Plumas/Lassen Study
2003 Annual Report
March 16, 2004

Sierra Nevada Research Center
2121 2nd Street, Suite A-101
Davis, California 95616

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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 in the 2004 ROD. This is discussed below but in short, the work being done now is oriented towards understanding the effects of a different strategy for altering wildland fire behavior that developed for the HFQLG pilot project area.

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 University 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 fuels treatment strategies.

A variety of factors convinced Forest Service managers to change their management direction towards a focus on managing these lands in full compliance with the Herger Feinstein Quincy Library Group Pilot Project. These changes have been clearly put forth in the 2004 ROD. This change in management direction required the research team to re-evaluate the research questions and sampling design necessary to address the original research objectives/questions. The primary consequence of these changes was that there would be no opportunity to assign treatments in a typical experimental design fashion, thus the strength of statistical inference that could be drawn from the results would need to be re-evaluated. Despite these changes the research team has retained as much of the original intention of the research objectives as possible.

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 other documents and will be fully developed as five research modules for peer review. 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? (These two types of actions are defined in the subsequent Proposed Action section.) 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 and weather. 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. 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 design standards 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 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:

Vegetation Module

1) How do large trees respond to thinning intended to reduce fuels and promote optimal densities of residual trees which would promote rapid growth while retaining stand-level canopy cover?

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

3) 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?

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?
- And, in the very long-term, how do SPLATs affect fuel loads and potential fire behavior?

California Spotted Owl Module

1) How are landscape-scale fuels treatments associated with CSO density, distribution, population trends and habitat suitability at the landscape-scale?

2) How are landscape fuels treatments associated with CSO occupancy, diet, reproduction, and survival, and habitat fitness potential at the nest site, core area and home range scales?

3) How are landscape-scale fuels treatments associated with CSO habitat use, home range configuration, and habitat suitability at the nest site, core area and home range scales?

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) Is the relative abundance and overall distribution of the avian community stable (as observed over space and time) in northern Sierran forests in response to the suite of forest management practices that affect these forests?

2) How do bird communities respond/change to landscape level fuels treatments such as defensible fuel profile zones at and in the vicinity of site-specific treatments (short-term and longer term response)?

3) What are the specific habitat affinities of birds species in northern Sierran forests? Can we predict species composition, abundance, and distribution in response to future landscape treatments?

Summary

This work represents some significant scientific study that is expected to occur 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 a capable 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 will be available as drafts in April of 2004 as they are circulated for scientific peer review. We expect to make the most of these opportunities in advancing our scientific understanding of forest ecosystem response to management practices.

Appendix A

2003 Fuels and Fire at the Landscape Scale Module Annual Report Plumas and Lassen Adminstrative Study

Principal Investigator:

Dr. Scott Stephens, Assistant Professor of Fire Sciences
Ecosystem Sciences Division
Department of Environmental Science, Policy, and Management
151 Hilgard Hall # 3110
University of California, Berkeley, CA. 94720-3114
510-642-7304 FAX 510-643-5438 e-mail stephens@nature.berkeley.edu

Project collaborator

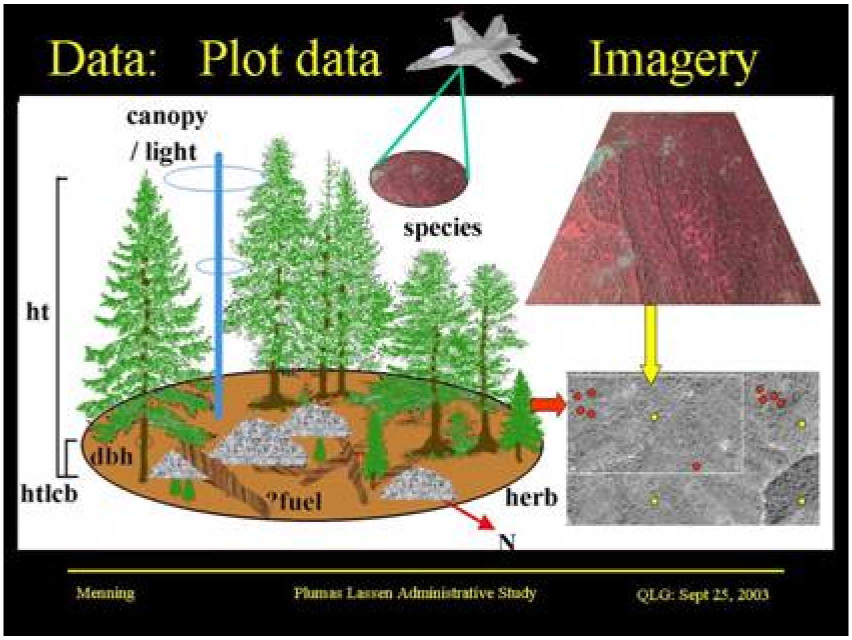
Kurt Menning, Postgraduate researcher
Ecosystem Sciences Division
Department of Environmental Science, Policy, and Management
151 Hilgard Hall # 3110
University of California, Berkeley, CA. 94720-3114
e-mail kmenning@nature.berkeley.edu

Objectives

The goal of this component in the project is to determine how landscape level fuels and silvicultural treatments affect potential fire behavior and effects. Past management activities including fire suppression, harvesting, and livestock grazing have changed the structure of many coniferous forest in the western United States, particularly those that once experienced frequent, low-moderate intensity fires (Biswell 1961, Hartesveldt and Harvey 1967, Parsons and DeBendeetti 1979). Changes in climate over the 20th century could have also influenced present ecosystem structure. Restoration of these ecosystems is the goal of the project but there currently is limited information on the effects of such treatments, especially at the landscape scale.

Data collection methods

Information is being collected at 2 scales, first within the nested vegetation plots (0.05 ha) and second, using remote sensing at the scale of the watersheds (17,800-32,000 ha). In 2003, ground data collection was coordinated with the Vegetation and Songbird modules to maximize efficiency in sampling and analysis. The 2003 field season was our inaugural pilot sampling season. We collected more data than we plan to collect in future summers. In December, 2003, we convened a meeting of the modules to determine which data collection efforts would persist and which would be eliminated. In 2004, we should have a streamlined data collection effort.



Plot Layout and Design

An extensive array of plots was established using a stratified-random approach. Plots were distributed in strata of elevation, aspect and vegetation type using the VESTRA layers previously supplied. This process identified over 500 plot locations in treatment units 3 and 4. The vegetation crew began sampling these locations in 2003.

Please refer to the Vegetation Module's report for the fullest description of plot layout and design. The Vegetation crew set up plots and led the effort to collect data. Basic plots were 12.6m in radius.

Additionally, less intensive forest structure and fuels data were collected along the songbird transects by the Songbird module. Along their transects of 12 plots, two were sampled intensively, following the vegetation crew protocols, and ten were sampled quickly using a less-intensive sampling scheme.

Forest structure and composition

In the Vegetation crew's 12.6m radial plots species and diameters were recorded for all trees along with categorical estimates of their heights and crown profiles. Additional data were collected on the degree of infestation by mistletoe (see Vegetation module for details).

Ground based sampling of ladder, surface, and ground fuels

Surface and ground fuels were sampled in each of the vegetation field plots using the line intercept method (Brown 1974) augmented with information collected from Sierra Nevada conifers (van Wagtendonk et. al 1996; 1998). At each plot center, two randomly placed azimuths were used to sample surface fuels. Along each azimuth we set up a 10 meter fuel transect and sampled 1 and 10 hour fuels were sampled from 10-12 meters, 100 hour from 9-12 meters, and 1000 hour fuels data from 2-12 meters. Duff and litter depth (cm) were measured at 5 and 8 meters along each transect. Maximum litter height was additionally sampled at three locations from 7 to 8m.

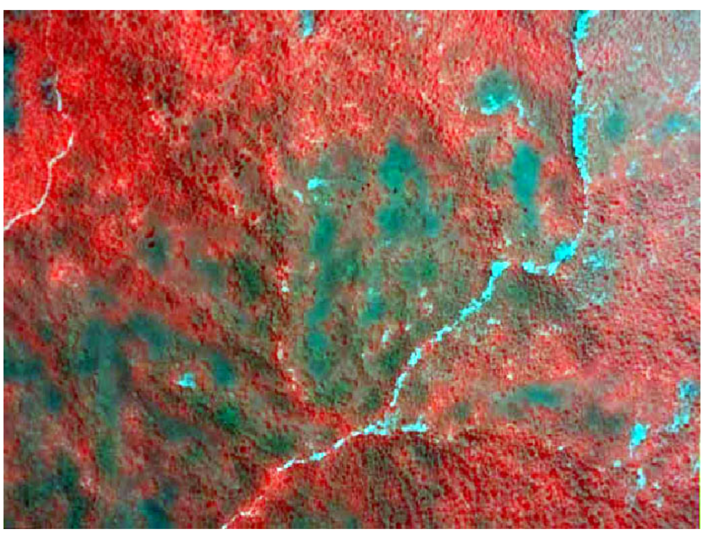
At the songbird sites, fuel loads were rapidly occularly estimated using the fuel photo series (Blonski and Schramel 1993) on ten of the twelve locations along transects. At two plots per transect a full inventory was done, following the Vegetation protocol.

Ladder Fuel Hazard Assessment (LaFHA)

We devised and implemented a mixed quantitative-expert system for assessing ladder fuels. Named the LaFHA approach, this system allows a trained field crew member to rapidly assess low aerial, mid aerial and aerial fuels in four regions of the plot while assessing the continuity of the fuel ladder. Later, slope and vegetation data are used to modify the ratings quantitatively. Please see the attachments for the flowchart that guides this process.

Remote sensing

Two different remote sensing methods are being implemented. First, high-resolution IKONOS imagery of several treatments was collected covering treatment units 3 and 4 to provide information on continuous forest pattern, structure, cover and variability using methods developed by Menning (2003) including spectral entropy canopy diversity analysis (SpECDA). These data and analyses have the benefit of being linked to analyses of vegetation and wildlife habitat conducted by other researchers in the project.



Second, an approach similar to that developed by van Wagtendonk and Root (2003) in Yosemite National Park is being used to provide information on fuel production on an annual cycle. 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. The spatial resolution of this second class of 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 high quality forest ecosystem map that will include rock, meadows (dry and wet), bare ground, montane chaparral, riparian areas over 30 m in width, and the 3 most common forest types (ponderosa pine, mixed conifer, white fir).

Analytical methods

Calculation of Fuel Loads

Ground and surface fuel loads are being calculated by using equations developed for Sierra Nevada forests (Menning 2003, van Wagtendonk et al. 1996; van Wagtendonk et al. 1998). 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 vegetation portion of this study. This methodology produces accurate estimates of fuel loads (Stephens 2001). 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). Van Wagtendonk’s comprehensive work in quantifying Sierra Nevada fuel properties, both surface and ground, allow custom fuel load equation to be developed for this project.

Fuel models

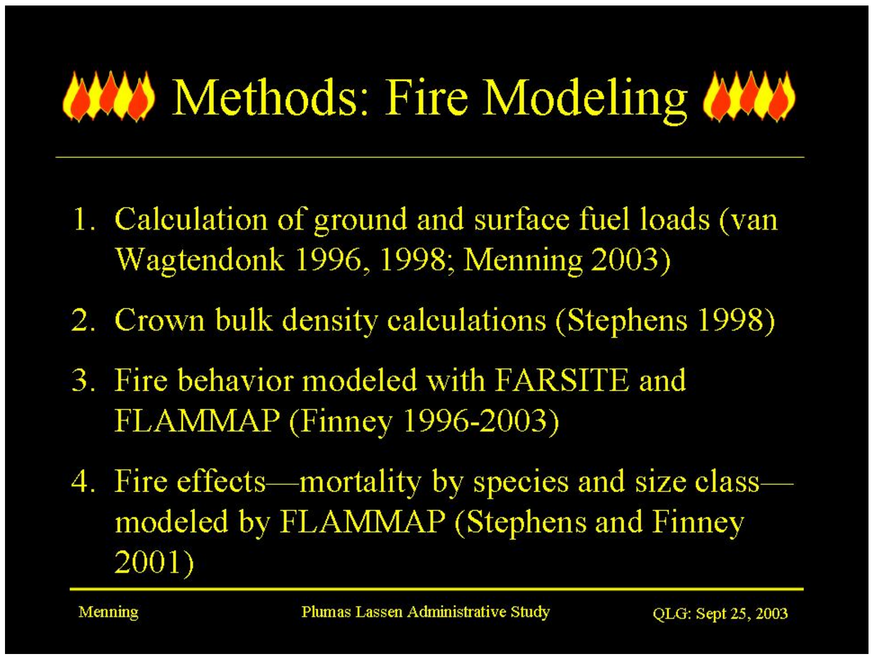
Plot based fuel measurements are being used to create a set of custom fuel models (Burgan and Rothermel 1984) for this area. Fuel model development includes a stochastic element to more closely model actual field conditions that have a large amount of spatial heterogeneity. Stochastic fuel models are being produced for each strata (forest type, aspect, seral stage, etc.). The vegetation component of this study measures crown cover and average tree height at each plot. Crown bulk density estimates comes from previous work by Stephens (1998). Topography information is generated from a digital elevation map (DEM) for all areas. All information is being produced at the 30m by 30m scale.

Potential fire behavior

Potential fire behavior is being estimated using a similar technique developed by Stephens (1998) but at much larger spatial scales. The effectiveness of the different restoration treatments will be assessed with computer models such as FARSITE (Finney 1996) and FLAMMAP. FARSITE is a deterministic, spatial, and temporal fire behavior model that uses fuels, slope, aspect, elevation, canopy cover, tree height, height-to-live crown base, crown density, and weather as inputs. 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 are being used to quantify the potential fire behavior of the different treatment approaches.

A historic fire risk map is being produced to estimate the probability of ignitions in the treated areas when FARSITE is used. The risk map is being used to generate an actual ignition point in each FARSITE simulation. The duration of each simulation would be 4 days approximating the duration of many large-scale wildfires in the Sierra Nevada. Weather information at the 90th percentile condition is being used and this data is being collected from local weather stations. Fire simulations would be constrained and unconstrained by suppression activities. Constrained simulations will use typical fire suppression tactics and resources. 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 is used to compare the effectiveness of the different landscape level restoration treatments.

Fire effects



Fire effects are being modeled using the GIS outputs from the FARSITE and FLAMMAP simulations coupled to quantitative models that estimate tree mortality (Stephens and Finney 2001). The percent tree cover removed and amount of bare mineral soil exposed by the simulated fires is being estimated for each 30m by 30m pixel. This will require generating GIS based fire effects models from published studies. This will enable the estimation of fire effects at the landscape scale.

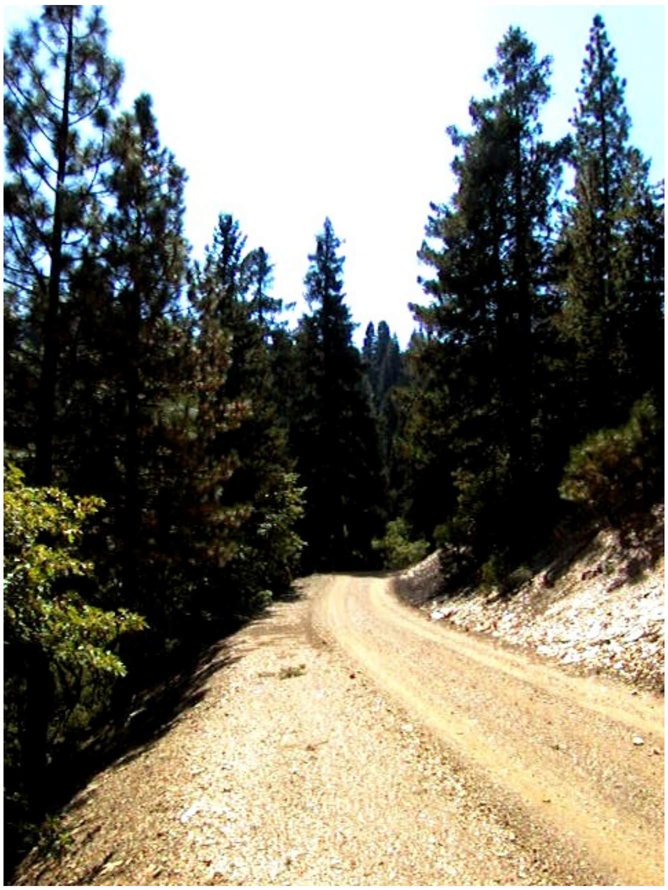
Response variables

Large wildfires in the Sierra Nevada are commonly high severity events that kill the majority of the small and medium sized trees within their perimeters. This tree mortality will significantly reduce canopy cover. Many wildlife species such as California spotted owls prefer diverse forest structure for foraging and breading. Research indicates that owls prefer to nest in areas with canopy cover in excess of 65 percent. Reduction of canopy cover below 55 percent may reduce the nesting habitat quality for the owl. Consequently, one response variable is being the percentage of the landscape where canopy cover was reduced from over 65 percent to below 55 percent after simulated wildfires. A spatial constraint (minimum of 50 ha) is being used in this analysis since small patches of habitat are probably not be used by this species. Spotted owl foraging habitat has a more diverse desired structure. Telemetry studies have indicated that owls prefer foraging habitat with patches of forest with at least 50 percent canopy cover. Some areas of lower cover can also be included in the foraging habitat but this should probably only comprise a maximum of 20 percent of the area. Foraging habitats are much larger than nesting habitats with a minimum size of approximately 500 ha. A second response variable is being the percent of the landscape after simulated fires that surrounded a nesting habitat where percent cover was reduced from over 50 percent to below 45 percent in 75 percent of an area (minimum of 500 ha). The GIS based fire mortality models will allow for such spatially explicit estimates.

The change in suppression efficiency from the different treatments will also be a response variable. All treatments employ defensible fuel profile zones and 2 treatments use the group selection silvicultural system. Addition of these landscape elements may affect the ability of a wildfire suppression crew to successfully extinguish a fire during initial attack. FARSITE is being used with realistic suppression elements (15 person hand crews, aircraft, bulldozers, etc.) to determine if these landscape level fuel treatments will increase suppression efficiency when compared to the untreated condition. The response variable is being the percentage of wildfires contained below 5 ha in size in one burning period (24 hours) before and after landscape fuel treatments.

It is common for wildfires to be propagated by spotting and this can exponentially increases the size of the fire during the early periods (1-24 hours). The ability of a treatment to reduce the number of spot fires is an important fire behavior characteristic. The number of spot fires is being estimated before and after treatments to determine if treatments reduce fire spread from spotting. The response variable is the percentage change in spot fire initiation before and after landscape level fuel treatments.

Field Season Progress 2003



Initial data collection began in summer 2003, with the Vegetation sampling crew. After being trained by Menning, the Vegetation crew visited 68 plots during the months of July and August to sample forest and fuels conditions. Basal area in these plots averaged 46.3m^2/ha. Fuller analysis of plot data is underway. Menning spent a total of 3 and a half weeks training the field crews and assisting data collection.

Remote sensing image acquisition will also began in the summer of 2003. High resolution IKONOS satellite imagery was collected over treatment units 3 and 4. Raw data were supplied to minimized acquisition cost and to allow the highest quality orthocorrection possible given the complex topography. This work is being performed in the Center for Assessment and Monitoring of Forest and Environmental Resources (CAMFER) by Menning.

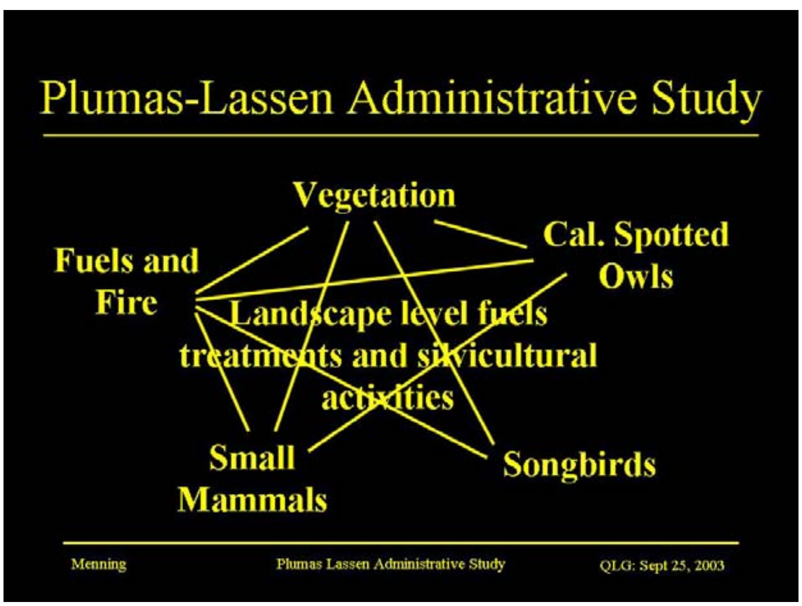
Field Season 2004

In 2004, the Fuels and Fire Module will send out its own field crew. This is intended to maximize the efficiency of both the Vegetation crew, which has other objectives, and to allow our module to focus on the data necessary for completion of our project. It is important that we acquire an extensive array of data for the characterization of landscape vegetation and fuels conditions. In addition, these extensive data are necessary to provide high quality ground reference for the remote sensing data. The field season is planned for 3 months of the summer.

We will continue to work with the Songbird module to have them collect extensive fuels and forest structural data along their transects.

Collaboration, Integration of Five Modules

All data collection beginning in 2003 was coordinated entirely with the vegetation and songbird modules. Menning trained approximately thirty members of these two crews, plus the owl crew, to collect vegetation and fuels data. Due to time constraints, the owl crew was not able to collect fuels data, however. We will continue to work with and train representatives of the Songbird Module to collect data from their plots.



Landscape-level analyses conducted using the remote imagery will provide data on continuous landscape characteristics such as fuel production, canopy cover, and forest structural diversity. We are coordinating with researchers from the Songbird and Owl modules about correlating our findings with their assessments of population and habitat suitability. We anticipate these collaborations may enhance all modules' abilities to extend analyses to the landscape scale.

Coordination with Interested Parties

We plan to work closely with Mark Finney, a fire-modeling expert in Missoula, Montana on fire behavior assessments. In addition, we anticipate close coordination with fire management offices at the Forest Service districts.

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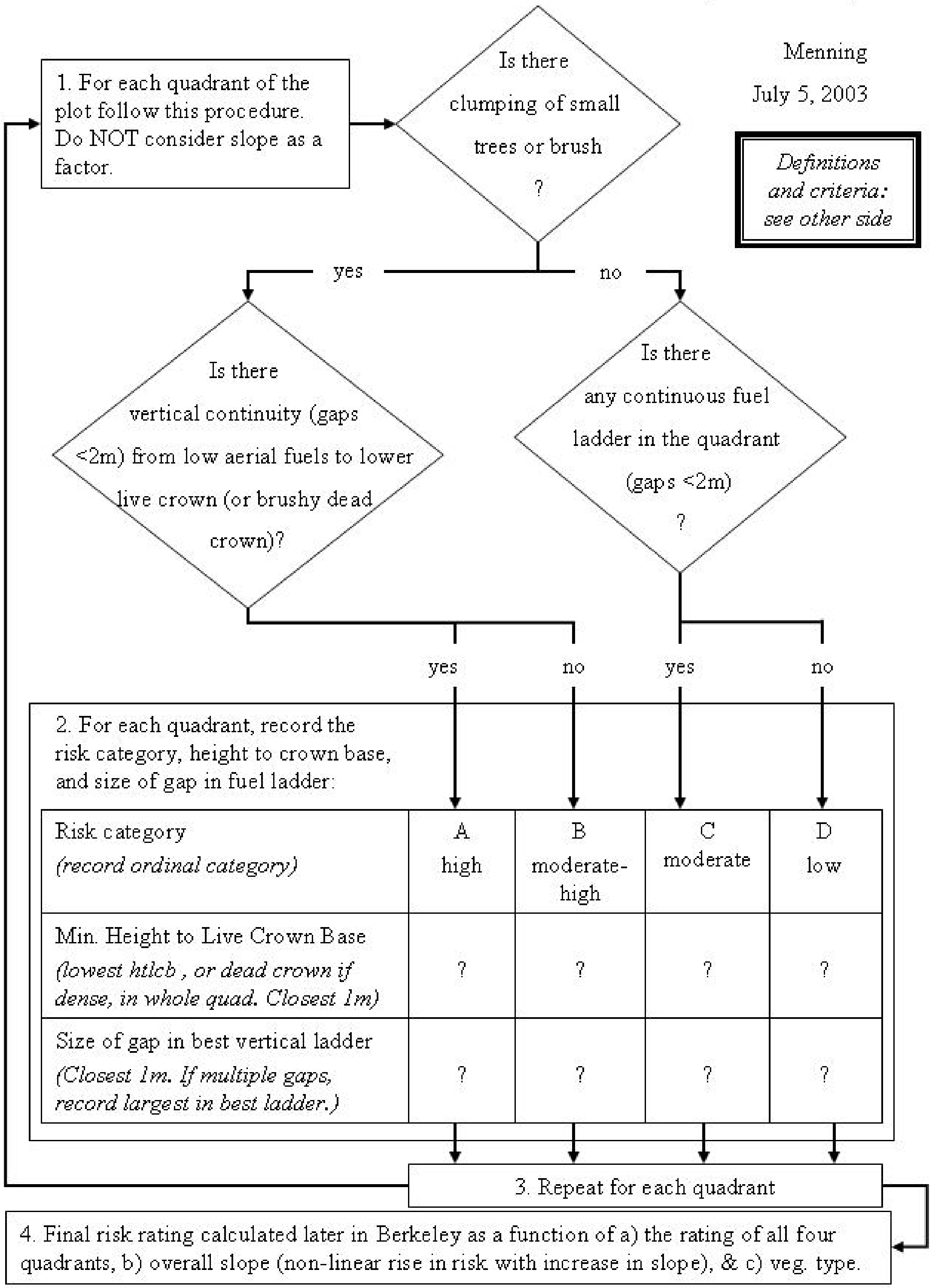
Ladder Fuel Hazard Assessment (LaFHA)



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.)*	?	?	?	?

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 $2m^2$ 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, D) instead of numbers to prevent confusion: categories are not of interval or ratio quality 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.

Datasheet for 2003, page 1

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										

Sheet 2

Plot

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

Appendix B

Vegetation Module

Principal Investigator:

Dr. Malcolm North, Research Plant Ecologist
Sierra Nevada Research Center, Pacific Southwest Research Station
U.S. Forest Service
2121 2nd Street, Suite A-101
Davis, CA 95616
530-754-7398 mnorth@fs.fed.us

Project Collaborator

Dr. Seth Bigelow, Postgraduate researcher
Sierra Nevada Research Center, Pacific Southwest Research Station
U.S. Forest Service
2121 2nd Street, Suite A-101
Davis, CA 95616
530-759-1705 sbigelow@fs.fed.us

<u>Background</u>

Ecosystem science can help evaluate current forest management by examining how silvicultural practices follow or depart from historic disturbance regimes. The central axiom of ecological forestry is that forest management practices should occur "within limits established by natural disturbance patterns prior to extensive human alteration of the landscape" (Seymour and Hunter 1999). Disturbance regimes can be characterized by three general criteria: 1) return interval or time between disturbances, 2) area and spatial pattern, and 3) quality or severity of disturbance including biological legacies of the disturbance (Pickett and White 1985). If a forest, however, is already outside of its range of historical variability, restoration may require management practices that do not directly mimic historical disturbance patterns. These management practices are means to an end and should be evaluated by their ability to move stand structure and composition toward a desired condition.

The heterogeneity of Sierran mixed conifer forests is remarkable. Vegetation composition and structure within these forests varies considerably as a function of aspect, slope, position within a watershed, elevation, latitude, as well as many other physical and biological factors. Forest managers are engaging in silvicultural treatments intended to return forest conditions more within the range of natural variation with respect to fire extent and severity, composition, and structure. While employing treatment strategies across entire landscapes, attention to local conditions cannot be overlooked. Better understanding of site specific variation in tree response to treatments and resulting environmental conditions is important information for management.

There is particular concern for how forest management activities are going to enable the regeneration of shade-intolerant tree species, including ponderosa pine, sugar pine, Jeffery pine, and black oak. Use of group selection silviculture is one method that is being explored. Collectively, past research suggests that shade-intolerants can seed into, become established, and grow rapidly in larger group select openings. Based on the literature reviews we believe that group selection may favor shade-intolerant regeneration but that the resulting distribution and age structure of groups may differ from pre-settlement forest conditions. There are several parts of the puzzle, however, which need research. First, there are few reconstructions of historical disturbance regimes and stand structures for the northern Sierra Nevada; although it is unlikely that fire dynamics differ greatly from elsewhere in the mixed-conifer belt (Skinner and Chang 1996), an investigation of the fire history of this area would be helpful.

Studies in the Pacific Northwest have shown tree growth in gaps is affected by tradeoffs between increased light, temperature and soil moisture (from both increased throughfall and reduced transpiration). The interaction of these factors varies depending on seedling location within the gap and gap size (Gray and Spies 1997; Gray et al. 2002). What the studies do not address is the light, moisture and soil conditions favorable to different species, information we are now collecting which can be used to determine how group size should vary with local conditions such as aspect, slope and soil texture.

It is not known how retention of large trees in canopy openings created by group selection will affect tree regeneration. Large trees may facilitate seedling establishment by reducing soil surface temperatures and increasing near-surface soil moisture through hydraulic lift (Dawson 1996). As seedlings become established, however, large trees may reduce sapling growth by casting shade or competing for soil moisture and nutrients. Research is needed on the effects of size and density of retained tree on regeneration establishment and growth.

The competitive or facilitative dynamics of shrubs and tree regeneration are not well understood and may play an important role in seral development of group selects. Although some silviculturists have sometimes worked to eliminate shrubs on harvest sites, as a source of nitrogen, shade and wildlife cover they have important ecological functions. Research is needed to understand tree/shrub interactions and develop guidelines for shrub abundance and composition.

Finally, research should also examine group selection effects on small mammals. Although effects on individual owl pairs may be difficult to detect, changes in prey abundance, particularly density and abundance of the northern flying squirrel, could indicate more subtle, long-term effects on owl habitat ‘quality’.

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, growth and competition of shrubs and juvenile trees, and growth of retained mature trees. A variety of approaches are used for studying tree canopy structure including 1) locating existing stands with different levels of canopy openness, and 2) carrying out manipulative experiments to change canopy openness. A second overarching objective is to assist other research modules of the Plumas-Lassen Administrative Study in achieving their vegetation-sampling objectives.

Accomplishments

Canopy cover and microclimate experiment. During the 2003 field season we established a medium-scale field experiment with the cooperation of the small mammal module researchers, and the ecosystem management team of the Mount Hough Ranger District. The experiment comprises nine 22-acre stands grouped in three areas (blocks) in mixed-conifer forest (Table 1). One stand in each block will serve as a control and the other two will undergo different levels of thinning, likely in the autumn of 2004, according to prescriptions established for use elsewhere on the National Forests. Trapping for small mammals is being done in all the stands by the small mammal research module.

Measurements of canopy structure were done in all the stands. In each stand a grid of 9 points at 50 m spacing was established where canopy-openness measurements were taken with an array of instruments: hemispherical-lens camera, moosehorn, spherical densiometer, and densitometer. Microclimate sensors were installed at a subset of points in each stand in fall 2003 and have been in continuous operation since then. The shrub community of the stands was assessed in conjunction with the small mammal researchers, which involved going to >100 points in each stand, identifying and measuring the shrubs present, and taking canopy photographs to assess canopy openness.

Table 1. Canopy cover (%) prior to treatment of nine 22-acre stands in experiment on thinning effects on microclimate. Cover was assessed with vertical sighting tube (i.e., canopy densitometer: 400 observations per stand).

Treatment	Location of block		
	Snake	Deane’s Valley	Waters
control	83	76	74
thin	63	70	60
thin	72	78	64

Mixed-conifer regeneration along natural gradients. A 20-mile long west-to-east transect was established to study regeneration of tree species of mixed-conifer forest. Field sampling for a study of sapling growth was completed: measurements of environmental variables (radiation interception and soil depth) and growth rate were done on 40 trees each of ponderosa pine, Jeffrey pine, sugar pine, white fir, incense cedar, and Douglas-fir (Figure 1). In addition, a suite of plant and soil variables are being analyzed in the lab. Growth ring analysis is underway in the Pacific Southwest Research Station dendrochronology lab (Figure 2), and carbon isotopic composition (an integrative measure of plant water status) will be analyzed in collaboration with Will Horwath of the U. C. Davis Department of Land, Air and Water Resources. Soil variables to be analyzed include pH, texture, nitrogen mineralization, extractable phosphorus, and magnesium-to-calcium ratio.

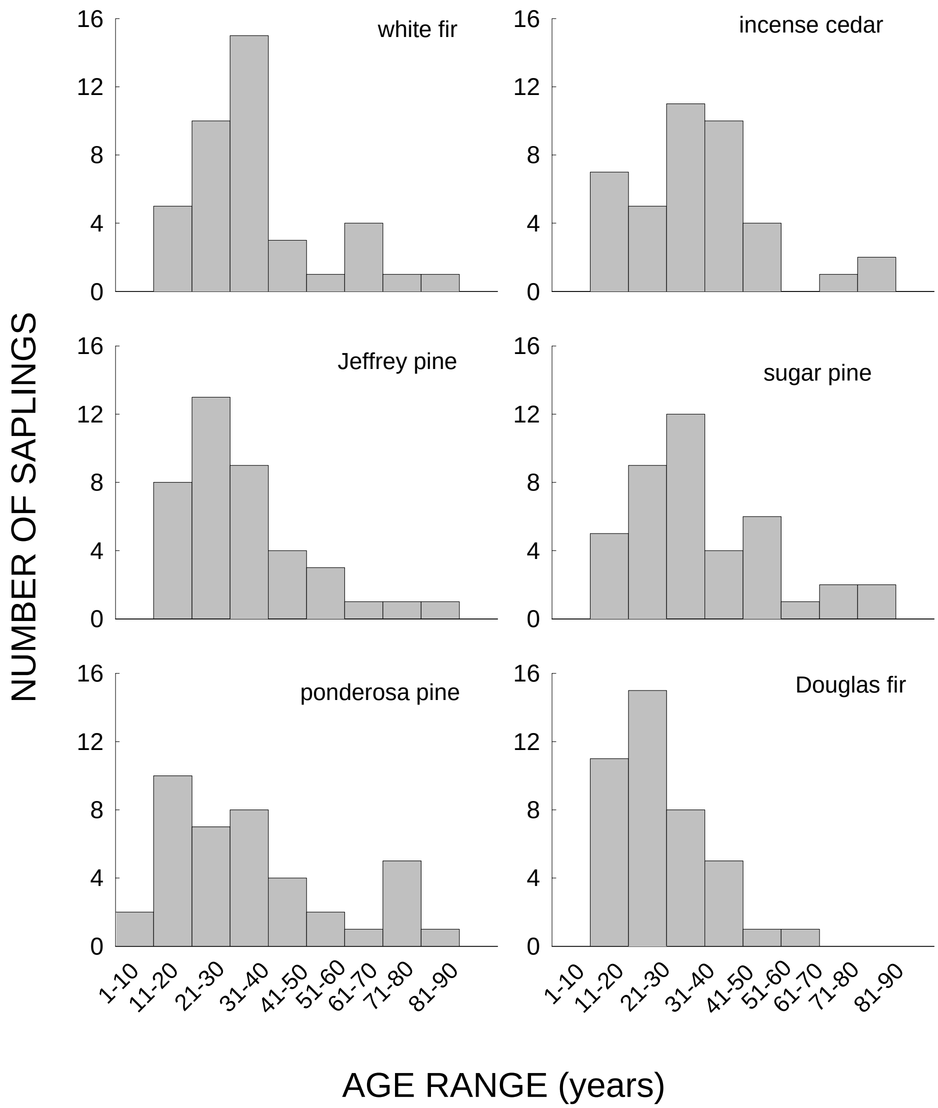


Figure 1. Age distribution of conifer saplings (0.5 - 3 m height) studied. Note the ability of all species to persist in the pre-reproductive state for many decades.

A companion study was established along the same 20-mile transect to examine survival along environmental gradients: 80 seedlings of the same species were tagged and measured, their survival will be monitored for an additional two years, and the same suite of environmental and plant variables will be measured. This same 20-mile transect may prove useful for understanding the conditions under which common shrub species thrive and hence compete with regenerating trees. A grant proposal was submitted to the Pacific-Southwest Research Station's Internal Competitive Grants program to apply the methods used in the regeneration study to the shrub community (Appendix 1).

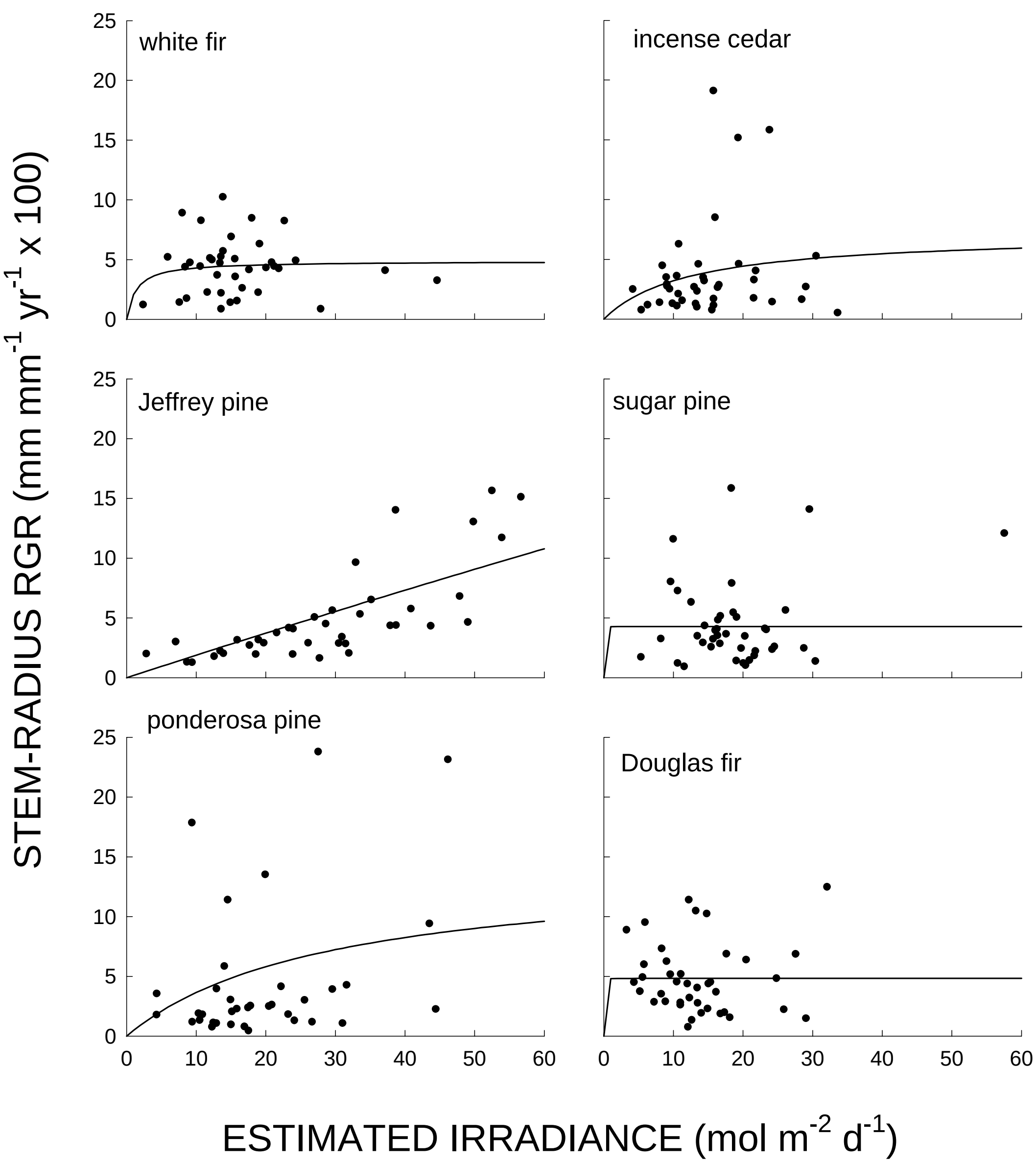


Figure 2. Relative growth rates of conifer saplings with respect to light. Ponderosa and Jeffrey pine saplings show typical shade-intolerant pattern of very low growth at low light, and high growth at high light. White fir exhibits a trade-off: high

growth rates at low light, but inability to grow rapidly at high light. Incense cedar, sugar pine, and Douglas fir show shade-tolerant behavior in this system.

Collaborative studies. Vegetation module personnel also designed an integrated scheme for sampling vegetation at scales appropriate to focal organisms and processes in the Administrative study (Appendix 2). Other collaboration (in addition to the above-described efforts with the small mammal research module included design of a menu-driven data-entry program for personal digital assistant using the Pendragon Forms program. The program allows direct field entry of data collected from releve (ocular macroplots) and fuels-module plots. The program interfaces with a Microsoft Access database. Personnel from the Terrestrial Bird module were trained in use of the data-entry program and in plot-assessment techniques. Vegetation module staff spent one month establishing plots for the Fire and Fuels research module.

Outreach. Vegetation module personnel participated in a presentation to community members and students from the U. C. Berkeley forestry camp at the Meadow Valley Schoolhouse, and also took part in a research presentation to the Quincy Library Group. Personnel also attended a field workshop on group selection silviculture organized by the Mt. Hough ranger district; and conducted a literature review of studies pertaining to the ecological basis of group selection silviculture in the northern Sierra Nevada.

Appendix 1. Research proposal submitted to PSW Internal Competitive Grants Program.

FROM CLOSED- TO OPEN-CANOPY FOREST:
ANTICIPATING UNDERSTORY RESPONSE

Principal Investigators

Seth Bigelow, Pacific Southwest Research Station
William Horwath, University of California at Davis.

Introduction/Problem Statement

A central challenge facing forest managers in the Sierra Nevada range and throughout the American west is to alter the trajectory of forest development from dense, closed-canopy forests with infrequent but catastrophical fire regimes, towards open-canopy forests dominated by crown-fire-resistant species that tolerate and thrive on low-intensity surface fire. The means of effecting this change in trajectory, however, is not clearly known. Several outcomes of management interventions are possible including establishment of an alternate ecosystem state of shrublands dominated by a crown-fire regime. Silvicultural research in plantations has focused on controlling shrubs to establish regeneration, but little is known about tree-shrub interactions in the context of uneven-age management. Understanding of the early successional plant communities that form after disturbance has been identified as a key research need (McDonald 1999).

The plant communities that form after large canopy opening from logging disturbance are often determined by priority effects: whichever plant arrives first preempts growing space making it difficult for subsequent plants to become established. Shrub communities are resistant to invasion by trees (Hill et al. 1995) and the communities of the northern Sierra Nevada/southern Cascades are no exception. Common shrubs of the northern Sierra Nevada have a soil seedbank, so in the absence of a good tree seedfall year, the shrub community establishes a dominant presence at a site (Helms and Tappeiner 1996). Studies of openings in which no replanted was done (and which had site disturbance) showed that 5 years after disturbance, shrubs contributed over 50% of canopy cover, with grasses and forbs taking over much of the remaining cover (McDonald 1999).

Once established, trees are still susceptible to severe competition from shrubs. Experiments have demonstrated competition between Sierra trees and shrubs, and several studies have have examined the mechanisms of tree-shrub competition. High shrub densities considerably reduce ponderosa pine (*Pinus ponderosa* Laws) productivity (McDonald and Abbott 1997), and experiments with greenleaf manzanita (*Arctostaphylos patula* E. Greene) have linked this effect to competition for soil moisture (Shainsky and Radosevich 1986). The suite of tree species in the mixed-conifer forest respond differently to shrub competition: ponderosa pine is more sensitive than white fir or sugar pine to canopy volume of neighboring shrubs (Lanini and Radosevich 1986), and total cover of all woody plants within a 2 m radius is the best predictor of growth of Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco) growth (Wagner and Radosevich 1991). One study, of competition between ponderosa pine and greenleaf manzanita varied the conditions under which the experiment was conducted (i.e., at different levels of soil moisture; Anderson and Helms 1994), but in general little is known about how environment changes the competitive balance between trees and shrubs.

Interactions between trees and shrubs in mixed-conifer forest should not simply be viewed as characterized by competition: there is substantial reason to believe that shrubs influence and even facilitate establishment of tree communities. Douglas-fir seedling establishment is limited by mycorrhizal inocula, but ericoid shrubs (e.g., *Arctostaphylos* sp.) can lifeboat inocula while sites are devoid of conifers (Hagerman et al. 2001). Perhaps more importantly, small mammals have been shown to be key dispersers of the seeds of one species, Jeffrey pine (*Pinus jeffreyi* Grev. and Balf.), to sites favorable for germination, and there is a tendency to bury seeds under the cover of shrubs to reduce risk of predation (Vander Wall 1993, Vander Wall et al. 1999). Although Jeffrey pine has been most intensively studied in this regard, other species of mixed-conifer forest have similar adaptations for secondary seed dispersal by rodents. Finally, in particularly harsh sites, shrubs can ameliorate abiotic conditions resulting in enhanced establishment of tree seedlings. *Arctostaphylos* plants in coastal California scrub facilitate first-year establishment of invading Douglas-fir trees (Dunne and Parker 1999), and other shrubs perform a similar role in the southern Sierra Nevada (Gray et al. *unpublished manuscript*), although they competed with the saplings. (Understory shrubs maintain site quality: Busse et al. 1996.

Shrubs in Sierra Nevada ecosystems, and the potential of shrub communities to serve either as a seral stage that facilitates the establishment of tree communities or an climax state (dysclimax?) the time is ripe for further investigation into management of shrub communities and in particular, the contingencies of tree-shrub competition.

Objectives

We plan to characterize the growth rates of three common shrubs in the northern Sierra/southern Cascades province: Deerbrush (*Ceanothus integerrimus* Hook. and Arn.), greenleaf manzanita, and whiteleaf manzanita (*Arctostaphylos viscida* C. parry) with respect to light availability, neighborhood density, and growth resources. We wish to know under what conditions of light and soil resource availability the competitive relationships between common shrub and tree species are likely to be reversed. We will do a one-time sampling of soil and light conditions and water status of three common shrubs of the northern Sierra Nevada ranges. From these data we will determine growth optima (conditions for best growth) for each species, the range of growth conditions, and the most-limiting soil nutrients. We will develop equations for each species of growth as a function of light and most-limiting soil factor. We will compare these equations to ones already being developed for common trees of mixed-conifer forest: ponderosa, Jeffrey, and sugar pines; red and white fir; and incense cedar. We will look for areas of shifting competitive dominance. 0

Research Approach

Experimental Design and Methods

Naturally established individuals of the two most locally common shrubs-deerbrush and whiteleaf manzanita--will be located in a variety of light and soil environments of the northern Sierra Nevada/southern Cascades region (Plumas and Lassen National Forests). Sampling will be stratified by four prevalent parent material types: basalt, andesite, serpentinite, and granodiorite. On soils developed *in situ* from each parent material type, eight individuals of each species will be located in each of three canopy-openness classes: <33%, 33-66%, and >66% (field estimates of canopy openness to be obtained with a spherical crown densiometer; Lemmon 1957). Total sample size will be 192 shrubs: 2 species × 4 parent materials × 3 canopy openness classes × 8 individuals. Measurements of growth rate, age, and light and soil environments will be done on each shrub.

Plants will be sampled in circular plots of radius 0.56 m (1 m^2), because greenleaf manzanita has dense clonal growth and individual deerbrush plants are difficult to discern. All stems within the plot will have their diameter measured at 8 cm above the root collar (Hughes et al 1987), and the length of the five longest stems will be measured, as well as the height of the tallest plant in the plot. A section of the largest sound stem will be removed for ring width analysis (Keeley 1993) in the laboratory using a microscope and computerized stands. Age of the stem will be determined, as well as width of the growth rings of the three past years.

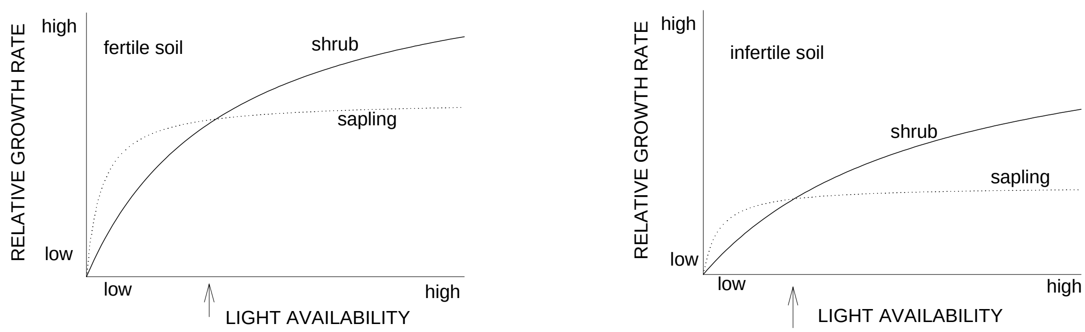
The annual photosynthetic photon flux density to each shrub will be estimated from a hemispherical-lens photograph taken of the tree canopy directly overhead using GLA software (Frazer et al. 2000). Three soil samples (0 to 20 cm depth) will be taken from around the base of each shrub and mixed together in the field. Soil will be analyzed for nitrogen mineralization rate (seven-day anaerobic incubation), exchangeable phosphorus (0.5 M HCl-1 M NH_4F extraction), exchangeable cations (1 M NH_4Cl extraction; Johnson 1995), and pH (0.01 M $CaCl_2$). Samples will be sealed in the field for gravimetric analysis of water content. Wood from the three most recent stem growth rings will be ground, purified, and tested for C13/C12 ratios to determine moisture stress.

Analysis

There will be three stages to the analyses. The first is to address how soil factors vary among the four parent materials and the two shrub species. The statistical approach is a multiple analysis of variance, with soil chemical and physical factors (including $^{13}C/^{12}C$ ratio in stem tissue and Ca: Mg ratio as a serpentine soil indicator) as response variables, and parent material, shrub species, and their interaction as main effects.

The second step is to select the best growth curve for the light response, then to test for limiting soil factors. An asymptotic curve is often used to describe tree growth (Pacala et al 1993) but this approach has not yet been used for shrubs, and it will be important to test whether a simpler formulation (e.g., a linear increase in growth rate in response to light) is appropriate. A maximum likelihood approach will be used, in which more complex models (e.g. curved compared to straight lines) are penalized in proportion to the additional numbers of parameters it takes to describe them mathematically (AIC?? Is so why not state it) (Hillborn and Mangel 1997). Once the appropriate light-response curve has been determined, we test for improvements in fit by modifying parameters of the light-growth equation according to soil chemistry, again using a maximum likelihood approach. This is a powerful, novel method for relating plant performance to soil chemistry (Bigelow and Canham 2002).

The final stage is to superimpose shrub light-growth curves on similar curves currently under development for saplings of mixed conifer species (see figure).The idea will be to search for points at which there is a switching of competitive performance so that we can predict canopy openness levels at which growth of sapling will exceed that of shrubs – such that the sapling are competitively dominant. Finally, we will introduce the concept of soil modulation of competitive relationships.



Hypothetical comparisons of shrub and sapling performance on fertile (left panel) and infertile (right panel) soils. Arrows denote light levels at which relative growth rate is equal between the two life forms: note shift to left at low soil fertility.

Research Timetable

Fieldwork will be carried out during the summer of 2004. Lab work will take place in the fall 2004, and data analysis and write-up will be done in spring of 2005.

Pitfalls/Limitations

The study will measure growth response of shrubs integrated over three years, but the plant’s environment may have changed during that time. In particular, tree-falls or growth of tree crowns can change canopy openness, so there is an unavoidable degree of uncertainty in the measurement of light availability. Soil chemistry is likely to change more slowly, but inferences made with soil chemistry data bear the caveat that plants have the ability to change the soil that they grow in over time. Also, the degree of clonal integration of the plants is unknown. If greenleaf manzanita transports carbohydrates and other internal resources among stems, precise measurements of environment around one part of a plant may not accurately predict growth if the environment is patchy at the scale of a single clone. Finally, although the results will be used to predict the ability of plants to change growth rates given a change in canopy openness and/or soil conditions, the plasticity of growth rates is unknown. There is no substitute for manipulative experiments followed over time.

Expected Outcomes and Future Direction of Proposed Study

The study's outcome will be a research paper published in the peer-reviewed literature that 1) establishes growth-light relationships of two common Sierra shrubs, 2) compares them to growth-light relationships of saplings of six tree species of the mixed-conifer forest, 3) explores how growth-light relationships are contingent upon soil moisture, parent material, and other site factors, and 4) discusses implications for forest management practices of thinning and green-tree retention. The next stage of this research will be to test the predictions of the study by measuring response of shrubs and saplings to manipulations of overstory vegetation. Implementation of this experiment is already underway in the northern Sierra Nevada: experimental sites have been identified and agreements with forest personnel have been made. Treatments will include two levels of thinning, and complete canopy removal. Results of these experiments will provide needed guidance for policy makers and forest managers who are formulating forest harvest guidelines with the aim of restoring forests while preserving wildlife and restoring a historic fire regime and providing for harvest of timber.

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Personnel

Seth Bigelow
Research Ecologist
Sierra Nevada Research Center
Pacific Southwest Research Station.

Seth Bigelow received his B.A. (1988) from the Department of Biology at the University of California, Santa Cruz and his M.S. (1992) and Ph.D. (1998) from the Department of Botany at the University of Florida, where his research concerned nutrient cycling in humid tropical forests. Since then he has studied tree-soil relationships in northern hardwood and western mixed-conifer forests as a post-doctoral researcher at the Institute of Ecosystem Studies (Millbrook, New York) and the Sierra Nevada Research Center.

William R. Horwath
Assistant Professor of Soil Biogeochemistry
Department of Land, Air, and Water Science
University of California-Davis.

Will Horwath received his B. S. in Forestry and Environmental Impact Assessment from Southern Illinois University, and his Ph. D. in Crop and Soil Science and Forest Ecology from Michigan State University. His research interests are in soil fertility and sustainability of managed and natural ecosystems; roles of soil organic matter in global climate change and soil C sequestration; and carbon and nitrogen cycling processes, soil organic matter dynamics, and microbial-plant interactions using stable isotopes.

Responsibilities and time.

Bigelow will hire and manage the field crew, provide criteria for selection of field sites, supervise lab activities, and manage, analyze, and write-up data. (20% of year). Horwath will provide facilities and technical assistance for conducting laboratory analyses, and will consult in data analysis and write-up (2%).

Selected Recent Publications-Bigelow

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Potential Neutral Referees

Jon Keeley
Research Ecologist, USGS Sequoia and Kings Canyon Field Station.
Email: jon_keeley@usgs.gov
Phone: (559) 565-3170.

David M. Wood
Professor, Department of Biology, CSU-Chico.
Email: dmwood@csuchico.edu
Phone: (530) 898-6311

Robert G. Wagner
Professor, Department of Forest Ecosystem Science, University of Maine
Email: bob_wagner@umenfa.edu
Phone: (207) 581-2903

Appendix 2. Integrated Sampling Scheme for Plumas-Lassen Administrative Study

I. PLUMAS VEGETATION SAMPLING: A 3 TIERED, INTEGRATED PROTOCOL

Objectives:

Provide a common protocol to all modules in the Plumas Lassen study that 1) facilitates data integration and cross-discipline analysis; 2) provides for different sampling intensities and time limitations; and 3) is nested around a set of common methods and protocols with additional measurements added at each higher level.

Approach:

We have focused on 3 perceived levels of detail desired by different studies:

- Bird Module: need for rapid assessment of forest structure with many plots to be widely distributed across the landscape along bird census grids
- Fire Module: need for more detailed information on fuels, forest structure and shrub cover with targeted plot locations in fuel treatment zones
- Spotted owl & small mammal module: need for intensive quantification of old-growth and canopy attributes in specific use areas

Strategy:

All three sample plots are organized around a common set of measurements and categories which will be standardized between crews through common training by the vegetation module. Field technicians will enter and store data in PDAs with the same fields and categories.

Bird Module

Plot Layout: Point centered, variable radius plot

Physiography: Record UTMs, slope, aspect, distance to water, road distance, forest type.

Trees and Snags: Using a 10 BAF prism in a Panama Angle Gauge, count how many trees (by species) and snags are "in". Include how many tallied trees have limbs at $\leq$ dbh height. Record canopy cover with a spherical densiometer.

Shrubs and Fuels: Secure the middle of a 50 m tape to the gridpoint and stretch out the tape 25 m each way (90^0 apart). Along each section of the tape tally shrub cover by species and Browns fuel classes.

Approximate time: 15-20 minutes

Fuels Module

(*italics are additions*)
Plot Layout: *1/20 ha fixed radius*

Physiography: Record UTMs, slope, aspect, distance to water, road distance, forest type, *litter depth*.

Trees and Snags: *All trees with 12.6 m of plot center are measured for diameter and species (trees) or decay class (snags). For each live tree, the height to the base of the live crown is visually estimated.* Include how many tallied trees have limbs at $\leq$ dbh height. Record canopy cover with a spherical densiometer *and moosehorn*.

Shrubs and Fuels: Secure the middle of *two* 50 m tapes to the gridpoint and stretch out the tape 25 m each way (90^0 apart). Along each section of the tape tally shrub cover by species, *in 3 height class (<0.5 m, 0.5-2 m, 2-4 m)* and Browns fuel classes.

Logs: *A visual estimate of the large and small diameter (nearest 10 cm), length, decay class*

Time estimate: 2 hours/plot

Spotted Owl and Small Mammal Modules

(*italics are additions*)
Plot Layout: *3 concentric fixed radii plots, different cutoffs for each size*

Physiography: UTMs, slope, aspect, distance to water, road distance, forest type, litter depth, *general description*.

Live tree: species, dbh, *canopy class (emer., dom., co-dom., inter., sup.) and a Hawksworth mistletoe rating*

Snags: dbh, *height (visual estimate)*, decay class and *number of visible cavities* $\geq$ *10 cm diam.*

Logs: [volume]—large and small diam (near 10 cm), length, decay class

Shrubs, Fuels and *Logs*: *Secure* the middle of *two* 50 m tapes to the gridpoint and stretch out the tape 25 m each way (90^0 apart). Along each section of the tape tally shrub cover by species, in 3 height class (<0.5 m, 0.5-2 m, 2-4 m) and Browns fuel classes. *Also along the tape tally log cover by decay class.*

Canopy openness: Hemispherical photograph taken at plot center

Canopy structure: For all trees in the 0.1 ha plot, 4 measurements are taken: total height, height to the beginning of ladder fuels, height to the base of the live crown,

crown diameter (avg of 2 cross diam.) and crown shape (i.e., cone, cylinder, truncated ellipse, umbrella).

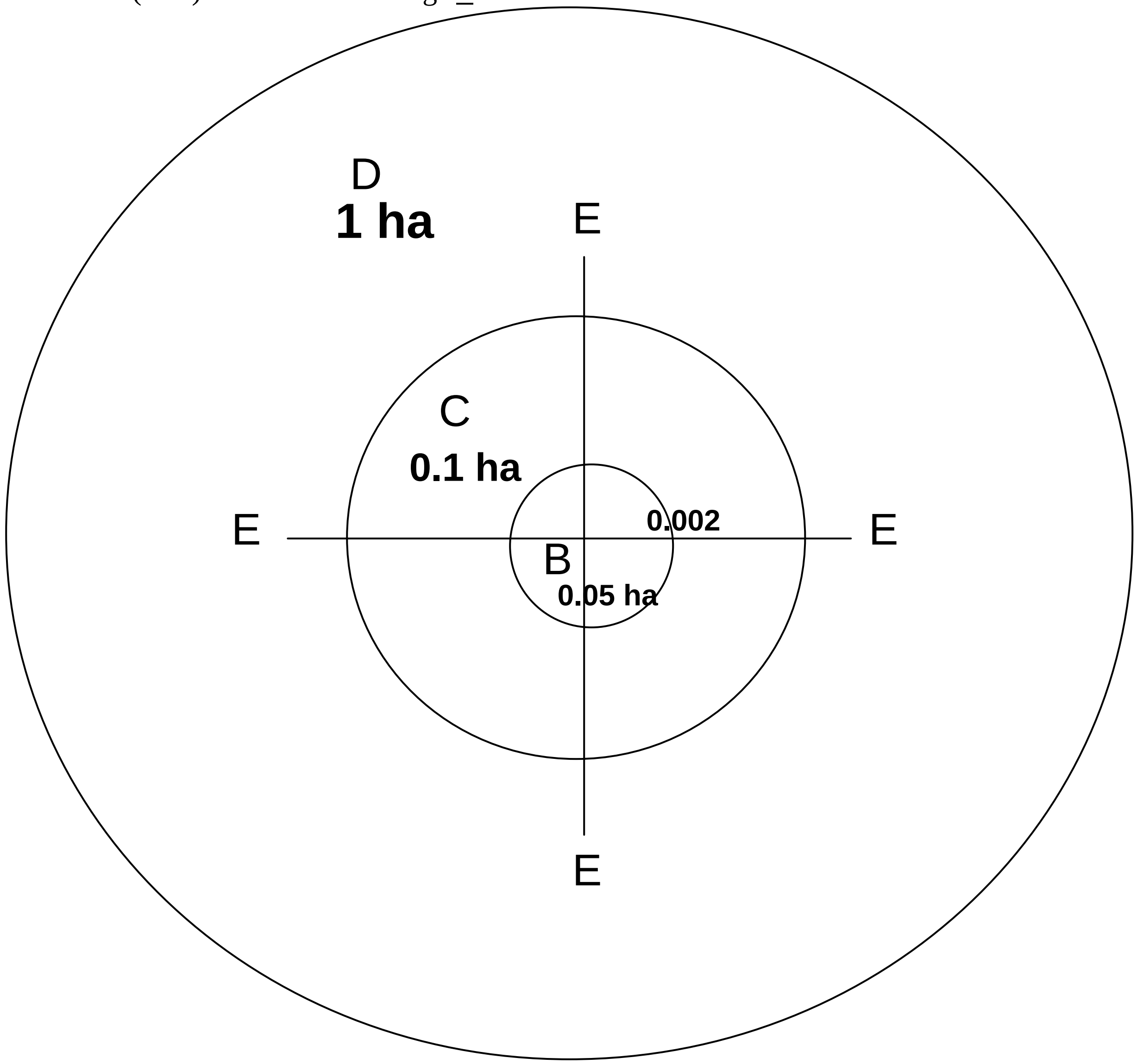
Plot layout

The principal plot is 3 nested circles:

B: 12.6 m radius (0.05 ha). All trees and snags ≥ 10 cm dbh are measured

C: 17.8 m (0.1 ha). All trees and snags ≥50 cm dbh. All logs ≥20 cm diam and 2 m long.

D: 56.4 m (1 ha). All trees and snags ≥80 cm dbh



Appendix C

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

Annual Report

March 2004

James A. Wilson[1], Doug Kelt[1], Dirk VanVuren[1], Mike Johnson[2], and Peter Stine[3]

[1]Wildlife, Fish Conservation Biology
University of California
One Shields Ave., Davis, CA 95616

[2]John Muir Institute for the Environment
University of California
One Shields Ave., Davis, CA 95616

[3]Sierra Nevada Research Center
Pacific Southwest Research Station, U. S. Forest Service
2121 2nd Street, Suite A101
Davis, CA 95616

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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 will establish nine semi-permanent live-trapping grids for use as experimental plots. Three sets of three experimental grids will be established throughout the treatment area with each set of three grids established in a cluster. The clustered grids

will consist of a 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 will be 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 will be investigated using multivariate techniques to identify key habitat characteristics used by individual species of small mammals. Nine additional grids will be established in various representative habitats throughout the study site. Habitat grids will be established in triplicate for each habitat. Habitat grids do not necessarily need to be located near other grids in the same habitat type. We will measure 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 will perform 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.

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.

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 – 2003 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. All Sherman traps were closed during the day to prevent deaths from heat exposure. All Tomahawk traps were checked periodically throughout the day (ca. every 3 hr) to capture diurnal species, but were also be closed from 11:00 – 15:00 to prevent deaths to animals. 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* or another appropriate computer program. Monthly survival and population densities will be modeled for each species on each site. These parameters can then 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 the grid was stratified into macro- and microhabitat characteristics. Macrohabitat variables were measured at alternate trap stations on each grid, whereas microhabitat variables were measured at all trap stations on each grid. 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 variables were measured in 2-m diameter circles centered on each trap station. Within each circle we recorded percent cover by bare ground, rock, litter, forbs, shrubs, mats (prostrate plant species), small trees (< 2m height), and downed woody debris (branches, small logs, and large logs).

In addition to macro- and microhabitat characteristics, numerous physical characteristics of the trap grids were measured. We recorded slope, aspect, and percent canopy openness at each of the 120 major trap stations (e.g., Tomahawk stations) on each gird. Canopy openness was recorded by taking a photograph using a hemispherical lens; photographs were taken at breast height and later analyzed using the computer program, *Gap Light Analyzer 2.0*. Finally, soil hardness was measured once in four equal quadrants at each trap point.

All habitat variables will be checked for colinearity using a principal components analysis at the sampling point level. Variables exhibiting colinearity will be eliminated from further analyses. All remaining variables will be tested for normality of variances and used in a multiple regression to determine which habitat variables significantly explain small mammal distribution. Significant habitat variables will be used to generate grid and habitat level values for use in developing habitat relationship models for all small mammal species. Habitat models will be developed for habitat use vs. availability and to identify patterns of distribution based on habitat characteristics associated with specific forest types. Finally, the effects of edge and other habitat characteristics will be investigated with respect to the probability of capture for each species.

<u>Dynamics of spotted owl prey taxa</u>:

To supplement species habitat relationships, individual woodrats were captured and fitted with radio-collars. These individuals were followed throughout the year as access is available to identify activity patterns and specific patterns of habitat use. We captured and collared 20 individual dusky-footed woodrats of various ages and sexes to follow throughout the study, and located nests and houses to determine the habitat type important for key prey habitation. Activity patterns and habitat use were determined using radio-telemetry and triangulation methods, with telemetry performed on a monthly basis throughout the season with a minimum of 5 days of telemetry per animal. A minimum of 3 independent locations was recorded for each animal during a single day of telemetry.

Program *Locate II* will used to calculate animal locations from bearing data obtained during triangulation. Animal locations will then be entered into an ArcView GIS database and plotted. Monthly minimum convex polygon 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.

<u>Fitness correlates to forest management</u>:

Twelve female golden-mantled ground squirrels were captured for use as experimental subjects in July of 2003 and fitted with a radio-collar. 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 three times per day for 5 days each month from July to September. Animal locations were determined using triangulation methods for radio-telemetry. Animal locations were calculated 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 minimum convex polygon for interspecific comparisons with previously published home range sizes. Adaptive kernel home range analyses will also be used to identify core usage for individuals during the entire field season.

Taxonomy and classification of Sierra Nevada chipmunks:

We collected a sample of reference chipmunks from areas throughout the study site and braught 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*.

2003 FIELD SEASON PROGRESS AND RESULTS

The 2003 season began in February with the hiring of 6 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, new trapping grids were established from May through June, and regular trapping began in July. For logistic and experimental design reasons all but three (Grids 10, 11, and 16) of trap grids from the 2002 season were abandoned. The addition of a new experiment requiring nine semi-permanent trap grids and the need to sample a number of representative habitat types required us to establish new trap grids for the remaining 15 grids (Table 1). Nine experimental grids (Grids 1-9) were established 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

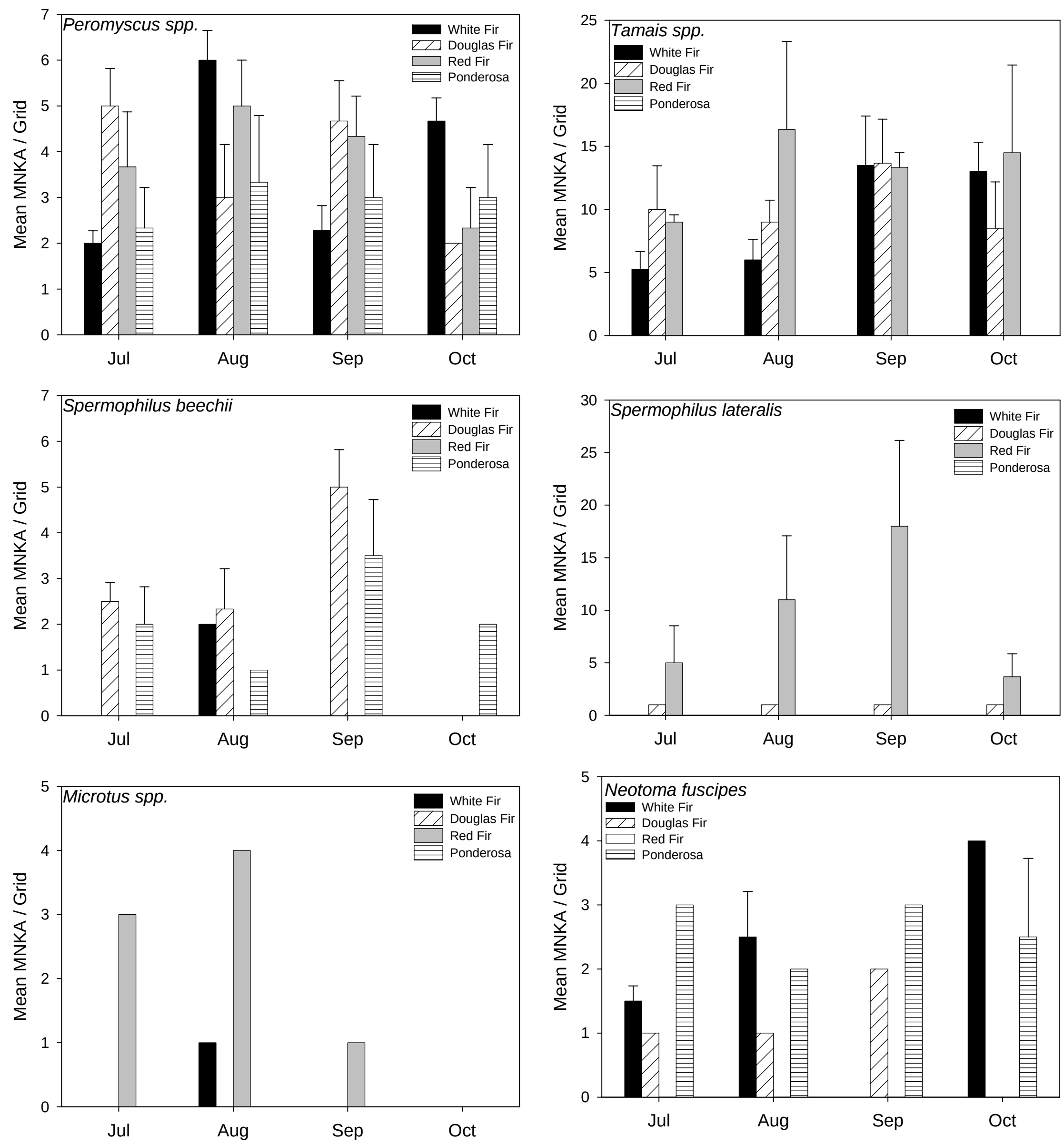

Figure 1. Mean minimum number of individuals known to be alive (MNKA) sampled in each of four forest types. Error bars represent standard error.

trap-nights total), and each grid experienced 688 trapnights during each month of trapping.

<u>Demographic profiles of small mammal populations inhabiting a variety of habitat types</u>:

During the 2003 field season we captured and marked a total of 555 individuals across all species of small mammal and all sites (Table 1). Predominant species in the study area include dusky-footed woodrat (*Neotoma fuscipes*), brush and deer mice (*Peromyscus boylii* and *P. maniculatus*), chipmunks (*Tamias* spp.), 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*).

The distribution of small mammals across the major habitat types is shown in Figure 1. Woodrats were found in significantly greater numbers ($F_{3,70} = 4.41$, $P = 0.007$) in ponderosa pine forests (1.13 ± 0.38 individuals/grid) compared to Douglas fir (0.27 ± 0.15 individuals/grid), and were completely missing from red and white fir forests. Similarly, voles differed across habitat types ($F_{3,70} = 5.52$, $P = 0.002$) with voles only found in red fir (0.6 ± 0.3 individuals/grid) and white fir (0.02 ± 0.02 individuals/grid) forests. Deer mice (*Peromyscus* spp.) were found in all four forest types; however their abundance differed between each forest type. *Peromyscus* abundance was 2.47 ± 0.59, 2.33 ± 0.51, 3.07 ± 0.58, and 1.51 ± 0.26 individuals/grid in Douglas fir, ponderosa pine, red fir, and white fir respectively. California ground squirrels showed an interaction between month and habitat ($F_{12,70} = 2.91$, $P < 0.002$; Fig 1). Although golden-mantled ground squirrels were found occasionally in Douglas fir forests, they occurred almost exclusively in red fir. Abundance of golden-mantled ground squirrels varied through the season by habitat and month ($F_{12,70} = 2.00$, $P = 0.04$), peaking in August and September, then dropping off in October as individuals began to hibernate (Fig. 1). Flying squirrels showed a pattern similar to golden-mantled ground squirrels and were predominantly found in red fir forests. However, the low number of captures makes identification of any patterns in abundance impossible. Characteristic of all sites was high temporal variability in abundance.

<u>Habitat associations of small mammal populations</u>:

All macro- and microhabitat measurements were taken on all trap grids during the 2003 field season. These data have been entered into a spreadsheet and will be analyzed during spring and summer of 2004.

<u>Dynamics of spotted owl prey taxa</u>:

We have captured and placed radio-collars on 20 individual woodrats, consisting of 11 females and 9 males. All woodrats were captured in the same general area and were found in ponderosa pine forest. Telemetry began in late July and continued until the beginning of October. All triangulation data has been entered into spreadsheets and is ready to determine animal locations. All animal locations will be calculated during February of 2004 and will be entered into ArcView before the start of the 2004 field season. In addition, monthly home ranges will also be calculated prior to the 2004 field season.

A total of 71 woodrat houses were found in the telemetry study area. Woodrat houses consisted of a variety of structures ranging from cavities in stumps and logs (n = 12 houses) to stick houses (n = 59) constructed to heights of 2-3 m. Vegetation characteristics were measured for each house and will be used to identify patterns in house use in relation to habitat characteristics.

Fitness correlates to forest management:

Twelve females were captured in July and monitored throughout the year. All females survived the season and have entered hibernation, and are expected to emerge in ca. April 2004. Females were subsequently captured in July and early August 2003 and all monthly measurements were taken as available.

Body mass fluctuated throughout the season, with an initial decrease likely associated with lactation (Fig. 2). Following August, both experimental groups increased in mass. Supplemental feeding began on September 1, 2003, and was followed by a divergence in control and supplemental mean mass (Fig. 2). Because only one individual per treatment was captured in October the full relationship between the experimental groups is not available; the marked divergence between the two individuals captured, however, strongly supports our contention that supplemental feeding was successful. Indeed, when data for August and September are compared (Fig. 3), it is apparent that the mass of control and supplemental animals showed a trend towards distinct trajectories, with slopes for mass gain from August to September being β = 14.56 and 42.49 respectively. The difference between these slopes was significant ($F_{1,18} = 3.25$, $P \approx 0.08$). No significant difference in total mass was observed between the two groups at the start of the experiment. The results of this analysis suggest that the dietary supplementation was successful in increasing the rate of fat reserve development, although the difference in mass between the two treatment groups is expected to be greatest in the spring following emergence from hibernation. As expected, maternal home range size for the two treatment groups did not differ during any of the

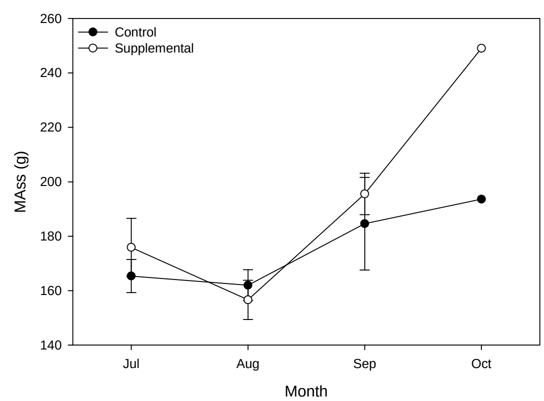

Fig. 2. Mean mass of female golden-mantled ground squirrels fed a control diet (solid) or a diet supplemented with black oil sunflower seeds (open). Error bars represent standard error, no error bars are present for October because only one individual from each group was captured. No statistics were performed using October captures.

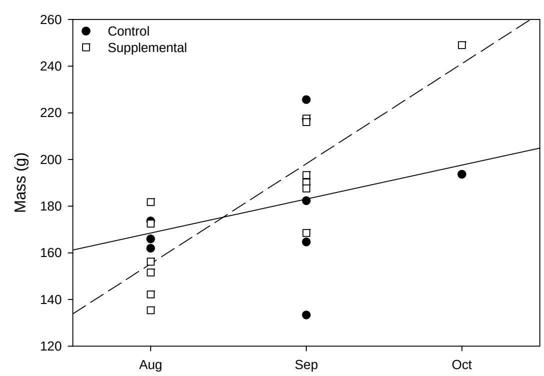

Figure 3. Mass of female golden-mantled ground squirrels fed a control (solid circles and lin) of fat supplemented (open circles, dashed) diet. Slope of mass gain was greater in supplemented females ($F_{1,18} = 3.25$, $P = 0.08$).

months studied, and decreased in size following July when energetic demands from lactation are greatest (Fig. 4).

We will initiate our sampling efforts in April 2004, and intend to capture all marked adults as well as their offspring. Of particular interest will be the relative success of treatment and control offspring, their ability to garner resources for their first independent winter, and their productivity as yearling mothers.

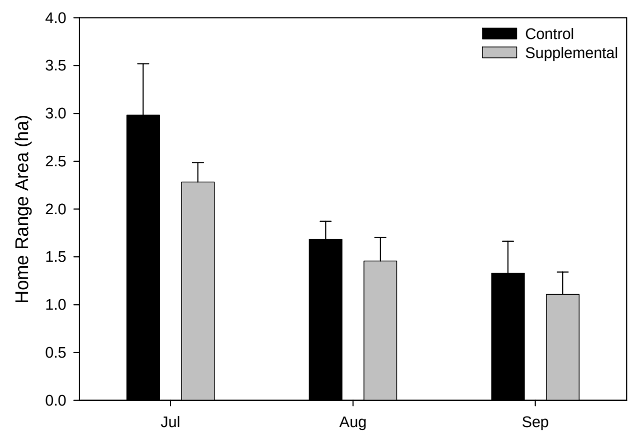

Figure 4. Home range size in hectares (ha) for female golden-mantled ground squirrels allowed to forage naturally (control, n=6) or fed a high fat supplemental diet in addition to natural foraging (supplemental, n=6).

<u>Taxonomy and classification of Sierra Nevada chipmunks</u>:

To date we have collected 241 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 stored and are ready to be sent to the University of Idaho for analysis.

COLLABORATION WITH OTHER MODULES

We have initiated collaborative efforts with the vegetation, and fire and fuels modules, 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 was 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 2003 calendar year marked the first full year of data collection. We began the field season by establishing semi-permanent trap grids for use in an experiment on the effects of thinning strategies on small mammals, vegetation, and fire behavior. We established 9 trap grids for use in the experiment and 9 additional grids for use in developing habitat models for small mammals.

With the budget forecast for 2004, we plan to continue trapping on the nine experimental grids to obtain a second year of pretreatment data. Thinning on the treatment grids will begin as early as fall 2004, but is likely to not be done until 2005. 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. One concern to be addressed early in the 2004 field season will be to find and capture 20 individual flying squirrels for use in radio-telemetry studies. 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 monitor female golden-mantled ground squirrels from last year and additionally monitor their offspring during the upcoming field season. We will continue to take tissue samples from newly captured chipmunks on all sites for use in genetic analyses. All samples of chipmunk tissue will be sent to the University of Idaho for molecular analyses during the spring and summer of 2004.

The methods we have developed for this project have been tested in the 2003 season, and they appear suitable for developing a large and significant dataset on the abundance, distribution, activity, phylogenetic relationship, and physiology of small mammals in the Sierra Nevada. 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 expect publication of data to begin following the 2004 field season and to include articles in peer reviewed on the following subjects:

1. Habitat relationships of small mammals in the northern Sierra Nevada.
2. Distribution and abundance of small mammals in the northern Sierra Nevada.
3. Northern flying squirrel home range size and structure.
4. Characteristics of woodrat house use.
5. Woodrat home range size and structure.
6. Effects of fat on offspring fitness in golden-mantled ground squirrels.
7. Genetic structure and hybridization of *Tamias* species in the Sierra/Cascade interface.

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 2003 was conducted by James A. Wilson, Meghan Gilbart, Dave Smith, Robin Jenkins, Camila Morcos, Aviva Goldman, Kevin Marsee, Rachel Kussow, and John Katz.

ACKNOWLEDGEMENTS

Funding for this project is provided by the Pacific Southwest Research Station and Region 5 of the U. S. forest Service. We would like to thank Jim Schaber of the University of California Meadow Valley field camp for providing housing and logistic support for our field crew. We would also like to thank the crew at Les Schwab Tire Center, Quincy for repairing a multitude of tires, and the repair crew at Willit's Jeep.

Table 1. Total individuals captured by genera on 12 sites in the Plumas/Lassen National Forests. Number of trapnights for each site were Barrel (6), Bear Holler (6), Beesting (5), Buck (5), Cedar (5), Greenbottom (9), Gulch (5), Lassen (16), Loop (16), Soloman's Meadow (9), Steep (9), and Trippin Falls (9).

Site	Elevation (m)	*Tamias*	*Spermophilus*	*Peromyscus*	*Tamiasciurus*	*Neotoma*	*Glaucomys*	*Microtus*	Total
Barrel	1310			4	2				6
Bear Holler	1305				2		1		3
Bee Sting	1660	20		1					21
Buck	1609	9		28					37
Cedar	1362			6					6
Green Bottom	2109	149	21	14				1	185
Gulch	1499	9		4	2	4			19
Lassen	1930	185	4	99					288
Loop	1695	72	18	95	4		1		190
Soloman's Meadow	2000	4	3	18				28	53
Steep	1563	69	2	19	11			1	102
Trippin Falls	1295			25		3			28

Appendix D

prbo

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

2003 Annual Report

Ryan D. Burnett, Diana L. Humple, Geoffrey R. Geupel

PRBO Conservation Science
4990 Shoreline Highway
Stinson Beach CA 94970

PRBO Contribution # 1178

BACKGROUND and 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 has led to major changes in the amount and quality of coniferous forest habitat. Problems that the forests have faced include loss of habitat to intensive logging operations; lack of replacement of old-growth stands due to harvest rotations of insufficient length in time; changes in forest structure due to fire suppression; elimination of snags and dead trees; and fragmentation (SNEP 1996, CalPIF 2002). Bird 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 for the Sierra Nevada Forest Plan Amendment (SNFPAA 2001) directs the Forest Service to maintain and restore old forest conditions that provide crucial habitat for a number of plant and animal species. Certain taxa are emphasized in this strategy because of their dependence on old forest habitat attributes. Simultaneously, the Forest Service is taking steps to reduce risks of catastrophic fire by removing vegetation and reducing fuel loads in overstocked forests. Achieving all of these potentially competing goals as well as meeting other demands placed on Sierra Nevada forests is a challenging task.

The SNFPAA Record of Decision called for an administrative study to test the effects of various forest management actions, intended to reduce fuels and re-introduce natural fire regimes, on California Spotted Owl populations and other components of old forests. In investigating this issue, valuable feedback can be gained by determining how the full complement of the avian community will respond 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?

Here we report on the progress of the landbird study module, one of an integrated series of studies 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).

In addition to this study PRBO has been monitoring songbird populations in the Northern Sierra since 1997. In the last three years these efforts have focused on assessing the importance of mountain meadows and montane shrub habitats to the bird community (Burnett and Humple 2003, Humple and Burnett 2004). In particular our efforts have focused on bird response to meadow restoration and removal of grazing, as well as assessing the value of clear-cut regenerations, basically large groups, to shrub dependent bird species. In 2004, we will commence two new monitoring efforts assessing bird response to hardwood enhancement projects. In the Eagle Lake Ranger District we will be monitoring the effects of Aspen enhancement through removal of encroaching conifers and fencing to eliminate grazing pressure. In the Almanor Ranger District we are assessing the effectiveness of forest thinning to promote regeneration of Black Oak and other shade intolerant forest tree and shrub species. Working closely with the project planners from both of these Ranger Districts these projects, along with the Plumas-Lassen administrative study, are being implemented as adaptive management experiments and will ideally act as effective models of collaboration between science and managers in administering public lands in the Sierra Nevada.

OBJECTIVES

The primary objective of our module is to assess the effectiveness of forest management practices in sustaining a long-term ecologically stable forest ecosystem by using songbirds as management indicators. We intend to monitor the distribution and abundance of birds across the landscape in response to changes in forest structure and composition as determined by vegetation growth/succession and by human-induced treatments. Will forest structure and composition resulting from a combination of continuous vegetative growth and specific management regimes create conditions capable of sustaining stable avian communities?

We are principally interested in measuring the response of variables over large geographic areas and over relatively long time periods. The reason for this is rooted in the rate and extent of treatments combined with the rate and extent of vegetation growth. This landscape-scale study endeavors to determine the impact to the bird community of forest treatments at various temporal and spatial scales.

In order to meet these objectives we will measure population trends at several different scales, including the watershed and treatment unit scale, to determine change in abundance and presence/absence of a suite of species. In addition we will build predictive models that can associate habitat conditions with expected avian species abundance. In addition to assessing population trends and determining habitat associations of landbirds at various scales within the study area, we will determine the influence of current forest management and succession in these observed trends. What are the site-specific changes in bird community composition and abundance in response to treatments over time, and are these changes those predicted by our habitat association models?

Our approach allows us to determine the trajectory, or trend, of the populations of many of the bird species within the study area over time, predict the habitat associations most important to those species, and determine the impact of forest treatments in the observed trends. By monitoring a suite of species our results are likely to provide information on the state of the overall system as apposed to one particular aspect, such as old growth. When interpreted properly this information will provide the Forest Service with a key tool for assessing the efficacy of proposed management actions across the northern Sierra forests, providing the information necessary to assess current management and provide ways to improve it in the future.

METHODS

General sampling method

We are using standardized five-minute variable circular plot (VCP) point count censuses (Buckland 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.

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 double observer 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 range finder to calibrate distances at each point before starting a survey.

Vegetation sampling methods

Vegetation will be assessed once every 3 years at untreated sites and once before and after treatment at treated sites and then every 3 years the initial post treatment assessment. 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 Analyses
We analyzed point count data in order to create preliminary 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., such as raptors, waterfowl, grouse, nightjars, swallows, crows, ravens, Band-tailed Pigeon, Belted Kingfisher, American Dipper). It is important to bear in mind that this data should be considered a preliminary result. It would be inappropriate to use one year of data to rank the importance or quality of any individual site over another. With future years of data collection and more complex analysis techniques we will be better able to assess the importance of particular sites as well as habitat types and features for songbird populations in the study area.

We present the mean by point (average per point per visit 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 per visit.

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.

GIS Project for Creating Species Maps
We created a GIS project incorporating all the bird data from this project collected in 2003 (CD Supplement A). This tool can be used by land managers to generate distribution maps for all species breeding within the ARD (see Appendices 5 and 6 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 3 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.

RESULTS and DISCUSSION

In 2003 we established 33 new transects and continued surveys on 46 transects that had been established in 2002 (Table 1, Appendix 1). These 79 transects consist of 12 points each for a total of 948 point count locations surveyed in 2003 in the study area (treatment units 2-5). Of these 948 points, 840 are located in areas not-currently slated for DFPZ treatment; the remaining 108 are located within areas scheduled for treatment. The majority of DFPZ transects are located in treatment unit 4 with the remainder in treatment unit 1. As the location of additional DFPZ networks is solidified in treatment units 2, 3, and 5, and potentially elsewhere, we will add additionally transects to those sites.

Table 1. Point count transects censused by PRBO in the 2003 breeding season in the PLAS study area, by treatment unit, watershed, and treatment type (Landscape or DFPZ).

Treatment Unit	Watershed	Number of Points	Transects (by Code)	DFPZ Points	DFPZ Transects
7	Taylor Creek	24	714, 722	0	-
7	**Total**	**24**		**0**	
5	Grizzly Forebay	39	GRZ1, GRZ2, GRZ3, 522	0	-
5	Frazier Creek	45	524, 522, 513, FRC1	0	-
5	China Gulch	36	CHG1,CHG2, CHG3	0	-
5	Bear Gulch	36	BEG1,523,514	0	-
5	Haskins Valley	36	D501, HAV1, HAV2	0	-
5	Red Ridge	36	RED1, RED2, RED3	0	-
5	**Total**	**228**			
4	Silver Lake	41	SIL1, SIL2, SIL3, D405	24	D407, D409
4	Meadow Valley Creek	51	414, MVY1, MVY2, D404	0	-
4	Deanes Valley	36	424, 413, 422,	0	-
4	Snake Lake	36	SNK1,SNK2,SNK3	12	D403
4	Miller Fork	36	MIF1, MIF2, MIF3	24	D408, D401
4	Pineleaf Creek	19	423, D405	12	D402
4	**Total**	**219**		**72**	
3	Rush Creek	64	313,322,324,RUS1,314,222	0	-
3	Soda Creek	0		0	-
3	Halsted Flat	36	HAL1, HAL2, HAL3	0	-
3	Lower Spanish Creek	36	323, SPC1, SPC2	0	-
3	Indian Falls	12	IND1	0	-
3	Black Hawk Creek	12	BLH1	0	-
3	**Total**	**160**		**0**	**-**
2	Mosquito Creek	36	MSQ1, MSQ2, 214	0	-

Treatment Unit	Watershed	Number of Points	Transects (by Code)	DFPZ Points	DFPZ Transects
2	Butt Valley Reservoir	36	BVR1, BVR2, BVR3	0	-
2	Ohio Creek	41	OHC1, OHC2, 223, 213	0	-
2	Seneca	45	224, SEN1, 222,314, 213	0	-
2	Caribou	24	CAR1, CAR2	0	-
2	**Total**	**182**		**0**	**-**
1	Coon Hollow	6	122	0	-
1	Philbrook	6	122	0	-
1	Upper Butte Creek	0	114,122	6	D109, HUSU
1	Grizzly Creek	2	214	9	D109, HUSU
1	Upper Yellow Creek	12	114	19	D107, D102
1	Soda Creek	0		2	HUSU
1	**Total**	**27**		**36**	
	Grand Total	**840**		**108**	

A total of 92 species were detected during point count surveys within the study area in 2003 (Appendix 2). We determined breeding bird diversity, richness, and abundance at all sites surveyed in 2003 (Table 2). Additionally, we included indices for transects that were surveyed in both years. All three of the population indices were lowest at the 214 transect and highest at the 313 transect. Abundance (the average number of individuals detected within 50 meters from each point in the transect on a given visit) ranged from a 1.63 to 7.58. Species richness ranged from 2.25 to 10, and ecological diversity ranged from 2.07 to 9.14.

Table 2. Mean abundance, ecological diversity, and species richness for all point count transects surveyed by PRBO in the Plumas/Lassen area study in 2003.

	Treatment	Abundance		Diversity		Richness	
Transect	Unit	2003	2002	2003	2002	2003	2002
114	1	3.58	7.63	4.15	7.41	4.58	8.42
122	1	4.17	3.33	3.26	3.88	3.42	4.17
Total	**1**	**3.88**	**5.48**	**3.71**	**5.65**	**4.00**	**6.30**
213	2	5.13	1.89	5.49	2.17	6.17	2.29
214	2	1.63	3.92	2.07	5.13	2.25	5.58
222	2	5.25	4.46	7.06	5.52	7.58	6.08
223	2	6.29	6.04	6.47	7.77	7.33	8.58
224	2	3.21	4.50	4.02	5.63	4.33	6.08
MSQ1	2	2.79	NS	3.79	NS	4.08	NS
MSQ2	2	2.75	NS	3.21	NS	3.50	NS
BVR1	2	5.17	NS	4.69	NS	5.42	NS
BVR2	2	3.63	NS	5.00	NS	5.33	NS
BVR3	2	4.67	NS	5.70	NS	6.25	NS
OHC1	2	3.00	NS	4.00	NS	4.33	NS
OHC2	2	4.08	NS	5.06	NS	5.58	NS
SEN1	2	3.00	NS	3.76	NS	4.08	NS
CAR1	2	3.42	NS	4.04	NS	4.42	NS

Transect	Treatment Unit	Abundance 2003	Abundance 2002	Diversity 2003	Diversity 2002	Richness 2003	Richness 2002
CAR2	2	2.50	NS	3.66	NS	3.83	NS
Total	**2**	**3.77**		**4.53**		**4.97**	
313	3	7.58	3.67	9.14	4.65	10.00	5.08
314	3	4.42	4.08	5.89	3.70	6.42	3.75
322	3	3.38	4.63	4.88	6.02	5.17	6.58
323	3	2.79	5.33	4.52	7.28	4.67	7.92
324	3	3.83	4.54	4.69	6.45	5.17	6.83
BLH1	3	2.42	NS	3.00	NS	3.25	NS
HAL1	3	3.46	NS	5.32	NS	5.58	NS
HAL2	3	3.92	NS	4.68	NS	5.17	NS
HAL3	3	6.96	NS	6.75	NS	7.67	NS
IND1	3	4.13	NS	5.06	NS	5.50	NS
RUS1	3	5.83	NS	6.94	NS	7.75	NS
SPC1	3	3.29	NS	4.48	NS	4.75	NS
SPC2	3	4.25	NS	5.18	NS	5.75	NS
Total	**3**	**4.33**		**5.43**		**5.91**	
413	4	2.83	5.83	2.53	7.15	2.58	7.83
414	4	4.38	6.79	6.13	7.87	6.50	8.58
422	4	4.54	4.29	4.82	5.49	5.42	5.92
423	4	3.29	4.58	4.11	6.38	4.50	6.75
424	4	5.46	5.75	6.80	7.22	7.42	8.00
MIF1	4	4.00	NS	5.08	NS	5.50	NS
D404	4	6.50	4.96	7.42	6.65	8.33	7.08
D405	4	4.79	4.46	6.44	5.97	7.00	6.50
MIF2	4	5.67	NS	6.76	NS	7.42	NS
MIF3	4	5.21	NS	5.25	NS	6.17	NS
MVY1	4	4.75	NS	6.38	NS	6.92	NS
MVY2	4	5.58	NS	6.42	NS	7.08	NS
SIL1	4	5.17	NS	5.91	NS	6.67	NS
SIL2	4	5.13	NS	6.54	NS	7.17	NS
SIL3	4	2.29	NS	3.63	NS	3.75	NS
SNK1	4	4.25	NS	4.91	NS	5.50	NS
SNK2	4	4.54	NS	5.79	NS	6.33	NS
Total	**4**	**4.61**	**-**	**5.58**	**-**	**6.13**	**-**
513	5	3.00	5.38	4.09	6.33	4.33	6.92
514	5	5.75	2.46	5.04	4.11	5.17	4.25
522	5	5.63	5.50	6.70	6.89	7.25	7.67
523	5	3.33	3.54	5.51	4.94	5.75	5.25
524	5	2.79	4.42	3.86	5.95	4.08	6.42
BEG1	5	3.42	NS	4.15	NS	4.42	NS
CHG1	5	3.46	NS	4.63	NS	5.08	NS

Transect	Treatment Unit	Abundance		Diversity		Richness	
		2003	2002	2003	2002	2003	2002
CHG2	5	6.67	NS	7.46	NS	8.25	NS
CHG3	5	3.54	NS	4.79	NS	5.17	NS
FRC1	5	5.25	NS	6.42	NS	7.08	NS
GRZ1	5	3.92	NS	4.61	NS	4.92	NS
GRZ2	5	3.58	NS	5.34	NS	5.67	NS
GRZ3	5	4.71	NS	6.58	NS	7.08	NS
RED1	5	4.75	NS	5.43	NS	5.92	NS
RED2	5	3.00	NS	4.85	NS	5.08	NS
RED3	5	4.13	NS	5.88	NS	6.25	NS
D501	5	4.21	NS	5.18	NS	5.75	NS
HAV1	5	5.75	NS	6.88	NS	7.67	NS
HAV2	5	4.92	NS	6.73	NS	7.25	NS
Total	**5**	**4.31**		**5.48**		**5.90**	
722	7	2.92	2.33	3.69	3.47	4.00	3.58
714	7	3.54	3.79	4.57	5.17	4.83	5.58
Total	**7**	**3.23**	**3.06**	**4.13**	**4.32**	**4.42**	**4.58**
DFPZ							
D102	1	3.54	5.29	4.70	5.20	5.00	5.92
D107	1	3.50	4.25	4.89	5.80	5.25	6.17
D109	1	5.71	6.13	6.43	7.96	7.08	8.67
HUSU	1	5.58	5.00	7.24	6.36	7.83	6.83
Total	**1**	**4.58**	**5.17**	**5.82**	**6.33**	**6.29**	**6.90**
D401	4	4.21	6.79	4.52	8.01	5.00	8.75
D402	4	4.13	4.71	5.15	6.24	5.58	6.75
D403	4	3.79	3.71	5.23	5.09	5.58	5.42
D407	4	3.46	4.42	5.08	5.90	5.33	6.33
D408	4	5.88	4.50	6.95	6.20	7.58	6.75
D409	4	1.92	NS	2.85	NS	3.00	NS
Total	**4**	**3.90**		**4.96**		**5.35**	

Species Abundance by Treatment Unit

We compared species abundance between treatment units (Table 3), and found that in 2003, Hermit Warbler was the most abundant species in treatment units two, four, and five reaching its highest abundance in unit four. Audubon's Warbler was the most abundant species in unit three. A total of thirteen species comprised the ten most abundant species in these four units. Two, three, and five each had one unique species among their ten most abundant species, while unit four did not have any unique species. The three unique species to a unit were Hammond's Flycatcher in unit two, MacGillivray's Warbler in unit three, and Spotted Towhee in unit five. It should be noted that these are data from one year of surveys and indices may vary annually.

Though little if any treatment has been implemented within the study area to date, the data collected in 2002 and 2003 is valuable for assessing pre-existing conditions and honing our study design in order to meet our objectives, thus forming the baseline for this long-term study.

With additional years of data collection we will build habitat association models to determine the factors influencing the abundance and distribution of a suite of forest songbird species in the study area. Following implementation of treatments we will assess the impact on the avian community.

Table 3. The mean abundance per point of the ten most abundant species in each treatment unit. Mean abundance is the average number of individuals per point per visit in 2003.

Treatment Unit 2		**Treatment Unit 3**	
Species	**Mean Abundance**	**Species**	**Mean Abundance**
Hermit Warbler	0.60	Audubon's Warbler	0.44
Nashville Warbler	0.41	Oregon Junco	0.40
Oregon Junco	0.33	Golden-crowned Kinglet	0.37
Fox Sparrow	0.27	Hermit Warbler	0.32
Mountain Chickadee	0.27	Mountain Chickadee	0.32
Audubon's Warbler	0.27	Red-breasted Nuthatch	0.23
Hammond's Flycatcher	0.22	Fox Sparrow	0.22
Dusky Flycatcher	0.21	Dusky Flycatcher	0.20
Golden-crowned Kinglet	0.21	MacGillivray's Warbler	0.16
Western Tanager	0.19	Western Tanager	0.16
Treatment Unit 4		**Treatment Unit 5**	
Species	**Mean Abundance**	**Species**	**Mean Abundance**
Hermit Warbler	0.64	Hermit Warbler	0.50
Audubon’s Warbler	0.39	Nashville Warbler	0.48
Oregon Junco	0.30	Mountain Chickadee	0.32
Mountain Chickadee	0.30	Oregon Junco	0.29
Nashville Warbler	0.25	Western Tanager	0.24
Western Tanager	0.24	Audubon's Warbler	0.23
Golden-crowned Kinglet	0.19	Fox Sparrow	0.21
Red-breasted Nuthatch	0.19	Spotted Towhee	0.21
Fox Sparrow	0.17	Golden-crowned Kinglet	0.19
Dusky Flycatcher	0.14	Red-breasted Nuthatch	0.18

GIS Project for Creating Bird Abundance and Distribution Maps

We have created a GIS project that can be used to generate maps of site-specific avian community indices as well as the abundance of every species detected within the study area. These data are a valuable resource that can be used by project planners on the location of species of interest, including sensitive species and management indicators.

Appendix 3 provides directions in how to create GIS maps based on the bird data. We created two sample maps that are presented in Appendices 4 and 5, for overall species richness in treatment unit 4, and for Olive-sided Flycatcher abundance in units 4 and 5. Similar maps for any other species detected, as well as for all community indices (species richness, ecological diversity, and bird abundance), can be created following our directions and using the ArcView project located in CD Supplement A.

PERSONNEL

This project is coordinated and supervised by PRBO staff biologist Ryan Burnett. Field work in 2003 was conducted by Ryan Burnett, Jim Destaebler, Eric Leibgold, Kim Maute, Tami Ransom, Chris Rintoul, Andrew Rothman, and Doug Zimmerman. PRBO staff biologists Diana Stralberg and Lazarus Pomara organized GIS resources. Computer programs used to manage and summarize data were created by PRBO staff biologists Grant Ballard, Dan Barton, and Mike Lynes. The study was carried out under the guidance of PRBO Terrestrial Program Director Geoffrey R. Geupel, PRBO Population Ecologist Nadav Nur, and Peter Stine of the PSW Sierra Nevada Research Center.

ACKNOWLEDGEMENTS

Funding for this project is provided by the Pacific Southwest Research Station and Region 5 of the U.S. Forest Service, and the National Fire Plan. We are grateful to Jim Schaber of the University of California Meadow Valley Field Camp for his kindness and generosity in providing housing and logistical support. This is PRBO contribution 1178.

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Appendix 1. Transects point counted by PRBO in the Plumas-Lassen Study Area in 2003 (the first digit in the numbered transect refers to treatment unit, the other transects are abbreviations of the watershed they are in, e.g. HAL1 is in the Halsted Flat watershed).

Transect	First Visit	Second Visit	Transect	First Visit	Second Visit
114	6/12/2003	6/28/2003	D404	5/26/2003	6/25/2003
122	6/14/2003	1 visit only	D405	5/27/2003	6/21/2003
213	6/1/2003	6/21/2003	D407	5/31/2003	6/16/2003
214	6/2/2003	6/15/2003	D408	5/30/2003	6/21/2003
222	5/29/2003	6/20/2003	D409	6/4/2003	6/16/2003
223	5/27/2003	6/19/2003	D501	6/6/2003	6/24/2003
224	5/28/2003	6/18/2003	FRC1	6/11/2003	6/26/2003
313	5/28/2003	6/20/2003	GRZ1	6/7/2003	6/23/2003
314	5/29/2003	6/20/2003	GRZ2	6/7/2003	6/23/2003
322	5/28/2003	6/20/2003	GRZ3	6/7/2003	6/23/2003
323	5/30/2003	6/22/2003	HAL1	5/27/2003	6/16/2003
324	6/2/2003	6/27/2003	HAL2	5/27/2003	6/18/2003
413	5/30/2003	1 visit only	HAL3	5/27/2003	6/18/2003
414	5/25/2003	6/29/2003	HAV1	6/6/2003	6/24/2003
422	6/7/2003	6/22/2003	HAV2	6/10/2003	6/24/2003
423	5/25/2003	6/13/2003	HUSU	6/14/2003	6/30/2003
424	5/25/2003	6/25/2003	IND1	5/29/2003	6/24/2003
513	6/10/2003	6/25/2003	MIF1	6/4/2003	6/19/2003
514	7/2/2003	1 visit only	MIF2	6/5/2003	6/26/2003
522	6/12/2003	6/28/2003	MIF3	6/4/2003	6/19/2003
523	6/19/2003	6/29/2003	MSQ1	5/28/2003	6/17/2003
524	6/10/2003	6/25/2003	MSQ2	6/2/2003	6/17/2003
714	6/11/2003	6/29/2003	MVY1	6/5/2003	6/18/2003
722	6/11/2003	6/27/2003	MVY2	6/8/2003	6/25/2003
BEG1	6/11/2003	6/23/2003	OHC1	5/27/2003	6/19/2003
BLH1	5/25/2003	6/16/2003	OHC2	6/1/2003	6/20/2003
BVR1	5/28/2003	6/27/2003	RED1	6/11/2003	6/23/2003
BVR2	5/29/2003	6/16/2003	RED2	6/6/2003	6/26/2003
BVR3	6/9/2003	6/27/2003	RED3	6/15/2003	6/27/2003
CAR1	5/28/2003	6/16/2003	RUS1	5/29/2003	6/27/2003
CAR2	6/2/2003	6/20/2003	SEN1	5/28/2003	6/18/2003
CHG1	6/15/2003	6/27/2003	SIL1	6/8/2003	6/21/2003
CHG2	6/10/2003	6/23/2003	SIL2	6/5/2003	6/30/2003
CHG3	6/10/2003	6/25/2003	SIL3	6/8/2003	6/21/2003
D102	6/14/2003	6/30/2003	SNK1	6/4/2003	6/17/2003
D107	6/12/2003	6/28/2003	SNK2	6/4/2003	6/17/2003
D109	6/14/2003	6/30/2003	SNK3	6/4/2003	6/17/2003
D401	5/30/2003, 6/1/2003	6/21/2003	SPC1	5/24/2003	6/16/2003
D402	5/25/2003	6/18/2003	SPC2	5/30/2003	6/24/2003
D403	5/27/2003	6/17/2003			

Appendix 2. List of all bird species detected by PRBO on point count surveys (common, AOU code, scientific name) in the PLAS in 2002 and 2003.

Common Name	AOU Code	Scientific Name
Acorn Woodpecker	ACWO	*Melanerpes formicivorus*
American Crow	AMCR	*Corvus brachyrhynchos*
American Dipper	AMDI	*Cinclus mexicanus*
American Kestrel	MAKE	*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 passerina*
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*
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*
Vaux’s Swift	VASW	*Chaetura vauxi*

Common Name	AOU Code	Scientific Name
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 3. Details on Supplement A ArcView Project for building species maps

I. PRIMARY ARCVIEW FILES

2003reportsupplement.apr - ArcView project file. Double click this file to open the project.

PLASabsum03l50 - table which contains one line of data per point with all associated bird data, 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: Statistical Analysis*). This has been imported into an ArcView project file. It means "Point count abundance summary for birds less than 50 m from the observer".

PLASabsum03all - 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."

With this 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).

II. 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 = number of total point count visits done at that point; in 2003 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*)

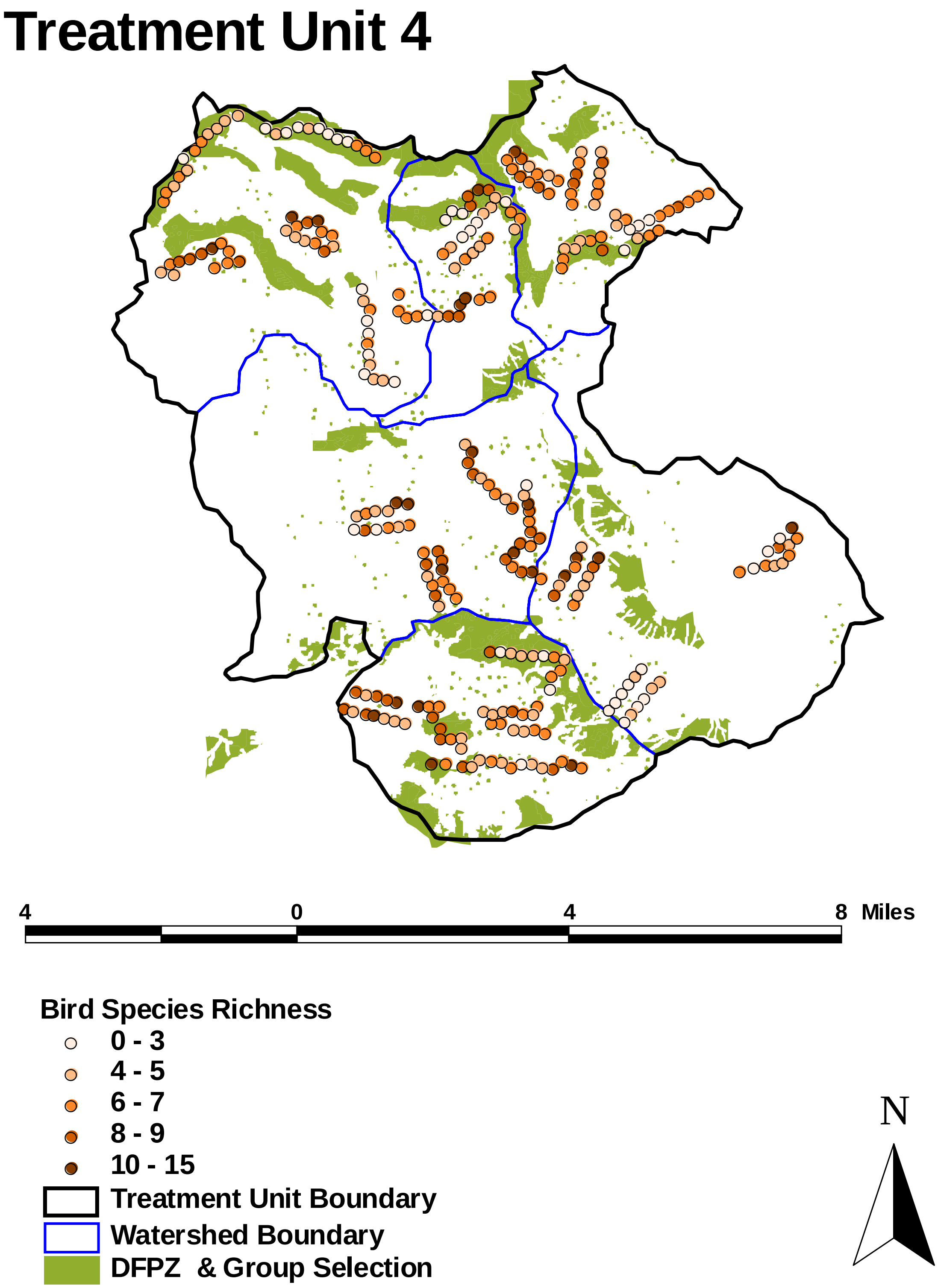
"SPEC"AB = multiple fields, detailing number of individuals of each species at each point (averaged across visits). Uses AOU 4-letter codes for each bird species, combined with "AB" for abundance (e.g., Audubon's Warbler abundance is delineated as *AUWAAB*). See Appendix 2 for explanation of all 4-letter bird species codes. This is done for 61 species within 50 meters (PLASabsum03L50.dbf) and 92 species when including all detections (PLASabsum03all.dbf).

Appendix 3, continued

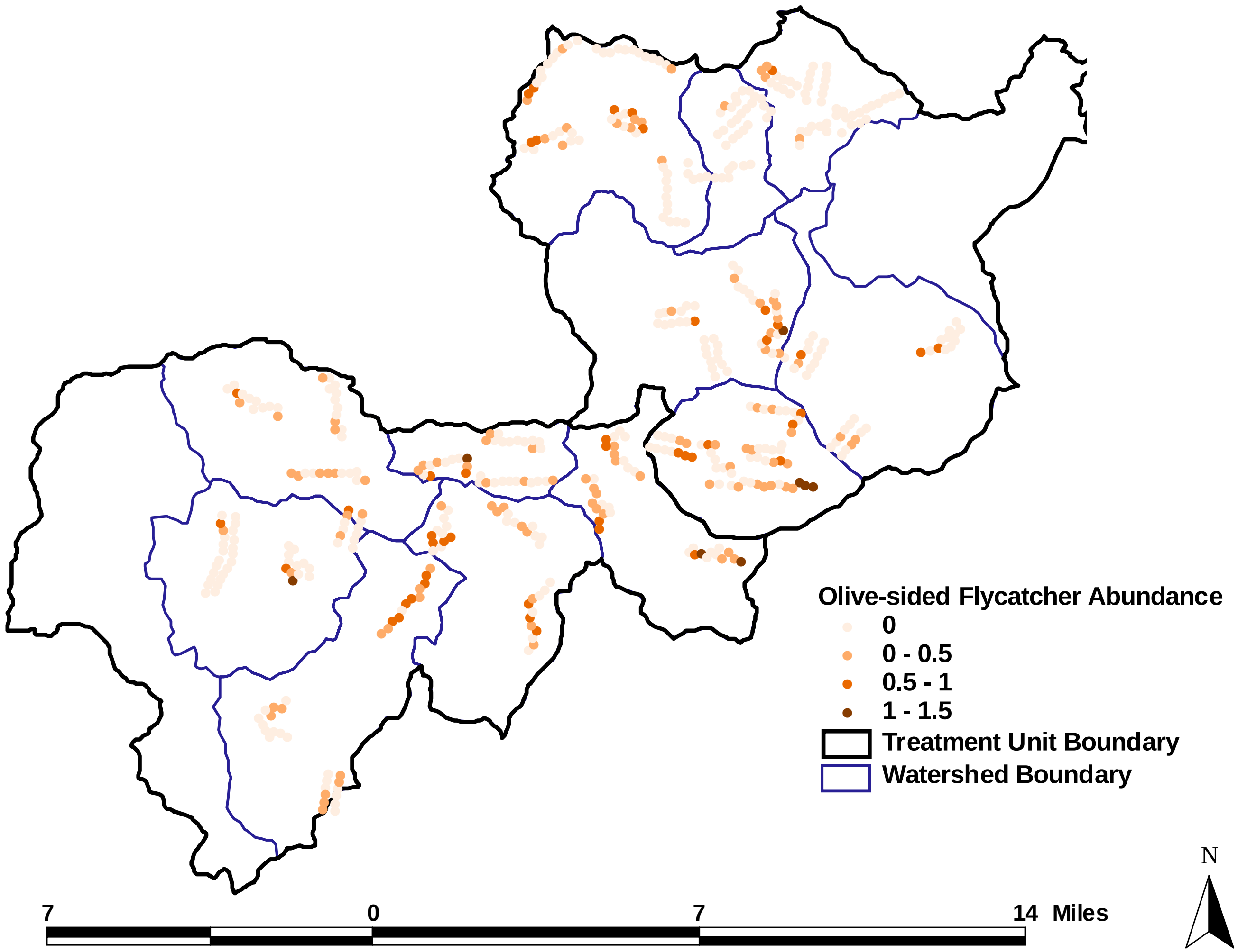
III. HOW TO GENERATE ABUNDANCE MAPS BY SPECIES

1. Save all files on the CD onto hard drive
2. Open **2003reportsupplement.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 or PLASabsum03all.dbf); 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 4. Sample ArcView Project Map of bird species richness in treatment unit 4 of the PLAS study area in 2003.



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



16 March 2004

Appendix E

California Spotted Owl Module

Principal Investigator:

Dr. John J. Keane
Sierra Nevada Research Center
Pacific Southwest Research Station
U.S. Forest Service
2121 2nd Street, Suite A-101
Davis, CA 95616
530-759-1704; jkeane@fs.fed.us

Team Members:

Paula A Shaklee, Dan L. Hansen, Claire V. Gallagher: Field Project Leaders
Sean A. Parks: GIS

Sierra Nevada Research Center
Pacific Southwest Research Station
U.S. Forest Service
2121 2nd Street, Suite A-101
Davis, CA 95616
530-759-1700;
pashaklee@fs.fed.us, danhansen@fs.fed.us, cgallagher@fs.fed.us, sean_parks@fs.fed.us

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 (Verner et al. 1992, Franklin et al. 2004, USDA 2004). Current fuels management concepts propose treatments at the landscape spatial scale, such as DFPZs and SPLATs, designed to modify fire behavior and facilitate suppression efforts. Resulting changes in vegetation structure and composition from treatments may affect CSOs and their habitat at multiple spatial and temporal scales. The goal of this module is to assess the effects of fuels and vegetation treatments on CSOs and important resources, such as vegetation and prey, that affect CSO distribution, abundance and population dynamics.

Habitat is operationally defined as the physical space occupied by an animal and the biotic and abiotic factors (e.g., resources) in that space (Morrison and Hall 2002). Habitat quality refers specifically to the ability of an area to provide conditions appropriate for individual and population persistence (Morrison and Hall 2002). Habitat selection is a hierarchical process by which an individual animal selects habitat to use at multiple scales. These scales range from the geographic range of a species, to use of an individual home range within the range, to use of vegetation patches within a home range, to use of specific resources (e.g., prey species, nest cavities) within vegetation patches (Johnson 1980). The multiple-scale nature of habitat selection indicates that the criteria for selection may be different at each scale, and that inferences garnered at each scale can have ramifications for understanding habitat relationships and subsequent development of management direction (Manly et al. 2002). Additionally, for species regulated by territorial behavior, including raptor species such as CSOs, population-level constraints can influence the density and distribution of individuals or breeding pairs, through territorial behavior and competition for space and resources. At the landscape-scale, raptor populations regulated by territorial behavior that are near carrying capacity exhibit a more-or-less regular distribution of territorial breeding pairs, with individual pair locations influenced by local habitat conditions, and landscape breeding density influenced by landscape distribution of habitat (Newton 1979).

The implications of habitat selection at the individual animal scale and of territorial regulation at the population level dictate that research seeking to understand landscape treatment effects should address habitat use and quality at the individual pair scale, as well as, population density and habitat relationships at the landscape-scale, to fully assess the effects of landscape fuels and vegetation management strategies. Current management direction is proposing landscape-scale treatment regimes to address fire and fuels issues, timber harvest, and vegetation restoration. It is necessary that research address management effects on CSOs at the appropriate scales at which management is being conducted. Proposed landscape treatments may have effects at either, or both, the individual territory or owl site scale as expressed through change in occupancy, diet, use of vegetation patches, survival or reproduction, or at the population level as expressed through change in the density or spatial distribution of territorial breeding pairs at the landscape-scale. The individual site scale and population level perspectives are complementary in that the population level provides context for interpreting change at the site scale. Most importantly, both perspectives are required by managers concerned with managing for high habitat quality sites, as well as, well-distributed, viable populations across landscapes while implementing management strategies to deal with large-scale fire and fuels issues.

Study Objectives

The overall objective of this module is to monitor the response of CSOs to full implementation of the landscape management strategy developed in the Herger- Feinstein Quincy Library Group (HFQLG) Act as called for in the Record of Decision for the Final Supplemental Environmental Impact Statement (USDA 2004). The CSO module is designed to provide information on treatment effects at the individual territory and population level scales, as described below under the specific questions.

From an experimental design perspective, establishing strong inferences regarding cause-effect relationships requires a rigorous experimental-control design with treatment and control experimental units under which the investigator attempts to control for extraneous variables and isolate treatment effects. Conducting rigorous experimental work at the landscape and home-range scale in nature is particularly challenging due to inherent variation at multiple spatial scales, lack of replication, particularly at the landscape scale, and prohibitive cost. A rigorous experimental approach also requires a working collaborative relationship between researchers and managers and the political will to prioritize treatment implementation in time and space to meet experimental design needs. In this project, treatments will be implemented in time and space by the USDA Forest Service as dictated by multiple management objectives surrounding full implementation of the HFQLG Act, and not prioritized to meet research objectives. This type of treatment application limits the strength of the resulting inferences that can be drawn regarding cause and effect relationships. Therefore, our research approach is designed to maximize the types of information that can be gained under an experimental context where the spatial and temporal application of treatments is not under control of the investigators.

The following objectives and questions will be addressed:

1) How do landscape-scale treatment regimes affect CSO density and habitat suitability at the landscape-scale?

2) How do fuels treatments and group selection harvest affect CSO occupancy, diet, reproduction, survival, and habitat fitness potential at the nest site, core area and home range scales?

3) How do fuels treatments and group selection affect diet, habitat use and home-range size and configuration?

Question 1: How do landscape-scale treatment regimes affect CSO density and habitat suitability at the landscape-scale?

Landscape vegetation patterns are a primary determinant of the density and distribution of spotted owls. Treatment regimes, along with natural disturbances, historical context and local conditions, are expected to result in differing landscape vegetation patterns across treatment units over time. Differences in vegetation patterns are expected to result in differences in the distribution, abundance, and quality of owl habitat at the landscape and home-range spatial scales. This question addresses owl population responses at the landscape scale and how owl density, distribution, population dynamics and habitat suitability are affected by the cumulative treatments and natural disturbances, and resultant landscape vegetation patterns. The general approach will have 2 major components: (1) monitor the number and location of territorial owl pairs and territorial singles over time within a subset of treatment units (TU) and (2) develop a habitat suitability model to assess how habitat suitability and owl numbers are projected to change as a result of treatments. The approach will be adaptive and based on an iterative process of habitat model development, predictions of treatment effects on owl density and habitat suitability, monitoring of treatment effects and model predictions, revision of habitat model as necessary, followed by the next iteration of the process. The goal is to assess treatment effects on CSO populations and their habitat within a habitat-modeling framework designed to improve understanding of wildlife habitat relationships and provide land managers with a tool to predict the effects of management actions on CSOs and their habitat.

CSO density will be estimated annually in each TU using extensive broadcast calling and intensive status surveys to determine owl CSO occupancy and social status. The target population is the territorial pairs and single CSOs within each TU. Each TU is mapped with polygons that conform to natural sub-watershed boundaries and are approximately the size of the core area of an individual owl pair. This size was used because it is large enough to potentially contain only one pair of owls. The sampling frame consists of the collection of polygons, with polygons functioning as the primary sample units (PSUs). Annual surveys will be conducted in each PSU with a combination of intensive status surveys and a maximum of 4 extensive broadcast call surveys. All CSO encountered will be captured and marked with a unique color band to allow subsequent identification of individual CSOs (Franklin et al. 1996). Mark-recapture techniques and reverse-time models will be used to estimate population trends, survival, and recruitment based on uniquely banded CSOs and to estimate trends in occupancy based on the polygon surveys across the study area, within TUs and to compare these parameters between treated and untreated CSO territories (Nichols 1992, Pradel 1996, Nichols et al. 2000).

Habitat models will be developed using resource selection functions to predict CSO habitat suitability and population numbers (Manly et al 2002) across the study area and TUs, and to project changes in habitat suitability resulting from treatments (Zabel et al. 2003). Logistic regression will be used to compare CSO territory locations to available habitat at multiple scales to develop a statistical function for assessing habitat suitability. A priori models will be identified and an information theoretic approach will be used to identify the best models (Burnham and Anderson 1998). An iterative process of model development, field-testing of predictions, and model refinement will be used in adaptive framework to improve knowledge of CSO habitat relationships and project potential management effects.

Question 2: California spotted owl diet, survival, reproduction, and habitat fitness potential at nest-site, core area, and home-range scales.

Habitat patterns at within home-range scales affect owl occurrence and demographic responses. The objectives at the home-range scale are: (1) determine owl habitat-use patterns and habitat selection; and (2) determine if there are differences in habitat quality or habitat fitness potential (i.e., owl survival and reproduction) associated with variation in habitat patterns. Each of the above questions will be assessed hierarchically at the nest-site, core area, and home-range scales within each owl home-range, as stronger associations between owl occurrence, demographic responses and habitat occur at the nest-site and core areas spatial scales within home ranges (Lehmkuhl and Raphael 1993, North et al. 2000, Franklin et al. 2000).

Extensive broadcast surveys and status surveys will be used to locate all owl pairs within treatment units as described above under Question 1. Reproductive status will be determined each year at each territory and all owls will be banded with unique color-bands (Franklin et al 1996). Pellets and prey remains will be systematically collected at nest-sites and roosts to determine diets. Habitat at nest-sites (plot data) will be measured following a modified FIA protocol. Habitat at the core area and home-range scales will be assessed using aerial PI vegetation information. Habitat-use and selection patterns will be ascertained by comparing habitat at owl sites versus random or unoccupied sites using logistic regression models, classification and regression tree models, and an information-theoretic approach to model selection (Burnham and Anderson 1998). Habitat fitness potential, or habitat quality, will be assessed by relating survival and reproduction to habitat patterns and additional explanatory variables, such as weather, prey abundance, and seed production, using both a components-of-variation and model selection approach (e.g., Franklin et al. 2000) and a Bayesian belief network approach (D.C. Lee, pers. comm.). Annual variation in diet will be determined and related to habitat patterns at core area and home-range scales.

Question 3: Acute responses of California spotted owls to treatment effects within core areas and home-ranges.

In addition to the chronic responses addressed in Questions 1 and 2 above, owls may also exhibit short-term, acute behavioral responses to treatments. Acute responses may range from no effect, to shifts in use of prey species or space within home ranges to territory abandonment, or to reproductive failure or death during periods or seasons of treatment implementation. Changes over longer time periods following treatments may range from no effect to shifts in habitat use patterns and prey selection within home ranges to changes in habitat quality (survival and reproduction), which at the most extreme can result in home ranges that are no longer suitable for occupancy

The objectives of this question are to determine behavioral responses and home range configuration, habitat use, and prey use patterns of a subset of owl pairs to treatments within core areas of home ranges. Radio-telemetry will be used on an estimated total of approximately 30-40 pairs of owls across treatment units to determine how the above variables change before, during, and after treatments within core areas and home ranges. Plot-scale habitat information will be collected at foraging locations using the modified FIA protocol to provide fine-scale habitat use information. The specific pairs to be included in the study will be determined pending completion of: (1) initial CSO surveys conducted over the first years of the study under Question 1 that will provide an assessment of current owl distribution and abundance across the treatment units: (2) completion of the aerial PI vegetation coverage for the study area; and (3) finalization of treatment locations within treatment units. Each of these pieces of information is needed to determine current vegetation patterns within existing owl home ranges and how each home range will be treated. This information is required to identify suitable owl territories appropriate for inclusion in the telemetry study. Therefore, this module of the overall study plan will not be implemented until the second or third year of the study after a stronger informational base is available for specifying the details of the sampling design. The design of this module of the study will require extensive cooperation between managers and researchers in the design and timing of treatment implementation to meet basic study design objectives.

Specific Objectives 2003

Current information is lacking on the distribution and abundance of California spotted owls (CSOs) within the Plumas-Lassen Administrative Study (PLAS) area, with the majority of existing CSO records recorded during 1990-1992. Understanding the current distribution and abundance of CSOs is required to determine their status, establish baseline information, provide data for developing first-generation habitat models, and for refining the spatial allocation of treatments. Our specific objectives for 2003 were to complete the survey polygon and survey point networks in the 11 Treatment Units (TU), conduct surveys in 5 TUs (2,3,4,5,7), color-band all territorial CSOs, assist the Plumas NF with the design of contract surveys for TUS 8-10, and systematically collect pellets around known roost/nest locations. Our primary objective was to develop an accurate understanding of CSO distribution and abundance in the surveyed TUs to provide the required baseline information for habitat modeling and monitoring the effects of HFQLG implementation.

Results and Accomplishments - 2003

A team of 3 field project leaders managed the field effort in 2003 along with a seasonal field crew of 16 technicians. A network of survey polygons and survey points was completed across all 11 original TUs in 2003. Each network is designed to provide 100% survey coverage of a TU. The distribution of survey points was tailored to the local topography within each TU such that points were located at prominent locations, such as ridge points, to provide efficient coverage of the TU. Points were established along roads as a first option to minimize travel time and maximize survey efficiency. Off-road, hike-in points were established as necessary to provide survey coverage of road-less areas. Point locations were recorded with a GPS and entered into a GIS, and points are field marked with flagging and a uniquely numbered metal tag. A total of 3730 survey points have been established, ranging from 166-518 per TU (Table 1).

CSO surveys were conducted on US Forests Service lands within TUs 2-5 and 7-10 during 2003. Surveys in TUs 2,3,4,5, and 7 were conducted by field crews from the Sierra Nevada Research Center, Pacific Southwest Research Station, Davis CA. Private contractors conducted surveys in TUs 8-10. All surveys adhered to the Region 5 Spotted Owl Survey Protocol (1991). Extensive broadcast surveys were conducted three (PSW) or six (Contractors) times at each survey point across the breeding period (April-August), unless owls were detected and follow-up status surveys determined territorial, pair and reproductive status. A 3-visit protocol was used in TUs previously surveyed in 2002, while a 6-visit protocol was used for the initial survey year in TUs 8-10 in 2003. Extensive surveys were terminated in the vicinity of documented pairs to minimize disturbance. Individual surveys were 10-min in duration and consisted of alternately playing spotted owl calls and listening for the first 8 minutes and then listening for the final 2 minutes. Extensive surveys were conducted using CD players and broadcast callers to minimize potential variation in calling ability across a large number of observers. We used the spotted owl calls and call sequence recommended on the PNW survey-training tapes (Eric Forsman, PNW, pers. comm.). A total of 9,499 extensive point surveys were conducted in 2003, resulting in 603 owl detections and confirmation of 70 territorial CSO pairs, singles, or unknown status pairs (Table 2, Figures 1-10). Based on clusters of detections of male and female owls and locations of historic sites recorded in the California Department of Fish and Game database, we suspect an additional 1-2 pairs of owls may be located in a few of the TUs. Surveys to be conducted in 2004 will be used to specifically evaluate pair status and location of nests or main roosts at these additional sites. We think this is especially true for TUs 8-10 where only 1 year of contractor survey information is available. A second year of surveys is required to have a confident assessment of the distribution and abundance of CSOs in these TUs. We color-banded 28 CSOs and collected approximately 500 pellets from roost/nest locations during 2003.

Discussion

Our efforts in 2003 focused on building on the initial baseline surveys conducted in 2002 on CSO distribution and abundance in a subset of the TUs. Existing information is 10-12 years old for most of study area outside of the region that overlaps with the Lassen demographic study in TUs 1 and 11. We documented 70 territorial CSO sites in 2003, plus 9 pairs confirmed in TU-1 during 2002, and suspect there may be an additional 1-2 sites in a few TUs based on clusters of male and female detections. An additional year of survey work is required to develop a more accurate estimate of the baseline number and distribution of territorial pairs that occur in TUs 7-10, since 2003 surveys were the first year these TUs have been inventoried. Survey results to date emphasize the importance of collecting current baseline information for assessing current status, providing accurate data for management and conservation planning, and generating the base data required to develop empirical habitat relationship models.

Our a priori expectation is that territorial pairs of CSOs should be distributed in a somewhat regular distribution across each TU, assuming suitable habitat is available and well distributed. This population distributional pattern is characteristic of territorial raptor species that breed as solitary pairs with populations regulated by territorial behavior (Newton 1979). Although are results are preliminary based on only one year of survey work, our results suggest that CSOs are distributed in a pattern that is consistent with our a priori expectation. Confirmed pairs and clusters of detections (possible, unconfirmed pairs) appear to be regularly distributed over most of the TUs where suitable habitat is present. Surveys on private lands within sample TUs will be conducted in 2004 to determine if gaps in some areas are actually occupied by CSOs on private lands.

Objectives - 2004

Priority objectives for 2004 are to continue CSO surveys in a subset of the original TUs and attempt to complete color-banding of all territorial CSOs within the survey areas. Efforts are under way to analyze and identify all prey items in the pellets that were collected in 2003 to assess CSO diets in the study area. Pellets will be systematically collected again in 2004 to address annual variation in diet. Evaluation of available radio-telemetry technological options is being conducted and initial field applications of radio-telemetry may be conducted in 2004. First generation predictive habitat models are being developed using the CSO data from 2003 and the vegetation map completed in 2003. Monitoring for West Nile Virus will be initiated in 2004 in conjunction with the Wildlife Genetic Laboratory at UC Davis. Collaborative efforts are being developed between the Lassen demographic study and the Plumas-Lassen Administrative Study to coordinate research efforts and efficiency.

Acknowledgements

Many people assisted our efforts in 2003. Christie Eckman and Peter Stine of the Sierra Nevada Research Center provided essential contributions to all aspects of the project. We thank Jim Schaber of the University of California Forestry Camp in Meadow Valley for support with housing and logistics. Mark Williams, Gary Rotta, Cindy Roberts, Russell Nickerson, and Dianne Arieta patiently assisted us during project implementation. Jim Pena, Ed Cole, Mark Madrid, Terri Simon-Jackson, Susan Matthews, Angie Dillingham, Jerome Caston, Rob Macwhorter, Dave Peters, Anthony Matthews, and Jim Crane provided support and guidance throughout the project.

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Table 1. Summary of the number of survey points per Treatment Unit, and the number of extensive surveys conducted and number of California spotted owl detected on extensive surveys during 2002 and 2003.

Treatment Unit	Number of Call Stations	Number of 2002 Extensive Surveys	Number of 2002 Owl Detections	Number of 2003 Extensive Surveys	Number of 2003 Owl Detections
1	518	2992	46	-[a]	-
2	339	1706	151	961	113
3	370	2027	58	1024	73
4	451	2783	97	1122	91
5	426	1803	119	1262	62
6	479	-	-	-	-
7	190	-	-	572	50
8	256	-	-	1471	42
9	276	-	-	1530	50
10	259	-	-	1557	122
11	166	-	-	-	-
Totals	**3730**	**11,311**	**471**	**9,499**	**603**

-[a] = indicates no surveys were conducted in the TU during that year.

Table 2. Summary of number of California spotted owl pairs, territorial singles and unknown pairs located by Treatment Unit during 2002 and 2003 in the PLAS study area.

Treatment Unit	Number of 2002 CSO Pairs		Number of 2003 CSO Pairs	Number of 2003 CSO Unknown Pairs	Number of 2003 Territorial Singles	2003 Total
1	9		-[a]	-	-	-
2	8		12	1	0	13
3	8		8	1	0	9
4	8		7	0	2	9
5	8		8	1	2	11
7	-		6	0	0	6
8	-		5	0	2	7
9	-		5	0	0	5
10	-		8	1	1	10
Total	**41**		**59**	**4**	**7**	**70**

-[a] = indicates no surveys were conducted in the TU during that year.

Figure 1. Summary of California spotted owl distribution by social status based on surveys during 2002 and 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

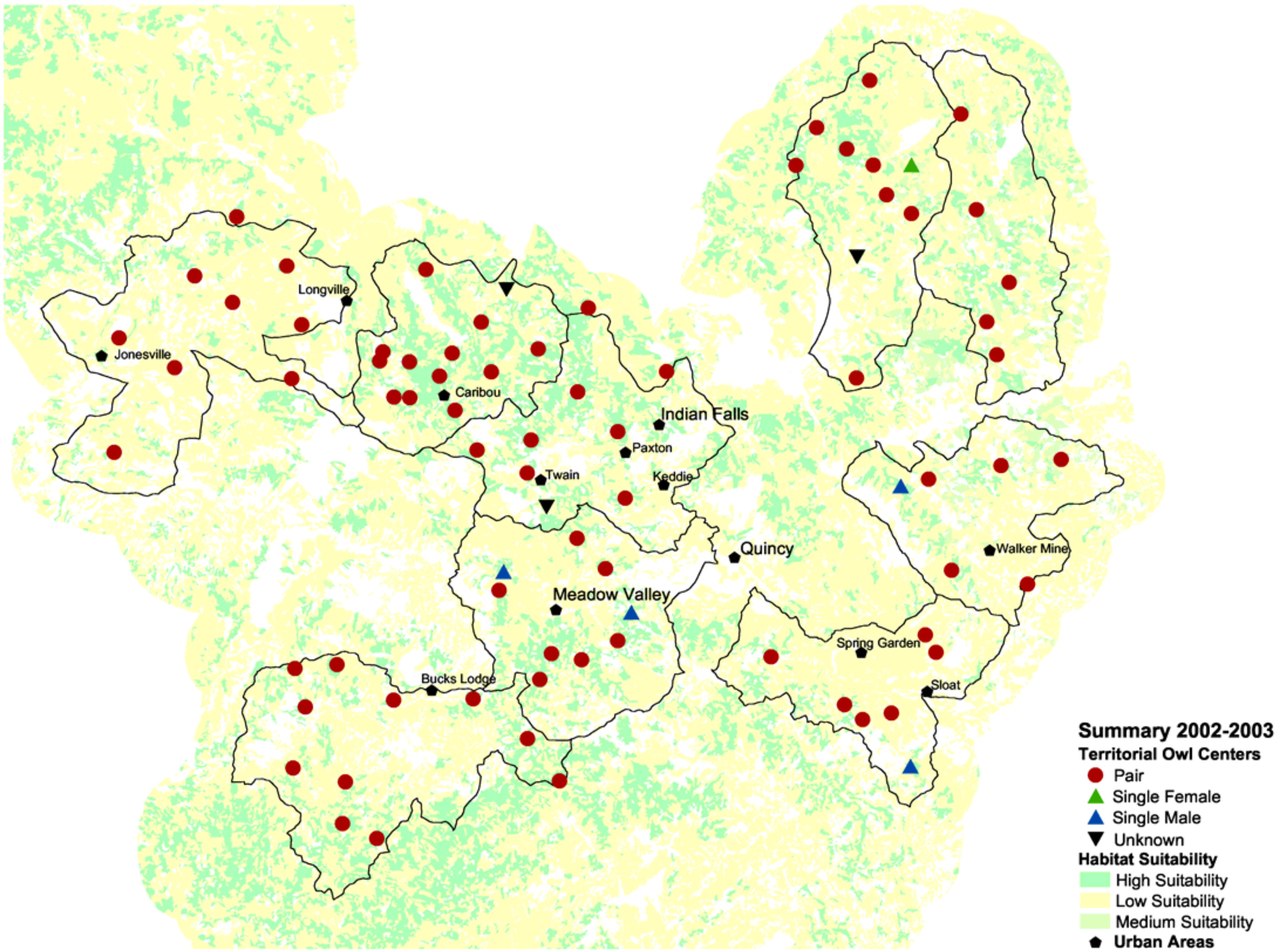


Figure 2. Distribution of California spotted owls detected on surveys conducted during 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

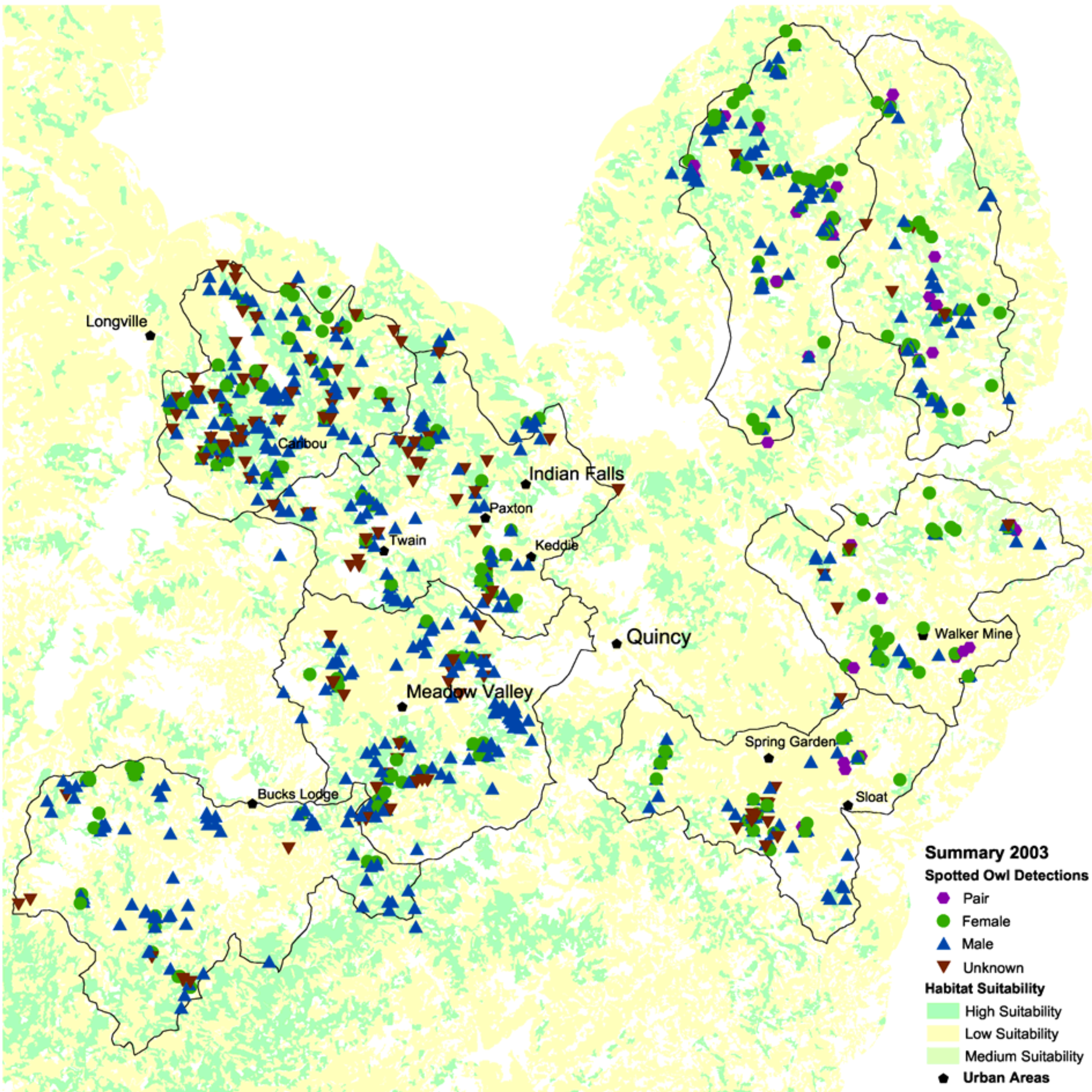


Figure 3. Distribution of California spotted owls detected in Treatment Unit 2 during surveys conducted in 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

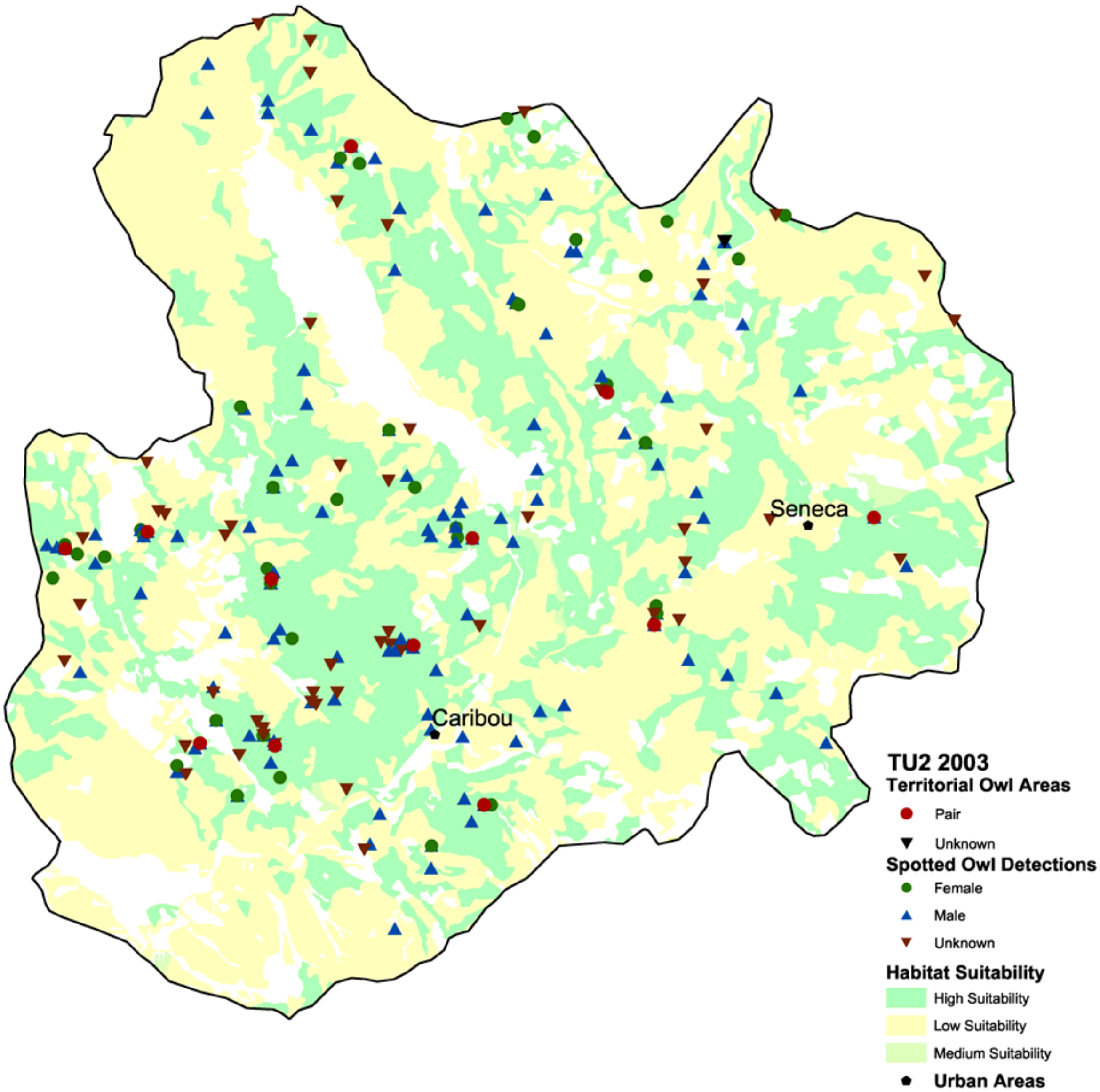


Figure 4. Distribution of California spotted owls detected in Treatment Unit 3 during surveys conducted in 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

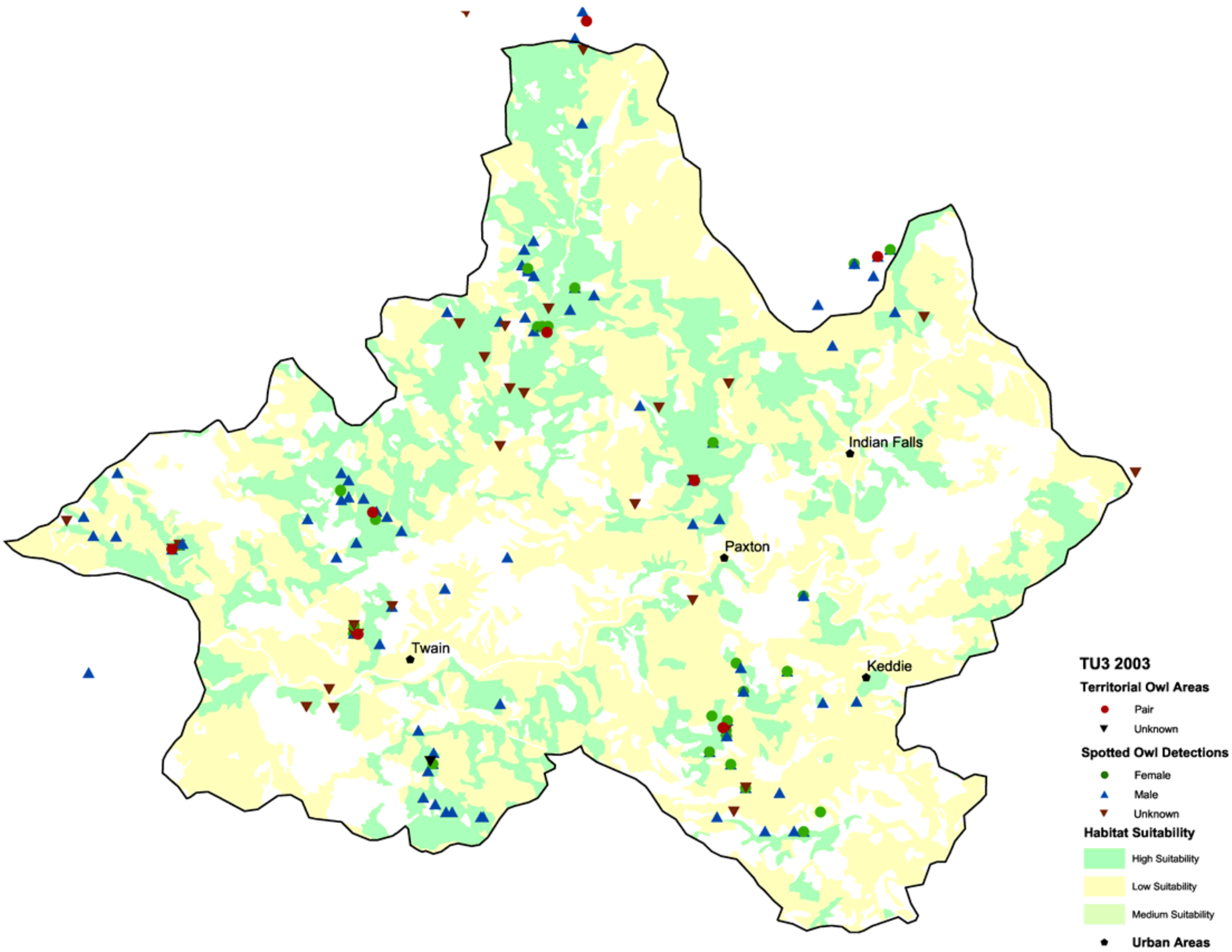


Figure 5. Distribution of California spotted owls detected in Treatment Unit 4 during surveys conducted in 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

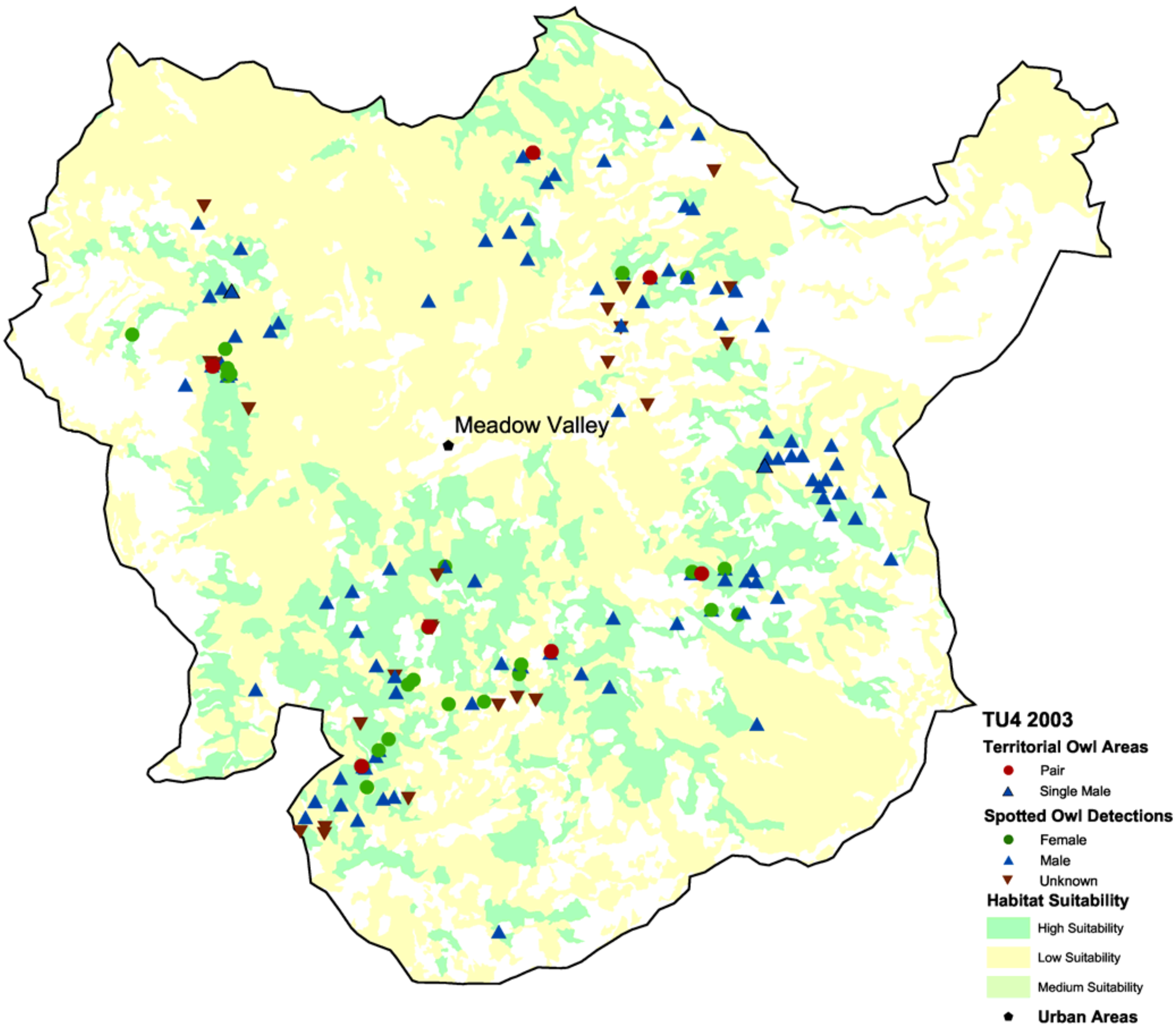


Figure 6. Distribution of California spotted owls detected in Treatment Unit 5 during surveys conducted in 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

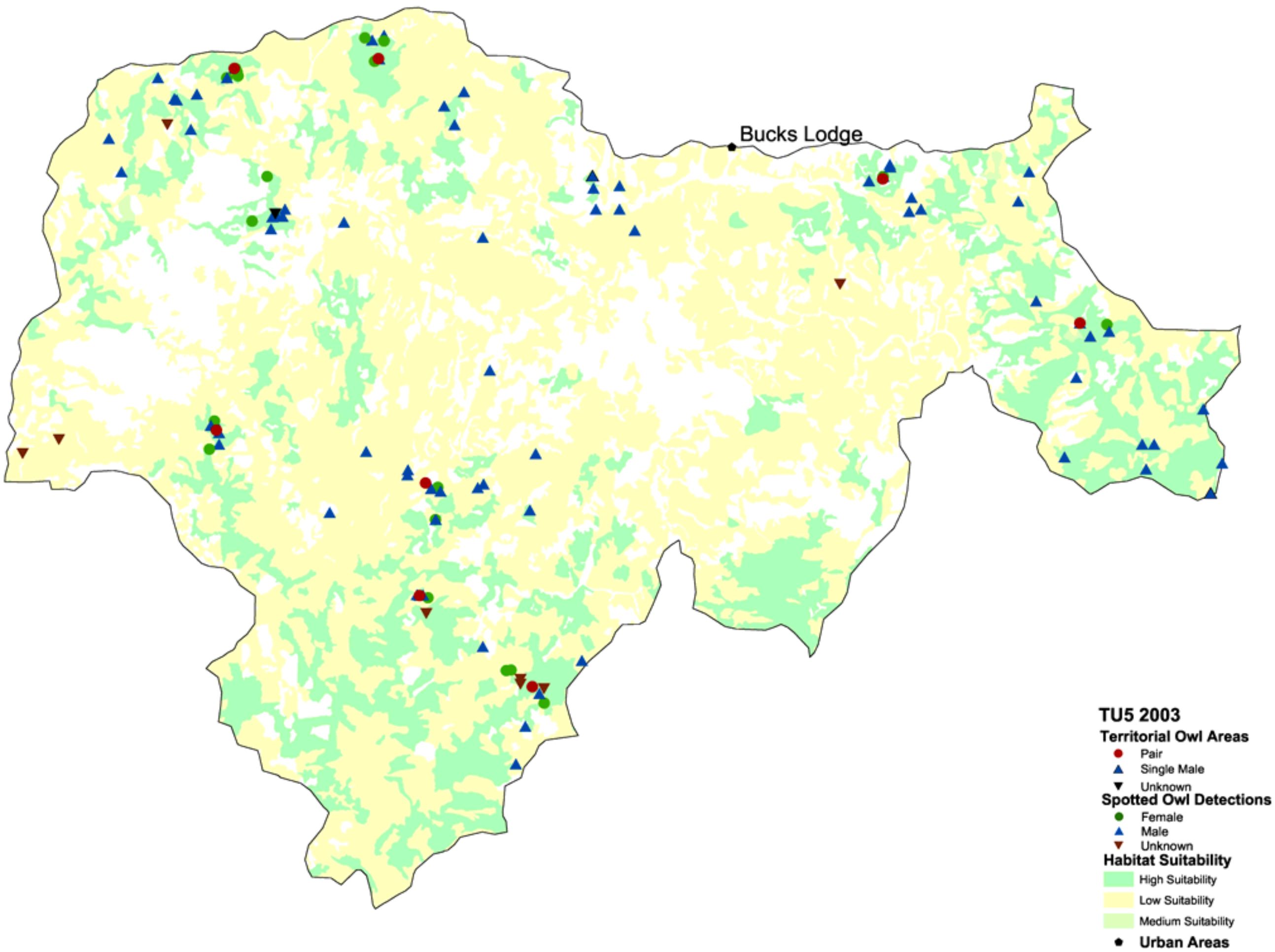


Figure 7. Distribution of California spotted owls detected in Treatment Unit 7 during surveys conducted in 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

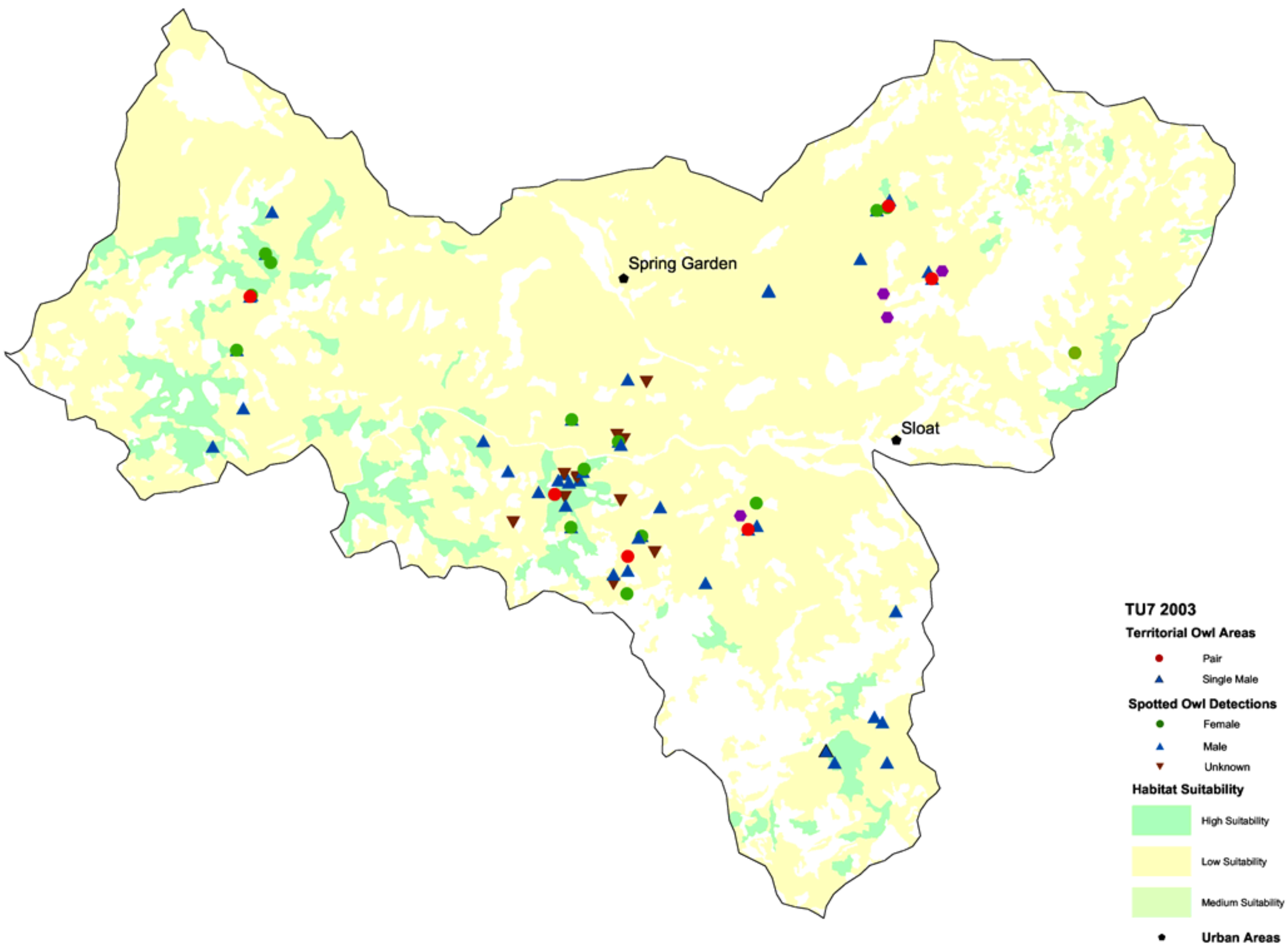


Figure 8. Distribution of California spotted owls detected in Treatment Unit 8 during surveys conducted in 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

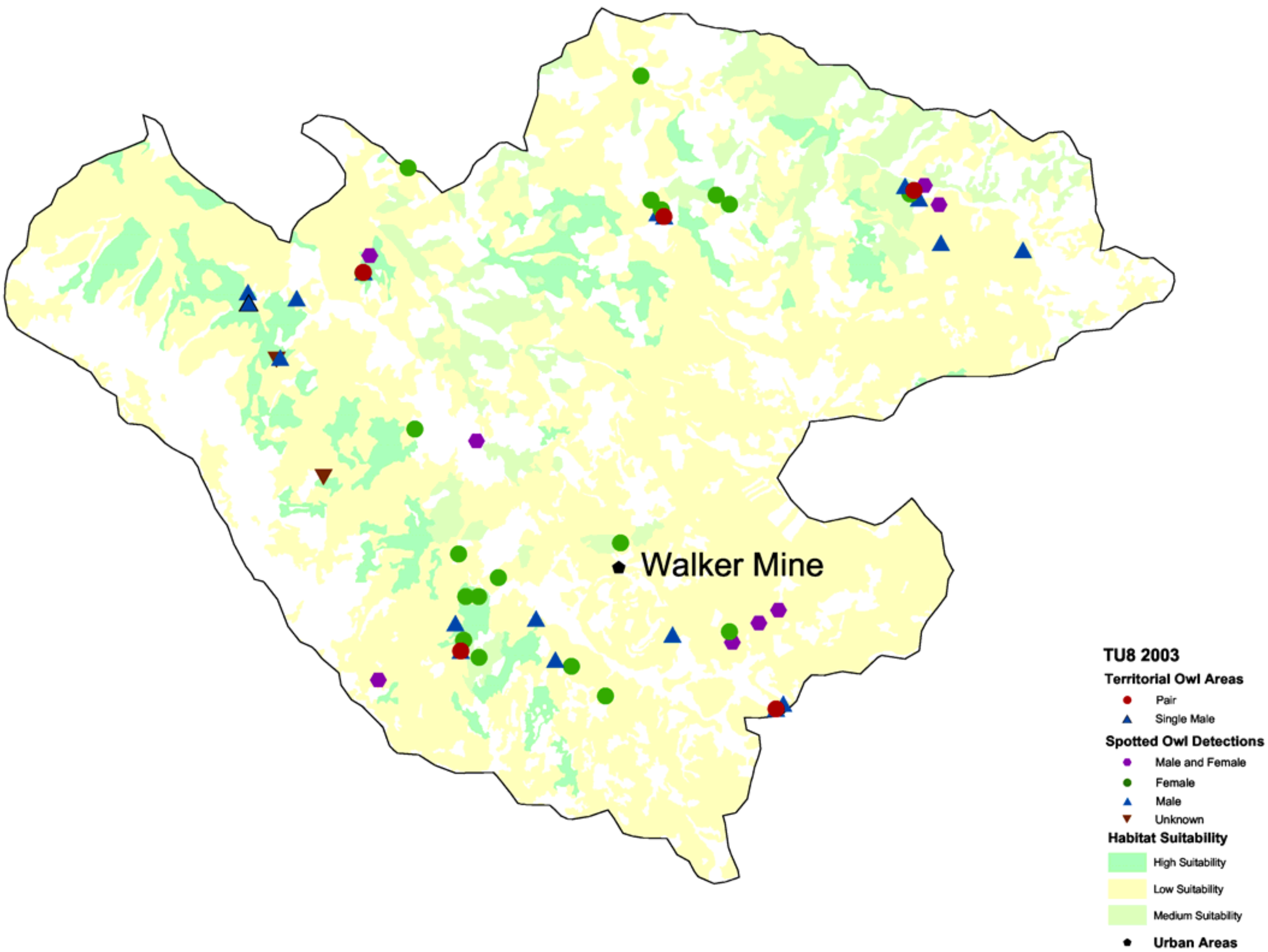


Figure 9. Distribution of California spotted owls detected in Treatment Unit 9 during surveys conducted in 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.

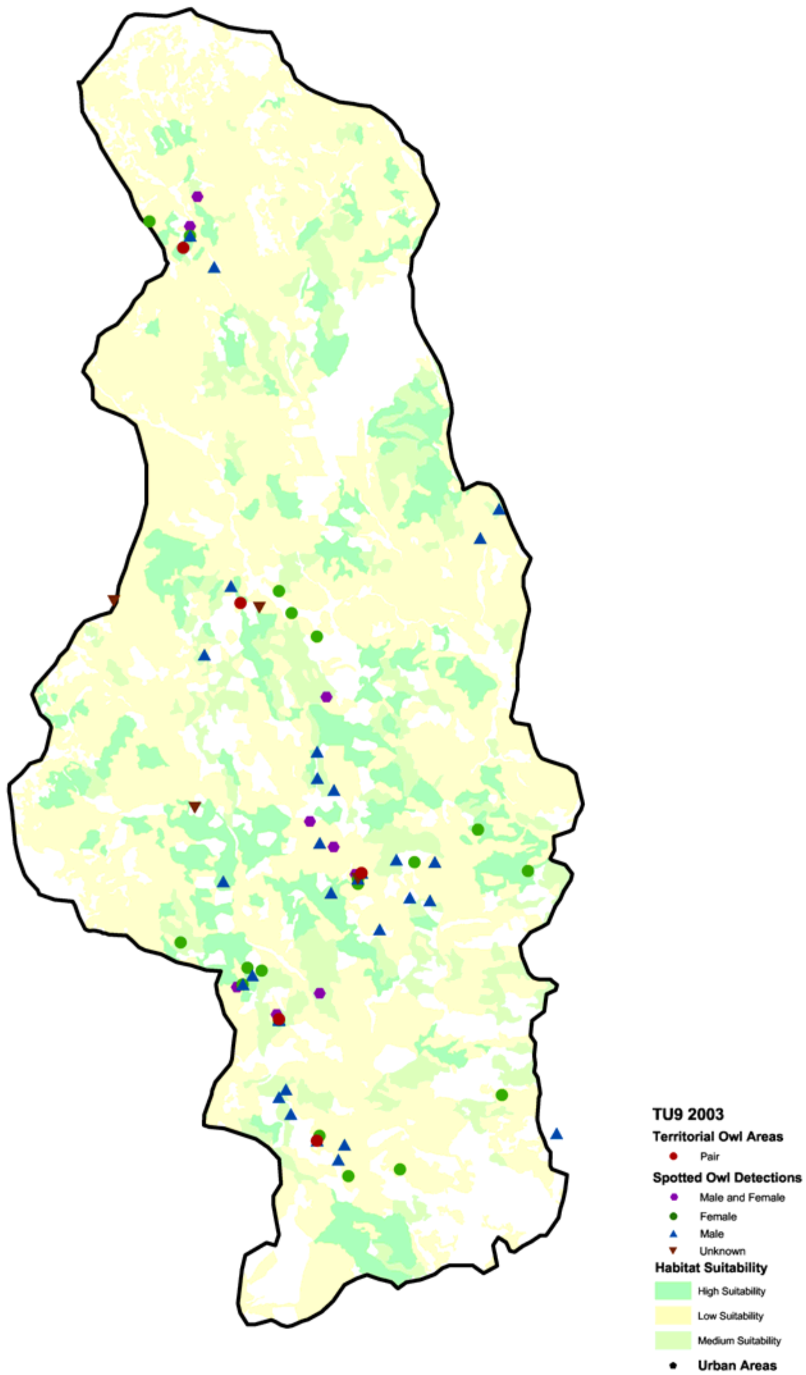
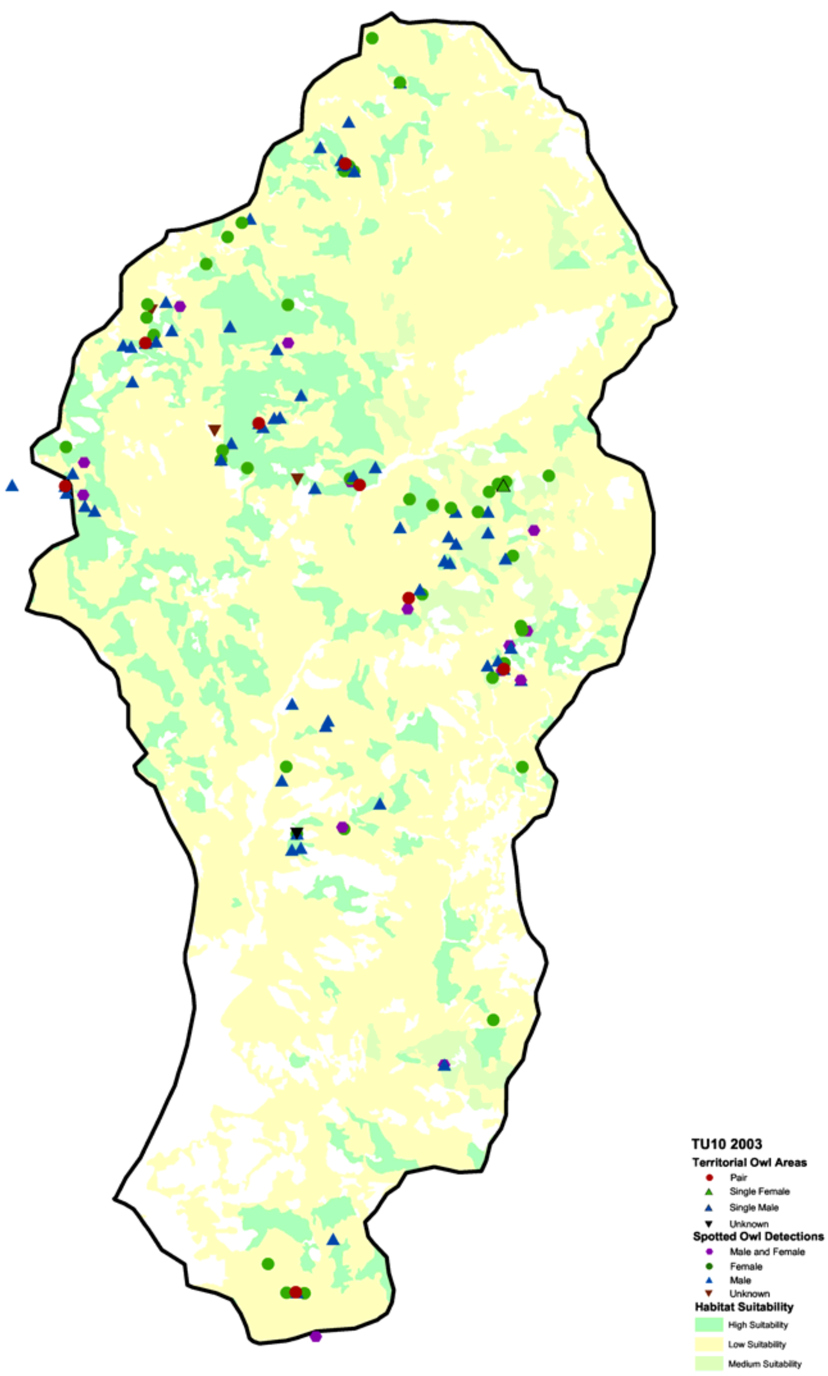


Figure 10. Distribution of California spotted owls detected in Treatment Unit 10 during surveys conducted in 2003 with reproductive habitat suitability as defined in the California Wildlife Habitat Relationship Database in the Plumas-Lassen Administrative study area.



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 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 Natioanl 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 30 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 six 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.