



Sierra Nevada National Forests Management Indicator Species Project

Final Study Plan and Sampling Protocols for Mountain Quail (*Oreortyx pictus*), Hairy Woodpecker (*Picoides villosus*), Fox Sparrow (*Passerella iliaca*), and Yellow Warbler (*Dendroica petechia*)

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I. Introduction

Background

The Sierra Nevada Mountains stretch nearly two thirds the length of California from south of Lassen Peak in the north to the Kern River in the South (Figure 1). Most of this mountain range is public land, with over 10 million acres (nearly half of the area) of National Forests. Known as “the land of many uses”, the United States Department of Agriculture Forest Service lands are managed for multiple objectives (as described in the Multiple Use Sustained Yield Act of 1960 and subsequent legislation and planning documents). While the Sierra Nevada forests were once managed primarily for resource extraction such as timber, minerals, and livestock forage, in recent years other resources including water, biological diversity, and carbon sequestration have been recognized as critical “uses” in a more ecosystem-focused approach (SNEP 1996; USFS 2004b). This shift in management direction poses significant challenges to resource managers who need a variety of tools to meet the myriad of (potentially competing) goals. Wildlife monitoring has been mandated as a means toward managing for biodiversity and other ecological conditions. But in order for management decisions to be robust, feedback from monitoring must be carefully designed and targeted toward producing informative results (Dale & Beyeler 2001).

The National Forest Management Act (NFMA) of 1976 was created to help guide management of National Forest lands in the United States. In 1982, planning regulations were adopted under NFMA that guided the establishment of Management Indicator Species (MIS). Each forest plan developed under the 1982 Planning Rule was required to identify certain vertebrate and/or invertebrate MIS as one of various elements to address NFMA requirements related to diversity of plant and animal communities [1982: 36 CFR 219.19(a)]. The direction

for MIS is related to forest plan development, forest plan implementation, and forest plan monitoring (see USFS 2008b, pages 2-4, for more detailed information). For forest plan monitoring, MIS are used in order to monitor the outcome of forest plan implementation. Specifically, “Population trends of the management indicator species will be monitored and relationships to habitat changes determined” [§219.19(a)(6)]. MIS monitoring tests the assumption (of the forest plan) that if a habitat is managed a certain way, the community of species associated with that habitat will be maintained over time. Because it is impossible to monitor all species, MIS are monitored as representatives of habitat communities to test the assumption. MIS monitoring is but one part of the Forest Service’s monitoring program. Thus, monitoring MIS populations informs and guides adaptive management and forest plan project implementation.

In 2001, and then reaffirmed in 2004, the Sierra Nevada Forest Plan was amended in order to adopt a common management strategy for the ten National Forest units in the Sierra Nevada planning region, including a portion of the Southern Cascades (USFS 2001, 2004b). In 2007, the plans were amended again in order to adopt a common list of MIS and associated monitoring strategies for all ten forests in the Sierra Nevada: the Eldorado, Inyo, Lassen, Modoc, Plumas, Sequoia, Sierra, Stanislaus, and Tahoe National Forests and Lake Tahoe Basin Management Unit. The amended MIS strategy identifies eleven terrestrial habitats or ecosystem components and twelve wildlife species whose populations are designated to be indicative of habitat management (USFS 2008b).

Herein we present a plan for monitoring and evaluating the population trends of four of the twelve species selected by the Forest Service to help guide management of the 10 Sierra Nevada National Forests. Mountain Quail (*Oreortyx pictus*) was selected as the indicator for

early and mid-seral conifer forest, Fox Sparrow (*Passerella iliaca*) as the indicator for chaparral shrubland, Yellow Warbler (*Dendroica petechia*) as the indicator for riparian habitat, and Hairy Woodpecker (*Picoides villosus*) as the indicator for snags in green forest (USFS 2008b). In this document we present a comprehensive strategy designed to estimate temporal and spatial trends in the distribution of these four indicator species. In order to inform the final study plan we initiated a pilot study in 2009 and the relevant results are incorporated throughout this document. This plan draws on PRBO's more than 30 years of experience monitoring landbirds in California - including 13 years in the Sierra Nevada - and the state of the science in avian monitoring and analysis approaches.

Monitoring objective

The aim of this study is to track the occupancy (MacKenzie et al. 2006) of the four MIS listed above at sites across the Sierra Nevada landscape and provide the Forest Service with data and analyses that will inform adaptive management. Our primary objective (as directed by USFS 2008b) is to calculate trends over both time and space for each of the four MIS and to evaluate these trends with respect to changes in habitat conditions and populations of other avian species occupying the same survey locations.

Our sampling strategy uses annually repeated surveys at locations designed to maximize the sample size and minimize variability and spatial bias, while efficiently and safely dealing with the numerous logistical constraints that arise as a result of working in a large study area and complex physiography. At each survey location we count all bird species seen and heard and also gather vegetation information. We believe a multiple species approach as outlined by California Partner's in Flight bird conservation plans will provide greater insight into the effects

of management actions within the selected habitat types or components (Burnett In Press; Chase & Geupel 2005) and have developed a list of complementary avian species for each of the four habitat types/components (Table 1). With this approach we expect to be able to infer the most likely causes of these patterns (e.g. natural disturbances, growth and succession, interspecific competition, and/or management activities).

II. Sample Design

In order to sample the distribution of these four species across the National Forests of the Sierra Nevada, we are using a standardized point count method (Ballard et al. 2003; Ralph et al. 1995) where a single observer estimates the distance to the location of each individual bird they detect within a five minute time span from a fixed location. Call-playback surveys are also conducted (for Hairy Woodpecker and Mountain Quail) on a subset of the point count locations by broadcasting the vocalizations of these species and then listening for a response. The methodology and rationale for selecting these field methods are presented in Section III and Appendix A. We introduce it here in order to provide necessary context to the discussion of sampling design.

Distribution of survey locations

There were a number of logistical considerations that influenced the sampling design of this monitoring project, the most evident of which was the need to maximize statistical precision (the amount of uncertainty in our parameter estimates) while at the same time minimizing the amount of sampling effort (including the number of sites, the amount of time required to navigate to each location, and the time and effort required to complete each survey). A good design attempts to maximize the ability to make inferences for an entire area while minimizing sampling effort. A design that takes too few samples will not be able to adequately measure an important change whereas too many samples will waste time and money.

The largest constraint on the number of point counts we can complete is the desire to spread our samples out over a large area (Bailey et al. 2007), thereby increasing the time it takes to travel to and locate survey sites in the field. We attempted to balance this tradeoff by

clustering point count survey locations, pairing point count clusters (transects) at a moderate distance (up to 1 km), and limiting the distance of sampling locations from roads. We also considered the seasonality (phenology) of avian migration and breeding activity, the detectability of the species of interest, the amount of training required to achieve an acceptable skill level for each field technician, and the number of field technicians that can be afforded. Within these limitations, we attempted to optimize the sample design to maximize the statistical rigor of the overall sample, both in terms of sample size and spatial distribution of survey locations.

To ensure that our monitoring program is efficient and representative of the actively managed Forest Service land in the Sierra Nevada region as well as within each individual forest, we used a spatially balanced sampling design (Stevens and Olsen 2003, 2004). Our goal was to ensure that our sampling design provides parameter estimates that are statistically sound (i.e. unbiased and precise) and applicable to populations across the entire region, while at the same time being flexible enough to adapt to logistical constraints as well as potential changes in effort across years due to varying levels of funding that are common to long-term monitoring projects. To achieve all this, we used a generalized random-tessellation stratified (GRTS) sampling scheme to distribute transects evenly across the region to avoid clustering in any given area (one particular forest for example) while remaining random at the local level to avoid bias due to natural spatial patterns of habitat and physiognomic conditions (Theobald et al. 2007). The spatial pattern of GRTS samples are therefore both balanced (at large scales, in this case the entire study area) and random (at small scales, in this case at approximately the National Forest Ranger District scale). GRTS is an efficient design for monitoring programs aimed at identifying trends of species with widely differing population metrics (Carlson & Schmiegelow 2002). Another feature of GRTS is that survey locations are ordered such that any consecutive

group of survey sites retains the overall spatial balance, allowing for easy adjustment to the number of sites surveyed each year (for example, due to different sizes of field crews between years) while maintaining the statistical rigor and minimizing the variance of the sample (Stevens & Olsen 2003).

The set of potential survey locations was built from a tessellation generated in ArcGIS 9 (ESRI 2006) consisting of a grid of cells with a random origin covering the entire study area. We did not choose to stratify by geographical location (e.g. latitude bands) or by jurisdictional boundaries other than Forest Service ownership, nor did we define *a priori* a target number of survey locations within different National Forests. Thus, we used the GRTS algorithm to select survey locations with equal weight across the entire study area, resulting in the placement of survey locations proportional to the amount and spatial distribution of suitable area for sampling (based on the habitats and other stratifications listed below).

We used two sampling frames to identify survey locations based on the species of interest. The target habitats for each species (see below) were identified from the Sierra Nevada Forests MIS Implementation Package (USFS 2008b). Habitats (Table 2) for Hairy Woodpecker ('green forest'), Fox Sparrow ('chaparral'), and Mountain Quail ('early to mid-seral conifer') are widely distributed and relatively abundant across the Sierra Nevada landscape and overlap or integrate with each other. In contrast, riparian habitats, for which Yellow Warbler is the chosen indicator, are sparsely distributed across the landscape, often in linear patches that are not sufficiently represented by existing GIS habitat layers, and are discretely different than habitat identified for the three other species. Thus, we built a common sampling frame for Fox Sparrow, Hairy Woodpecker, and Mountain Quail, and a separate one for Yellow Warbler. A separate sampling frame for identifying riparian habitats and selecting survey locations for Yellow

Warbler was necessary due to the finer scale pattern of this habitat and to overcome the deficiencies of the existing vegetation maps in identifying it.

GIS resources

We relied heavily on GIS resources to select the set of potential field survey locations, with limited site reconnaissance prior to visiting them. We assembled and processed GIS layers (Table 3) downloaded from the USFS Pacific Southwest GIS Clearinghouse (USFS 2009) and the State of California CAL-ATLAS Geospatial Clearinghouse (California 2009). The main layers that we incorporated in the selection process are: existing vegetation from the USFS, digital elevation from the USFS, Tiger roads from the US Bureau of the Census, roads and trails from the USFS, and hydrology from the State of California. We assembled the existing vegetation layer, or EVEG (USFS 2004a), from a set of 57 different tiles accessed through the Region 5 GIS clearinghouse. These data were converted from polygon coverage to 30m resolution grids and mosaiced into a single layer. The resulting layer shows the distribution of over 40 different California Wildlife Habitat Relationship (CWHR) land cover types (USFS 2004a).

Upland sample design (Hairy Woodpecker, Mountain Quail, Fox Sparrow)

A common set of GIS processes and stratifications was used to select survey locations in Hairy Woodpecker, Fox Sparrow, and Mountain Quail habitats. The sampling frame was stratified by elevation, slope, habitat, and proximity to roads. In general we felt it was necessary to bracket widely the habitats and elevations at which these species are likely to occur in order to

verify the published habitat and elevation limits, and also to account for potential range shifts such as those predicted under various climate change scenarios (e.g. Stralberg et al. 2009).

We selected upland survey locations in montane chaparral and ‘green forest’ (see Table 2 for a list of habitat types included). We selected a broad set of habitats so that any CWHR types that are currently considered appropriate habitat, or could transition to them through natural processes or management actions (e.g. fire, silvicultural treatments) were included. Thus we chose to include all conifer forest regardless of age structure, since even old-growth stands have the potential to become early-seral forest. The EVEG habitat GIS layer was created using a relatively broad definition of forest as 10% or more cover by trees (CDFG 2005). We felt that many areas delineated as forest by the EVEG GIS layer could in fact be chaparral shrubland under a sparse tree canopy and would therefore provide suitable habitat for Fox Sparrow. Conifer is by far the most predominant habitat type throughout the study area (approximately 50% of the entire Sierra Nevada under Forest Service ownership, Table 2), but it is unknown what proportion of the conifer forest delineated by the EVEG GIS layer could be considered shrubland with a sparse tree cover. We considered this further justification to combine the same sampling area for Hairy Woodpecker, Mountain Quail, and Fox Sparrow.

We limited the set of potential survey locations to elevations between 1000 and 2800 m, on slopes less than 35%, and areas within 1 km of roads (see Table 3 for list of GIS layers used). We chose to use this elevation range to restrict the inclusion of low elevation foothill oak woodland and foothill chaparral habitat types and high elevation subalpine habitats as we discovered that these habitats were frequently misclassified in the EVEG GIS layer during our 2009 pilot year surveys. The three upland species were detected infrequently below 1200 m elevation, while the bulk of detections were at the middle of our elevation range (1600-2000 m).

Thus by bracketing the elevation bounds we can ensure that our sample is more focused on the intended habitats and avoids wasting field effort. We chose not to survey on steep slopes or far from roads in order to maximize field crew efficiency and safety. Given that the primary goal of this project is to identify trends in the distribution of populations of the MIS species in response to management activities, we feel that these stratifications were appropriate. In other words, there is little need to sample extremely steep slopes that make harvesting unfeasible or in areas far from roads where very little active management takes place.

The survey location selection procedure started by building a tessellation (represented by a grid of evenly-spaced points) at 1 km resolution with a random origin, covering the entire extent of the Sierra Nevada National Forests (Figure 2). We chose a 1 km resolution because it represents approximately the maximum home range size of the MIS included in this study. Our stratifications on this tessellation removed all points that are outside areas meeting the criteria outlined above. The area within the National Forest ownership boundaries was reduced by just over 50% using these stratifications. We then selected 250 locations using the program S-Draw (McDonald 2003) which generates spatially balanced GRTS samples. These locations defined the center point for a 5-point transect. The point count locations within each survey transect are arranged in a diamond-shaped group of four stations with a center station where both a point count and call playback for Hairy Woodpecker and Mountain Quail is conducted (Figure 3). The four perimeter point count stations in each transect are 250 m from the call playback station in the four cardinal directions.

Point count transects are paired in relative proximity such that the “A” transect locations are the 250 tessellation grid cells selected with the GRTS routine, and then an adjacent “B” transect was chosen manually for each location. The “B” transects were selected with the

criterion of choosing the most easily accessible location from the four neighboring cells (1 km in each cardinal direction) given topography, roads, other potential obstructions, and appropriate habitat present. We paired transects in such close proximity because field technicians generally share a vehicle (therefore minimizing time spent travelling between transects) and because we feel that the proximity of field workers is important as a safety precaution. We understand that the criteria for selecting B transect locations imparts additional bias towards proximity to roads in our sample, but the logistical constraints are severe and we feel this was justified.

Occasionally individual point count locations (or less frequently entire transects) are inaccessible and are moved by field technicians to an accessible nearby location (with strict guidelines to maintain the spatial integrity of the overall sample, described later). The result of this site selection process is 2500 point count locations on 500 transects, distributed as 250 spatially balanced pairs. The number of transects in each forest is proportional to the amount of area (within our stratification criteria) inside the forest ownership boundaries (Table 4).

We were not able to visit 42 of the 250 sites selected in 2009 due to time constraints, access restrictions, or after field reconnaissance determined that they were outside the targeted habitats, and we dropped an additional 46 sites that were visited for similar reasons. New locations were selected as replacements using GRTS to ensure that the overall sample retains the originally-intended balanced spatial design. At some other locations that we visited in 2009, one transect in a pair was inaccessible or outside the targeted habitats and an alternate adjacent location was chosen to replace it. The final set of 250 paired transects will be resurveyed annually and will be replaced only if access to them is lost. In 2009, we did not remove areas in wilderness and other remote areas (> 1 km from road) prior to selection of transect pair locations but those locations were largely excluded due to inaccessibility. We will continue monitoring a

subset of 20 transect pairs in remote areas (Table 4) to maintain a range of distances from roads in our data set from which to evaluate road bias questions. Although road effects on avian distributions in western North American forests may be relatively minor, (Hutto et al. 1995; Keller & Fuller 1995; Rotenberry & Knick 1995), there is still a potential for the proximity of field sites to roads to impart bias on a large-scale avian monitoring program (Coffin 2007; Forman 2000; Hutto & Young 2002).

GRTS samples are such that any ordered list of field sites will retain the desired spatial balance, and we plan to implement this feature when presented with fluctuations in funding to support field crews of different sizes over different years (Stevens and Olsen 2003). The 500 upland transects will be the maximum sample size that is achievable given a 15-member field crew. When we have funding to support fewer than 15 field biologists we will adjust the upland sample by surveying only the number of transects that are logistically feasible, while retaining the GRTS order to ensure spatial balance of the sample each year.

Riparian sample design (Yellow Warbler)

Yellow Warbler survey locations were selected with a GRTS sampling protocol focused on identifying riparian habitats that are poorly represented by the EVEG GIS layer (only about 1% of the study area, Table 2). Riparian habitats are highly variable and can be structurally diverse, leading in part to the difficulty in accurately classifying them on land cover maps. In the Sierra Nevada, riparian habitats are composed of a variety of broadleaved shrubs and trees that occur adjacent to a ground or surface water source (CDFG 2008). The challenge in building this sample was to identify sites that currently have appropriate riparian habitat, or that could have riparian habitat given appropriate management (e.g. meadows or pastures with streams where

willow or other shrubs could grow if disturbance was abated or the natural stream channel was restored). We feel it is important to avoid only sampling locations where relatively pristine riparian habitats currently occur, but instead to survey a wide range of locations that could support Yellow Warblers in the future (or have supported them in the past). By doing so, we feel that we will have a better chance of identifying both positive and negative trends in Yellow Warbler populations, and will have a lower chance of misidentifying a real trend.

The riparian sampling frame consisted of a finer resolution tessellation (100 m as opposed to 1 km for the upland sample) to account for the fact that these habitats tend to be arranged as patches or linear stretches much smaller than 1 square km, and would largely be missed by using that resolution. Yellow warbler territories also tend to be less than 1 ha (Lowther et al. 1999), which is 100x100 m square. The grid was stratified to include only areas under National Forest ownership, within 1 km of roads, the habitats of interest (EVEG augmented with the Sierra Montane Meadows vegetation layer), elevations between 500 and 2500 m, and slopes less than 20% (see Table 3 for list of GIS layers used). We then selected 50 locations using the program S-Draw.

Yellow Warbler point count locations were selected using the GRTS-selected location and then manually choosing seven adjacent points from the 100 m grid that make navigating between the points logistically feasible (Figure 3). Adjacent points within each transect are separated by 200-300 m. Transects are arranged in two distinct sets of four point count locations with approximately 300 m separating the closest points between adjacent transects. The upland and riparian samples differ in that riparian point count locations typically fall in a linear arrangement along a stream channel, as opposed to two separate clusters spaced exactly 500 m apart (at their closest point) in one of the four cardinal directions like the upland sample

transects. We arranged point counts in this manner for the logistical and safety reasons listed previously. The result of this site selection process is 400 point count locations on 100 transects distributed as 50 spatially balanced transect pairs.

Despite the stringent stratifications and the relatively fine resolution of the sampling frame, we included many locations that were inappropriate habitat (meadows and pastures with no associated stream channel, steep slopes, upland habitats, and riverine areas naturally without riparian habitat). Some of the riparian survey locations were subject to background noise created by running water, especially early in the season while large volumes of snowmelt swelled streams. Due to the issue of noise and other logistical constraints, field technicians found that they needed to adjust the coordinates of many point count locations (up to 100 m from the original location, keeping at least 200m between point count locations) in order to fall within the riparian habitat of interest or to gain a sufficient distance from the stream in order to be able to hear bird vocalizations. Even using a much finer resolution (100 m vs. 1 km) there was still not enough detail in the vegetation, stream, and other GIS data to accurately locate all the riparian point count locations using only digital maps, so the majority of riparian transects relied on field reconnaissance to select the point count survey locations. Less frequently, entire transects were relocated to more appropriate habitat within the same stream system (up to 3km of the originally selected location). As with the upland sample, these 100 transects are intended as permanent sampling locations and will be visited annually throughout the course of the study as long as access permits. We will adjust the number of riparian transects given fluctuations in field crew size as funding levels dictate (as described for the upland sample), while retaining the GRTS order of sites to ensure spatial balance between years.

Influence of sample design on analyses: detectability

The detectability (probability of recording the presence of a species when it is in fact present at a location) of targeted species is a key measure for converting occurrence records into indices of abundance, occupancy, distribution, habitat associations, and other metrics used to glean information from monitoring data (Nichols et al. 2008). For species with low detectability, it is difficult to establish whether a non-detection at a survey location is because the bird is actually absent or just not detected (Kery & Schmidt 2008). We can have greater confidence therefore in calculated indices from highly detectable species than less detectable ones.

A major tradeoff exists between sample size and the number of repeat surveys (returning to same location a certain number of times within one season) that are conducted. Occupancy analysis relies on repeated surveys over time at the same locations to establish more reliable estimates of presence/absence and to calculate detectability. For species with low detectability a large number of repeated surveys within a season may be required to establish its presence at a survey location (Kery & Schmidt 2008; Royle et al. 2005). However, the total sample size is reduced with each repeat. We chose to balance the need to cover more area with the need for many repeat surveys by only visiting each transect a maximum of twice per season, but also conducting multiple counts within a relatively small area.

All four MIS included in this project vocalize frequently (by singing, calling, or drumming) and can be easily distinguished from other species likely to be in similar habitats (with the exception of Hairy Woodpecker drumming). We documented with 2009 data that all four species have relatively high detectability rates at the transect scale (i.e. probability of detection = 0.5 or greater). However, the distance at which their songs can be detected varies greatly and depends on many different factors (Simons et al. 2007). An examination of our 2009

field survey data revealed that there was a wide range of effective detection distances (from 100m to over 300m) among these four species (Figure 5).

Playback survey utility

The call-playback surveys contributed a large number of unique detections to the total sample in 2009. We compared the number of observations unique to the call-playback surveys to observations from the passive point counts (four counts lumped into one transect). For Hairy Woodpecker, the call-playback surveys were responsible for 25% of all records (i.e. if only passive point counts were conducted the number of detections would have been 25% smaller). Approximately 13% of the Mountain Quail records were unique to the call-playback surveys. This suggests that adding a call-playback survey after passive point counts increases detection rate for both species, but is more valuable for Hairy Woodpeckers than for Mountain Quail. Hairy woodpeckers do not appear to reduce their response rate later in the breeding season, but in 2009 Mountain Quail showed a seasonal reduction in detection rates with the second survey which matches our previous field experience with this species. Unfortunately, it is logistically unfeasible to move our survey efforts for Mountain Quail earlier in the season due to limited access (snow) prior to May and the extra effort required to conduct early Mountain Quail surveys would take away from our sampling for the other species later in the spring. Despite the apparent offset of optimal timing of our surveys with Mountain Quail vocalizations we have a large number of detections and detectability is high for this species using our current methods.

Influence of sample design on analyses: scale

Species' home range size influences the interpretation of occurrence estimates (regardless of whether abundance, occupancy, or another state variable is used) calculated from point count records (Royle et al. 2007). Our transect design was purposely built to be flexible for analyzing species occurrence records of many species where both detectability and home range size may vary widely. Fox Sparrow (Weckstein et al. 2002) and Yellow Warbler (Lowther et al. 1999) territories generally run up to approximately 1 ha (about a 57 m radius circular area) and thus adjacent point counts are unlikely to survey the same territory, but individual points are likely to survey multiple territories. Hairy Woodpecker territories can be as large as 3 ha or more (Jackson et al. 2002) and Mountain Quail (Gutiérrez & Delehanty 1999) have territories up to 100 ha. This fact influenced our transect design, where each point within the transect samples about 3-30 ha (or a 100-300 m radius) depending on the effective detection distances of the species recorded, while aggregated counts from all five points (or eight, for the riparian sample) within a transect are representative of a much larger area (up to 1 square km, or 100 ha). We have the flexibility therefore to consider each point count an individual sampling unit for species with smaller territories, while the entire transect can be treated as a sampling unit (by lumping all the point count records together) for species with large territories. We will include spatial dependency factors in any models assuming independence of sampling units to account for spatial autocorrelation.

Sample size and effort

In choosing the number of survey locations to visit, we weighed tradeoffs between power (probability of detecting a real trend), spatial coverage, sample design issues (e.g. randomization of survey plots, minimizing bias, maximizing detection probability), effort, number of revisit

surveys, and travel time between survey locations and other logistical constraints. Although we viewed power as being of secondary importance compared to adequate spatial coverage and careful sample design to maximize the precision of parameter estimates (Seavy & Reynolds 2007), we strove to have high confidence in our trend estimates at the Sierra Nevada bioregional scale, and when possible at the individual forest scale as well. For the upland sample, 500 transects distributed using the GRTS sampler gives us between 46 and 70 sampling units on the larger forests in this study area (Table 4). With a sample of 50 transects, we estimate a minimum of 90% power to detect a 5% annual trend in occupancy over 5 years (assuming 50% coefficient of variation, $\alpha = 0.2$, 2-tailed test, exponential growth model, and only one count per transect per year). This level of power should be attainable for each of the larger forests, or for two adjacent smaller forests combined. We estimate that similar power to detect trends from the riparian sample (100 total transects) will be achievable only by combining sampling units across three or more forests. However, these numbers are coarse estimates and we will be able to verify these values only after 3-5 years of survey data are available from which to calculate coefficient of variation values for each species of interest.

We assessed the prevalence (proportion of surveys with detections) for the MIS from 2009 data to determine whether our upland and riparian samples were generating adequate detection rates for these four species from which to calculate trends over time. In this analysis we used only the detections within 200 m of the observer, which removed few Fox Sparrow, Hairy Woodpecker, and Yellow Warbler records, but did remove a sizeable portion of Mountain Quail records (Figure 5). In the case of Mountain Quail and Hairy Woodpecker, the results also include the call-playback survey records. We treated adjacent transects (i.e. the A and B point count clusters) as independent surveys, even though they may be subject to high spatial

correlation. Fox Sparrow was the most frequently detected of the MIS (6th most common species in our sample, based on the number of individuals recorded), recorded on 33% of point counts and 50% of transects. Mountain Quail was next most abundant (ranked 15th in detection frequency) and was recorded on 17% of all point counts and 42% of all transects, followed by Hairy Woodpecker (ranked 25th in detection frequency, 15% of point counts, 46% of transects). Yellow Warbler was recorded on 14% of riparian point counts and 28% of riparian transects (as well as on 6% of upland point counts, and 14% of upland transects).

A prevalence of 50% would be ideal for identifying trends since it gives the maximum range of local colonization (establishment at previously unoccupied transects) and local extinction (extirpation at previously occupied transects). Given that all three of the upland species were present on more than 40% of the transects, the upland sample is well suited to for calculating population trends. Yellow Warbler was the least prevalent of the MIS in 2009, and we altered the riparian sampling frame significantly following the 2009 pilot field season (to more accurately depict riparian habitat) and more than doubled the number of transects surveyed in order to increase the probability of detecting trends at the targeted level and time frame.

The total amount of field effort (person-days available for completing point counts) is difficult to predict, but we expect to complete repeat surveys on less than 100% of our transects. Approximately 75% percent of the 300 transect pair locations (250 upland and 50 riparian, 600 total transects, 2900 total point count plots) will be surveyed twice each year with the remaining 25% surveyed once. This survey effort is based on the number of field technicians we can afford under current funding levels, the number of point counts each can complete in a single morning, and an estimated frequency of restrictions to completing fieldwork (such as weather, absence of road access, and other unforeseen circumstances). In 2009 12 field biologists surveyed 2252

point count stations (1828 passive point counts and 424 playback surveys) at 229 transect pair locations (207 upland sample transect pairs and 22 riparian). We conducted repeat surveys at only 58% of the 229 transect pairs. We have increased the size of the field crew to 15, and therefore: $15 \text{ field techs} \times 30 \text{ survey mornings} \times 1 \text{ transect pair per day} = 450 \text{ transect pair surveys}$ (75% of 600 total transect pair surveys). With increased efficiency following the pilot field season we expect this repeat survey rate to be feasible, but given factors outside of our control or ability to predict it may be slightly higher or lower in some years. Sites surveyed only a single time in a given year will be prioritized for surveying twice the following year in order to bolster the confidence in occupancy estimates at those locations.

III. Field Methods

Details of point count methods

We are employing a standardized point count method to survey each of the four MIS and associated species. Here we summarize the point count protocol and explain the rationale for the various options within it that we have chosen. A complete description of the point count methodology is provided in the point count standard operating procedures in Appendix A. We employ a 5 minute variable circular radius plot (VCP) survey method (Ballard et al. 2003; Ralph et al. 1995) and record the exact distance (to nearest 1 m) to each detection. We chose five minute point count surveys because it is the method used by most researchers currently conducting landbird monitoring in the Sierra Nevada and Cascades (Siegel et al. 2007; Stine et al. 2005) and it provides a compromise between the need to detect species that vocalize less frequently (rationale for a longer count, Barker et al. 1993) with the need to survey more sites. We chose to record the exact distance to each individual bird detected as it allows for estimation of detection probability functions (Buckland 2001) while also allowing for the greatest data processing and analysis options including binning of data for comparison with previously used methods in the Sierra Nevada and elsewhere (e.g. Siegel & DeSante 2003).

Based on our 13 years of experience conducting landbird surveys in the Sierra Nevada the appropriate window for point count surveys extends from mid May through the end of June. This period coincides with the arrival of the latest arriving Neotropical migrants (such as flycatchers) and the time when numerous species reduce their singing rates in early July (R. Burnett pers. obs.). Surveying sites at lower elevations and lower latitude first and working north and upslope through the season allows for extending the season as much as possible. Each year, we will determine the counting window based on the timing of particular migratory

species' arrivals to begin up to one week earlier or extend the season one week later into July. This approach will allow us to take advantage of the yearly variation in the breeding season and maximize our sampling effort.

Point count surveys begin after sunrise and are completed within four hours. Point counts are not conducted in adverse weather conditions including high winds, fog, snow and rain, when bird activity levels and detection probabilities are substantially reduced. Weather data will be recorded throughout the morning and if conditions are questionable observers will discuss with field crew leaders if counts need to be repeated.

Playback surveys

In order to increase detection rates for Hairy Woodpecker and Mountain Quail, we are conducting call playback surveys (BCMELP 1999) at the center of the 1 km grid cell, in addition to passive point counts (Figure 3). We perform the call-playback survey following the passive point counts in order to avoid drawing individuals to the playback calls from territories that intersect adjacent point count locations and thereby removing them from detection at those locations or increasing their detectability at adjacent locations. Calls for Hairy Woodpecker (vocalizations and drumming) and Mountain Quail (vocalizations only) are played in 30 second increments followed by a 30 second listening period, in two segments each, followed by a final 1 minute listening period for a total survey length of five minutes (Figure 4). We broadcast “peek” and “rattle” calls and drumming for Hairy Woodpecker (Jackson et al. 2002), and the advertisement call or “queerk” and rapid clucking crow call of male Mountain Quail (Gutiérrez, and Delehanty 1999). We use FoxPro digital game callers to broadcast the calls, and recordings are taken from Bird Songs of California (Keller 2003) with the volume of calls standardized

among all game callers (at 75 db). Technicians rotate the direction of calls during playback, and record all woodpecker species and quail (e.g. California and Mountain) that appear to respond to the calls.

Field technician training

Observer variability can greatly influence the integrity of point count data (Sauer et al. 1994), thus it is critical to hire experienced technicians and then put them through a rigorous training program. Field technicians who conduct point counts will have previous experience identifying western landbirds and/or experience using variable circular plot point count methods. The most experienced personnel with multiple years of experience point counting for western birds will lead the three week training program. At least two months prior to arrival, each field technician will receive a CD with vocalizations of all bird species that occur within the study area. Field technicians are expected to study bird vocalizations prior to arriving for spring training and arrive with a solid knowledge of Sierra Nevada bird species identification by both sight and sound. During late April-mid May, we spend 3 weeks in the field training technicians on bird identification, distance estimation, and point count and call playback methodologies. A complete description of the standard operating procedures for crew training are provided in Appendix B.

Vegetation surveys

Vegetation surveys using a relevé'-based protocol are conducted in July and August by members of the field crew with plant identification experience. All data are collected within a 50 m radius circle centered on each point count station. Vegetation measurements rely on visual

estimates of cover and rapid acquisition of diameter, height, and basal area measurements using timber cruising tools. Measurements include plant cover in four vertical layers; height, diameter, and cover of each species within the shrub, sub-canopy, and canopy layers; ground cover; basal area; CWHR type; snag counts; coarse woody debris assessment; and other measurements (see Appendix D for complete details of the field vegetation survey methodology). Vegetation surveys will be repeated every 3 years at each point count location, or immediately following a major change in vegetation structure due to management or other disturbance. These surveys will also be instrumental in ground truthing the GIS habitat classification at each survey location to ensure we are monitoring these species within the habitats they were chosen to indicate.

Field logistics and staffing

We anticipate the need for fourteen full-time field technicians to complete the sampling outlined in this plan. Based on our pilot season in 2009 we plan on having these fourteen technicians divided into Northern, Central, and Southern crews. Individual crew size depends on the logistics of accessing sites within each forest and number of sites per forest. For example, forests in the southern Sierra are larger, intersected by two national parks and have less road coverage and will thus require more hiking and a larger crew. The north crew will consist of a crew of four and will cover the Modoc, Lassen and one-third of the Plumas NF. The central crew will also have a crew of four in addition to the field manager (A. Fogg), and will cover two-third of the Plumas, the Tahoe, the Lake Tahoe Basin Management Unit, the Eldorado, and the Inyo National Forests. The southern Sierra will consist of a crew of six, with three teams of two stationed separately; they will cover the Stanislaus, Sierra, and Sequoia National Forests.

Safety

Safety is our highest concern for the MIS field crew. Technicians work with at least one teammate with two-way radio contact between each member. Each vehicle is equipped with a forest service two-way radio and all personnel receive USFS training on its use. During training we discuss typical hazards (including wildlife, marijuana gardens, and hypothermia) encountered in the Sierra Nevada, the best way to deal with them, and subsequent actions should an incident occur (see Appendix C for a list of hazards and suggested solutions). Crew members are required to notify crew leaders and project leaders of dangerous situations and any injuries that occur on the job. Crew leaders and project leaders will follow up with the crew member, fill out appropriate documentation of any injuries, and contact Forest Service personnel if necessary. Each crew member will be trained on driving on forest service roads and will be instructed on the dangers and procedures for reporting dangerous road conditions to the Forest Service. We will work with Forest Service personnel to maximize the driving skills of our seasonal technicians and reduce the risk of accidents. Crew members will immediately report any accidents that occur to project leaders, whether they cause visible damage to the vehicles or not.

At the beginning of the field season, project leaders will contact forest staff to inform them about MIS project activities in their forests. Crew leaders will contact forest and district staff weekly via email or phone to let them know the specific areas MIS crew members will be working in and to obtain updates on forest conditions and to identify potentially dangerous areas to avoid, including: drug activity, snowed-in roads, downed trees, washouts, and other dangerous road conditions, as well as fire (natural and prescribed burning) and logging activity. Each crew member will be supplied with a list of Forest Service contacts and crews will be encouraged to

visit district ranger stations to inquire about road conditions and areas that may be closed due to wildlife or illicit drug activity.

Data management

Field crews are responsible for data entry in timely manner (typically within a few days of collection) and uploading point count and vegetation survey data multiple times per week into an online data entry tool through the California Avian Data Center (CADC) where databases are backed up frequently and reliably (Ballard et al. 2008). Before uploading data, technicians are required to proof their data by comparing raw data to what was entered in the database. At the end of each field season crew leaders and experienced point count technicians extensively re-proof all field surveys and correct mistakes. The project manager then conducts a final analysis of data integrity to identify systematic errors unique to each field technician prior to the data being made available on CADC. All raw data sheets will be scanned and digital copies will be stored on regularly backed up PRBO servers. All data will be available online (on CADC) by December 1 of the year the data were collected.

IV. Data analyses and reporting

Occupancy analyses

We feel that it is valuable in a monitoring project such as this one to adjust species occurrence records to remove biases inherent in point count data (Seoane et al. 2005). Without adjusting for detectability and other factors, occurrence data are still useful as indices of abundance and density, but must be considered in the proper context or they can be misleading (Johnson 2008). In particular, ignoring inter-specific differences in detectability can lead to underestimating abundance for inconspicuous species and makes comparisons across species difficult (Kery & Schmid 2004).

There are a number of methods for adjusting point count data to reveal more realistic estimates of occurrence, and these indices are generally based on corrections using distance to recorded individuals (Buckland 2001), multiple observers (Alldredge et al. 2006), or repeated samples at the same locations (Royle et al. 2005). We have chosen to use occupancy analysis (MacKenzie et al. 2006), a technique that relies on repeated sampling at the same locations. We will then average the estimates within larger groups of survey locations (e.g. ranger districts and forests), and throughout the entire project study area (the entire Sierra Nevada) and track the trends and spatial pattern of changes in occupancy over time. Since the objective of this project is to determine the changes in distribution of populations over time (USFS 2008a, b), we feel that occupancy is the most appropriate metric to track as it allows us to minimize our reliance on accurate distance estimates which are very difficult to collect in forested habitats (Alldredge et al. 2007). Distance estimates will be used only to select a cutoff for each species at maximum effective detection distance to remove the records that we have lower confidence in. We take advantage of the fact that these four MIS have relatively high detectability (discussed later and in

Figure 6), thus allowing us to conduct relatively few repeat surveys at each location and maximize our sample size and spatial distribution (Mackenzie & Royle 2005).

Occupancy modeling is a method for estimating the probability of a species' presence at a site when the probability of detection of that species is less than 1 (which it nearly always is). Covariates including site conditions (habitat type, slope, elevation, aspect) and survey variables (observer, weather conditions, time of day, day of year) can be included in occupancy models as these factors can influence both detectability and occupancy.

The interpretation of occupancy parameter values depends on the scale at which point count records are aggregated. The biological meaning of occupancy at the point count scale (treating each point count location as an independent sample unit) is similar to an individual-level population parameter, in other words the probability of encountering an individual at that location. Given certain restrictions, e.g. when the effective area surveyed is approximately the same as that of an average individual territory, then occupancy will very closely track changes in abundance (MacKenzie & Nichols 2004). Alternatively we can aggregate point count records at the transect level, in which case the biological meaning of the occupancy parameter is akin to a population-level distribution measure, or the proportion of the sampled area occupied. When multiple sampling units are aggregated and occupancy estimates are averaged over those locations (e.g. within a ranger district or forest) then occupancy can represent the proportion of a broader area occupied by the species.

Preliminary occupancy results

We have completed a very simple initial set of analyses based on calculation of the metric occupancy using the program PRESENCE (Hines 2006). PRESENCE provides a flexible

framework to calculate overall and per-sample occupancy, as well as species detectability, while incorporating covariate information. It also allows for missing observations. We have kept this first set of calculations on our 2009 results very simple, using the presence or absence at each point count location, and we incorporated only elevation, slope, latitude, and a very general habitat group classification including: conifer forest, broadleaved forest, chaparral, and non-forest (generated from EVEG GIS layers at a 300m resolution) as covariates in occupancy and detectability calculations. We discuss the results for each of the four MIS with occurrence records aggregated at the transect level (Fox Sparrow and Yellow Warbler results include all upland sample and riparian sample transects, Mountain Quail and Hairy Woodpecker results include only the upland sample transects but also include the call-playback survey records in each transect estimate).

Detectability (probability of counting a species as present on a survey when it is in fact present) is highest for Fox Sparrow (0.81) and Mountain Quail (0.72), and somewhat lower for Yellow Warbler (0.55) and Hairy Woodpecker (0.48). Values greater than 0.3 are generally considered to provide acceptably low variance for producing reliable occupancy estimates with relatively few repeat samples (MacKenzie et al. 2002). Mountain Quail showed a relatively large difference in detectability between the first and second visit (decrease in detectability of 0.14 from first to second visit) indicating that there is a seasonal/temporal effect on calling rates. In future occupancy modeling we plan to include site and survey-level covariates to account for the influences of seasonality, habitat, time of day, and other effects on detectability.

We fit occupancy models (Figure 6) using the covariates listed above, and detectability was held constant across all surveys except for Mountain Quail (detectability varied by visit #). The ‘naïve estimate’ shows the proportion of all transects in which each species was recorded as

present in the sample, while the occupancy values show the estimates corrected for imperfect detection. The species with the highest detectabilities (Fox Sparrow and Mountain Quail) have the smallest proportional correction. In other words their naïve estimates are more similar to the occupancy estimates than are those for species with lower detectability (Yellow Warbler and Hairy Woodpecker). Note also that the rank order differs with Hairy Woodpecker estimated as the species with highest rates of occupancy, vs. Mountain Quail according to the naïve estimate (Figure 6).

Reporting and access to results

This project is unique in that a larger number of biologists and other Forest Service personnel will have access to the data and a wide variety of analyses from this project. Thus, we are developing an interactive Sierra Nevada avian monitoring information website (hosted by PRBO) that will serve as a portal for accessing the data we have collected and for conducting analyses (see Appendix E for a description, or visit <http://data.prbo.org/partners/usfs/snmis/>). On this website we provide: a general description of the PRBO MIS project goals and methodology; a link to this study plan; access to raw project data, maps of survey locations and species occurrence records; and the results of a wide variety of analyses and text describing the methods that were employed to generate them. Visualizations and other data (e.g. graphs, charts, and maps) are available for use in the production of MIS reports and other analyses by Forest Service personnel. This website is online as of March 2010, but currently in a beta-design format. Updates and refinements of all aspects of the website are ongoing.

Data collected by this project will be stored in the California Avian Data Center (Ballard et al. 2008) and subsequently made available on PRBO's Sierra Nevada avian monitoring

website in the fall following the field season. We believe this unprecedented online access to data and analysis is the most efficient approach to making the results of this project readily available to USFS personnel in a timely manner. Thus, we propose to limit our annual reporting each year to a summary of work completed with a brief synopsis of the current status of each of the four MIS. This synopsis will be intended as a companion document to data available online. We intend to regularly produce manuscripts and other publications from this project and will present results at appropriate scientific conferences.

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Tables

Table 1 – MIS and associated complementary habitat species

The Sierra Nevada National Forest Management Indicator Species (MIS), the habitats they were chosen to indicate, and PRBO suggested complementary focal species for those habitats are listed below. Data for each of the complementary species will be collected simultaneously when MIS species are being surveyed. The majority of these species have already been identified by California Partners in Flight as focal species for either the Coniferous Forest or Riparian bird conservation plans (CALPIF 2002, 2004). These species will provide further insight for interpreting the observed trends of the four selected MIS and will be instrumental in developing management recommendations and in guiding changes in management actions.

* Denotes a California Partners in Flight Coniferous Forest or Riparian habitat focal species

<i>MIS Species</i>	<i>MIS Habitat</i>	<i>Complementary Species</i>
Mountain Quail	Early & Mid Seral Conifer Forest	Western Tanager* Dark-eyed Junco* Golden-crowned Kinglet* Black-throated Gray Warbler* Chipping Sparrow
Fox Sparrow	Montane Chaparral Shrublands	Dusky Flycatcher MacGillivray's Warbler* Mountain Quail Yellow Warbler* Green-tailed Towhee
Yellow Warbler	Montane Riparian	Song Sparrow* Wilson's Warbler* Warbling Vireo* Black-headed Grosbeak* MacGillivray's Warbler*
Hairy Woodpecker	Snags in Green Forest	White-headed Woodpecker Mountain Chickadee Red-breasted Nuthatch* Olive-sided Flycatcher* Brown Creeper*

Table 2 – Areas of habitat calculated from Existing Vegetation (EVEG) GIS layers

Habitat areas are summed across all Sierra Nevada national forests using the CALVEG wildlife-habitat relationship (CWHR) vegetation types (Mayer & Laudenslayer 1988). Habitat codes in bold type are included in the sampling area, and x's indicate each CWHR targeted as habitat for that species [Hairy Woodpecker: HAWO, Mountain Quail: MOUQ, Fox Sparrow: FOSP, Yellow Warbler: YWAR].

CWHR	Habitat description	Hectares	% area	HAWO	MOUQ	FOSP	YWAR
ADS	Alpine Dwarf Shrub	39,046.41	0.76	-	-	-	-
AGS	Annual Grass	97,423.65	1.91	-	-	-	-
ASC	Alkali Desert Scrub	11,329.29	0.22	-	-	-	-
ASP	Aspen	10,977.12	0.21	x	-	-	-
BAR	Barren	296,282.07	5.79	-	-	-	-
BBR	Bitterbrush	65,413.80	1.28	-	-	-	-
BOP	Blue Oak-Foothill Pine	10,497.87	0.21	-	-	-	-
BOW	Blue Oak Woodland	31,722.03	0.62	-	-	-	-
CRC	Chamise-Redshank Chaparral	4,843.44	0.09	-	-	-	-
DFR	Douglas Fir	35,770.50	0.70	x	-	-	-
DSC	Desert Scrub	39,131.19	0.77	-	-	-	-
EPN	Eastside Pine	388,582.20	7.60	x	x	-	-
JPN	Jeffrey Pine	66,454.11	1.30	x	-	-	-
JUN	Juniper	112,230.99	2.19	-	-	-	-
LAC	Lacustrine	44,638.65	0.87	-	-	-	-
LPN	Lodgepole Pine	92,547.90	1.81	x	-	-	-
LSG	Low Sage	197,132.67	3.85	-	-	-	-
MCH	Mixed Chaparral	128,253.51	2.51	-	-	x	-
MCP	Montane Chaparral	301,823.28	5.90	-	-	x	-
MHC	Montane Hardwood-Conifer	126,959.31	2.48	x	-	-	-
MHW	Montane Hardwood	215,378.28	4.21	x	-	-	-
MRI	Montaine Riparian	15,912.81	0.31	-	-	-	x
PAS	Pasture	1,647.27	0.03	-	-	-	x
PGS	Perennial Grass	76,651.11	1.50	-	-	-	-
PJN	Pinyon Juniper	153,746.55	3.01	-	-	-	-
PPN	Ponderosa Pine	161,100.00	3.15	x	x	-	-
RFR	Red Fir	306,884.07	6.00	x	x	-	-
SCN	Subalpine Conifer	165,139.38	3.23	-	-	-	-
SGB	Sagebrush	426,733.38	8.34	-	-	-	-
SMC	Sierran Mixed Conifer	1,243,550.52	24.32	x	x	-	-
VOW	Valley Oak Woodland	183,15.27	0.36	-	-	-	-
VRI	Valley Foothill Riparian	376.02	0.01	-	-	-	-
WFR	White Fir	181,368.63	3.55	x	x	-	-
WTM	Wet Meadow	33,805.71	0.66	-	-	-	x
<u>Total:</u>		<u>5,113,691.10</u>	<u>100%</u>				
Sampled (bold):		3,317,470.02	64%	55%	45%	8%	1%

Table 3 – List of GIS layers used and locations for metadata and downloads

The ownership boundary was used to clip feature layers of interest and as a stratification for sample point selection. The existing vegetation tiles were joined into a single coverage for the entire Sierra Nevada region and used as a stratification. The roads and trails layers were buffered to 1 km and used as a stratification. The digital elevation model was used to calculate slope and elevation stratifications. The California hydrology and Sierra Nevada Montane Meadows layers were used to identify potential riparian habitat locations.

<i>Layer description</i>	<i>Metadata web address (url)</i>	<i>Date accessed</i>
Forest service basic ownership	www.fs.fed.us/r5/rsl/projects/gis/data/calcovs/BasicOwnership09_1.html	3/1/2009
Tiger local and major roads	projects.atlas.ca.gov/frs/download.php/784/LocalRoadsTiger.shp.xml , projects.atlas.ca.gov/frs/download.php/785/MajorRoadsTiger.shp.xml	1/23/2009
USFS transportation (roads and trails)	www.fs.fed.us/r5/rsl/clearinghouse/r5gis/transportation/	1/23/2009
California hydrology	projects.atlas.ca.gov/frs/download.php/677/metadata.xml	1/23/2009
National Forest Existing Vegetation	www.fs.fed.us/r5/rsl/projects/frdb/layers/ev_mid.html	1/27/2009
USDA Forest Service digital elevation model	www.ice.ucdavis.edu/snep/dictionary/metadata.html#Metadata.sndem	2/12/2009
Sierra Nevada Montane Meadows	www.fs.fed.us/r5/rsl/projects/gis/data/calcovs/SNV_MontaneMeadowVeg.html	8/1/09

Table 4 – Summary of transect locations within each forest

This table lists the number of transect pairs (generated by the GRTS algorithm) in each forest. The distribution of sampling units among forests depends on the amount of area available for sampling given our stratifications and the spatial distribution of available areas. The first column shows both the total area in each forest, and the number of potential sampling units from the upland sampling frame (a 1 km² tessellation). The 20 remote area sites are part of the upland sample (250 total). The 50 riparian sites are selected from a separate sampling frame (a 100 m² tessellation).

<i>Forest</i>	<i>Area [km²] (stratified tessellation points 1 km² grid)</i>	<i>Upland transect pairs</i>	<i>(Remote area transect pairs)</i>	<i>Stratified riparian tessellation points [100 m²grid]</i>	<i>Riparian transect pairs</i>
Eldorado	3222 (1084)	23	(3)	141	4
Inyo	8499 (482)	14	(3)	77	2
Lassen	6029 (2720)	38	(0)	274	9
Modoc	7099 (2166)	26	(0)	281	7
Plumas	6402 (2669)	35	(1)	130	8
Sierra	5634 (1757)	35	(5)	92	5
Sequoia	4804 (1069)	29	(8)	104	3
Stanislaus	4421 (1402)	23	(0)	134	5
Tahoe	4861 (1504)	25	(0)	144	5
LTBMU	1343 (201)	2	(0)	95	2
Total	52314 (15055)	250	(20)	1471	50

Figures***Figure 1 – Sierra Nevada National Forests map***

The ten National Forests in the Sierra Nevada and southern Cascades include Modoc, Lassen, Plumas, Tahoe, Lake Tahoe Basin Management Unit, Eldorado, Stanislaus, Inyo, Sierra, and Sequoia. The study area for this project includes all the riparian, chaparral shrubland, and conifer forest habitats under National Forest ownership within these boundaries.



Figure 2 – Example of GRTS transect-selection routine

The black squares indicate potential sampling locations identified by stratifying a 1 km grid tessellation. The yellow dots indicate grid cells selected by GRTS for field surveys. The extent of this figure shows only a very small portion of the entire sampling area (this particular location is in the Lassen National Forest). No potential sampling locations are distributed in private (white) lands or in the National Park (orange) lands. The grid cells in the Caribou Wilderness Area (dark green area in the bottom/center) do not have road access and thus have not been included in the final sample (note, however, that we are conducting some surveys in roadless areas, but at a lower intensity, see Table 4).

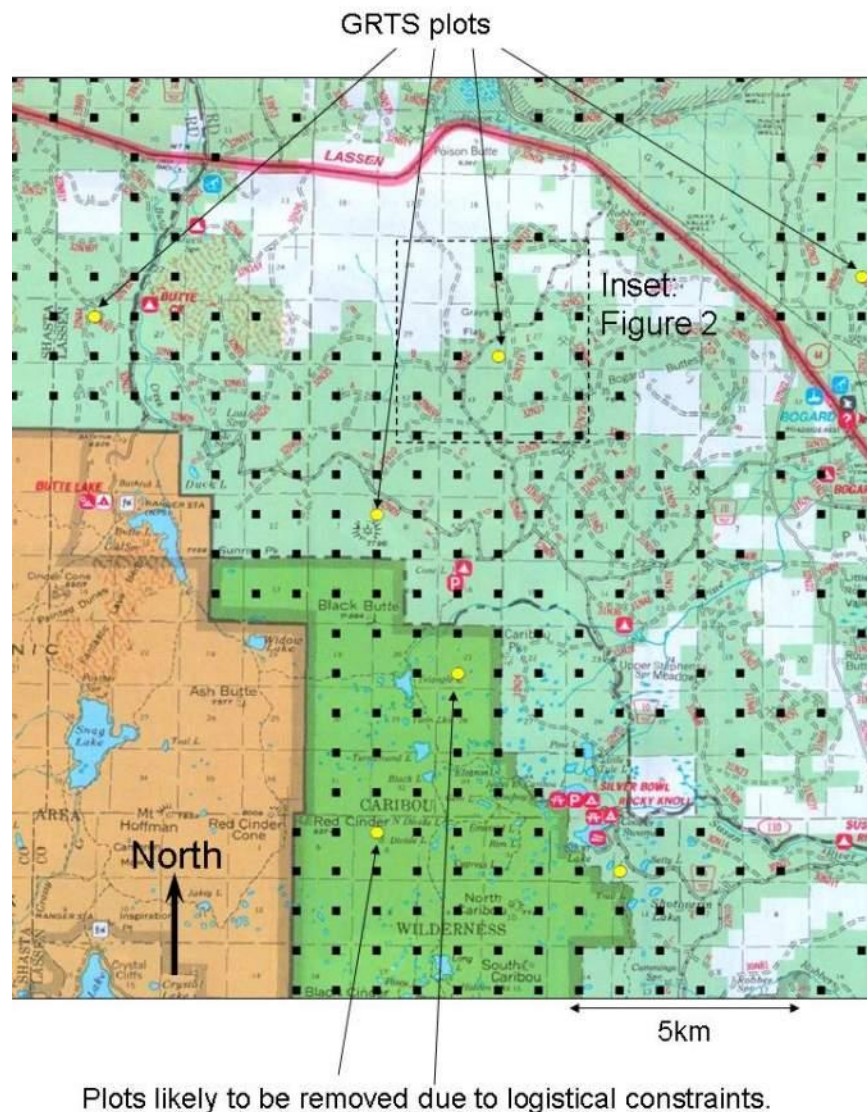


Figure 3 – Point count spatial arrangement

The spatial arrangement of point count transects is shown below. A) – Upland transects consist of a center point corresponding to a location from the original set of potential sampling locations (Figure 2), and four perimeter points spaced at 250m intervals from the center point. 5-minute passive point counts are conducted at all five locations, and one 5-minute call-playback survey is conducted at the transect center point following the passive point counts. B) Riparian transects consist of eight point count stations typically arranged in a linear pattern along a stream channel. No playback surveys are conducted at riparian point count locations.

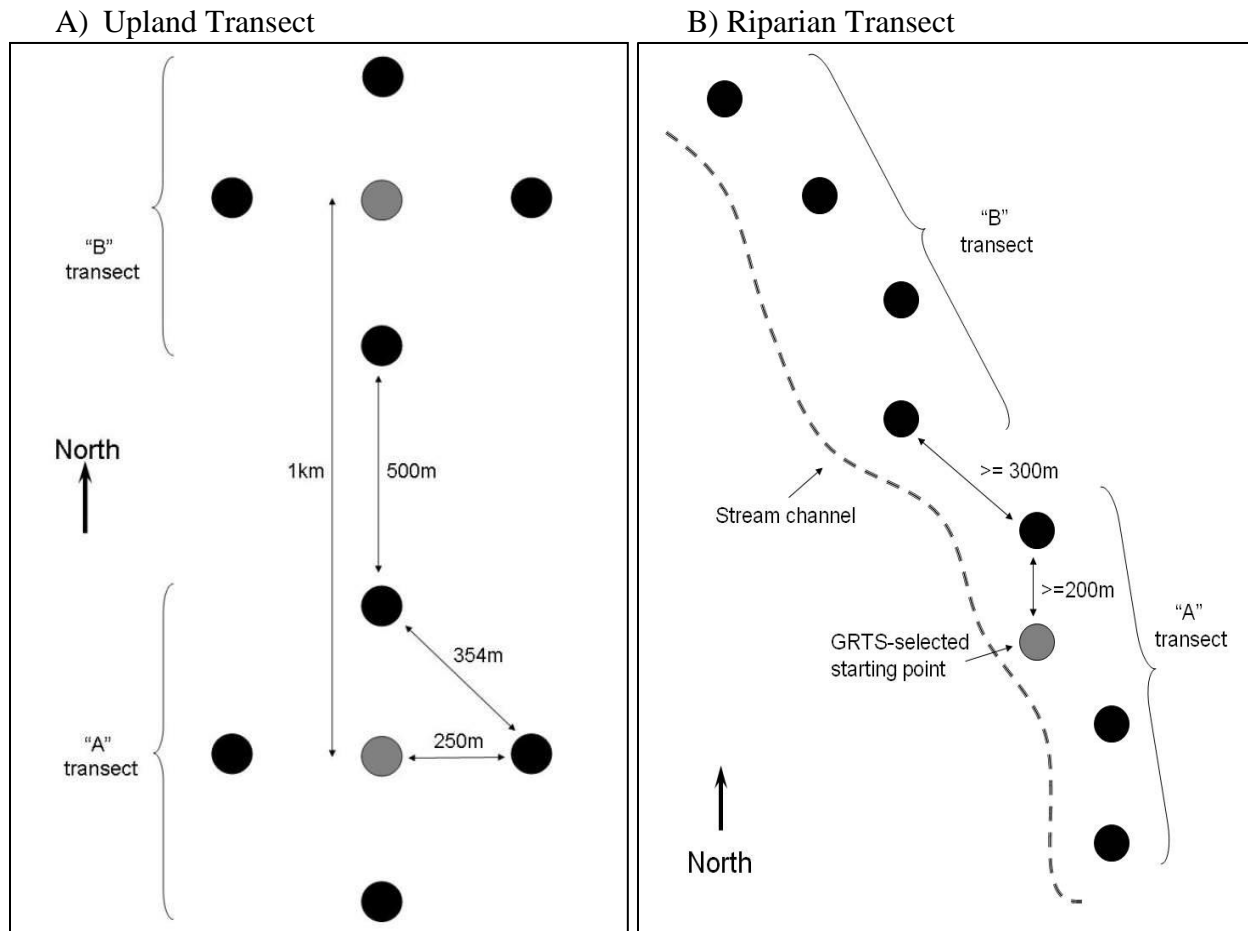


Figure 4 – Call-playback survey timing

A 30 second call broadcast (shaded boxes) is followed by a quiet 30 second listening period for Hairy Woodpecker and Mountain Quail, and then repeated, followed by a final one minute listening period.

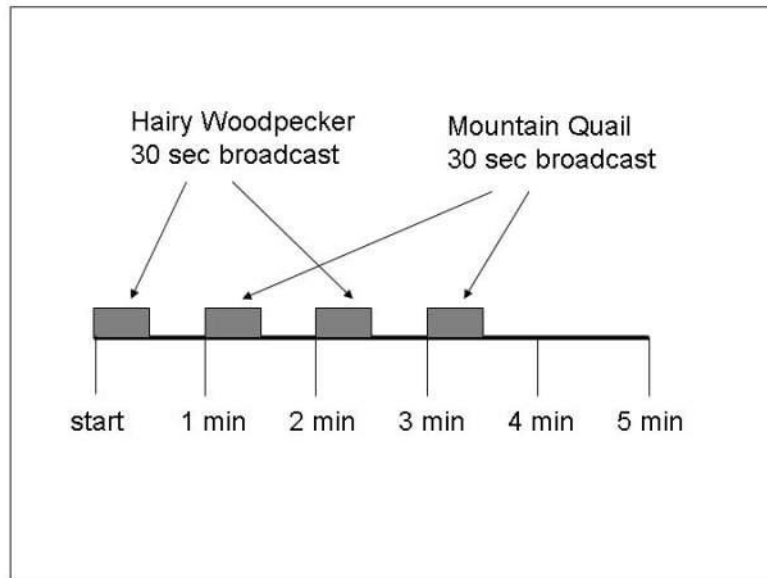


Figure 5 – Detections by distance for MIS from the 2009 field season

The number of detections (proportion of all individuals of each species recorded) for each of the MIS is shown within 20m distance bands. 90% of Yellow Warbler (YWAR) detections were at less than 100m. 90% of Fox Sparrow (FOSP) and Hairy Woodpecker (HAWO) detections were at less than 140m. Mountain Quail (MOUQ), on the other hand, were frequently detected at greater than 300m (37% of all detections). X-axis labels show the midpoint of each distance band.

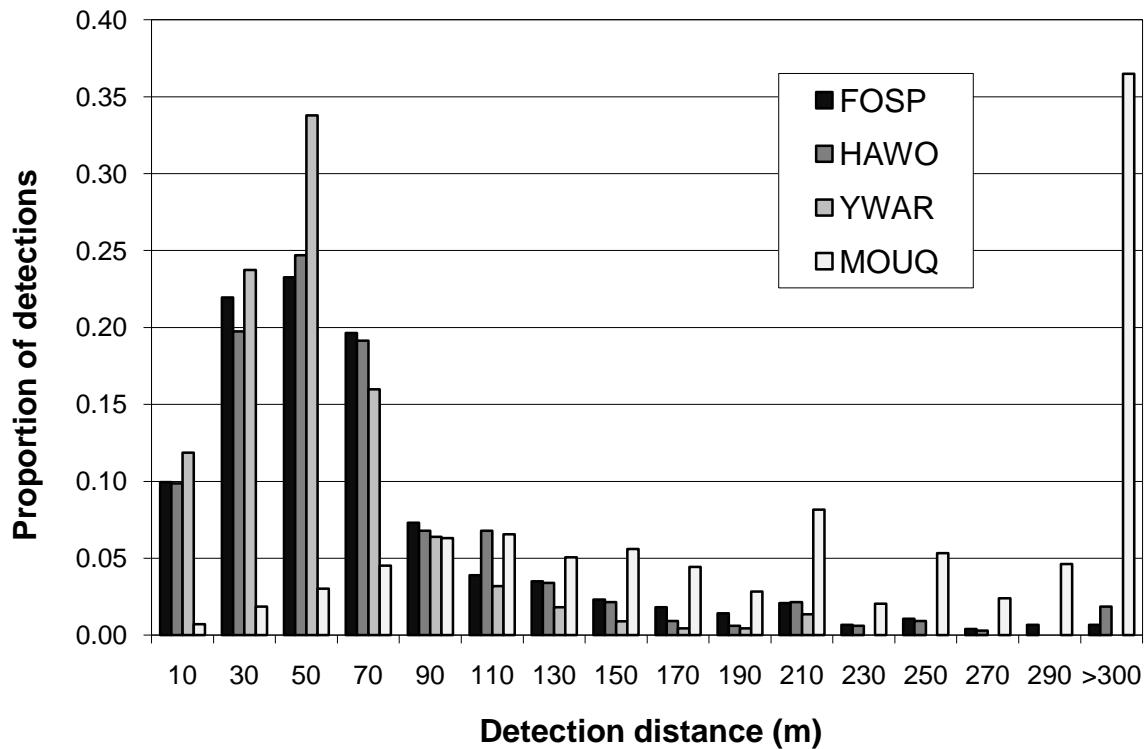
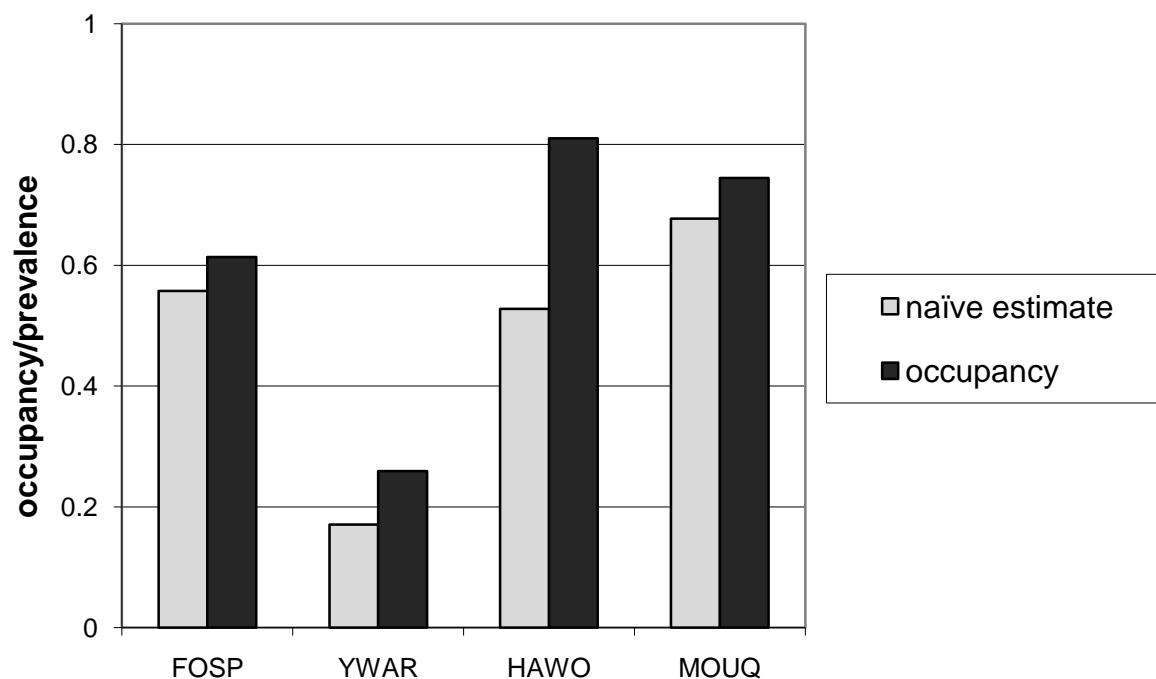


Figure 6 – Occupancy results for MIS from the 2009 field season

Occupancy estimates are plotted next to naïve estimates (in this case prevalence, the proportion of transects at which at least one individual was present) for each of the MIS. Fox Sparrow (FOSP), Hairy Woodpecker (HAWO), and Mountain Quail (MOUQ) were all present on more than 40% of transects in 2009, while Yellow Warbler (YWAR) was present on only 17%. Occupancy estimates are always higher than the naïve estimates, due to detectability < 1.0 for each of these four species (i.e. occupancy corrects for the fact that sometimes the species went undetected at sites where it was in fact present). Despite the fact that Hairy Woodpecker has the 3rd highest naïve estimate, it shows the highest occupancy estimate. Fox Sparrow and Mountain Quail, the two species with highest detectability (see text), have the smallest divergence between occupancy and naïve estimates.



Reviewer comments

We thank the following reviewers for providing many useful comments and suggestions for improving this document. Their comments and suggested edits to the draft version of this document were received in December 2010. Their comments have been incorporated into this final revision, and notable changes are listed below.

D. Craig:

Inserted text regarding MIS language in planning process and references to 1982: 36 CFR 219.19(a) on pages 3-4 (in Background section).

P. Flebbe:

Incorporated various small edits throughout.

Added a figure depicting riparian transect design (Figure 3b).

Clarified discussion of point count locations as “independent” sample units by stating that we will include spatial dependency factors in any models assuming independence of sampling units. (Influence of sample design on analyses: scale Section, page 19).

R. Siegel:

Comment 1 – including the Pinyon-Juniper habitat class. Pinyon-Juniper was not identified in the USFS MIS documentation as a habitat of interest and we feel that it does not receive regular management that would necessitate monitoring with MIS protocols. Resolution: no change to study plan.

Comment 2 – establishing B transects in easy to access areas instead of randomizing location relative to A transect. We have built this monitoring program to rely on road-based access and without that feature the sample size would be critically reduced. We feel that given the extreme logistical challenges involved in returning to such a large number of field sites every year that choosing B transect locations with the criteria of minimizing access difficulty is similar to a true road-based design where transect starting points would be on a road and the transect would extend perpendicular if possible given physiographic limitations. However, our design further reduces the bias imparted by roads. Resolution: no change to study plan.

Comment 3 – extending length of point counts and using temporal intervals as repeat surveys for occupancy models. There is the potential for significant phenological change within our field season and we feel that distributing repeat visits throughout the field season is the optimal

solution for establishing species presence at the largest number of point count locations. Extended point counts using temporal replication as repeat surveys for occupancy modeling and eliminating revisits would reduce the detectability of certain species (e.g. those that may arrive late to breeding territories or that frequently temporarily emigrate). Resolution: no change to study plan.

Comment 4 – independence of sampling units, both at the point and transect scales. R. Siegel and P. Flebbe both correctly flagged the use of the term “independent” in this context. We edited the text to say “individual” and included additional text to say that whenever models assume independence of sample units we will include spatial dependency factors to account for the dependence of data that are in close proximity. Resolution: edited study plan.

Comment 5 – temporal pattern of Mountain Quail detection probability. In 2009 we saw a decrease in Mountain Quail detectability towards the end of the field season. In 2010 there was no such pattern, likely due to the late snowmelt and delay in breeding activities for this species (and potentially other ground-nesters). We will include a day-of-year factor in occupancy models to account for temporal variation in detectability, and have added text to the study plan to clarify this. Resolution: edited study plan.

Comment 6 – power analysis discussion is inadequately explained. The text covering estimated power is intentionally simple, but does warrant clarification. We added text to explain that the estimates are coarse only and do not apply to any current data, but will be verified once 3-5 years of survey data are available from which to calculate coefficient of variation values for each species of interest. Resolution: edited study plan.

Comment 7 – marking survey locations. We rely exclusively on recreation-grade GPS and feel that we consistently are able to achieve a ± 10 m accuracy in locating field sites. Given that errors in the estimated detection distances are likely to be much greater than 10m, we feel that this level of accuracy is more than adequate. We also collect photos of each point count location in four cardinal directions as a secondary source of location information and as a comparison to field vegetation surveys. Resolution: no change to study plan.

Appendices

Appendix A: Point count survey – Standard Operating Procedure

Part 1: Schedules and point count sites

Weekly Schedule

During the point count season (~May 10 – July 7), we generally conduct surveys 5 mornings a week although each crew can dictate their own schedule as long as all surveys are completed. Field techs are expected to complete two transects on each of five mornings per week. A typical workweek begins Sunday afternoon when crews leave for a site and camp there that night. One site contains two transects (A and B transect). Two sites are visited in one morning per team – either having each person do an entire site or splitting it and traveling to another site that same morning. Monday through Friday we usually travel between sites and return home Friday afternoon or occasionally before then.

Second visits to point count stations

Each point count station will be visited twice with different observers unless it is logistically very difficult to have two different observers. Second visits are ideally conducted 14-21 days after the first visit to account for phenological differences within the breeding season.

Daily Schedule

Field techs should begin their first survey 15 minutes after local sunrise to avoid the dawn chorus and complete it within 3-4 hours, generally by 0930 and never later than 1000. GPS units can be used to check on the local sunrise time (Main Menu < Calendar or Sun & Moon). For second visits to the site, we reverse the order in which point counts were conducted by changing the direction or switching which transect is done first. No observer should conduct point counts at the same transect twice in the same year.

Adverse weather conditions

We do not conduct surveys during weather conditions that reduce detectability (e.g., high winds or rain). In the Sierra Nevada, bird detections may even diminish in fog. If it is not possible to see clearly (due to fog) 100 m away and up to the top of trees then the survey should not be done. The consistency of data collection is of first priority. If conditions change for the worse while doing a count, remaining points can be completed within 3 days.

What to Bring

Field techs are responsible for the following:

- binoculars
- watch with countdown timer and beeping noise when time is up
- bird field guide
- food and water for a 5 hour survey + hike
- drab and earth-toned clothing

PRBO will provide:

- sufficient blank data forms

- clipboard
- at least two black ink pens
- directions and maps
- GPS unit & extra batteries
- Laser range finder
- digital game caller
- walkie-talkie or radio

Approaching the point count station

Approach the point count location with as little disturbance to the birds as possible and allow the birds to settle down for a period of 1-2 minutes, during which time you can delineate distances to visual landmarks using laser rangefinders. Attracting devices, recordings, or “pishing” are never used BEFORE or DURING a count. Pishing while chasing unknowns after a count is ok.

Duration of counts

Point counts are 5 minutes duration at each point. Use countdown timers on a watch set to 5 minutes, set to beep once that time has elapsed. If something interferes with the ability to detect birds during the 5-minute count (e.g. train, plane, or chainsaws), stop the count until the disturbance has passed and start over.

Part 2: Collecting bird survey data

Point Count Data Form: Header and point information

Use a new point count datasheet for each transect (e.g. one each for an “A” and “B” transect). Complete the header information on the first page of each datasheet and take care to note how many pages are included in the plot survey (e.g., 1 of 2). Write down the crew name (North, Central, South), the National Forest name (eg, Plumas) and the 5-digit alphanumeric transect ID code (eg, EL01A, SQ23B, MO07A). For riparian sites, the code is only 4-digits (eg, RI12, RI08). Header information also includes the month, day, year and visit number (01, 02 or 03).

Weather Data

At the first point count location record weather data at the bottom of the datasheet. Estimate the temperature, percent cloud cover, and wind speed. We use the Beaufort scale to estimate wind speed. Any significant changes in weather (such as increasing winds, cloud cover, rain or snow) are recorded in the margins or in the “Notes” section of the datasheet.

Point information and bird species codes

At each point, write down the name (N, S, W, E, C), the time in 24-hour format (eg, 0723) and for each field record, species are recorded using a 4-letter code (eg, FOSP for Fox Sparrow). PRBO uses codes based on the AOU checklist of North American bird species. Techs are provided with a copy to carry with into the field. A wavy line should be used to separate each point’s data from the next.

Point Count Data Form: Bird data

Every species detected at a point is recorded, regardless of distance from the observer. It is very important that all species are identified (especially those within 50 m). Field technicians should focus on identifying birds farther than 100 m once birds within 100 m are identified and counted. Closer birds should be given greater attention than distant ones as these observations are more valuable. Technicians can chase down unknown birds after the five minute count if time is available. Technicians are strictly instructed to only record bird detections with the 5-minute period and to not go “birding” after the count to include species they may have missed. Technicians are encouraged to keep track of all species observed throughout the morning in their field notebooks.

Unknown bird detections

For unknown species heard during the count, record “XXXX.” For unknown members of various families, use “XX” plus two letters to signify the family – “XXHU” for unidentified hummingbird, for example. Technicians must take notes on identifying features of unknown bird detections.

No detections

If no birds are detected at a point, “No birds detected” should be written on the form, across from the time in the data fields.

Detection codes

We record the behavioral cue that alerted us to the presence of the individual bird:

S = song

C = call

V = visual

D = drumming woodpecker

H = humming hummingbird

J = juvenile birds (birds born that year – see note below)

If a bird sings or a woodpecker drums after it has been detected via a different cue, circle the original detection (“C” or “V”). For behaviors such as wing flaps (eg, Band-tailed Pigeons), bill snaps (eg, Black Phoebe), or bark foraging (woodpeckers and nuthatches), simply use the default “C” for call.

Juvenile birds

Juvenile birds are recorded regardless of their behavior but are not included in analyses. This includes birds in the nest, fledglings following parents and birds in juvenal plumage like a spotty robin. *If you see or hear a juvenile bird always record it as “J” – not by its detection cue.*

Distance Estimation

We use a variable circular plot (VCP) and exact distance estimation up to 300 m, in which the distance to each individual detection is recorded. Record the distance from the point to the first location an individual was observed, regardless of its behavior. If the bird subsequently moves, do not change the original distance recorded. If a bird is flying (but not “flying over” – see below), or perched high in a tree, the distance recorded is to the point at which a plumb line would hit the ground if hung from the point at which the bird was first observed. Thus, there is

no vertical distance included in the measurement, only horizontal. Distances beyond 300 m are recorded as “B300”.

Writing bird data on the datasheet

Bird species are written down in the order they are observed. Only one species can be listed per row but include multiple individuals of that species are fine. Record the data elements by first writing number of individuals (blank assumes only 1) followed by the type of detection, followed by the exact distance up to 300 m. For example, in a row where “FOSP” is written in the species column, the code “2V35, C110” means that there were two individuals detected visually at 35 m and another individual called at 110 m.

Fly-overs

Birds that are flying over but not using the habitat on the study area (such as Mallards) are recorded using the FLO code. Remember to put a detection cue, such as C or V, before the FLO code. Birds flying below canopy level, flying from one perch to another, or actively foraging on or above the study area (e.g., swallows) are recorded as described above with distance estimation.

Birds flushed at the point

A bird flushed from within 10m of the point when the technician arrives should be included in the count. Birds that are flushed from farther away should be noted in the margins of the form if they are species that didn't occur during the count.

Double counting

Make every effort to avoid double counting individuals detected at a single point. Always keep track of individuals during a point count. However, if an individual is known or thought to have been counted at a previous point (e.g. Pileated Woodpecker), it should still be recorded at the next point but note in the margin that it is believed to be the same bird from the previous point. Generally this delineation will only be possible for rare or uncommon vociferous species.

Behavioral Observations

We record any potential indications of breeding in the “Notes” section for each species as follows:

CO-copulation	FS-fecal sac
DI-territorial display	MC-material carry
DD-distraction display	NF-nest found
FC-food carry	PA-pair
FL-fledglings	CS –counter singing

Call-playback procedures

The Sierra MIS project uses Hairy Woodpecker and Mountain Quail recordings to effectively sample these wide-ranging species. After completing the 4 passive point counts on a plot, go to the center to do the call-playback. Always do the call-playback survey after all plot-level point counts are finished. Call-playback surveys last for 5 minutes.

Time line:

0-30 sec: play Hairy Woodpecker call (#1 on the gamecaller)
31 sec to 1:00 min: Listen quietly and search area for woodpeckers
1:01 min to 1:30 min: play Mountain Quail call (#2 on the gamecaller)
1:31 min to 2:00 min: Listen and search
2:01 min to 2:30 min: play Hairy Woodpecker call
2:31 min to 3:00 min: Listen and search
3:01 min to 3:30 min: play Mountain Quail call
3:31 min to 5:00 min: Listen and search

What to write down:

Write down any Mountain Quail detections (with cue and distance) and any woodpecker detections. The Hairy Woodpecker recording has a drumming sequence that other woodpecker species often respond to. Quite often, a Hairy Woodpecker will fly in quietly to investigate the recordings and will not vocalize or drum. You may only hear the noise of the HAWO's wings as it flies close. Spend the entire five minutes searching your surroundings and look for any movement in the trees. Also write down when the MOUQ or HAWO responded in the notes section (eg, "after first call-playback" or "was calling when I arrived at the point"). Make note of any breeding observations.

Other observations and notes

Technicians should write down anything that may impact their ability to detect birds such as surprising a bear during a point count.. They also make a note on their datasheet if they see or hear an MIS species (Hairy Woodpecker, Fox Sparrow, Mountain Quail, Yellow Warbler) while moving between points on the plot.

PRBO Point Count Data Form – Exact Distance version - SIERRA NEVADA MIS

Pg. _____ of _____

Crew	Forest Name	Plot ID	Month	Day	Year	Visit#
------	-------------	---------	-------	-----	------	--------

First Name	Last Name	initials (used in data entry)
------------	-----------	-------------------------------

[illegible]

Weather Information: Please estimate temperature, cloud cover (% of sky covered by clouds), and approximate wind speed.

Temperature _____ ° F or C (circle one) Cloud Cover _____ % Wind Speed _____ mph

ENTERED _____ PROOFED _____

Behavioral codes (record initial detection cue): S = song, V = visual, C = call, D = drumming, H = humming, W = wing/whir/wind noise. Circle if the same bird is heard singing after initial detection.
Breeding Observation Codes (list any that apply in Notes column): CO=copulation, MC=material carry, FC=food carry, NF=nest found, FL=fledglings, FS=fecal sac carry, DD=distraction display, PA=pair, DL=display.

Appendix B: Field technician training – Standard Operating Procedure

We conduct a rigorous 3-week training period during late April – mid-May. During this time, project leaders and crew leaders will lead discussions in landbird identification and we will encourage field technicians to review field guides and their field notes along with using auditory recordings to quiz each other. Outlined below is our training schedule.

Week 1:

We spend mornings birding locally in groups of 4-5 with one experienced person leading each group. We target a variety of conifer, shrub and riparian habitats to expose technicians to the widest variety of Sierra bird species and habitats possible. During the afternoons, we provide instruction on visual ID of Sierra bird species, pneumonics to help technicians remember difficult bird songs, and tree and shrub species identification. Crew leaders will also present instructions on the use of digital topographic mapping software including Garmin Mapsource, Google Earth, and National Geographic California Topo! maps for site reconnaissance.

Week 2:

We continue birding in the mornings, review call-playback survey protocols, and practice identifying species and number of individuals during a five-minute period. We will start exact distance estimation training based on techniques summarized in Walker (2005) during the afternoons. Field technicians use laser range finders to practice estimating distance to prominent objects from the center of a point. Our training materials also include a call/song volume index for Sierra bird species to aid technicians in estimating distances to unseen birds (which comprise well over 90% of all detections).

Week 3: We split into crews (North, Central, South), travel to focus areas and begin practicing point counts using standardized protocols including timed surveys, distance estimation, and filling out datasheets. We also practice navigating to sites using GPS, map and compass work, and extensive safe driving training.

Technician evaluation:

Crew leaders evaluate species identification and distance estimation skills of their crew members by conducting several paired point counts with each technician. Technicians must be able to correctly identify number of individuals detected, at least 90% of songs heard and all vocalizations of MIS species including calls. Distance estimates must be relatively close to the crew leader's estimates. We also employ two types of quizzes to evaluate field technicians: auditory and visual. We use a CD of bird vocalizations where technicians need to correctly identify up to 60 species in a short period of time (i.e., song duration will be < 20 sec) to simulate a point count. Technicians also need to pass a visual quiz where they can correctly identify 20-30 photographic images of species and we generally emphasize female songbirds and rarer species. Field technicians will also be given an auditory quiz using a CD of Sierra bird songs with at least 60 species on the quiz and a visual quiz using a PowerPoint presentation. If technicians have trouble with the quizzes or paired point counts, the crew leader has flexibility in continuing training or allowing part of their crew to begin surveys while technicians who need more instruction can shadow the crew leader for several more days.

Appendix C: Safety topics discussed with field crews

- **Hypothermia:** Typically we do not experience precipitation in the Sierra Nevada during MIS surveys but you must be prepared for changes in the weather common in any mountainous terrain that can lead to hypothermia. These include snow at any point, wind and rain. Symptoms to look for are “umbling” including stumbling, mumbling and other changes that can indicate changes in motor coordination and level of consciousness. Avoid wearing cottons and carry a lightweight waterproof layer and warm hat if you are working in the High Sierra.
- **Heat exhaustion:** Usually not a problem in the Sierra’s mild temperatures but heat waves usually strike California at some point during the field season. Watch the weather forecast and on hot days, start early in the morning and complete all work by midday. Wear a sunhat, breathable clothing, drink plenty of fluids, including ones with electrolytes. Symptoms of heat exhaustion include heavy sweating, paleness, muscle cramps, headache, dizziness and nausea or vomiting. If you experience these symptoms, stop all activities, drink cooling liquids, stay in the shade and find a stream to stick your head in (but don’t drink untreated water). Alert your field partner who will monitor your condition and contact help if needed. Once temperatures cool down, resume activity.
- **Poison oak:** At lower elevations you may encounter poison oak. Make sure you are familiar with the 3-leaf pattern and avoid it when you can. Use cold water, soap or Tecnu to rid yourself and your clothes of poison oak oils.
- **Ticks:** Lower elevations, especially in areas with tall grass, have ticks. Deer ticks, which carry Lyme disease, occur in the Sierra Nevada. Tick season is brief and early – usually March-May. If you are in a lower elevation oak-pine forest or grassy areas don’t sit on the ground. Find a rock to sit on. Wear long pants and tuck in your shirt. When a tick bites you it often doesn’t hurt so it is necessary to check yourself over after working in lower elevations. In the event of a tick bite, make sure you remove the entire tick with tweezers, wash the area thoroughly with soap and water and monitor the bite for any rashes or infection. Let your crew supervisor know if you are ever bit by a tick.
- **Lightning:** Thunderstorms are common at higher elevations in the Sierra Nevada. Luckily, they generally occur in the afternoon so they shouldn’t interfere with point count duties. If you see lightning or hear thunder, move to a protected location away from open rock outcrops and water. Dry lightning can bring forest fire danger.
- **Bears:** Most of the time bears avoid people. But they can be unpredictable and potentially dangerous. If a bear is visible but not close (and not running away) then alter your route so that you avoid the bear. If a bear approaches you, remain calm and slowly back away. Try to scare the bear away by making noise. If a bear does attack you fight back with whatever you have at hand. Bears are hunted on national forest land and generally avoid people except in locations where they associate people with food (such as national parks or the Lake Tahoe area).

- **Mountain Lions:** If you see or encounter a mountain lion consider yourself extremely lucky. They want absolutely nothing to do with people and will avoid you. If you see one make lots of noise, act aggressively, contact your field partner and immediately leave the area. Fight back if you are attacked – stabbing in the eye is found to be effective.
- **Rattlesnakes:** In the Sierra Nevada, western rattlesnakes (*Crotalus oreganus*) could occur at all elevations but are more common below 6000 ft in rocky areas or near streams. They are slow, rarely aggressive and rarely rattle. Watch your footing and if you encounter a rattlesnake give it plenty of room. If you are bit, contact your field partner and have them immediately call 9-1-1 or locate someone who can (like a Forest Service employee). Lie down and keep the affected area lower than your heart. If you have to hike out, sit calmly for 20-30 minutes to let the venom localize at the bite site and try to hike without any unnecessary exertion.
- **Yellowjackets:** These ground-nesting wasps are active mid-June through the fall. They attack you whenever you step on or near their nest. Field personnel have had up to 15 stings at one time, took some antihistamines and recovered just fine. You need to worry about this if you are allergic to insect stings or have never been stung by a wasp or bee and don't know how you would react. If you are stung and experience difficulty breathing immediately contact your field partner and have them call 9-1-1. If you have an EpiPen carry it with you and let your crew know that you are allergic to insect stings.
- **Marijuana gardens:** Could occur at any elevation throughout the entire region at any time of year. Look for signs of black tubing, buckets, containers of fertilizer, bags of potting soil, etc., along with marijuana plants. Leave the area immediately and contact your crew leader by phone or in person, do not use the radio, he or she will then contact law enforcement. Your crew leader will contact the appropriate forest personnel prior to field work to find whether an area is active or not.

Appendix D: Vegetation survey – Standard Operating Procedure

Filling out the data sheet: All data is collected within a 50 m radius circle centered on the point count station. If the plot covers two distinct habitats (e.g. it is on a distinct edge between forest and grassland, forest and a lake, chaparral and a river, etc.) then make a note of the habitat arrangement and decide whether your measurements reflect the entire plot, or only the vegetated portion. Either method is acceptable, but the notes must clearly reflect which choice was used. Generally, if the plot is entirely vegetated, but of two distinct stands, then you should combine the measurements and estimates to reflect the entire plot, not one or the other stand. If the plot is partly vegetated and partly open, water, road, or barren, then note that a portion of the plot is not vegetated, and use measurements and estimates that reflect the vegetated portion only.

1st Section – General Information:

PlotID = 5 digit code (e.g. EL09B, SI32A, MO11B...). **Point#** = single digit identifier of point count station within the cluster (N, E, S, W, C, X, Y, Z).

Habitat (WHR) = three letter CWHR code (eg. SMC, MCF, MCP), see Appendix A for list of habitat types. **Habitat (Desc)** = verbal description of habitat type (eg. “mixed conifer”, “montane chaparral”).

Aspect = the direction of the slope (the direction a drop of water would flow if poured onto the plot center) given in text (Dir, eg. NW, SE).

Slope = the average slope of the plot, where 45 degrees = 100% and 0% = flat.

Water = yes or no (Y/N) is there any water in the plot boundary; running or standing?

Recent management? = Describe any sign of harvesting, mastication, fire, or other human activities related to altering the structure and/or composition of the forest stand.

Stand edge/interior = circle edge if the plot overlaps a road, open river, another habitat type or a stand of the same habitat type but different age of origin. Otherwise circle interior.

2nd section – Cover, height, basal area and snag counts

Vertical Cover Layers

These are divided up into 4 layers (Canopy, Sub-canopy, Shrub, and ground), as described above, and all are estimated as the total cover (as if you were viewing from above) of that layer over the 50m radius plot. Note: the maximum cover theoretically is 100% for all of these categories but practically that would be impossible to achieve. See Appendix B for a description of estimating cover.

Canopy includes all supercanopy, dominant, and co-dominant trees. Intermediate trees can be included in either the canopy or sub-canopy cover estimates, at the discretion of the field surveyor, but do not include these trees in more than one layer! Similarly, trees that are not

distinctly in the sub-canopy or the shrub layer can be included in either one, but not both. The low, average, and high height estimates will reflect which trees are included in which layer's cover estimates, so the decision about which layer to include each tree is not a critical one.

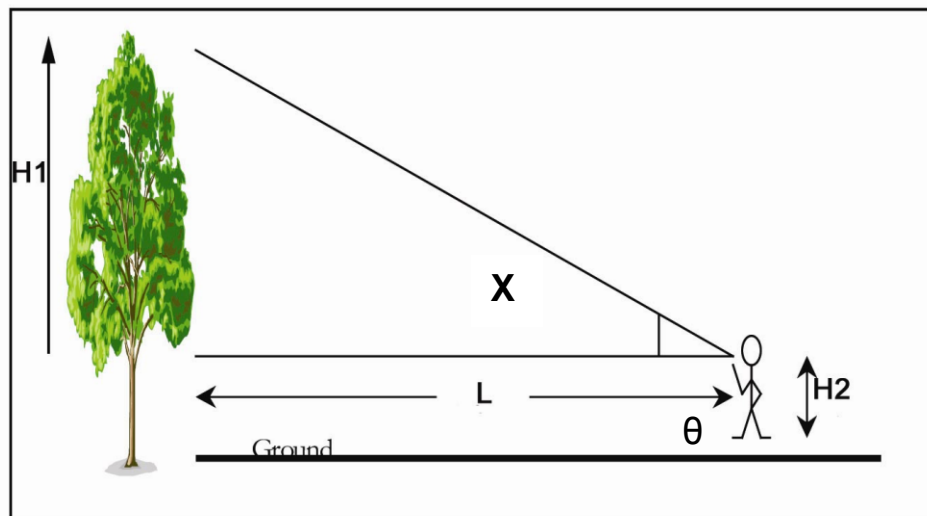
Height Bounds

High – estimate is to the nearest 1 m of the average height of the upper bounds of the vegetation layer (canopy, sub-canopy, shrub). This is not the height of the tallest outlier tree it is the average height of the tallest trees in the plot.

Low – the average (as defined in the high) of the lowest living branches of trees in the canopy, sub-canopy, or shrub layers. Do not record this for the ground layer.

Average – the height at which the majority of living (green) vegetation material can be seen within each layer.

Height (H1 in the diagram below) is calculated with a very simple technique. Regardless of the distance (L) you happen to be from the tree that you wish to measure, only two measurements are required, plus one simple calculation. First, using your laser rangefinder, measure the distance (X) to the top of the tree of interest. Second, using your compass (which is equipped with a clinometer) measure the angle (θ) to the same spot on the tree. Third, multiply X by the sine of θ (a list of values is on the data sheet) to get H1. If necessary, be sure to add H2 (your eye-level height) and/or the distance above or below your eye level is from the base of the tree if you happen to be up or down slope from the tree.



Basal Area

Standing in three different locations off the center of the plot (each measurement should be separated by at least 30 m) using either a 10BAF prism or Cruz-All (aka angle gauge), record the number of trees (live trees only, all species) that the tool says are “in” the plot. Basal area tools allow the surveyor to tally the number of stems that are large enough and close enough to be counted, this tally can then be converted into a square feet per acre measurement (and further into a timber volume estimate when combined with height and shape of the trees). Only record

stems that are 10cm in diameter or larger (you would have to be standing very close to anything smaller than that for it to count). Do not multiply by the BAF (BAF = “basal area factor”, the multiplier used to calculate area), just record number of trees counted. Make sure you are using a 10BAF tool!

Coarse woody debris – record the number of both standing snags and down logs of dead trees in the appropriate size classes. Down logs must still have the form of a tree, once they’ve decomposed into a pile of crumbs they are no longer countable. If there are too many to count, or you cannot see the entire area, then count the number in ¼ of the plot and multiply by 4. You may also want to estimate the percent cover of small branches and other tree material (bark, twigs) on the ground – and record that estimate in the ground cover table below.

3rd and 4th Sections – Species lists, cover estimates, and canopy DBH

Species Lists

In each table (Canopy, Sub-canopy, Shrub, and Ground) record each species present and the portion of the total cover of each layer that it represents (this number should add up to 100% regardless of the % total cover). List as many species as can easily be recorded in a timely manner (up to a maximum of seven). Chasing down that lone shrub off in the corner of the plot is not worth the effort. Generally estimates in intervals of 5% are plenty precise. However, we are interested in species diversity so if something is present in small numbers recording them even if they are less than 5% (eg. a single large tree) is worth the effort. Record the ground cover from the following list: Grass/Sedge, Ferns, Forbs, Leaf Litter/Moss/Lichen, and Barren (includes rocks, road, soil, etc.).

DBH recording

Using a DBH tape, measure the diameter of approximately five trees in the canopy layer, paying close attention to which measurements represent the average, minimum, and maximum diameters. Using either your measurements, or a combination of your measurements and estimation, record the maximum, minimum, and average of all the trees included in the canopy layer. Record these estimates for each species, and also for all species combined. Record these latter estimates in the three boxes at the bottom of the table. No DBH records necessary for sub-canopy, shrub, or ground layers individually, but even if there are no canopy-level trees, you will still record an overall min/max/avg diameter estimate (put zeros in for meadows and open areas).

CWHR Classification System

Habitat Type:

The California Wildlife Habitat Relationships System (CWHR classifies existing vegetation types important to wildlife. This system was developed to recognize and logically categorize major vegetative complexes at a scale sufficient to predict wildlife-habitat relationships.

SIERRA NEVADA MIS HABITAT/VEGETATION ASSESSMENT FORM

Name(s): _____ Crew: _____ Date: _____

State: _____ Forest Name: _____ PlotID: _____ Point#: _____

Habitat: _____ (WHR) _____ (Desc.) Slope: _____ %Aspect: _____ (Dir)

Water: running _____ standing _____ (Y/N) Recent mgmnt? _____

Stand edge/interior(circle one) Notes: _____

Total Cover		Height (m)			10BAF Basal Area		Snags and CWD		
Layer	%	Low	Avg.	High	Swing#	Count	Size(cm)	Snags	Down logs
Canopy					1		10 – 30		
Sub-can					2		30 – 60		
Shrub					3		>60		

Common sine x angle values		Canopy		DBH (cm)		
		Cover	Species	Min	Avg.	Max
sin(10) = 0.17						
sin(20) = 0.34						
sin(30) = 0.50						
sin(40) = 0.64						
sin(50) = 0.77						
sin(60) = 0.87						
sin(70) = 0.94						
sin(80) = 0.98		100%	Total			

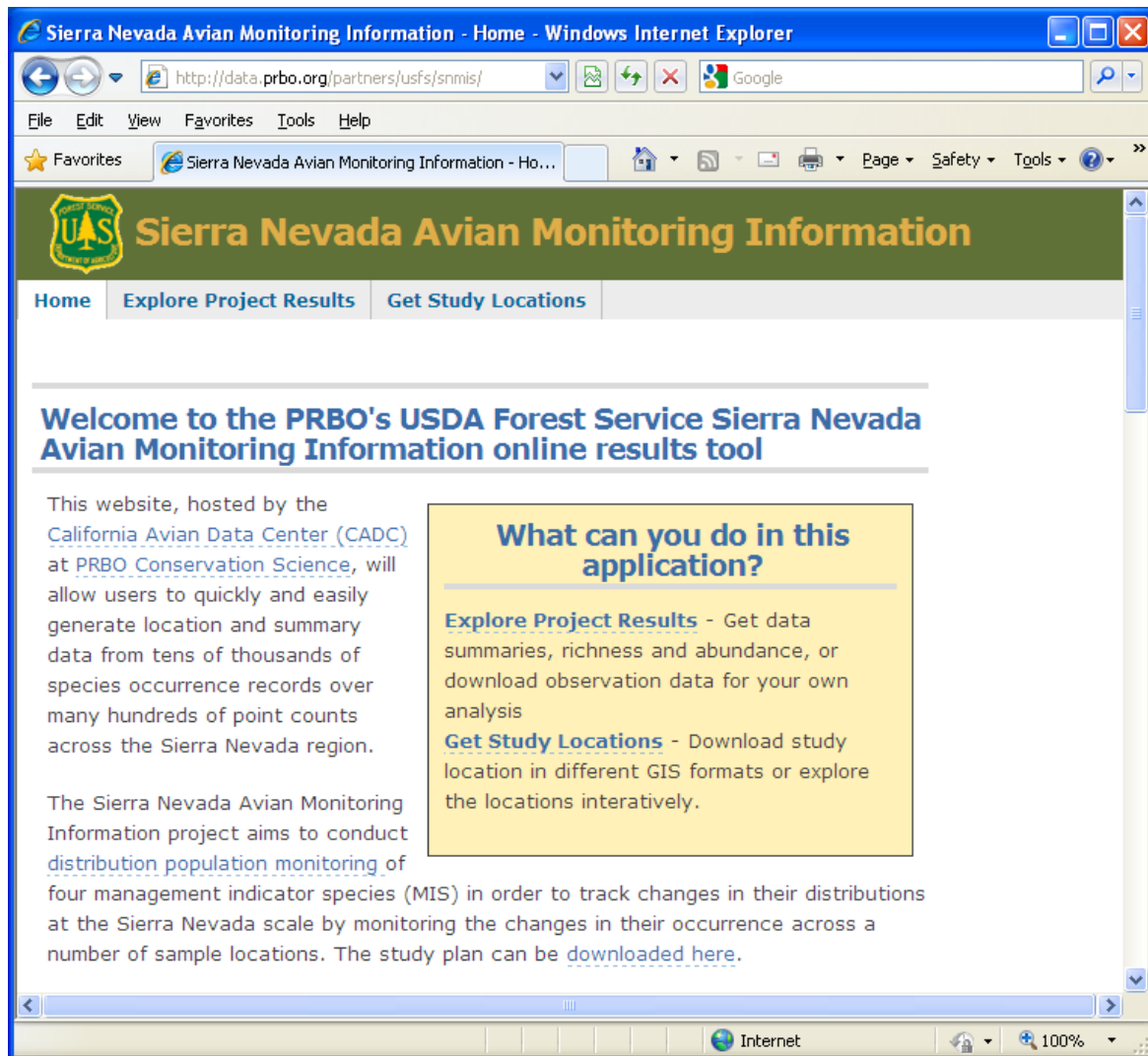
Sub-canopy			Shrub			Ground	
Cover	Species		Cover	Species		Cover	Species
							Forbs
							Ferns
							Grass/Sedge
							Litter/Moss
							Slash/CWD
							Barren/soil/rocks
100%	Total		100%	Total		100%	Total

Notes:

Data Entered?: _____

Appendix E: PRBO Sierra Nevada Avian Monitoring Information Website

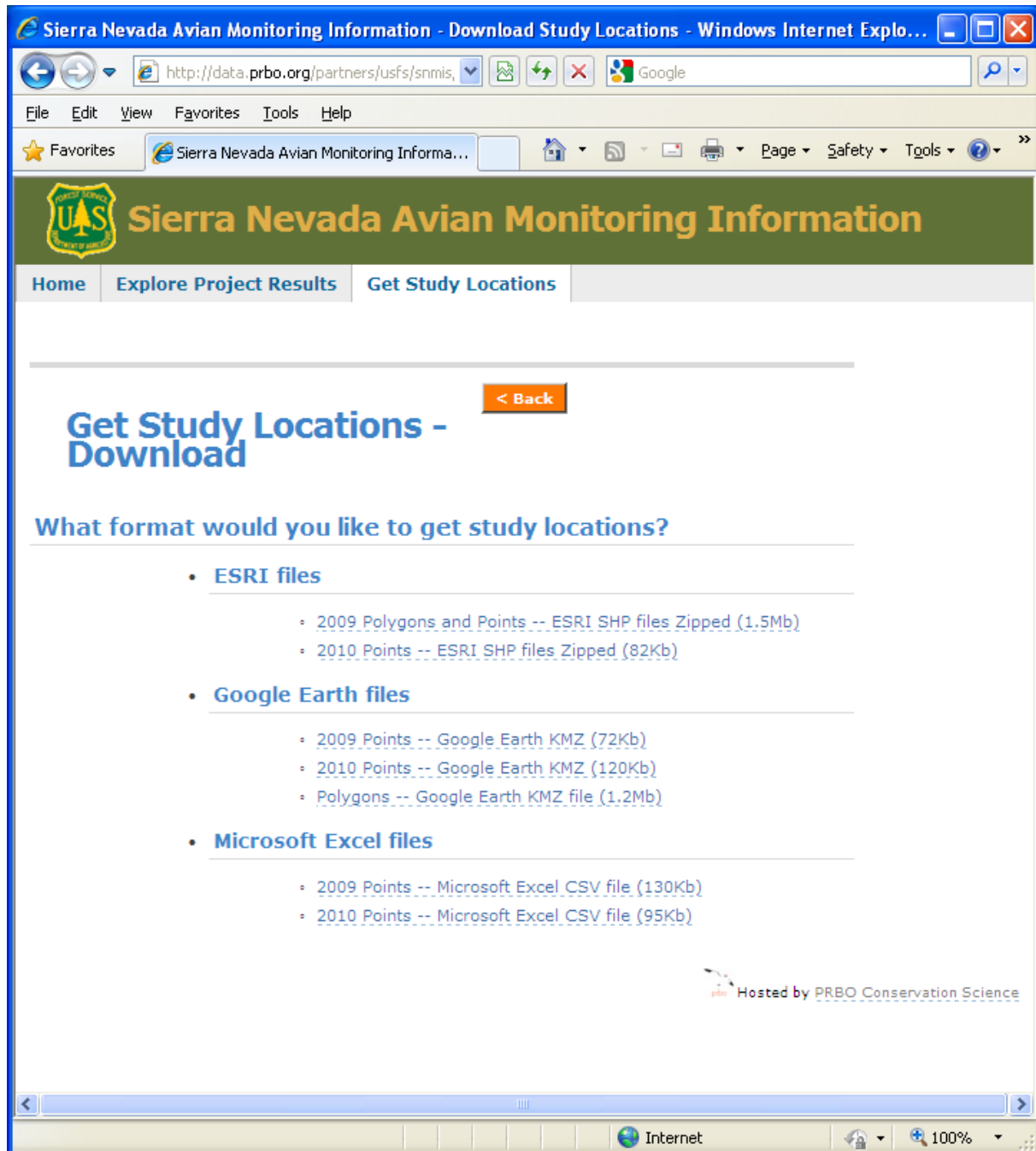
<http://data.prbo.org/partners/usfs/snmis>



This project is unique in that Forest Service personnel and the public will have access to raw data, a variety of analyses, maps and other products in a very short time period following each field season. To achieve all this, we are developing an interactive Sierra Nevada avian monitoring information website (hosted by PRBO) that will serve as a portal for accessing the data we have collected and for producing visualizations (e.g. graphs, charts, and maps) to include in MIS and other reports. On this website we provide: a general description of PRBO Sierra Nevada avian monitoring projects; a link to this study plan; access to raw project data, maps of survey locations and species occurrence records; and the results of a wide variety of analyses and text describing the methods that were employed to generate them. This website is online as of

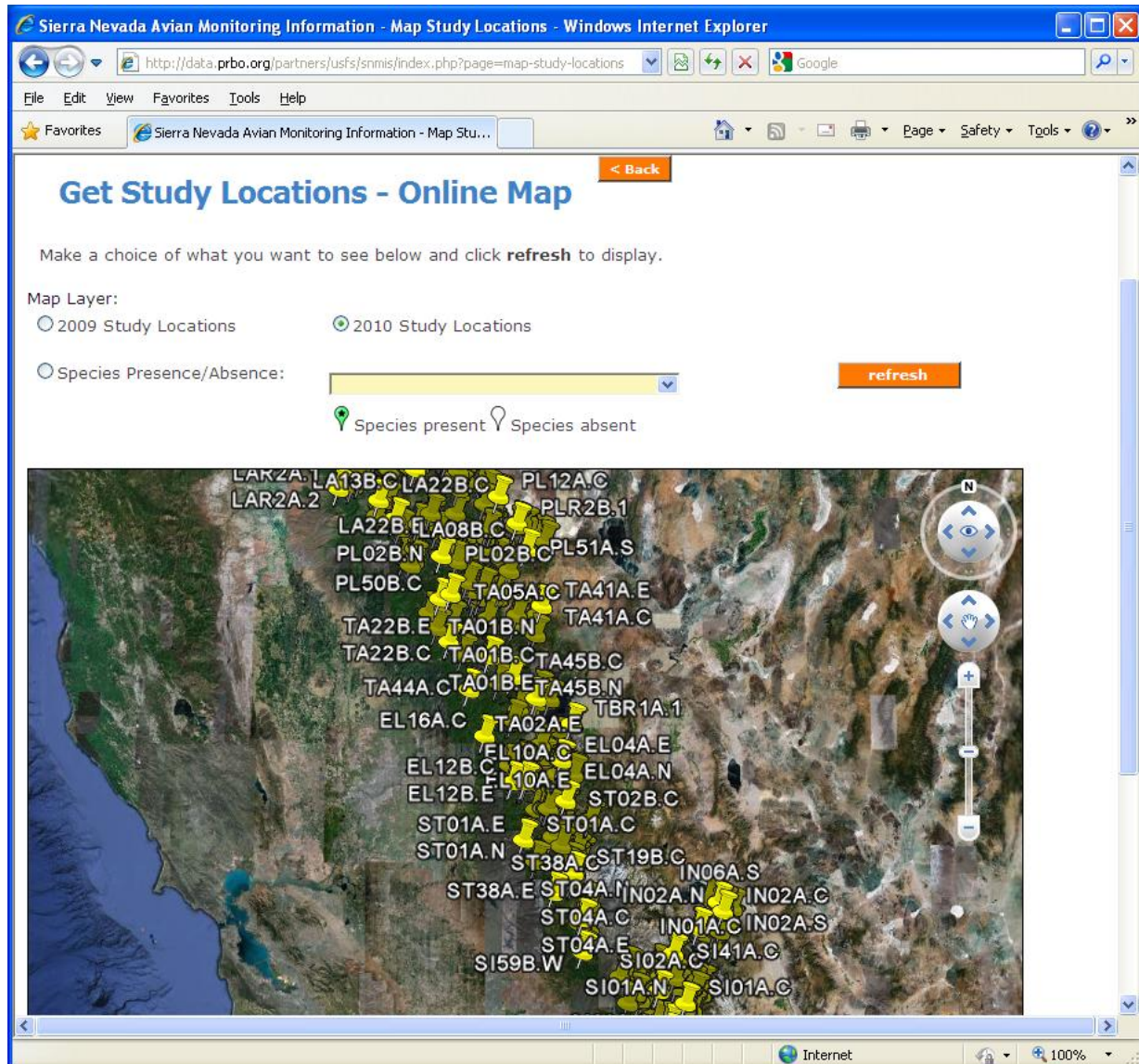
March 2010, but currently in a beta-design format. Updates and refinements of all aspects of the website are ongoing.

Currently you can view point count locations by downloading a file for use in another program (for example: Google Earth, ArcGIS, or Excel):

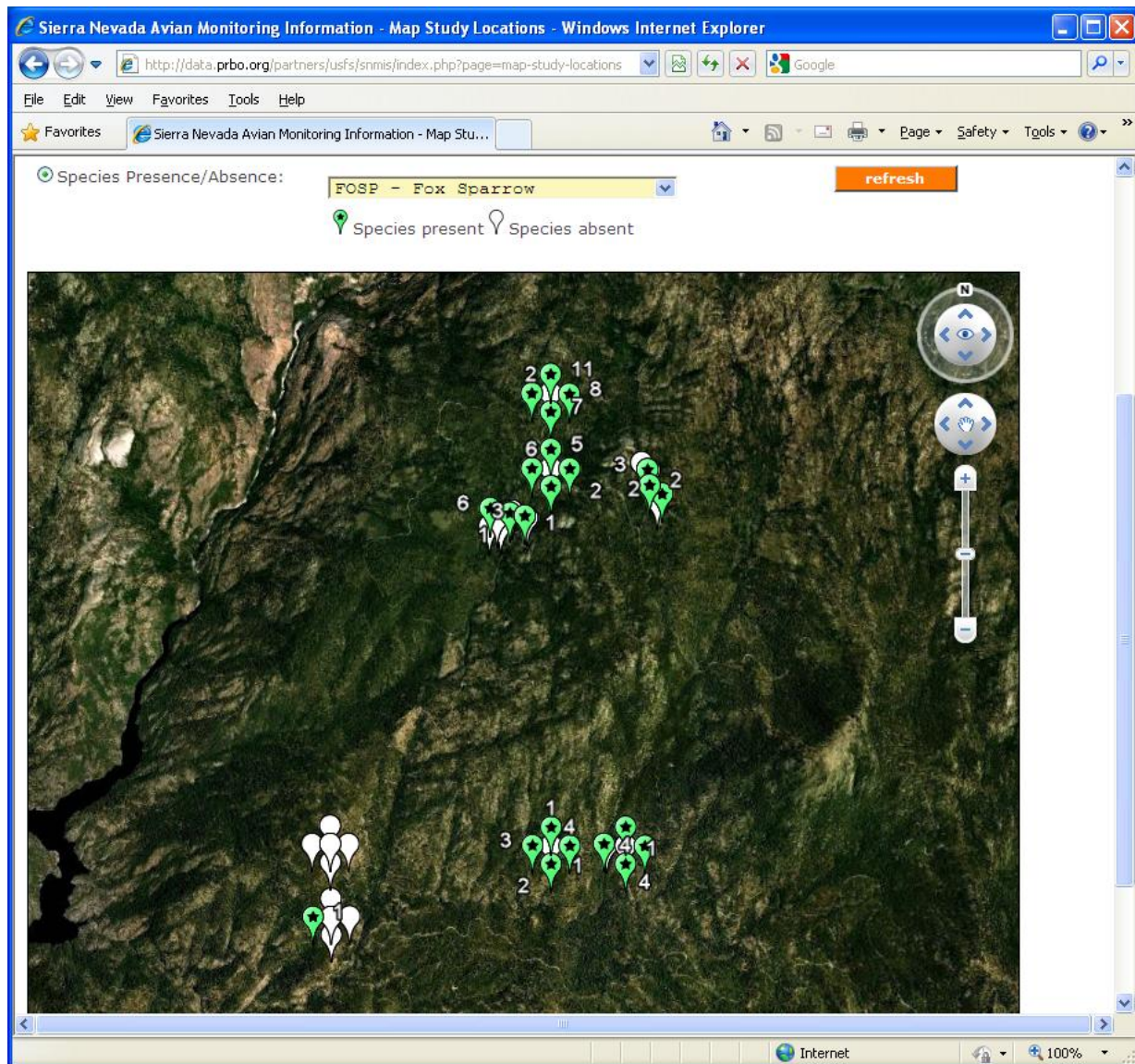


Or you can view the points in an online map with a built in Google Earth application (you may have to install the application prior to using this feature):

View just the locations –



Or view presence/absence for a selected species –



Currently you can also generate results by first selecting the forest(s) of interest;

Sierra Nevada Avian Monitoring Information - Explore Project Results - Windows Internet Explorer

http://data.prbo.org/partners/usfs/snmis/index.php?page=exp

File Edit View Favorites Tools Help

Sierra Nevada Avian Monitoring Information - Explore ...

Home Explore Project Results Get Study Locations

Explore Project Results

< Back Step 1 2 3 4

What area are you interested in?

To select more than one USFS Forest or District, hold down the Shift or Ctrl key while selecting.

☒ Forest ☐ District

Forest

- Eldorado
- Inyo
- Lake Tahoe Basin
- Lassen
- Modoc
- Plumas
- Sequoia
- Sierra
- Stanislaus
- Tahoe

District

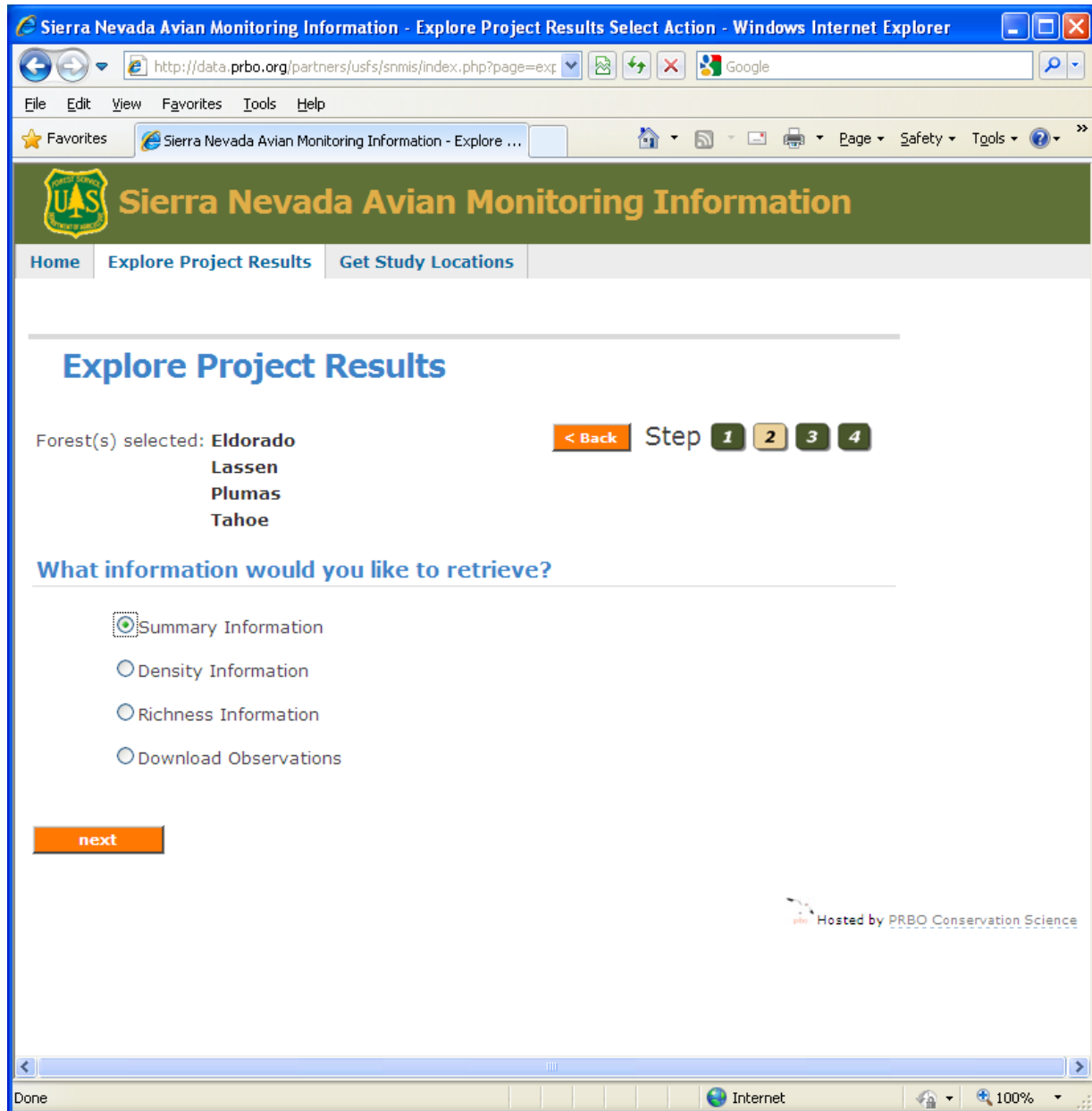
- Almanor Ranger District
- Amador Ranger District
- American River Ranger District
- Bass Lake Ranger District
- Beckwourth Ranger District
- Big Valley Ranger District
- Calaveras Ranger District
- Devils Garden Ranger District
- Doublehead Ranger District
- Eagle Lake Ranger District

next

Hosted by PRBO Conservation Science

Done Internet 100%

Then choose what type of information you would like. Choices include: summary information (general indices of sampling effort and intensity), density, richness, or download the raw observation data.



Example Summary Information output:

Sierra Nevada Avian Monitoring Information - Explore Project Results Summary - Windows Internet Explorer

http://data.prbo.org/partners/usfs/snmis/index.php?page=exp

File Edit View Favorites Tools Help

Sierra Nevada Avian Monitoring Information - Explore ...

Total Number of Observations by Forests and Year

copy table to: [CSV](#) [HTML](#) [DOC](#) [PDF](#)

SpatialGroup	2009
Eldorado	2486
Lassen	1686
Plumas	1884
Tahoe	1478

4 rows

Notes:
Total records = 7408; null ObservationCount = 21

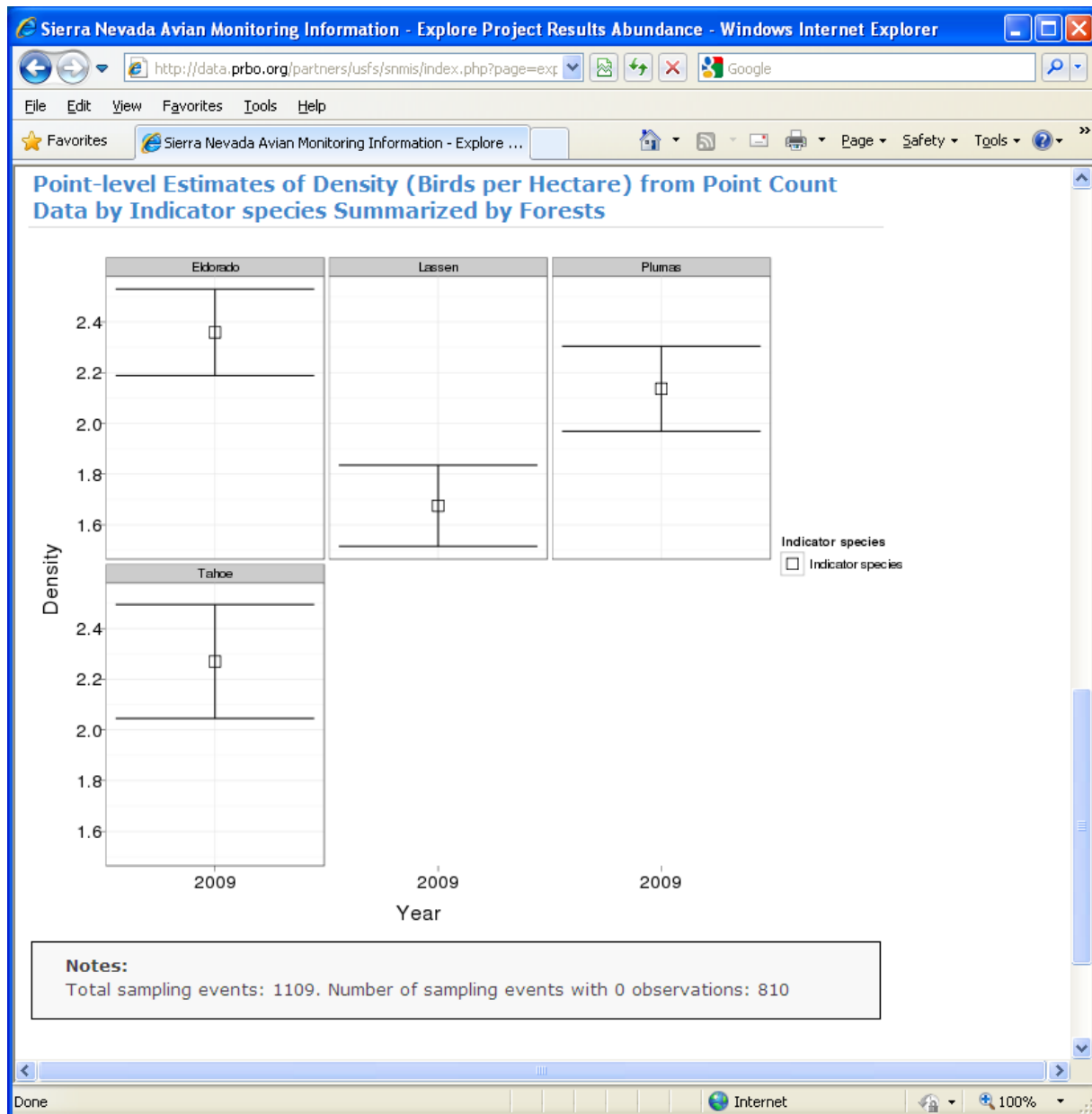
Total Number of Observations of each Species by Year

copy table to: [CSV](#) [HTML](#) [DOC](#) [PDF](#)

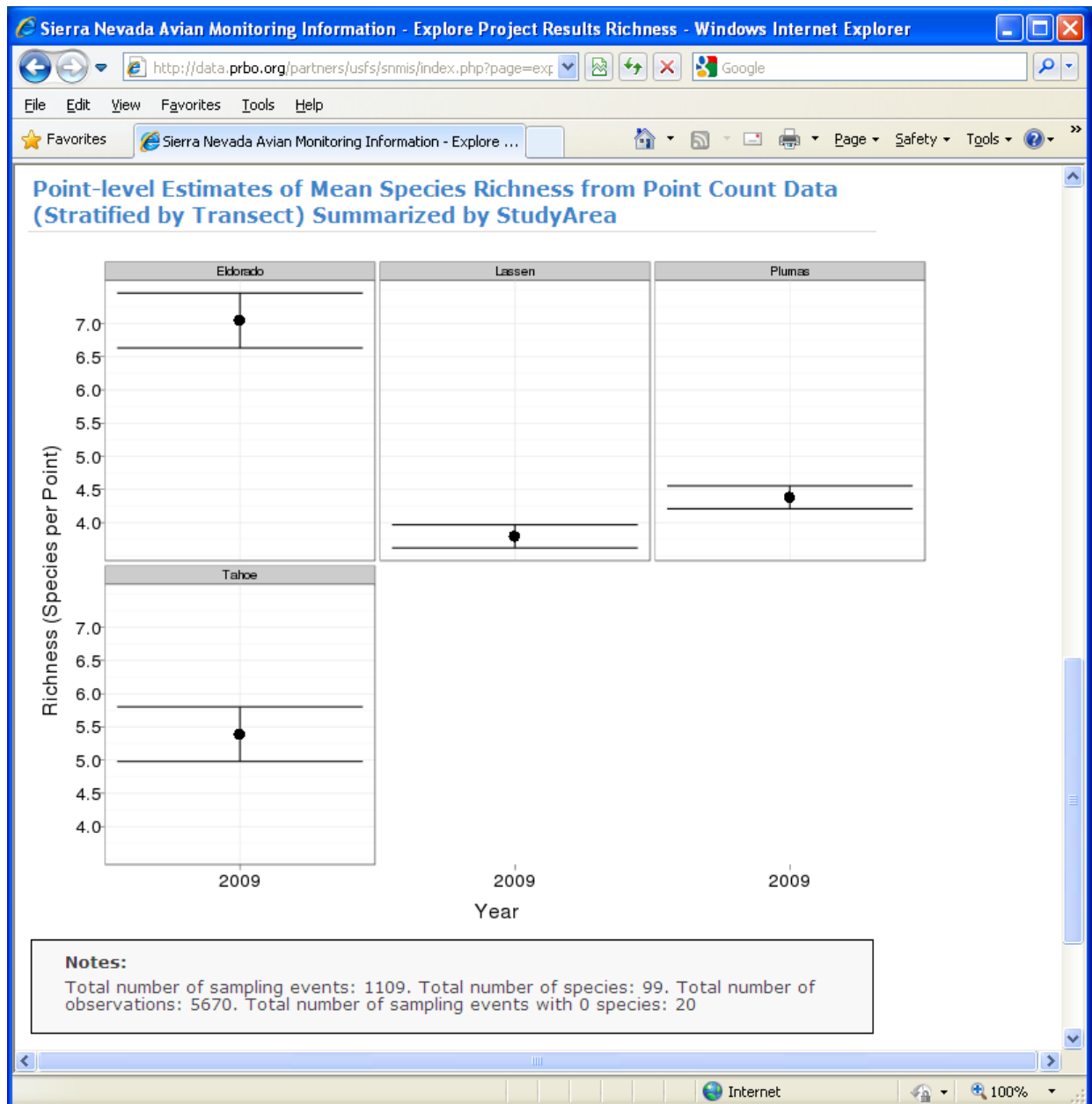
Common Name	2009
American Robin	180
Anna's Hummingbird	10
Ash-throated Flycatcher	1
Band-tailed Pigeon	8
Bewick's Wren	8
Black-headed Grosbeak	113
Black-throated Gray Warbler	44
Blue-gray Gnatcatcher	8
Brewer's Sparrow	15
Brown Creeper	177

Done Internet 100%

Example Density Information output:



Example Richness Information output:



Appendix F: Indicator species concept and application

An indicator species is an organism that can be sampled relatively easily and whose abundance and distribution are proportional to a particular ecological feature or process of interest (Carignan & Villard 2002). Using indicator species as a management tool is a necessary approach to monitoring biodiversity resources over large areas where tracking ecological integrity or the abundance and distribution of very many species (or other more proximate metrics) is logistically difficult (Lindenmayer 1999; Niemi et al. 1997). By tracking just a few targeted species of interest, it may be possible to infer the ecological effects of forest management activities and to inform future management with a minimal investment of effort and resources (Wiens et al. 2008).

Landbirds are considered excellent indicators to help guide land management (Burnett et al. 2005; Hutto 1998). Landbird monitoring is among the most cost-effective of ecological feedback mechanisms, since many species that represent a wide range of habitat conditions can be monitored simultaneously with standardized survey methods. Data collection and analysis techniques are well developed for avian monitoring, and existing broad scale monitoring programs that use these approaches (such as the Breeding Bird Survey) can be used to compare results across geographical regions and at multiple scales (Peterjohn & Sauer 1993).

Additionally, there are several ongoing long-term monitoring programs in the Sierra Nevada investigating the effects of management actions (e.g. fuel reductions, post-fire treatments, and meadow enhancement) that will provide complementary results and potentially increase our ability to interpret the observed trends from a Sierra-wide monitoring program.

Three of the four species targeted in this project have ranges that extend across a large portion of the continent, while the fourth (Mountain Quail) occupies a more restricted set of

high-elevation locations in the mountain ranges of the west coast of the United States. The Sierra Nevada mountains represent the heart of the Mountain Quail's range (Gutiérrez & Delehanty 1999). Fox Sparrow breeding grounds are widely distributed across the boreal regions of North America, however the Sierra Nevada (along with the southern Cascades) represents the heart of the breeding range of the *Megarhyncha* ("large billed") subspecies which is considered distinct from each of the three other subspecies (Weckstein et al. 2002). Both the Yellow Warbler and Hairy Woodpecker are widely distributed across North America from the boreal forests in the north to south of the Mexican border (Jackson et al. 2002; Lowther et al. 1999). Given these patterns, we do not expect that the populations of MIS in the Sierra Nevada are subject to fluctuating population vital rates due to range-edge effects or metapopulation influences (Guo et al. 2005) that might mask the habitat-population relationship.

Both the Hairy Woodpecker and Mountain Quail are non-migratory residents in this region. Fox Sparrows migrate a relatively short distance to central and southern California, and Yellow Warblers are neotropical migrants. These latter two species therefore may be more prone to population fluctuations unrelated to management activities in the Sierra Nevada region. However, by monitoring a suite of species that are associated with the same habitat types/components that the four MIS were chosen to indicate for (Table 1) we will be better able to infer whether observed changes are the result of changes on the breeding grounds in the Sierra Nevada. For example, if Fox Sparrow shows significant population declines and several other species strongly associated with montane shrub habitats, such as Dusky Flycatcher and MacGillivray's Warbler, also show declines we will be more confident that the declines are a result of changes on shrub habitats in the Sierra Nevada.