 0.04
Brown Creeper	0.14 ± 0.02	Cassin's Vireo	0.13 ± 0.02
Fox Sparrow	0.14 ± 0.04		

Treatment Unit 4 Species	Mean Abundance	Treatment Unit 5 Species	Mean Abundance
Hermit Warbler	0.62 ± 0.06	Audubon's Warbler	0.41 ± 0.04
Nashville Warbler	0.33 ± 0.04	Oregon Junco	0.38 ± 0.04
Oregon Junco	0.33 ± 0.04	Mountain Chickadee	0.34 ± 0.04
Audubon's Warbler	0.30 ± 0.04	Golden-crowned Kinglet	0.33 ± 0.04
Dusky Flycatcher	0.25 ± 0.04	Hermit Warbler	0.28 ± 0.04
Mountain Chickadee	0.25 ± 0.04	Dusky Flycatcher	0.22 ± 0.04
Fox Sparrow	0.23 ± 0.06	Red-breasted Nuthatch	0.21 ± 0.04
Red-breasted Nuthatch	0.21 ± 0.04	Fox Sparrow	0.17 ± 0.04
Golden-crowned Kinglet	0.22 ± 0.04	MacGillivray's Warbler	0.15 ± 0.02
Western Tanager	0.20 ± 0.04	Western Tanager	0.14 ± 0.02
		Hammond's Flycatcher	0.14 ± 0.02
		Brown Creeper	0.14 ± 0.02

[1] Mean abundance is the average number of individuals per point, per visit.

DFPZ vs. Non-DFPZ Abundance and Species Richness

We compared the abundance of the ten most abundant species per point in 2004 in Treatment Units 1 and 4 at (non-DFPZ) and DFPZ (slated for treatment) point count locations (Table 4). In treatment unit 1, four species were significantly more abundant at points within proposed DFPZ treatments (Mountain Chickadee, Audubon's Warbler, Hermit Warbler, and Dusky Flycatcher), while no species were significantly more abundant in non-treated areas. In treatment unit 4, two species were significantly more abundant at points within proposed DFPZ's than at points outside of proposed treatment; those species were Dusky Flycatcher and Mountain Chickadee.

Table 4. Mean abundance per point (within 50 meters) for the ten most abundant species in treatment units 1 and 4 at DFPZ and Non-DFPZ point count stations in 2004 with 95% confidence interval (* = significantly more abundant than Non-DFPZ transects in the same TU)

TU-1 DFPZ Species (n=72)	Mean Abundance & (CI)	TU-1 Non-DFPZ Species (n=59)	Mean Abundance & (CI)
Mountain Chickadee	1.11 ± 0.28*	Mountain Chickadee	0.41 ± 0.14
Audubon's Warbler	1.00 ± 0.24*	Audubon's Warbler	0.58 ± 0.13
Hermit Warbler	0.78 ± 0.23*	Hermit Warbler	0.34 ± 0.16
Dusky Flycatcher	0.74 ± 0.26*	Dusky Flycatcher	0.31 ± 0.13
Golden-crowned Kinglet	0.58 ± 0.22	Golden-crowned Kinglet	0.40 ± 0.12
Hammond's Flycatcher	0.57 ± 0.19	Hammond's Flycatcher	0.30 ± 0.12
Red-breasted Nuthatch	0.51 ± 0.19	Red-breasted Nuthatch	0.32 ± 0.14
Oregon Junco	0.46 ± 0.15	Oregon Junco	0.23 ± 0.12
Western Tanager	0.44 ± 0.17*	Western Tanager	0.19 ± 0.08
Brown Creeper	0.24 ± 0.13	Brown Creeper	0.15 ± 0.07

TU-4 DFPZ Species (n=70)	Mean Abundance & (CI)	TU-4 Non-DFPZ Species (n=240)	Mean Abundance & (CI)
Hermit Warbler	0.47 ± 0.17	Hermit Warbler	0.56 ± 0.08
Nashville Warbler	0.19 ± 0.11	Nashville Warbler	0.24 ± 0.05
Oregon Junco	0.50 ± 0.19	Oregon Junco	0.50 ± 0.19
Audubon's Warbler	0.24 ± 0.14	Audubon's Warbler	0.25 ± 0.06
Dusky Flycatcher	0.71 ± 0.24*	Dusky Flycatcher	0.29 ± 0.07
Mountain Chickadee	0.46 ± 0.20*	Mountain Chickadee	0.19 ± 0.04
Fox Sparrow	0.26 ± 0.14	Fox Sparrow	0.20 ± 0.05
Red-breasted Nuthatch	0.36 ± 0.18	Red-breasted Nuthatch	0.23 ± 0.04
Golden-crowned Kinglet	0.23 ± 0.14	Golden-crowned Kinglet	0.18 ± 0.05
Western Tanager	0.23 ± 0.12	Western Tanager	0.19 ± 0.04
Hammond's Flycatcher	0.26 ± 0.12	Hammond's Flycatcher	0.16 ± 0.04

[1] Mean abundance is average number of individuals per point per visit.

Habitat Associations

Landscape Statistics

Landscape variables showed small to moderate variation (Table 5) and indicate that bird transects are located in areas with 64-99% forest cover (mean of 90.8%, where forest cover is based on GIS coverage indicating that hardwood or coniferous forest is present). On average the majority of the forested areas are conifers of size classes 3 and 4. The high degree of forest cover translates to relatively low levels of edge density, although this varies among transects. IJI approaches 0 when the distribution of adjacencies among seven unique patch types becomes increasingly uneven. IJI = 100 when all patch types are equally adjacent to all other patch types (i.e., maximum interspersion and juxtaposition; McGarigal et al. 2002). Our interspersion index results indicate a moderate IJI index with some variability. The contagion index shows more variability (relative to interspersion) with higher values in landscapes with a few large, contiguous patches. The Shannon's diversity index indicates the range in landscape diversity.

Table 5. Descriptive statistics for landscape parameters for 32 point count transects (variable codes are described above in the Methods section under *Landscape Statistics*).

Variable	N	Mean	Std Dev	Minimum	Maximum
forPLAND	32	90.8869281	7.6381994	63.9834000	99.1871000
forED	32	16.4710406	10.5643708	3.5360000	46.9302000
IJI	32	55.5290625	12.1933653	21.9600000	80.7500000
CONTAG	32	68.8243750	10.7759149	51.5500000	92.6900000
SHDI	32	0.9396875	0.3510674	0.1800000	1.4600000
NONVEG(C1)	32	3.2272235	3.8385896	0	16.4729025
SHRUB(C2)	32	5.3331657	6.8590950	0.2961719	37.7818053
GRASS(C3)	32	0.7166696	1.1529072	0	4.7365397
HARDWD(C4)	32	5.5687633	7.7700850	0	31.2991778
CONIF(C12)	32	2.3826364	2.5415887	0	7.6253205
CONIF(C13)	32	58.2231898	24.1011872	21.1674476	96.7774733
CONIF(C14)	32	24.5483517	21.1235108	0	65.9004509

Local vs. Landscape Effects on Bird Abundance

All of the 18 breeding bird species analyzed exhibited one or more significant correlations with landscape or vegetation variables in our stepwise multiple regression (Tables 6 - 8). However, only 10 of the species (56%; Golden-crowned Kinglet, Fox Sparrow, Nashville Warbler, Audubon's Warbler, Black-headed Grosbeak, Dusky Flycatcher, Hammond's Flycatcher, Hermit Warbler, MacGillivray's Warbler, Mountain Chickadee) had results which explained greater than five percent of the variation in abundance.

The abundances for three species (17%; Golden-crowned Kinglet, Fox Sparrow, Nashville Warbler) were explained exclusively by vegetation variables or variables that were "local" to the transect (e.g. slope and elevation). The remaining seven species (39%; Audubon's Warbler, Black-headed Grosbeak, Dusky Flycatcher, Hammond's Flycatcher, Hermit Warbler, MacGillivray's Warbler, Mountain Chickadee) were explained by a combination of local variables and landscape variables. For two of these species (Audubon's Warbler and Dusky Flycatcher) a landscape variable was the first to enter the model and explained the greatest amount of variation. Hermit Warbler showed a negative relationship with the density of forest edge; Hermit Warbler, Hammond's Flycatcher, and Dusky Flycatcher had relationships with the percent of hardwoods in the landscape; and Mountain Chickadee had a positive relationship with non-vegetated areas.

Table 6. Multiple regression models for avian species sensitive to local vegetation features in the Plumas Lassen study area.

Golden-crowned Kinglet ($F_{3,792}$=63.37, P < 0.0001, R^2=0.1942)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.07542	0.03993	-1.89	0.0593
abiconba	1	0.02098	0.00206	10.19	<.0001
abimagba	1	0.02355	0.00363	6.48	<.0001
maxtrdbh	1	0.00192	0.00040	4.78	<.0001

Fox Sparrow ($F_{3,793}$=76.32, P < 0.0001, R^2=0.2247)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.60810	0.10284	-5.91	<.0001
realshrbco	1	0.00858	0.00075	11.41	<.0001
elev	1	0.00041	0.00007	5.76	<.0001
snags1030	1	-0.00990	0.00243	-4.08	<.0001

Nashville Warbler ($F_{5,799}$=54.21, P < 0.0001, R^2=0.2554)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.77996	0.13113	5.95	<.0001
elev	1	-0.00041	0.00008	-5.48	<.0001
quekelba	1	0.08283	0.01412	5.87	<.0001
slope	1	0.00948	0.00152	6.22	<.0001
basal	1	-0.01129	0.00209	-5.40	<.0001
treshrbcov	1	0.00545	0.00139	3.93	<.0001

Table 7. Multiple regression models for species sensitive to both local and landscape vegetation features in the Plumas Lassen Study Area.

Audubon’s Warbler ($F_{4,792}$=46.37, P < 0.0001, R^2=0.1905)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.01074	0.06923	-0.16	0.8767
C13	1	0.00663	0.00072	9.17	<.0001
ttlshrbcov	1	-0.00330	0.00089	-3.71	0.0002
cedar	1	-0.02011	0.00419	-4.79	<.0001
maxtrdbh	1	0.00172	0.00053	3.24	0.0012

Mountain Chickadee ($F_{3,792}$=17.24 , P < 0.0001, R^2=0.0615)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.39753	0.13019	-3.05	0.0023
maxtrdbh	1	0.00225	0.00056	4.01	<.0001
elev	1	0.00031	0.00009	3.52	0.0005
C1	1	0.01548	0.00471	3.28	0.0011

Hermit Warbler ($F_{4,795}$=32.94, P < 0.0001, R^2=.1428)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.56232	0.06014	9.35	<.0001
basal	1	0.01315	0.00356	3.70	0.0002

forED	1	-0.01743	0.00230	-7.59	<.0001
abicont1	1	0.00587	0.00141	4.15	<.0001
C4	1	-0.01313	0.00294	-4.47	<.0001

Dusky Flycatcher ($F_{4,795}$ =41.98, P < 0.0001, R^2=0.1751)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.03459	0.04185	-0.83	0.4087
C13	1	0.00279	0.00061	4.56	<.0001
realshrbco	1	0.00451	0.00066	6.79	<.0001
pinjefba	1	0.32171	0.06310	5.10	<.0001
C4	1	-0.00835	0.00185	-4.52	<.0001

Hammond’s Flycatcher ($F_{4,791}$ =24.17, P < 0.0001, R^2=0.1094)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.11706	0.02616	4.47	<.0001
abicont1	1	0.00357	0.00059	6.02	<.0001
C4	1	-0.00580	0.00134	-4.32	<.0001
snagsg30	1	0.00584	0.00222	2.63	0.0088
ttlshrbcov	1	-0.00134	0.00053	-2.52	0.0121

MacGillivray’s Warbler ($F_{2,783}$ =52.51, P < 0.0001, R^2=0.1185)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.05770	0.02575	-2.24	0.0253
realshrbco	1	0.00462	0.00049	9.43	<.0001
C13	1	0.00090	0.00041	2.21	0.0274

Black-headed Grosbeak ($F_{3,783}$ =30.86, P < 0.0001, R^2=0.1061)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.23954	0.05194	4.61	<.0001
elev	1	-0.00015	0.00003	-4.87	<.0001
C4	1	0.00403	0.00078	5.18	<.0001
slope	1	0.00158	0.00063	2.50	0.0126

Table 8. Multiple regression models for species with low explanatory power in the Plumas Lassen study area.

Oregon Junco ($F_{2,795}$ =63.37, P < 0.0023, R^2=0.0152)

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.49506	0.07797	6.35	<.0001
quekelba	1	-0.04045	0.01745	-2.32	0.0207
IJI	1	-0.00280	0.00140	-1.99	0.0466

Hermit Thrush ($F_{2,790}$ =5.87, P < 0.0006, R^2=0.0225)

```
                        Parameter       Standard
Variable     DF          Estimate          Error       t Value    Pr > |t|
Intercept     1          -0.15660        0.05207         -3.01      0.0027
C13           1           0.00218        0.00059          3.67      0.0003
C14           1           0.00202        0.00068          2.96      0.0032
hirsht        1           0.01122        0.00550          2.04      0.0417
```

Red-breasted Nuthatch ($F_{3,792}$ =12.11, $P < 0.0001$, R^2=0.0440)

```
                        Parameter       Standard
Variable     DF          Estimate          Error         t Value    Pr > |t|
Intercept     1           0.05823        0.05075          1.15      0.2516
maxtrdbh      1           0.00132        0.00047          2.82      0.0050
pinlamt1      1           0.01103        0.00332          3.32      0.0009
C4            1          -0.00556        0.00197         -2.82      0.0049
```

Western Tanager ($F_{3,779}$ =7.57, $P < 0.0001$, R^2=0.0284)

```
                        Parameter       Standard
Variable     DF          Estimate          Error         t Value    Pr > |t|
Intercept     1           0.21324        0.02908          7.33      <.0001
pinlamt1      1           0.01182        0.00310          3.82      0.0001
pinlamba      1          -0.02445        0.00793         -3.08      0.0021
hirsht        1          -0.02731        0.01056         -2.59      0.0099
```

Brown Creeper ($F_{2,791}$ =11.18, $P < 0.0001$, R^2=0.0276)

```
                        Parameter       Standard
Variable     DF          Estimate          Error         t Value    Pr > |t|
Intercept     1          -0.03005        0.03794         -0.79      0.4286
hitreeht      1           0.00387        0.00118          3.29      0.0010
snagsg30      1           0.00612        0.00215          2.85      0.0044
```

Cassin’s Vireo ($F_{4,795}$=24.17, $P < 0.0001$, R^2=0.0377)

```
                        Parameter       Standard
Variable     DF          Estimate          Error         t Value    Pr > |t|
Intercept     1          -0.30399        0.10271         -2.96      0.0032
psement1      1           0.00197        0.00081          2.45      0.0146
forPLAND      1           0.00298        0.00097          3.06      0.0023
IJI           1           0.00201        0.00064          3.16      0.0016
pinpont1      1          -0.00365        0.00143         -2.54      0.0111
```

Olive-sided Flycatcher ($F_{3,783}$ =10.27, $P < 0.0001$, R^2=0.0375)

```
                        Parameter       Standard
Variable     DF          Estimate          Error       t Value    Pr > |t|
Intercept     1          -0.00409        0.00445         -0.92      0.3589
abimagba      1           0.00364        0.00082          4.43      <.0001
C4            1           0.00137        0.00038          3.56      0.0004
pinlamba      1           0.00300        0.00164          1.83      0.0677
```

Hairy Woodpecker ($F_{2,790}$ =4.62, $P < 0.0101$, R^2=0.0116)

```
                        Parameter       Standard
Variable     DF          Estimate          Error       t Value    Pr > |t|
Intercept     1          -0.01631        0.01916         -0.85      0.3950
mintrdbh      1           0.00330        0.00146          2.27      0.0236
snagsg30      1           0.00238        0.00124          1.92      0.0550
```

GIS Project for Creating Species Maps

We created a GIS project incorporating all bird data collected in 2003 and 2004 (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 10 and 11 for examples), identify birds species present at specific sites of management interest, present detection information for species of management interest, and present community indices (e.g., species richness) as determined by point count analysis. Appendix 12 outlines directions for creating additional maps for any species of interest or for bird community indices, and describes all aspects of this ArcView project and associated database tables. In future years we will update the bird data for this project to incorporate the most up to date information on the distribution and abundance of birds in the study area.

DISCUSSION

Annual Variation in Indices

Indices in 2004 were lower almost across the board when compared to the same transects in either 2003 or 2002. Though every effort is made to minimize it, some of this variation may be attributable to differences in observers across years which were not controlled for in this analysis. However, natural variability does occur between years and is part of the rationale to conduct longer term studies with multiple years of pre and post treatment data. In future analysis of trends and in analyzing changes following treatment we will model for the effects of observer variability.

Abundance and Species Richness By Treatment Unit

The two highest elevation units, 1 and 5, had the highest species richness and abundance. We also found a significant positive relationship between avian diversity and elevation across the entire sampling area. We find this relationship interesting as we know that many of the higher elevation sites are fir dominated and often lack the hardwood component with which many of the species in the study area have a positive correlation. It may be that the lower elevation sites have been subjected to more intensive resource extraction and are thus in a more degraded state and elevation in and of itself is not influencing bird richness. The lowest richness and abundance indices were for TU-2, as it was the only unit that had significantly lower species richness per point. Interestingly, TU-2 also has the highest density of Spotted Owl territories in the study area (J. Keane pers. Comm.). It should be noted that the area we are sampling is limited to navigable terrain (slopes average <30%) within the study area. It may be that the owls are utilizing habitat in and on many of the steep canyons and hillsides within TU-2 where we are not able to sample. We intend to further investigate the relationship between Spotted Owl habitat the rest of the avian community by directly sampling within known owl territories starting in 2005.

Our analysis shows that Hermit Warbler is the most abundant breeding species in the navigable forested habitats (slope<30%) in the study area (our sampling area). We found this species associated with both basal area and white fir (*Abies concolor*), two forest attributes believed to have increased in the last century due to fire suppression and other management practices. Thus, this species may have benefited from the changes to forest conditions that current management is attempting to reverse. We hypothesize that Hermit Warbler might be one of the species negatively impacted by implementation of current forest management direction.

It should be noted that while we plan on using the most abundant species as tools for indicating changes in habitat conditions, some of the less common species are of greater management concern due to their scarcity (e.g., Olive-sided Flycatcher, Pileated Woodpecker). We are monitoring the entire bird community and it is our intention to determine the appropriate management actions that should be taken to prevent these species from becoming less common.

DFPZ vs. Non-DFPZ Abundance and Species Richness

Ideally, planned forest thinning would occur on average in areas with lower habitat quality than the surrounding forests. Using species richness as a measure of habitat quality we found that the planned DFPZ's in TU-4 are in less species-rich avian habitat than the surrounding forest. Contrastingly, the proposed DFPZ's in the TU-1 (within the Almanor Ranger District's "Creeks" project) are in more species rich habitat than the surrounding forest. In fact, three of the DFPZ transects in TU-1 where among the most species rich transects surveyed in 2004. Though many factors go in to determining the placement of DFPZ's, we believe proposed forest treatments would have less negative and more positive effects on the avian community if results from our monitoring were incorporated into the final decision making process surrounding their placement. It is our aim to make available, in a timely and user friendly fashion, our data (species richness and the other measures of avian habitat quality) to forest service staff for incorporation into their planning process (see ArcView GIS CD supplement).

Of the ten most abundant species encountered, almost all were more abundant at DFPZ sites than at non-DFPZ sites in 2004, including all six of the significant differences found. The species we found significant differences with are among the most abundant species in each of these units (though this may be driven by the increased power associated with a larger sample). Several other less common species (e.g., Hammond's Flycatcher and Western Tanager) were marginally significantly more abundant at DFPZ sites in TU-1.

We expect the DFPZ treatments to have the largest immediate impact on the landscape due to their size and extensiveness, and thus a significant impact on the composition of the bird community within their footprint (and possibly beyond). If understory fuels are cleared, canopy significantly reduced, and most of the snags removed in these areas, we would expect a decrease in species richness and a decrease in the abundance of most of the current local breeding species at these sites. While short-term effects are relevant, more important are the long-term effects of these treatments on the avian community. In the longer time frame, we expect that species that are associated with closed canopy, basal area, and other shaded forest or heavily stocked conditions will remain below pre-treatment levels (e.g. Hammond's Flycatcher, Golden-crowned Kinglet, and Hermit Warbler). In contrast, we would expect species that favor open forest conditions, including not present pre-treatment, to increase following treatment, though this is highly dependent on the future management of the treated areas.

One would expect that the more open forest canopy conditions created should benefit shade intolerant plant species such as hardwoods and shrubs which are habitat for many bird species (see habitat associations above). As a result one would expect to observe an increase in the years following treatment of species such as Nashville Warbler, Black-headed Grosbeak, Fox Sparrow, Dusky Flycatcher, and MacGillivray's Warbler. However, if these areas are managed to discourage the development of many of the natural open forest habitat attributes (e.g. shrubs, herbaceous layer, and hardwoods), we predict these areas to have depressed avian species richness and total bird abundance when compared to the surrounding untreated forests over extended time periods.

Habitat Associations

Overview

By considering both local and landscape habitat attributes to explain variation in bird abundance it is possible to better explain the factors driving observed differences as well as determine which have the larger influence on the distribution of species in the study area.

It is intriguing that none of the species we examined had relationships exclusively with landscape variables, and that only two species (Dusky Flycatcher and Audubon's Warbler) had a landscape variable enter the model first. Landscape effects have been shown to be strong correlates of bird abundance in other studies (Howell et al. 2000, Bolger et al. 1997), especially with numerous Neotropical migratory birds. Our analyses may be limited because there was not large variation in the landscape metrics that we considered. This is partly due to the fact that this area is fairly contiguous forest with a high degree of forest cover. However, there is also heterogeneity in the area (e.g., among different forest stand types); additional and more complex landscape metrics may be required to tease apart landscape differences. Alternatively, the relative homogeneity of these forests - when considered at a landscape scale - may increase our power to determine the impact of treatment at this scale, which is a key component of this study.

Species Models

The landscape variable with the most explanatory power for both Dusky Flycatcher and Audubon's Warbler was the amount of size class 3 forest within a 3km circle. Since it was the first variable to enter the model, it suggests these species are particularly sensitive to landscape attributes. Interestingly, both of these species tend to use different habitat, with Dusky Flycatcher rarely if ever found away from areas with substantial shrub cover (hence the associations with shrub cover; Table 7), and Audubon's Warbler is most abundant in coniferous forest with substantial canopy closure and has a negative association with shrub cover (Table 7). By further exploring these differences it will allow us to gain a greater understanding of the factors influencing the abundance and distribution of many of the species in the study area. This in turn will help focus our future analysis as well as provide insight into the potential effects of different forest treatment strategies.

The variables that occurred in the most models were shrub cover (mostly positive), maximum tree dbh (all positive), and the amount of hardwood habitat within 3 km (mostly negative). It is important to note that the variable measuring hardwood habitat used only habitat classified as hardwood and does not include coniferous habitats with hardwood components. The species with negative relationships with hardwood habitat (Hammond's Flycatcher and Hermit Warbler) are strictly found in coniferous habitats. At lower elevations closely related Pacific-slope Flycatcher is more abundant in hardwood habitats while Black-throated Gray become more abundant than Hermit Warbler (pers. Obs.). These interactions may partially explain the negative relationship between hardwoods and these two species.

Many of the associations found in our habitat modeling exercise were not surprising, based on our previous knowledge of the life history of these species. For example, shrub cover was positively correlated with Fox Sparrow, Dusky Flycatcher, and MacGillivray's Warbler, three species we know nest only in shrub habitats and appear to reach their greatest abundance in shrub dominated habitats (such as those on the flanks of Spanish Peak in TU-4). Additionally, we rarely if ever have found Nashville Warbler away from habitat with a Black Oak (*Quercus kellogii*) component. However, knowing this species is also negatively correlated with basal area, elevation, and positively correlated with tree cover less than 5 meters tall helps us gain a better understanding into the exact habitat conditions required to maximize its abundance. Additionally, we have gained insight into associations with other species that we did not consider before, such as Hammond's Flycatcher and large snags, Hermit Warbler and forest edge, and Dusky Flycatcher and the extent of size class 3 forest in the surrounding landscape. The information gained here will contribute to our body of knowledge of ecological requirements of the Northern Sierra bird community. Taking into consideration this knowledge we will be able to make more specific management recommendations and better able to evaluate the efficacy of future management decisions in achieving an ecologically sustainable forest bird community and ecosystem.

For the species where the regression model explained less than five percent of the variance (Brown Creeper, Cassin's Vireo, Hairy Woodpecker, Hermit Thrush, Oregon Junco, Olive-sided Flycatcher, Red-breasted Nuthatch, and Western Tanager) additional measures may be required to capture their landscape and vegetation preferences. Many of these species are detected in relatively small numbers in the study area (Olive-sided Flycatcher, Hermit Thrush, Brown Creeper, Cassin's Vireo, and Hairy Woodpecker) and are not ideal candidates for analyzing factors influencing abundance. We will explore other analysis techniques such as factors influencing the presence or absence of these species.

CONCLUSION

Though no treatment has been implemented within the study area to date, the data collected in 2002 through 2004 is valuable for increasing our understanding of the habitat features many of the breeding species respond to, assessing pre-existing conditions at sites scheduled for treatment, honing our study design to ensure we will be able to properly evaluate the effects of forest management, and provide the knowledge necessary to make meaningful and timely management recommendations for maximizing the quality of coniferous forest habitats.

In order to determine the short term response of the avian community to forest treatments it appears it will be necessary to collect several years of post-treatment data in order to separate out the effects of annual variation from the treatment effects. In order to properly evaluate the impact of forest treatments it will be necessary to monitor the avian community over much longer time frames.

Our analysis of habitat associations illustrates the vast array of habitat types and attributes that the avian community in the Northern Sierra Nevada are associated with. It also illustrates that some species will likely decline as a result of these treatments. This is not to say that current management plans should not go forward just because they may cause declines in certain species. In fact we believe it would be impossible to change these forests in any significant way and not have a negative impact on one, and probably many species. The key to good management will be to ensure that negative the impacts to some species are met with positive ones for others so that a balance is struck where no one habitat type or conditions is disfavored to the extent that the species that depend on it are sent on a trajectory towards local extirpation. Determining an acceptable "balancing" point will be a difficult challenge. Long-term, landscape based ecological monitoring will be critical to determining when an acceptable balance has been struck. 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 recent years fire suppression and timber harvest practices (among others) have tipped the balance of these systems in favor of overstocked forests with small to medium sized trees. Here we present several management recommendations to increase habitat attributes that have been reduced as a result of forest management practices over the past century or more and ones we perceive might disfavored under new management direction.

MANAGEMENT RECCOMENDATIONS

Snags

Our analysis, as well as that of many others, has shown that snags are a critical component of forest ecosystems. A myriad of avian species in these forests are completely dependent upon snags. Retaining four snags per acre should be an absolute minimum guideline, we recommend maintaining as many snags as possible with priority given to the largest ones.

Shrubs

Shrub habitats are a critical component of the forest ecosystem with many avian species fully dependent on them. Allowing group selection treatments and where appropriate DFPZ's to naturally regenerate would ensure this habitat type does not dramatically decline in the next 100 years. Additionally, shrub understory within forested habitats should be valued and managed as an important habitat attribute.

Hardwoods

Thinning projects (both DFPZ and groups) can provide a duel benefit when incorporated into a Black Oak and Aspen enhancement projects (e.g. Almanor and Eagle Lake ranger Districts of the Lassen National Forest). Hardwoods in general have suffered from fire suppression resulting in a dramatic decrease in the amount of these habitat types/attributes. Hardwoods and other shade intolerant species will benefit from creating openings in the forest.

Old Seral Forests

Many bird species are positively correlated with large tree habitat attributes in the study area. Undoubtedly this habitat has been drastically reduced here in the last century. With the abundance of size class 3 and dearth of size class 4 and 5 forest currently on the landscape, every effort should be given to avoiding placement of groups or DFPZ's in size class 4 or 5 forests.

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PERSONNEL

This project is coordinated and supervised by PRBO staff biologist Ryan Burnett. Kim Maute is the field crew supervisor. Field work in 2004 was conducted by Ryan Burnett, Gabriel Cahalan, Jon Hall, Jennipher Karst, Kim Maute, Garr Owens, and Beth Peluso. Diana Humple was instrumental in preparing databases for analysis and helping develop the ArcView project that is used to generate species maps. Computer programs used to manage and summarize data were created by PRBO staff biologists Grant Ballard and Diana Humple. The study was carried out under the guidance of PRBO Terrestrial Program Director Geoffrey R. Geupel and PRBO Population Ecologist Nadav Nur.

ACKNOWLEDGEMENTS

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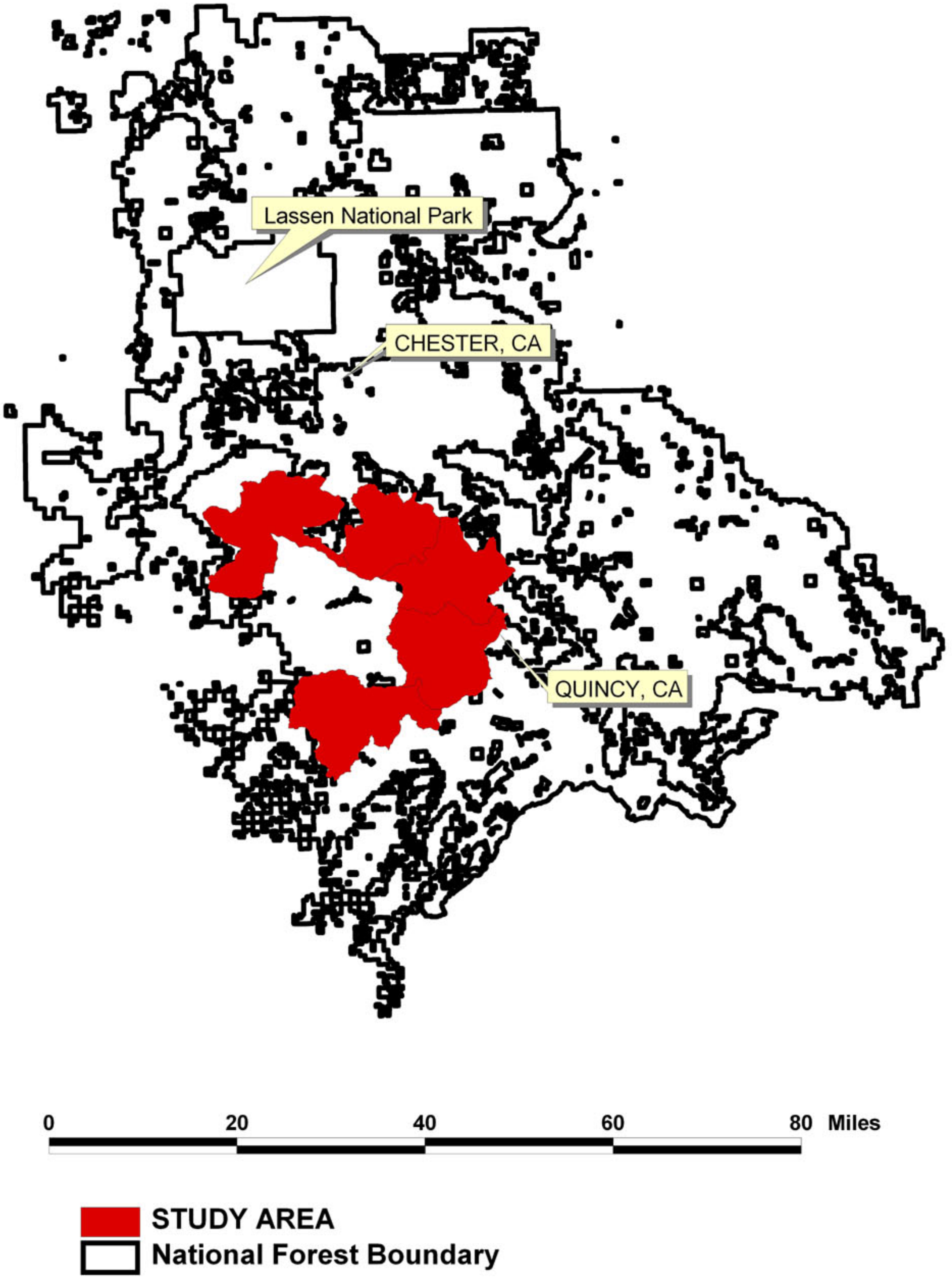
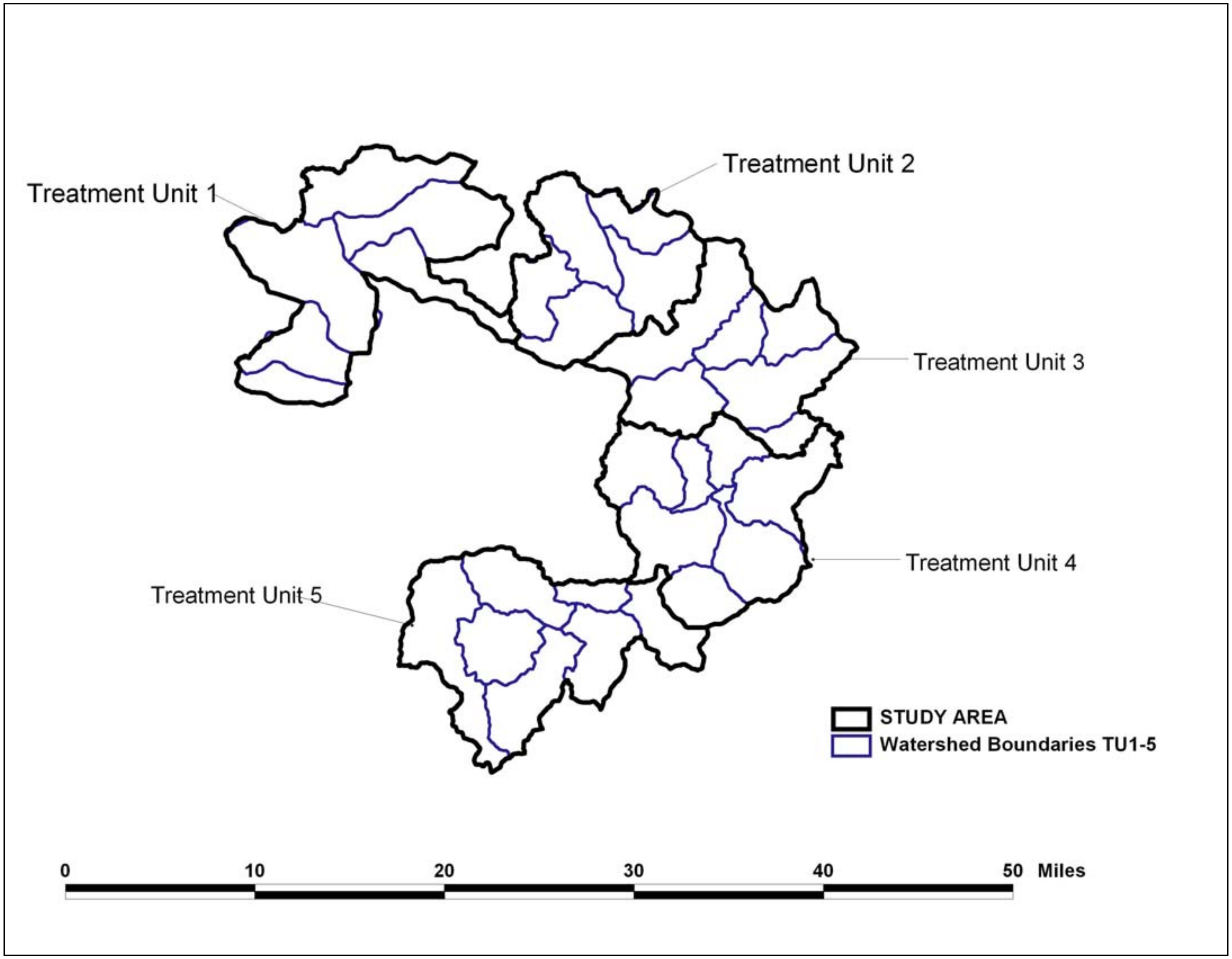
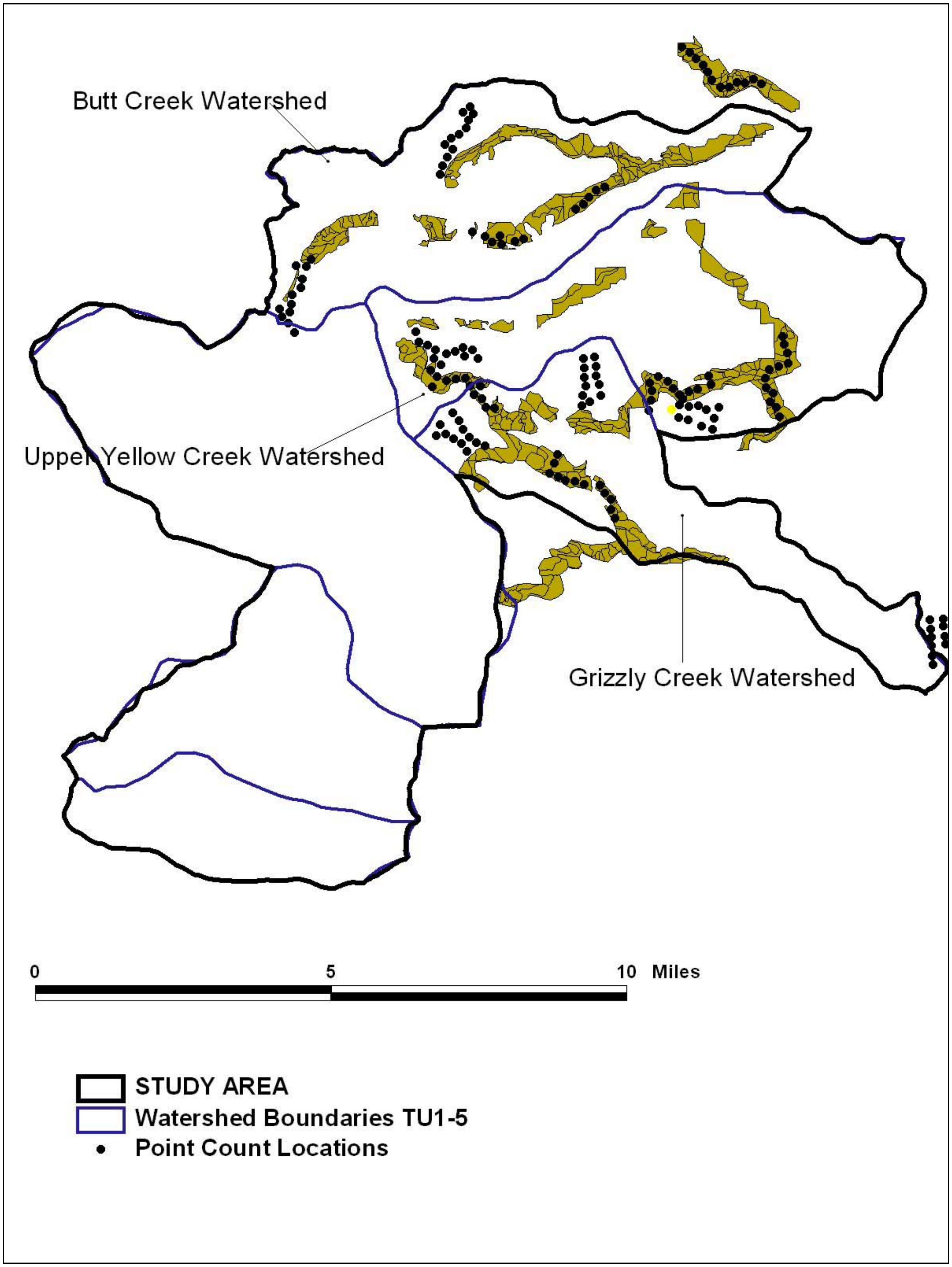
Appendix 1. Study area overview map of the PRBO Plumas Lassen module of the Administrative Study.



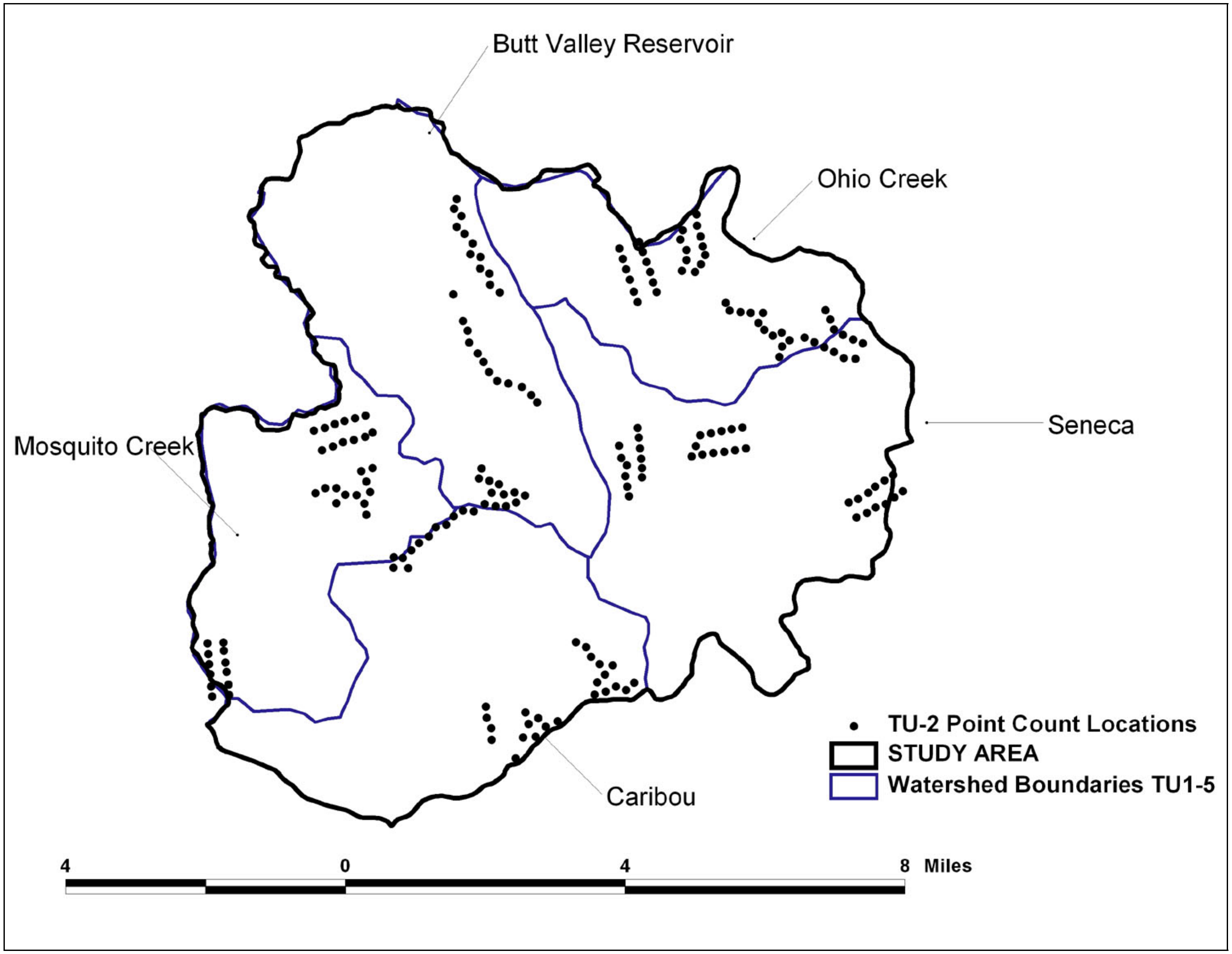
Appendix 2. Treatment Units and Watershed boundaries of the PRBO Plumas Lassen Avian Study Area, 2004.



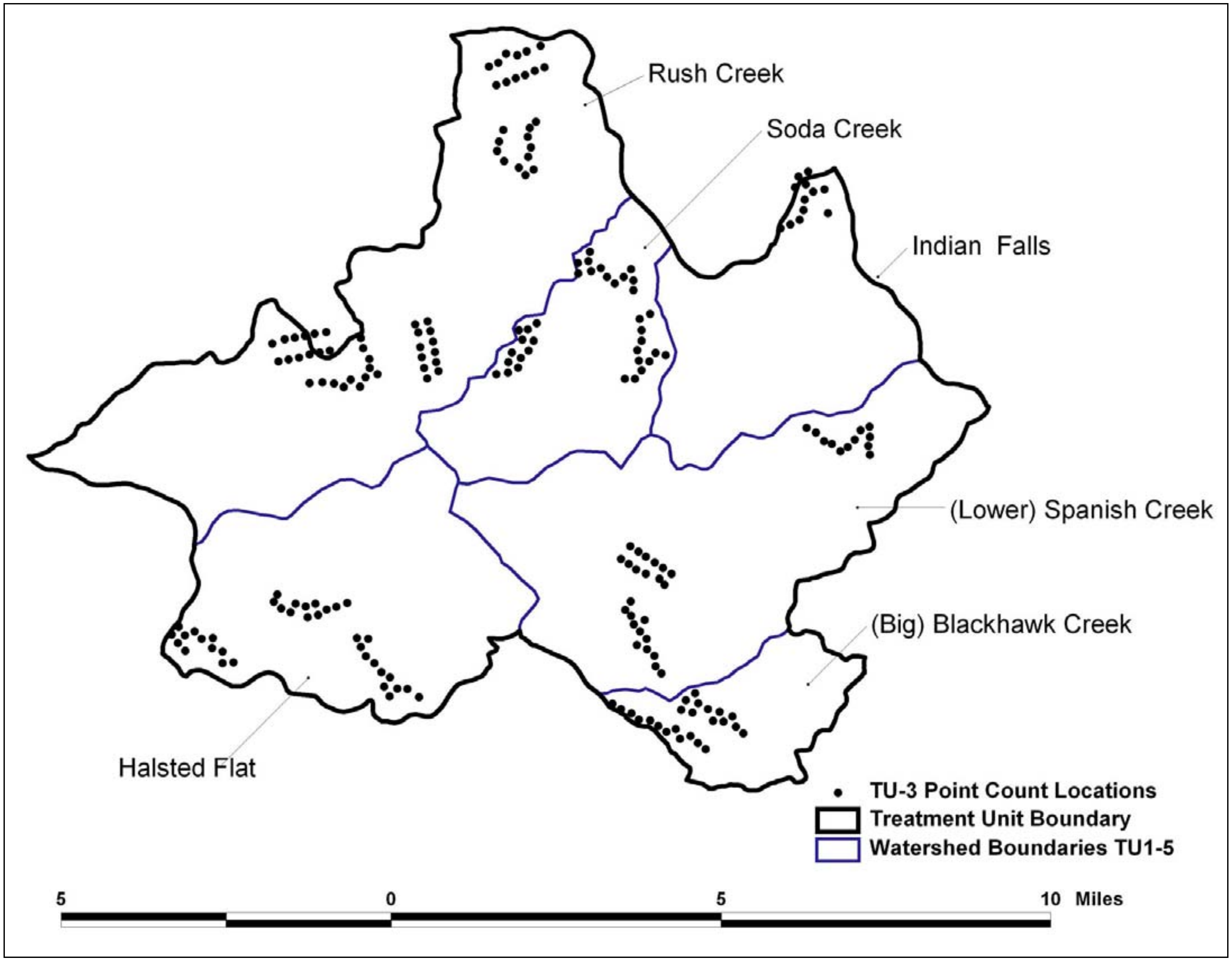
Appendix 3. Treatment Unit 1 Map with watersheds, DFPZ outlines, and locations of point count transects surveyed in 2004 for the PRBO Plumas Lassen Administrative Study.



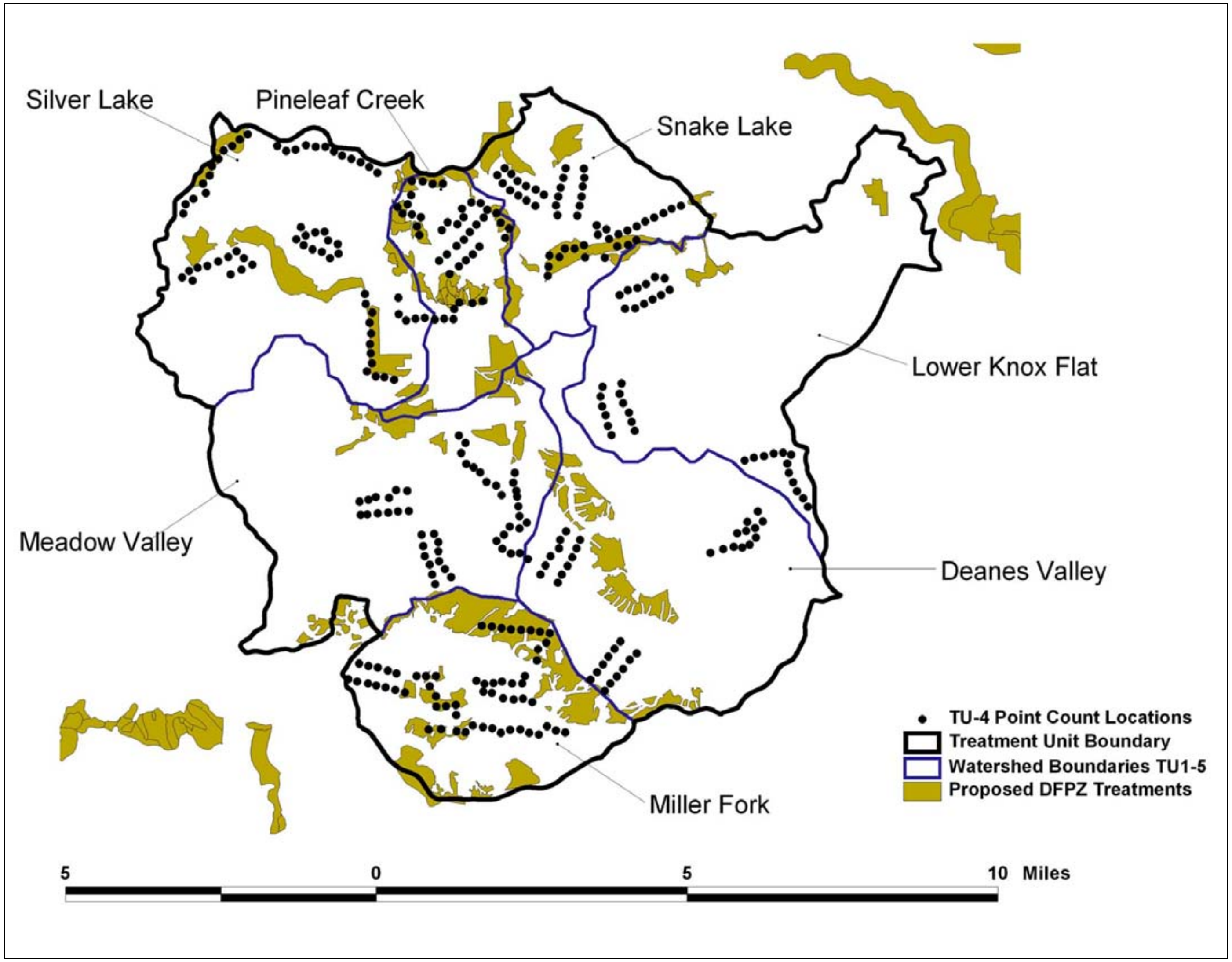
Appendix 4. Treatment Unit 2 map with watersheds, DFPZ outlines, and locations of point count transects surveyed in 2004 for the PRBO Plumas Lassen Administrative Study.



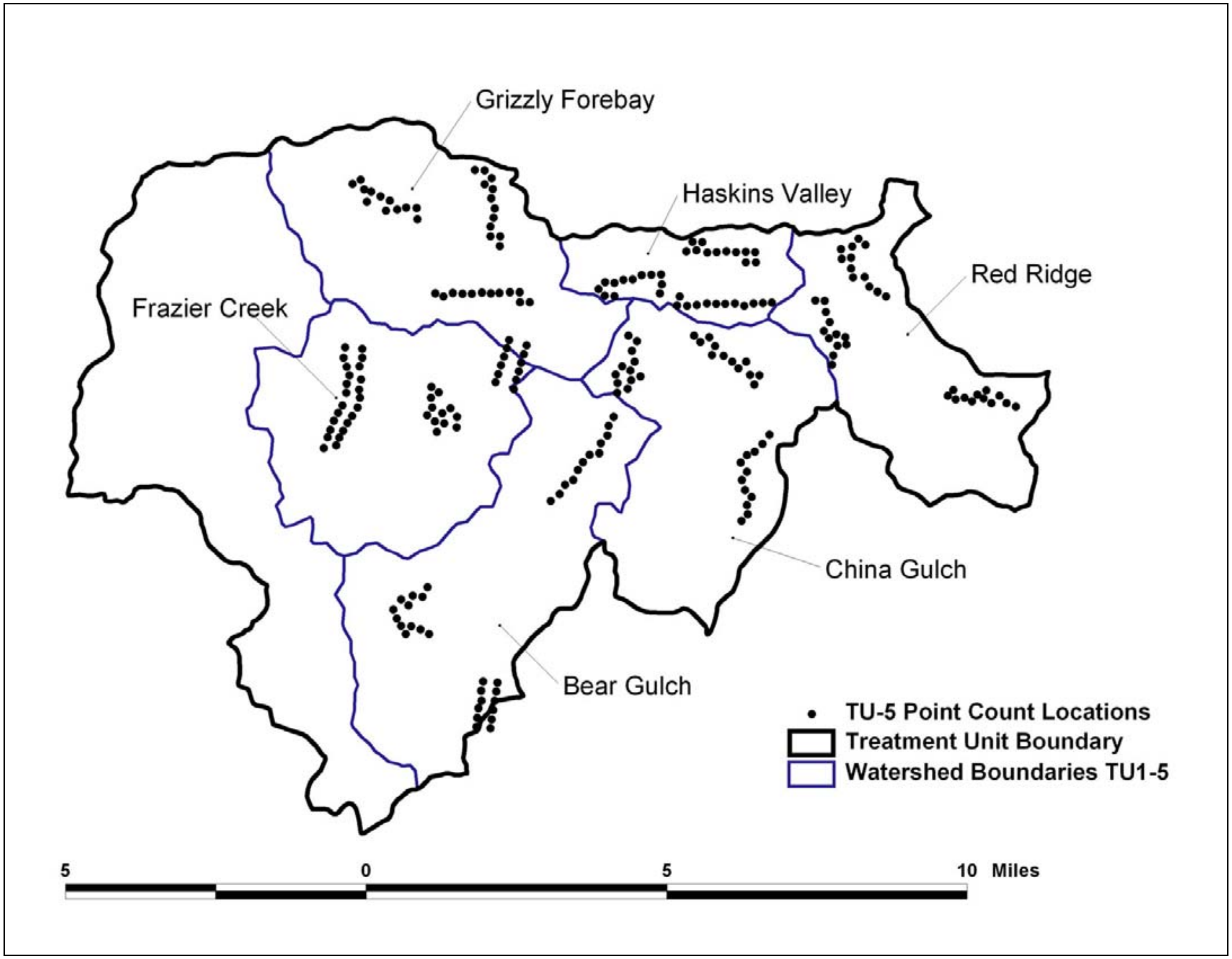
Appendix 5. Treatment Unit 3 map with delineating watersheds and locations of point count transects surveyed in 2004 for the PRBO Plumas Lassen Administrative Study.



Appendix 6. Treatment Unit 4 map delineating watersheds, DFPZ outlines, and locations of point count transects surveyed in 2004 for the PRBO Plumas Lassen Administrative Study.



Appendix 7. Treatment Unit 5 map delineating watersheds and locations of point count transects surveyed in 2004 for the PRBO Plumas Lassen Administrative Study.



Appendix 8. Protocols for local point count vegetation data collection for variables used in habitat association analysis (landscape methods are described in methods above).

All data is collected from a 50 meter radius circle using ocular estimates (accept basal area).

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.

Snags<10 - the 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 definition of a snag).

Snags >30 - the total number of snags greater than 30 cm DBH in the plot.

Cover Layers - these are divided up into 5 layers (Tree, Tree Shrub, Real Shrub, Total Shrub, and Herbaceous)

Tree layer 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 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 Shrubs this is the true shrub species as well as a few shrubby trees that rarely get above 5 meters tall (e.g. Dogwood, Mountain Alder, ARCPAT, CEACOR, 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 old releve way of doing it).

High Heights

Estimate to the nearest ½ meter the average height of the upper bounds of the vegetation layers (tree, tree shrub, real shrub). This is not the tallest outlier it is the average high of the tallest plants in that layer.

Relative Covers – the relative cover of the most dominant (make up at least 90% of the cover) in each of the cover layers [T1 (tree layer), TS (true shrub), and RS (real shrub), relative covers add to 100% regardless of the total cover recorded for the layer above (absolute cover will be calculated later for analysis by multiplying this number by the total cover for the layer).

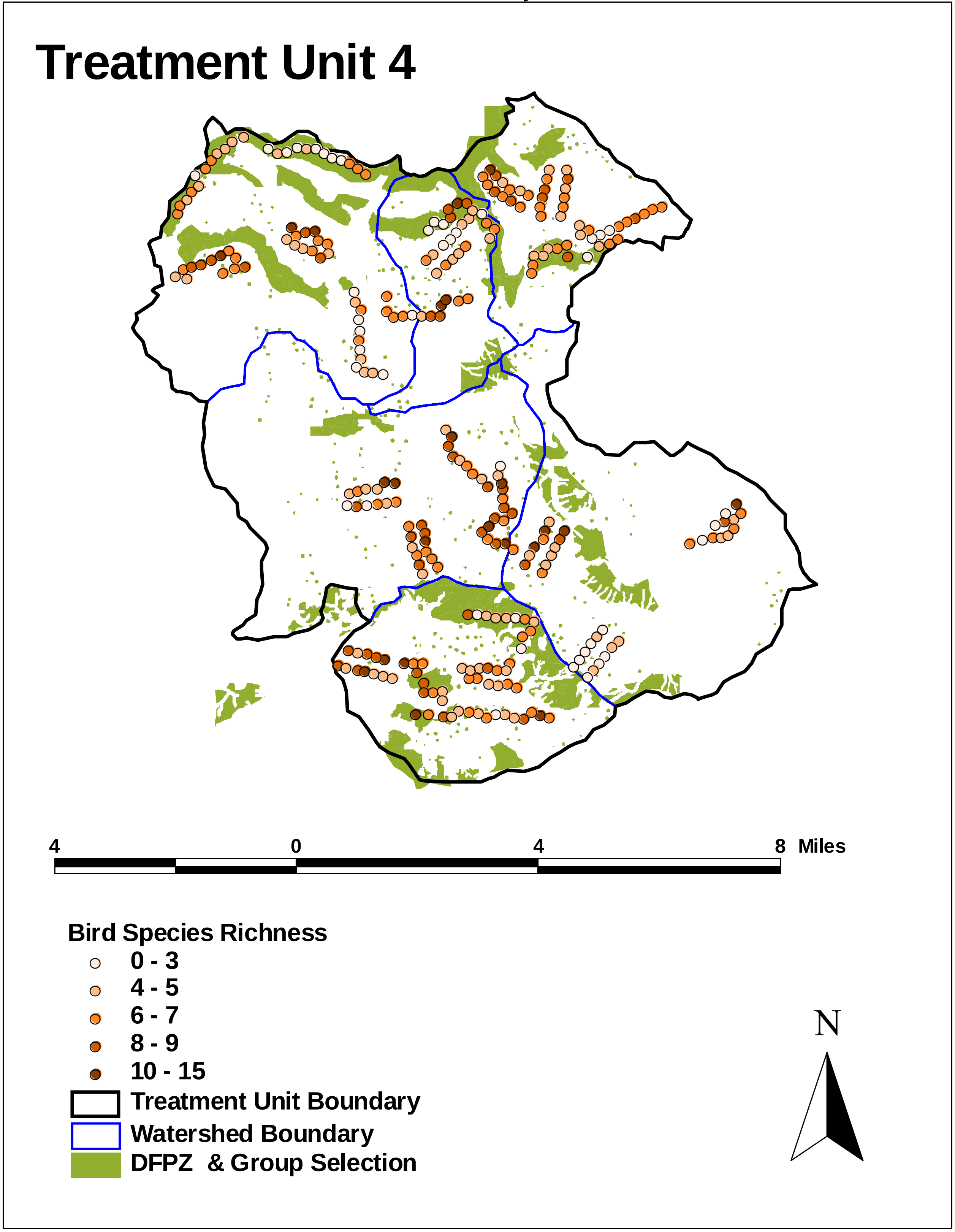
Appendix 9. List of all bird species detected by PRBO on point count surveys (common, AOU code, scientific name) in the PLAS in 2002 - 2004.

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 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*
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*
Green Heron	GRHE	*Butorides virescens*
Green-tailed Towhee	GTTO	*Pipilo chlorurus*
Hairy Woodpecker	HAWO	*Picoides villosus*

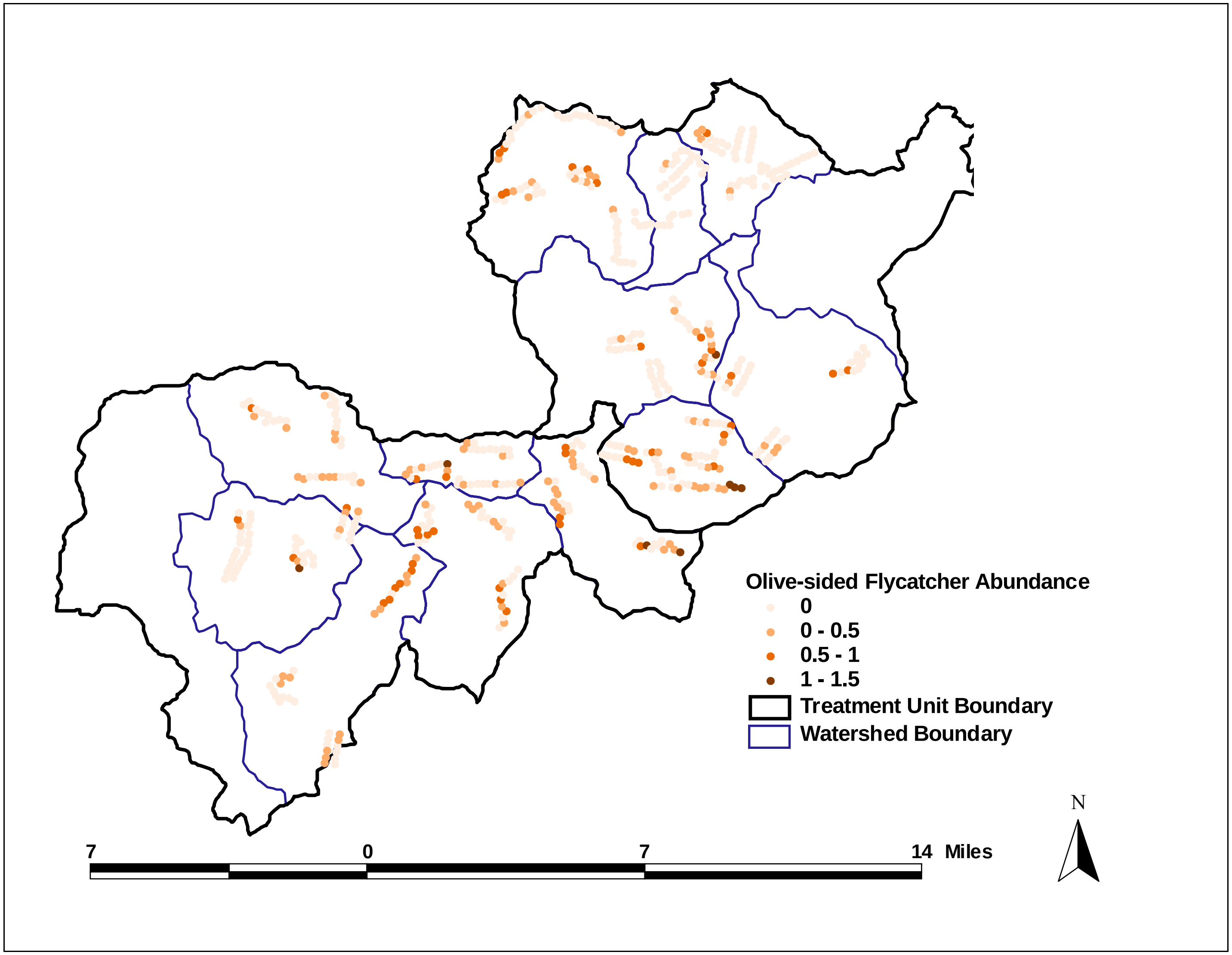
Common Name	AOU Code	Scientific Name
Hammond's Flycatcher	HAFL	*Empidonax hammondii*
Hermit Thrush	HETH	*Catharus guttatus*
Hermit Warbler	HEWA	*Dendroica occidentalis*
House Wren	HOWR	*Troglodytes aedon*
Huttons Vireo	HUVI	*Vireo huttoni*
Lazuli Bunting	LAZB	*Passerina amoena*
Lesser Goldfinch	LEGO	*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*
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	*XXXX*
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*
Stellar's Jay	STJA	*Cyanocitta stelleri*
Swainson’s Thrush	SWTH	*Catharus ustulatus*
Townsend's Solitaire	TOSO	*Myadestes townsendi*
Tree Swallow	TRES	*Tachycineta bicolor*
Turkey Vulture	TUVU	*Cathartes aura*

Common Name	AOU Code	Scientific Name
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 10. Sample map from GIS CD supplement of bird species richness in treatment unit 4 of the PLAS study area in 2003.



Appendix 11. 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 12. 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 and 2004 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_PSWreportsupplement04.apr – ArcView project file. Double click this file to open the project.

PLASabsum04_allGIS.dbf – table which contains one line of data per point with all associated bird data from the 2004 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 2004".

PLASabsum04_l50GIS.dbf – table which contains one line of data per point with all associated bird data, 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 2004."

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 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 2 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_PSWreportsupplement04.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 (PLASabsum03L50.dbf, PLASabsum03all.dbf, or 2004 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 E

California Spotted Owl Module: 2004 Annual Report

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Introduction

Knowledge regarding the effects of fuels and vegetation management on California spotted owls (***Strix occidentalis occidentalis;*** CSOs) and their habitat is a primary information need for addressing conservation and management objectives in Sierra Nevada forests. The specific research objectives of the California spotted owl module as identified and described in the Plumas-Lassen Study (PLS) Plan are:

1) What are the associations among landscape fuels treatments and CSO density, distribution, population trends and habitat suitability at the landscape-scale?

2) What are the associations among landscape fuels treatments and CSO reproduction, survival, and habitat fitness potential at the core area/home range scales?

3) What are the associations among landscape fuels treatments and CSO habitat use and home range configuration at the core area/home range scale?

4) What is the population trend of CSO in the northern Sierra Nevada and which factors account for variation in population trend?

5) Are barred owls increasing in the northern Sierra Nevada, what factors are associated with their distribution and abundance, and are they associated with reduced CSO territory occupancy?

6) Does West Nile Virus affect the survival, distribution and abundance of California spotted owls in the study area?

Current information on the distribution and density of CSOs across the HFQLG study area is required to provide the data necessary to build predictive habitat models and provide baseline population information against which we will assess post-treatment changes in CSO populations and habitat. Our focus in 2004 was to complete collection of CSO surveys and continue banding to provide the required baseline information to meet the objectives of Research Questions 1-4 identified above. Complete landscape inventory surveys were conducted across 5 survey areas in 2004 (Figure 1). Details on survey methods are described in the study plan. Efforts were made to monitor the pair and reproductive status of each owl, and to capture, uniquely color-mark, and collect blood samples from each individual owl. Color-marking is necessary to estimate survival and population trend, and to assess exposure to West Nile Virus (WNV)(Research Question #5). We also recorded all barred and hybrid barred-spotted owls encountered in the study area and synthesized all existing barred owl records for the northern Sierra Nevada to address Research Question #6.

Results

CSO Numbers, Reproductive Success, and Density:

A total of 50 territorial CSO sites were documented in 2004 across the study area (Figure 2). This total consisted of 43 pairs and 7 territorial single CSOs (single owl detected multiple times with no pair-mate detected). Eighteen pairs successfully reproduced in 2004 (42% of documented pairs). A total of 29 young were fledged (1.61 young per successful nest).

We estimated the crude density of CSOs based on the number of territorial owls detected in each of the 5 survey areas during 2004 surveys at the Treatment Unit and Cal-Planning Watershed spatial scales (Table 1, Figure 3). The estimated crude density across the study area was 0.084 owls/km^2 (Table 1). Estimated mean crude density across 32 CAL-Planning Watersheds was 0.075 owls/km^2 (Figure 3).

Table 1. Crude density of territorial California spotted owls across treatment units on the Plumas National Forest in 2004.

Survey Area	Size (km^2)	Crude Density of Territorial CSOs
TU-2	182.4	0.013 /km^2
TU-3	214.4	0.093 /km^2
TU-4	238.2	0.067 /km^2
TU-5	260.2	0.077 /km^2
TU-7	210.3	0.071 /km^2
Total Study Area	1,105.5	0.084 /km^2

Seventy-nine CSOs were captured and uniquely banded in 2004. Blood samples were collected from 68 individuals and screened at the University of California, Davis for West Nile Virus exposure. None of the 68 individuals tested positive for WNV exposure in 2004.

Barred and Sparred (spotted/barred hybrid) Distributional Records:

We detected one barred owl and one sparred owl during 2004 surveys. Our synthesis of barred-sparred records from Forest Service and California Department of Fish and Game databases indicates that there are a minimum of 31 individual site records across the northern Sierra Nevada (Figure 4). The first barred owl in the region was reported in 1989. Nineteen of the 31 site-records were recorded and known occupied between 2002-2004. The pattern of records suggests that barred/sparred owls have been increasing in the northern Sierra Nevada between 1989-2004.

California Spotted Owl Diet:

A single survey plot was established at a CSO nest or roost location at each CSO territory in 2003 and 2004. Systematic searches for pellets and prey remains were conducted in each plot during each year. A total of 1424 pellets have been collected over the two years. To date 495 pellets have been sorted and all prey items identified to species or taxonomic group when species identification could not be ascertained. Mammals comprised the dominant taxonomic group identified in the diet. The three most frequently detected species were the dusky-footed woodrat, northern flying squirrel, and *Peromyscus* species (Table 2).

Table 2. Composition of prey items identified in California spotted owl pellets from the Plumas National Forest, 2003-2004.

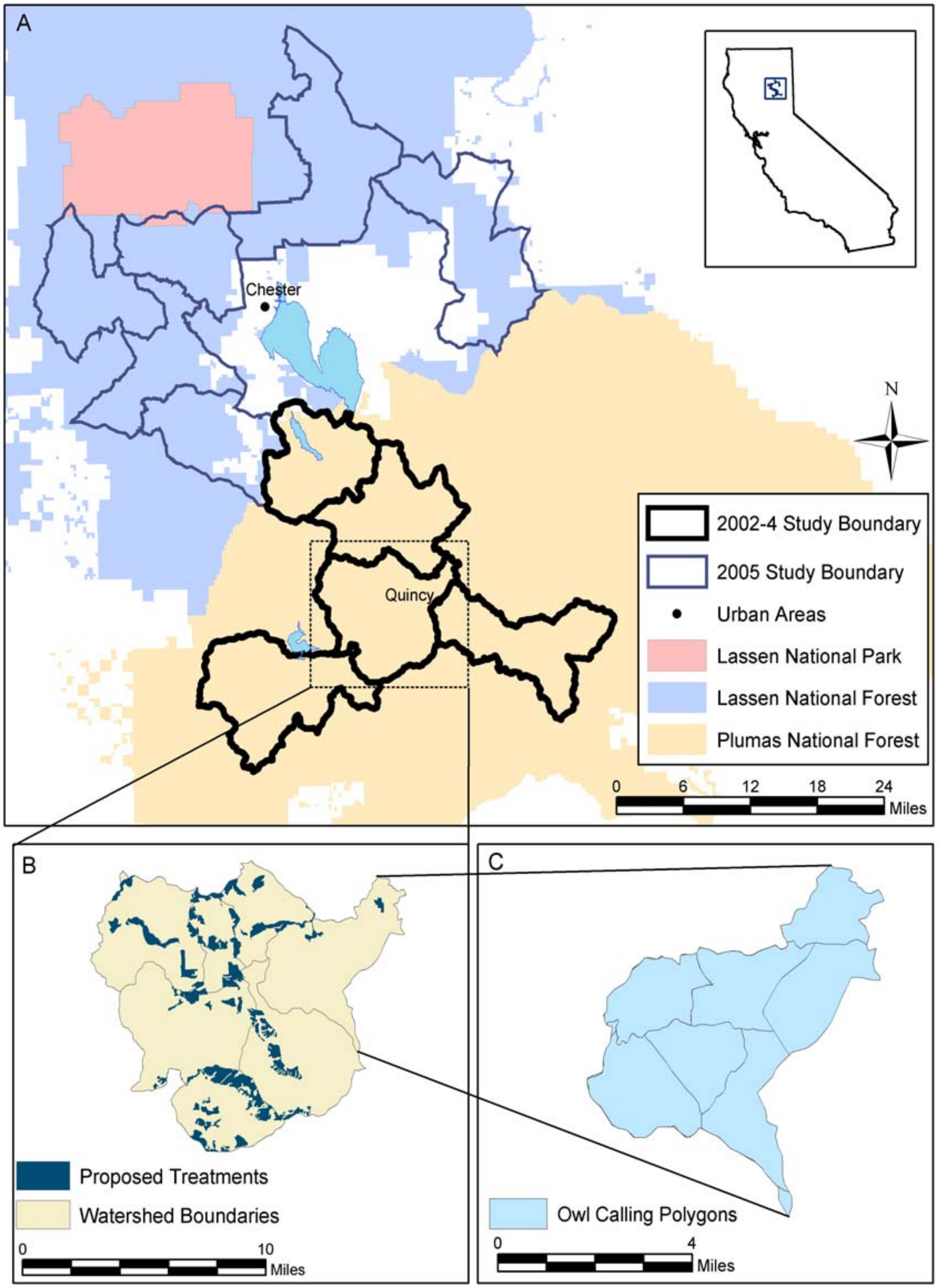
	Percent Occurrence (n=495)		Number of Individuals	
Prey Species	n	%	n	%
Dusky-footed Woodrat (*Neotoma fuscipes*)	217	43.8%	225	20.0%
Northern Flying Squirrel (*Glaucomys*	175	35.4%	208	18.5%

sabrinus)				
Deer Mouse (*Peromyscus spp.*)	122	24.6%	222	19.7%
Botta's Pocket Gopher (*Thomomys bottae*)	28	5.7%	29	2.6%
California Mole (*Scapanus latimanus*)	22	4.4%	23	2.0%
Voles (*Microtus* spp.)	16	3.2%	18	1.6%
Shrews (*Sorex* spp.)	16	3.2%	16	1.4%
House Mouse (*Mus musculus*)	13	2.6%	23	2.0%
Bats (*Chiroptera*)	10	2.0%	9	0.8%
Western Harvest Mouse (*Reithrodontomys megalotis*)	2	0.4%	2	0.2%
Unidentified Rodent	57	11.5%	59	5.2%
Total Mammals	**452**	**91.5%**	**834**	**76.6%**
Birds (*Aves*)	**65**	**14.0%**	**65**	**6.0%**
Insects (*Insecta*)	**100**	**18.0%**	**190**	**17.4%**
Total Prey	**na**	**na**	**1089**	**100.0%**

[1] Percent Occurrence = Percentage of the total 495 pellets in which the species was identified (e.g., Dusky-footed woodrats were identified in 217/495 pellets (43.8%), mammals were detected in 452/495 (91.5%)).

Current Research - 2005

In addition to continuing field surveys in 2005 designed to address our six research questions, our emphasis will broaden to focus on the development of predictive habitat relationship models as described in the module study plan. Baseline information collected in 2002-2004 forms the foundation for this phase of the research. These models should be completed in Winter 2005. We also are expanding the scope of our study to fully collaborate and integrate our work with the ongoing Lassen Demographic study. This collaboration and integration will broaden the base of CSO distributional and demographic information that can be used to develop predictive habitat models for our use in an adaptive management framework and to directly monitor implementation of the HFQLG project.


A
Chester
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N
2002-4 Study Boundary
2005 Study Boundary
Urban Areas
Lassen National Park
Lassen National Forest
Plumas National Forest
0
6
12
18
24
Miles
B
Proposed Treatments
Watershed Boundaries
0
10
Miles
C
Owl Calling Polygons
0
4
Miles

Figure 1. (A) Location of CSO Survey Plots surveyed in 2004. (B) Example of original survey plot consisting of multiple Cal-Planning watersheds. (C) Example of Primary Sampling Units for surveying for CSOs. See text and study plan for further details .

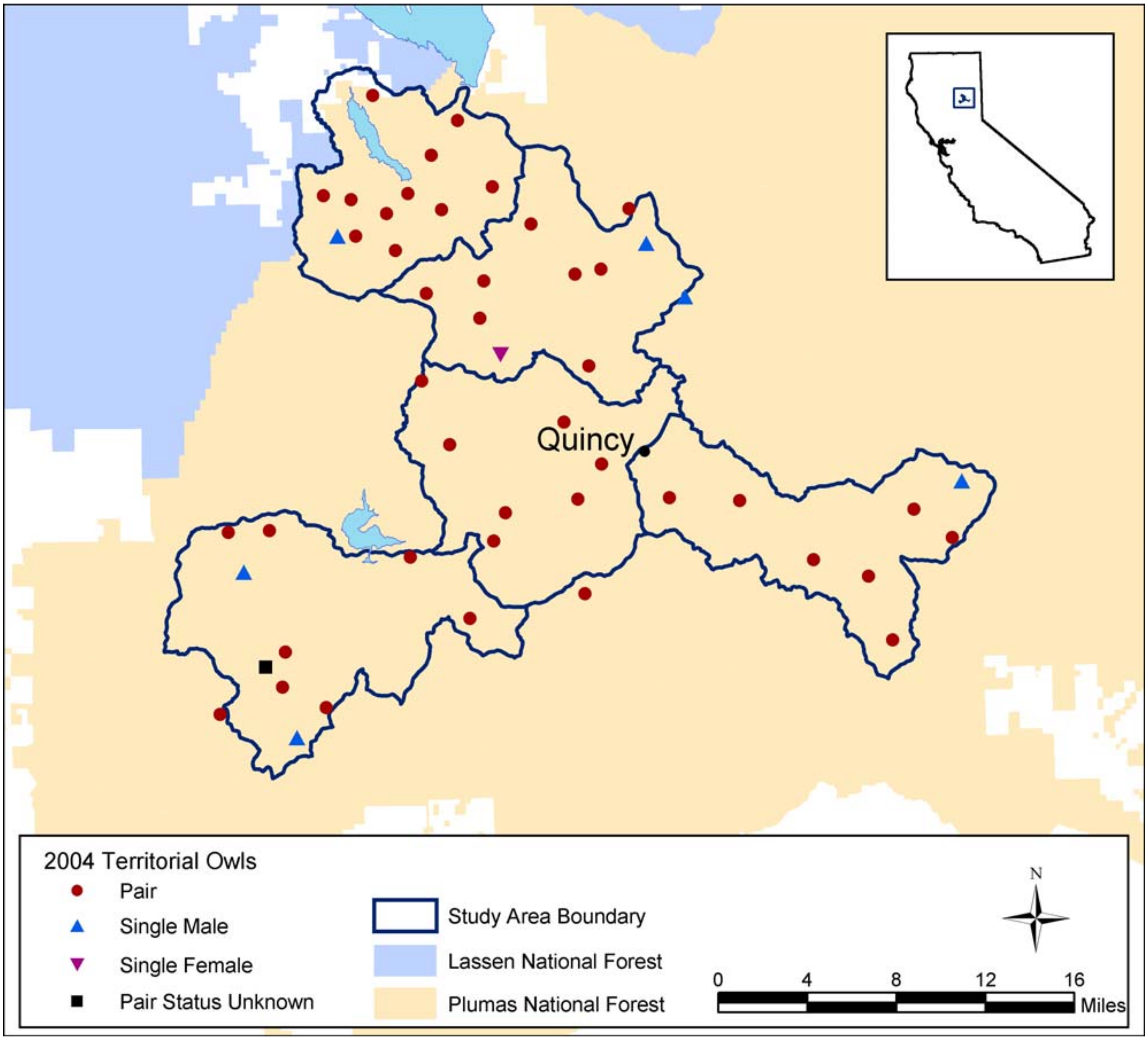

Figure 2. Distribution of California spotted owl territories within CSO survey plots across the Plumas National Forest, 2004.

Figure 3a.

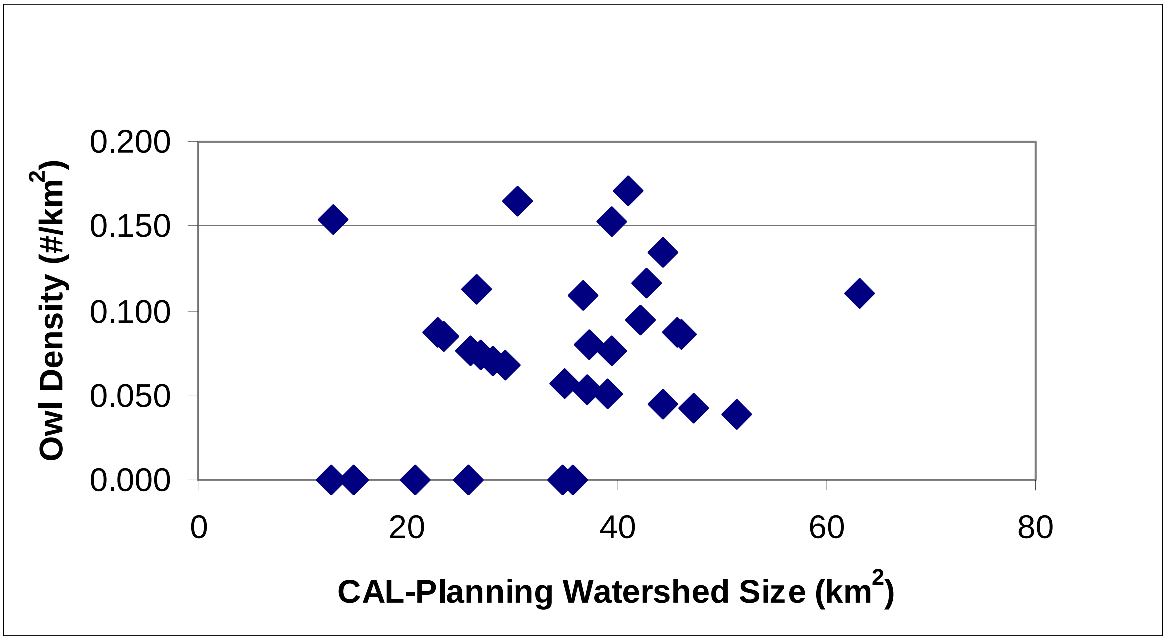

Figure 3b.

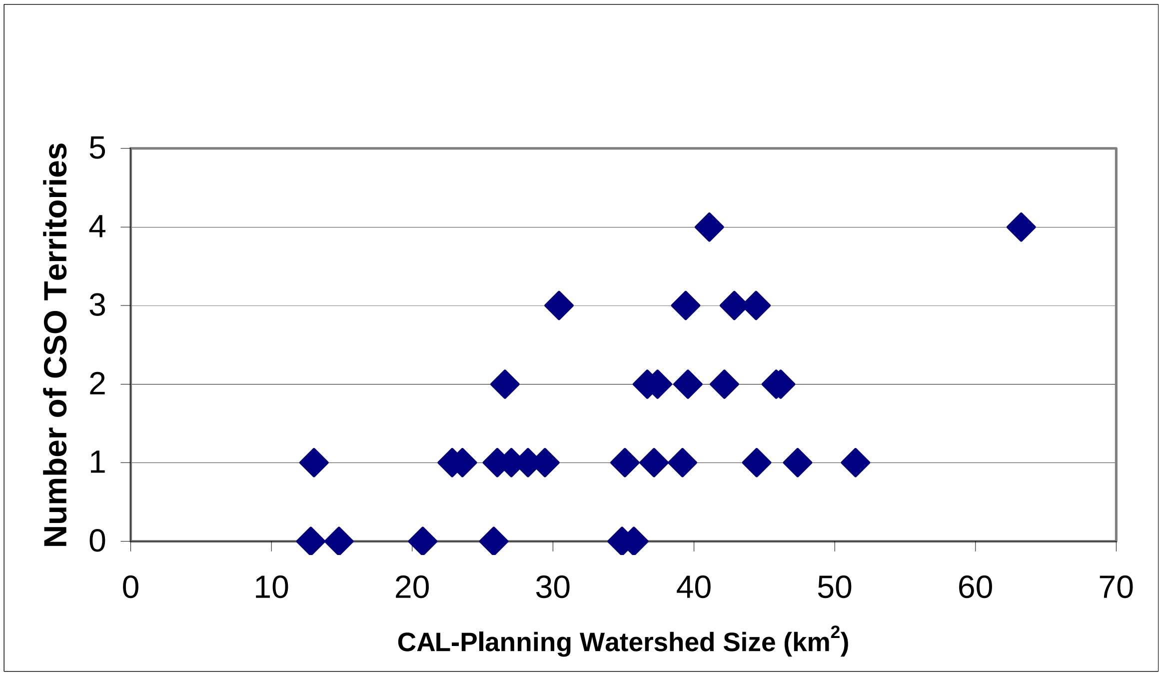

Figure 3. (a) Estimated crude density of territorial California spotted owls across CAL-Planning Watersheds, and (b) number of California spotted territories across CAL-Planning Watersheds on the Plumas National Forest during 2004.

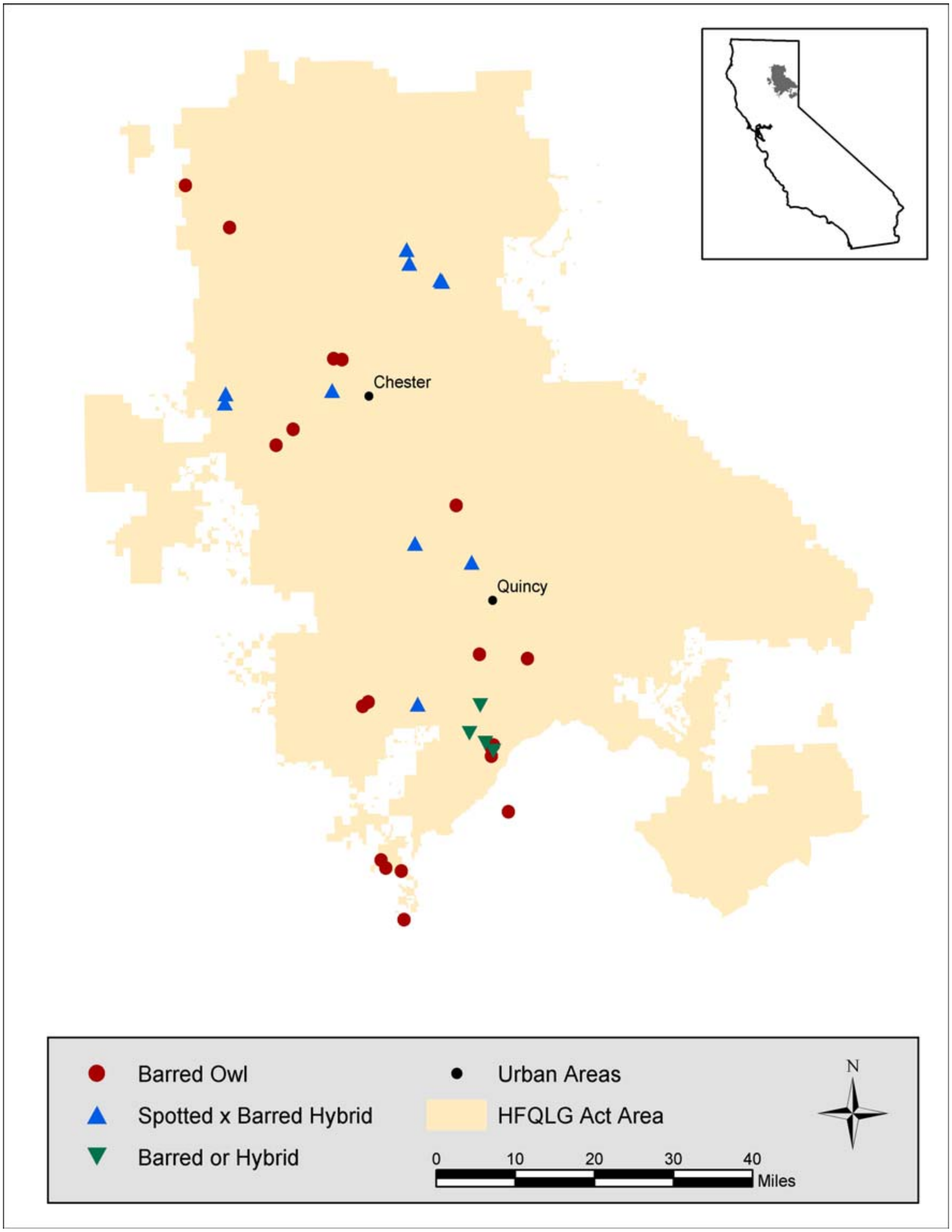

Figure 4. Distribution of Barred and Sparred (Spotted-Barred hybrids) Owls between 1989-2004 within the HFQLG Project area.

Appendix F

Coordination with National Forest System Staff

This project requires constant and careful collaboration with National Forest System (NFS) staff. There are many reasons this is required, including:

- Research is oriented towards management questions
- NFS staff are important "consumers" of the research results
- Treatments are executed by NFS
- Research work is done on Ranger Districts
- Safety of employees in the field is a shared concern

This project represents a program of significant geographic magnitude and thus coordination is especially important. Success is dependent on effective cooperation, communication, and understanding of the respective roles of the parties. Thus many people involved in this project have worked hard to accomplish this coordination.

Intra-Agency Agreement

The Pacific Southwest Region (REGION) and the Pacific Southwest Research Station (PSW) have developed an Intra-Agency Agreement to jointly develop and fund the study. This agreement was signed by the Regional Forester and the Station Director in April of 2002. This agreement lays the foundation for the close cooperation and collaboration between Region 5 (including the Lassen and Plumas National Forest staffs) and PSW (in particular the scientists and support staff of the Sierra Nevada Research Unit). The agreement establishes a commitment for up to twenty years to complete the objectives of this study.

QLG Steering Committee

Although the Plumas Lassen Study is not directly related to the HFQLG Pilot Project, the QLG Steering Committee has been an effective forum in which to coordinate with key individuals from the Plumas and Lassen National Forests. In particular the Forest Supervisors meet with PSW Research personnel regularly to stay in touch with study design and implementation issues. Other key personnel, including the HFQLG Pilot Project coordinator and his staff are consulted regularly regarding study issues. We use this venue as one of several for communicating on issues and findings.

Plumas Lassen Study Team

The Plumas Lassen Study Team is comprised of Principal Investigators for all five research modules, research support staff, and project coordinators from the Plumas and/or Lassen National Forests. The Study Coordinator provides liaison to National Forest managers and staff, coordinates National Forest activities related to Regional responsibilities, participates in annual reviews and provide for participation by other relevant National Forest staff in these reviews, and facilitates review of study design leading to concurrence from NFS decision-makers. We have had approximately 40 meetings since the inception of the project and coordination has been excellent. We have attempted to integrate the research modules as much as possible to gain more insights into forest response to fuels management than would normally be possible through individual projects.

District Rangers/Plumas Lassen Study Team

All parties agreed that perhaps the most crucial coordination required for this project is the coordination in the field. This study involves extensive field work and deployment of field personnel who move about the Ranger Districts from March through November each year. As many as 40 permanent, term, temporary, and university/collaborator staff are in the field almost every day during much of this time period. Furthermore, the assistance of District staff; biologists, fuels specialists, etc. and the support of the District Rangers is vital to the ultimate success of the study.

In furtherance of the objective of close coordination with District staff we have initiated periodic meetings between Study scientists and their staff with District Rangers and their staff. All four participating District Rangers have participated, in particular the personnel from the Mt. Hough Ranger District, as well as selected staff, depending on the topic. We have had four meetings over the last 12 months and covered a range of topics including:

- Research objectives/specific study strategies for each of the five modules
- Safety policy and procedures
- Communication strategy
- Logistics of working in the field on the Districts
- Housing for field crews

These meetings have been very valuable and productive and we plan to continue them on an as needed basis. Individuals from our team have been consulting with individuals on the Forest and Districts on an ongoing basis, as needed. We expect this practice to continue.