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Problem Reference

The Record of Decision for the Sierra Nevada Forest Plan Amendment (both the 2001 ROD and 2004 ROD) 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 presumed dependence on old forest habitat attributes. Simultaneously, the Forest Service is taking steps to reduce risks of large and severe fire by removing vegetation and reducing fuel loads in overstocked forests. Striking a balanced approach to achieving these potentially competing goals is a significant challenge to effectively accomplish the various desired outcomes of forest management.

The 2001 Record of Decision (reaffirmed in the 2004 ROD) called for an administrative study to examine the effects of various forest management techniques on California Spotted Owl populations and other ecological components of old forests. In investigating this issue, and as has been demonstrated in other studies, land birds may be used to show a distinct and quantifiable response to different forest management regimes, particularly as it is manifested over large spatial and long temporal scales.

Forest Service management practices, primarily in the form of timber harvest will result in changes in habitat quantity and structure across the study area in the coming years. By monitoring the populations of a suite of landbird species we will be able to measure the effectiveness of management actions in achieving a sustainable and ecologically functional forest ecosystem. Specifically, we are interested in determining the response of landbirds to management practices intended to produce forests with larger trees and high canopy cover along with more open-canopy, smaller size class forest with reduced ladder and ground fuels.

Study Area

The location of the study is the western slope of the northern Sierra Nevada, including portions of the Plumas and Lassen National Forests. See the main study plan for more specific location information.

Objectives and Approach

This study module is designed to complement the work investigating how California Spotted Owls respond to changes in vegetation structure and composition that occur when forests are managed to reduce fuels and generate timber products. Using a suite of the more common breeding bird species, hereafter referred to as landbirds, (e.g. passerines, woodpeckers, and corvids) as ecological indicators allows us to assess the response of the avian community to changes in forest structure and composition that occur as a result of forest management practices. This module is the only component of this study that will elucidate the response of multiple species to forest management at both the local and landscape scale. Given that the Spotted Owl is but one member of the avian community in these forests, understanding the response to management actions of a whole suite of landbirds will be of considerable value, allowing forest mangers to make more informed and ecological based management decisions. Thus, landbird monitoring is considered the most appropriate and cost effective tool for detecting changes in land management at the ecosystem scale (Greenwood et al. 1993, Hutto 1998, Hutto and Young 2002).

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

In order to meet our primary objective of assessing the impacts of forest management practices on landbirds at local and landscape scales, this module will address the following objectives.
(1) Determine landbird habitat associations at local scales.
(2) Determine landscape effects on bird habitat associations.
(3) Based on the results of objectives 1 and 2, develop predictive bird models to forecast how individual species may respond to forest management practices in the future.
(4) Quantitatively assess the impacts of forest management treatments on avian abundance and species diversity.
(5) Determine population trends for landbirds to identify if populations are changing temporally.
(6) Evaluate population trends to assess factors responsible for observed trends.

This multi-objective approach will allow us to interpret both the effects of specific management practices, the extent to which they influence the greater landscape (in the short term), and the integrated effects of treatments and natural processes that influence forest structure, composition, and function over extended periods. This will elucidate whether site-specific responses will be mitigated or dampened by the overwhelming influence of forest conditions occurring over the larger spatial scales of individual planning watersheds, aggregates of adjacent watersheds, up to the scale of the entire study area. In addition to the above objectives, our study design will allow us to address numerous other questions that may arise over the duration of this study as has been done with similar projects on other National Forest land in the West (Hutto and Young 2003) and Midwest (Shifely and Kabrick 2002).

Methods and Study Design

Overview

In a landscape-scale study, where intrinsic physical and biological conditions within watersheds are highly variable and lands are subject to different levels and types of treatments, traditional experimental design can be difficult to employ. It is difficult to delineate treatment units (in this case aggregations of watersheds) where we can block uniform areas and thus create true replicates; it is impossible to simultaneously and consistently apply treatments; and controls are difficult, if not impossible, to locate. However, the goal of the forest management at the landscape scale is not to reach a static state of old forest, but to incorporate changes from both treatments and successional processes into a sustainable and dynamic landscape. At the largest scale, such an experiment is a continual application of controlled manipulations without replication, where response is measured at different spatial (stand to landscape) and temporal (immediate to decadal) scales. Thus, we will evaluate bird responses at several spatial scales: the entire study area, aggregates of watersheds, individual watersheds, and within treated Defensible Fuel Profile Zones (DFPZ's). At the smaller scale, the effects of specific treatments will be studied using the more traditional experimental design given the limitations outlined above.

Due to logistical constraints outlined below under *Landscape scale methods* it should be noted that we have been limited to National Forest lands navigable to within 250 meters by vehicle and lands where slopes did not exceed 30 percent in order to safely navigate transects within four hours. Despite these limitations, we believe our sampling area closely resembles those Forest Service lands that timber harvest has affected in the past and where the vast majority, if not all, forest treatments will occur under the HFQLG Pilot Project.

We will use variable radius point counts to monitor landbirds at both scales (Buckland et al. 1993, Ralph et al. 1993, Thomas et al. 2003). This method involves establishing counting transects within a study area and counting every individual bird at each point over a set period of time during the breeding season. Point counts will be conducted for 5 minutes, with each individual bird recorded throughout the 5-minute period. We will estimate distance to the initial detection from the point count center within one of six radius bands, 0-10 meters, 10-20 m, 20-30 m, 30-50 m, 50-100 m, and > 100 m. Using a variable radius point count will allow us to estimate and thus control for differences in detectability as well as provide more precise estimates of density of birds, while still being compatible with fixed radius counts conducted in the region in the past (Burnett and Humple 2003, Humple et al. 2001) and other national forest lands in the west (e.g. Hutto & Young 2003 and Purcell 2002).

Extensive Sampling Rationale and Design

"Extensive Point Counts" (Ralph et al. 1993) will be used to monitor landbirds across the study area, grouped by watersheds. We will establish three transects of approximately twelve points in every individual CalWater Planning watersheds (typically 5,000 to 10,000 acres) nested within larger watersheds (aggregations of individual CalWater Planning watersheds) within the areas formerly designated as treatment units 2, 3, 4 and 5 on the Plumas National Forest. We will re-evaluate this strategy as the Forest Service plan of work is solidified and assess whether we have the ability to add additional watersheds in other portions of the Plumas or Lassen National Forests within the greater study area.

Landscape level transect selection (those in untreated areas) was carried out using different protocols in 2002 and in 2003. Those set up in 2002 were originally established under a different study plan and design, in which a much more extensive area was being sampled. Thus, effort in that year was assigned by the former treatment units and not by watershed as in the current design. We decided to retain all transects established in the former treatment units 2, 3, 4, 5 in order to maximize our pre-treatment data, thus we described the methodologies for site selection in both years.

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

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

Analysis from GIS coverages and field classification of all points established in 2002 revealed that points were distributed across the six different structural strata proportionate to the frequency of that stratum across the entire study area (Burnett et al. 2003). We believe this was due to the amount of area a transect covers combined with the extreme heterogeneity (in size and canopy closure) across the study area. Since only the first point was stratified;

the remaining eleven points were laid out in a U-shape across the landscape and thus allowed to fall into any structural category.

In 2003, following changes to the study plan mandated by changes in direction from the Plumas and Lassen National Forests it was necessary to reassess our original study design. With the new direction of the Forests, and following an analysis of data power conducted after the 2002 pilot year we determined we needed larger sample sizes in order to detect changes in bird populations following treatment. Thus, we modified our design to place three transects in each individual CalWater Planning Watershed (CalWater 1999) within the previously defined treatment units 2, 3, 4, and 5. The remainder of the former treatment units were dropped from our monitoring efforts for now, but may be revisited in future years as treatment is planned in those areas. Starting with sites established in 2002, we determined how many additional transects were needed in each watershed to attain this goal. Based on our finding that stratifying points by habitat structure resulted in a distribution of points no different than would have been expected by non-stratified random points, and the logistical difficulties in placing transects in 2002 using this method, we decided not to stratify random starting points in 2003 or 2004 by structural class.

Other than not stratifying points by cover and size class, in 2003 and 2004 our site selection methodology was very similar. Here we highlight the differences in site selection in 2003 for landscape based transects. If a transect could not be placed with the 2002 criteria then we attempted with the subsequent criteria until a transect could be established in the watershed:

1) We attempted to place it as a straight line along a random bearing.
2) We attempted to place it as any shape along any bearing starting with a U.
3) We attempted to place it anywhere within 200 meters of the random point in any shape starting first with a U.
4) We attempted to place it with points alternating on either side of the nearest road to the starting point, which was always within 250 meters of the random point (based on stratification for access purposes as discussed above).
5) We attempted to place it on the nearest secondary road.
6) We attempted to place the transect anywhere in the watershed that was accessible and surveyable.

With all of these allowances three transects could not be established in several of the steepest watersheds where most of the accessible area was dominated by private property. Thus we plan to drop those watersheds from our monitoring efforts (Table 1).

DFPZ Treatment Sampling Rationale and Design

In addition to the landscape level monitoring, we propose to include before and after monitoring in a sample of treated stands. The number of stands surveyed will be based in part on the amount and timing of the implementation of treatment within the life of this project. We expect to establish a minimum of 48 points in sites scheduled for treatment within each of former treatment units 2 through 5. Sampling effort will be weighted so that more treated site points are placed in treatment units that have more treated area with a maximum of 96 treated site points in any one treatment unit. Thus we expect to establish between two and three hundred points within areas slated to be treated as DFPZ’s.

Table 1. Landscape and DFPZ transects surveyed in the Plumas – Lassen Study area in 2003.

Treatment Unit	Watershed	Extensive Survey Points	DFPZ Survey Points
5	Grizzly Forebay	39	0
5	Frazier Creek	45	0
5	China Gulch	36	0
5	Bear Gulch	36	0
5	Haskins Valley	36	0
5	Red Ridge	36	0
5	**Total**	**228**	**0**
4	Silver Lake	41	24
4	Meadow Valley Creek	51	0
4	Deanes Valley	36	0
4	Snake Lake	36	12
4	Miller Fork	36	24
4	Pineleaf Creek	31	12
4	**Total**	**231**	**72**
3	Rush Creek	64	0
3	Halsted Flat	36	0
3	Lower Spanish Creek	36	0
3	Black Hawk Creek	24	0
3	**Total**	**160**	**0**
2	Mosquito Creek	36	0
2	Butt Valley Reservoir	36	0
2	Ohio Creek	41	0
2	Seneca	45	0
2	Caribou	36	0
2	**Total**	**194**	**0**
	Grand Total	**813**	**72**

Specific forest stands within the overall study area will be subject to one of three treatment types: DFPZ thinning, group selection, and area thinning (refer to the main study design for details). These treatments will be conducted incrementally over time at selected locations that are defined by the overall HFQLG Pilot Project land management strategy.

Point count stations will be placed using a stratified random sampling technique. As the boundaries for DFPZ treatments are finalized by the Forests, we will use a random point generator in ArcView GIS (ESRI 2000) to choose treatment polygons to be sampled. We will block polygons so that random points can only fall into DFPZ's where at least 8 point counts can be established in close enough proximity that one person can survey each point within a four hour morning period. Based on the design of DFPZ's in the former Treatment Unit 4 area, already established using this method, we expect that very few DFPZ's will be removed from consideration.

Controls for each treatment site will be the landscape points with similar pre-treatment conditions, located within the same watershed or treatment area. Because the DFPZ treatments will create the largest footprint upon the landscape and are further along in the planning process, we will focus our efforts initially on this treatment type. Sites will be prioritized based on time until treatment is implemented, with those scheduled for treatment sooner, chosen first.

Avian data collection

Each point count will be conducted twice within the breeding season for as many years of pretreatment conditions as possible and post-treatment for the length of the study (i.e. ten years). Data from 2002 was used in a power analysis to evaluate the adequacy of this sampling design for detecting changes in avian population and community parameters. Over the course of the study, other treatment types will be monitored, time and funding permitting, using a similar study design.

Using the extensive sample of transects in untreated areas as controls for treated sites allows us to maximize our sample size of treated areas. These landscape scale transects will allow us to choose sites that are similar in pre-existing condition and bird community composition for use as reference sites in order to measure the impact of treatment on bird response.

Vegetation and Habitat Data Collection

Habitat data will be used to examine the relationship of bird relative abundance to specific vegetation condition and change in condition at both the landscape level (using broader landscape characteristics) and at the local scale (each individual point count).

Initially we expect that vegetation data will be collected at all stations every two to three years. Data on stand composition and structure (total cover, height, species, size classes, canopy cover, and other habitat characteristics (Ralph et al. 1993) will be collected using a standardized releve method. In addition, we will be collecting fuels data at each of our points and intensive fuels data as outlined in the Fuels and Fire Behavior module study plan, on two points from each transect. This effort is being conducted in order to associate bird distribution with fuel conditions and to assist our collaborators with collecting a more robust and extensive data set.

Personnel

One person can survey 12 stations per day (1 transect) and approximately 32 count days per season thus 6 people can survey approximately 1200 points in one season (Table 2). We anticipate surveying approximately 85-90 transects in 2004 based on the progress of DFPZ planning. If in future years we decide to add transects to group selection, area thinning, or into additional watersheds in the overall study area, we will have to either add additional personnel or consider surveying the existing sites less frequently than every year.

Table 2. Anticipated annual survey effort and personnel needed to conduct PLAS avian monitoring.

Transects Surveyed	Visit per Transect	Count Days Per Person	Persons Needed
100	2	32	6

Owl Site Surveys

In order to more directly compare overall bird community composition and dynamics in response to management actions intended to sustain or improve habitat for Spotted Owls we will add additional points counts within a subset of the known owl territories that have been identified in the first two years of this study. Using the 300 acre protected activity centers (PAC's) as our sampling area we will place 3 to 4 survey points within each PAC. We will randomly choose owl PAC's to survey within each of the 5 treatment units. If any of our existing point count routes fall within PAC's we will incorporate those points into our sample. Directly monitoring bird populations within known owl PAC's will allow us to examine the effectiveness of current Spotted Owl habitat management strategies in providing high quality habitat for other avian species. Specifically we will compare species richness, the composition of species, the abundance of select species, and the change in abundance of those species over time between known owl territories and non-owl areas.

Analyses

Bird Habitat Associations (Objective 1)
We will determine the preferred habitat associations for individual bird species by building statistical models that relate avian abundance with habitat attributes. Avian abundance data on individual species are available from the extensive point counts (see *Methods*). Habitat attribute data will include vegetation composition and structure data (collected from releve surveys) as well as georeferenced habitat data provided by the Forest Service. We will determine the habitat attributes at each point count station within a Geographic Information System. We will then use linear models to determine which habitat attributes explain the greatest amount of variation in bird abundance. These *Bird Habitat Association* analyses will occur prior to the application of forest management treatments.

Specific habitat features to be examined include: (a) quantity and quality of snags; (b) early seral stage vegetation (montane shrub habitat), (c) frequency and abundance of hardwood tree species (primarily Black Oak), (d) frequency and extent of large tree stands, (e) canopy closure, and (f) forest structural heterogeneity.

Landscape Metrics
We will associate landscape scale metrics with each individual point count station using the FRAGSTATS spatial analysis software (McGarigal and Marks 1995) within a GIS environment. Landscape metrics will be calculated within radii of 1, 2, 5, and 10 km for each point count station based on previous studies (Robinson et al. 1995, Tewksbury et al. 1998, Tewksbury et al. 2002). We will use existing imagery and land cover data provided by the Forest Service. Within the 1, 2, 5 and 10 km radius circles, we will calculate the landscape metrics, including: mean forest patch size, core index (e.g., amount of forest >250 m from any edge), percent forest cover, percent of different size and cover classes. Although these landscape metrics may be highly correlated, they each reflect a distinctive aspect of the landscape (see Howell et al. 2000).

Landscape Influence on Bird Habitat Associations (Objective 2)
We will re-run the bird habitat association statistical models (see above) for each species with the appropriate local scale habitat variables as well as the landscape metrics. This will allow us to determine the extent to which bird habitat associations are influenced by attributes of the landscape. We will be able to partition the variance in bird abundance

between local and landscape features using this approach. Other studies of Neotropical migrant birds have found that some species are more sensitive to landscape attributes than to local habitat scale variables, but this varies among bird species (Howell et al. 2000, Spautz et al. in press) and can vary regionally (Verner and Larson 1989 and Tewksbury et al. 1998). Based on our knowledge of the biology and life history attributes of the songbirds in the region, we suspect that local habitat attributes will explain most of the variation in avian abundance; however, by including landscape metrics we will be able to test this assumption and gain insight into the extent forest treatments will influence certain avian species.

Predictive Bird Models (Objective 3)
Once we have developed Bird Habitat Models and determined the relative influence of the landscape on avian abundance, we will develop predictive statistical models to forecast how individual species may respond to differing forest management practices or other sources of habitat change (e.g., succession). This will also allow us to predict how species will respond to the forest treatments in this long term study. We will examine the consistency of our models across Former Treatment Units and later in the study, across time periods (comparing bird habitat associations in pre-treatment years with post-treatment years, later in the study).

Forest Management Treatment Effects (Objective 4)
<u>Independent Variables and Experimental Design</u>
Using linear models we will examine the main effects of Former Treatment Unit (FTU), Planning Watershed (nested within FTU), and Treatment. FTU is essentially a blocking variable for the aggregate of watersheds and which we assume will not be significant, but we will test this assumption by including it in the model. Planning watersheds are nested inside of the larger FTU. By including the main effect of watershed in the model we can examine whether there is an inherent effect of watersheds (perhaps due to their geography). The two levels of treatment are DFPZ and control. Depending on the timescale that this project is implemented over, we may also include two other treatments in the analysis (group selection and area thinning). Control points are defined in the Methods and will be a subset of the untreated extensive point count data set. Depending on the results of the *Landscape Influence* analyses we may include landscape covariates in the analysis.

Aside from the main effects of FTU, Watershed (nested within FTU), and Treatment, we will also examine the interaction between Treatment and Watershed (nested within FTU). The interaction will allow us to determine whether the Treatment effects varied among the Watersheds. We may also opt not to treat Watershed as a categorical variable, but instead treat it as a continuous variable (covariate) - if some continuous measure of watershed (such as slope or aspect) is more biologically meaningful than a categorical variable.

<u>Dependent Variables</u>
We plan to use avian abundance (transformed as necessary) as our dependent variable in these analyses, but if data are limited for some species we may conduct the analyses using presence or absence. We will use the analyses appropriate to the error-distributions of the data when conducting our analyses, using Generalized Linear Models (McCullagh and Nelder 1989). In particular, we expect negative-binomial regression to be the most appropriate analysis tool. We will also consider species diversity as a dependent variable because it will allow us to determine how forest management practices impact the wider landbird community (and not just individual species).

Temporal Analyses (Objective 5)
We anticipate that there will be four to five years of pre-treatment avian abundance data for much of the study area. We will use these data to determine population trends of individual species at the local scale, watershed, aggregate of watersheds, and the region for those species with sufficient sample sizes. A minimum of four years is necessary to conduct trend analyses. We anticipate that only a fraction of the species (10 to 20 species out of approximately 100) will be detected in numbers sufficient to perform population trend analyses upon; however these more "common" species can serve as important indicators to changes in habitat conditions.

Analysis of Trends (Objective 6)
We will analyze trend data in the context of the results from our habitat associations and effects of treatment analysis. This will enable us to identify those trends that can be ascribed to changes in vegetation condition and those that may be due to extraneous reasons, such as problems on the wintering grounds. Additionally, by surveying the avian community annually for many years, we will be able to test for non-linearity in response (e.g., it is negative in year one but turns positive four years after treatment), allowing us to gain a greater insight into bird response to treatment and the potential long-term effects of forest management.

Quality Assurance and Control

All field personnel hired have previous experience conducting avian field work and are provided with a CD with the songs and calls of all birds of the Northern Sierra Nevada. Once they arrive on site they undergo an intensive three week training workshop in landbird identification and distance estimation prior to beginning surveys. Each observer must past a field test in identification before they are allowed to begin official surveys. The field supervisor will regularly test and calibrate personnel on these techniques throughout the field season.

All field data will be entered into a Fox Pro or Access Database. Field crews will have access to computers at the field station(s) so data can be entered the same day they are collected. Data is then regularly backed up on CD and CD copies of data are backed up off site at least twice a month. Standard data formats for point counts and vegetation characteristics will be used. Paper records will be archived at PRBO after entered data has been proofed and backed up on PRBO servers.

Data Management and Archiving

The principle investigators for this study module will manage all data. These data will be archived annually at the Sierra Nevada Research Center in Davis, California. Data will also be available through the website once it has been used in model building or in a publication.

Expected Products

The immediate product is an inventory of the distribution and abundance of forest birds within the study area (see Burnett and Geupel 2004). Baseline data on the relative abundance and species composition of landbirds will be collected prior to treatments.

After year three we will produce projects relating to Bird Habitat relationships and the influence of the landscape on these relationships (per objectives 1 and 2). We will also develop the predictive models to forecast potential management effects (per objective 3).

Two years following management treatments we will conduct the analyses related to objective 4. This will result in a publication on landbird responses (and variation in responses) to forest management practices. We will also publish the results of the temporal analyses (objective 5).

Once the study is completed, publications will compare landbird responses (and variation in responses) to forest treatments with other study module metrics (e.g. Spotted Owl abundance). Additional final products will include a detailed evaluation of forest management practices and recommendations of potential modifications to manage these forests in an ecologically sustainable manner.

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