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Habitat-Based Bird Community Monitoring Protocol for the Southern Colorado Plateau Network

Natural Resource Report NPS/SCPN/NRR—2015/1041

ON THE COVER
Loggerhead shrike (*Lanius ludovicianus*)
Photography by NPS

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Natural Resource Report NPS/SCPN/NRR—2015/1041

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Executive Summary

The Southern Colorado Plateau Network (SCPN) is monitoring bird communities in predominant upland ecosystems and riparian zones in network parks using Variable Circular Point counts with distance estimation. This protocol describes SCPN's Habitat-based Bird Community Monitoring Program, how it was developed, and how it is being implemented.

Birds are present in almost every terrestrial habitat around the world. Often, the actions of birds can have major influences on the ecosystems they inhabit. For example, they help to regulate pest populations; they are a major force in seed dispersal, contributing to reforestation and increasing genetic diversity; they create habitat for other wildlife species that use old nest sites; they can contribute to nutrient cycling as they move through different habitats; and they aid in decomposition as they tear and shred vegetation in their search for food or nesting materials.

Not only do birds contribute to the functioning of ecosystems, they are also good barometers of overall ecosystem health. Ecological systems are composed of numerous interdependent abiotic and biotic elements, and their responses to changes in the environment are often not well understood. Bird communities are composed of a diversity of species and integrate the influences of a broad array of ecosystem conditions. Birds, because they are mobile, relatively short-lived, and have different environmental requirements, are sensitive to environmental perturbations. They can provide a measure of the cumulative effects of changes in ecosystem conditions that would otherwise be difficult to monitor. In addition, birds have important human values and are a highly valued component of biological diversity.

On the Colorado Plateau in the southwestern United States, bird communities face numerous threats. Human land-use practices over the last 150 years, including livestock grazing, timber production, fire management, and urban development have fragmented and altered Colorado Plateau ecosystems. The last several decades have witnessed an increase in the size and severity of early summer wildfires across Colorado Plateau forests and woodlands. Fire, in combination with recent drought and concomitant tree mortality, has dramatically changed the vegetation structure and composition of some ecosystems, which, in turn, affect resident and migrating bird populations. Climate scientists predict a warmer, drier climate in the coming decades, which will result in continued vegetation re-structuring of predominant bird habitats and may also result in shifting food source phenologies.

The Southern Colorado Plateau Network (SCPN) monitors bird communities associated with specific habitats and habitat conditions in selected ecosystems within network parks as a core vital sign representing the overall health and condition of park natural resources. Monitoring bird communities and associated habitat characteristics can help us to identify how key drivers and stressors in the ecosystem affect bird populations. SCPN will monitor bird communities in the following habitats and parks:

- Mixed conifer forest in Bandelier NM
- Riparian zone in Canyon de Chelly NM
- Mixed conifer forest and pinyon-juniper woodland in Grand Canyon NP
- Pinyon-juniper woodland in Mesa Verde NP

- Grassland/shrubland in Petrified Forest NP
- Grassland/shrubland in Wupatki NM

The Habitat-based Bird Community Monitoring Protocol for the Southern Colorado Plateau Network describes SCPN's bird monitoring program and comprises a narrative, 11 Standard Operating Procedures (SOPs), and five appendices.

- The protocol narrative explains the rationale for monitoring habitat-based bird communities and the associated physical habitat characteristics. It establishes specific monitoring objectives and provides an overview of the bird monitoring program, including the monitoring design, field methods, and data management, analysis and reporting.
- The SOPs provide detailed descriptions of all procedures and activities related to bird community and physical habitat monitoring, and include
    - Preparing for the field season
    - Hiring and training the field crew
    - Establishing bird sampling points
    - Conducting the bird sampling
    - Habitat characterization
    - After the field season
    - Project workspace
    - Quality control: Data entry and verification
    - Quality control: Data validation
    - Data summary and reporting
    - Revising the protocol.
- Appendices provide supporting information for the protocol that includes descriptions of how sampling frames were developed for bird community monitoring, a list of bird species likely to be detected during monitoring in SCPN parks, and vegetation map classes that occur in target habitats for SCPN parks.

The goal of bird community monitoring is to acquire data on the status and trends of bird communities within habitats where SCPN is monitoring integrated upland or riparian vegetation, also core vital signs for the network. These vital signs are closely integrated and together they provide information critical to understanding trends in ecosystem integrity for network parks.

1 Introduction

The Southern Colorado Plateau Network (SCPN) has elected to monitor habitat-based bird communities as a core vital sign representing the overall health and condition of park natural resources (Thomas et al. 2006). The goal of bird community monitoring is to acquire data on the status and trends of bird communities within habitats where SCPN is monitoring integrated upland or riparian vegetation, also core vital signs for the network. These vital signs are closely integrated and together they provide information critical to understanding trends in ecosystem integrity for network parks.

This protocol consists of a narrative and 11 standard operating procedures (SOPs). The narrative portion of the protocol first describes the advantages of and rationale for monitoring habitat-based bird communities and associated physical habitat characteristics; it establishes specific monitoring objectives; and finally, it provides an overview of the monitoring effort, including the monitoring design, field methods, and data management, analysis, and reporting. The SOPs, which follow the narrative, provide detailed descriptions of all procedures and activities related to bird community and physical habitat monitoring.

2 Background and Objectives

2.1 Background

SCPN parks encompass a broad range of elevations (from 350 to 3080 m elevation) and precipitation zones (mean annual precipitation ranging from 16 to 54 cm), resulting in a diverse array of ecosystems and associated vegetation types. Dryland ecosystems predominate across the Colorado Plateau and are characterized by pinyon-juniper woodlands, big sagebrush, four-wing saltbush, sand-shrub shrublands, and galleta and blue grama grasslands (Miller 2005, West and Young 2000). Montane and subalpine ecosystems occur at higher elevations and include ponderosa pine forest, mixed conifer forest, spruce-fir forest, Gambel oak shrubland, and montane grasslands (Vankat 2006).

These differences in elevation and precipitation occur in varying combinations with different latitudes, slope exposures, and rock types, influencing natural disturbance processes across the Colorado Plateau (Tuhy et al. 2002). In addition, the region is surrounded by the Rocky Mountain biotic province and the four great American deserts—Chihuahuan, Great Basin, Mohave, and Sonoran—which all exert an influence on the biota of the Colorado Plateau (Stevens and Nabhan 2002). This mosaic of ecological and biogeographical influences, many of which are juxtaposed within the same landscape, has created distinctive habitats for wildlife and given rise to the high level of biological diversity found on the Colorado Plateau (Harper et al. 1994, Stevens and Nabhan 2002). It has also produced the diverse habitat-based bird communities of the region—at least 190 species of breeding birds are found there (Biedleman 2000).

Historic land uses have dramatically altered the soils and vegetation of the Colorado Plateau. Furthermore, a number of stressors threaten the ecological integrity of the Colorado Plateau's plant communities and their associated habitat-based bird communities. These include drought, climate change, alteration of fire regimes, visitor impacts, land use change, and the introduction of exotic species.

Ecological systems are composed of numerous interdependent abiotic and biotic elements, and their responses to changes in the environment are often not well understood. In order to effectively and efficiently monitor the conditions of complex and diverse ecosystems, SCPN has identified a set of vital signs—elements that provide information on multiple aspects of ecosystem function—to represent the overall health or condition of the ecosystem (Thomas et al. 2006). Landbirds exhibit characteristics that make them meaningful indicators of ecosystem integrity (O'Connell et al. 2000, Bock and Jones 2004). Bird communities, comprised of a

diversity of species with varying ecologies, integrate the influences of a broad array of ecosystem conditions, including productivity, landscape integrity, vegetation structure and composition, and water quality (O'Connell et al. 2000, Adamus et al. 2001). Because they are mobile, short-lived, and differ in their environmental requirements, birds are sensitive to environmental perturbations (Martin 1995) and can indicate the cumulative effects of alterations in these ecosystem conditions that would otherwise be difficult to monitor (Canterbury et al. 2000). For these reasons, SCPN selected habitat-based bird communities as a vital sign to be monitored. In those ecosystems where both bird and vegetation vital signs will be monitored, we anticipate developing a deeper understanding of ecological condition and the relationships between bird communities and their habitats. Birds are one of the most commonly monitored vital signs across the 32 I&M networks (monitored in 189 of the 300+ parks included in the program).

2.2 Rationale for monitoring habitat-based bird communities

The ability of the monitoring program to detect the ecological effects of natural drivers and anthropogenic stressors is dependent upon interpreting trends in resource condition against the backdrop of intrinsic variation. We used conceptual models to summarize how natural drivers and anthropogenic stressors might affect upland bird communities on the Colorado Plateau, including mixed conifer, pinyon-juniper, grassland/shrubland, and riparian bird communities (Holmes and Johnson in preparation). Data collected following this protocol will help to identify associations between bird communities and habitat conditions that can be linked to key drivers and stressors in the system. In association with integrated upland monitoring, the resulting data will provide park managers with information on the long-term status and trends in the integrity of upland and riparian ecosystems relative to natural processes and anthropogenic stressors. An advantage of using habitat-based bird communities as a vital sign is that bird monitoring has been conducted in relatively numerous places and comparable regional and national datasets exist. For SCPN, there is a history of inventorying and monitoring birds at Bandelier NM (BAND), Grand Canyon NP (GRCA), Glen Canyon NRA (GLCA), Mesa Verde NP (MEVE), Petrified Forest NP (PEFO), Wupatki NM (WUPA), and Walnut Canyon NM (WACA).

In addition to being indicators of ecosystem integrity, landbirds fit into another category of vital signs—elements that have important human values. Many parks already provide information on birds through their interpretive programs. It has been suggested that birds are perhaps the most highly valued component of North America's biological diversity (Rich et al. 2004). As such, they should be managed in such a way as to assure their sustainability "for the enjoyment of future generations." Effective monitoring is an important way to ensure the viability of native bird species and communities in North America. Through monitoring, we can track changes in abundance and distribution of bird species and attempt to identify causes of any population changes, enabling proactive rather than reactive management responses. In addition, SCPN's monitoring helps to cover underrepresented areas, habitat conditions, and bird species (see Martin 1995, Sauer 2000).

Monitoring bird communities by simply estimating bird abundance does not provide us with information about the underlying demographic parameters that influence community dynamics. Although monitoring vital rates, through efforts such as Monitoring Avian Productivity and Survivorship (MAPS, http://www.birdpop.org/pages/maps.php), can provide insights into the demography of individual species, we decided not to pursue this approach for several reasons. These include cost, the need for a continuous effort over a significant length of time, and the need to focus on a relatively small area (<50 ha; Cooper and Nur 2000), limiting spatial inference.

The goal of the SCPN bird monitoring program is to monitor habitat-based bird communities in target habitats where vegetation composition and structure are also being monitored. Integrated trend analyses may then be conducted to assess overall ecosystem integrity. We define habitat-based bird communities as assemblages of bird species that co-occur, based on their habitat preferences, which are driven by vegetation structure and composition. The ability of a bird species to occupy a particular place is ultimately restricted by species-specific features of physiology, ecology, morphology, and behavior. Whether or not a species actually occurs in an area may be further constrained by various biological interactions (e.g., density, competition, and predation). A local bird community, then, is comprised of individual species' patterns of distribution and abundances, existing in a spatio-temporal mosaic. What happens in communities is ultimately a product of the behavior, physiology, and ecology of individuals of different species, and of the factors and processes, including disturbance events, which determine the distribution and abundance of each species (Wiens 1989, Morrison et al. 1992). Some disturbance events (e.g., extreme weather events) can affect demography (e.g., survival, productivity) while others (e.g., fires) largely change habitat structure and affect birds through habitat-selection processes (Martin 1995).

There are advantages to monitoring habitat-based bird communities, rather than monitoring just one, or a few species. Because of the different environmental requirements of individual bird species, each species can be assumed to respond differently to environmental changes. Monitoring a single "indicator species", however, may not reflect trends in other co-occurring species and may not measure community responses (Morrison 1986, Landres et al. 1988, Block et al. 1995, Canterbury et al. 2000). Likewise, only monitoring the overall abundance of a guild (a collection of species that exploit the same class of environmental resources in the same way; Root 1967), or changes in a species-diversity index, such as species richness, can mask the decline or loss of individual species within the community. In the situation where the population of one or more species is declining, this represents a potentially large risk (Block et al. 1995).

Recognizing that each species' response is unique, species can be categorized into functional groups based on their habitat preference (i.e., habitat-based bird communities) and can be used as indicators for monitoring disturbance to habitat-based ecosystems (we define habitat in the narrow sense of vegetation composition, rather than the full array of physical, chemical, and biological factors in the environment; Canterbury et al. 2000). Furthermore, habitat-based assemblages have the advantage of allowing direct evaluation of community responses to the modification of vegetation structure by land-management practices (Canterbury et al. 2000) and can provide an index of the general health of an ecosystem (Martin 1995, Bryce et al. 2002). These assemblages may be particularly useful as conceptual tools that focus on common links among species, and can provide insights about factors that limit populations and management approaches to sustain their populations (Block et al. 1995). Within SCPN parks, these habitat-based bird communities are of particular interest because many of the bird species are obligates in habitats that are distributed across the network. Some of these bird species and habitats are of conservation concern due to population declines and/or changes in habitat health (Latta et al.1999, Beidleman 2000, Parrish et al. 2002, Tuhy et al. 2002, Rustay et al. 2003).

Bird habitats selected for long-term monitoring were identified during the SCPN vital sign selection process (Thomas et al. 2006). Criteria for selecting particular habitat-based bird communities as vital signs for monitoring were based on literature reviews and conceptual models, and included whether

- the habitats and species that comprise the bird community are suitable indicators of ecological integrity of SCPN park

units

- SCPN lands are of special importance to these species
- the species are of local, regional, or national importance (Holmes and Johnson in preparation.).

The targeted habitats included mixed conifer forest, pinyon-juniper woodlands, and grassland/shrublands in five parks (Bandelier NM [BAND], GRCA, MEVE, PEFO, and WUPA); and riparian habitat in one park (Canyon de Chelly NM [CACH]). Generally, these target habitats correspond to the parks' most widespread vegetation types (Thomas et al. 2006). The exceptions are riparian habitats and mixed conifer forest, which account for relatively little of the overall park landscapes, but are disproportionately important to birds and other wildlife.

2.3 Previous studies of birds in national parks on the Colorado Plateau

Bird populations and communities have been surveyed in SCPN park units under a variety of inventory and monitoring projects (Thomas et al. 2006). Monitoring has mostly focused on raptors and federally-listed species, including the southwestern willow flycatcher (*Empidonax traillii extimus*, GRCA and MEVE), Mexican spotted owl (*Strix occidentalis lucida*, GRCA, MEVE, and WACA), California condor (*Gymnogyps californianus*, GRCA), peregrine falcon (*Falco peregrinus*, GLCA, GRCA, MEVE, and WACA), bald eagle (*Haliaeetus leucocephalus*, (GLCA, GRCA, MEVE, and Yucca House[YUHO]), golden eagle (*Aquila chrysaetos*, GLCA, MEVE, WUPA, and YUHO), and northern goshawk (*Accipiter gentilis*, WACA). Landbird monitoring has been conducted at BAND, GLCA, GRCA, MEVE, Rainbow Bridge NM (RABR), and WUPA. Most of these monitoring efforts were not designed to detect specific levels of change, and sites were not randomly selected. Inference in these studies is generally limited to the sampled areas. An exception is a study of breeding bird response to juniper woodland expansion conducted, in part, at WUPA (Rosenstock and van Riper 2001). In this study, stands were randomly selected within each of three successional stages, and randomly-located transects of points were established in each stand. Distance sampling was then used to estimate breeding bird abundance across two breeding seasons (1997 and 1998).

SCPN has also conducted avian inventories (Johnson et al. 2007, LaRue and Mikesic 2008a, LaRue and Mikesic 2008b) as part of a nation-wide effort to inventory vertebrate and vascular plant species within National Park Service units. The network determined which park units would be inventoried for birds, based upon the extent of the knowledge of avian resources in each park. Generally, the small cultural park units were selected because they tended to lack information regarding avian resources. For example, during the 2001, 2002, and 2003 breeding seasons, avian inventories were completed in Aztec Ruins NM (AZRU), El Malpais NM (ELMA), El Morro NM (ELMO), Petroglyph NM (PETR), Salinus Pueblo Missions NM (SAPU), and YUHO (surrounding habitats were also surveyed at YUHO). The goal was to document at least 90% of species present in order to provide a baseline inventory for avifauna in each park unit. Sampling methods depended on the size of the park unit and accessibility. Area searches were conducted in small parks (AZRU and SAPU), where it was impossible to locate an adequate number of random sampling plots. At all other park units, Variable Circular Plot (VCP) point count locations were randomly selected and/or systematically located from a random start. Distance sampling was conducted to estimate abundance of species, and sample sizes were sufficient to model density for a few to several species in five parks. Adequate sample sizes were obtained for: ash-throated flycatcher (*Myiarchus tuberculifer*) in ELMA and SAPU; lark sparrow (*Chondestes grammacus*) in ELMO and YUHO; western meadowlark (*Sturnella neglecta*) in ELMO and YUHO; juniper titmouse (*Baeolophus ridgwayi*) at SAPU and

YUHO; mourning dove (*Zenaida macroura*) in PETR and YUHO; eastern meadowlark (*Sturnella magna*), horned lark (*Eremophila alpestris*), and rock wren (*Salpinctes obsoletus*) in PETR; chipping sparrow (*Spizella passerina*) in ELMO; and Bullock's oriole (*Icterus bullockii*), Bewick's wren (*Thryomanes bewickii*), gray vireo (*Vireo vicinior*), lesser goldfinch (*Carduelis psaltria*), and spotted towhee (*Pipilo maculates*) in YUHO and surrounding areas.

2.4 Monitoring objectives

The monitoring objectives defined for this protocol cover upland bird communities and riparian bird communities.

2.4.1 Upland bird communities

Objective 1: Determine status and trends in composition and abundance of breeding bird communities associated with selected predominant upland habitats within individual parks.

Objective 2: Improve our understanding of breeding bird habitat relationships by correlating changes in species composition and abundance/density with changes in specific habitat variables.

2.4.2 Riparian bird communities

Objective 3: Determine status and trends in composition and abundance of breeding bird communities associated with riparian vegetation of selected streams within individual parks.

Objective 4: Improve our understanding of breeding bird-habitat relationships in riparian zones by correlating changes in species composition and relative abundance/density with changes in specific habitat variables.

Bewick's wren (*Thryomanes bewickii)*, NPS photo.

Rock wren (*Salpinctes obsoletus*) at Bandelier National Monument, NPS photo.

3 Monitoring Design

3.1 Rationale for selected sampling designs

A long-term monitoring program must specify how to efficiently sample numerous parameters through space and time. An overall sampling design contains multiple components including:

- a spatial design – how sample sites are located and the area of statistical inference
- a response design – the field plot design and the data to be collected
- a revisit design – the frequency and pattern of revisits to the field plots.

To effectively use limited monitoring resources, information derived from a relatively small number of sample sites must be used to infer changes over a much larger area. For the inference to be valid, a probability-based sample design within a defined reference frame is required.

Variance in counts of birds over space and time is the major determinant of how many samples are needed for a program to be effective. The design for SCPN's habitat-based bird community monitoring was selected specifically to meet the requirements of the monitoring objectives.

Two objectives of the SCPN habitat-based bird monitoring program are to determine the status and trends in composition and abundance of breeding bird communities associated with riparian and predominant upland habitats within select park units. Meeting these objectives requires that the monitoring program is designed to provide adequate statistical power to detect a trend if one exists. As part of sampling design development, we used existing datasets of bird counts conducted in similar habitats within the region to make a conservative estimate of power. We estimated variability and the number of VCP counts needed to track changes in species abundance and richness, and to model detection functions and estimate densities of individual species. We estimated that, within a target habitat, 150 to 200 VCP counts (i.e., samples) should be conducted within a breeding season. The number of years of monitoring required to detect a given level of change will depend on the species' abundance and variability in nature. We estimate that over a period of decades we will be able to detect trends for at least 50 to 65% of the species in a community (Holmes 2007). For the most abundant species or large changes we will be able to detect trends more quickly.

We improved power in our sampling design by monitoring within specific habitat types, reducing spatial variability; sampling the same points within and across years, reducing site variability; and conducting multiple visits (2) per year, reducing variability due to phenological changes in breeding behavior.

3.1.1 Rationale for variable circular plot (VCP) count sampling design

Landbirds can be readily and effectively monitored (O'Connell et al. 2000, Hutto and Young 2002). No other vertebrate group can have as large a proportion of its members simultaneously surveyed using simple techniques (Hutto 1998, 2005; MacNally et al. 2004), making it much easier and more cost effective to systematically collect field data for landbirds than for other taxa. Point counts, such as variable circular plot (VCP) counts, which can be used to simultaneously survey multiple species over relatively large areas, often represent the best compromise between economy of sampling effort and precision and accuracy of the estimates of population trends or population indexes (Verner 1985, Ralph et al. 1995).

Bird counting techniques for long-term monitoring of multiple bird species can be divided into two groups: (1) methods that use counts or maps of bird detections as an index to relative abundance and (2) empirical modeling techniques that estimate bird density (Rosenstock et al. 2002), such as distance sampling using VCP counts, or occupancy modeling. The empirical modeling techniques were developed recognizing that

birds are missed during sampling, and incorporate a method to estimate the number of birds missed. These techniques use field procedures similar to index counts, and have an analytic component that models variation in species' detectability to yield direct estimates of density or occupancy. In the field, the VCP distance sampling method is basically the same as unlimited distance point counts, except that the horizontal distance from the observer to the bird is estimated for each bird heard or seen during the VCP count.

Distance sampling is considered the best method currently available for collecting abundance and trend information (Fancy and Sauer 2002). Distance sampling using VCP counts (rather than line transect sampling) is recommended when terrain, such as the terrain found in SCPN parks, or other variables make it difficult to traverse a straight line safely, while working to detect and record birds (Buckland et al. 2004). VCP counts are also the preferred approach in patchy habitats if the goal is to associate bird data with vegetation or other habitat information, as it is in this program. Distance sampling allows data from repeated surveys of the same area, or areas with similar habitat characteristics to be combined in order to increase sample size (Buckland et al. 2004). Combining surveys makes it possible to develop detection functions for uncommon species for which too few detections are recorded during a single survey.

Another advantage of using VCP counts is that keeping track of when a bird was detected (i.e., within the first 3 minutes of the count, or between minutes 3-5), allows a direct comparison to historical point count data, such as those obtained during BBS counts; and also can contribute to ongoing programs, such as the National Point Count Database (USGS Patuxent Wildlife Research Center) and the Avian Knowledge Network. Thus, this type of data can have a number of valuable uses beyond local assessments, and can also be used for comparison with data from more widespread assessments (Ralph et al. 1995).

While point counts, including VCP counts, do not provide information on demographic parameters, data generated from point count sampling can be integrated with vegetation sampling and used to (1) model bird-habitat relationships, (2) investigate responses of populations to management treatments or environmental disturbances, and (3) estimate the spatial distribution of species.

In this protocol we describe two methods—cluster sampling and grid sampling—to spatially allocate VCPs, depending upon the size of the sampling frame for the target habitat. These methods are described in section 3.2. VCP count sampling plots are dispersed evenly over the extent of the sampling frame (the habitat polygon). Plot center points are a minimum of 150 m apart in riparian habitats, 200 m apart in forest habitats, and 250 m apart in open habitats, such as shrublands and grasslands. Observers walk along a series of plots, stopping at each plot center for 8 minutes, and recording information for each bird that is detected—including species, sex, method of detection, and radial distance from the observer to the first detection of an individual.

All birds detected at a plot are recorded, regardless of distance from the observer. The time-dependent, distance-based sampling at plots provides a standard sampling effort within and among habitats. The trend information is derived using data from the VCP counts.

3.1.2 Rationale for habitat sampling design

One objective of the avian monitoring program is to improve our understanding of breeding bird habitat relationships by correlating changes in species composition and abundance/density with changes in specific habitat variables. As described in literature reviews and conceptual models of habitat-based bird communities (Holmes and Johnson in preparation), vegetation structure and composition have been closely linked to bird community composition and dynamics at multiple spatial scales. Attributes, such

as vegetation type, slope, and aspect are (1) relevant to bird community composition, (2) place the plot in a landscape context, and (3) link bird data to park vegetation and/or ecosite maps. Vegetation structure and composition data at the plot-level characterize the habitat structure available to birds, improve our understanding of bird habitat relationships, and also link bird data to long-term vegetation monitoring. Habitat data can aid in understanding trends in breeding bird densities and/or site occupancy, and may have practical applications for management of habitat.

Nur et al. (1999), in their Statistical Guide to Data Analysis of Avian Monitoring Programs, describe how data on vegetation and habitat features collected as part of avian monitoring studies generally are collected and analyzed at several different scales:

- Habitat classification is the broadest scale, and includes vegetation maps.
- The stand level is the next broadest scale, and is the level commonly used to construct birdhabitat/vegetation cover type correlations.
- The next scale involves vegetation measures used to characterize the study area at a smaller scale than habitat classification and stand. Methods employed at this scale often follow James and Shugart (1970) and use an 11.3 m radius circle as the sampling plot. The sampling plot is often centered on a bird sampling plot, or a nest site. This scale allows for the collection of data that are more quantitative in nature, compared to other scales and "provides a good means to establish bird habitat relationships; such data can be gathered quickly, accurately and efficiently." The monitoring program's vegetation sampling to improve understanding of bird-habitat relationships emphasizes measures and measurement techniques at this scale (within stand or habitat polygon).

Within-habitat vegetation metrics should include compositional characteristics, such as vegetation association, and structural characteristics ,such as tree density and canopy closure within the habitat patch or stand (Ralph et al. 1993).

3.2 Spatial sampling design

The spatial sampling design process begins by defining the target population, or the total collection of sampling units for a system of interest. The target populations for monitoring upland bird communities correspond to dominant vegetation types of interest at the park where monitoring is occurring. In most cases, we are matching the upland bird sampling frame to the sampling frame used for integrated upland vegetation monitoring in order to integrate information from both projects and provide an overall description of ecosystem condition. The target populations for monitoring riparian bird communities are the riparian corridors along streams that correspond to the focus of riparian vital sign monitoring. As in the upland sampling design, our intent is to match the riparian bird sampling frame to the riparian vegetation frame as much as possible in order to address questions on the condition of both riparian vegetation and bird communities.

The sampling frame for upland bird communities is similar to the ecological site-based frame used for upland vegetation monitoring. Some areas (e.g., steep slopes, remote sites) may be eliminated from the initial sampling frame so that all remaining areas are accessible and can be monitored safely and efficiently. Another consideration was the need to group sampling plots so that they could be sampled within a constrained time period (i.e., within a few hours in the morning). Although natural disturbance processes such as fire may be integral to upland ecosystems, including too great a range of current conditions may detract from our ability to detect trends in the target population. Consequently, we consulted with park staff as we considered whether or not to exclude areas exposed to recent moderate or high severity fire. As monitoring continues over time, we will consider a range of options in con-

sultation with park staff, including further sampling frame modifications or following disturbed plots in response to severe disturbance events.

Depending upon the size of the sampling frame, we use one of two methods to spatially allocate sampling plots: cluster sampling or grid sampling. For large sampling frames, involving large target populations (e.g., mixed conifer forests on the North Rim of GRCA), we use a cluster sampling method in which primary sampling units (PSU) are selected in a probabilistic manner using the GRTS design (Stevens and Olsen 2004) from a grid of regularly-spaced (e.g., 250 m) points. Each PSU serves as the center plot for a cluster of 8 or 9 other sampling plots that are 200 to 250 m apart, and each of these serve as a secondary sampling plot (SSU) where VCP data are collected (Figure 1). In cluster sampling, 10 primary sampling units are selected, each consisting of a cluster of 9 or 10 sampling plots, for a total of 90 or 100 plots per sampling frame.

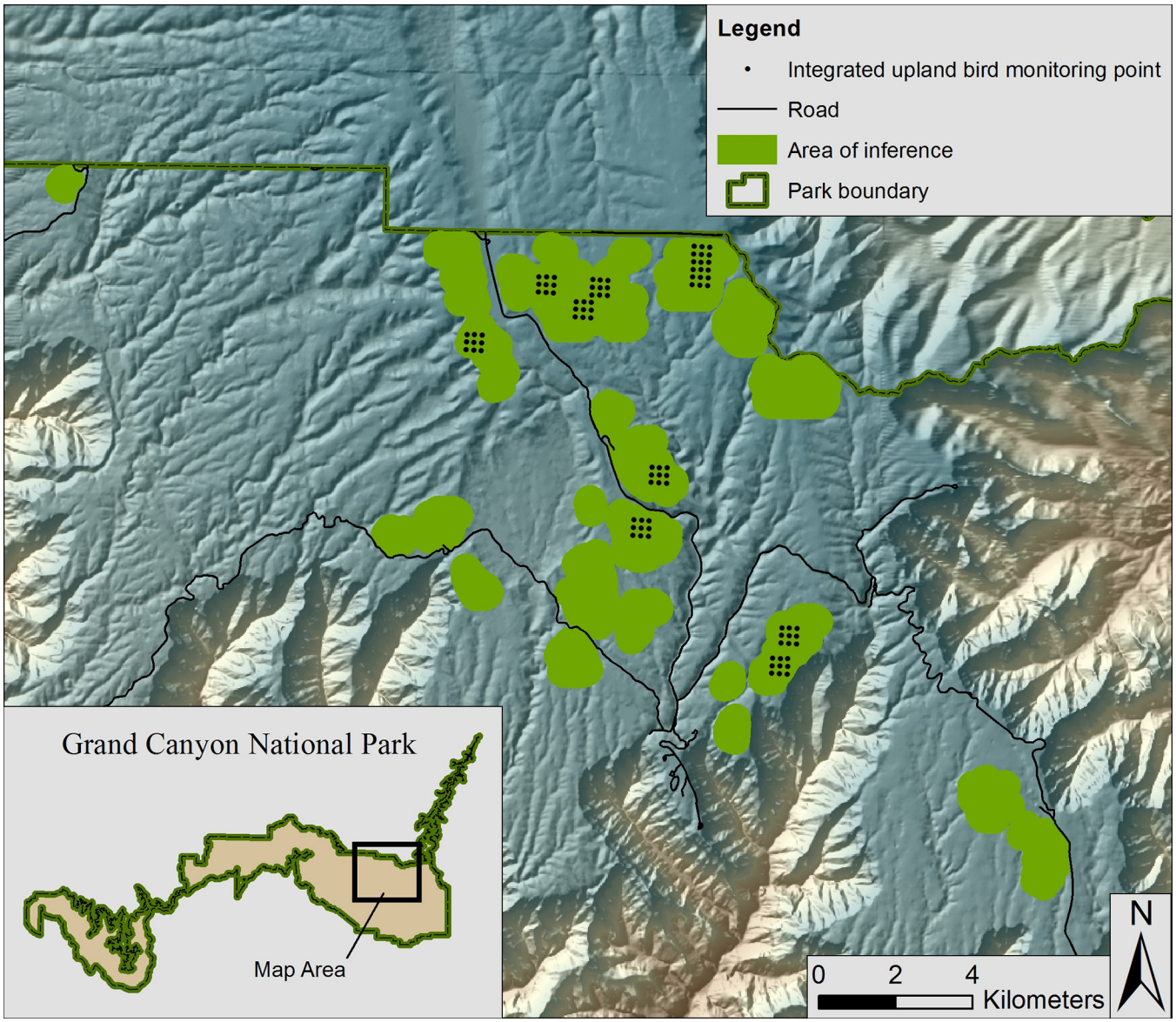

Figure 1. Bird sampling points in Grand Canyon NP mixed-conifer habitat. An example of the cluster sampling design, which is used for large sampling frames involving large target populations.

The second method, simple grid sampling, is used for target populations with limited spatial extent (e.g., pinyon-juniper at MEVE) and is similar to a census sampling design. For these sampling frames, all plots falling within a grid of regularly-spaced points (e.g., 250 m) form the sampling plots, provided they meet the target population definition. A minimum of 80 sampling plots are selected and monitored for each of these smaller sampling frames. Once established the same sampling plots are sampled every year unless the sampling frame is changed due to disturbance event(s), as described above. Park-specific sampling frames are described in Appendix A.

When monitoring riparian bird communities, the bird sampling frame initiates from an individual stream length of a targeted system, and a GIS stream line is identified using the National Hydrography Dataset. A line of plot center points are then placed evenly, usually 150 m apart, along the stream. Each plot is either surveyed in the field or examined in an aerial photo, and is then moved to the center of the widest occurrence of riparian vegetation (using a line perpendicular to the stream line). These plots within the target riparian habitat form the sampling units. Plots with insufficient surrounding riparian vegetation (<50 m radius of riparian vegetation) are rejected. In cases where the riparian vegetation zone is sufficiently wide, additional sampling plots are placed in the zone if the 150 m spacing between plot center points can be maintained. The process is repeated until sampling plots have been placed throughout the entire target riparian area.

This protocol directs the monitoring of breeding bird species and communities at the habitat level and includes all of the bird species that may potentially breed in each of the target habitat types (see Appendix B). Thus, it is designed to provide inference to the populations of breeding bird species that occur in each of the target habitat types within each selected park unit.

Changes in patterns of species abundance will be tracked over time within each target habitat. Collecting information on an entire habitat-based bird community allows one to compare trends among species, and obtain insights into bird-habitat relationships. It also permits summarization to a single number (e.g., "20 species of the mixed conifer bird community are declining").

The monitoring design also enables the tracking of species richness. For example, one can track changes in the number of species present over time and estimate the number of extinctions, the number of colonizations, and the species turnover that has occurred. It assumes that while not every species in the area may have been detected, the proportion of species detected is similar in all time periods. As with an index to population size, the ratio of species found to species missed will vary from year to year (USGS Patuxent 2005). An estimator (e.g., jackknife estimate) can be used to estimate the fraction of the species total that was missed. Of course, while these estimators give information about how many species were likely present but undetected, they do not give information about which particular species were estimated to be present (USGS Patuxent 2005).

3.3 Timing of sampling

Based on power analysis using data from other studies in similar habitats, we estimated that, within a target habitat, 150 to 200 VCP counts (i.e., samples) should be conducted within a breeding season (Holmes 2007). In all parks we were constrained by the number of plots (in the simple grid design) or clusters (in the cluster design) that would fit inside the target habitat and were accessible. For all parks, the number of accessible plots ranged from 89-100.

Therefore, to achieve adequate sample sizes of VCP counts, we elected to conduct bird counts at plots more than once during the breeding season. In addition, by sampling plots early in the breeding season, as well as later in the breeding season, we increased the possibility of detecting resident species that typically are more detectable (e.g, sing-

ing and calling frequently) in the start of the breeding season and migratory species that arrive on their breeding grounds later than the residents.

Bird sampling will be limited to the breeding season, with the sampling schedule based on peak breeding bird phenology and logistic considerations. Bird sampling should begin when resident species have initiated breeding and after migrant species (i.e., species that winter outside of, but breed in the target habitat) have arrived within the target habitat, presumably to breed (generally early May). Lower elevation sites (e.g., grassland/shrubland and riparian) are to be sampled first, and higher elevation sites later. Each bird sampling point should be visited twice within the year, with approximately three to four weeks between samplings. The second counts should be scheduled to coincide with peak migrant breeding phenology. Generally, plots should be visited at approximately the same time each year, although adverse weather conditions (e.g., heavy snow) may necessitate changes in the sampling time.

3.4 Response design

The sampling unit for habitat-based community monitoring will be the variable circular plot (VCP) and the associated habitat characterization macroplot (50 m radius circular plot centered on the VCP center point). At each VCP, the observer records all birds seen or heard, regardless of the distance from the observer, during an 8-minute sampling period. Habitat attributes are recorded in the 50 m radius macroplot and in 4 subplots—one located at the VCP center point, and three located 30 m from the center point, and at 120° from one another (Figure 2). At each of the 4 subplots, nested vegetation plots of 11.3 m, 5 m, and 1.78 m radii are sampled.

3.5 Revisit design

The design of the revisit schedule considered retrospective power analysis, logistical, and financial considerations. The design calls for a particular park and habitat to be sampled once every three years. The proposed schedule is shown in Table 1.

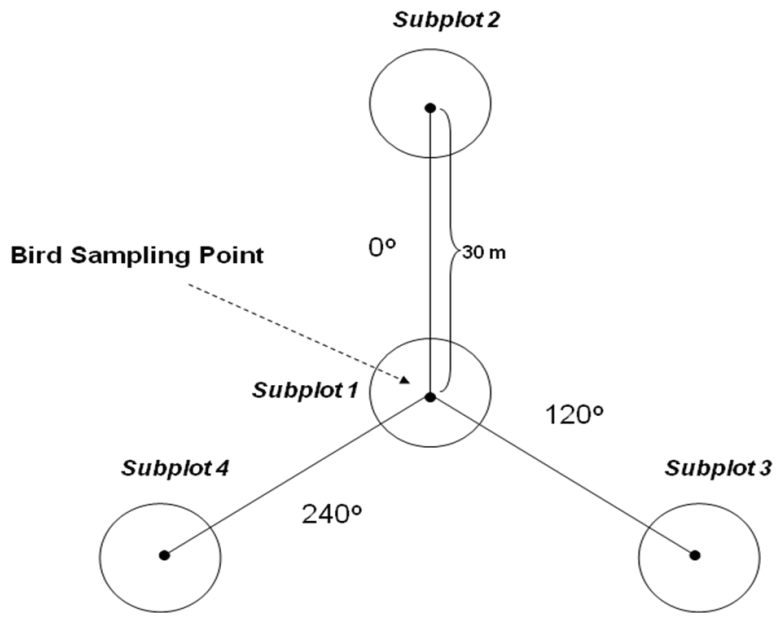

Figure 2. Layout of habitat subplots at each VCP. Based on James and Shugart (1970), Martin et al. (1997).

Table 1. Revisit design for habitat-based bird community monitoring in SCPN parks

	Year					
Park/Habitat	**1**	**2**	**3**	**4**	**5**	**6**
PEFO/grassland	X			X		
BAND/mixed conifer	X			X		
CACH/riparian	X			X		
MEVE/pinyon-juniper	X			X		
WUPA/grassland			X			X
GRCA/pinyon-juniper			X			X
GRCA/mixed conifer			X			X

4 Field Methods

4.1 Field season preparations

Logistics must be arranged well before the start of the field season. This includes renewing research permits, hiring the field crew, and arranging transportation and accommodations (see Appendix C, SOP #1 and SOP #2). The process of hiring the field crew should be initiated prior to the field season each year (in December), and all crew members should be hired by early March. The SCPN crew is hired through Northern Arizona University (NAU), and ample time should be allowed for the university staff to process the paperwork. In order to ensure high-quality data, every effort should be made to hire crew members who are either proficient, or nearly proficient at identifying Southern Colorado Plateau species by sight and sound, or who are proficient at identifying birds from other regions and can demonstrate an ability to quickly learn to identify new bird species (see section 7.2 *Crew qualifications and training*). By March or early April, the project manager should have reviewed this entire protocol, including all of the SOPs. All of the equipment and supplies listed in SOP #1 should be assembled prior to the field season to ensure that they are available and that necessary repairs have been made (see SOP #1).

Dusky grouse (*Dendragapus obscurus)* has been found in Bandelier National Monument, as well as in Grand Canyon National Park. NPS photo.

Field crew members must attend training for bird identification, distance estimation, and habitat data collection procedures in late April or early May, immediately prior to the field season. Training in bird identification by sight and sound (see SOP #2) is particularly important. The misidentification of a species is perhaps the most serious error that can be made during a point count, much more serious than errors in estimating distances (Peitz et al. 2003). A detailed explanation of this protocol, including all of the SOPs, should be provided during the training.

Field crew members will be provided with a recreational GPS unit for navigating to VCP sampling locations and marking locations. Before going to the field, waypoints for established VCP sampling locations must be uploaded into the GPS unit and sampling location information should be printed for field copies (see SOP #4). Sampling dates should be scheduled and logistics organized prior to the start of each field season. The schedule should provide an initial plan for the entire season, but also be flexible enough to allow for shifting sampling times due to inclement weather, and other unforeseen conditions. Multiple field trips of ten days in length will be necessary to complete bird sampling within the breeding season. The schedule should be sent to relevant park staff prior to the start of the field season.

4.2 Overview of sampling procedures

Permanent sampling locations (VCP plots) should be established at least 150 m to 250 m apart (depending on habitat type). Sampling locations are not to be physically marked on the ground, but will be relocated by returning to the permanent UTM coordinates with a GPS unit. Refer to section 3.2 in the narrative and SOP #3 for information and instructions for establishing sampling plots. Daily activities during a typical field trip are

described below.

Each morning, the field crew should arrive at their first plot in time to conduct the first sample as soon as it is possible to see at least 200 m, generally 30 minutes before sunrise. They should sample ten VCPs within a time period that spans from 30 minutes before sunrise to approximately four hours after sunrise. After completing bird sampling, the field crew should meet to conduct habitat sampling at the VCPs. It is usually not possible to complete habitat sampling for all the VCPs sampled in a morning, and some plots will need to be sampled at a later date. No habitat sampling should be scheduled after July 21.

4.2.1 Conducting VCP counts

Details on how to conduct VCP counts during the breeding season and for filling in datasheets are given in SOP #4 and are summarized here. At each plot, the observer records all birds seen or heard during an 8-minute sampling period, regardless of the distance from the observer. Observations are recorded within one minute time segments, i.e., those detected during the first minute of the count are recorded as detected in minute 1, and any new individuals detected are recorded in the appropriate subsequent 1 minute intervals of the count. Details recorded include the species, method of detection, gender (if known), and distance from the VCP center to the individual bird. For most species, each individual bird will be recorded as a separate observation. For species that usually occur in clusters or flocks, the appropriate unit to record would be the cluster or flock size (see SOP #4).

4.2.2 Sampling habitat characteristics

SOP #5 provides instructions on how to conduct habitat sampling at the level of the macroplot (a 50 m radius plot, centered on the bird VCP) and how to correctly fill out the datasheets. These procedures are summarized here.

Habitat sampling is plot-based and linked to bird sampling such that each bird VCP within a target habitat is described, and together, they describe the target habitat as a whole. A 50 m radius circular macroplot is centered at each bird VCP center point and contains four circular subplots of fixed radii (see SOP #5). Habitat sampling can take place after the conclusion of bird sampling each day, during days between bird sampling, on days when the weather prevents bird sampling, and near the end of the field season.

Mixed conifer habitat in Grand Canyon NP. NPS photo.

The field crew will collect several types of data in the macroplot and subplots. Within the macroplot, data on broad-scale site attributes are collected, including slope, aspect, topographic position, and cover of dominant vegetation types. In each subplot, vegetation data are collected, including vegetation strata, basal area of trees and snags, density of sapling trees, canopy closure, and foliar cover in the understory.

4.2.3 Additional data for plots affected by fire

Fire, especially wildfire, is a driver of ecosystem change, affecting the local and the landscape levels, both above and below ground. When a fire occurs in an area where long-term vegetation and wildlife monitoring has occurred, it provides an opportunity to

examine the effects of fire on, for example, species composition and distribution, vegetation structure and ground cover of vegetation communities, which, in turn, affect wildlife habitat. Burn severity will affect vegetation response, as well as soils, topography, climate, etc. When a monitoring plot has been affected by wildfire or prescribed fire, it is important to record information about the effects of the fire on the plot, including the burn severity and the pattern of the burn. SOP #5 provides instructions for filling out the Burn Severity datasheet.

5 Data Management

Managing monitoring data involves procedures to collect, enter, document, archive, and distribute data (Figure 3). The project manager, data manager, and crew members will ensure the integrity and security of the data during a given field season by adhering to standard operating procedures (SOPs) presented in this protocol. Additional details are provided in the SCPN Data Management Plan (Tancreto and Hendrie 2006).

Data management may be best understood as an ongoing process, as shown in Figure 3. Each step in the data management process is explained in detail below.

5.1 Pre-season preparations

Field observations for this project are captured on paper datasheets in the field and then entered digitally into the database on a field laptop as soon as possible. Prior to the field season, the SCPN data manager ensures that project staff members have access to, and are fully trained in the use of, the laptop resident Microsoft Access database software. Complete field crew training includes procedures for performing back-ups on the laptop database on a daily schedule.

The project manager works with the GIS specialist to ensure that target coordinates and any navigational waypoints, routes, tracks and backdrop maps are loaded on GPS units prior to each trip. The GIS specialist also provides paper maps to aid in navigating.

5.2 Recording data

Data are recorded on paper datasheets during the sampling field trip. Before leaving a sampling plot, the field crew is responsible for ensuring that all forms have been filled out completely and that the information on each form is logical and legible. At the end of each sampling day, the data are digitally entered into the database on field laptops. A backup should be made every time the database is exited after a data entry session.

Upon returning from each field trip, datasheets should be scanned to PDF files. If changes are subsequently made to paper datasheets, they should be re-scanned. The project manager is responsible for the safekeeping and organization of the datasheets until data entry and verification procedures have been completed. Once the project manager is satisfied with data verification procedures, the database and datasheets will be transferred to the data manager.

5.3 Data entry, verification, and validation

5.3.1 Data entry

Bird monitoring data are managed through the SCPN bird database, a relational database based on the NPS Inventory and Monitoring Program's Natural Resources Database Template (NRDT) (http://science.nature.nps.gov/im/apps/template/index.cfm). The database is divided into two components: the "working database" for entering, editing, and error-checking data for the current season, and the "master database" that contains the complete set of certified data for the monitoring project.

During the field season, each crew is provided with a copy of the working database into which they will enter and edit data for the current season (refer to SOP #8). As soon as possible, the bird monitoring data recorded on the paper forms should be entered into this working database. Data entry should be completed by someone who participated in

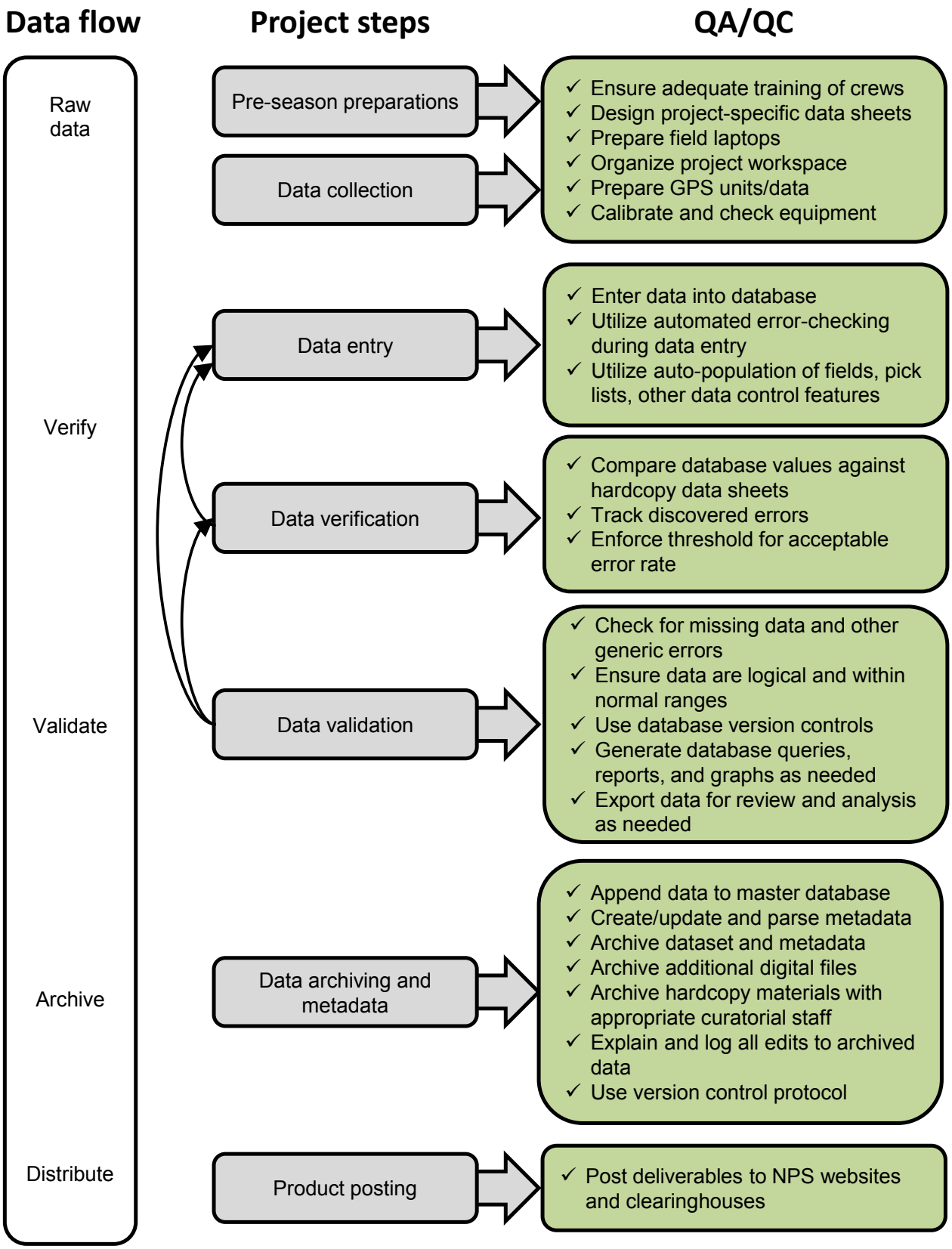

Figure 3. Data management steps and associated quality assurance/quality control (QA/QC) procedures that accompany the data flow in the SCPN bird monitoring program.

data collection or someone who is familiar with the project and data. The primary goal of data entry is to transfer the data from the paper datasheets into the database with 100% accuracy.

It is recommended that a backup copy of the database be created every time new data are entered. This ensures that the initial data entry starting point can be recovered should irreversible errors or problems occur during the data entry session. Any time a revision of the protocol requires a revision to the database, a complete copy of the database will be made and stored in an archive directory.

5.3.2 Data verification

The goal of data verification is to ensure that data was correctly and completely transcribed from the physical datasheets to the database. The data entry forms for the bird database incorporate limits on value ranges (cover class limited to 1–7), list boxes (cover types limited to defined values), and required fields (date always has to be entered) to minimize the potential for data entry errors and/or the transcription of erroneously recorded data. Following completion of the data entry for macroplots, subplots, and bird observations, code is run to check for logical inconsistencies and missing data (for example, no bird observations recorded, but No Detection is unchecked or total cover less than or greater than 100%). If inconsistencies or missing data are found, an alert message appears and the data enterer is taken back to the data entry forms to make corrections.

Although useful for minimizing errors, these controls cannot identify or eliminate incorrectly entered data (a cover class of 3 was recorded on the data sheets, but a 5 was entered in the database). As a final check, each of the records in the database are reviewed after data entry has been completed to correct any data entry errors. SOP #8 describes the steps that the project manager and data management staff will take to ensure that the data records within a given season's dataset are verified (i.e., database values are compared against hard-copy datasheets). 100% of the data will be verified, preferably by the project manager. As verification is completed for each plot, the verification status for that plot is updated to "verified".

Once all data have been verified, the data manager will merge all databases from the current season into one single database file.

5.3.3 Data validation

Data validation is the process of ensuring that the data are complete and make sense. The project manager and data manager work together to validate a given season's dataset. Some validation methods are incorporated into the bird database logic (see SOP #7). Other, more specific validation routines are worked out with the project manager and/or project staff, and incorporated into the database as appropriate. The data manager works closely with the project manager and project staff to provide any additional database queries, reports, graphs, or export files required to accomplish overall database validation. If errors are discovered and/or data is missing, the data manager and project staff shall work together to correct the errors and and document any changes.

The last steps of the validation process are to flag data that don't meet expected quality requirements, and document the verification and validation process. Once these tasks are complete, the data is considered certified. The data certification flag will be changed from provisional to certified for the appropriate data and the data manager will append the dataset to the master project database.

5.3.4 Data certification

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks (SOP #9, Data Quality Review); and 3) they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies that may or may not

have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is a requirement for all tabular and spatial data. In collaboration with the IMD Central Office, SCPN is in the process of establishing specific data certification processes that will be implemented in the near future.

5.3.5 Data edits

Any changes to the data that result in discrepancies between the values in the database and the data sheet are tracked in the database and are identified by the table level unique ID. In addition, the master database is under version control in GIT, so that any changes made after certification are tracked. This allows any previous changes to be reversed or the state of the data at any point in time to be recreated.

5.3.6 Geospatial data

The Project Lead and GIS Specialist work together to review the surveyed coordinates and other geospatial data for accuracy. The purpose of this joint review is to make sure that geospatial data are complete and reasonably accurate, and also to determine which coordinates will be used for subsequent mapping and field work.

5.4 Archiving data

Metadata can be defined as structured information about the content, quality, condition, and other characteristics of a given dataset. Additionally, metadata provide the means to catalog and search among datasets, thus making them available to a broad range of potential users. Metadata for all protocol monitoring data will conform to Federal Geographic Data Committee standards.

Metadata are updated annually for both tabular and spatial data. Specific procedures for creating and posting the metadata record are provided in the SCPN Data Management Plan. Final metadata records are posted to the online NPS Integrated Resource Management Applications (IRMA, https://irma.nps.gov/App). This both makes the information available to park staff and the public, and satisfies the requirements of Executive Order 12906 (http://www.archives.gov/federal-register/executive-orders/pdf/12906.pdf).

Secure data archiving is essential for protecting data files from corruption (SCPN Data Management Plan). Once the master project dataset and metadata are considered final, the data manager will place a copy of the dataset and the metadata record into the appropriate folder within the archive directory on the network server. These archived files will be stored in read- only format. Any subsequent changes made to this database must be documented in an edit log and in the metadata and stored in the same folder as the dataset.

Digital materials can be made available to park curators upon request. Hard-copy materials (e.g., datasheets, field notebooks, and reports) are currently stored in the network office but will be moved to an NPS-approved repository for permanent storage.

5.5 Data maintenance

Any editing of archived data must be documented in the edit log and accompanied by an explanation that includes pre-and post-edit data descriptions (Tessler and Gregson 1997). Datasheets can be reconciled to the database through the use of the edit log.

Prior to any major changes of a dataset, a copy should be stored with the appropriate version number to enable tracking changes over time. Each additional version will be assigned a sequentially higher number. Frequent users of the data are notified of the updates and provided with a copy of the most recent version.

Full metadata records are available through IRMA. Records for reports and other publications are created in the Data Store section (https://irma.nps.gov/App/Reference/Search) of IRMA. Digital report files, in

PDF format, are then uploaded and linked to the IRMA record. Species observations are extracted from the database and entered into the NPSpecies section of IRMA. NPSpecies is the NPS application and database used to create and maintain park-specific species lists and observation data (https://irma.nps.gov/App/Species/Search).

Data requestors should contact the data manager who will fulfill data requests. These requests can be made through the network website contact page (http://science.nature.nps.gov/im/units/scpn/contact/contactUs.cfm). Only certified datasets will be shared outside NPS. See the SPCN Data Management Plan for more details.

6 Data Analysis and Reporting

Two types of reports will be prepared based on data collected following this protocol. Data Summary reports will provide simple descriptive information on the occurrence and abundance of birds, with little data analysis beyond a summary of the year's data. More in-depth trend reports will be prepared at longer intervals and will include comprehensive analysis of the data gathered to date.

This section describes the metrics and approaches to use for analysis and reporting.

6.1 Metrics commonly used to evaluate bird communities

The objectives of the SCPN habitat-based bird monitoring program are 1) to determine the status and trends in composition and abundance of breeding bird communities associated with upland and riparian habitats within select park units, and 2) improve our understanding of breeding bird habitat relationships by correlating changes in species composition and abundance/density with changes in specific habitat variables. To meet monitoring objectives, the pattern of changes in abundance of the suite of species which comprise each habitat-based bird community will be tracked over time.

Collecting information on an entire community of species enables one to compare trends among species, search for patterns of change within an ecological guild (e.g., nesting guild, migratory guild), and gain insights into landscape conditions (USGS Patuxent 2005). Two metrics primarily used to track trends in individual species are 1) relative abundance (the total number of individuals observed of each species scaled by survey effort), often referred to as index counts, and 2) detectability-based density and/or occupancy estimates.

In addition to tracking trends in individual species, we will also track community level parameters, such as species richness, the number of local extinctions and colonizations, and species turnover. An important assumption is that while not every species in the area may have been detected, the proportion of species detected is similar for all time periods. As with using an index count to track abundance, the ratio of species found to species missed will vary from year to year. In addition to reporting observed species richness, we will estimate species richness using a bootstrap method in which plots are resampled with replacement.

Metrics used to characterize bird habitat can be collected and analyzed at several different scales. Habitat classification is the broadest scale, and often employs metrics derived from vegetation maps. The next broadest scale, the stand-level or ecosite-level, is the level commonly used for ground-truthing aerial photos and, depending on the methods, for constructing birdhabitat/ vegetation correlations.

We are collecting habitat data at a smaller scale, by focusing on a circular 0.8 ha area (a macroplot) centered on each bird sampling plot. This scale allows for the collection of data that are more quantitative in nature, compared to other scales, and provides a good means to establish bird habitat relationships (Nur et al. 1999). Most studies of bird-habitat relationships and monitoring have gathered data at this scale. We based the habitat metrics described in this protocol on metrics commonly used in state and national monitoring programs (e.g., Martin et al. 1997, Leukering and Levad 2000, Huff et al. 2000), and on published guidelines (e.g., Ralph et al. 1993, Noon 1981). The metrics selected (listed in SOP #5) mainly characterize vegetation structure and floristics of woody species, which are generally considered to influence the distribution and abundance of each bird species and affect individual survival and reproduction. The development and use of metrics and indices for monitoring bird communities in the SCPN will be ongoing as monitoring data are collected.

Analyses of the data will emphasize correlating changes in bird species composition and abundance/density with changes in specific habitat variables. Instructions for calculating these metrics and correlating changes in bird species composition and abundance/density with changes in specific habitat variables, can be found in SOP #10.

6.2 Expected associations between habitat-based bird communities and changes in habitat quality or physical habitat

Changes in quality or physical structure of habitats in the SCPN are driven by complex interactive processes and factors that include regional climate, natural disturbances, stressors, and species-specific attributes that can alter the abundance of bird species and overall community patterns. Some disturbance events (e.g., extreme weather events) can affect demography (e.g., survival, productivity) while others (e.g., fires) largely change habitat structure and affect birds through the habitat-selection processes (Martin 1995). The presence and magnitude of factors differ across the landscape and across time and may contribute to a substantial amount of variation in populations in communities over time and space. Bird populations and communities vary from year to year; no single year is 'typical' (Wiens 1989).

Long-term studies are required to see the true dynamics and determine whether populations do track resource variation closely, or to assess how frequently populations are exposed to environmental crunches or conditions of resource plenty (Wiens 1984, 1989). The natural drivers and predominant stressors of Colorado Plateau ecosystems, their effects on ecosystems, and the expected bird responses associated with their effects are summarized in Tables 2 and 3. Ecosystem dynamics likely vary among the habitat-based communities to be monitored. Literature reviews and conceptual models describing the structure and functioning of the habitat-based bird communities to be monitored, including mixed conifer forest, pinyon-juniper woodland, grassland/shrubland, and riparian zone bird communities, are provided in Holmes and Johnson (in preparation.).

Individuals, populations, and communities of birds are affected by ecosystem processes and factors in the habitats where they breed, migrate, and winter. They are exposed to different disturbances and stressors within and across years and across the range of habitats they use, which, in turn, affects their fitness. Resident birds (i.e., those that remain within the ecosystem or region throughout the year) are primarily affected by factors and processes within the region. Most migrant birds (i.e., those that winter south of their breeding areas), are also exposed to factors and processes occurring outside the region, as well as within. Ecosystem factors and processes within the parks primarily affect these migratory species during the spring/summer breeding and/or migration periods.

Documenting that a particular process does occur in a community does not mean that it is responsible for the patterns observed. Its influences may not extend to a population or multispecies level, or may be overridden by other factors, especially if disturbance is frequent or intense. It is also essential to consider that contemporary communities are not static but bear the imprint of their history over time scales ranging from years to geologic epochs (Wiens 1989). All these issues should be considered when interpreting community patterns.

6.3 Data analysis

The primary focus guiding the statistical approach is to estimate abundance and conduct trends analyses, including hypothesis testing, to determine if changes have occurred. We apply this approach in three main areas: (1) determining status and trends in bird species abundance, (2) tracking changes in species richness, and (3) examining relationships between habitat-based bird communities and their habitats.

Table 2. Natural drivers of Colorado Plateau ecosystems

Drivers	Effects	Expected bird response
Regional climatic & atmospheric conditions		
Precipitation; wind; radiant energy; CO_2; N_2; dust and other airborne constituents	• determines vegetation structure and composition • triggers episodes in plant mortality or establishment and changes in dominance by different vegetative life forms and functional groups • changes availability of food • alters disturbance regimes and the capacity of ecosystems to resist or recover from natural disturbances and human land-use activities	• differential mortality • changes in distribution and abundance of bird species • changes in bird community composition and dynamics
Distrubance regimes		
Extreme climatic events (drought, floods, wind storms	• differential mortality of long-lived plants that are structural dominants and changes to community composition • redistribution of soil resources and site alteration • changes in ecosystem's susceptibility to subsequent disturbances and resistance and resilience to anthropogenic stressors • changes in habitat and food availability	• changes in breeding productivity and/or distribution and abundance through habitat-selection processes
Fire	• selective damage or elimination of fire-intolerant life forms or age classes and alteration of vegetation composition and structure • strong vegetation interactions with soil, hydrology, and geomorphic processes; • alteration of nutrient cycling	• changes in distribution and abundance of bird species • changes in bird community composition and dynamics
Insect and disease outbreaks	diminished vigor of host plants and/or insect resistance which affect the life cycles and dispersal patterns of insect herbivores long-term changes in vegetation structure; vegetation interactions with nutrient cycles, hydrological processes, and geomorphic processes	changes in breeding productivity changes in distribution and abundance of bird species changes in bird community composition and dynamics
Herbivory and trampling	• altered plant population dynamics and changes in plant community composition, structure, and distribution • changes in ecosystem processes and properties due to strong interactions between vegetation, nutrient cycling hydrologic processes, disturbance regimes, and geomorphic processes	• changes in breeding productivity • changes in distribution and abundance of bird species • changes in bird community composition and dynamics

6.3.1 Correcting VCP count data for detectability

Numerous factors may influence the detectability of birds in the field, including observer acuity, environmental factors affecting bird behavior and observer efficiency, temporal factors, and physical and behavioral attributes of birds. Consequently, the probability of detecting all birds present is less than 100%, leading to incomplete and unequal counts. The software program Distance (Thomas et al. 2010) can be used to model detectability and estimate the absolute density of species from raw counts, and to test assumptions concerning detectability.

Ideally, park/habitat-specific detectability-based density estimates could be modeled annually for each species. But, approximately 100 detections are necessary in order to

Table 3. Predominant stressors for ecosystems on the Colorado Plateau and their potential general effects on habitats and birds

Stressor	Potential effect on habitat	Potential bird response
Climate change	• altered physiological processes and competitive relationships of vascular plants, invertebrates and vertebrates, nutrient cycles, hydrological processes, and disturbance regimes • altered structure and functioning of ecosystems • disruption of the connectedness among species • extirpations and local extinctions • shifts in species' ranges and available habitat	• shifts in species' ranges of occurrence • changes in species composition of breeding bird community • changes in migration timing, earlier arrival dates and breeding, decoupling of birds from their dominant food resource and reduced productivity • breakdown of control mechanisms between birds and prey leading to more damaging insect outbreaks of some species • loss of bird species' ecological services
Air pollutants	• increased pollutants in soil, air, vegetation, and foods • increased susceptibility to exotic plant species invasions • increased plant species diversity and loss of essential food and cover resources • increases in density of small rodent populations and other predators that prey on eggs and chicks • decreases in the amount of calcium- rich food items (important for egg production?) • reduction in biomass of invertebrate prey	• bioaccumulation of pollutants in organs and tissues of birds • physiological damage to individuals • decline or loss of specialized bird species • reduced calcium uptake resulting in fragile eggs and lower breeding success • reduced breeding productivity
Water availability	• lowered quality and quantity of water resources • changes in riparian habitat structure, vegetation composition, invertebrate abundance and composition, diversity, function, and sustainability.	• decrease or loss of riparian-dependent species, changes in distribution and abundance • changes in breeding productivity
Adjacent land use activities	• changes in habitat structure/fragmentation for wide- ranging species • changes in microclimates and microhabitats • changes in fire regime • altered ecosystem structure and functioning • increases in transfers of soil and water resources • increases in airborne and waterborne pollutants • altered hydrologic processes and water availability • increases in exotic species • increases in brood parasites and predators.	• changes in distribution and abundance of bird species • isolation of individuals or populations and lowered pairing success • changes in interspecific competition • reduced breeding productivity
Livestock and large herbivores	• damage or destruction of biological soil crusts • changes in plant community composition, structure, and distribution • changes in plant population dynamics • changes in nutrient cycling, hydrologic and geomorphic processes, and disturbance regimes • alteration of ecosystem processes and properties	• reduced breeding productivity • changes in distribution and abundance of bird species • changes in bird community composition and dynamics • greatest negative effects on species that use dense ground cover for nesting and foraging

Table 3. (*continued*) Predominant stressors for ecosystems on the Colorado Plateau and their potential general effects on habitats and birds

Stressor	Potential effect on habitat	Potential bird response
Fire suppression	• altered fire regimes • changes in vegetation structure, composition, diversity, and functioning of associated ecosystem processes • changes in ecosystem dynamics • diminished hydrologic functioning and increased erosion rates • loss of post-fire habitats	• changes in breeding productivity • changes in distribution and abundance of bird species • changes in bird community composition and dynamics
Invasive exotic species	• changes in community composition, structure, diversity • competitive displacement of native species • alteration of ecosystem-level properties	• changes in breeding productivity • changes in distribution and abundance of bird species • changes in bird community composition and dynamics
NPS management	• Park-specific impacts are affected by matrix of land-uses surrounding the park, park's management objectives and practices, and ecosystems involved	• changes in breeding productivity • changes in distribution and abundance of bird species • changes in bird community composition and dynamics
Visitor use	• trampling of soils and vegetation • dispersal of invasive exotic species • disturbances of wildlife • increased levels of water and air pollutants • bank erosion • contamination from human waste, other pollution, trash • increased vehicular traffic	• disruptions in breeding behavior • decreased nest success • increased mortality from collisions with vehicles • changes in bird distribution and abundance patterns • increased densities of avian human-commensal predators and increased predation on birds and bird nests • changes in breeding productivity • changes in distribution and abundance of bird species • changes in bird community composition and dynamics

reliably model species detection functions (Buckland et al. 2004). Using distance sampling allows us to combine data from repeated surveys of the same area or areas with similar habitat characteristics in order to increase sample size (Buckland et al. 2004). By combining surveys, it is possible to develop detection functions for uncommon species, for which too few detections are recorded during a single survey. It should be possibleto model detection functions and estimate densities for the more common species, which have frequent detections within the target habitat, on an annual basis. Multiple years of sampling may be required for distance sampling to work for rare/uncommon species with infrequent detections.

We will use the software program Distance to model relationships between detectability and distance from the observer, and use those models to adjust detection rates, thereby producing estimates of absolute density (Buckland et al. 2004). Some of the many factors that may influence detectability are likely to vary over time and space, and therefore should be taken into account. Two methods of handling heterogeneity in data and for improving precision and reducing bias of estimates are stratification and inclusion of covariates in the analysis (Buckland et al. 2004). For some species, we may be able to model factors, such as observer, as a covariate, rather than conduct a completely separate analysis for each observer (Buckland et al. 2004). When we amass an adequate number of detections, we will further

test whether detection probability varies with factors, such as observer, year, and habitat characteristics. For example, we will model observer-specific detectability functions, at least for species with sufficient detections within a given habitat, and use an information-theoretic approach (Akaike 1973, Burnham and Anderson 1998) to observe whether observer-specific models are preferable to 'pooled observer' models. For some rarer species, we may never gather enough data to adequately model detectability. For all species, data will be used to construct the best possible detectability functions, accounting for sources of variation in detectability, to the extent that the data permit.

6.3.2 Determining trends in bird species abundance

As previously described, two metrics will be used to track trends in individual species abundances: relative abundance (the total number of individuals observed of each species scaled by survey effort), and detectability-based density estimates. We will have sufficient data to estimate density for a given year for only the more common species. Therefore, initially, we will monitor trends associated with annual relative abundances for less common species, and assess trends of annual density estimates for common species (with adequate numbers of detections to estimate yearly densities).

To detect trends in density and relative abundance for each species, we will use least-squares regression to test for significant differences among years. In cases where a cluster sampling design is used, the density estimate will be calculated by pooling data for all plots to derive the detection function, and density will be estimated for each cluster and for the entire habitat. We will use an information-theoretic approach (Akaike 1973, Burnham and Anderson 1998) to determine whether cluster-specific models are preferable to "pooled plots" models. If we are able to use density estimates at the level of the cluster, the cluster slope estimates will be treated as replicate measurements of habitat-specific trends, and tested for differences from zero using a modified t-test approach. In cases where the sampling design included sampling throughout the target habitat (i.e., the simple grid design), we will use Distance to produce a single habitat-specific density estimate (and variance) for each species. Although the sampling designs and corresponding analytical methods may differ slightly between parks, they should provide unbiased estimates, and therefore comparable results.

6.3.3 Tracking changes in bird species richness

To detect trends in bird species richness, we will use least-squares regression to test for significant differences among years. An important assumption of this test is that, while not every species in the area may have been detected, the proportion of species detected is similar in all time periods. This assumption may be violated, especially over extended time periods. There are several ways to address this issue. For example, species richness can be estimated by modeling detections using a capture-recapture model (Williams et al. 2002), or employing an estimator, such as jackknife, to estimate the fraction of the species total that were missed. These data enable one to estimate the number of local extinctions and colonizations, as well as species turnover rates.

6.3.4 Tracking changes in occupancy

In cases where it may not be possible to estimate the actual abundance of a species within a particular bird habitat sampling frame (for example, of a rarely detected species), occupancy, defined as the proportion of the area occupied by the species, can be considered as an alternate state variable for abundance. Occupancy estimation and modeling, as developed and described by MacKenzie et al. (2006), take into account issues of detectability (i.e., the non-detection of a species does not imply the species is genuinely absent) and permit unbiased estimation of the proportion of area occupied, colonization, and local extinction probabilities. In addition to estimating occupancy for a single species in a season, these methods can

be used to estimate the processes of change over time for multiple species (Mackenzie and Nichols 2004, Mackenzie et al. 2006).

6.3.5 Assessing relationships among habitat-based bird communities and their habitats

Data collected through this monitoring program can provide valuable information for estimating bird abundance and distribution, and for detecting trends In addition, because we're simultaneously collecting habitat data at the bird plots, and can integrate even more intensive vegetation data from the upland vegetation monitoring project, we have the ability to link changes in bird communities to corresponding changes in habitat. After multiple years of sampling, these data could be used to build habitat-association models that would (1) facilitate identification of important habitat variables at multiple spatial scales, (2) identify target species for conservation, and (3) build predictive models (e.g., Scott et al. 2002). Guidance for building habitat association models is beyond the scope of this protocol, however, the following references provide useful reviews and examples of various approaches: McGarigal et al. (2000), Scott et al. (2002), and Morrison et al. (2006).

Initially, it will be useful to examine the response patterns of bird species to environmental gradients and habitat variables. A first step is to relate key habitat measures with bird species abundance and distribution using correlation and multivariate analysis. Correlation analysis can be used to identify the bird-habitat variables that are most closely related and are of greatest interest. The strength of the relationship may be determined using Pearson's correlation (or Spearman's rank correlation as a nonparametric method). Multivariate techniques (e.g., PCA) may be used to examine the structure, or interdependence, of habitat variables (Morrison et al. 2006). Multivariate techniques (e.g., multiple regression, logistic regression) may also be used to further analyze relationships between bird abundance and one or more explanatory variables (e.g., % canopy closure, basal area). In addition, Distance and occupancy modeling programs allow the user to explain animal distribution with respect to habitat and other variables (Buckland et al. 2004, MacKenzie et al. 2006).

We may also use ordination techniques to arrange bird abundance data or habitat variables in terms of their similarity, to investigate bird-habitat relationships. Ordination methods that conduct indirect gradient analysis are appropriate for SCPN bird abundance data because sampling units are not formally partitioned along an environmental gradient.

6.4 Reporting

The monitoring data collected and analyzed following this protocol will be used to prepare data summary reports and trend reports, following NPS Natural Resource Publication Management standards and guidance. Data summary reports of habitat-based bird community monitoring will be prepared for each year that sampling occurs (see the SCPN website for examples of bird community monitoring data summary reports: http://science.nature.nps.gov/im/units/scpn/publications.cfm?tab=2). The main objectives of the data summary report are to (1) summarize annual data and document monitoring activities for the year, (2) describe current conditions of the resources sampled, and (3) provide data to park managers in a timely way to increase data utility and improve communication within and among network parks. The details of summarizing data for annual reports are provided in SOP #10; annual reports are available on the SCPN website (http://science.nature.nps.gov/im/units/scpn/publications.cfm).

Trends reports will be prepared every seven to ten years and will provide statistical analyses of long-term data. The main objectives of trends reports are to (1) report patterns and trends of bird species abundance and distribution, (2) report information on bird-habitat relationships, (3) report the degree of change that can be detected by the current level of sampling, and (4) provide interpre-

tation of monitoring data in a park, multi-park, and regional context. Trend reporting will be a shared responsibility between the cooperating project manager and SCPN staff (quantitative ecologist, data manager, etc.).

A record for reports and other publications will be created in the References section (https://irma.nps.gov/App/Reference/Welcome) of the IRMA Portal. The digital report file, in PDF format, will be uploaded and linked to the IRMA record.

7 Personnel Requirements and Training

7.1 Roles and responsibilities

The program manager is responsible for the overall management and supervision of the network monitoring program. The project manager is responsible for the overall management and supervision of bird monitoring, and will work with the program manager to coordinate the involvement of other network staff. The roles and responsibilities for all pertinent staff are summarized in Table 4.

The SCPN is accomplishing the work associated with this protocol through a Colorado Plateau Cooperative Ecosystems Study Unit (CESU) agreement with Northern Arizona University (NAU). The project manager is an NAU employee and works closely with SCPN personnel. Overseen by the project manager, the SCPN bird monitoring field crew is responsible for carrying out a year's bird monitoring and habitat sampling across SCPN parks, data entry and verification, generally from late April to early July. The field crew includes three to four research technicians, depending on the number of parks and habitats to be sampled in a year. The program's sampling design calls for sampling to be conducted by "teams" of two to three field crew members. Individual field crew members conduct bird sampling at a set of VCPs, generally 10, in a morning. Individuals of the team meet after bird sampling, or on non-bird sampling days, to conduct habitat sampling. Each team conducts sam-

Table 4. Key roles and responsibilities for personnel implementing bird monitoring

Position	Roles and responsibilities
Program Manager	The program manager is responsible for the overall management and supervision of the monitoring program. Duties include overseeing the development and testing of monitoring protocols, hiring and supervising network staff, managing the implementation of monitoring projects, and ensuring that the data are appropriately analyzed, reported and made available for park planning and management.
Cooperating Project Manager	The project manager is responsible for implementing the bird monitoring project. Duties include working collaboratively with park staff to understand management issues and information needs, developing protocols, obtaining research permits, hiring, training, and supervising the field crew, analyzing data and writing reports. The project manager works closely with the data manager, spatial analyst, quantitative ecologist, and botanist to ensure that high-quality standards are achieved and maintained in collecting, processing, and analyzing bird and bird habitat data. The project manager is responsible for ensuring that field crew members are well qualified and appropriately trained. The project manager supervises the field crew and ensures that crew members adhere to the protocol and perform their duties appropriately and on schedule. The project manager will serve as the point of contact concerning data content and will work to establish partnerships as appropriate.
Data Manager	The data manager is responsible for the information and data stewardship of the habitat- based bird community monitoring project. The data manager designs databases, writes the data management plan and protocols, and works with the project manager and network staff to ensure that the datasets are fully documented, validated, and archived. The data manager, in collaboration with the project manager, develops data-entry forms and other database features as part of quality assurance, and automates report generation. The project manager and the data manager share responsibility for preparing data for analysis. The data manager populates NPS servicewide databases, maintains digital document libraries and maintains the network website.
Spatial Analyst	The spatial analyst is responsible for managing the spatial data and providing GIS support to the habitat-based bird community monitoring project. Duties include managing, documenting, and distributing spatial data resulting from the monitoring project, maintaining a library of relevant park spatial data, and working with the project manager and quantitative ecologist in developing the reference frames.
Quantitative Ecologist	The quantitative ecologist works with the program manager and project manager to develop spatial and temporal sampling designs for the project, develop sound statistical approaches to analyzing monitoring data, and provide analytic support to the project.
Botanist	The botanist is responsible for providing taxonomic expertise to the project manager and bird field crew. Duties include helping the project manager to train the bird crew in identification of woody plant species in the target habitats, training field crew members in foliar cover estimation, and provide up-to-date plant species lists for the park
Cooperating bird field crew members	The field crew will consist of 3–4 members, depending on the habitats to be sampled that year. They are responsible for field data collection, data entry, and data verification. Other duties include maintaining the equipment, ordering supplies and assisting with field logistics.

pling in two or three target habitats, usually located in different parks, using one to two project vehicles.

7.2 Crew qualifications and training

Competent, well-qualified, and detail-oriented observers are essential for the collection of credible, high-quality data. Crew members must be proficient or nearly proficient at identifying Colorado Plateau bird species by sight and sound, or proficient at identifying birds from other regions and be able to demonstrate an ability to quickly learn to identify new bird species. They should also have good organizational skills, a good memory, and the ability to work methodically and consistently under difficult conditions. They should be physically fit and experienced with backcountry hiking and camping.

An intensive training session will be conducted immediately preceding the field season. The training will emphasize correct identification of bird species by sight and sound, accuracy in distance estimation, and promote accuracy and consistency in habitat data collection by observers (field crew members).

The duration of the training session will depend somewhat on the skill and experience level of the field crew members. However, our experience in training crews during the pilot year of the SCPN monitoring project, and for other similar projects, has shown that two weeks of training provides enough time for experienced individuals to familiarize themselves with the study areas, and hone their bird identification skills and ability to accurately estimate distances.

The training session will include orienting crew members to NAU and SCPN safety procedures, including a review of the network Safety Plan. Wilderness First Aid and CPR are recommended for all crew members and the network requires that at least one crew member have current training.

The project manager will be responsible for planning and scheduling the training session, as well as conducting the training. The training should be carefully planned to ensure that all topics are adequately covered, and that field crew members receive adequate exposure to the bird communities they will be sampling. We have found that this can best be achieved by conducting the training session in the target habitats to be sampled that year. Lower elevation sites (grassland/shrubland and riparian) should be visited first and higher elevation sites (pinyon-juniper, mixed conifer) should be visited during the second week. SOP #2 provides more details.

8 Operational Requirements

8.1 Annual workload and field schedule

The field season for bird monitoring, including approximately two weeks for training at the outset, generally extends from late April through early July. In any given field season, the implementation schedule and revisit design will determine which plots will be sampled. We have found that two field crews can sample two target habitats, with approximately 100 sampling plots each, conducting bird sampling at each plot twice in a season, and habitat sampling at each plot once in a season.

The project manager will prepare annual summary reports and periodic trend reports. The project manager will also participate in a variety of local, regional and national ecology and bird monitoring forums. In addition, several network staff will support the bird monitoring project, including the data manager, spatial analyst, quantitative ecologist, and botanist (see Section 7, Personnel requirements and training, for details).

8.2 Facility and equipment needs

The SCPN habitat-based bird community monitoring project will be based out of the Colorado Plateau Research Station (CPRS) office on the NAU campus. An office and equipment storage space are available at this location. The SCPN and CPRS will acquire and maintain all equipment required to implement this protocol. A complete equipment list, and the entity responsible for acquisition and maintenance, can be found in SOP #1. Crew members will need to maintain the equipment regularly and the project manager will need to replace the equipment periodically due to normal wear and tear.

Travel accommodations for the field crew will include park housing when available, use of campgrounds in or near parks, and occasionally overnight camping at remote, primitive locations.

8.3 Budget considerations

SCPN bird monitoring occurs over two years with no monitoring in the third year. Thus the total cost for one complete cycle of monitoring is $135,000 to $139,000. The estimated costs for conducting bird monitoring in SCPN parks, shown in Table 5, are annualized over three years. The start-up field equipment costs of approximately $5,600 are not included in Table 5. SCPN staff support including project oversight, data management and analysis support, and editing assistance are not included.

Table 5. SCPN habitat-based bird community monitoring project budget

Budget item	Annualized cost over three years
NAU project manager	$22,000–$22,600
NAU bird field crew	$26,500–$27,100
Equipment and supplies	$200–$300
Travel	$8,600–$9,200
Indirect costs, CESU 17.5%	$10,100–$10,400
Total	$67,400–$69,600

8.4 Procedures for making/implementing changes to the protocol

Revisions to the protocol narrative and SOPs will be inevitable over time. Explicit documentation of these changes is critical for proper collection, analysis and interpretation of data. Procedures for changing the protocol narrative and related SOPs are documented in SOP #11. The protocol narrative and all SOPs are labeled with version numbers, which are included in the revision history log. Changes to either document type are to be accompanied by updated version numbers. Version numbers, dates, the changes, reasons for the changes, and author of the changes are to be recorded in the revision history log. The updated version table is provided to the data manager for proper updating of the master version table database.

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10 Revision history

Provide the following information for each revision made to the SCPN bird monitoring protocol narrative

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Standard Operating Procedure #1: Preparing for the Field Season

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Only changes in this specific SOP will be logged here. Record the previous version number and date of revision; identify sections and paragraphs where changes were made, who approved the revision, and the new version number. More detailed descriptions of the changes made and the reason for the changes is provided at the end of this SOP.

This standard operating procedure (SOP) describes pre-season procedures for the SCPN Habitat-Based Bird Community Monitoring Program. The procedures described here are primarily the responsibility of the project manager. Included in this SOP are descriptions of general preparations, staffing, field season scheduling considerations, permitting, and a list of necessary supplies and equipment for sampling. A complete, yearly project task list is provided in Appendix C. The procedures described here should begin no later than three months prior to the field season.

1 General preparations and review

1.1 Review monitoring narrative and all SOPs

The project manager should be thoroughly familiar with the objectives described in the SCPN bird monitoring protocol. He or she should also have a solid working knowledge of the conceptual models that summarize existing knowledge and hypotheses concerning the structure and functioning of bird communities of the Colorado Plateau. The project manager should review the narrative and all SOPs prior to the field season so that he or she can explain the procedures clearly and completely to the field crew during training.

1.2 Review sampling notes from the previous year

At the end of each field season, the project manager will write a report outlining issues and problems encountered during the field season, and including suggestions for improving methods and/or efficiency. Before the beginning of the next field season, the project manager will review this report and implement any proposed changes, as appropriate.

1.3 Initiate planning

The project manager should initiate discussions of specific sampling objectives, staffing, budget, and vehicle needs with SCPN personnel. Goals for the upcoming season and a

realistic timeline to meet the goals should be established.

1.4 Develop a field schedule

The field schedule will begin in April or early May at lower elevation sampling sites, and continue through late June to early July. Sites will be sampled based on peak breeding bird phenology and logistical considerations. Sites should be sampled at approximately the same time every year. The schedule should propose an initial plan for the entire season, but allow flexibility in scheduling VCP counts so that sampling can be postponed during inclement weather and other unforeseen conditions. Permitting delays, snowmelt timing, and backcountry road conditions could all cause schedule changes mid-season. The number of sites to be sampled and staffing constraints will also affect scheduling.

1.5 Begin hiring process

The project manager should begin the process of hiring field crew in late December or early January (see SOP #2).

1.6 Prepare the field folders

The project manager and/or supervisory field crew should create field equipment packets for each target habitat to be sampled during the field season, and should check existing packets to make sure that all of the items listed are included (see Table 1-1). The packets should contain the protocol, including SOPs #4, #5, and #8, datasheets, maps of the sampling plots, and paper copies of lists of the UTMs for all sampling points.

1.7 Obtain permits

The project manager should obtain all necessary permits well in advance of the field season. These include Scientific Research and Collecting permits, as well as backcountry hiking and camping permits (where necessary). Scientific Research and Collecting Permits should be obtained for each park using the National Park Service Research Permit and Reporting System website (https://irma.nps.gov/rprs/Home). Other permits should be obtained through park natural resource staff or rangers.

1.8 Arrange housing and transportation

The project manager should contact appropriate park staff to arrange park housing or campground use, and request vehicles for field season from appropriate entity (e.g., Northern Arizona University transportation, GSA).

1.9 Prepare supplies and equipment

The project manager should review inventory lists of field equipment from the previous field season, or assign a trusted senior field lead to do the same. All equipment needs to be checked to ensure that it is in optimum working condition. In addition to sampling equipment, additional items that should be available include field guides, datasheets, field notebooks, GPS units, maps, camping gear, and safety equipment. For a complete list of supplies and equipment, see Table 1-1 and associated data collection SOPs (SOPs #4 and #5).

In addition,

- Working with the SCPN program administrative assistant, all necessary equipment should be ordered from suppliers before the beginning of the field season.
- All field equipment should be available and organized before field work is scheduled to begin, and examined for functionality and completeness.
- Field crew should print datasheets for the field season and organize them into packets for each datasheet type.

Table 1-1. Equipment list.

Equipment	SOPs	Notes
Bird sampling and habitat characterization		
GPS unit (4-5; with UTM coordinates et al.)	4, 5	1 per field crew member for navigating to bird sampling points & subplot establishment
Binoculars (4-5)	4, 5	1 for project manager, 1 per field crew member
Compasses (34)	4, 5	1 per field crew member for habitat characterization and plot layout
Laser Rangefinder, with clinometer (3-4)	4, 5	1 per field crew member for bird sampling and habitat characterization
Clipboards	4, 5	1 per field crew member
Pencils, eraser, extra lead	4, 5	Multiple
Sharpies	4, 5	Multiple
Datasheets	4, 5	Multiple
Laptop	8	1 per sampling team
Flagging, pin flags	4	Optional, to facilitate relocation on second bird survey and habitat sampling
Extra batteries	4, 5	Multiple
Maps (of bird and habitat sampling plots, access maps)	3, 4, 5	Complete set per field crew member
Hard copy of VCP UTMs	3, 4, 5	Complete set per field crew member
Copy of park research permit, parking placard (if required)	All	1 per sampling team (generally 2 field crew members/team)
Habitat sampling		
Digital watch or timer	4	1 per field crew member for bird sampling
Bird field guides	4	1 per field crew member
Bird song recordings	4	1 per field crew member; contains songs and calls of most species, for use after morning sampling
List of sunrise times for each area to be sampled	4	1 per sampling team
Habitat sampling		
Diameter tape (metric) (2)	5	1 per sampling team
Basal Area Angle Gauge (2; "cruise angle" with 25 inch bead chain)	5	1 per sampling team
Convex Spherical Densiometer (2)	5	1 per sampling team
Rope (4) – 11.3 m long, marked at 1.78m, 5 m, and	5	For demarcating habitat sampling subplot. Two ropes per sampling team
Stakes (2)	5	For securing subplot rope end
Ziplock bags	5	Multiple
Plant identification guides	5	1 per sampling team
Group safety		
First aid kit (3-4)		Backcountry kit, 1 per field crew member
Hand-held radio (3-4)		1 per field crew member
Emergency contact information		1 per field crew member
SCPN Field Safety Binder with park contact information		1 per field vehicle
Habitat sampling		
Day pack		
Rain gear		
Sun hat		
Drinking water		
Sunscreen		
Multi-Tool		

2 Revision history

Provide the following information for each revision made to SOP 1.

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Standard Operating Procedure #2: Hiring and Training the Field Crew

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This standard operating procedure (SOP) describes the steps for hiring and training seasonal field personnel to collect data for the Southern Colorado Plateau (SCPN) habitat-based bird community monitoring project. Once hired, the crew must be properly trained in monitoring protocols, bird identification, and distance estimation. Hiring an experienced and qualified field crew is critical in order to collect accurate, high-quality data.

1 Hiring the field crew

The project manager oversees the SCPN bird monitoring field crew, which is responsible for carrying out bird monitoring and habitat sampling across selected SCPN parks. Current SCPN operational plans call for accomplishing field bird monitoring through a cooperative agreement with Northern Arizona University (NAU) and the Colorado Plateau Cooperative Ecosystems Study Unit (CESU) This arrangement provides a pool of students, graduates, and affiliated staff with ecological and avian experience and skills, and is conducive to hiring a well-qualified crew.

In order to ensure high-quality data, every effort should be made to hire technicians who are proficient or nearly proficient at identifying SCPN species by sight and sound, or who are proficient at identifying birds from other regions and can demonstrate an ability to quickly learn to identify new bird species. See Table 2-1 for a detailed description of the bird monitoring field crew position.

The field crew will include three to four research technicians (GS-5 to GS-7 equivalent, depending on experience), depending on the number of parks and habitats to be sampled in a year. The program's sampling design calls for sampling to be conducted by "teams" of two to three field crew members. Team members conduct bird sampling at a set of variable circular plots (VCPs), generally nine or ten, in a morning. After bird sampling, or on non-bird sampling days, team members will work together to conduct

Table 2-1. Bird monitoring field crew position.

Research technician
Minimum qualifications:
• Bachelor's degree in biology, wildlife biology, ecology, or environmental sciences, botany, ecology, soil science, AND two years related bird research or experience; OR
• Four years research or work experience in biology, ecology, botany, or environmental sciences; OR
• Any equivalent combination of experience, training, and/or education.
Desired qualifications:
• Two to four years of specialized experience as a Biological Technician with duties similar to those of this position, especially conducting multi-species bird surveys within the region and distance-sampling experience.
• Experience with Microsoft Word, Access, and Excel software.
• Field experience working in remote backcountry settings and harsh field conditions.
Knowledge, skills and abilities:
• Knowledge in the following subject areas as related to the Colorado Plateau: bird identification by sight and sound, and estimating distances.
• Familiarity with the methods, procedures, and techniques of collection of bird and habitat data.
• Skills conducting field research in ecological, biological, or environmental topics.
• Ability to perform detailed data collection, data organization, and record keeping duties.
• Ability to communicate information in a clear and concise manner, in order to report on field activities and communicate results of data collection.
• Ability to work with a wide variety of people from federal, state, and tribal land management agencies, educational and research institutions, and non-profit organizations.
• Skills and ability to work in remote backcountry settings with little supervision.

habitat sampling. Each team conducts sampling at two or three target habitats, usually located in different parks, using one to two project vehicles.

The NAU field crew positions are temporary, with full-time work continuing for 14 weeks or less during the NAU fiscal year. To attract the most qualified candidates, job announcements should be disseminated in December or January. Appropriate outlets include Flagstaff-area and NAU job listings, and the following websites: The Ornithological Newsletter (http://www.aou.org/jobs) and Texas A&M Wildlife Science job board (http://wfsc.tamu.deu/jobboard/index.htm).

2 Technical training

An intensive training session will be conducted immediately preceding the field season. The training emphasizes (1) familiarization with the protocol and with all sampling methods related to collecting bird and habitat data (SOPs #4 Conducting the Bird Sampling and #5 Habitat Characterization), (2) correct identification of bird species by sight and sound and accuracy in distance estimation, and (3) accuracy and consistency in habitat data collection among observers.

The optimal duration of the training session will depend somewhat on the skill and experience level of the field crew members, but our experience in training crews during the pilot year of the SCPN monitoring project, and during other similar projects has shown that two weeks of training allows time for experienced individuals to hone their bird identification skills, develop the ability to accurately estimate distances, and to familiarize themselves with the study areas.

The project manager is responsible for planning and scheduling the training session, and conducting training. The training should be carefully planned to ensure that all topics are adequately covered, and that field crew members receive adequate exposure to the bird communities they will be sampling. We have found that this can best be achieved by conducting the training session in the target habitats to be sampled that year. Lower elevation sites (grassland, riparian) should be

visited first and higher elevation sites during the second week (pinyon-juniper, mixed conifer).

2.1 Identifying birds by sight and sound

Soon after being hired, field crew members should be sent bird species lists, and other training materials (e.g., recordings of songs of birds likely to be encountered), and be urged to begin preparing themselves prior to the start of the training session. During the training session, most mornings should be spent birding, listening to and learning bird songs, and observing birds. People learn to identify new species most quickly when they actually see and hear them in the field. Field crew members should also spend time throughout the training session studying field guides, listening to recordings, and reviewing the species encountered that day. During the second week of training, the field crew members should be tested on their ability to identify birds by sight and sound. This allows them to assess their own strengths and weaknesses, and also helps the project manager identify individual species or groups of species that the crew may be having trouble learning. Field crew members should be proficient at identifying birds in the target habitats they will be sampling before they are sent out to collect VCP count data for the SCPN bird monitoring program.

2.2 Estimating distances

In many of the target habitats for SCPN bird monitoring, it will be possible to measure the distance to bird detections during VCP counts by using a laser range finder. But there will be times when conditions prohibit the use of the range finder, such as in dense vegetation. Therefore, in addition to training field crew members on the use of a range finder, **it is extremely important that field crew members be trained to estimate distances, both to seen birds and to unseen, singing birds.** The importance of skill in estimating distances to unseen birds can't be overestimated, as the majority of birds detected during VCP counts can be heard but not seen. Training should occur in each of the habitats to be sampled, as vegetation and terrain can affect estimates.

Field crew members should first learn to estimate distances to seen objects. The project manager should begin training by placing flagging at 10, 25, 50, 100, and 200 m from a central point and having crew members estimate distances to trees, bushes, or rocks, and flagging that are visible from the central point. Distances should be estimated to the nearest meter and the project manager should look for and caution against the tendency to round off estimates to the nearest 5 or 10 m. As proficiency increases, field crew members should estimate distances to objects (including birds) outside of the flagged area. After estimating a distance, the field crew member should use a laser range finder or pacing to determine the actual distance. Both the estimated and actual distance should be recorded in a notebook, so that field crew members can assess their own tendencies to overestimate or underestimate distances, and thus improve their estimates.

This exercise should be repeated within each target habitat to be sampled, and on flat ground and slopes. With practice, field crew members should be able to estimate most distances within 10-15 percent of the actual distance. Accuracy may be reduced somewhat for distant birds or objects, but this is not of great concern, as far-off detections have less effect on detectability models than do closer observations.

When field crew members have become skilled at estimating distances to seen birds, they should start estimating distances to singing or calling, but unseen, birds. Estimating distances to unseen birds is challenging because birds can sound louder or quieter depending on how far away they are, how much vegetation exists to muffle sound, how loud they are actually singing, and the acoustic properties of a species' vocalizations. Nevertheless, individuals can greatly improve their estimates with practice.

Measuring distances to unseen birds after estimating distances can be problematic.

A useful exercise during training is to have the field crew stand at a sampling point and mark the location (in UTMs) using a GPS unit. The crew then independently estimates the distance to an unseen, singing bird. Then they walk toward the singing bird, locate it, and use their GPS unit to determine the distance back to the sampling point. While walking towards the bird, care must be taken to approach quietly, to prevent disturbing it and causing it to move. If it does move, the measurement cannot be taken. For this exercise, it helps to select a bird that is singing repeatedly from the same location, and is thus less likely to move.

This exercise should be repeated several times within a target habitat, and in all habitats to be sampled that year. The same technique can be used to check the distance to an unseen bird after completing a VCP count.

2.3 Conducting VCP counts

A few days into the training, after field crew members can identify most species and have had some training in distance estimation, the field crew should conduct practice VCP counts in the same place and at the same time. After the survey, they should compare notes and discuss any discrepancies in the species detected, and their estimates of distances to them. **These simulations should be continued until there is consistency among the field crew in the species and distances recorded.**

The field crew should know and adhere to the procedures for conducting the VCP counts (SOP #4) prior to conducting practice surveys. They should use the VCP count datasheets during practice counts, and the project manager should ensure that they are completed correctly.

2.4 Identifying plants and collecting habitat data

Throughout the training session, the field crew members will be taught to identify the trees and common shrubs in the target habitats. The crew will learn to identify plants while in the target habitats, and during birding and other training. In addition, they will receive instruction, as needed, in using plant guides to identify unknown species.

The crew should practice collecting habitat data, as a group, in order to standardize classification of vegetation types, cover assessments, densiometer readings, and the use of the basal area angle gauge. Practice should continue until crew-wide standardization is achieved. The crew should use habitat sampling datasheets during practice sampling, and the project manager should ensure that they are completed correctly.

2.5 Orienteering

During the training session, field crew members should become proficient at using a GPS unit and compass, using a map, and locating and navigating between sampling points. These skills should be practiced until all crew members are proficient.

2.6 Preparing for field conditions

Field work in SCPN parks often occurs in remote locations and can be extremely physically demanding. All field crew members should be prepared for difficult field conditions, and have the physical capacity for camping at remote field sites and long days of hiking in rugged, steep terrain. Field crews may remain in the field for long periods of time, possibly experiencing extreme and highly variable weather. The remote nature of this work requires the crew member to function as a member of a crew and also to independently exercise excellent judgment in difficult situations. Crew members should have prior experience working and camping in backcountry situations.

2.7 Safety training

Wilderness First Aid and CPR training are recommended for all field crew members and required for at least one member of each crew. In addition, training will be provided on SCPN safety procedures. Crew members will review the SCPN Safety Plan paying particular attention to

- field operations safety

- field communications
- vehicle safety
- responding to an incident
- job hazard analyses

2.8 Entering data

During the training session, field crew members will receive training on data entry procedures (see SOP #8), so that they can enter data during the field season. Field crew members may need security clearances or other specific authorization, depending on the computers to be used. Arrangements for authorization should be made well in advance of the field season.

2.9 Briefing on park procedures and coordination with park personnel

SCPN field crew members should be familiar with the rules, regulations, and guidelines of individual park units. An important aspect of maintaining good working relationships with park staff is to ensure that all crew members adhere to permit and check-in requirements, backcountry hiking and camping guidelines, and emergency procedures for the parks in which they will be working.

2 Revision history

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Standard Operating Procedure #3: Establishing Bird Sampling Points

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This standard operating procedure (SOP) describes the process for establishing bird sampling plots for the SCPN Habitat-based Bird Monitoring Program using a cluster sampling method for large sampling frames, or a simple grid sampling method for Variable Circular Plot (VCP) counts. Habitat sampling is conducted at these same sites (see SOP #5 for instructions on establishing habitat sampling plots). The project manager, working with SCPN personnel, will establish the bird sampling plots prior to the start of bird monitoring. Once established, these plots will be sampled in subsequent years. The first step in the process is to establish the sampling frame (see Appendix A for park specific spatial designs). This SOP helps to determine whether the potential sampling sites are accessible and whether the potential sampling plot is located in the target habitat. Analysis of pilot data indicated that from 80 to 100 points should be sampled twice within the field season in order to acquire sufficient data for tracking trends.

1 Sampling frame

A sampling frame is the area from which sites are randomly selected, and hence the area to which statistical inferences can be made, based on monitoring data. The sampling frames for upland bird community and habitat monitoring are derived from elevation data and the maps of ecological sites developed by the U.S. Natural Resources Conservation Service (NRCS) (see Appendix A of DeCoster et al. 2012). Ecological sites are based on soil survey data and are landscape divisions with characteristic soils, hydrology, plant communities, and disturbance regimes and responses (Butler et al. 2003). For some target habitats, two or more ecological sites may be merged into one. To derive bird community monitoring sampling frames, we modified the map of a sampling frame using Geographical Information System (GIS) technology to eliminate

- areas that were not within the target habitat (e.g., roads, buildings, and

infrastructure)

- areas that were expected to differ substantially from the norm for the target habitat, such as areas that have experienced fire of moderate to high burn severity, and mechanically treated areas because these areas would have increased ecological variation, making it more difficult to detect trends
- areas too small to fit an entire cluster of 9 to 10 points spaced at least 200 to 250 m apart within the target habitat, in target habitats with a cluster sampling design
- areas with slopes ≥20% or 30% to prevent erosion from occurring as a result of the field work

Depending upon the size of the sampling frame, we use one of two methods to spatially allocate sampling plots: cluster sampling or grid sampling. For large sampling frames involving large target populations (e.g., mixed conifer forests on the North Rim of GRCA or grasslands in Petrified Forest National Park), we use a cluster sampling method in which primary sampling units (PSU) are selected in a probabilistic manner using the GRTS design (Stevens and Olsen 2004) from a grid of regularly spaced (e.g., 250 m) points. Each PSU serves as the center plot for a cluster of 8 or 9 other sampling plots that are 200 to 250 m apart, and each of these serve as a secondary sampling plot (SSU) where VCP data are collected. In cluster sampling, 10 primary sampling units are selected, each consisting of a cluster of 9 or 10 sampling plots, for a total of 90 or 100 plots per sampling frame.

The second method we use, simple grid sampling, is used for target populations with limited spatial extent (e.g., pinyon-juniper at MEVE) and is similar to a census sampling design. For these sampling frames, all plots falling within a grid of regularly spaced points (e.g., 250 m) form the sampling plots, provided they meet the target population definition. A minimum of 80 sampling plots are selected and monitored for each of these smaller sampling frames.

Following plot selection, park staff will review the sampling plots and reject those plots that land in proximity to archeological sites. Next, the project manager will evaluate the accessibility of sampling clusters and plots (see section 2 *Accessibility assessmen*t below). Then, at accessible sites, the project manager will conduct an ecological site assessment for each potential sampling plot to determine whether or not it falls within the targeted habitat. From the pool of accessible sites that fall within the targeted habitat, the project manager will select sites for monitoring based on the following criteria:

- Cluster (for cluster sampling) or plots (for simple grid sampling) are spatially distributed across the sampling frame to as great an extent as possible.
- Pairs of clusters, or groups of 9 to 10 points, are near each other to ensure communication between a pair of field crew members (by radio).

For riparian monitoring, the bird sampling frame will initiate from an individual stream length of a targeted system, and a GIS stream line will be identified using the National Hydrography Dataset. A line of points should be placed evenly, usually 150 m apart, along the stream. Each point will be examined, either using an aerial photo or by surveying in the field, and then moved to the center of the widest occurrence of riparian vegetation (using a line perpendicular to the stream line).

These points within the target riparian habitat will form the sampling frame. If there is insufficient riparian vegetation (<50 m radius of riparian vegetation) surrounding a point, it should be rejected. In other cases where the riparian vegetation zone is sufficiently wide, additional sampling points can be placed in the zone, as long as the 150 m spacing between points can be maintained. The process is repeated until the entire target riparian area has been assessed for placement of potential sampling plots. As above, park staff should check the sampling plots, rejecting those that land in proximity to archeological sites. The project manager will

evaluate the accessibility of the plots, and then conduct an ecological site assessment for each potential sampling plot.

2 Accessibility assessment

Prior to visiting potential sampling sites (clusters or plots), the network spatial analyst or assistant will load a shapefile (a digital vector storage format for geometric location and associated attribute information) with all of the potential sampling points onto a minimum of two GPS units. The spatial analyst will also load background files, such as topographical and habitat maps, if applicable. Small and large scale topographical maps should be generated for field use, as well as aerial photos if available. The project manager should request this from the spatial analyst far enough in advance of fieldwork to ensure there is sufficient time to complete these tasks.

The project manager will determine the accessibility of the sites (clusters and/or plots), and reject sites that are deemed inaccessible. Sites are deemed inaccessible if

- The site is greater than two hours of traveling time (by car and foot) from the location where the field crew camps.
- The terrain prevents access to the site (e.g., there is a cliff or inaccessible ravine between the parking spot and the site).

3 Ecological assessment

After inaccessible sites have been rejected, the project manager will evaluate each remaining cluster and/or plot to ensure that it

- Falls within the target habitat. At each potential sampling point, the area within a 50 m radius (the macroplot) must be comprised of the target habitat. Macroplots are rejected if they do not match the target habitat. Target habitats are described in Table 3-1.
- Has a slope less than 30%. Macroplots are rejected if they have a slope greater than or equal to 20% or 30%, depending on the target habitat.
- Does not fall within or contain a major disturbance. The macroplot and the area surrounding the macroplot must be examined for major natural and human disturbances. Any such disturbances that may have altered the vegetation composition in the plot must be noted in a field notebook. Whether or not a disturbance is considered "major" may vary by target habitat, based on park management priorities. For example, at GRCA for the mixed conifer habitat, areas of mechanically thinned fuel treatments were removed from the sampling frame, while in BAND, areas of mechanically thinned treatments, or areas that were scheduled to be treated, were included in the reference frame for mixed-conifer habitat. Macroplots should be rejected if they contain major disturbances.

Any plots that do not meet these criteria are rejected.

Table 3-1. Descriptions for target habitats in SCPN parks where bird community monitoring is conducted.

Target habitat	Park	Description
Mixed conifer forest	BAND GRCA	Dominated by various combinations of ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), blue spruce (*Picea pungens*), southwestern white pine (*Pinus strobiformis*), and sometimes other species. Typically consists of a topographically determined heterogeneous mosaic of patches, some of which are dominated by quaking aspen (*Populus tremuloides*).
Pinyon-Juniper	GRCA MEVE	Canopy dominated by pinyon and juniper, with an understory comprised of various understory plants such as antelope bitterbrush (*Purshia tridentata*), Datil yucca (*Yucca baccata*), muttongrass (*Poa fendleriana*), opuntia, mountain mahogany (*Cercocarpus montanus*) and big sagebrush (*Artemisia tridentata*).
Grassland	PEFO WUPA	Mix of grass and shrubs. Common shrubs can include *Atriplex* spp., rubber rabbitbrush (*Ericameria nauseosa*), snakeweed (*Gutierrezia sarothrae*), and in some areas, sandsage (*Artemisia filifolia*). Dominant grasses include *Bouteloua gracilis* and *Pleuraphis jamesii*, and spike dropseed (*Sporobolus contractus*) in some areas.
Riparian	CACH	Areas dominated by riparian vegetation, including cottonwoods (*Populus* spp.), willows (*Salix* spp.), Russian olive (*Elaeagnus angustifolia*), and salt cedar (*Tamarix* spp.)

3 Revision history

Provide the following information for each revision made to SOP 3.

New version:

SCPN_Birds_SOP3_YYYYMMDD

Date:

Author:

Sections affected:

Changes & reasons:

Standard Operating Procedure #4: Conducting the Bird Sampling

Version SCPN_Birds_SOP4_20150930				
Revision History Log				
Previous version number	**Revision date**	**Section and paragraph**	**Change(s) made**	**Approved by**

Only changes in this specific SOP will be logged here. Record the previous version number and date of revision; identify sections and paragraphs where changes were made, who approved the revision, and the new version number. More detailed descriptions of the changes made and the reason for the changes is provided at the end of this SOP.

This standard operating procedure (SOP) describes materials and procedures for bird sampling in target habitats for the SCPN Habitat-based Bird Community Monitoring Project. In this process 8-minute variable circular plot (VCP) counts are used, with distance estimation. Topics covered include planning the sampling activities, conducting VCP counts, making observations between sampling points, and reviewing the sampling data. Instructions include how to collect data and fill in the *VCP Count datasheet*.

1 Equipment

A list of the equipment and supplies needed for conducting VCP counts is presented in Table 4-1.

2 Developing a sampling schedule

Prior to the field season, the project manager will develop the season's sampling schedule based on peak breeding bird phenology and logistical considerations. Bird sampling will begin in early May after a two-week training

Table 4-1. List of equipment and supplies needed for conducting VCP counts.

Quantity	Item description	Quantity	Item description
1	Hard copy of SOP #4: Conducting the bird sampling	1	Compass
1	Binoculars	1	Datasheets
1	GPS unit with VCP locations entered; extra batteries	1	Clipboard
1	Laser Rangefinder with extra batteries	3–6	Pens, pencils, and sharpies
1	Digital watch or timer	1	Radio
1	Map of survey points	1	Copy of park research permit
1	Hard copy of VCP UTMs		

session. Initiation of sampling is tailored to the breeding phenology of the bird community within the target habitat, and should begin when resident species have initiated breeding and after migrant species (i.e., species that winter outside of, but breed in, the target habitat) have arrived, presumably to breed, within the target habitat. Lower elevation sites (grassland, riparian) are to be sampled first and higher elevation sites later. Each bird sampling point should be visited twice within the year, with approximately three to four weeks between samplings. The second counts should be scheduled to coincide with peak migrant breeding phenology. Generally, plots should be visited at approximately the same time each year, although adverse weather conditions (e.g., heavy snow) may necessitate changes in the sampling time.

3 Sampling overview

Three sampling designs can be employed when establishing sampling locations. The designs vary depending upon the size of the sampling frame used to spatially allocate sampling points. For large sampling frames involving large target habitats (e.g., mixed conifer forests on the North Rim of GRCA), we will use a cluster sampling design. Primary sampling units (PSU) are selected in a probabilistic manner from a grid of regularly-spaced points (e.g., 250 m apart). Each PSU serves as the center point for a cluster of 8 to 9 other sampling points, and all the points together comprise a secondary sampling unit (SSU) where VCP count data are collected. In general, 10 PSUs are selected, each consisting of a block of 9–10 sampling plots, for a total of 90–100 plots per sampling frame.

The second design is simple grid sampling, which is similar to a census sampling design and is used for target habitats with limited spatial extent (e.g., pinyon-juniper at MEVE). In these sampling frames, all plots that fall within a grid of regularly spaced points (e.g., 250 m) become the sampling plots, provided they fall within the target habitat and are accessible (see SOP #3). A minimum of 80 sampling plots are selected and monitored for each of these smaller sampling frames.

The third design is unique to monitoring riparian bird communities (i.e., riparian habitat at CACH), and is similar to a census sampling design. Riparian sampling frames initiate from an individual stream length of a targeted system, and a GIS stream line is identified using the National Hydrography Dataset. A line of plot center points are then placed evenly along the stream, usually 150 m apart. Each plot is either surveyed in the field or examined in an aerial photo, and is then moved to the center of the widest occurrence of riparian vegetation (using a line perpendicular to the stream line). Plots with insufficient surrounding riparian vegetation (<50 m radius of riparian vegetation) are rejected. In cases where the riparian vegetation zone is sufficiently wide, additional sampling plots are placed in the zone if the 150 m spacing between plot center points can be maintained. The process is repeated until sampling plots have been placed throughout the entire target riparian area. These plots within the target riparian habitat form the sampling units. Park-specific spatial designs are described in Appendix A.

Permanent sampling points (the center of the VCP for bird sampling) are established at a minimum distance of 150 m to 250 m apart (depending on habitat type). Sampling locations are not physically marked on the ground, but are relocated by navigating to permanent UTM coordinates using a GPS unit.

On the day of sampling, field crew members should arrive at the first VCP early enough that the count can begin as soon as it is light enough to see a distance of at least 200 m (approximately one half hour before sunrise). Sampling of the last VCP of the day should be completed no later than four hours after sunrise. Singing rate for most species is usually highest before or near sunrise, and then declines slowly for the next four hours.

Generally, two field crew members will travel in one vehicle to get to their two separate sets of sampling plots. Field crew members will conduct bird counts alone. Each will walk to a series of VCPs (usually 10), and conduct counts from each VCP center point for eight minutes. The field crew member, considered an "observer" in this context, will record on the datasheet information for each bird detected, including species, minute of detection, gender (if known), method of detection, and radial distance from the observer to the first detection of an individual bird (See Figure 4-1 *VCP Count datasheet* at the end of this SOP). The observer will record all birds detected at a VCP, regardless of the distance from the observer. This time-dependent, distance-based VCP sampling provides a standard sampling effort within and among habitats.

The VCP count is conducted as a "snapshot" in time. The count results should represent the actual distribution of the birds relative to the VCP center point. The underlying theory of distance sampling requires that each individual detection of a bird be recorded as close to a "snapshot in time" as possible (i.e., you record the distance from the point to the location where you initially detect the bird). Any birds that flush as you approach the point, or birds that seem to be attracted by your presence, should be noted in the comments.

The field crew will collect bird data as described in detail in sections 5 through 9 of this SOP. In preparing for and conducting a VCP count, **it is important to keep the following in mind**:

- The field crew member will start the count as soon as they arrive at the VCP center point by starting the timer and recording the start time. Use a digital watch with a timer set at eight minutes. A watch type that signals the passage of each one minute interval is ideal because it helps to record the specific minute in which the detection takes place. The count is stopped at the end of the 8th minute. Avoid the tendency to "pack" observations made after the 8th minute into that minute. Birds observed after the 8th minute are recorded following a different procedure (see sections 7.5 and 8).
- A laser rangefinder is used to estimate distances to birds whenever possible. The closer the bird, the more accurate the distance estimation should be. Record the distance to the nearest meter; **do not** round-off distances.
- Conduct the 8-minute count without interruption, being sure to fill in all the appropriate fields on the datasheet. Occasionally, aircraft noise can be loud enough to affect detectability and can last for up to 30 seconds. In these instances, stop the count, then start it again once the noise has subsided and increase the count period by the amount of time the count was disturbed (i.e., the total time spent counting birds should equal 8 minutes). If excessive noise interrupts the count for more than two minutes, start the survey anew after the disturbance has passed.
- Use a new datasheet for each VCP count. If observations from one VCP span multiple pages, be sure to complete the VCP location information and the "page___of___" (e.g., page 1 of 2), at the top of each datasheet."

4 Planning sampling activities the night before

Proper advance planning will help to ensure that your sampling session goes smoothly and is completed on time.

4.1 Determine which VCPs will be sampled and in what order.

The field crew members will maintain a schedule of plots to be sampled, and will work together to determine the sets of VCP to be sampled on a particular day.

4.2 Confirm VCP UTM coordinates.

Make certain that your UTM coordinates for the VCPs to be sampled are in your GPS

unit. **As a backup, bring a written list of UTM X and UTM Y coordinates for each VCP, as this information can be entered manually into the GPS unit in the field.**

4.3 Organize equipment for the following morning's counts.

Prepare clipboard with datasheets (take extra datasheets). Gather equipment and prepare food and personal gear to facilitate a timely departure from camp. Take appropriate gear, including extra batteries, water, and a first aid kit every day.

4.4 Set a time for departure.

Sampling will occur in the morning, beginning as soon as it is light enough to see a distance of at least 200 m (approximately one half hour before sunrise), and ending no later than four hours after official sunrise. Estimate how long it will take (for each crew member) to travel (by car and foot) to the first VCP to be sampled. Then establish a departure time for the following morning that will ensure arrival at the first VCP approximately one half hour before sunrise.

4.5 Consult weather reports.

Canceling counts during the breeding season is rare in our region, but strong storms can occur. Unless extreme conditions are predicted for the morning surveys (i.e., strong winds and/or heavy rain or snow), we recommend that observers attempt to conduct VCP sampling. Often weather reports for the region overestimate storm strength and therefore sampling may be possible. If strong winds and/or heavy rain are extremely likely, cancel the bird sampling for the day and try again on the next day. Conduct vegetation sampling or data entry on days where bird sampling has been canceled. **Contact the project manager that day to inform them of the scheduling change.**

5 Arriving at the sampling site

Depart camp/housing at a time that ensures you will arrive at the first VCP as soon as it is light enough to see a distance of at least 200 m (approximately one half hour before sunrise). As you approach each VCP to be sampled, follow these instructions:

5.1 Assess the weather

Counts should not be conducted if wind strength on the Beaufort scale is a sustained four or greater, or if it is raining hard or snowing. If you encounter these conditions, wait approximately 30 minutes or until the weather improves to start. If the weather does not improve after approximately 30 minutes, or show any sign that it may improve, cancel the sampling for the day and try again on the following day. Conduct vegetation sampling or data entry on days where bird counts are canceled.

5.2 Navigate to the point

Check the map of points and make sure you are navigating to the correct VCP center point. Navigate to the VCP center point using the GPS. Stop at the point when you get to within two m of the point (as read on the GPS unit). If hiking was extremely strenuous, rest at least 50 m away from the point for a few minutes, then continue to the point.

5.3 Record flushing birds

When navigating to the point, if you observe a bird close to the center of the VCP that flushes as a result of your approach, keep track of the spot where you first detected the bird, continue to the plot center point, and ***record the distance from the plot's center point to the spot where you first detected the bird*** on the datasheet. A critical assumption of the distance methodology is that any bird directly at, or very close to (e.g., <5–10 m), the plot center will always be detected. Write a separate line for each individual flushed as you would for species observed during the 8-minute active period and ***enter "0" in the Minute field***. Be sure to note in the comments section that the bird flushed as you approached the point.

6 Conducting the VCP count

Once you arrive at the VCP center point, record any birds that were flushed on the way to the point (see section 5.3) and start

the VCP count. Start the timer to begin the count. Record the start time on the *VCP Count datasheet* (see Figure 4-1 at the end of this SOP for a sample *VCP Count datasheet*).

Start time. Record the time the count is begun in the hour and minute format of military time. Fill in all four digits. For example: 0630 for 6:30 am.

For each bird or group of birds detected during the 8-minute active survey period, record the following:

Minute (0, 1-8, X). Record the minute in which each new bird (or group of birds) was first detected. Minute 1 is from 0-60 seconds and is recorded as minute "1". "0" is used to record birds that were flushed when approaching the point (see section 5.3); "X" is used for any bird species that were detected within the VCP, but not during the 8-minute count (see section 8). By recording this information, we can compare the data to those collected by other researchers (e.g., BBS counts) that use varying time intervals to conduct counts.

Species (AOU Code, UNBI, ND). Enter the 4-character American Ornithological Union (AOU) alpha code for the species detected (http://www.birdpop.org/pages/birdSpeciesCodes.php). Some examples are ATFL for Ash-throated Flycatcher, BHCO for brown-headed cowbird, and BHGR for black-headed grosbeak. These codes are usually easy to determine based on a bird's AOU common name, except where two species have the same code and one of the codes has to be modified from the convention. An example is BTYW for Black-throated Gray Warbler. Codes for species known to occur in Southern Colorado Plateau Network parks are listed in Appendix B of this protocol.

If no birds are detected during an 8-minute count, you should enter all data on the top portion of the *VCP Count datasheet* and record the code "ND" (No Detections) in the Species column. It is highly unusual to have no detections during a count when following the weather criteria for conducting a VCP count (i.e., it is not too windy, rainy, or snowy; see 5.1).

For birds that you cannot identify to species, record "UNBI" and provide a detailed description of the bird in the comment section, immediately after the count is finished and an attempt has been made to locate the inidividual. Make every attempt to identify the bird after the count has been completed by getting closer to it and using a field guide.

 # Detected. Record the number of individuals detected for each detection. In most cases this will be "1". Even for breeding pairs, you very rarely actually detect a pair simultaneously (exactly at the same time). For example, if you hear a bird call and then turn to see a pair, you should record the species and the number detected as "1", the distance, and a detection type of "call"; for the second individual of the pair you should record information on the next line and record species and the number detected as "1", the distance, and a detection type of "visual".

Distance (m). Record the horizontal distance in meters between the VCP center point (where you should be standing), and the location or presumed location of the bird where you first detected it. Use a laser rangefinder whenever possible to get as accurate a distance as possible. Estimate the distance to the nearest meter. Do not round off numbers to the nearest 2 or 5 meters.

- If you cannot see the bird, estimate the distance to some object (tree, bush, rock) where you think the bird is located.
- If the bird is flying directly at you, and then lands nearby, record the distance to where you first saw it flying towards you, not the distance to where it landed.
- If a bird is high in a tree or flying, imagine dropping a plumb bob from the bird down to the ground, and measure the distance from the observer to that spot on the ground (the horizontal distance).
- If birds occur in clusters or flocks, record the distance from the observer to

Table 4-2. Codes used to record detection type (DT) during bird surveys.

Code	Description
S	singing
C	calling
V	visual detection
D	drumming (woodpeckers, grouse) H
H	hummingbird wing
F	visual detection of flock

the center of the flock, plus the flock size (see below).

Detection type. Record the detection type that corresponds to the first detection of that individual (Table 4-2).

- If an individual was first observed visually, and then later sang, record "V" for the detection type.
- If an individual was detected through its singing, record "S", or its calling, record "C". It may be difficult to differentiate between singing and calling, however. For some species they are the same. Practicing with songs and calls will make the distinction clear for most species.

The detection type code can be used later in various analyses. For example, distances to birds that are seen are probably more accurate than those to birds that are only heard. Recording the detection type makes it possible to develop distance histograms to compare birds that are seen with birds that are only heard.

Seen? (X). Record an "X" if you observed the individual upon or after detecting it. Leave blank if you did not observe the individual (i.e., you only heard it).

Sex. Most detections will be of singing males, but for visual detections of non-singing birds, sex (gender) is important to note if the species is sexually dimorphic.

- If birds are singing (even if they were first detected visually) record as "M".
- If it is possible to differentiate between males and females of the species visually, record "M" for male and "F" for female.
- If a bird of a species that is not sexually dimorphic is detected visually, and the individual is not singing, record sex as "U" for unknown.

If you see a flock in which there are multiple males and females, note the number of males and females in comments column.

Age. Record the age class (adult as "A" or juvenile as "J") if known.

Flock size. In most cases, each individual bird will be treated as a separate detection (i.e., one line on the datasheet), but for species that are usually detected in clusters or flocks, the appropriate unit may be the cluster or flock and not the individual bird. For example, quail almost always occur in coveys of 10 to 40 birds. When you detect a covey of 40 quail during a count, it is not appropriate to treat them as 40 independent detections (you detected the flock, not 40 individuals). In such a case, record it as a single detection (i.e., use one row on the datasheet), record the number of individuals in the flock, and distance to the center of the flock when it was first detected, rather than the distance to each individual bird.

Previous plot (Prev. plot?). Place an "X" in this column if the individual was already detected from a previous plot. Bias caused by repeatedly counting the same individual in more than one plot is usually small, unless repeated counting is common during a survey, or a rare bird is counted from multiple plots. Noting that an individual is thought to have been counted at a previous plot gives future investigators the option of analyzing data in different ways.

Flyover? If birds fly high above the top of the vegetation canopy, never touch down in your field of view, and do not appear to be foraging, displaying, or behaving in any other way that might suggest a link to the habitat below them, record "X" in the Flyover? column.

Breeding code. Record any breeding behavior that you may observe using the codes listed in Table 4-3. If you locate a nest after

Table 4-3. Breeding behavior codes.

Code	Explanation
CN	Carrying nesting material (e.g., stick, grass, mud, cobwebs).
NB	Nest building seen at actual nest site.
DD	Distraction displays. Defense of unknown nest or young or injury feigning. Used if adult bird is seen trying to lead people away from nest or young (e.g., killdeer broken-wing act, Cooper's hawk diving at you). Does not include agitated behavior.
UN	Used nest or eggshells found. Use only when identification is unmistakable.
FL	Young that recently fledged (left the nest) of altricial species, incapable of sustained flight or still being fed by adults, or downy young of precocial species restricted to the natal area by dependence on adults or limited mobility. Presence of young cowbirds confirms both cowbird and host breeding.
ON	Occupied nest indicated by adult entering or leaving nest in circumstances indicating an occupied nest, including those in high trees, cliffs, cavities, and burrows where the contents of the nest and incubating brood cannot be seen.
CF	Adults seen carrying food, excluding raptors, corvids, roadrunners, and shrikes.
FY	Adults feeding recently fledged young. Young cowbirds begging food confirm both the cowbird and the host.
FS	Adult carrying fecal sac.
NE	Nest with eggs found. Be careful with identification unless you see adult. Cowbird eggs confirm both the cowbird and the host.
NY	Nest with young seen or heard. Use when you see or hear the young. Cowbird chick in the nest confirms both the cowbird and the host.

the count is complete, indicate in the comments section of the datasheet what plant species it is, and note the number of eggs or nestlings, and the number of brown-headed cowbird eggs or nestlings, if appropriate.

Comments. Record any comments that seem appropriate and that might provide insights on the status of the bird(s) detected. Use this space to describe breeding behavior.

7 Finishing the VCP count

Immediately after finishing the 8-minute count, identify unknown birds. Then confirm distance estimations and complete the general information and survey conditions on the top of the *VCP Count datasheet*.

7.1 Identify unknown birds

Immediately after the count, make every attempt to identify birds that you could not identify to species ("UNBI") Make every attempt to identify the bird by getting closer to it and, if necessary, using a field guide. Record the species in the species column in the row used for the original detection. Provide a detailed description of the bird, and how you identified it to species in the comment section.

7.2 Confirm distance estimations.

Quickly review distance estimations. If an individual is still singing from the same location as when it was first detected, and you are unsure of your estimate, locate the bird and, standing at the bird location, use the GPS unit to measure the distance back to the VCP center point.

7.3 General information

Fill out relevant information at the top of the *VCP Count datasheet* (see Figure 4.1 at the end of SOP #4). Use one datasheet for each VCP count. Information includes:

Park. Record the standard 4-letter code to indicate the park unit (BAND, CACH, GRCA, MEVE, PEFO, WUPA).

Cluster ID. Some target habitats (grassland at PEFO, mixed conifer and pinyon-juniper at GRCA) have a cluster sampling design consisting of randomly located clusters with 9–10 bird sampling plots in each cluster. Each cluster has a pre-assigned alphanumeric code. A Letter designates the park unit (e.g., "G" for GRCA) and target habitat (e.g., "M" for mixed conifer habitat), and a two-digit number is assigned (01 through 10), when the plot is established. For example,

cluster 2 in GRCA mixed conifer is assigned "GM02". Enter the Cluster ID, as indicated on the appropriate map.

If the target habitat has a simple grid sampling or riparian design (mixed conifer at BAND, pinyon-juniper at MEVE , grassland at WUPA, or riparian at CACH), leave this line blank.

Point ID. Each VCP plot has a pre-assigned alphanumeric code. For cluster sampling, letters designate the park and target habitat, followed by the cluster number (e.g., 01 through 30), followed by a "P" (indicating a VCP sampling plot) and the plot's pre- assigned number (e.g., 001 through 100). (Refer to mapped points on the GPS unit and/or map hard copy).

If the target habitat has a simple grid sampling design (mixed conifer at BAND, pinyon- juniper at MEVE, grassland at WUPA), or is riparian at CACH, the Point ID consists of a letter that designates the park, followed by a letter that designates the target habitat, followed by a "P" (indicating a bird sampling point), and the point's pre-assigned number (001 through the highest). For example, point twenty in WUPA grassland is WGp020.

Date. Enter the month, day and year that data were collected: yyyy/mm/dd.

Observer. Record first initial, middle initial, and last name.

7.4 Survey conditions

The following information must be filled in for each 8-minute VCP count, using the codes provided in Tables 4-4, 4-5, and 4-6. Record the average conditions that occurred during the count.

Wind (0–6). Record the wind code (0 through 6; Table 4-4) as it applies to the strength of the wind during the count. Record the average wind conditions for each count, not the maximum condition (e.g., periods of gusty winds).

Cloud cover (0–100). Visually estimate the percent cloud cover, rounded off to the nearest 10 percent. This should be a number between 0 (no clouds) and 100 (completely overcast). If there are patches of clouds in different areas of the sky, try to imagine gathering all of them together into one part of the sky and recording what percent of cloud cover that would represent.

Table 4-4. Wind codes. Beaufort scale used to record wind strength during bird counts.

Wind code	Explanation
0	calm, smoke would rise vertically (<2 km/h)
1	smoke would drift (2–5 km/h)
2	light breeze felt on face, leaves rustle (6–12 km/h)
3	leaves and twigs in constant motion (13–19 km/h)
4	small branches move, raises loose paper, dust rises (20–29 km/h)
5	constant wind, small trees sway (30–39 km/h)
6	strong wind, large branches moving, wind whistling (40–50 km/h)

Table 4-5. Precipitation codes. Used to record precipitation during bird counts.

Precipitation code	Description
0	no precipitation
1	mist or fog
2	light drizzle
3	light rain
4	heavy rain; difficult to hear birds; discontinue count
5	snow

Table 4-6. Noise codes. Used to record level of background noise as it affects observer's ability to hear birds.

Noise code	Explanation
0	quiet; normal background noises; little to no interference
1	low noise; might be missing some high-pitched songs/calls of distant birds
2	medium noise; detection radius is probably substantially reduced
3	high noise; probably detecting only the loudest/closest birds

Precipitation (0–5). Record the appropriate code (0 through 5; Table 4-5).

Noise (0–3). Record the noise code (0–3; Table 4-6) that applies to background noise conditions during the count as it relates to your ability to hear birds.

7.5 Before leaving the plot

Record additional bird observations. Record new species detected within a minute or two after the count was completed (i.e., after the 8th minute of the survey). First draw a short line below the count. Then record all information as you would during the count, but put an "X" through the **Minute** field.

Review the datasheet. Make sure that all fields on the datasheet have been filled in before departing for the next point.

Quickly scan the area. Ensure that no equipment is left behind.

Navigate to the next VCP. Use the GPS to attain a bearing to the next VCP center point and hike to it (as described below).

8 Making observations between bird sampling points

Unique observations (e.g., previously unrecorded species, rare species, nests) can be made when you are navigating from one VCP to another, and should be recorded. When you have completed sampling at one VCP, use the GPS to get a bearing to the next point, and then hike to it. Along the way, observe and record any unusual species or breeding behavior, and identify unknown calls or songs.

Record observations of "new" species. Record any unique bird species (e.g., previously unrecorded species, rare species) or observations (e.g., breeding behavior) that were not detected during the count(s), but that occur near to the VCP, as you travel between points. For the purpose of record keeping, it is important to attribute an observation to a VCP.

For example, if you are traveling between two VCP center points and observe a bird 50 m from the VCP center point that you just left, attribute the observation to the point you just left (make the entry near the bottom of the datasheet for that VCP, recording "X" in the **Minute** column), and note the distance from the VCP center point to the detection in the comments section of the datasheet. However, if you observe a bird 200 m from the VCP center point you left and that bird is only 50 m from the point that you are approaching, make a note of this bird near the bottom of the datasheet for the VCP you are approaching. If this bird was not flushed-by you on your approach to the point, it may be observed and recorded during the 8-minute active period (and you should draw a line through your note made previously). If the bird is not subsequently observed during the 8-minute VCP count, use the comment section next to the record for this bird and describe the observation (e.g., observed 50 m from point, prior to conducting survey, not detected during survey). Then record all information as you would during the count, but put an "X" through the **Minute** field.

Record breeding behavior. Record any breeding behavior that you observe below a line demarking the VCP count data. Use the standard Breeding Bird Atlas Codes (Table 4-3), and describe particulars in the comment section. If you locate a nest, indicate what plant species it is in, and note the number of eggs or nestlings (if possible), and the number of brown-headed cowbird eggs or nestlings, if appropriate.

Observations outside of bird sampling. While conducting habitat sampling, or while walking out of the sampling area, but still within the target habitat, look for species that were not recorded during the survey. Note those species at the end of the datasheet for the nearest point; note the VCP Point ID; estimate the distance from its center point; and record the time in the **Comments** section. This is much like the incidental observations made while traveling between points. If you are far from the sampling area and observe an unusual bird, note it in your field note-

book and file the observation in the "Incidental Observations" folder when you return from the field.

9 Reviewing the bird sampling data

Soon after returning from the field, on the same day as the VCP counts were conducted, perform the following tasks:

Review the datasheets. Carefully review all datasheets, making sure the location information is complete, all data is complete and readable, species codes are correct, unknown species are identified, comments are clear, and multiple pages are numbered.

Verify bird species identification. Compare vocalizations with recordings of known bird sounds to identify any unknown bird species recorded in the field. If a species is seen in the field and characteristics recorded but the species was not identified, it should be identified at this time using reference materials such as field guides and breeding bird atlases. If you are unable to identify a species, ***you must explain why you cannot identify the species in the comments section***.

File datasheets. After reviewing datasheets, file them in the appropriate file.

Contact project manager. If necessary, contact the project manager to discuss scheduling, concerns or questions, and to report any unusual sightings.

VCP Count Datasheet

Park:_____ Cluster ID:_____ Point ID: _____ Date (yyyy/mm/dd): _____

Observer(s): _____

Wind (0–6*): _____ Cloud cover (0–100*): _____ Precipitation (0–5*): _____ Noise (0–3*): _____

Start time: (2400 hour format) _____

Minute (0,1-8, X)	**Species** (AOU Code, UNBI, ND)	**#Detected**	**Distance** (m)	**Detection type** (S,C,V,D,H,F*)	**Seen?** (X)	**Sex** (M,F,U)	**Age** (A,J)	**Flock size**	**Previous plot?** (X)	**Flyover?** (X)	**Breeding code***	**Comments**

* See tables on reverse side for explanations of codes

Table 1. Wind codes. Beaufort Scale used for recording wind strength during bird counts.

Code	Explanation
0	calm, smoke rises vertically (< 2 km/h)
1	smoke drifts (2-5 km/h)
2	light breeze felt on face, leaves rustle (6-12 km/h)
3	leaves and twigs in constant motion (13-19 km/h)
4	small branches move, raises loose paper, dust rises (20-29 km/h)
5	constant wind, small trees sway (30-39 km/h)
6	strong wind, large branches moving, wind whistling (40-50 km/h)

Table 2 Precipitation codes. Used to record precipitation during bird counts

Code	Explanation
0	no precipitation
2	mist or fog
3	light drizzle
4	light rain
5	heavy rain; difficult to hear birds; discontinue count
6	snow

Table 3. Noise codes. Record level of background noise as it affects observer's ability to hear birds.

Code	Explanation
0	quiet; normal background noises; little to no interference
1	low noise; might be missing some high-pitched songs/calls of distant birds
2	medium noise; detection radius is probably substantially reduced
3	high noise; probably detecting only the loudest/closest birds

Table 4. Detection type codes. Record how birds were detected during bird counts

Code	Explanation
S	Singing
C	Calling
D	Drumming (woodpeckers, grouse)
H	Hummingbird wing whirr
V	Visual detection
F	Visual detection of flock

Table 5. Breeding behavior codes

Code	Explanation
CN	Carrying nesting material (e.g., stick, grass, mud, cobwebs).
NB	Nest building seen at actual nest site.
DD	Distraction displays. Defense of unknown nest or young or injury feigning. Used if adult bird is seen trying to lead people away from nest or young (e.g., killdeer broken-wing act, Cooper's hawk diving at you). Does not include agitated behavior.
UN	Used nest or eggshells found. Use only when identification is unmistakable.
FL	Recently fledged young of altricial species incapable of sustained flight or downy young of precocial species restricted to the natal area by dependence on adults or limited mobility. Presence of young cowbirds confirms both cowbird and host breeding.
ON	Occupied nest indicated by adult entering or leaving nest in circumstances indicating an occupied nest, including those in high trees, cliffs, cavities, and burrows where the contents of the nest and incubating brood cannot be seen.
CF	Adults seen carrying food, excluding raptors, corvids, roadrunners, and shrikes.
FY	Adults feeding recently fledged young. Young cowbirds begging food confirm both the cowbird and the host.
FS	Adult carrying fecal sac.
NE	Nest with eggs found. Be careful with identification unless you see adult. Cowbird eggs confirm both the cowbird and the host.
NY	Nest with young seen or heard. Cowbird chick in the nest confirms both the cowbird and the host.

10 Revision history

Provide the following information for each revision made to SOP 4.

New version:

SCPN_Birds_SOP4_YYYYMMDD

Date:

Author:

Sections affected:

Changes & reasons:

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Standard Operating Procedure #5: Habitat Characterization

Version SCPN_Birds_SOP5_20150930				
Revision History Log				
Previous version number	**Revision date**	**Section and paragraph**	**Change(s) made**	**Approved by**

Only changes in this specific SOP will be logged here. Record the previous version number and date of revision; identify sections and paragraphs where changes were made, who approved the revision, and the new version number. More detailed descriptions of the changes made and the reason for the changes is provided at the end of this SOP.

This standard operating procedure (SOP) describes materials and procedures for characterizing the habitat of bird sampling sites or the SCPN Habitat-Based Bird Community Monitoring Program. This is done at the level of the macroplot, a 50 m radius plot centered on the VCP; and at the level of the subplot (one main subplot centered on the VCP and three "satellite" subplots) located within the 50 m plot. Topics covered in this SOP include 1) establishing macroplots and subplots, 2) conducting sampling within the 50 m macroplot, 3) conducting sampling within the subplots, and 4) collecting data and filling in the *Macroplot Habitat Characterization Datasheet* and the *Subplot Habitat Characterization Datasheet*.

1 Equipment

Equipment and supplies that the field crew should have when conducting habitat characterization of bird sampling points are listed in Table 5-1.

Table 5-1. Field equipment and supplies for habitat characterization of bird sampling points.

Item description
Laser Rangefinder/Clinometer with extra batteries
Basal Area angle gage ("cruise angle" with 25 inch bead chain)
Compass
Stake – for securing ropes
Radio

2 Sampling schedule

Habitat sampling will take place after the conclusion of bird counts each day, or during days between bird sampling, on days when the weather prevents bird sampling, and

near the end of the field season. In preparation for this, the SCPN botanist will spend approximately 2 days during training to assist the project manager in training field crew in plant identification and habitat sampling methods.

3 Sampling design

Vegetation data will be collected in the macroplot (a 50 m radius plot centered on the VCP center point), as well as in 4 subplots within each macroplot (Figure 5-1). Subplot 1 is centered on the bird sampling point. Subplots 2, 3, and 4 are located 30 m from the bird sampling point, and at 120° angles from one another (Subplot 2 is at 0°, Subplot 3 is at 120°, and Subplot 4 is at 240°). This plot layout is based on work by James and Shugart (1970), as modified by Martin et al. (1997).

Several types of data will be collected in the macroplot and subplots. Data on broad-scale site attributes will be collected within the macroplot, including slope, aspect, topographic position, and cover of dominant vegetation types. Vegetation data collected within the subplots will include vegetation strata, canopy closure, basal area of trees and snags, and foliar cover in the understory.

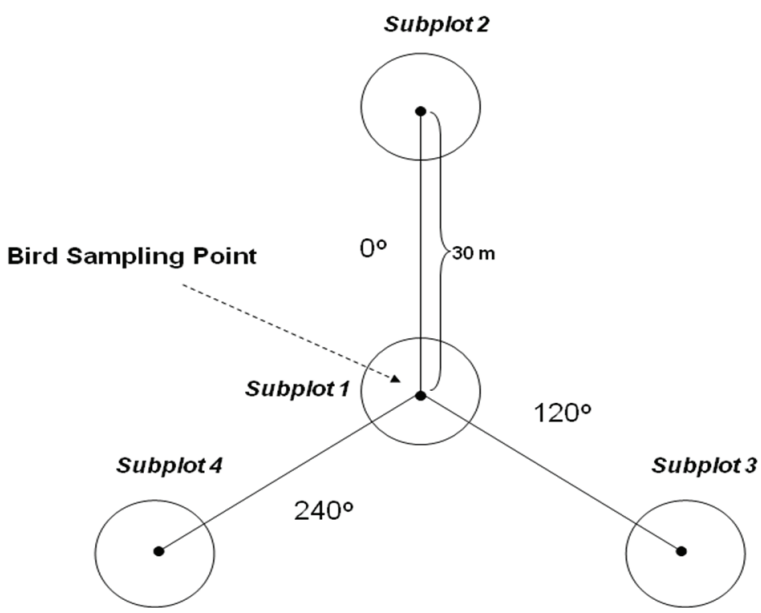

Figure 5-1. Layout of habitat subplots at each VCP point. Subplot 1 is centered on the bird sampling plot.

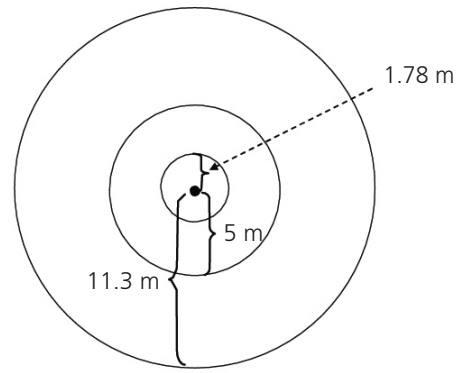

Figure 5-2. Diagram of a subplot showing the nested 1.78 m, 5 m, and 11.3 m radius circles.

Each subplot consists of three nested circular plots (1.78 m radius (=10 m^2), 5 m radius (=78.5 m^2), and 11.3 m radius (=401 m^2); Figure 5-2) and different habitat data will be collected at each scale.

4 Macroplot sampling procedures

This section gives instructions for collecting data within the macroplot (a 50 m radius plot centered on the bird sampling plot), and filling out the *Macroplot Habitat Characterization* datasheet (see Figure 5-5 at the end of this SOP). Macroplot-level characterization of vegetation serves two purposes. First, macroplot vegetation description characterizes habitat at a scale that is appropriate for correlation with local patterns of bird occupancy. Secondly, by describing macroplot vegetation using the vegetation map classes described in each park's most current vegetation mapping report, we can link plot level habitat data to the vegetation map. Through the NPS Inventory and Monitoring Program, vegetation maps have been completed for all park units with significant natural resources, using the U.S. National Vegetation Classification Standard (NVCS). The following instructions allow a subjective determination of the physical characteristics within 50 m of each bird sampling point.

4.1 Establish the macroplot

Use a laser range finder to determine the edge of a 50 m radius circle, while standing at the center of the VCP.

4.2 Fill in the Macroplot Habitat Characterization datasheet

Fill out the relevant information at the top of the datasheet (see Figure 5-4 at the end of this SOP). Fill out one sheet for each bird sampling point. Information to include:

- **Park**. Record the standard 4-letter code to indicate the park unit.
- **Target habitat**. Record the appropriate habitat (grassland, pinyon-juniper, mixed conifer, riparian).
- **Cluster ID**. Some target habitats (grassland at PEFO, mixed conifer and pinyon-juniper at GRCA) have a cluster sampling design consisting of randomly located clusters with 9–10 bird sampling points in each cluster. Each cluster has been assigned an alphanumeric code. Letters designate the park and target habitat, and the number is assigned and mapped when the plot is established (SOP #3). Record the Cluster ID on the datasheet as indicated on the map of bird sampling points.

  If the target habitat has a simple grid sampling design (mixed conifer at BAND, pinyon- juniper at MEVE, grassland at WUPA), or is riparian at CACH, leave this entry blank.
- **Point ID**. Record the alphanumeric code that has been assigned to each bird sampling point. For cluster sampling, letters designate the park and target habitat, followed by the cluster number, followed by a "P" (indicating a bird sampling point) and the point's pre-assigned number). When filling this in, refer to mapped points on the GPS unit and/or map hard copy).

  If the target habitat has a simple grid sampling design (mixed conifer at BAND, pinyon-juniper at MEVE, grassland at WUPA), or is riparian at CACH, the Point ID consists of a letter that designates the park, followed by a letter that designates the target habitat, followed by a "P" (indicating a bird sampling point) and the point's pre-assigned number (001 through the highest). For example, point twenty in WUPA grassland is WGp020.
- **Date**. Record the date using this format: mm/dd/yyyy.
- **Observer**. Record the first initial, middle initial, and last name of each person collecting data.

4.3 Collect macroplot physical data

Measure and record the information in the *Macroplot Habitat Characterization* datasheet as described below.

- **Slope (%)**. Measure the slope of the ground across the entire 50 m radius plot using a clinometer. Select 2 locations that are at a distance great enough to capture the average slope of the land across the 50 m radius plot. The field crew member using the clinometer (the observer) stands at an uphill location. The second location can be marked by a tree, or by a field crew member standing on the point. The height of the eye of the observer must be marked on the object constituting the second location (a tree or another field crew member). The observer points the clinometer at the marked eye-level of the second location, and reads the slope (% slope).
- **Slope variability**. Circle high, medium, or low on the datasheet to describe the up and down variability in the slope across the entire 50 m radius plot.
- **Aspect**. Indicate the slope direction of the 50 m radius plot. Take compass readings with the declination set at 0°. Aspect should be measured at a representative point within the 50 m radius circle, and is recorded in degrees, from 0° to 359°, with 360° recorded as 0°. The person measuring aspect should measure in the direction that water would flow from the uphill side of the macroplot to the downhill side.
- **Aspect variability**. Circle high, medium, or low to describe the variability in the direction of the slope across the entire

Table 5-2. Definition of topographic position for use in SCPN bird habitat characterization.

Topographic position	Description
Level	level top of a plateau or valley floor or shoreline representing the former position of an alluvial plain, lake, or shore
Crest	linear top of a ridge, hill or mountain; the elevated area between two drainageways that sheds water to the drainageway
Upper-slope	the uppermost inclined surface at the top of a slope, typically convex in profile
Mid-slope	intermediate slope position
Lower-slope	inner gently inclined surface at the base of a slope, generally concave in surface profile; this includes toe slope, the outermost gently inclined surface at the base of a slope, commonly gentle and linear in surface profile
Depression	bowl shaped or similarly depressed area
Draw	depressed V-shaped drainage that carries water toward a stream
Escarpment/face	sloping or vertical side of a stream bank or former stream bank

50 m radius plot.

- **Topographic position**. Circle the position on the datasheet that bests describes the location of the macroplot, relative to its local position on the earth's surface (Table 5-2).

4.4 Estimate cover of vegetation types in macroplot

Make visual estimates of the percent cover of major vegetation types (see Appendix E for a list of vegetation map classes for each park and habitat) and other land-use cover types (described below) for the 50 m radius macroplot using modified Braun-Blanquet cover classes (Table 5-3).

- **Vegetation type(s)**. Estimate the percent cover for predominant vegetation type(s) using the park- and habitat-specific pick-lists of vegetation map classes from Appendix E.
- **Other cover types**. Estimate the percent cover for:
  - roads (paved and unpaved)
  - trails
  - standing water (only if it is permanent)
  - stream (perennial) stream (intermittent) dry arroyo
  - historic structures/ruins rock outcrop
  - other (list)

Table 5-3. Modified Braun-Blanquet cover class scales.

Cover class	Range of cover (%)
1	<1
2	1–5
3	5–10
4	10–25
5	25–50
6	50–75
7	75–100

4.5 Macroplot notes

Describe the 50 m radius plot and areas immediately surrounding it. Note any recent disturbance or any feature outside of the macroplot that you think may influence the bird community and estimate the distance to, and size of, such features. Examples of disturbance include fire, trash dumps, tire tracks, or structures. Describe other features that you think may influence the bird community such as a riparian area, a large meadow, a fence, or nearby road.

5 Subplot sampling procedures

This section gives instructions for collecting data within the subplots and filling out the *Subplot Habitat Characterization* datasheet (see Figures 5-5 and 5-6 at the end of this SOP). Each subplot consists of three nested circular plots (1.78 m radius (=10 m^2), 5 m radius (=78.5 m^2), and 11.3 m radius (=401 m^2) (Figure 5-2). Different data are collected

at each of the nested plots and include basal area of trees and snags, vegetation strata, canopy closure, number of tree saplings, and foliar cover.

5.1 General information

Enter the following information into a separate *Subplot Habitat Characterization* datasheet for each subplot (1-4).

- **Park**. Record the standard 4-letter code to indicate the park unit.
- **Target habitat**. Record the target habitat for sampling (grassland, pinyon-juniper, mixed conifer, riparian).
- **Cluster ID**. Some target habitats (grassland at PEFO, pinyon-juniper at GRCA, mixed conifer at GRCA) have a cluster sampling design consisting of randomly located clusters with 9–10 bird sampling points in each cluster. Each cluster has been assigned an alphanumeric code. Letters designate the park and target habitat, and the number is assigned when the plot is established and mapped. Enter the cluster ID on the datasheet, as it is indicated on the appropriate map. If the target habitat has a simple grid sampling design (mixed conifer at BAND, pinyon-juniper at MEVE, grassland/shrubland at WUPA), or is riparian at CACH, leave this entry blank.
- **Point ID**. Record the alphanumeric code that has been assigned to each bird sampling point. For cluster sampling, letters designate the park and target habitat, followed by the cluster number, followed by a "P" (indicating a bird sampling point) and the point's pre-assigned number). When filling this in, refer to mapped points on the GPS unit and/or map hard copy).

  If the target habitat has a simple grid sampling design (mixed conifer at BAND, pinyon-juniper at MEVE, grassland at WUPA), or is riparian at CACH, the Point ID consists of a letter that designates the park, followed by a letter that designates the target habitat, followed by a "P" (indicating a bird sampling point) and the point's pre-assigned number (001 through the highest). For example, point 20 in WUPA grassland is WGp020.
- **Subplot #**. Record the subplot number. Refer to Figure 5-1.
- **Date**. Record the date using this format: mm/dd/yyyy.
- **Observer(s)**. Record the first initial, middle initial, and last name of each person collecting data.

5.2 Plotless sampling from subplots: Basal area of trees and snags

Stand basal area is a measure of the number and the size of trees in a stand (an area of forest). From the sampling point (the center of the subplot), all trees larger than a certain critical size (which is a function of the diameter of the plant and its distance from the sample point), will be counted using a Cruz-All (a type of angle gauge). The Cruz-All measures basal area and consists of a metal sight with four different size openings (basal area factors [BAF] of 5, 10, 20, and 40) and a bead chain that is 63.5 cm (25 inches) long and used to measure the distance from the observer's eye to the metal sight. The Cruz-All must be held the same distance from your eye to function; so, the observer holds the button at the end of the chain against their chin and extends the Cruz-All away from their chin until the chain is taut. Then, while standing directly over the subplot center, the observer slowly turns 360°, while looking through the Cruz-All (using the appropriate factor) at every tree, at breast height. If the tree viewed is sufficiently large or sufficiently close to be wider than the critical angle (i.e., the BAF 10 or BAF 40 opening), the tree counts as a "hit" (see explanation below). The species of tree and the total number of hits are tallied for each species, being careful not to count the first tree twice.

In mixed conifer sites, the 10-factor opening of the angle gauge is always used. The 10-factor opening is also used for typically single-stemmed tree species in pinyon-juniper woodlands and riparian sites. However,

in some pinyon-juniper sites and in riparian sites, some tree species typically display a shrubby, multi-stemmed growth form lacking a central dominant trunk (e.g., *Juniperus monosperma*, *Tamarix* spp., *Salix exigua*). For these multi-stemmed tree species, the Cruz-All is held horizontally and the 40-factor opening is used. Multi-stemmed trees that appear as wide as, or wider than, the opening, measured at breast height (1.4 m above ground), are counted.

Tree counts will be converted to basal area estimates (m^2/ha) during the data summary process, after the field season, using the formula: Basal Area = (#hits)(BAF [ft/acre]) ($0.0929 m^2/ft^2$)(1 acre/0.405 ha). Total basal area is the combined basal area of all tree species.

- **Basal area of trees**. Count and record the number of hits per tree species.
    - **In all areas**, for tree species that are typically single-stemmed (i.e., with a dominant trunk), look through the 10-factor opening and count trees that have stem(s) that appear as wide or wider at breast height than the 10-factor opening (these are called "hits"). Count each stem wider than the factor, regardless of how many stems a tree has, as long as they are distinct stems at breast height. Record the number of hits for each tree species.
    - In pinyon-juniper areas with *Juniperus monosperma* and in riparian areas, for tree species with multiple similarly sized stems (i.e., J*uniperus monosperma, Salix exigua, and Tamarix* spp.), without a dominant trunk at breast height, use the 40-factor opening (by holding the gauge horizontally) to count multi-stemmed trees. Count multi-stemmed trees that appear as wide as or wider than the opening, measured at breast height (1.4 m above ground). Use the 10-factor opening for tree species with discernible trunks. Record separate tallies of hits for each tree species and basal area factor (e.g., 10 *Juniperus monosperma* hits using BAF 40, 3 *Pinus edulis* hits using BAF=10).
- **Basal area of snags**. While counting the number of hits for tree species, also count the hits attributed to snags (completely dead trees with no green foliage). Measure basal area of snags using BAF 10 of the Cruz-All. Count all hits (disregard species).

5.3 Sampling within the 11.3 m radius subplot

The 11.3 m radius plot is used to describe vegetation strata for each subplot (1-4).

- **Vegetation strata**. The vegetation strata, or layers, described below are meant to be flexible enough to describe a range of ecosystems of varying structural complexity. At some sites, only a single tree layer or shrub layer may be present. At others, one layer or another may be entirely absent from the site.
    - **Emergent**. Tree(s) whose crown rise above the canopy (which is fairly contiguous). Often absent, or consists of a solitary tree, or a few scattered trees within the plot.
    - **Canopy**. The tallest strata of trees on the plot that forms a contiguous or nearly contiguous layer. If only one tree layer is present, enter the height and cover into this category.
    - **Sub-canopy**. A distinct stratum of trees (not shrubs) below the canopy stratum. May or may not be present on plot. May include some individual shrubs that are taller than the shrub layer (if present).
    - **Shrub**. A distinct stratum of shrubs on the plot. May or may not be present on plot. Taller than and distinct from the **Dwarf Shrub** stratum (if present).
    - **Dwarf shrub**. Dwarf shrubs are generally less than 0.5 m tall when mature, and are considered a stra-

tum if their foliar cover in the plot is 10% or greater.

For each of the strata present in the 11.3 m radius plot, measure the height, visually estimate foliar cover (see Table 5-3), and record the dominant species in each.

- **Height class**. For each stratum present, choose a point in the stratum that represents the average height of the stratum within the 11.3 m radius plot. Measure the height of this point with a clinometer. Record the appropriate height class code of the stratum in the Height class code column, using the **Height class scale** at the bottom of the form (see Figure 5-5). If a stratum is not present in the plot, enter a "-" onto the datasheet.
- **Cover class**. For each stratum present, enter the cover class code for the foliar cover for that stratum, considered over the 11.3 m radius plot, in the second column, using the modified Braun Blanquet cover class scale at the bottom of the form and in Table 5-3. If a stratum is not present in the plot, enter a "-" onto the datasheet.
- **Dominant species**. For each of the strata in the 11.3 m radius plot, indicate the species that dominate a particular stratum. List only the top 1–3 species, in order of dominance (from dominant to least dominant).

5.4 Sampling within the 5 m radius subplot

Data collected within the 5 m radius plot, at all subplots (1-4), include canopy closure and a tally of tree saplings.

- **Canopy closure**. Measure canopy closure using a convex spherical densitometer. Take readings from the subplot center, with readings taken facing each of the four cardinal directions (located using a compass). To read the densiometer, hold the instrument level (use the leveling bubble; see Figure 5-3) at elbow level, in front of your body and far enough away from your body so that your head is just outside of the grid area (30 to 46 cm). Imagine four equally-spaced dots in each square of the grid on the densiometer (as illustrated in Figure 5-3), and systematically count either the number of dots covered by vegetation OR the number not covered by vegetation. When percent canopy closure is high, it is easier to count dots not covered and subtract the total from 96. When canopy closure is low, it is quicker to count covered dots and record that number.

  Always record number of dots covered, not number uncovered. Do not break the squares into four imaginary squares and try to decide if each one has greater or less than 50% cover. The four squares within a square method introduces bias because individuals tend to decide close calls more frequently in one direction than another. Deciding whether or not an imaginary dot is covered is a simple objective decision, and is less susceptible to bias. Avoid counting trunks as cover when possible, particularly when they make up a substantial portion of the cover. Step away from the trunk if necessary. Dot counts will be converted to percent canopy closure (#dots covered/96)(100) during data summary and

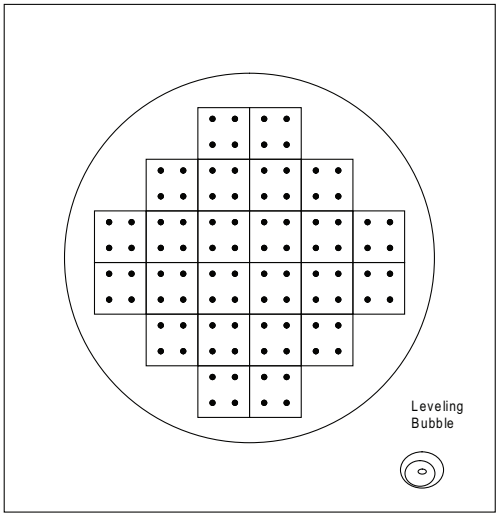

Figure 5-3. Diagram of a spherical densiometer.

analysis, after the field season.

- **Tree sapling tally**. Tally the number of trees of each species within 2 sapling size classes: 2.5 to less than 5.0 cm DBH; and 5.0 to less than 10.0 cm DBH. Record species using 6-letter codes derived from using the first 3 letters of the genus and species. For example, *Ericameria nauseosa* is ERINAU .

5.5 Sampling within the 1.78 m radius subplot

Foliar cover is estimated within the 1.78 m radius subplot while standing at the plot center.

- **Foliar cover** (by functional vegetation categories). Visually estimate the percentage of the ground covered by each of the functional vegetation categories (defined in Table 5-4) within the 1.78 m radius subplots. Enter the corresponding modified Braun-Blanquet cover class for each on the *Subplot Habitat Characterization* datasheet. Vegetative cover categories can sum to more than 100% because of vertical stratification of plant layers. They can also sum to 25% or less in sparsely vegetated habitats.

6 Burn severity

Wildfires and prescribed fires can alter the structure and composition of vegetation, in addition to changing fuels and soil properties. In order to track long-term change as a result of fire, the burn severity assessment is conducted during plot establishment, if there is evidence of a recent wildfire or prescribed fire; or during visits to any plot where there has been a prescribed fire or wildfire since the previous visit. It is also conducted if a fire has burned a large portion of the ecological site, whether or not the fire impacted the plot.

The purpose of this assessment is to describe the burn severity for the area of the plot only. If a burn severity datasheet is filled out for a plot, it is not necessary to describe the fire on the Site Disturbance datasheet. Because burn severity is assessed irregularly, instructions for completing the burn severity datasheet are also included on the back of the datasheet.

6.1 General information

Fill out the general information at the top of the *Burn Severity datasheet* following these guidelines:

- **Park.** Use the 4-letter code for the park unit.
- **Target habitat**. Record the appropriate habitat (grassland, pinyon-juniper, mixed conifer, riparian.
- **Cluster ID**. Some target habitats (grassland at PEFO, mixed conifer and pinyon-juniper at GRCA) have a cluster

Table 5-4. Foliar vegetation categories. The percent of ground covered by each category is estimated in the 1.78 m radius subplot.

Tree seedlings	Definition
Total shrub and herbaceous cover (no trees)	Foliar cover of all living herbaceous and shrub vegetation (excluding trees) less than 2 m in height
Perennial grasses, graminoids	Perennial grasses, sedges, rushes and other graminoid plants
Annual grasses	Annual grasses
Forbs	Broadleaf, non-woody plants
Shrubs, dwarf shrubs and woody vines	Live, woody shrubs and vines <1.4 m above ground
Cacti, succulents	Cacti, succulents
Standing dead herbaceous	Herbaceous dead vegetation produced in previous (not the current) growing season(s) not in contact with the soil surface.
Woody standing dead	Woody dead plant material still attached to a rooted plant (less than 2 m in height), not in contact with soil surface

sampling design consisting of randomly located clusters with 9–10 bird sampling plots in each cluster. Each cluster has a pre-assigned alphanumeric code. A Letter designates the park unit (e.g., "G" for GRCA) and target habitat (e.g., "M" for mixed conifer habitat), and a two-digit number is assigned (01 through 10), when the plot is established. For example, cluster 2 in GRCA mixed conifer is assigned "GM02". Enter the Cluster ID, as indicated on the appropriate map.

If the target habitat has a simple grid sampling or riparian design (mixed conifer at BAND, pinyon-juniper at MEVE , grassland at WUPA, or riparian at CACH), leave this line blank.

- **Point ID.** Each VCP plot has a pre-assigned alphanumeric code. For cluster sampling, letters designate the park and target habitat, followed by the cluster number (e.g., 01 through 30), followed by a "P" (indicating a VCP sampling plot) and the plot's pre- assigned number (e.g., 001 through 100). (Refer to mapped points on the GPS unit and/or map hard copy).

  If the target habitat has a simple grid sampling design (mixed conifer at BAND, pinyon- juniper at MEVE, grassland at WUPA), or is riparian at CACH, the Point ID consists of a letter that designates the park, followed by a letter that designates the target habitat, followed by a "P" (indicating a bird sampling point), and the point's pre-assigned number (001 through the highest). For example, point twenty in WUPA grassland is WGp020.

- **Date**. yyyy/mm/dd (e.g., 2008/03/14).
- **Observer**. Write down the first initial and last name of the person recording data.

6.2 Fire information

If known, fill in

- **Name** of the fire
- **Date** of the fire (yyyy/mm)
- **Type**. Circle whether the fire was a wildfire or prescribed fire.
- If the fire impacted a large portion of the final samplinhg frame, but did not impact this plot, check the box **Plot was not impacted by fire** and d**o not fill out the remaining three sections of the datasheet.**
- Fill out any additional information in **Comments**.

6.3 Assess burn severity

6.3.1 Burn heterogeneity

Determine the level of heterogeneity in the severity of the burn. This applies to broad spatial patterns of both the trees and the understory/substrate across the plot. Check the box for whether the heterogeneity is

- **Low -** fire severity is uniform across the plot
- **Medium** - plot has 2 or 3 distinct areas of differing severities
- **High** - plot has 3 or more patches of different severities

6.3.2 Burn severity of trees

- **Canopy not affected by fire.** Check this box if there appears to be no impact on the trees from fire. **Do not fill out the remainder of this section of the datasheet.** It is rare that a fire would occur under a tree canopy without some scorch to the canopy.
- Examine the impact of the fire to both the overstory trees and saplings to assess the burn severity level for the trees. Check **Canopy scorch** or **tree mortality** to indicate which method you are using to determine burn severity. Use canopy scorch in the year following the fire, or tree mortality if a year or more has elapsed since the fire. In general, canopy scorch should be used if you cannot tell whether the trees have died; tree mortality should be used if the majority of scorched needles have fallen.
- If the plot burned at approximately the same severity across its entirety, i.e. the burn heterogeneity is low, identify

that level of burn severity (Low, Low-medium, Medium-high and High), using the definitions provided on the datasheet and in Table 5-5. If there was variation in the burn severity across the plot, i.e. the burn severity was medium or high, identify the different levels of burn severity, taking into consideration that mortality of individual trees, an indicator of burn severity, may vary with species and size. For example, mortality may be restricted to saplings, or to aspen overstory. Estimate the amount of area for each burn severity class in the plot, and assign a cover class (Table 5-6). Assign the cover class of 1 for all burn severity classes that do not occur in the plot.

- Estimate the **percent mortality of the overstory trees** based on basal area to the nearest 10%. Circle the appropriate number on the datasheet.
- Enter any comments about burn severity of trees and saplings in the **Comments** section.

6.3.3 Burn severity of understory/substrate

- Check **Understory/substrate not affected by fire**, or **Burn severity of understory/substrate unclear**, if you cannot determine levels of burn severity. It may be difficult to assess the impacts of a low severity fire to the understory/substrate 5 years after the fire occurred. **If you check either of these boxes, do not fill out the remainder of this section**
- Examine the impact of the fire to the herbaceous and shrub vegetation, the litter and duff, and woody debris. If the fire burned uniformly across the plot, i.e. the burn heterogeneity is low, identify the level of severity (Low, Low-medium, Medium-high and High) using the definitions in Table 5-7. If the burn heterogeneity of the understory/substrate is medium or high, look at broad areas across the plot and identify the different levels of burn severity. For each burn severity class, estimate the cover in the plot, and circle the appropriate cover class (Table 5.2). These areas may differ from the areas that were identified in the burn severity of canopy. Note the criteria for your rating or further descriptions of the burn in the **Comments.**

Table 5-5. Burn severity classes for tree canopy.

Class	Description
Low	<25% scorched canopy, OR <5% tree mortality by basal area
Low-Medium	25 to <75% scorched canopy and needle consumption, OR 5 to 20% tree mortality based on basal area
Medium-high	75 to <100% scorched canopy and needle consumption, OR 20 to 80% canopy tree mortality based on basal area
High	100% scorched canopy and needle consumption, OR 80 to 100% tree mortality based on basal area

Table 5-6. Cover classes for burn severity assessment.

Class	Cover %
1	0%
2	1 to < 5%
3	5 to < 10%
4	10 to < 25%
5	25 to < 50%
6	50 to < 75%
7	76 to < 100%

Table 5-7. Burn severity classes for understory/substrate.

Class	Description
Low	Most foliage and twigs remain intact, small organic material on ground is scorched but not entirely consumed; mineral soil is rarely exposed.
Low-Medium	Majority of shrub/herbaceous layer, woody debris is scorched to partially burned; most fine organic materials are partially burned; mineral soil is intermittently exposed.
Medium-High	Most woody debris <7.5cm diameter and organic matter entirely consumed. Mineral soil exposed, but intact. Vigorous vegetative regrowth may be evident.
High	All woody debris entirely consumed, except an occasional large log; all litter and duff consumed, exposing bare mineral soil. Substantial soil erosion may be evident.

Macroplot Habitat Characterization Datasheet

Park:_____ Target habitat: _____Cluster ID:_____ Point ID: _____

Date (yyyy/mm/dd): _____ Observer(s): _____

Plot attributes (50 m radius plot)			
Slope (%)	Slope variability (circle one) high med low	Aspect (degrees)	Aspect variability (circle one) high med low

Topographic position (circle one, see Table 2 on the back of this form for definitions)							
Level	Crest	Upper-slope	Mid-slope	Lower-slope	Depression	Draw	Escarpment/face

Macroplot cover type (50 m radius plot)			
Vegetation type	**Cover class***	**Other cover types**	**Cover class***
		Roads	
		Trails	
		Standing water	
		Stream (perennial)	
		Stream (intermittent)	
		Dry arroyo	
		Historic structures/ruins	
		Other:	
		Other:	

* See table 1 for explanation of codes

Table 1. Braun-Blanquet cover class scale	
Code	**Range of cover**
1	<1
2	1 to <5
3	5 to <10
4	10 to <25
5	25 to <50
6	50 to <75
7	75 to <100

Macroplot notes

Table 2. Definition of topographic position for use in SCPN bird habitat characterization.

Topographic Position	Description
Level	level top of a plateau or valley floor or shoreline representing the former position of an alluvial plain, lake, or shore
Crest	linear top of a ridge, hill or mountain; the elevated area between two drainageways that sheds water to the drainageway
Upper-slope	the uppermost inclined surface at the top of a slope, typically convex in profile
Mid-slope	intermediate slope position
Lower-slope	inner gently inclined surface at the base of a slope, generally concave in surface profile. This includes toe slope, the outermost gently inclined surface at the base of a slope, commonly gentle and linear in surface profile
Depression	bowl shaped or similarly depressed area
Draw	depressed V-shaped drainage that carries water toward a stream
Escarpment/face	sloping or vertical side of a stream bank or former stream bank

Subplot Habitat Characterization Datasheet

Park:_____ Cluster ID:_____ Point ID: _____ Subplot # _____

Date (yyyy/mm/dd): _____ Observer(s): _____

Basal area of trees and snags (Plotless)		
Tree Species	**# of hits**	**Basal area factor**
Snags		

Vegetation strata - 11.3 m radius subplot			
Stratum	**Height class code (Table 1)**	**Cover class code (Table 2)**	**Dominant species***
Emergent			
Canopy			
Sub-canopy			
Shrub			
Dwarf shrub (generally <0.5 m)			

* list species in order of dominance, from dominant to least dominant, separate with commas

Table 1. Height class codes for vegetation strata								
Height range	<0.5 m	0.5 to <1 m	1 to <2 m	2 to <5 m	5 to <10 m	10 to <20 m	20 to <30 m	30 to <40 m
Code	0.5	1	2	5	10	20	30	40

Table 2. Braun-Blanquet cover class codes for vegetation strata							
Range of cover	<1	1 to <5	5 to <10	10 to <25	25 to <50	50 to <75	75 to <100
Code	1	2	3	4	5	6	7

Canopy closure - 5 m radius subplot
Stand at the subplot center point. Record number of dots covered (total dots = 96)

Densiometer reading	N	E	S	W
# Dots covered				

Tree sapling tally - 5 m radius subplot Tally number of trees of each species in 2 size categories.

2.5 to <5.0 cm DBH		5.0 to <10.0 cm DBH	
Tree species	Total #	Tree species	Total #

Foliar cover - 1.78 m radius subplot
Percent ground covered by each category (using B-B cover class scale)

Functional vegetation categories	Cover class
Tree seedlings (<2.5 cm DBH)	
Total shrub and herbaceous cover (no trees, < 2 m in height)	
Perennial grasses, graminoids (include sedges, rushes)	
Annual grasses	
Forbs (broadleaf, non-woody plants)	
Shrubs, dwarf shrubs and woody vines (< 1.4 m in height)	
Cacti, succulents	
Standing dead herbaceous (produced in previous growing season(s))	
Woody standing dead (still attached to a rooted plant, less than 2 m in height)	

Braun-Blanquet (B-B) cover class scale

Code	Range of cover
1	<1
2	1 to <5
3	5 to <10
4	10 to <25
5	25 to <50
6	50 to <75
7	75 to <100

Burn Severity Datasheet

Park:_____ Target habitat: _____ Cluster ID:_____ Point ID: _____

Date (yyyy/mm/dd): _____ Observer(s): _____

Fire information

Name: Date: Type: (circle one) Wildfire Prescribed

☐ Plot was not impacted by fire (if checked, do not fill out the rest of the form)

Comments: (use back of datasheet if necessary)

Burn heterogeneity *See back of datasheet for instructions*

Check the appropriate level based on overstory and understory/substrate across the plot

☐ **Low:** Plot uniformly affected by fire

☐ **Medium:** Two or three discrete areas of differerent burn severities

☐ **High:** Patchy distributions of > 3 different burn severities

Comments: (use back of datasheet if necessary)

Table 1. Cover classes

1	0%
2	1 to < 5%
3	5 to < 10%
4	10 to < 25%
5	25 to < 50%
6	50 to < 75%
7	76 to < 100%

Burn severity of trees (overstory and saplings) *See back of datasheet for instructions*

Check appropriate box. If less than 1 year post-fire, use canopy scorch to determine burn severity. If more than 1 year post-fire, use tree mortality to determine burn severity. Circle a cover class for each burn severity class.

☐ Canopy not affected by fire

Burn severity determined by ☐ Canopy scorch ☐ Canopy tree mortality

		Cover class (see Table 1)
Low:	< 25% scorched canopy OR < 5% tree mortality by basal area	1 2 3 4 5 6 7
Low-medium:	25 to < 75% scorched canopy and needle consumption OR 5 to 20% tree mortality based on basal area	1 2 3 4 5 6 7
Medium-high:	75 to < 100% scorched canopy and needle consumption OR 20 to 80% tree mortality based on basal area	1 2 3 4 5 6 7
High:	100% scorched canopy and needle consumption OR 80 to 100% tree mortality based on basal area	1 2 3 4 5 6 7

Percent tree mortality: Circle the approximate % of overstory tree mortality across the plot based on basal area. NA 0 10 20 30 40 50 60 70 80 90 100

Comments: (use back of datasheet if necessary)

Burn severity of understory/substrate *See back of datasheet for instructions*

Check the appropriate box. Circle a cover class for each burn severity class, if possible.

☐ Understory/substrate not affected by fire ☐ Burn severity of understory/substrate unclear

		Cover class (see Table 1)
Low:	Most foliage and twigs remain intact, small organic material on ground is scorched but not entirely consumed; mineral soil is rarely exposed.	1 2 3 4 5 6 7
Low-medium:	Majority of shrub/herbaceous layer, woody debris is scorched to partially burned; most fine organic materials are partially burned; mineral soil is intermittently exposed.	1 2 3 4 5 6 7
Medium-high:	Most woody debris <7.5cm diameter and organic matter entirely consumed. Mineral soil exposed, but intact. Vigorous vegetative regrowth may be evident.	1 2 3 4 5 6 7
High:	All woody debris entirely consumed, except an occasional large log; all litter and duff consumed, exposing bare mineral soil. Substantial soil erosion may be evident.	1 2 3 4 5 6 7

Comments: (use back of datasheet if necessary)

Figure 5-7. Burn Severity Datasheet, page 1.

Instructions for filling out the *Burn Severity datasheet*

1. Fill in the **general information** at the top of the datasheet: park code, target habitat, cluster ID, point ID, date, and observer.

2. Fill in the **fire information**: name, date of fire; indicate whether it was a wildfire or prescribed fire, if that is known. If the plot is located within an ecological site where a large fire has occurred but the plot was not impacted by fire, check *Plot not impacted by fire*, and **do not fill out the remainder of the datasheet**. Make any notes about the fire under *Comments.*

3. **Burn heterogeneity** refers to the variation of burn classes across the landscape. If a plot has been uniformly affected by fire, the burn heterogeneity is low. If there are 2–3 discrete areas of different burn severities, assign a burn heterogeneity of medium. Patchy distributions of serveral different burn severities, would be assigned a heterogeneity of high. Make any notes about the burn heterogeneity under *Comments.*

4. **Burn severity of trees** encompasses the overstory and saplings, which are collectively referred to here as the canopy. If the canopy doesn't appear to be affected by the fire, check *Canopy not affected by fire* and **do not fill out the rest of the section.** If the fire occurred within the year, burn severity will be determined by canopy scorch. If the fire occurred more than a year past, use canopy tree mortality. Check the appropriate box.

In assessing the burn severity, consider how the the fire impacted both overstory trees and saplings, taking into account how burn severities may differ among size classes and species. If the burn heterogeneity of the plot was low, choose the burn severity class that best applies. If the burn heterogeneity was medium to high across the plot, choose all the burn severity classes that are present on the plot. For each burn severity class, circle the appropriate cover class for the area of the plot affected. For burn severity classes that were not present in the plot, circle 1 for 0%. Make sure that all classes add up to 100%.

Estimate the percent tree mortality, based on basal area, across the entire plot. If mortality is difficult to assess shortly after a fire, circle NA

Make any notes about burn severity of trees in the plot under *Comments.*

5. **Burn severity of understory/substrate** encompasses both understory vegetation and the underlying soil and minerals. If the understory/substrate of the plot does not appear to be impacted by the fire, check *Understory not affected by fire*. If it is difficult to assess how the understory/substrate was affected (e.g. a low severity fire that occurred 5 years previously), check the *Unclear how understory/substrate was affected by fire*. If you have checked either of these boxes, **do not fill out the rest of this section.**

If the burn heterogeneity of the plot was low, choose the burn severity class that best applies. If the burn heterogeneity was medium to high across the plot, choose all the burn severity classes that are present on the plot. For each burn severity class, circle the appropriate cover class for the area of the plot affected. For burn severity classes that were not present in the plot, circle 1 for 0%. Make sure that all classes add up to 100%.

Make any notes about burn severity of the understory and substrate in the plot under *Comments.*

Comments continued from front of datasheet:

Figure 5-7. Burn Severity Datasheet, page 2.

7 Revision history

Provide the following information for each revision made to SOP 5.

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Standard Operating Procedure #6: After the Field Season

Version SCPN_Birds_SOP6_20150930				
Revision History Log				
Previous version number	**Revision date**	**Section and paragraph**	**Change(s) made**	**Approved by**

Only changes in this specific SOP will be logged here. Record the previous version number and date of revision; identify sections and paragraphs where changes were made, who approved the revision, and the new version number. More detailed descriptions of the changes made and the reason for the changes is provided at the end of this SOP.

This standard operating procedure (SOP) describes post-field season procedures for the SCPN Habitat-based Bird Community Monitoring Program. The procedures described include management of field equipment, handling of datasheets, review of the field season, and preparation of Investigator's Annual reports.

1 Returning field equipment

- **Clean all equipment before storage.** Crew members should ensure that all equipment used during the field season is clean and fully operational. Any problems with equipment should be reported to the project manager.
- **Inventory field equipment.** All equipment should be properly stored. Crew members should inventory all equipment as it is returned to storage. Any damaged equipment should be set aside to be repaired or replaced.
- **Repair/replace damaged equipment.** When possible, damaged equipment should be repaired. Otherwise, damaged equipment should be replaced to ensure that all necessary equipment is on hand and functional prior to the next field season.
- **Clean vehicles.** All field vehicles should be thoroughly cleaned.

2 Datasheets and data management

The datasheets contain the original field observations made in the field, and as such are an important artifact of each field season and need to be properly organized and archived. After the field season, and before crew members depart, the following steps should be completed:

- **Complete data entry and proofread datasheets.** Throughout the field season, data will be entered into the database, and the datasheets proofread. Any data that were not entered during the field

season should be entered and proofread by the crew members at this time.

- **Organize datasheets.** The datasheets should be organized according to how they will be scanned and archived. Data sheets first need to be separated by park, then by datasheet types (macro plot, subplot, and point-count), and finally ordered by point ID.
- **Scan datasheets.** The datasheets need to be scanned after they have been organized as described above. Each set should be scanned into multipage PDF format, if at all possible. Each park and datasheet type should be scanned into a separate PDF file, and each file labeled by park, datasheet type and sample year.

The file naming conventions described in SOP #7 should be adhered to. In addition, the label "macros" should be used for the file containing macro plot vegetation datasheets, the label "subplot" should be used for the subplot vegetation datasheets , and "pt_counts" should be used for the point count datasheets. For example, for sample year 2009, the scanned datasheets for Petrified Forest NP (PEFO) should be scanned into three files. These files will be named PEFO_macros_2009.pdf, PEFO_subplot_2009.pdf, and PEFO_pt_counts_2009.pdf.

- **Proofread scanned datasheets.** The scanned datasheets should be proofread to ensure that they are complete and legible. All datasheets should have been reviewed for completeness in the field and during data entry, but some deficiencies may not be identified until later.
- **Mark corrections on datasheets and re-scan datasheets.** If changes to data on the datasheets need to be made subsequent to scanning, corrections should be made on the original by drawing a horizontal line through the original value, and writing the new value adjacent to the original value, with the date and initials of the person making the change. Corrected errors and changes made on a datasheet should be circled. A short explanation of the change should be included in the margin of that form, along with the date and initials of the person who made the correction. The corrected datasheet should then be re-scanned.
- **Store original and scanned (digital) datasheets.** The project manager will work with the data manager to store the original and scanned datasheets. The original datasheets will be stored with the project manager until the annual reports for that season are completed. They will then be stored by the network. Digital copies will be stored in a subfolder called "ScannedDatasheets" under the archive folder on the network file server, where daily back-ups are made.

3 Review of field season

- **Field season review**. The project manager should perform a review of the field season before the departure of the field crew. This can be done individually, or as a group. Topics for the review should focus on aspects of the field season that went well and aspects that could be improved. Specific topics should include (but are not limited to): planning, scheduling, logistics (travel, lodging, meals), protocols, efficiency, field conditions and safety.
- **Prepare field season report.** The project manager will prepare a brief report based on the field season review. The report will be reviewed prior to the next field season to refine protocols if necessary.

4 Reporting scientific collecting activities

Prepare and submit reports. The project manager will prepare and submit the Investigator's Annual Reports for each park using the NPS Research Permit and Reporting System (RPRS) web site. (https://irma.nps.gov/rprs/Home)

5 Revision history

Provide the following information for each revision made to SOP 6.

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Standard Operating Procedure #7: Project Workspace

Version SCPN_Birds_SOP7_20150930				
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This standard operating procedure (SOP) describes how and where data and other records, both digital and hard-copy, are stored for theSCPN Habitat-based Bird Community Monitoring Program. Guidelines for structuring and accessing digital data are provided, as well as specific standards for digital file and folder naming. The archiving and management of records should be carefully accomplished based on the direction provided by this SOP.

1 File directory structure

Two areas on the network file server are reserved for the habitat-based bird community monitoring project: one provides a space for working files, and the other a space for the project archive. The project manager's computer also includes a working file section. The project manager will store all working files there and transfer database copies to the network file server periodically.

The folder structure of the working files is shown in Figure 7-1 and the archive in Figure 7-2.

1.2 Naming conventions

1.2.1 Folder naming standards

Additional folders can be created as needed to promote the organization and progress of the project. Folder names should follow these guidelines:

- When creating a park specific folder, use the offical 4-letter park code (e.g., BAND).
- Do not use spaces or special characters in the folder name.
- Use the underscore ("_") character rather than spaces to separate words in folder names.
- Limit folder names to 20 characters or fewer.
- Dates should be formatted YYYYMMDD (e.g., January 23, 2008 is 20080123).
- Folders named old or temp indicate a temporary nature and should be re-

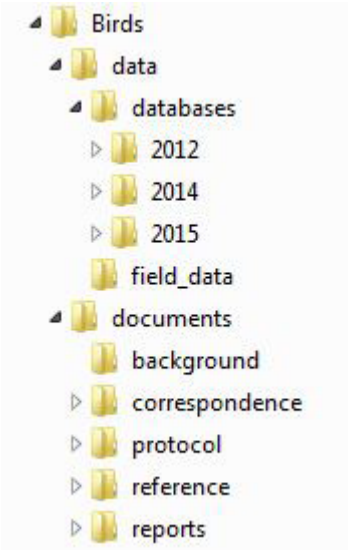

Figure 7-1. Working file directory structure.

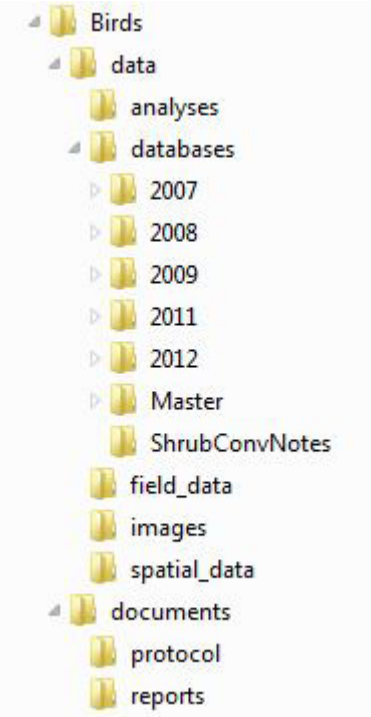

Figure 7-2. Archive directory structure.

moved at the end of the season.

1.2.2 File naming standards

- Newly created files should be named according to these guidelines:
- When creating a park specific file, use the offical 4-letter park code (e.g., BAND).
- Do not use spaces or special characters in the file name.
- Use the underscore ("_") character rather than spaces to separate file name components.
- Dates should be formatted as yyyy/mm/dd (e.g., January 23, 2008 is 20080123).
- Use leading zeroes for numbers 1 through 9, for sorting purposes.
- File names should be as short as possible, but include all necessary identifying information.
- The file name should be unique so that no other electronic file is likely to have the same name on the SCPN file server.
- Do not use version numbers on working documents (e.g., version1, final, etc.). The file date (yyyymmdd) will be used as the file version.

An example of an acceptable file name is "GRCA_Vegetation_ 20080101.pdf".

2 Archival and records management

All project files should be reviewed and organized by the project manager on a regular basis. Decisions on what to retain and what to destroy should be made following the guidelines stipulated in NPS Director's Order 11D (http://www.nps.gov/applications/npspolicy/DOrders.cfm). This order provides a schedule for how long various kinds of records should be retained.

2.1 Digital data

Once the master project dataset and metadata are considered final, the data manager will place a copy of the dataset and the metadata record into a folder within the archive directory on the network server, named for the sample year (e.g. the folder named 2012 will contain all data collected during the 2012 monitoring field season). These archived files will be stored in read-only format. Any subsequent changes made to this dataset must be documented in an edit log in the archive directory and in the metadata.

Prior to any major changes of a dataset, a copy should be stored with the appropriate version number to allow for tracking of changes over time. Versions of archived datasets should be marked by adding a three digit number to the file name, with the first version being numbered 001 (e.g., bird_BE_20081101_v001, for the first version of a back-end data file validated by the project manager and data manager at the end of the 2008 field season). Each additional version is assigned a sequentially higher number. This should also be documented in the edit log. Frequent users of the data should be notified of the updates and provided with a copy of the most recently archived version.

Field images and datasheets will also be archived. Images from digital field cameras will be provded to the data manager by the project manager, along with any image related documentation. The data manager will place these in a subfolder called "Images" within the appropriate field season year folder. Field datasheets will be scanned into .pdf format and placed in a subfolder called "ScannedDatasheets" within the field season year folder.

Additional digital files to be archived include any digital files associated with data analysis products and project reporting. Official project reports will be cataloged in the online NPS Integration of Resource Management Applications (IRMA at https://irma.nps.gov). All digital materials are to be stored in the network office and can be made available to park curators upon request.

2.2 Hardcopy materials

Hardcopy materials (e.g., datasheet, field notebooks, photo prints, reports) are stored in the network office. Both the project manager and SCPN staff will work with the curatorial staff at the park(s) to achieve timely and efficient archiving of hardcopy materials.

3 Revision history

Provide the following information for each revision made to SOP 7.

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Standard Operating Procedure #8: Quality Control: Data Entry and Verification

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This standard operating procedure (SOP) describes the procedures for entry and verification of field data from paper datasheets into the digital working project database for the for the SCPN Habitat-based Bird Community Monitoring Program. For related guidance, and a clarification of the distinction between the working database and the master database, refer to chapter 5 of the protocol narrative (Data Management).

1 Data entry overview

The primary goal of data entry is to transcribe the data from paper into the database with 100% accuracy. Data entry should occur as soon as possible after data collection is completed and before the next sets of observations occur. Data entry should be completed by the people who collected the data or someone who is familiar with the project and data collection methods. It is the project manager and the data manager's shared responsibility to ensure that all data entry staff understand how to enter data. Data enterers are responsible for being familiar with the field datasheets, the database, and any standard codes for data entry.

Each data entry form has built-in quality-assurance components such as pick lists and validation rules to test for missing data or illogical combinations. Users are strongly encouraged to use only the pre-built forms to provide the maximum level of quality assurance.

As data are being entered, the person entering the data should visually compare each data form to make sure that the data on screen match the datasheet values. This should be done for each record prior to moving to the next form for data entry. At regular intervals and at the end of the field season, the bird monitoring staff and data manager should inspect the data that have been entered to check for completeness and to identify avoidable errors.

2 Database instructions

2.1 Getting started

The Bird Monitoring Database is fully documented in Appendix D. The database consists of 2 parts: a front-end and a back-end. The front-end is the user interface, containing the data entry forms, and queries; the back-end consists of the data tables and look-up tables. The working back-end database has "_BE_" as part of its name, and should be stored on the server in the project workspace (see SOP #7) so that all data enterers can enter data into the same back-end file. Section 2.3 below (Connect data tables) describes how to connect the front-end with the back-end. For enhanced performance, users should copy the front-end database onto their workstation hard drives and open it there. This front-end copy may be considered "disposable" because it does not contain any data, but rather acts as an interface with data residing in the back-end working database. For field laptops, the front-end and back-end will necessarily reside on the same laptop. If multiple field laptops are used, the back-end files from the different laptops will be merged by the data manager at the interval agreed upon by the data manager and the project manager.

When new versions of the front-end application are released, there should be no need to move or alter the back-end file. Instead, the front-end file may be deleted and replaced with the new version, which will be named in a manner reflecting the update. When this occurs, the front-end application will prompt the user to update the links to the back-end database file. This updatewill only need to be done once for each new release of a database.

Note: Depending upon system configuration, it may be necessary to have the computer mouse wheel control dynamic link library (MouseHook.dll) resident in the same folder as the front-end file.

2.2 Startup form

The *Startup form* (Figure 8-1) is the entry point for the application, and opens automatically when the application starts. Double-clicking the network name at the top left of the form will open the web site for the Southern Colorado Plateau Network (http://science.nature.nps.gov/im/units/scpn/). Double-clicking the NPS Arrowhead or the title "National Park Service" at the top right of the form will open the National Park Service web site (www.nps.gov).

At the top right of the form is an exit button which can be used to close the application.

This form contains three tabs: the Main menu tab, the Defaults tab, and the About tab. Each of the tabs will be examined in more detail in the sections that follow.

At the bottom of the form is a box that displays the full pathname of the back-end data file to which the application is linked.

2.3 Main menu tab

The Main menu tab (Figure 8-1) hasthree-buttons that provide the following functions:

- **Enter/edit data.** Allows the user to enter or review data (see section 2.3.2).
- **Back up data.** Creates a date-stamped copy of the back-end database file (see section 2.3.4).
- **Connect data tables.** Allows the user to connect to a different back-end database file (see section 2.3.5).

Each of these buttons is described in detail below.

2.3.1 Enter/edit data button.

Clicking the **Enter/edit data** button on the *Main menu* tab of the **Bird Monitoring Database** start-up menu (Figure 8-1) opens the *Set application default values form*, which allows the user to verify or change the application defaults (Figure 8-2). Clicking the **OK** button closes this form and opens the *Data Gateway Form* (Figure. 8-3).

Data Gateway form. This form displays location and event information to help the user determine which record to edit/view.

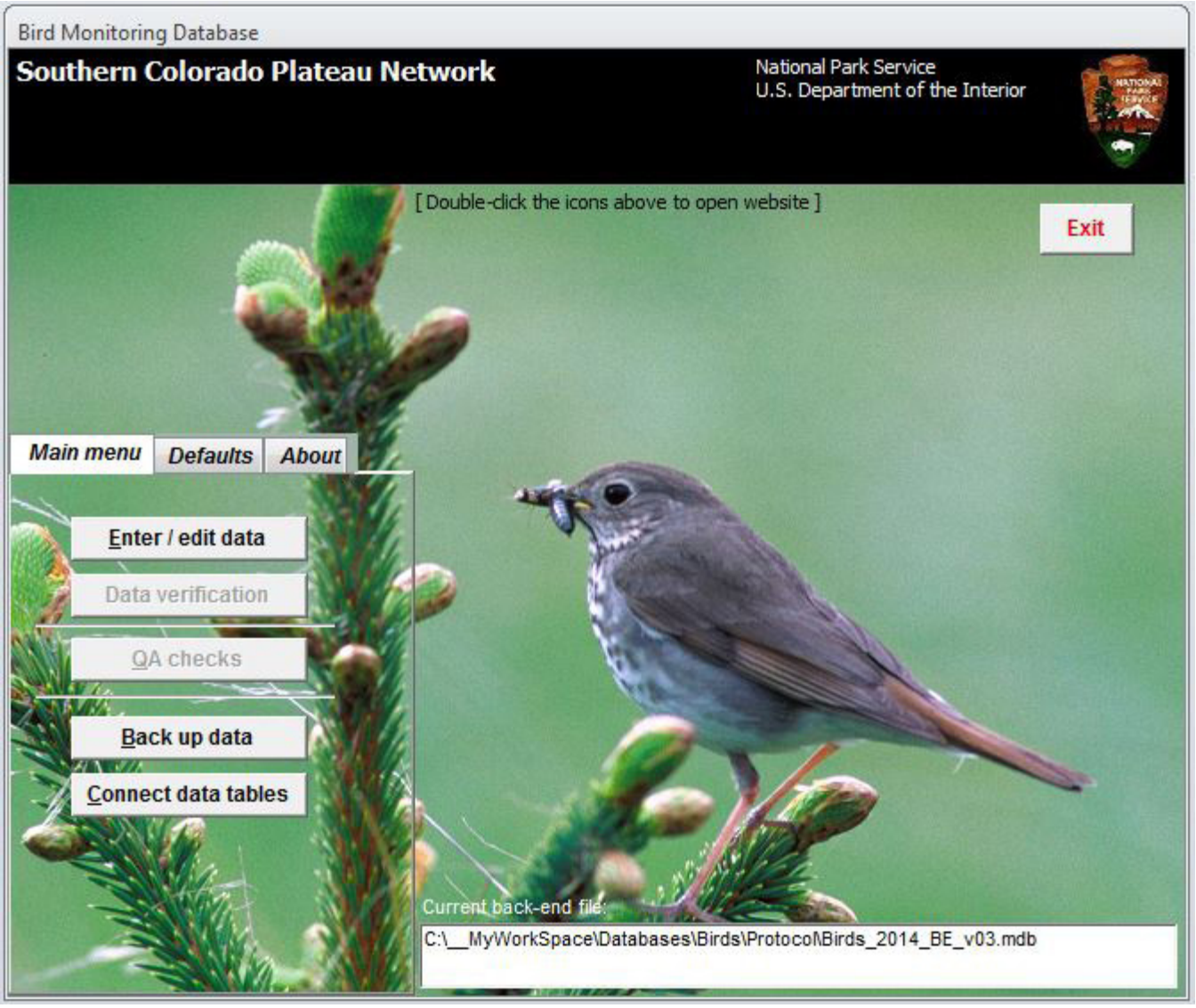


Figure 8-1. The Main menu tab of the *Bird Monitoring Database startup menu*. (Note: greyed out buttons have been disabled due to changes in the database)

- Reviewing existing records. Both filter and sort functions are available on the *Data Gateway form* to help a user find a needed record. Filters for **Park**, **Cluster**, and **Point** are set by selecting from the drop-down lists in the Filters box at the top of the form. Filters are turned on and off by clicking the **Filter button**, which will reflect the current status of the filters, either on or off. A specific filter can be removed by deleting the text that is currently displayed in one of the filter controls.
- Sorting records. Double-clicking column headings with an asterisk will cause the records to be sorted in ascending order by that column value. The column heading will change to a bold italic format to indicate that it is the column being used to determine sort order. If the same column is double-clicked a second time, the records will be sorted in descending order by that column value.

  Double-clicking on the blue text in the **Point** column will open the *Data Entry form* for that particular record, allowing the user to review or edit the data entered.
- Adding new records. To add a new data

Figure 8-2. *Set application defaults Form.*

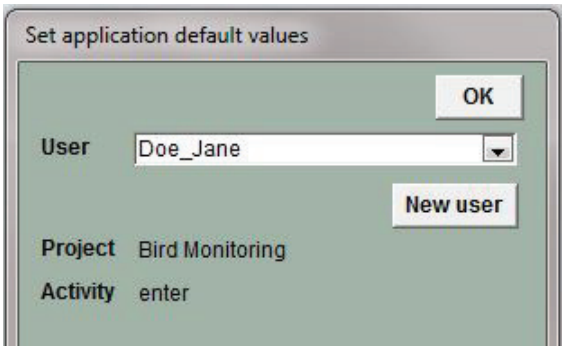
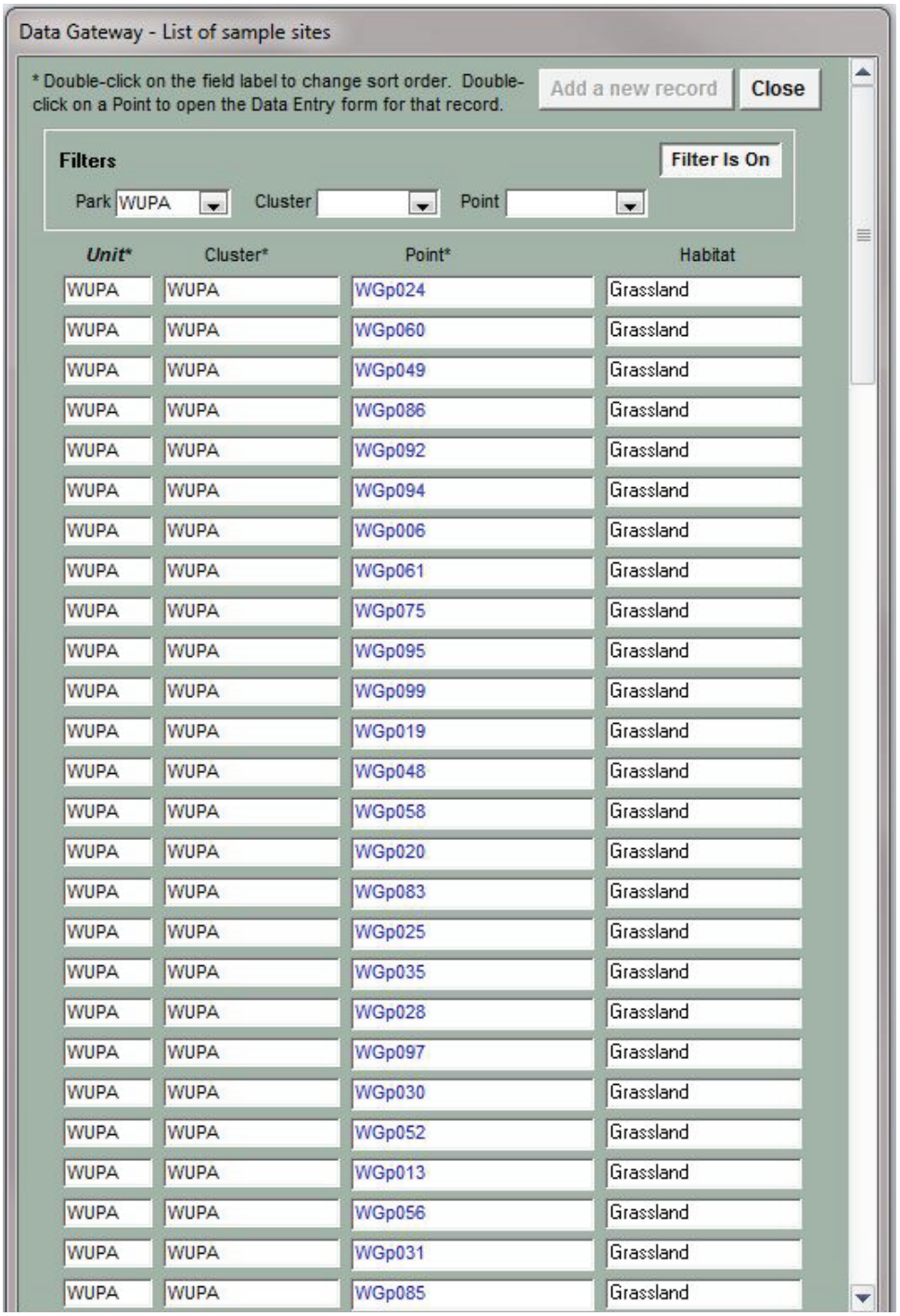


Figure 8-3. *Data Gateway Form.*



record, click the **Add a new record** button at the top of the form. This action will open the *Main Data Entry form* (Figure 8-4).

Main Data Entry form. This form is used to enter all the field data for a sampling point. At the top of the form users can select previously entered **Park, ClusterID**, and **PointIDs** from a dropdown list. Note that clusters are not used in simple grid sampling; the park name will be substituted in these situations.

Clicking on the **View all records** button on the *Main Data Entry form* will cause the *Data Gateway form* (Figure 8-3) to be displayed over the *Main Data Entry form*. Double clicking on an individual point will cause the data for that point to be displayed in the *Main Data Entry form*.

The information from the *Macroplot Habitat Characterization Datasheet (***Park, Target Habitat, Cluster ID, and Point ID)** will be entered at the top of the *Main Data Entry form*, which has three tabs: **VCP, Macroplot**, and **Subplot.**

- **VCP tab** (Figure 8-5). Data from the *VCP Count Datasheet* (see SOP 4) is entered in the **VCP tab** of the *Main Data Entry form*. Enter the **Date, Observer(s), Wind, Clouds, Precipitation, Noise**, and **Point Start Time.** For every bird detection recorded on the *VCP Count datasheet*, fill in the cells for **Minute, Species, # Detected, Distance (m), Detection type, Seen?, Sex, Age, Flock Size, Prev. Plot?, Flyover?, Breeding Code**, and any comments.
- *View and edit contact information form*. If the observer is not listed in the Observer(s) drop down list on the VCP tab, click **Add a Person**. This will open the *View and edit contact information form* (Figure 8-6). This form collects information about individuals who participate in bird community monitoring for SCPN and who enter information into the database. It can be accessed from the **VCP, Macroplot** and **Subplot** tabs. Previously entered addresses can be selected from the Address 1 drop-down list, and the associated street address, City, State, Zip, and Country values will fill in automatically. The Organization and Position/Title drop-down lists will also allow selection from previously entered values or new entries. The Contact ID value, which uniquely identifies a contact, is automatically generated by

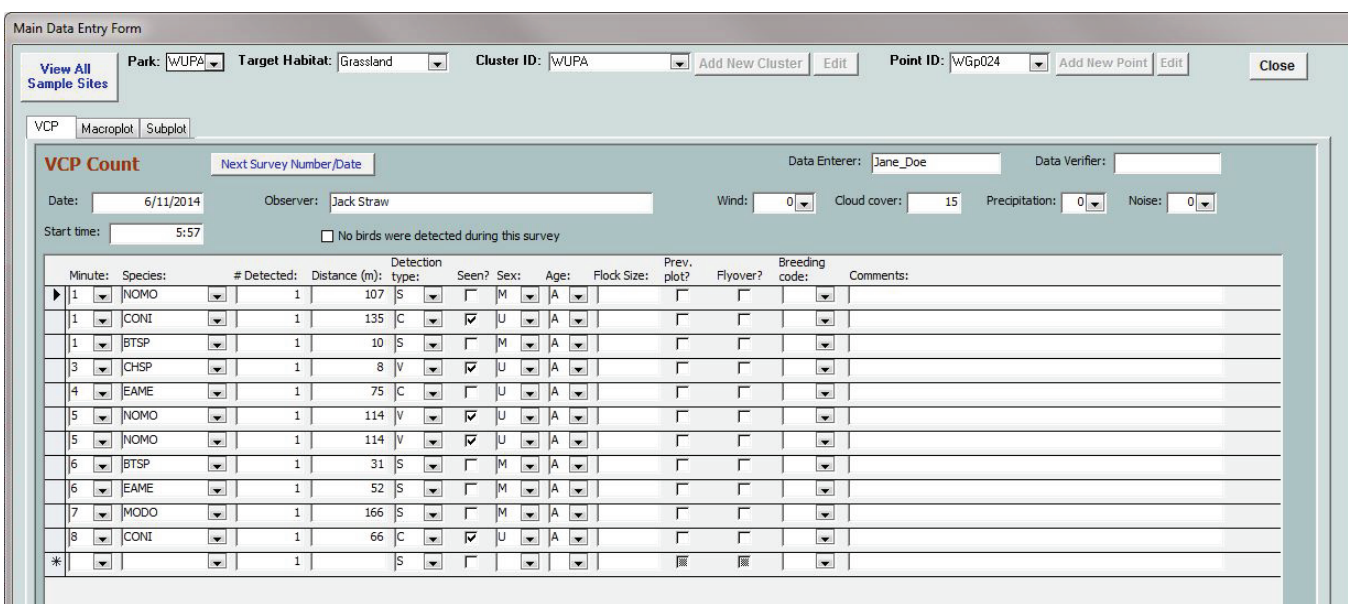


Figure 8-4. *Main Data Entry Form.*

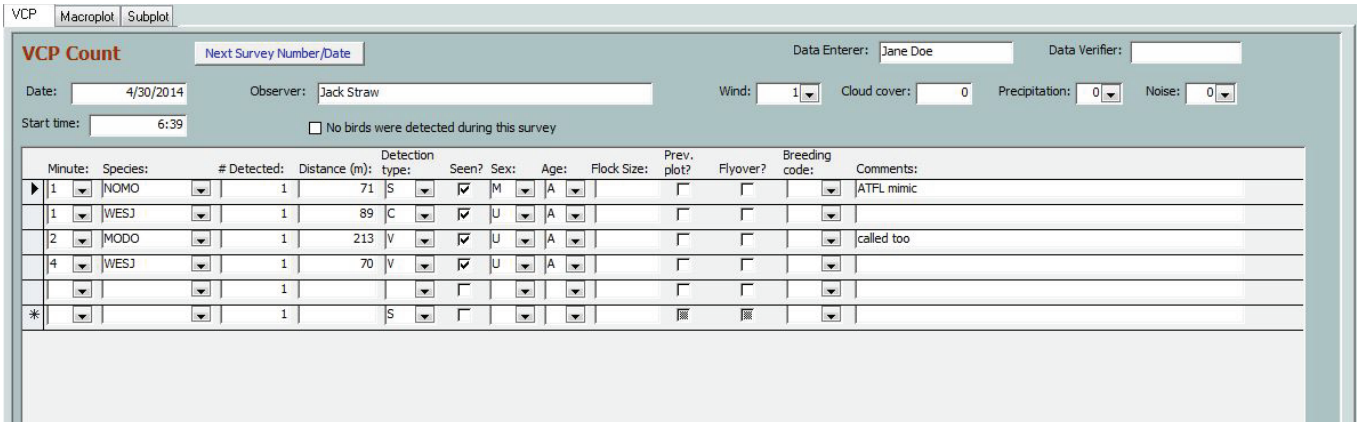


Figure 8-5. VCP tab of the *Main Data Entry Form.*

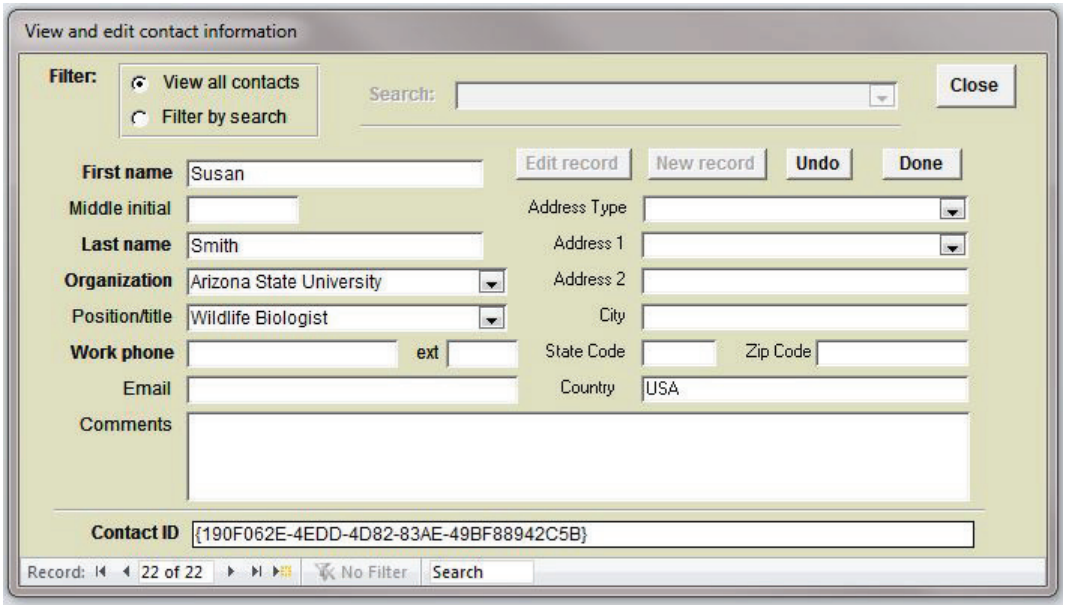


Figure 8-6. *View and edit contact information Form.*

the application.

- **Macroplot tab** (Figure 8-7). Enter information from the *Macroplot Habitat Characterization Datasheet* in the *Macroplot* tab of the *Main Data Entry form*. Enter **Date, Observer(s), Slope, Slop variability, Aspect, Aspect variability**, and **Topographic position**. List **Vegetation type** and **Cover class**. If there is cover other than vegetation, enter **Other cover types** and **Cover class**. More than one vegetation type or cover type can be entered. Add any **Macroplot notes**.
- **Subplot tab** (Figure 8-8). Data from the *Subplot Habitat Characterization Datasheet* is entered in the **Subplot tab**. There are four subplots per PointID and a record must be created for each. Enter the **Subplot Number, Date**, and **Observer(s)**. In the *Basal Area of Trees and Snags Form*, enter **Tree species, # of hits**, and **Basal area factor**. Under **Snags** enter **# of hits** and **Basal area factor**.

  This form includes three tabs for the different size subplots: **11.3 m Radius Plot**, **5 m Radius Plot**, and **1.78 Radius Plot**. Click on the appropriate tab and enter the relevant data for each size subplot. When one complete subplot entry is complete, click on **Add Next Subplot Record** to enter the next subplot.

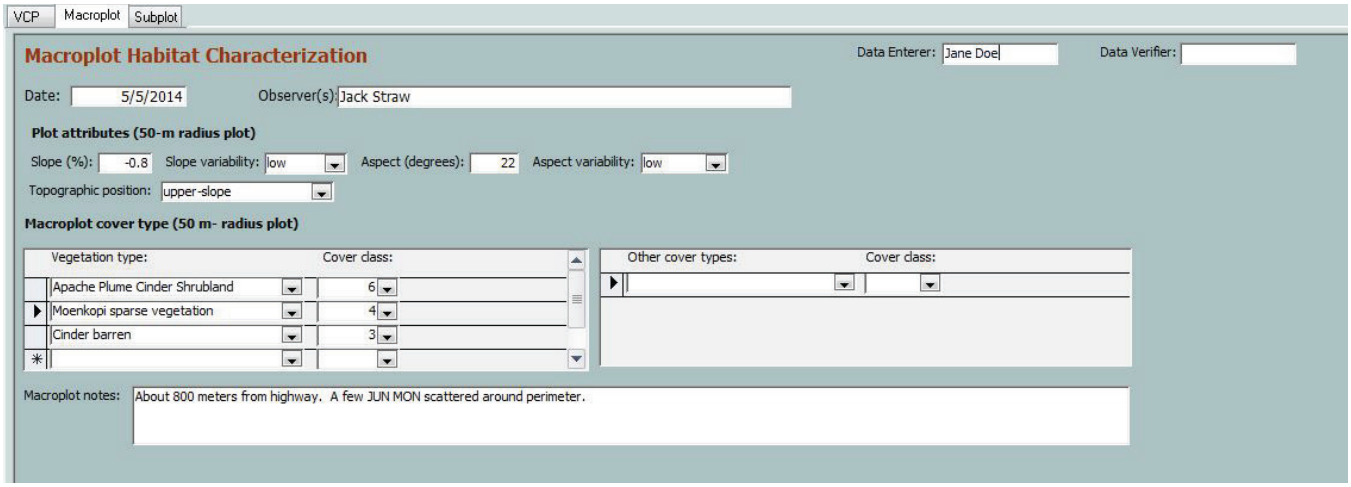


Figure 8-7. Macroplot tab of the *Main Data Entry Form*.

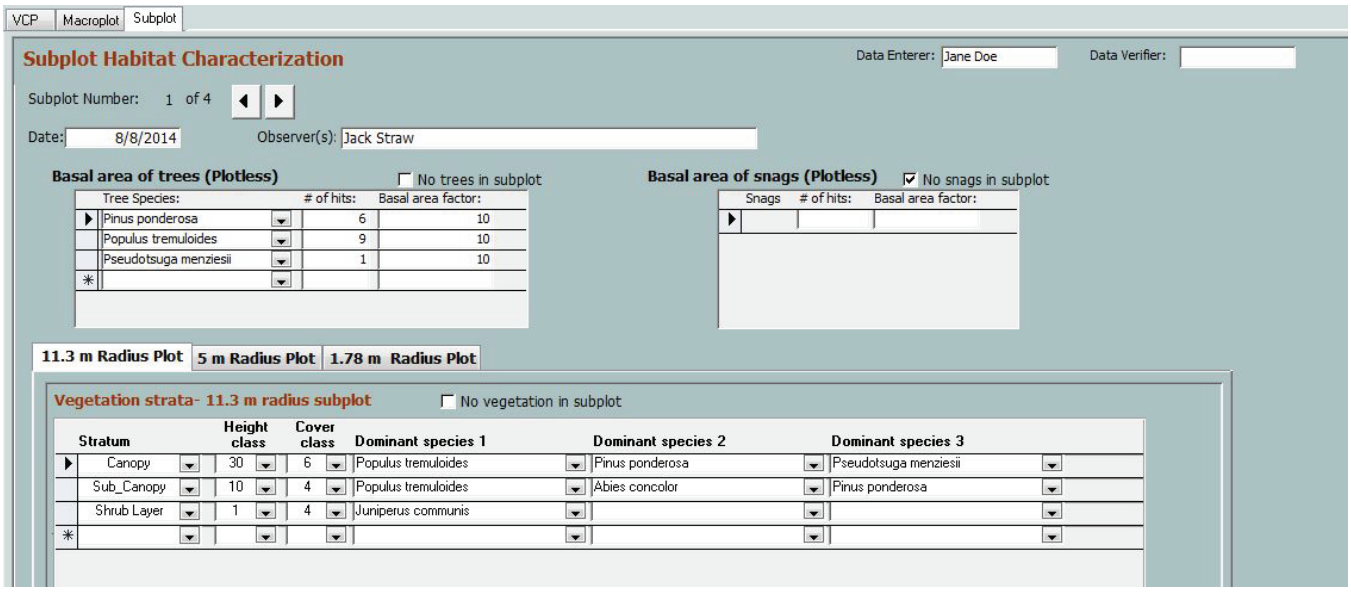


Figure 8-8. Subplot tab of the *Main Data Entry Form,* showing the **11.3 m radius plot tab**.

- **11.3 m Radius Plot tab** (Figure 8-8). List each Stratum that exists on the plot. Fill in each respective **Height class** and **Cover class.** List the three most dominant species per strata in the following fields: **Dominant species 1, Dominant species 2,** and **Dominant species 3**. If nothing exists in the plot, check "**No vegetation in subplot**".
- **5 m Radius Plot tab** (Figure 8-9). For canopy closure, enter 4 densiometer readings for each of the cardinal directions: N, E, S, and W. Each reading must be 96 or less. There are two subforms for tree saplings: those that have a DBH from 2.5 cm to <5 cm, and those that have a DBH from 5 cm to <10 cm. In each, enter the **Tree species** and **Total #**.
- **1.78 m Radius Plot tab** (Figure 8-10). Select **Functional vegetation** categories and the corresponding Cover class for each category from the drop down menus.

2.3.2 Data verification.

The goal of data verification is to ensure data was correctly and completely transcribed from the physical datasheets to the database. Re-open each data entry form and carefully

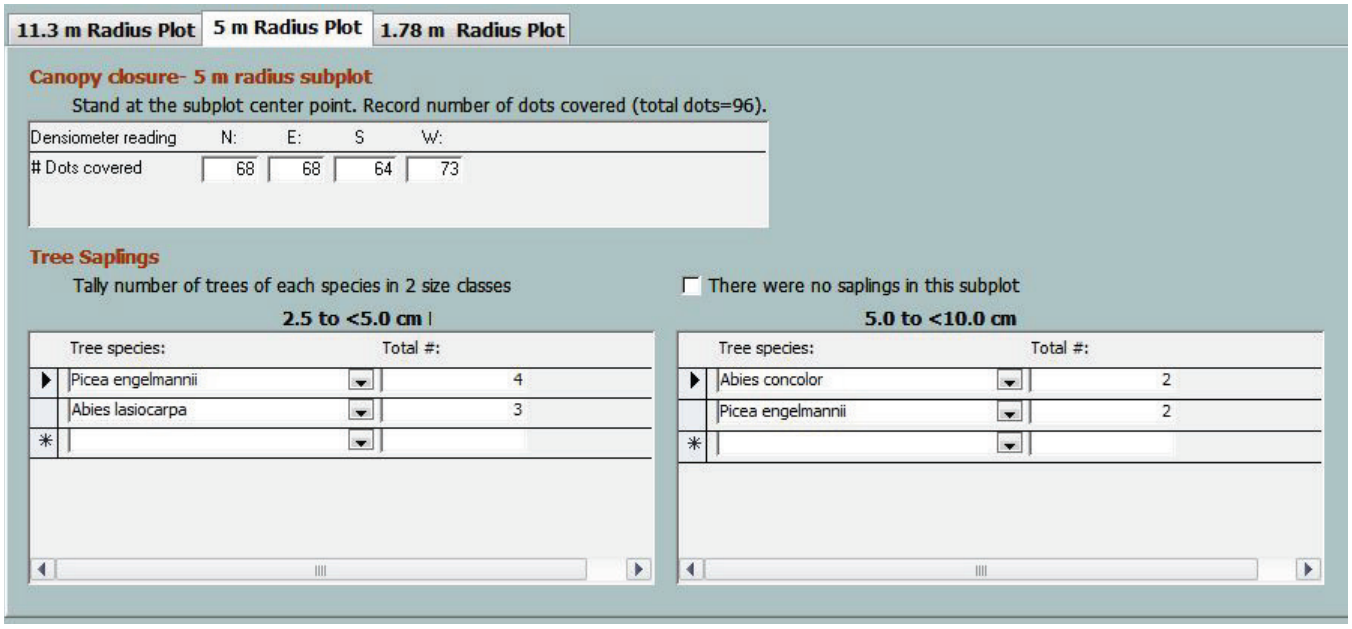


Figure 8-9. 5 m radius plot tab **of the Subplot tab** of the *Main Data Entry Form.*

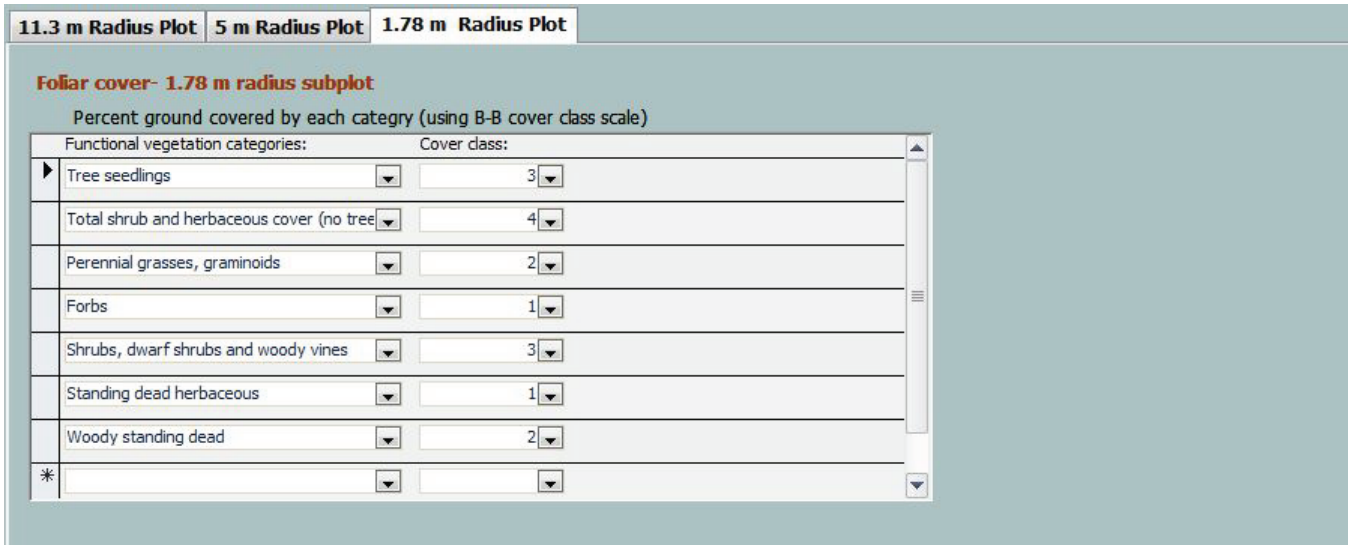


Figure 8-10. 1.78 m radius plot tab **of the Subplot tab** of the *Main Data Entry Form.*

review the values entered in the database against the values recorded on the datasheet. The most important errors to catch in this process are transcription errors that fall within an acceptable range or list of values but were incorrectly transcribed from the datasheet to the database. For example, a cover class value of 3 entered in the database when the cover class was recorded as 5 on the datasheet may not be captured by any of the automated checks – it is within the acceptable range of values and may still allow 100% cover to be bracketed when adding all of the cover classes for a plot. It is preferable to have the project manager complete verification. However, at a minimum, verification should be completed by someone other than the original data enterer.

After completing verification of the bird observations, macroplot data, and subplot data for each plot, select the **Verification Completed** checkbox.

2.3.4 Back up data button.

Clicking the **Back up data button** on the **Main menu tab** will open a Yes/No box asking if the user would like to make a backup copy of the data. If **Yes** is selected, the user will be prompted to select a folder in which to place the backup copy. The backup files will be named by adding the current date, time, and user's initials to the end of the back-end file name (e.g., bid_BE_v1.0_20070605_1711_JH.mdb for a backup file created on June 5, 2007 at 5:11PM by Jennifer Holmes). Back-up copies are used for the current field season only and will not be archived. All such backups may be deleted after the quality review and certification of the data. Clicking the **Save button** creates the backup file and displays a success message.

2.3.5 Connect data tables.

The application has two parts, a user-interface front-end and a database back-end (see 2.1). For the application to work properly, the front-end must be connected to the correct back-end.

Clicking the **Connect data tables** button on the **Main menu tab** opens the *Update Data Table Connections form* (Figure 8-11), which is used to establish the link from the front-end to the back-end.

When this form is opened, the database name, file name and path of the current back-end file are displayed. To change the back-end file connection, click the **Browse** button, navigate to the new back-end file, and click the **Open** button. To make the actual connection, click the **Update links** button. If the connection is successfully made, an "Update complete" message will be displayed.

2.4 Defaults tab

The **Defaults** tab (Figure 8-12) on the *Bird Monitoring Database startup menu* displays current default values, and check box options for automatic backups on startup or exit, data file compaction on backup, and link verification on startup.

2.4.1 Current defaults.

The current defaults section of the **Defaults** tab displays values for **User, Project,** and **Activity**. To change values, click the **Change** button to bring up the *Set application default values form* (Figure 8-13). Click the **New user** button to add a new user (see the *View and edit contact information form* in section 2.3.2, Figure 8-6 of this document for more information). When you have finished entering default values, click the **OK** button to return to the **Defaults** tab.

2.4.2 Automatic backups at startup or exit.

The application can be set to automatically prompt for backups every time it is started and/or every time it is closed (using the Exit button on the main form). Making backups

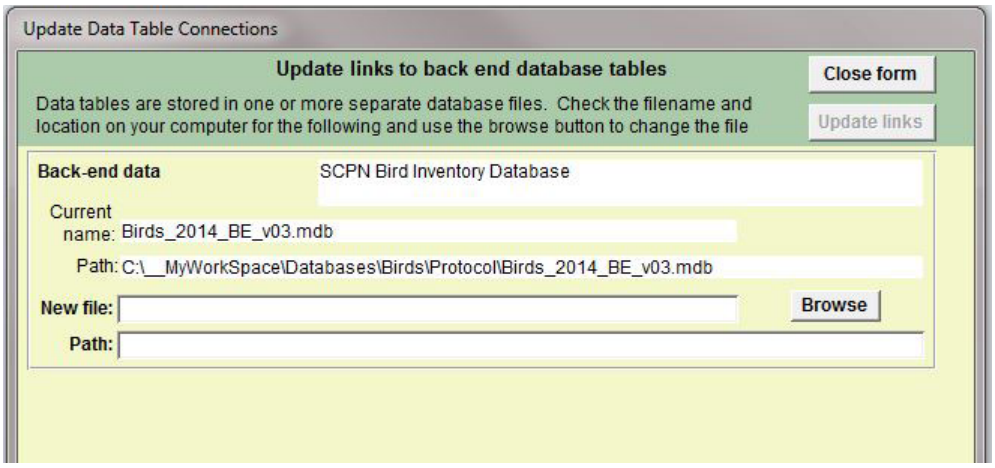
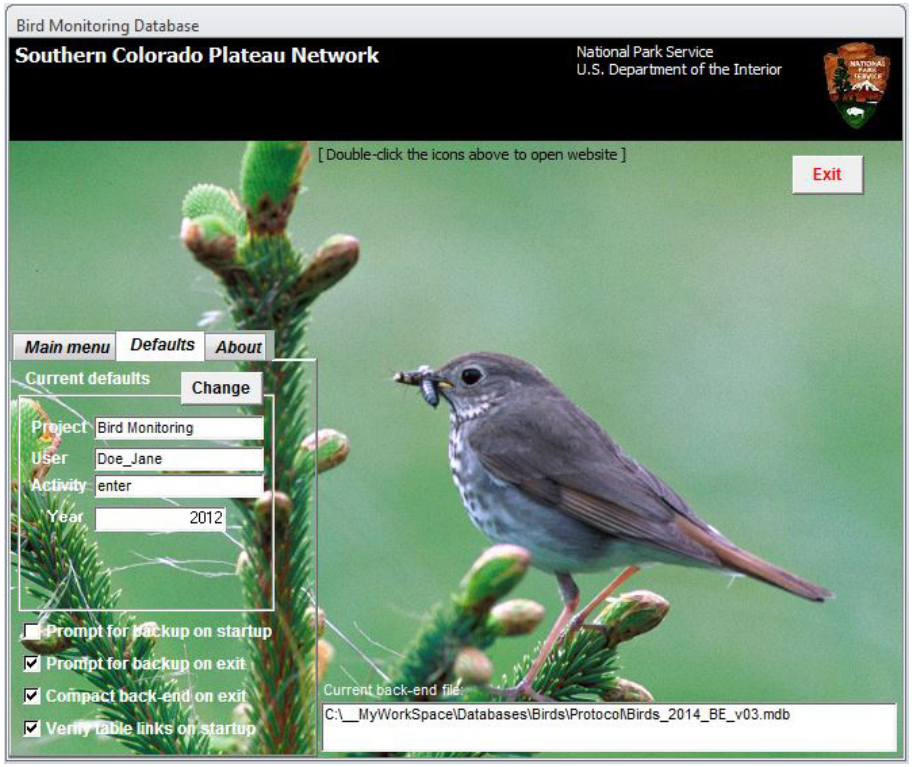


Figure 8-11. Clicking the **Connect data tables** button on the **Main menu** tab opens the *Update Data Table Connections Form*.

Figure 8-12. **Defaults** tab of the *Bird Monitoring Database startup menu*.



before and after data entry sessions is recommended, in case of database corruption or data entry mistakes. Backups can also be run manually by clicking the Back up data button on the Main menu tab.

2.4.3 Compact back-end on exit.
Compaction causes Microsoft Access to optimize the organization of the file, making it smaller and faster at accessing data. Check the option to Compact back-end on exit so that the application will compact the linked back-end when the application is closed using the Exit button on the main form.

2.4.4 Verify table links on startup.
The application is structured with a front-end (user interface) and a back-end (data tables). In order for the application to work properly, the front-end must be linked to the tables in the back-end. When this option is check-marked (recommended), the link to the back-end file(s) will be verified when the application is started.

2.5 About tab

The **About** tab (Figure 8-14)on the *Bird Monitoring Database startup menu* presents

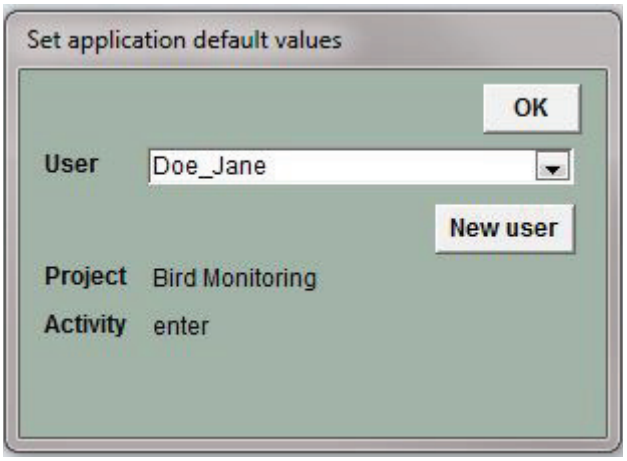


Figure 8-13. *Set application default values Form.*

information about the application, including version number, application author, author organization, author phone, and author email. Buttons for viewing release history and reporting bugs are also provided on the **About** tab.F**2.5.1 View release history.**

Click on the **View release history** button of the **About** tab on the *Bird Monitoring Database startup menu to* open the *Application Releases form* (Figure 8-15). This form provides information about all of the

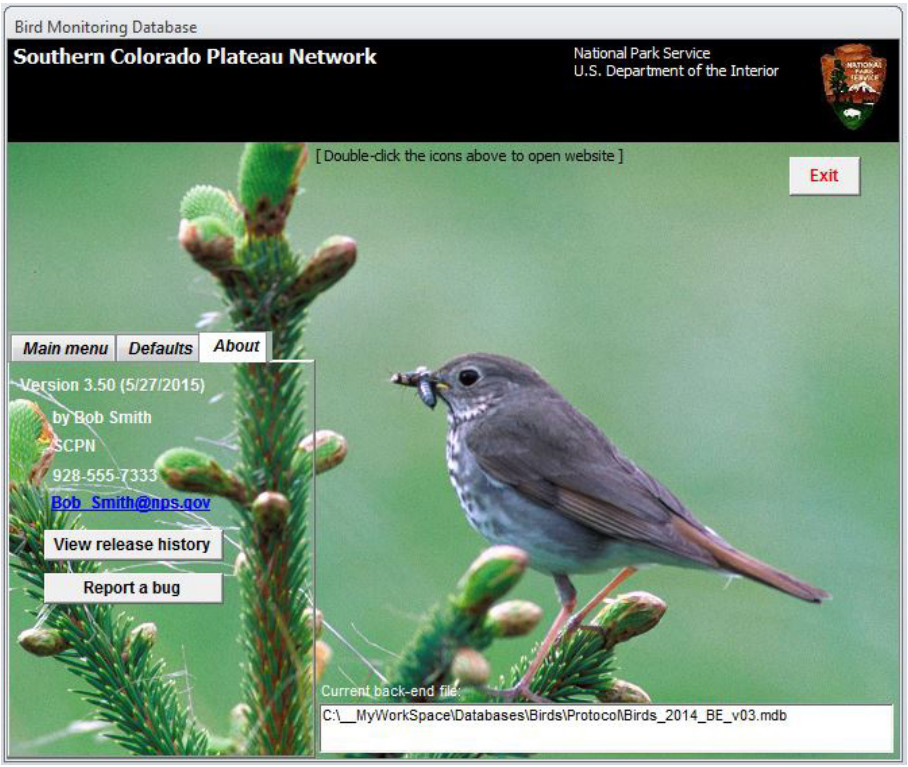


Figure 8-14. **About** tab of the *Bird Monitoring Database startup menu*.

different versions of the application that have been released. It is filled in by the application developer before the application is distributed and is therefore read- only.

The *Application Releases form* details specific release information (including version number, date, and known bugs) as well as author information.

2.5.2 Report a bug.

The **Report a bug** button on the **About** tab will prompt the user to contact the application developer with the details of the bug. Developer contact information is located above the **Report a bug** button.

The following information is useful when reporting a bug:

- application name
- application version
- name of the form/report you were on when the bug happened
- action, if any, you took right before the bug occurred
- screen capture of any error messages

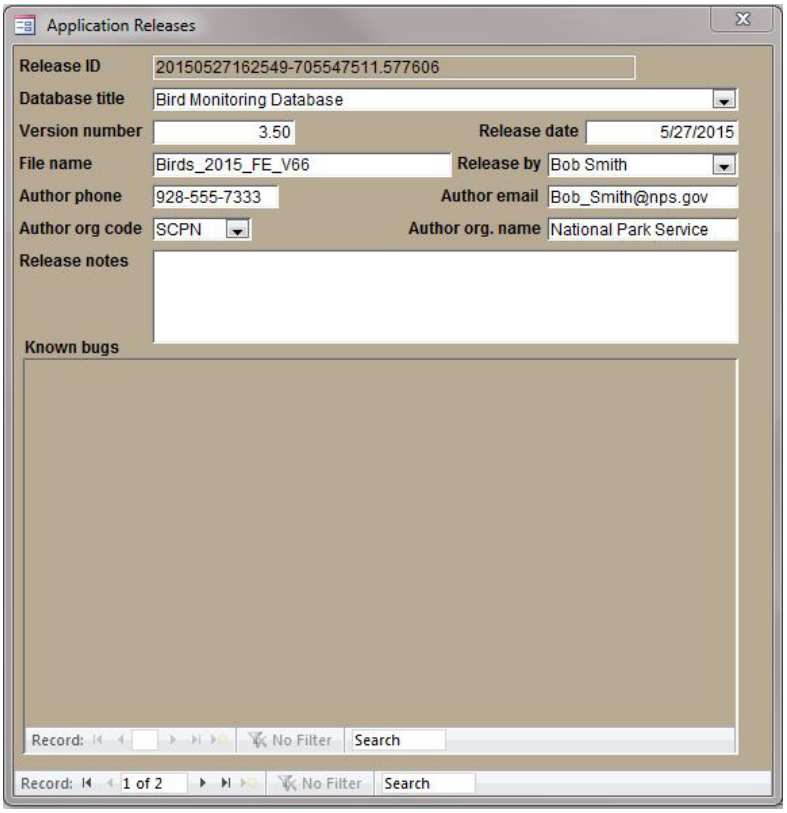


Figure 8-15. *Application Releases Form.*

3 Revision history

Provide the following information for each revision made to SOP 8.

New version:

SCPN_Birds_SOP8_YYYYMMDD

Date:

Author:

Sections affected:

Changes & reasons:

Standard Operating Procedure #9: Quality Control: Data Validation

Version SCPN_Birds_SOP9_20150930				
Revision History Log				
Previous version number	**Revision date**	**Section and paragraph**	**Change(s) made**	**Approved by**

Only changes in this specific SOP will be logged here. Record the previous version number and date of revision; identify sections and paragraphs where changes were made, who approved the revision, and the new version number. More detailed descriptions of the changes made and the reason for the changes is provided at the end of this SOP.

This standard operating procedure (SOP) describes the procedures for validating the working project database for the SCPN Habitat-based Bird Community Monitoring Program. Data validation is the process of checking data for completeness, structural integrity, and logical consistency. It must be done after every field season's data have been entered into the database.

1 Overview

Validation can be accomplished using Access queries, SQLServer queries, R-scripts (R Core Team 2014), or any other method that allows summarization of the data to identify missing data, out of range values, and logical errors in the data that were not captured by the value range restrictions and automated checks implemented in the database or the verification process. Validation should involve the systematic check of each table field for missing values. Validation can involve summarizing the number of samples per park or plot, the species found at each park, the distribution, maximum, and minimum of continuous values, plotting the relationships between correlated values, confirming consistency of linear values, etc.

Both Access queries and R-scripts have been developed for validation. We are transitioning to using R-scripts because they provide superior documentation and more complex summarization. However, the Access queries in the database can still be used to quickly find issues with the data. Figures 9-1 through 9-4 present a few different types of validation summaries from an R generated report that facilitate the discovery of errors in the database. Because these scripts are constantly being updated to refine and improve the validation process, it is not useful to include the entire script here. However, the scripts and their generated reports will be stored in the same folder as the database it validated.

As errors and missing data are discovered, the data manager and project staff work together to correct and document any changes.

tbl_Sites : Habitat

Summarize the number of clusters for 2012 by park, sampling type, and habitat.

```
sites %>%
  group_by(Unit_Code, Site_Type, Habitat) %>%
  summarize(ClusterCount = sum(!is.na(Cluster)))
```

```
## Source: local data frame [8 x 4]
## Groups: Unit_Code, Site_Type
##
##   Unit_Code            Site_Type             Habitat ClusterCount
## 1      BAND Simple grid sampling       Mixed Conifer            1
## 2      BAND Simple grid sampling      Pinyon-Juniper            1
## 3      CACH Simple grid sampling            Riparian            1
## 4      GRCA     Cluster sampling       Mixed Conifer           10
## 5      GRCA     Cluster sampling      Pinyon-Juniper           10
## 6      MEVE Simple grid sampling      Pinyon-Juniper            1
## 7      PEFO     Cluster sampling Grassland/Shrubland           10
## 8      WUPA Simple grid sampling           Grassland            1
```

Figure 9-1. Example of data summary table in R.

tbl_VCP_Count : Minute

Integer minute of an 8 minute observation period when a bird was observed.

Plot a histogram of the time distribution of observations.

```
source("C:\\Users\\lmccoy\\Desktop\\Documents\\Projects\\leeplottheme.txt")
ggplot(sandlev)+
theme_leeplot +
geom_histogram(aes(x=Minute), fill="slategray",color="gray") +
facet_wrap(~Unit_Code)
```

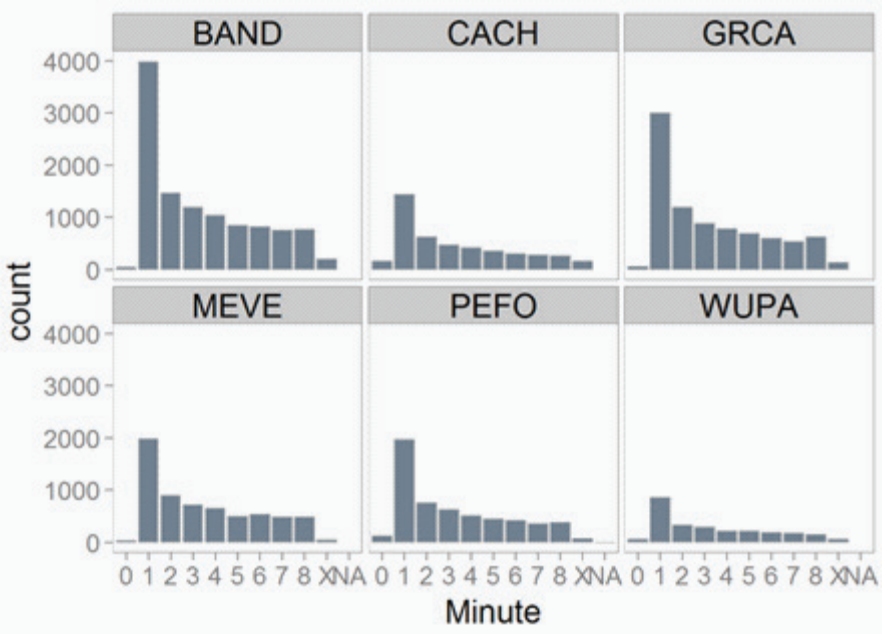


Figure 9-2. Example of a graphical summary of the data in R.

5.3.4 Data edits

Any changes to the data that result in discrepancies between the values in the database and the data sheet are tracked in tbl_DBChanges and are identified by the table level unique ID. In addition, the master database is under version control in GIT, so that any changes made after certification are tracked. This allows any previous changes to be reversed or the state of the data at any point in time to be recreated.

5.3.5 Geospatial data

The Project Lead and GIS Specialist work together to review the surveyed coordinates and other geospatial data for accuracy. The purpose of this joint review is to make sure that geospatial data are complete and reasonably accurate, and also to determine which coordinates will be used for subsequent mapping and field work.

5.3.4 Data certification

Data certification is a benchmark in the project information management process that indicates that: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks (SOP 9, Data Quality Review); and 3) they are appropriately documented and in a condition for archiving, posting and distribution as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies that may or may not have been detected during quality assurance reviews.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is a requirement for all tabular and spatial data. In collaboration with the IMD Central Office, SCPN is in the process of establishing specific data certification processes that will be implemented in the near future.

As recently announced revisions to the IMD data certification guidance are completed, a more detailed Quality Assurance Plan will be developed for this protocol to include: data quality objectives, required QA/QC procedures, and how QA/QC data will be used to improve overall data qualtiy.

tbl_VCP_Count : Sex

Report the values for Sex.

```
sandlev %>%
  count(Sex)
```

```
## Source: local data frame [6 x 2]
##
##   Sex     n
## 1   F   356
## 2   M 11294
## 3   U  4098
## 4   f    13
## 5   m    33
## 6  NA 22937
```

Figure 9-3. This table illustrates how you can detect discrepancies in data with R. Notice that the sex "Female" is represented by both upper case F and lower case f. Only upper case values are acceptable for this category.

Report NA values in Vegetation_Type and VegCoverClass.

```
sandlmveg %>%
  filter(is.na(Vegetation_Type) | is.na(VegCoverClass)) %>%
  select(Unit_Code, PointID, Year, Vegetation_Type, VegCoverClass, Notes) %>%
  arrange(Unit_Code, PointID)
```

```
##    Unit_Code PointID Year          Vegetation_Type VegCoverClass Notes
## 1       CACH  CRp001 2012                     <NA>            NA  <NA>
## 2       CACH  CRp002 2012                     <NA>            NA  <NA>
## 3       CACH  CRp003 2012                     <NA>            NA  <NA>
## 4       CACH  CRp004 2012                     <NA>            NA  <NA>
## 5       CACH  CRp005 2012                     <NA>            NA  <NA>
## 6       CACH  CRp006 2012                     <NA>            NA  <NA>
## 7       CACH  CRp007 2012                     <NA>            NA  <NA>
## 8       CACH  CRp008 2012                     <NA>            NA  <NA>
## 9       CACH  CRp009 2012                     <NA>            NA  <NA>
## 10      CACH  CRp010 2012                     <NA>            NA  <NA>
## 11      CACH  CRp011 2012                     <NA>            NA  <NA>
```

Figure 9-4. An example of an R table that shows which plots are missing data.

2 Revision history

Provide the following information for each revision made to SOP 9.

New version:

SCPN_Birds_SOP9_YYYYMMDD

Date:

Author:

Sections affected:

Changes & reasons:

Standard Operating Procedure #10: Data Summary and Reporting

Version SCPN_Birds_SOP10_20150930				
Revision History Log				
Previous version number	**Revision date**	**Section and paragraph**	**Change(s) made**	**Approved by**

Only changes in this specific SOP will be logged here. Record the previous version number and date of revision; identify sections and paragraphs where changes were made, who approved the revision, and the new version number. More detailed descriptions of the changes made and the reason for the changes is provided at the end of this SOP.

This standard operating procedure (SOP) describes the steps required to prepare and summarize the SCPN Habitat-based Bird Community Monitoring Program data for analysis, and provides guidelines for preparing annual summary reports and periodic trend reports.

1 Data summary

1.1 Preparation and summary of variable circular plot (VCP) data

Data will be summarized at the level of the target habitat within a particular park. The target populations for monitoring upland bird communities correspond to a dominant vegetation type of interest at each park where monitoring is occurring. For example, the target populations for monitoring riparian bird communities are the riparian corridors along streams that correspond to the focus of riparian vital sign monitoring.

For VCP data, the sample unit is dependent on the methods used to spatially allocate sampling points, which vary by the size of the sampling frame. For large sampling frames involving large target populations (e.g., mixed conifer forests on the North Rim of Grand Canyon NP and grasslands at Petrified Forest NP), the cluster sampling method is used. Primary sampling units (PSU) are selected in a probabilistic manner from a grid of regularly-spaced (e.g., 250 m) points using the Generalized Random-Tessellation Stratified (GRTS) design (Stevens and Olsen 2004). Each PSU serves as the center plot for a cluster of 8 or 9 other sampling plots, and all 9 or 10 of these plots serve as secondary sampling plots (SSU) where VCP data are collected. For target populations with cluster sampling, the cluster is the sample unit. The data for a given cluster are averaged across the two counts at each VCP, and a cluster's mean and standard deviation are calculated. Then a mean and standard deviation for the target habitat-based population are calculated from the cluster means.

The second method used to spatially allocate sampling points, simple grid sampling, is similar to a census sampling design, and

will be used for target populations with limited spatial extent (e.g., pinyon-juniper at Mesa Verde NP). For these sampling frames, all points falling within a grid of regularly-spaced points (e.g., 250 m) form the sampling plots. For simple grid sampling, the sampling unit is the VCP; to calculate a mean and standard deviation for the target habitat-based population, the data are averaged across the two counts and all VCPs.

The following data are summarized for the target habitat-based bird community:

- Observed species richness (unadjusted for detectability) is the number of species detected within a given area and specified time.
- Total number of detections is calculated as the total number of detections for each species summed across the VCP counts.
- Proportion of all detections is the percentage of the total detections of all species contributed by a particular species.
- Mean number of individuals detected for each species is reported as the average number of individuals detected per 8-minute VCP count. To calculate mean number of individuals detected for each species with cluster sampling, the data for a given cluster are averaged across the VCP counts, and the mean number of individuals detected and the standard deviation are calculated. Then the cluster means are used to calculate the mean number of individuals detected, and the associated standard deviation for the target habitat. For simple grid samples, the data for all VCP counts are averaged, and a mean number of individuals detected and standard deviation are calculated for the target habitat.
- Frequency is the proportion of plots "occupied" by each species. To calculate species frequency for cluster samples, the proportion of plots occupied in each cluster is calculated first. For example, if a hermit thrush was detected on six of the nine plots in a cluster during any or all of the three visits to that plot, the proportion of plots occupied in that cluster is 0.67 (67%). Then the mean proportion of plots occupied across the ten clusters is calculated for the target habitat. For simple grid samples, the proportion of VCPs in the target habitat in which the species was detected is calculated. For example, if a gray flycatcher is detected on 30 of 86 VCPs in the target habitat during any or all of the counts conducted at a VCP, the proportion of plots occupied in the target habitat is 0.35 (35%).

Table 10-1 provides a list of all calculations made using the bird data for the annual reports.

1.2 Preparation and summary of habitat data

Habitat data will be used with bird sampling data to examine bird habitat relationships. Habitat data are collected within a circular 0.8 ha macroplot which contains four subplots and is centered on each VCP. Habitat data are summarized at two to three levels, depending on the sampling design (cluster or simple grid). For cluster designs, data are summarized at three levels: the macroplot, the cluster, and the target habitat-based population. For simple grid designs, data are summarized at two levels: the macroplot, and the target habitat-based population.

The metrics shown in Table 10-2 are used to describe bird community habitat. They are generally considered to influence the distribution and abundance of bird species, and affect individual survival and reproduction. Use and development of metrics and indices for monitoring bird communities of the SCPN will be an ongoing process as monitoring data are collected. Initial analyses will emphasize correlating changes in bird species composition and abundance/density with changes in habitat variables.

- **Vegetation type cover.** The macroplot provides estimates of the percent cover of the major vegetation type(s) and other land-use cover types within a 50 m radius plot centered on the bird sampling

Table 10-1. Bird sampling data summary calculations for data summary reports.

Metric	Description	Units	Cluster-based calculation	Simple grid-based calculation
Total number of detections	Total number of detections per bird species	Individual detection	Σd_i (where di is the number of detections of the species in a VCP count)	Σd_i (where d_i is the number of detections of the species in a VCP count)
Proportion of all detections	Proportion (%) of detections of all species contributed by a species	%	$1/n \Sigma d_i$ (where d_i is the number of detections of the species in a VCP count, and n is the total detections of all species)	$1/n \Sigma d_i$ (where d_i is the number of detections of the species in a VCP count, and n is the total detections of all species)
Mean number of individuals	Mean number of individuals detected per VCP count	Individual detection	$1/N \Sigma (1/n_c \Sigma d_{ic})$ (where d_{ic} is the number of detections of the species during a VCP count in a cluster, nc is the number of VCP counts conducted in a cluster, and N is the number of clusters in the target habitat)	$1/n \Sigma d_i$ (where d_i is the number of detections of the species in a VCP count, and n is the number of VCP counts conducted in the target habitat)
Frequency of occupied plots	% of VCP plots where a species was detected	%	$1/N \Sigma (1/n_c \Sigma f_{ic})$ (where f_{ic} is the number of VCP where the species was detected in a cluster, nc is the number of VCP in a cluster, and N is the number of clusters in the target habitat)	$1/n \Sigma f_i$ (where f_i is the number of VCPs where the species was detected and n is the number of VCPs in the target habitat)
% clusters occupied	% of clusters in a target habitat where a species was detected	%	C/N (where C is the number of clusters where a species was detected and N is the number of clusters in the target habitat	

Table 10-2. Metrics used to describe bird community habitat.

Metric	Description	Units	Calculation
Macroplot vegetation type cover	mean vegetation cover based on cover class midpoints	%	$1/n \Sigma V_i$ (where V_i is the midpoint of the cover class of the vegetation type for a macroplot and n is the number of macroplots)
Tree basal area (Cruz- All)	total tree basal area, and by species	m^2/ha	(#hits)(BAF) (ft/acre)(0.0929m^2/ft^2)(1 acre/0.405 ha)
Snag basal area (Cruz- All)	total snag basal area	m^2/ha	(#hits)(BAF) (ft/acre)(0.0929m^2/ft^2)(1 acre/0.405 ha)
Height of vegetation strata	mean functional group height based on height class midpoints	m	$1/n \Sigma h_i$ where h_i is the midpoint of the height class of the vegetation strata for a functional group in a subplot and n is the number of subplots in a macroplot
Cover of vegetation strata	mean functional group cover based on cover class midpoints	%	$1/n \Sigma c_i$ (where c_i is the midpoint of the cover class of the vegetation strata for a functional group in a subplot and n is the number of subplots in a macroplot
% Canopy closure	mean canopy closure	%	1/n Σ (#dots covered/96×100) where % canopy closure for a subplot =1/n ∑ (#dots covered/96×100), and n is the number of measures taken per subplot (i.e., 4)
Sapling density	sapling density by species and by size class	stems/ha	#s/0.007854 where #s=number of saplings in a subplot; presumes saplings are sampled in a 5 m radius circular subplot
Foliar cover of functional groups	mean cover of functional vegetation category based on cover class midpoints	%	$1/n \Sigma f_i$ where f_i is the midpoint of the cover class of the functional group for a subplot and n is the number of subplots

point. In each macroplot, cover of major vegetation types, and other cover types, are estimated by cover class; and the mean cover class midpoints are calculated for the cluster (if appropriate).

The mean cover class midpoints and their corresponding standard deviations are then calculated for the target habitat. Frequency of vegetation type is the number of macroplots where a specific vegetation type has been recorded as a proportion of the total number of macroplots. To calculate frequency for cluster samples, the proportion of plots in each cluster where the specific vegetation type had been recorded is calculated. Then the mean proportion of plots where the specific vegetation type had been recorded is averaged across the ten clusters to calculate frequency for the target habitat. For simple grid samples, the number of macroplots where a specific vegetation type had been recorded is calculated as a proportion of the total number of macroplots in the target habitat.

- **Tree and snag basal area**. Tree and snag basal area are measures of the number and size of trees and snags in a stand (an area of forest). From the sampling point (the center of the subplot), a count is made of all trees and snags larger than a certain critical size (which is a function of the diameter of the plant and its distance from the sample point). Basal area is measured using a Cruz-All, a type of angle gauge that consists of a metal sight with four different size openings (basal area factors [BAF]) of 5, 10, 20, and 40. In mixed conifer sites, the 10-factor opening of the Cruz-All is used. For multi-stemmed trees with no clear central stem (i.e., trunk) at some pinyon-juniper with *Juniperus monosperma*, and riparian sites, the Cruz-All is held horizontally and the 40-factor opening is used. For trees—the species of trees and tally the total number of "hits" for each species is recorded. For snags—the tree species is disregarded and the tally—the total number of hits—is recorded. Tree and snag counts are converted to basal area estimates (m^2/ha) using the formula: basal area = (#hits)(BAF [ft/acre])(0.0929 m^2/ft^2)(1 acre/0.405 ha). Total tree basal area is the combined basal area of all tree species.
- **Vegetation strata.** The vegetation layers categories (emergent, canopy, sub-canopy, shrub, and dwarf shrub) are meant to be flexible enough to describe a range of ecosystems of varying structural complexity. At some sites, only a single tree layer or shrub layer may be present. In others, one layer or another may be entirely absent from the site. Means of the height and cover class midpoints are calculated to provide the height and cover of strata in the macroplot. Mean height and cover of the functional groups are calculated for the cluster (if appropriate), and mean height and cover of the strata and their corresponding standard deviations are calculated for the target habitat.
- **Canopy closure** is estimated at four points within the subplot using a spherical densiometer. The number of covered "dots" is converted to percent canopy cover using the formula: (#dots covered/96)(100). The mean of the four measures comprises the canopy closure for the subplot. The mean of the four subplots is calculated to provide the canopy closure of the macroplot, a mean is calculated for the cluster (if appropriate), and mean canopy closure and its corresponding standard deviation are calculated for the target habitat.
- **Sapling density** is measured in two size classes (2.5 to < 5.0 cm DBH, and 5.0 to < 10.0 cm DBH), and is tallied in the 5 m radius subplot. Sapling density for each size class is calculated as the # saplings/0.007854 ha (the area of a 5 m radius circle). The mean of the sapling densities in the four subplots is calculated for the macroplot; mean density is calculated for the cluster (if appropriate);

and mean density and the corresponding standard deviation are calculated for the target habitat.

- **Foliar cover** of functional vegetation categories is estimated by cover class; and the means of the cover class midpoints are calculated to provide the cover of functional groups in the macroplot. Mean cover of the functional groups is calculated for the cluster (if appropriate), and mean cover of the functional groups and their corresponding standard deviations are calculated for the target habitat.

2 Preparation of data summary reports

Data summary reports will be generated for each park unit sampled for each year that sampling occurs (see the SCPN website for examples of bird community monitoring data summary reports: http://science.nature.nps.gov/im/units/scpn/publications.cfm?tab=2). In park units where multiple habitat-based bird communities are monitored, the data should be summarized in one report for each park. The primary objectives of these reports are to 1) summarize annual data and document monitoring activities for the year; 2) describe the current conditions of the resources; and 3) provide this information to park managers in a timely manner to increase data utility and improve communication within and among network parks.

Annual reports will consist of the following sections:

1. **Introduction and background**. This section includes background, purpose and objectives of the habitat-based bird monitoring program, park- or site-specific objectives, and report-specific objectives. This section should also contain site descriptions, management concerns, and new and ongoing park management activities with the potential to impact bird and bird-habitat resources.
2. **Methods**. This section includes a summary of monitoring activities that occurred at the target habitat during the sampling year. This summary should include sampling locations, sampling dates, the type of data collected, and methods that were used. Methods should be briefly summarized, with references cited to indicate where to find more detailed descriptions. A brief description of data analysis methodology should be included.
3. **Results.** This section should include a summary of all the data collected in graphical, tabular, and narrative form. When appropriate, selected data from previous years should be included to provide a frame of reference for the present year's data. The report should also include a habitat-scale summary of the habitat data, including measures of central tendency and variability. Documentation of antecedent habitat conditions (if information is available) that may influence this year's data should also be included in this section.
4. **Discussion.** This section should provide a description of the current conditions of habitat-based bird communities, and a comparison with previous sampling years' conditions. The narrative should include how this year's sampling effort fits within the context of previous years (e.g. annual precipitation was above average, or the sampling was conducted earlier in the field season).
5. **Literature cited.** This section provides references for literature cited in the text.

Examples of bird community data summary reports can be found on the SCPN webpage under the heading Monitoring Data Summary Reports (http://science.nature.nps.gov/im/units/scpn/products.cfm#Monitoring).

3 Preparation of periodic trend reports

3.1 Conducting distance modeling and estimating density

After multiple years of sampling within a target habitat, the software program Distance (Thomas et al. 2010) will be used to

model detectability. The data analyst should use the most recent version of Distance, available free at http://distancesampling.org/ to model detectability and estimate density. Guidance for analyzing the SCPN bird data in Distance is provided below, but details on how to use the software and conduct analyses associated with distance sampling are beyond the scope of this SOP. Distance has a user-friendly interface and a user's manual that explains how to use the software. The user's manual assumes that the user is already familiar with distance sampling concepts and statistics. Data analysts that lack familiarity with distance sampling theory and analytic options provided by Distance should consult Buckland et al. (2004).

The SCPN analyst will model detection probabilities using a database comprised of all detections for a given target habitat. Adequate sample size of bird detections is essential to obtain reasonably precise density estimates from detectability modeling. Thus, only the more common species, those with approximately 100 detections within a given target habitat, will be included in analyses.

For less common species, with less than 100 detections, it will be necessary to derive detection functions based on species detections amassed during additional years of monitoring. In cases where it may not be possible to estimate the density of a species within a particular bird habitat sampling frame (for example, of a rarely detected species), occupancy, defined as the proportion of the area occupied by the species, can be used as an alternate state variable for abundance. As data is amassed over multiple years, sample sizes will allow the analyst to test the effects of variables, such as year, survey period, and observer on detection probability, and develop the best possible detection functions for particular species.

For target habitats with a simple grid sampling design, the density estimate for each species will be calculated by pooling data for all VCP counts conducted in the habitat to derive the detection function. For target habitats with a cluster sampling design, the density estimate for each species will be calculated by pooling data for all VCP counts conducted within the cluster to derive the detection function. An information-theoretic approach (Akaike 1973, Burnham and Anderson 1998) will be used to assess whether cluster-specific models are preferable to "pooled points" models for the target habitat.

The following are guidelines for building and testing detectability models.

1. First, import monitoring data into Distance.
    - Create a text file that contains all detection records for all species of interest within the target habitat.
    - The file should contain fields indicating park, habitat, cluster ID, VCP identification, species (4-letter codes), and detection distance.
    - Detections classified as "flyovers" should be omitted from the text file.
    - There must be a record for every VCP and VCP count made at the VCP, in the year of interest.
    - For VCP counts where no birds were detected, there should be a single record with species = "none". Failure to account for VCP counts with no detections will cause an upward bias in the results.
    - Other fields may be added to enable exploring additional possible covariates of detectability (e.g., observer).
    - The records in the text file must be sorted in the correct order: habitat (and/or grouping defined by other variables that may affect detectability, such as observer or year), cluster ID, and species.
2. Once the text file is complete, follow the general instructions provided in the Distance User's Manual to create a project and import the data.
3. When data have been imported, use the **Analysis** tab to construct and test detectability models for each species with

adequate data.

- Use criteria, including Akaike information criterion (AIC), model fit statistics, and biological 'reasonableness', of the models to determine the best model for estimation.
- Record the essential parameters of the selected model(s) for each species: truncation point (w), detection probability estimate (P), standard error of the detection probability estimate (se of P), and degrees of freedom of the detection probability estimate (df of P). These values should be included in the multi-year report.

3.2 Estimating species density

Once the detectability model parameters have been derived, they should be used to estimate density of each species at each cluster (if appropriate) or at the target habitat level, for each year(s) under consideration.

1. To estimate site-specific densities for a particular year in Distance, use the dataset text file described above, which contains all detections for the target habitat and year of interest.
   - The file should contain fields indicating park, habitat, cluster (if appropriate), VCP identification, species (4-letter codes), and detection distance.
2. Import the text file into Distance.
   - At step 5 in the *New Project Setup Wizard* check the box indicating **Add Multipliers for: Other**.
   - When running the calculations for each species and each target habitat, use the **Data** tab to enter the appropriate, species-specific multiplier (detection probability) estimate, standard error, and degrees of freedom values from the previous modeling efforts.
   - Use the data filter to specify the species, and the truncation point (the distance that was used in generating the model).
3. When defining models, select the uniform key function with no series expansions—this way the program will simply use the parameter values that you have specified, without constructing new models.
4. Specify 'Site' under **Level of Resolution of Estimates** in the **Model Definition Properties** box to instruct the program to return a density estimate of the species indicated in the data filter at each cluster or, for target habitats with simple grid sampling, at each target habitat.

3.3 Analyzing trends

Trend reports will be prepared after multiple years of sampling within a target habitat. The main objectives of trend reports, as described in Thomas et al. 2006, are to (1) report patterns and trends in condition of resources being monitored, (2) report new characteristics of resources, and correlations among related vital signs, (3) report the degree of change that can be detected by the current level of sampling, and (4) provide interpretation of monitoring data in a park context.

To enable tracking trends in species richness, a capture-recapture model (e.g., Williams et al. 2002), which corrects for species present but undetected, will be used. A capture-recapture model estimates species richness using a bootstrap method in which points are resampled with replacement. The model provides an estimate of the mean number of species present, standard errors, and 95% confidence intervals.

Least-squares regression will be used to test for significant differences in relative abundance and density among years. Initially, it will be useful to examine the response patterns of bird species to environmental gradients and habitat variables. A first step is to relate key habitat measures with bird species abundance and distribution using correlation and multivariate analysis.

Correlation analysis is used to identify the

bird-habitat variables that are most closely related and are of highest interest. The strength of the relationship can be obtained using Pearson's correlation (or Spearman's rank correlation as a nonparametric method).

Multivariate techniques (e.g., PCA or Principal Component Analysis) can be used to examine the structure, or interdependence, of habitat variables (Morrison et al. 2006). Multivariate techniques (e.g., multiple regression, logistic regression) can be used to further analyze relationships between bird abundance and one or more explanatory variables (e.g., % canopy closure, basal area). In addition, programs such as 2t spatial modeling to explain animal distribution with respect to habitat and other explanatory variables (Buckland et al. 2004, MacKenzie et al. 2006).

Ordination techniques may also be used to arrange bird abundance data or habitat variables in terms of their similarity to investigate bird-habitat relationships. Ordination methods for conducting indirect gradient analysis are appropriate for SCPN bird abundance data because sampling units are not formally partitioned along an environmental gradient.

Two commonly used methods of indirect gradient analysis are Detrended Correspondence Analysis (DCA) and Nonmetric Multi-Dimensional Scaling (NMDS). One difference between these methods is that DCA is based on an underlying unimodal model for species distributions. NMDS does not assume an underlying data structure, and thus may be a good choice when factors determining species composition are unknown.

Aerts et al. (2008) analyzed bird community composition and environmental data using NMDS, and found community changes along a gradient of vegetation structure and density. They also used Spearman rank correlations to identify several significant habitat variables correlated to the first two NMDS axes. Kirk and Hobson (2001) used DCA and CCA (canonical correspondence analysis) to identify important environmental gradients in the composition of 42 bird species in Canadian pine forests.

Data could also be used to model changes in bird communities (abundance, distribution, richness) in response to changes in habitat characteristics. After multiple years of sampling, these data could be used to build habitat-association models that would facilitate identification of important variables at multiple spatial scales, identify target species for conservation, and build predictive models (e.g., Scott et al. 2002). Guidance for building models of bird-habitat relationships is beyond the scope of this protocol; useful references providing reviews and examples of various approaches include McGarigal et al. (2000), Scott et al. (2002), and Morrison et al. (2006).

4 Revision history

Provide the following information for each revision made to SOP 10.

New version:

SCPN_Birds_SOP10_YYYYMMDD

Date:

Author:

Sections affected:

Changes & reasons:

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Standard Operating Procedure #11: Revising the Protocol

Version SCPN_Birds_SOP11_20150930				
Revision History Log				
Previous version number	**Revision date**	**Section and paragraph**	**Change(s) made**	**Approved by**

Only changes in this specific SOP will be logged here. Record the previous version number and date of revision; identify sections and paragraphs where changes were made, who approved the revision, and the new version number. More detailed descriptions of the changes made and the reason for the changes is provided at the end of this SOP.

This standard operating procedure (SOP) explains how to make and track changes to the Habitat-Based Bird Community Monitoring Protocol for the Southern Colorado Plateau Network. Over time, the protocol narrative and SOPs may require modifications. The following procedures must be followed when making changes to ensure that previous data collection and processing procedures are clearly understood and accounted for when using and interpreting data collected under this protocol. Similarly, clearly articulating new methods is critical to credible interpretation of data acquired after the implementation of changes. Personnel making changes must be familiar with this SOP to ensure that proper reviews are conducted, and that documentation standards are followed.

1 Modifications

Small changes or additions to existing methods will be reviewed in-house by SCPN staff. An outside review will be considered for major changes in methods. All modifications will trigger the creation of a new version of the SOP or narrative that will go through the process outlined here. In short, modifications will result in a new version of the narrative or an SOP. The new SOP will be used in data collection, identified by version in the database to allow linking data to collection methods, and will be published as a unique version to IRMA.

2 Revision history

All changes must be documented, and updated protocol versions must be recorded in the Revision History Log that accompanies the protocol narrative and each SOP, and a more detailed explanation of the changes and justifications will be provided at the end of each document. Changes are recorded only in the document being modified (protocol narrative or SOP). Date stamps are used to identify versions because they are more intuitive and easier to manage. The revision history will include the SOP version, author, sections affected, a description of the changes, and the justification (reason) for the

changes.

Here is an example:

SCPN_Birds_SOP11_20150910

Author: Lee McCoy

Section(s) affected: 11.2

Changes & reasons: The method used for documenting revisions was changed from a table, with limited space for describing the changes made to the SOP, to a more narrative approach as an addendum to each SOP

3 Narrative and SOP updates may occur independently

A change in one SOP will not necessarily invoke changes in other SOPs, or the narrative (but it could). The narrative and SOPs will be maintained as separate documents so that changes can be made and tracked independently. As the narrative or SOPs are revised, they will go through the steps described in section 11.6, including adding the updated SOP to IRMA. Updates to an SOP can be quickly tracked independently of the other SOPs and independently linked to the data collected by version.

4 Tracking the SOP used to collect data

All of the data in the Habitat-Based Bird Community Monitoring Database must be linked to the exact methods and procedures used during collection. Since the SOPs can change over time, it is critical to identify the SOP version associated with each record in the database. The SOP version used to collect each of the major types of data will be included for each record. To facilitate linking data with the exact methods used to collect it, a look up table in the database identifies the current version of each of the SOPs. As data is collected, each record is tagged with the relevant active SOP version. Data comparability between years and with other datasets can be confirmed or filtered by reviewing the SOP versions used during data collection.

5 Proposed file structure

Since the narrative and SOPs will be tracked and modified independently, each SOP will be maintained in its own sub-directory of the protocol folder. Figure 3 illustrates a suggested file structure that will facilitate the process of modifying and tracking each of the SOPs. The narrative and each SOP will have the same sub-folder structure as is shown for SOP04. The MS Word, Adobe Indesign, and PDF files are examples to show the file name convention.

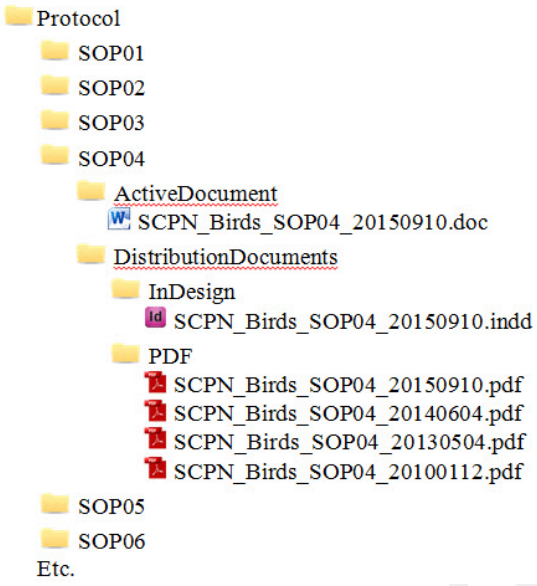

Figure 11-1. Proposed file structure for tracking Habitat-based Bird Community Monitoring Protocol SOPs.

6 Revision procedures

This section describes the process and person responsible for each step in revising the narrative or SOPs. When it is determined that changes are needed, the project manager should alert the data manager as soon as possible–especially if the methods changed will occur mid-field season. The project manager makes a copy of the active version from the ActiveDocument folder and makes the desired changes. After consulting with the program manager and data manager and securing the proper internal or external reviews, the project manager gives a completed draft to the editor. The editor replaces the

old version with the new in the ActiveDocument folder. The editor then creates and updates a new version in InDesign. The editor and project manager may make additional changes as the editor transfers these changes into InDesign. These changes should also be made in the MS Word version in the ActiveDocument folder so they are present in the active version for future editing. When complete, the editor creates a final pdf, publishes the new version to IRMA (https://irma.nps.gov/App/Portal/Home), and alerts the data manager and project manager that the new version has been published.

7 Tracking SOPs in the database

The SOP used when collecting each data record is recorded in the database at the appropriate level. For example, SOP04 version (which covers collecting bird counts) should be recorded for each record in tbl_Events_VCP. The current version of each relevant SOP is kept in a look up table (tlu_CurrentSOP) and is set to auto-populate as each record is created. When a change is made to the SOP, the name of the active SOP is updated in tlu_CurrentSOP. New data collected with the methods described in the new SOP are tagged with the new SOP version. The timing of changing an SOP version in the database is critical. For the most part, the expectation is that changes to SOPs will occur in between sampling seasons. After the SOP changes are complete, the new SOP version can be incorporated into the blank back end and front end database sent into the field. If, however, the method change occurs mid-season, it may be necessary to change the SOP version in the database before the changes are completely documented and published. Any methods changes made in the field should be immediately brought to the attention of the data manager so that the SOP version can be updated in the database.

8 Revision history

Provide the following information for each revision made to SOP 11.

New version:

SCPN_Birds_SOP11_YYYYMMDD

Date:

Author:

Sections affected:

Changes & reasons:

Appendix A

Sampling Frame for Habitat-based Bird Community Monitoring

1 Overview of sampling frame development

This appendix describes the development of the sampling frames for the Southern Colorado Plateau Network (SCPN) habitat-based bird community monitoring project. Detailed descriptions are given for each park and ecological site.

Six SCPN park units and seven habitat types have been selected for bird monitoring. Habitat-based bird monitoring was designed in conjunction with the SCPN Integrated Upland Vegetation and Soils Monitoring project. As a first step, discussions were held with SCPN and staff of selected parks staff to determine the park's management priorities. Depending on the size of the park and complexity of the ecosystems, these discussions took place in meetings, teleconferences, and/or emails. Science advisors may have participated in the discussions, but the final priorities were determined by park staff. The target habitats for bird monitoring were typically a subset of those chosen for upland vegetation monitoring. SCPN staff then identified the associated NRCS ecological sites and/or soil map units that corresponded to the ecosystems or habitats of interest. In addition to upland habitats, riparian habitat at CACH was selected for bird community monitoring and that spatial design is described in section 7 of this appendix.

For monitoring upland vital signs, SCPN has adopted the characterization of landscapes into ecological sites as the basis for sampling site selection. The concept of ecological sites was developed by the Natural Resources Conservation Services (NRCS) in association with the Soil Survey Geographic Database (SSURGO) information (U.S. Department of Agriculture 2003). An ecological site is a landscape division with specific physical characteristics that differs from other landscape divisions in its ability to produce distinctive types and amounts of vegetation, and in its response to management (Society for Range Management Task Group on Unity in Concepts and Terminology 1995). Ecological sites have characteristic soils, hydrology, plant communities, and disturbance regimes and responses (U.S. Department of Agriculture 2003). As defined, ecological sites are not expected to change.

Additionally, ecological sites are characterized by state and transition models that describe vegetation dynamics and management interactions for each site. Ecological sites are not explicitly mapped in NRCS soil surveys. Instead, ecological sites are associated with specific map unit components, which, in turn, are associated with 'map units'—the finest spatially-defined features. Each map unit may be composed of multiple map unit components, and the soil survey includes an estimate of the proportion of each component (and therefore ecological site) within a map unit. Table A-1 provides a summary of the targeted upland habitats and selected ecological sites to be monitored. At two parks (GRCA, BAND), there was not a direct correspondence between ecological sites and specific vegetation types. At GRCA, the ecological sites dominated by mixed conifer forest also contained large areas of ponderosa pine forest at lower elevations. The soil-based ecological site was modified to remove these lower elevation areas. At BAND, the most recent high resolution soils map did not have ecological sites assigned to the soils and was not part of a SSURGO survey. Consequently, target soil units were chosen through additional field visits and consultations with park resource managers.

Habitat-based bird community monitoring is conducted in fewer parks than upland vegeta-

Table A-1. The target habitats and selected ecological sites for SCPN upland bird monitoring.

Park	Target habitat	Selected ecological site
BAND	Mixed conifer forests	Multiple, dominated by Calaveras soil component
GRCA	Mixed conifer forests	(1) Loamy Hills, Cold, 25–33″ pz (2) Loamy Hills, 25–33″ pz
	Pinyon-juniper woodlands	Limestone Upland 13-17″ pz
MEVE	Pinyon-juniper woodlands	(1) Loamy Mesa Top (2) Shallow Loamy Mesa Top
PEFO	Grasslands and shrublands	(1) Sandy Loam Upland (2) Clayey Fan
WUPA	Grasslands and shrublands	(1) Volcanic Upland 10–14″ pz (2) Loamy Upland, 6–10″ pz

tion monitoring. In general, we limited implementation of habitat-based bird community monitoring to parks with large contiguous areas of the target habitats. Within those parks, the same ecological sites were generally chosen for both vegetation and bird monitoring. An exception was MEVE, where the original target ecological site for upland vegetation monitoring had a limited extent. It was expanded for bird monitoring to include an adjacent ecological site with similar vegetation. Since then the upland vegetation monitoring program has added this ecological site.

We are also monitoring habitat-based bird communities within the riparian zone at CACH. See section 7 for a description of the CACH sampling frame.

The objectives of the SCPN habitat-based bird monitoring program are (1) to determine the status and trends in composition and abundance of breeding bird communities associated with riparian and predominant upland habitats within select park units and (2) to improve our understanding of breeding bird habitat relationships by correlating changes in species composition and abundance/density with changes in specific habitat variables. Meeting these objectives requires that the monitoring program be designed to provide adequate statistical power to detect a trend if one exists.

As part of sampling design development, we used existing datasets of bird counts conducted in similar habitats within the region to make a conservative estimate of power. We estimated variability and the number of VCP counts needed to track changes in species abundance and richness, and to model detection functions and estimate densities of individual species. We estimated that, within a target habitat, 150 to 200 VCP counts (i.e., samples) should be conducted within a breeding season. We improved power in our sampling design by 1) monitoring within specific habitat types, reducing spatial variability; 2) sampling the same points within and across years, reducing site variability; and 3) conducting multiple visits (2) per year, reducing variability due to phenological changes in breeding behavior and detectability.

1.1 Sampling frame adjustments

After the target ecological sites and associated map units were chosen, SCPN staff refined the sampling frame to create a realistic sampling population (steps used to modify the sampling frame are described in Table A-2). Areas not suitable for monitoring were excluded from the final sampling population. There were three general categories of exclusion:

- Areas not within the target ecological sites. These included areas on or near roads, some utility lines, visitor facilities, ruins, or other developed areas. A buffer was applied to these features to ensure that all areas within likely hearing distance (for bird songs and calls) were excluded. In some cases, additional buffer distance was added if it seemed

Table A-2. Steps used to modify the sampling frame

Condition	Additional buffer distance	Comment	Affected parks
Areas outside ecological site soil unit	100 -125 m	Based on likelihood of hearing bird songs or calls from beyond this range	All
Roads or other infrastructure (developed areas, ruins, buildings, structures)	200 m for interstate highways, 100 m for all other features.		All
Slope: retained ≤20% in unforested and shrubland ecological sites (PEFO, WUPA), and ≤30% in forest and woodland ecological sites (BAND, GRCA, MEVE)	0–45 m		All
Fires (forest and woodlands)	100 m in mixed conifer, 125 m in pinyon-juniper woodland	Removed moderate to high severity categories in BAND and GRCA; removed all area within burn perimeter in MEVE	BAND, GRCA, MEVE
Fuels treatments	100 m	Variable by park and treatment plan	BAND, GRCA, MEVE
Research plots	50 m	In consultation with park staff	MEVE
Accessibility/site grouping	Retained areas within two hours combined driving and walking distance and with groups of nine or more points		All

likely that the disturbance from the feature would affect a larger area. In some cases, good spatial data are not available and field visits were required to identify sites to be rejected.

- Areas where site conditions differ substantially from the norm. Although natural disturbance processes, such as fire, may be integral to upland ecosystems, including too great a range of current conditions may detract from our ability to detect trends in the target population. Consequently, we consulted with park staff as we considered whether or not to exclude areas exposed to recent moderate or high severity fire. As monitoring continues over time, we will consider a range of options in consultation with park staff, including further sampling frame modifications or following disturbed plots in response to severe disturbance events. Other exclusions were generally based on human disturbances, such as mechanical thinning treatments. Removal because of thinning or wildland fires was limited to mixed conifer forest and pinyon-juniper woodland ecological sites.
- Areas excluded due to practical sampling considerations. Steep slopes and areas with difficult access were excluded based on practical considerations. Areas on steep slopes were rejected because of safety concerns and concerns of increased erosion due to trampling from repeated site visits. Slope filters varied depending on vegetation type, with more heavily vegetated areas (mixed conifer forest and pinyon-juniper woodland) retaining areas with less than 30% slope, and shrubland, and grasslands site types retaining areas with less than 20% slopes.

1.2 Site accessibility

Monitoring birds places an additional constraint on site locations—field crew members must sample plots early in the morning, when birds are most active and singing. To accomodate this, a two-hour limit was set on the combined hiking and driving time to reach each group of 9 to 10 plots. This affected design of the sampling frame for parks. At MEVE,BAND, and WUPA, the sampling area was reduced to a size where a census of the entire remaining sampling area in the form of a simple grid was more appropriate. In this case, sampling days will still be organized by groups of points, but the groups represent a census, or simple grid,

rather than a sample of the target frame.

For parks with large sample areas, this constraint results in a cluster sampling design, where the primary sampling location must be large enough to accommodate 9–10 nearby points, such that the group can be sampled in a single morning. In most parks with a cluster sampling design, the sampling area was large enough to create organized 3×3 clusters of points, with the primary sampling unit in the center. However, at PEFO, the target sampling areas were smaller and more irregularly shaped, and so the clusters of points were also irregularly shaped. Figure A-1 presents a flow chart illustrating the decision process for selecting the spatial design. At most parks the accessibility of points was easy to determine, based on distances and average walking times. At some parks (PEFO, GRCA) average walking speeds could not be used because of site-specific conditions such as steep slopes or large areas of downed trees. At these parks a field assessment of accessibility was made after the preliminary site visits. This assessment was used to modify the final area of statistical inference to exclude areas that would not have met the accessibility and grouping limits.

1.3 Sampling site selection

The SCPN uses a Generalized Random-Tessellation Stratified design (GRTS) to provide spatial balance in site selection. This design also allows for rejection of sites, establishment of additional sites, and weighting of selection areas based on user-selected criteria (e.g. accessibility).

For most ecological sites, a set of spatially distributed sampling points was created using a script incorporating the GRTS design. These points represent starting points for creating the groups of points. The script was run using the R statistical computing software and the P.survey and P.design modules (http://www.r-project.org/). For bird monitoring sites, the script prioritizes points from an input grid of points covering the sampling area. The spacing of the grid points depends on the ecological site and is intended to ensure that bird sampling plots are independent (i.e. birds calling from one location cannot be heard from more than one sampling plot (see Table A-3 for spacing of grid points for habitat-based bird community monitoring). The output from the GRTS script is a set of primary points, around which the cluster of points are placed depending on the type of clustering used. All cluster points must also fall upon the grid of points, as shown in Figure A-1. Spatial balance is maintained by considering primary points in a sequential order; if a primary point is rejected, the next point in sequential order is used. For a few ecological sites, the sample frame was small, and so a census, or simple grid, was used instead of a sample.

1.4 Rejection criteria

Park staff typically reviewed the locations of the GRTS points or simple grid points provided in the initial research application, and rejected sites near sensitive areas (typically archaeological sites). Prior to plot establishment, the project manager conducted an assessment of

Table A-3. Spacing of grid points for habitat-based bird community monitoring

Park	Target ecosystems	Grid spacing
BAND	Mixed conifer forests	200 m
GRCA	Mixed conifer forests	200 m
	Pinyon-juniper woodlands	200 m
MEVE	Pinyon-juniper woodlands	200 m
PEFO	Grasslands and shrublands	250 m
WUPA	Grasslands and shrublands	300 m

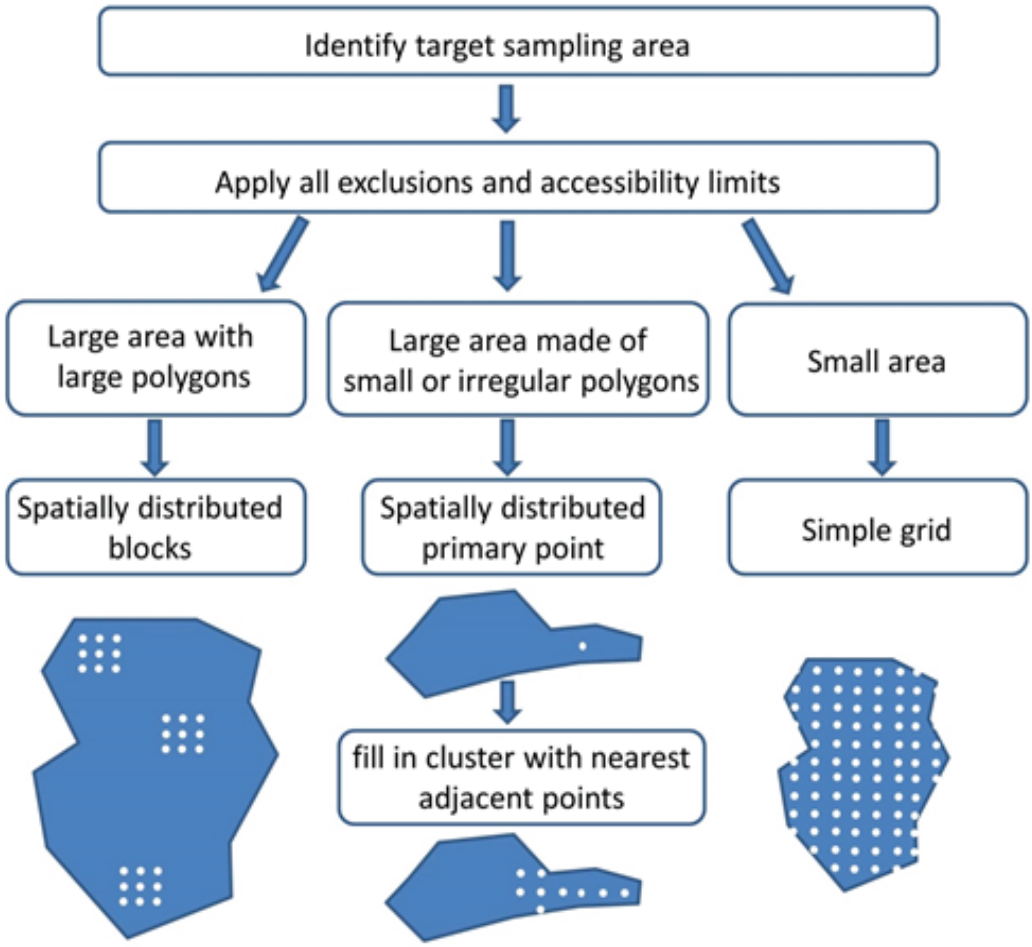

Figure A-1. Flow chart showing process for selecting cluster sampling or a simple grid as spatial sampling design. Decisions were based on the size and shape of the available sampling area.

each site. Sites were rejected if they were greater than two hours of traveling time (by car and foot) from the park's main entrance or camping area. Each sampling point was assessed to ensure that (1) it fell within the target habitat, (2) it did not exceed the slope steepness limits set for that ecological site, and (3) it did not contain a major disturbance. Any points that did not meet these criteria were rejected.

2 Grand Canyon National Park

2.1 Monitoring priorities

At Grand Canyon National Park (GRCA), two ecosystems were selected for upland monitoring by park and SCPN staff: mixed conifer forest, and pinyon-juniper woodland.

In the Grand Canyon, the mixed conifer forest type occurred within three ecological sites. One ecological site was eliminated because it occurred as a mix in soil map units with an unforested ecological site. The remaining two ecological sites were Loamy Hills, Cold (ABLA, PIEN) 25–33 in. p.z. and Loamy Hills (ABCO, PIPO, POTR5) 25–33 in. p.z. Each of these was estimated to occur at proportions of 80% or more within four associated soil map units. The

pinyon-juniper woodland occurred in the Limestone Upland 13–17 in. p.z (JUOS, PIED) ecological site with a single soil map unit estimated to occur at proportions of 75%. In consultation with the park, it was decided to focus monitoring efforts in the South Rim pinyon-juniper area because pinyon-juniper areas on the North Rim had a very sparse understory.

2.2 Mixed Conifer Ecological Site sampling frame

Four soil map units were combined to create the initial sampling frame for the mixed conifer forest. Each of the four soil map units contained 80% or more of the target Loamy Hills or Loamy Hills, Cold ecological site (Table A-4).

Table A-4. Soil map units for the targeted mixed conifer forest at GRCA. Source data from Natural Resource Conservation Services (NRCS 2001).

Soil map unit	Map unit Symbol	Percent of map unit associated with the target ecological site
Kaiparowits gravelly fine sandy loam 15–40% slope	49	80
Kanabownits-Kippers-Kaiparowits complex, cool, 2–15% slope	53	90
Kanabownits fine sandy loam 15–40% slope	51	80
Kanabownits-Kippers-Kaiparowits complex, 2–15% slope	52	95

2.2.1 Field reconnaissance

A field assessment of the target Mixed Conifer Ecological Site was made in October, 2006. The conclusions of this assessment were that 1) areas below 2,500 m in elevation should be excluded because of the prevalence of ponderosa pine forest at these lower elevations, and 2) upper elevation portions of the mixed conifer forest should be retained. Some of these high elevation areas had been mapped as spruce-fir forest on the most recent vegetation map. However, only small areas were found to be pure spruce-fir during the field visit; most had some mix with ponderosa pine.

2.2.2 Site grouping

Because bird monitoring sites must be arranged in groups of 9–10 sampling points, we chose a spatial grouping that would keep the sites in groups of 9 points, arranged in clusters of 3×3 points (Figure A-1). This 3×3 block method was chosen because of the relatively large polygons present in the Grand Canyon Mixed Conifer Ecological Site. To accomplish this, the sampling frame was further buffered to ensure that any point chosen for sampling could accommodate the 3×3 grid surrounding that point without falling outside the boundaries for the ecological site and its existing buffers. As a result, the area of statistical inference is limited to areas within which one of these blocks could have fallen. The finalized sampling frame for GRCA is shown in Figure A-2.

2.3 Pinyon-Juniper Ecological Site sampling frame

The pinyon-juniper woodland in Grand Canyon occurred within the Limestone Upland 13-17 in. p.z (JUOS, PIED) ecological site. A single soil map unit, estimated to occur in proportions of 75% (Table A-5) in the Limestone Upland ecosite, was used to create the initial sampling frame for the pinyon-juniper woodland. Target soil lineage came from the NRCS SSURGO database for Grand Canyon Area, Arizona, Parts of Coconino and Mohave Counties (NRCS 2005), and the target map unit is shown in Table A-5.

2.3.1 Field reconnaissance

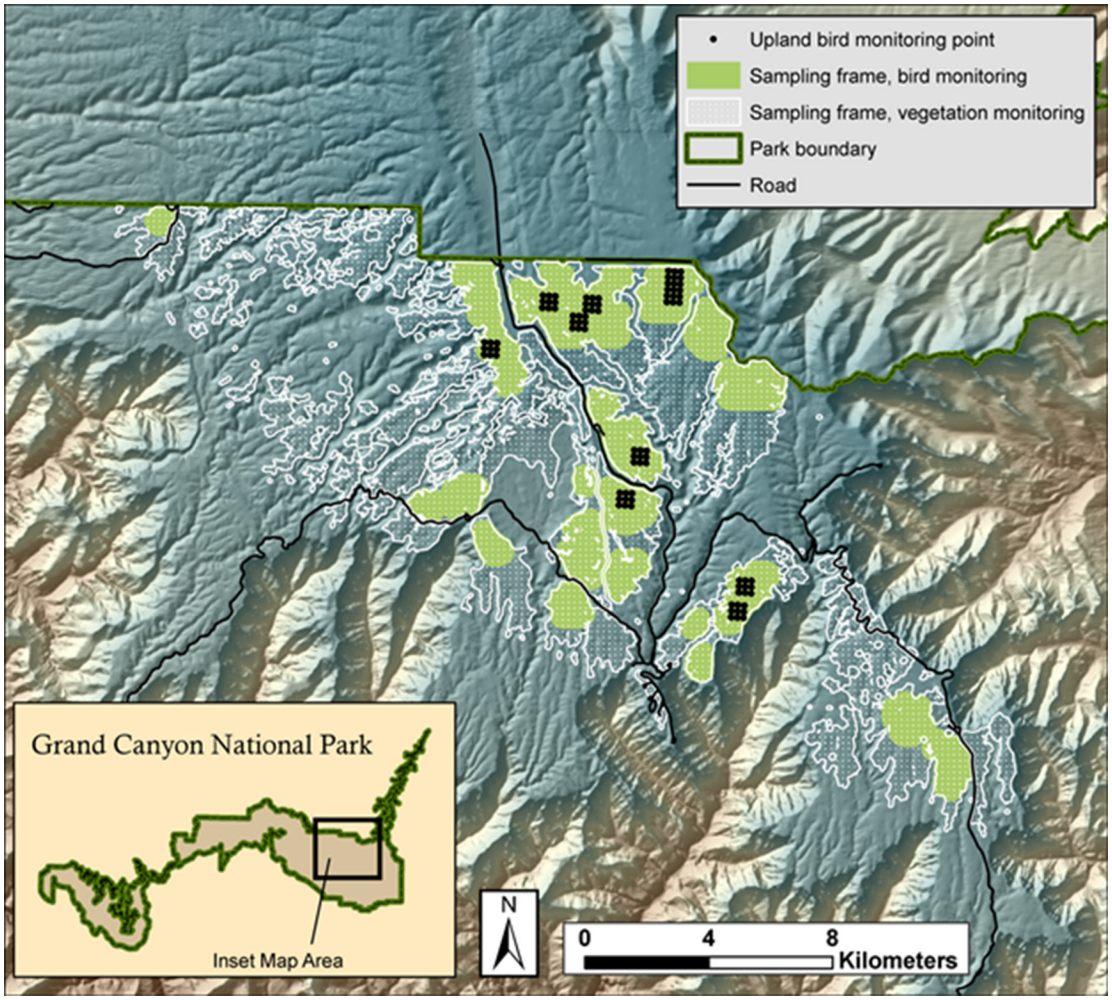

Figure A-2. Grand Canyon Mixed Conifer forest. Final sampling frame with location of bird monitoring plots and upland vegetation monitoring sampling frame.

Table A-5. Soil map units for the targeted pinyon-juniper woodland at GRCA. Source data from NRCS, 2005.

Soil map unit	Map unit Symbol	Percent of map unit associated with the target ecological site
Chunkmonk-Wodomont-Toqui families complex, 2 to 15% slopes	23	75

In fall, 2009, SCPN staff conducted a series of short reconnaissance trips to examine the variability in pinyon-juniper woodland composition. Areas on the North Rim in the Tuweep area had a very sparse understory, likely the result of grazing and fire history. It was decided to focus monitoring efforts on the accessible area around Pasture Wash and west of Hermit's Rest, on the South Rim. This area consists of a single soil map unit, the Chunkmonk-Wodomont-Toqui families complex, 2–15% slopes.

2.2.3 Site grouping

Because bird monitoring sites must be arranged in groups of 9–10 sampling points, we chose a spatial grouping that would keep the sites in groups of 9 points, arranged in clusters of 3×3 points (Figure A-1). This 3×3 block method was chosen because of the relatively large

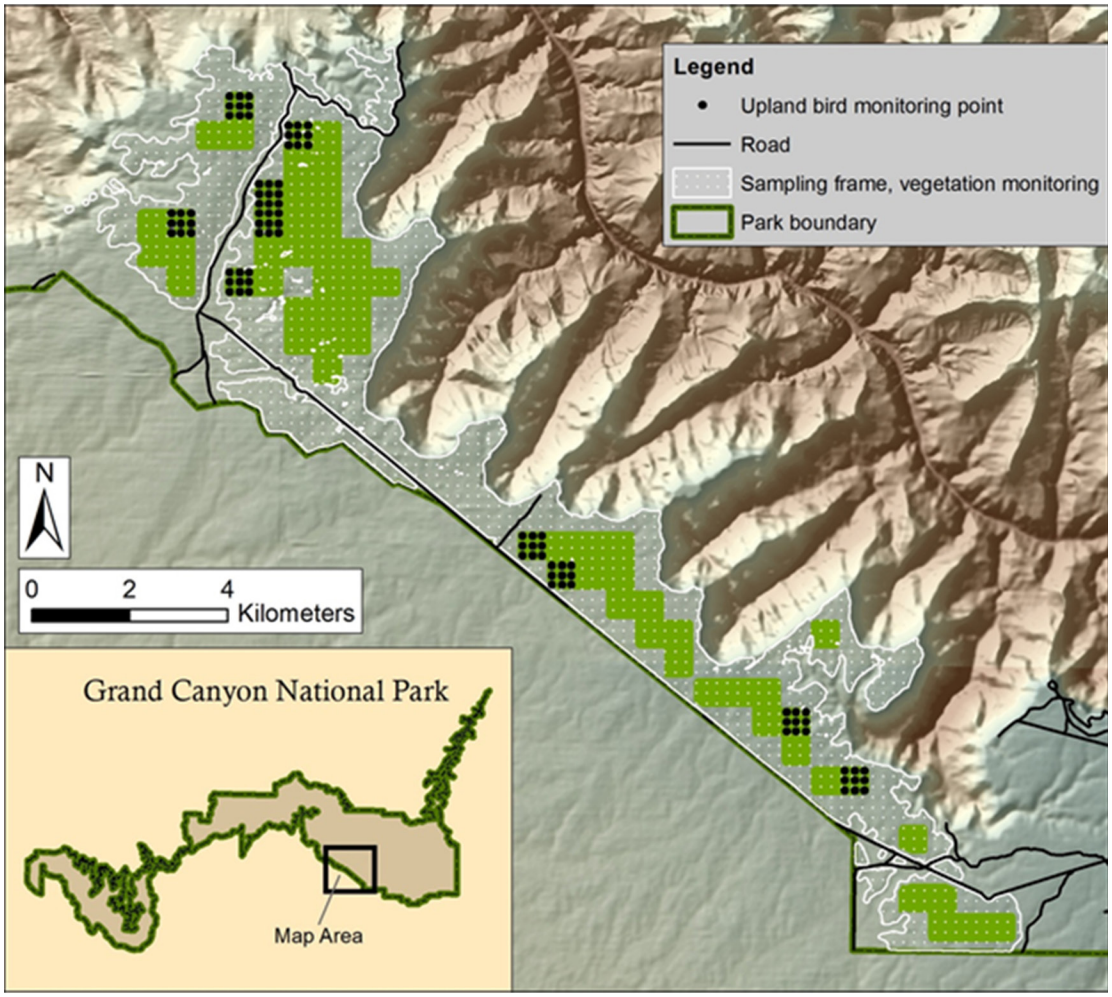

Figure A-3. Grand Canyon Pinyon-Juniper woodland. Final sampling frame with location of bird monitoring plots and upland vegetation monitoring sampling frame.

polygons present in the Grand Canyon Pinyon-Juniper Ecological Site. To accomplish this, the sampling frame was further buffered to ensure that any point chosen for sampling could accommodate the 3×3 grid surrounding that point without falling outside the boundaries for the ecological site and its existing buffers. As a result, the area of statistical inference is limited to areas within which one of these blocks could have fallen The finalized sampling frame for GRCA pinyon-juniper is shown in Figure A-3.

3 Mesa Verde National Park

3.1 Monitoring priorities

At Mesa Verde National Park (MEVE), high priority ecosystems were identified during meetings between network and park natural resources staff in May 2006. The pinyon-juniper ecosystem was selected as the first priority for upland ecosystem monitoring. In addition to the pinyon-juniper ecosystem, the mountain shrub community was identified as an important ecosystem, but considered less likely to respond to environmental change and so was not prioritized for monitoring at this time. For more information about ecological site selection, refer to DeCoster et al. (2012).

3.1.1 Pinyon-juniper communities

At Mesa Verde there are three major ecological sites dominated by pinyon-juniper communities. The SCPN upland vegetation program chose the Loamy Mesa Top Pinyon-Juniper ecological site as the single target ecological site for monitoring at MEVE. A second ecological site, Shallow Loamy Mesa Top Pinyon-Juniper, was also considered because it had very similar vegetation, but it has shallower soils and occurs on the mesa shoulders adjacent to the Loamy Mesa Top Pinyon-Juniper. After a field assessment, three adjacent map units, dominated by Shallow Loamy Mesa Top, were added to the target ecological site for bird monitoring because 1) although the soils were different, the vegetation and bird habitat appeared quite similar between the sites, and 2) excluding the second ecological site would have removed large areas of pinyon-juniper habitat from monitoring because of the larger ecological site buffer required for bird monitoring (125 m at MEVE). The third ecological site dominated by pinyon-juniper woodland occurred in the canyon bottoms; it was substantially different and was not included.

3.2 Loamy Mesa Top and Shallow Loamy Mesa Top Pinyon-Juniper sampling frame

Six map units were combined to create the Loamy Mesa Top and Shallow Loamy Mesa Top Pinyon-Juniper sampling frame (Table A-6). Target soil lineage came from the NRCS SSURGO soils geodataset for the Cortez soil survey area CO671 (NRCS 2004). Individual polygons of the target map units were selected from the NRCS soils shapefile, and then merged to remove boundaries between polygons.

Table A-6. List of target soil map units for Shallow Loamy Mesa Top Pinyon-Juniper and Loamy Mesa Top Pinyon-Juniper ecological sites at MEVE

Map unit name	Map unit symbol	Percent of map unit associated with the target ecological site
Arabrab-Longburn complex, 3–15% slopes	4	85
Longburn-Rock outcrop complex, 10–45% slopes	68	65
Longburn-Rock outcrop complex, 45–80% slopes	69	50
Morefield loam, 1–3% slopes	76	90
Morefield loam, 3–6% slopes	77	90
Roubideau loam, 1–6% slopes	111	80

3.2.1 Field reconnaissance

Field visits were made to the Loamy Mesa Top Ecological Site during 2006 and 2007. During the first trip, the Loamy Mesa Top Pinyon-Juniper site was evaluated for soil properties and consistency of vegetation. During the second trip, the ecological site was evaluated for habitat-based bird monitoring. It was observed that there was a limited area covered by Loamy Mesa Top ecological site, and that the adjacent Shallow Loamy Mesa Top ecological site was very similar and appeared suitable to combine for bird monitoring.

Two areas were excluded from the sampling frame based on the 2006 reconnaissance visit: a small northern area having considerably different understory vegetation caused by wetter and cooler conditions, and a small area near the developed Spruce Tree House area on Chapin Mesa, which had been cleared as a firebreak.

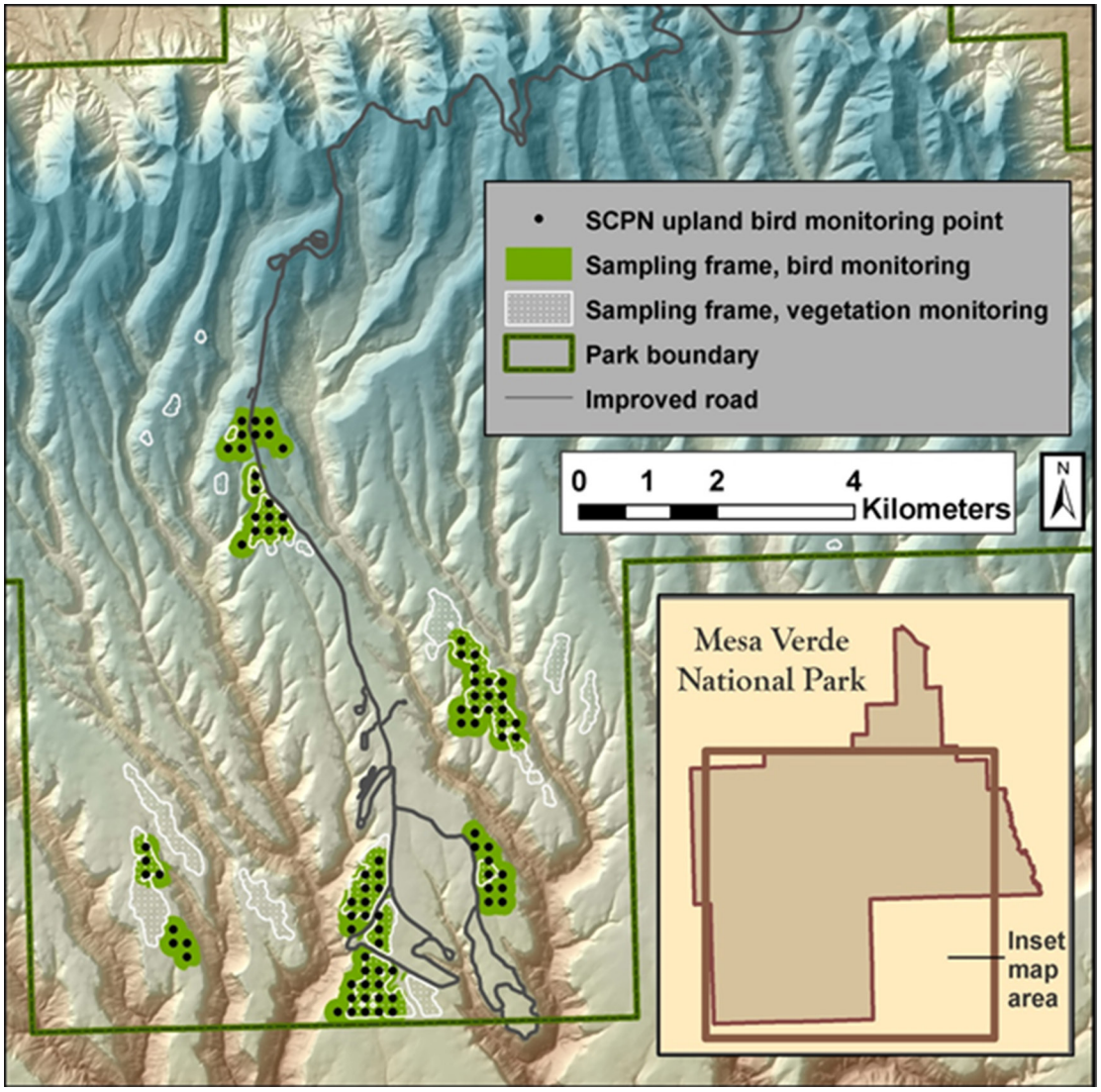

Figure A-4. MEVE pinyon-juniper woodlands. Final sampling frame with location of bird monitoring plots and upland vegetation monitoring sampling frame.

3.2.3 Sampling sites

At Mesa Verde, a grid of points spaced 200 m apart was used. Because much of the sampling frame in Mesa Verde is not accessible for sampling, the final sampling frame was not large, and a census method (i.e. simple grid sampling) was used instead of cluster sampling (see Figure A-1). In 10 cases the initial road and burn buffer limits were slightly lowered based on field evaluations of impacts on habitat. Nine points were slightly closer than 100 m to a road, and one point was slightly less than 125 m from a burn. The finalized sampling frame for MEVE is shown in Figure A-4.

4 Petrified Forest National Park

4.1 Monitoring priorities

At Petrified Forest National Park (PEFO), three grassland ecological sites were identified as priorities for upland ecosystem monitoring: Sandy Loam Upland, 10–14 in. p.z., Loamy Upland, 10–14 in. p.z., and Clayey Fan, 6–10 in. p.z..

Each ecological site was evaluated for upland vegetation monitoring during a field visit in 2006. The number of target ecological sites was reduced to two when an updated soil survey was published in 2007, which reclassified the Loamy Upland ecological site into the Sandy Loam Upland ecological site. For upland bird monitoring, the remaining two grassland ecological sites were combined to create a single grassland sampling frame. The vegetation and bird monitoring efforts share similar sampling areas; however, individual plots are located separately using independent site location methods.

4.2 Clayey Fan and Sandy Loam Upland sampling frame

At PEFO, the target ecological sites were estimated to occur at proportions of 50% or more within six soil map units (Table A-7). These six map units were combined to form the initial sampling frame.

Table A-7. Target map units associated with the Clayey Fan and Sandy Loam Upland ecological site at PEFO. Source data from NRCS, 2002.

Map unit name	Map unit symbol	Percent of map unit associated with a target ecological site
Clovis-Palma Association, Undulating	CTB	95
Fruitland Sandy Loam, 1–8% slopes	FRB	79
Palma-Sheppard Association, Undulating	PSB	50
Clovis Loamy Sand, 0–8% slopes	CLB	100
Jocity Sandy Clay Loam	JR	100
Jocity-Claysprings complex Clovis Loamy Sand, 0–8% slopes	JS	85

4.2.1 Field reconnaissance

A field assessment of the target ecological sites was made in the fall of 2006. At randomly selected points, the dominant vegetation was recorded, the surface soil was textured by hand, and photos of soil surface and surrounding landscape were taken.

4.2.3 Site grouping

The resulting sampling frame was relatively large but had many polygons that were small or irregularly shaped. To address this, we decided on a spatial grouping that would keep the sites in groups of ten points, with nine points arranged around a center seed point. The nearest nine points to the seed point were chosen, and a random number assignment was used to choose points in case of ties due to identical distances (see Figure A-1). As a result, the area of statistical inference was adjusted to limit it to areas within which one of these groups of points could have fallen The final sampling frame for PEFO is shown in Figure A-5.

5 Wupatki National Monument

5.1 Monitoring priorities

At Wupatki National Monument (WUPA), SCPN and park staff identified two grassland ecological sites as priorities for upland ecosystem monitoring: Limy Upland (6–10 in. p.z.) and Sandstone Upland (6–10 9 in. p.z.). Upland ecosystem monitoring has been implemented in two parts: habitat-based bird community monitoring, which is described here, and upland vegetation monitoring, described in DeCoster et al. (2012).

Each ecological site was evaluated for upland vegetation monitoring during a field visit in

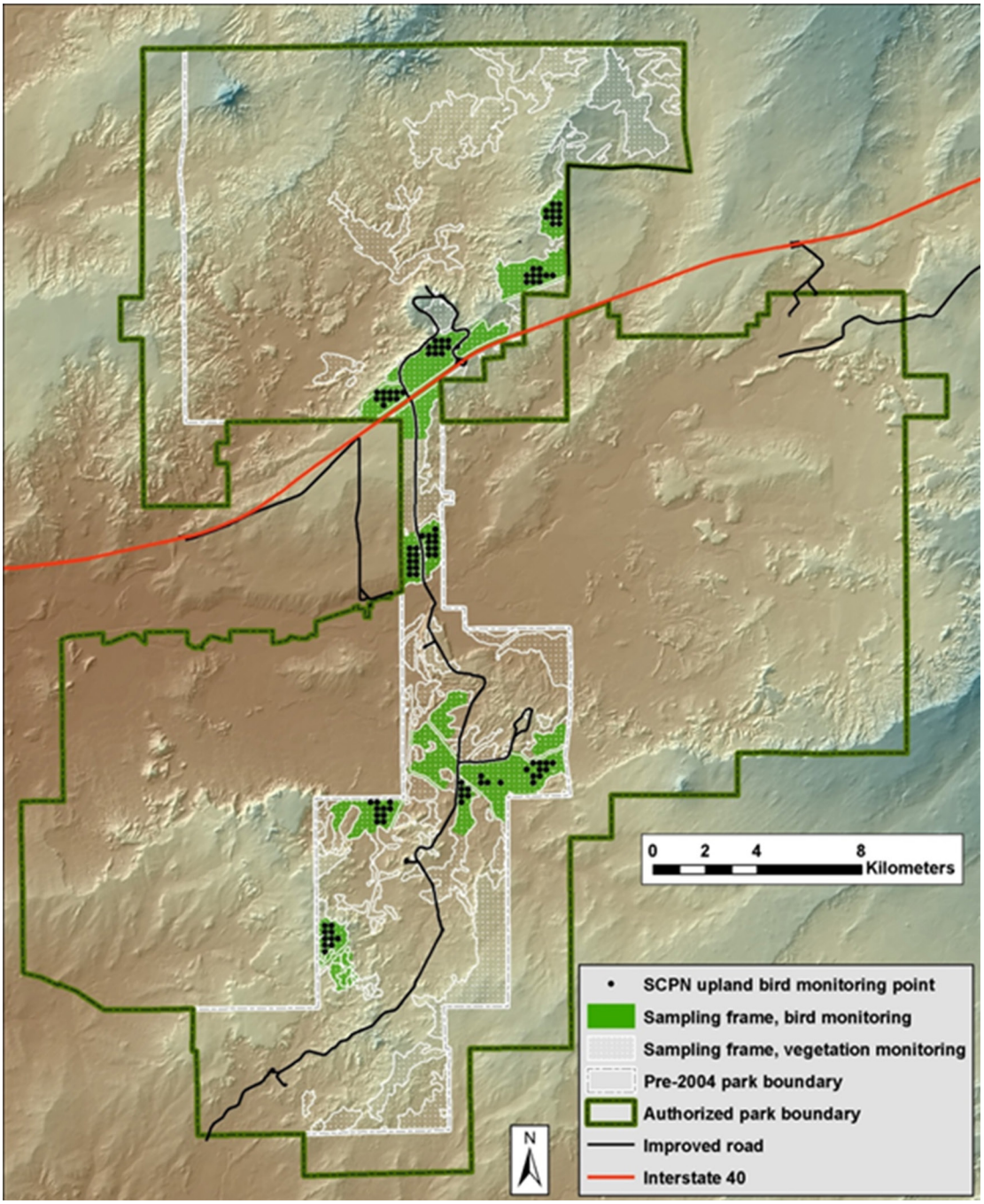

Figure A-5. Petrified Forest Clayey Fan and Sandy Loam Upland ecological sites. Final sampling frame with location of bird monitoring plots and upland vegetation monitoring sampling frame.

2006. For bird monitoring, the two ecological sites were combined to create a single grassland sampling frame. The vegetation and bird monitoring efforts share similar sampling areas; however, individual plots are located separately using independent site location methods.

5.2 Limy Upland and Sandstone Upland sampling frame

At WUPA, the target ecological sites were estimated to occur at proportions of 90% or more within three soil map units (Table A-8). These three map units were combined to form the

Table A-8. Target map units associated with the Limy Upland and Sandstone Upland ecological sites at Wupatki National Monument. Source data from NRCS, 2002.

Map unit name	Map unit symbol	Percent of map unit associated with the target ecological site
Tuweep very gravelly loam, 0–15% slopes	56	100
Epikom very cindery loamy sand, 0–5% slopes	17	100
Epikom complex, 0–15% slopes	18	90

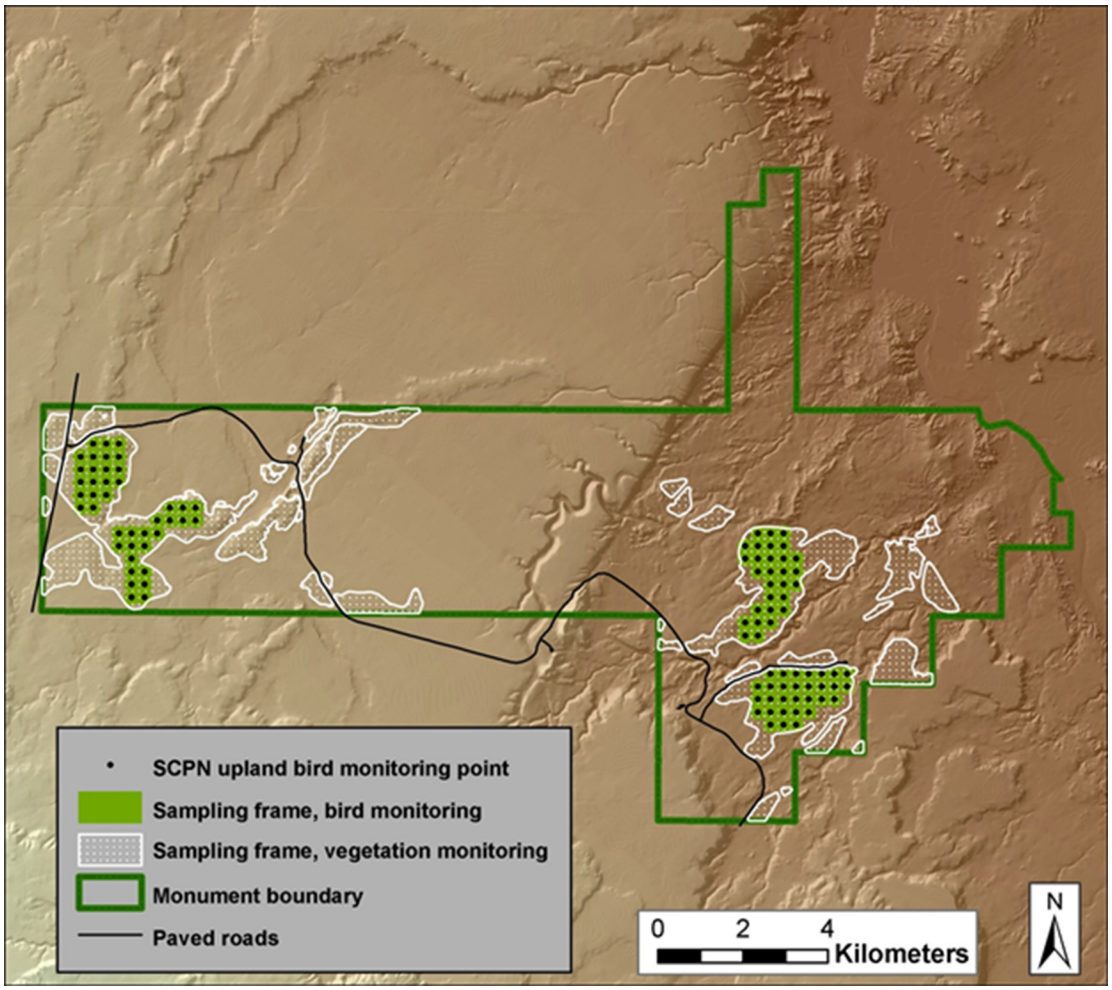

Figure A-6. Wupatki Limy Upland and Sandstone Upland ecological sites. Final sampling frame with location of bird monitoring plots and upland vegetation monitoring sampling frame.

sampling frame, which was then modified with several GIS steps.

5.2.1 Field reconnaissance

Field visits were made to WUPA during 2006 and 2007. During the first trip, the ecological sites were evaluated for soil properties and consistency of vegetation. During the second trip, the ecological site was evaluated for upland bird monitoring. Three points on the western edge of the park were rejected because they were too close to Highway 89, and traffic noise would have interfered with bird sampling. One point was rejected because it fell too close to an inhabited dwelling. One hundred points were selected for monitoring.

5.2.2 Sampling sites

At Wupatki a grid of points spaced 300 m apart was used. Because the final sampling frame was not large, a simple grid method was used instead of cluster sampling (see Figure A-1). The finalized sampling frame for WUPA is shown in Figure A-6. (previous page)

6 Bandelier National Monument

6.1 Monitoring priorities

In October 2006, SCPN and the natural resources staff of Bandelier National Monument (BAND) met to discuss park priorities for upland monitoring. Three ecosystems were considered: mesa top pinyon-juniper woodland, mixed conifer forest and montane meadows. The mesa top pinyon-juniper ecosystem was determined to be the top priority as this ecosystem has not been well studied. Moreover, the park was planning to implement a landscape–scale restoration of these woodlands, entailing the reduction of juniper density through mechanical thinning. The mixed conifer forest was considered the second priority. In 2008, a pilot season of assessing the accessibility of bird sampling plots and conducting bird sampling was completed in the pinyon juniper and mixed conifer habitats. Based on this assessment and sampling, the pinyon juniper was dropped due to high variability in the vegetation cover among plots and an insufficient number of accessible plots.

6.2 Mixed Conifer Ecological Site sampling frame

The mixed conifer forest type occurred in multiple target ecosites dominated by Calaveras soil components at BAND. Twelve soil map units from the 1999-2000 Natural Resource Conservation Service (NRCS) soil survey were combined to create the initial sampling frame for the mixed conifer forest (Table A-9).

Soil types from the 1999-2000 NRCS soil survey dataset were identified by overlapping the soils dataset with a draft version of the vegetation map provided by the park. Soils were

Table A-9. Soil map units for the targeted mixed conifer forest at BAND. Source data from NRCS, 2001.

Map unit name	Map unit symbol	Percent of map unit associated with the target ecological site
Rock outcrop-Urioste complex, 30 to 45% slopes	801	n/a
Metate ashy loam, cool, 1 to 4% slopes	807	n/a
Cymery very gravelly ashy sandy loam, 15 to 35% slopes	811	n/a
Hoxoh gravelly ashy loam, 1 to 15% slopes	813	n/a
Jemez sandy loam, 2 to 8% slopes	814	n/a
Lucito loam, 1 to 8% slopes	820	n/a
Mapache loam, 25 to 55% slopes	821	n/a
Mapache gravelly loam, 10 to 25% slopes	822	n/a
Tschicoma-Tranquilar complex, 0 to 5% slopes	823	n/a
Mapache gravelly loam, 30 to 70% slopes	824	n/a
Cosey complex, 5 to 20% slopes	825	n/a
Estaban extremely gravelly loam, 45 to 90% slopes	826	n/a
*Calaveras loam, 15 to 35% slopes	82	85
*Calaveras-Rubble land association, 35 to 60% slopes	83	60

*Soil map units included from the SSURGO soil survey NM656. These are the only ones that provide percent of map unit associated with the target ecological site.

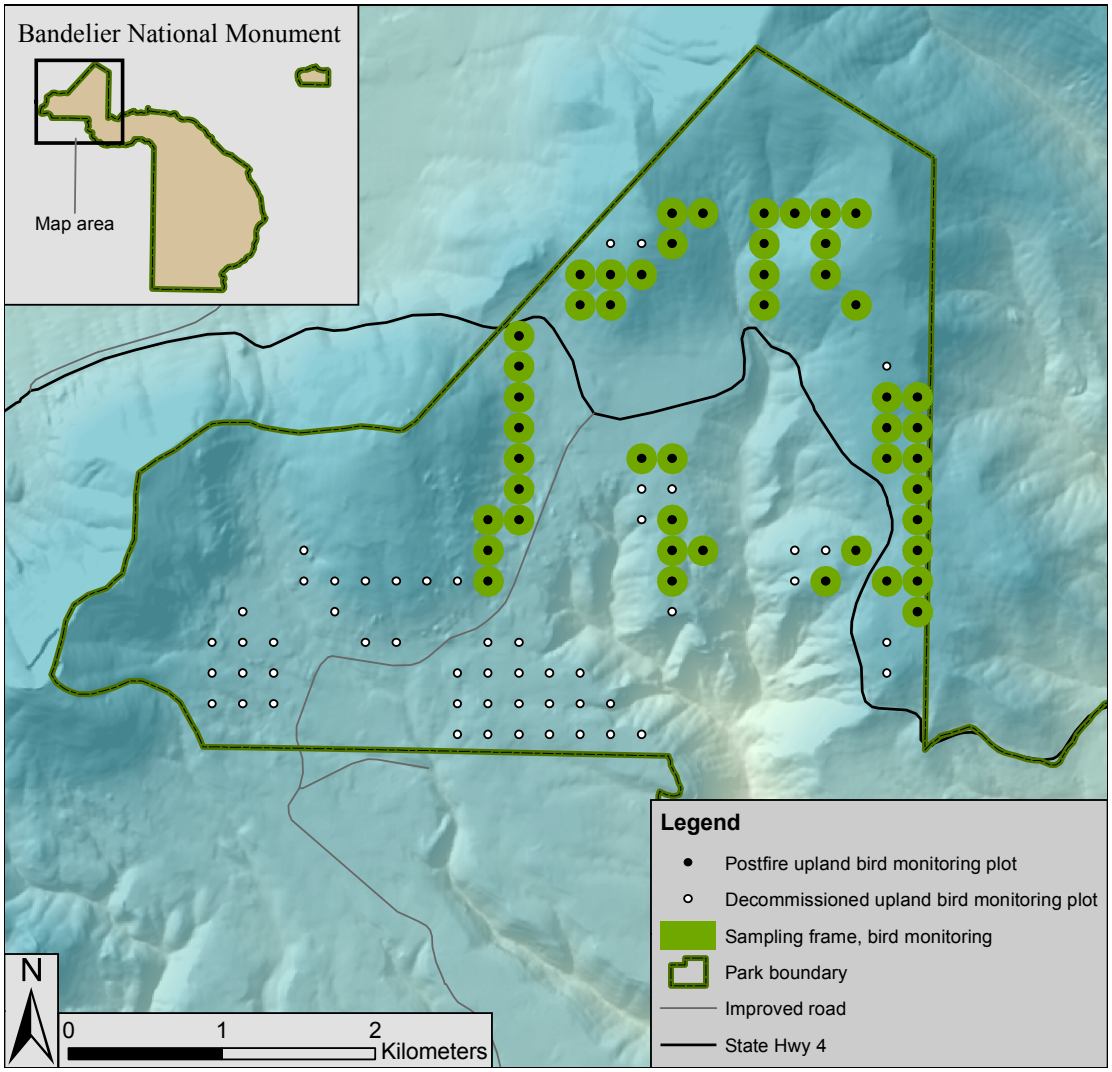

Figure A-7. Bandelier Mixed Conifer forest. Sampling frame with location of 48 postfire upland bird monitoring plots. After the 2011 Las Conchas Fire, the original sampling frame, which included 100 plots, was modified to exclude areas that experienced high to moderate burn severity (decommissioned upland bird monitoring plots in the figure).

selected that had a total of at least five hectares of overlap with any one of the six possible mixed conifer-associated map classes in the draft vegetation map. The six broad map classes included all conifer and aspen vegetation classes, except those dominated by ponderosa, pinyon, or juniper. Aspen vegetation type was included because of the potential for aspen to co-occur with and be replaced by conifer species, depending on local conditions (occurrence of disturbance and recruitment events and potential seed sources). Three soil types (401,806, and 816) were excluded because they occurred almost entirely on steep slopes and their distribution spanned both low and high elevation areas of the park and were not particularly associated with mixed conifer vegetation. Two additional soil map units from the NRCS SSURGO database for soil survey NM656 were added to the sampling frame to cover an area of the northwest portion of the park that was outside the boundary of the 1999-2000 NRCS survey. The SSURGO map units 82 and 83 were included because they adjoined target polygons within the NRCS-1999-2000 dataset.

In June 2011, the Las Conchas Fire burned over 156,000 acres of the park, and much of the

park's mixed conifer forest was burned. Continued monitoring of the mixed conifer bird community required that we modify the original sampling frame by excluding areas of high and moderate burn severity. The post-fire sampling frame occurs in six soil map units (814, 820, 821, 822, 824, and 825) from the 1999-2000 NRCS soil survey.

6.2.1 Field reconnaissance

After the Las Conchas fire in 2011, we assessed vegetation burn severity using high resolution aerial photography showing each plot before and after the fire. We decommissioned 44 plots as having high or moderate vegetation burn severity and classified 56 plots as unchanged or with minimal structural change. We then made field visits to the 56 plots classified as unchanged or having low burn severity to further assess vegetation burn severity and accessibility. From this assessment we decommissioned an additional eight plots due to moderate to high vegetation burn severity.

6.2.2 Sampling sites

At BAND, a grid of points spaced 200 m apart was used. The final sampling frame was not large, and a simple grid method was used instead of cluster sampling (see Figure A-1). After field checking the plots, 100 plots were accepted and monitored in 2008 and 2009 using the original sampling frame (Figure A-7, page A-15). After the Las Conchas fire in 2011, we decommissioned 52 of the original monitoring plots due to moderate and high vegetation burn severity and retained 48 monitoring plots (Figure A-7).

7 Riparian Bird Monitoring at Canyon de Chelly National Monument

7.1 Monitoring priorities

At Canyon de Chelly National Monument (CACH), riparian habitats were identified as a priority for ecosystem monitoring. CACH is dominated by two canyons: Canyon de Chelly, and Canyon del Muerto (Figure A-8). Extensive riparian areas occur in both canyons and downstream of the confluence of the two canyons. The upstream parts of both canyons were excluded from riparian bird monitoring because riparian habitat in those areas is generally too narrow for effective single-habitat monitoring.

7.2 Riparian sampling frame

Because most riparian systems have a linear distribution, we chose a linear, evenly spaced sampling approach. Source streamline features came from the high-resolution National Hydrography Dataset (http: nhd.usgs.gov/). A 150 m minimum spacing threshold was set to avoid detecting the same bird from adjacent monitoring plots. To compensate for the curvature of the streamline, points were spaced 155 m apart along the streamline to help maintain a minimum straight-line separation of 150 m. Each point was then examined using an aerial photo backdrop and moved in a direction perpendicular to the stream such that it was centered within the riparian habitat (as defined visually by overstory and shrub vegetation). Once centered, two buffers of 50 and 150 m were created around the points. These buffers were used to identify and reject individual points if that point had less than 50 meters of riparian vegetation around the point in all directions, or if that point was within 150 meters of another point. Where the riparian vegetation zone was sufficiently wide, additional sampling points were placed in the riparian zone, as long as the 150 m spacing between points was retained. Any questionable or marginal points were flagged but retained, and all potential points were field checked. In a few cases, points were adjusted a short distance upstream or downstream if the riparian area was sufficiently wide at those locations and if the 150 m spacing between points could be maintained.

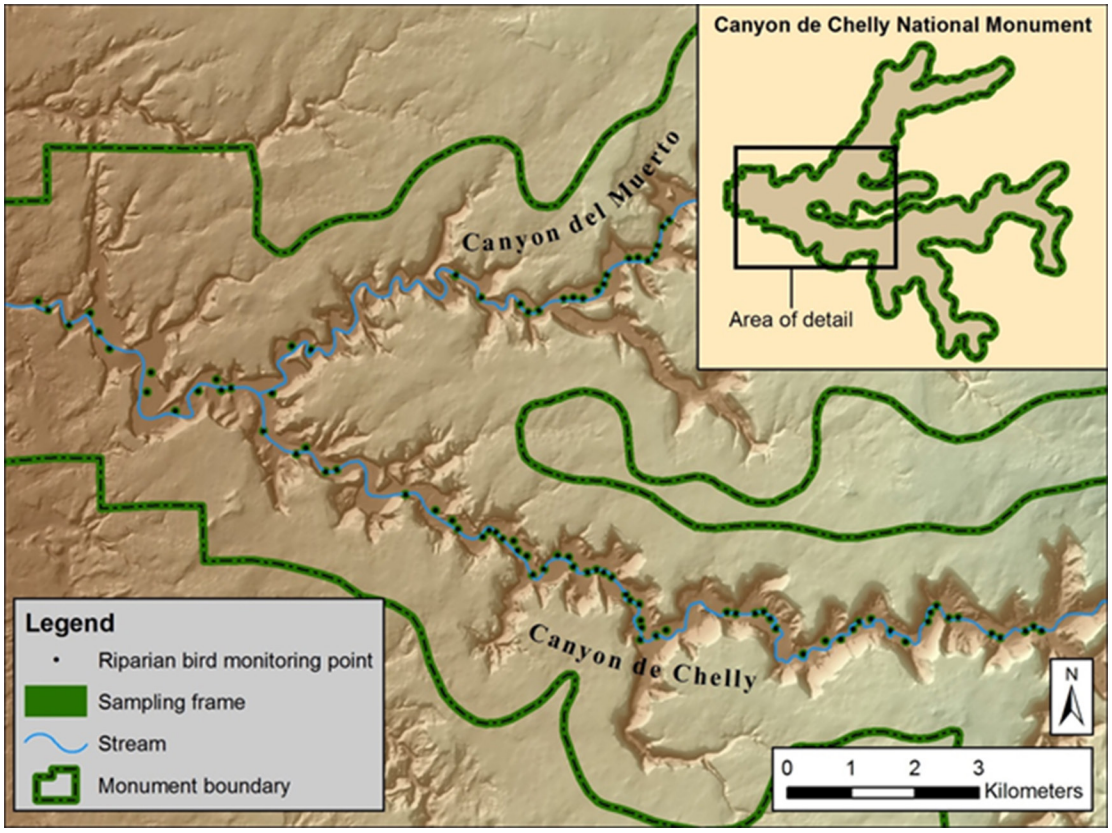

Figure A-8. Canyon de Chelly National Monument. Final sampling frame with location of bird monitoring plots.

7.2.1 Field reconnaissance

All points were field checked in 2008 and 2009. If there was not at least a 50 m radius of riparian vegetation surrounding a point, it was rejected. Ninety-one sampling plots within the riparian habitat were selected and 47 were rejected.

7.2.2 Sampling sites

After field-checking the points, 91 points were suitable for monitoring. Because of the relatively small population size, a simple grid approach was used (see Figure A-1) and the entire set of 91 points were sampled.

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Appendix B

Avian Species List for the Southern Colorado Plateau Network

Bird species likely to be detected by habitat-based bird community monitoring during the breeding season in the Southern Colorado Plateau Network parks where this monitoring is conducted. Monitored parks are Bandelier NM (BAND), Canyon de Chelly NM (CACH), Grand Canyon NP (GRCA), Mesa Verde NP (MEVE), Petrified Forest NP (PEFO), and Wupatki NM (WUPA). Monitored habitats are mixed conifer (mc), riparian (ri), pinyon-juniper (pj), and grassland (gr). Bolded species are considered breeding habitat obligates (North American Bird Conservation Initiative, U.S. Committee 2009; available at http://www.nabci-us.org/main2.html).

Common name	Scienfic name	Code	BAND mc	CACH ri	GRCA mc	GRCA pj	MEVE pj	PEFO gr	WUPA gr
American crow	*Corvus brachyrhynchos*	AMCR	X						
American goldfinch	*Carduelis psaltria*	AMGO					X		
American kestrel	*Falco sparverius*	AMKE		X			X	X	X
American robin	*Turdus migratorius*	AMRO	X	X	X	X	X		
American three-toed woodpecker	***Picoides dorsalis***	**ATTW**	**X**		**X**				
ash-throated flycatcher	*Myiarchus cinerascens*	ATFL		X		X	X	X	X
band-tailed pigeon	*Columba fasciata*	BTPI	X						
barn swallow	*Hirundo rustica*	BARS				X	X	X	X
Bendire's thrasher	***Toxostoma bendirei***	**BETHR**						**X**	**X**
Bewick's wren	*Thyromanes bewickii*	BEWR				X	X		
black-billed magpie	*Pica hudsonia*	BBMA					X		
black-chinned hummingbird	*Archilochus alexandri*	BCHU		X	X	X	X	X	
black-headed grosbeak	***Pheuticus melanocephalus***	**BHGR**	**X**	**X**	**X**	**X**	**X**		
black-throated gray warbler	***Dendroica nigrescens***	**BTYW**	**X**			**X**	**X**		
black-throated sparrow	***Amphispiza bilineata***	**BTSP**						**X**	**X**
blue grosbeak	*Passerina caerulea*	BLGR		X					
blue-gray gnatcatcher	*Polioptila caerulea*	BGGN		X		X	X	X	X
Brewer's blackbird	*Euphagus cyanocephalus*	BRBL					X		X
Brewer's sparrow	*Spizella breweri*	BRSP				X	X	X	X
broad-tailed hummingbird	*Selasphorus platycercus*	BTLH	X		X	X	X	X	X
brown creeper	*Certhia americana*	BRCR	X		X				
brown-headed cowbird	*Molothrus ater*	BHCO	X	X		X	X	X	X
Bullock's oriole	*Icterus bullockii*	BUOR		X					X
burrowing owl	*Athene cunicularia*	BUOW						X	
bushtit	*Psaltriparus minimus*	BUSH		X		X	X		X
Canada goose	*Branta canadensis*	CAGO				X	X		
canyon wren	*Catherpes mexicanus*	CNWR		X			X		
Cassin's kingbird	*Tyrannus vociferans*	CAKI				X	X	X	X
Cassin's finch	***Carpodacus cassinii***	**CAFI**	**X**		**X**				
Cassin's sparrow	***Aimophila cassinii***	**CASP**						**X**	**X**
cedar waxwing	*Bombycilla cedrorum*	CEDW		X			X		
chipping sparrow	*Spizella passerine*	CHSP	X	X	X	X	X		X
Clark's nutcracker	*Nucifraga columbiana*	CLNU	X		X		X		
cliff swallow	*Petrochelidon pyrrhonota*	CLSW					X	X	

Common name	Scienfic name	Code	BAND mc	CACH ri	GRCA mc	GRCA pj	MEVE pj	PEFO gr	WUPA gr
common nighthawk	*Chordeiles minor*	CONI					X	X	X
common poorwill	*Phalaenoptilus nuttallii*	COPO	X				X		
common raven	*Corvus corax*	CORA	X	X	X	X	X	X	X
Cooper's hawk	*Accipiter cooperii*	COHA	X	X	X		X		X
cordilleran flycatcher	***Empidonax occidentalis***	**COFL**	**X**		**X**				
crissal thrasher	***Toxostoma crissale***	**CRTH**							**X**
dark-eyed junco	*Junco hyemalis*	DEJU	X		X	X	X		
downy woodpecker	*Picoides pubescens*	DOWO	X		X				
dusky flycatcher	***Empidonax oberholseri***	**DUFL**	**X**		**X**	**X**	**X**		
dusky grouse	***Dendragapus obscurus***	**DUGR**	**X**						
eastern meadowlark	***Sturnella magna***	**EAME**						**X**	**X**
evening grosbeak	*Coccothraustes vespertinus*	EVGR	X		X				
flammulated owl	***Otus flammeolus***	**FLOW**	**X**						
golden eagle	*Aquila chrysaetos*	GOEA						X	X
golden-crowned kinglet	*Regulus satrapa*	GCKI	X						
Grace's warbler	***Dendroica graciae***	**GRWA**	**X**		**X**				
gray flycatcher	***Empidonax wrightii***	**GRFL**				**X**	**X**	**X**	**X**
gray vireo	***Vireo vicinior***	**GRVI**				**X**	**X**		
great blue heron	*Ardea herodias*	GBHE					X		
great horned owl	*Bubo virginianus*	GHOW	X						
greater roadrunner	*Geococcyx californianus*	GRRO							X
green-tailed towhee	*Pipilo chlorurus*	GTTO	X		X		X		X
hairy woodpecker	*Picoides villosus*	HAWO	X	X	X	X	X		
Hammond's flycatcher	***Empidonax hammondii***	**HAFL**	**X**				**X**		
hepatic tanager	***Piranga flava***	**HETA**	**X**						
hermit thrush	*Catharus guttatus*	HETH	X	X	X		X		
horned lark	*Eremophila alpestris*	HOLA						X	X
house finch	*Carpodacus mexicanus*	HOFI	X	X	X	X	X	X	X
house sparrow	*Passer domesticus*	HOSP						X	X
house wren	*Troglodytes aedon*	HOWR	X		X		X		
indigo bunting	*Passerina cyanea*	INBU		X					
juniper titmouse	***Baeolophus ridgwayi***	**JUTI**		**X**		**X**	**X**		
lark sparrow	*Chondestes grammacus*	LASP						X	X
lazuli bunting	***Passerina amoena***	**LAZB**		**X**			**X**		
lesser goldfinch	*Carduelis psaltria*	LEGO		X		X	X		X
Lewis's woodpecker	***Melanerpes lewis***	**LEWO**			**X**				
loggerhead shrike	*Lanius ludovicianus*	LOSH						X	X
Lucy's warbler	*Vermivora luciae*	LUWA		X					
MacGillivray's warbler	***Oporornis tolmiei***	**MGWA**	**X**	**X**					
mallard	*Anas platyrhynchos*	MALL		X					
mountain bluebird	*Sialia currocoides*	MOBL			X		X		
mountain chickadee	*Poecile gambeli*	MOCH	X	X	X	X	X		
mourning dove	*Zenaida macroura*	MODO	X	X	X	X	X	X	X
northern flicker	*Colaptes auratus*	NOFL	X		X	X	X		

Common name	Scienfic name	Code	BAND mc	CACH ri	GRCA mc	GRCA pj	MEVE pj	PEFO gr	WUPA gr
northern goshawk	*Accipiter gentilis*	NOGO			X	X			
northern harrier	*Circus cyaneus*	NOHA						X	X
northern mockingbird	*Mimus polyglottos*	NOMO						X	X
northern pygmy-owl	*Glaucidium gnoma*	NOPO					X		X
northern saw-whet owl	*Aegolius acadicus*	NSWO					X		
olive-sided flycatcher	*Contopus cooperi*	OSFL	X		X				
orange-crowned warbler	*Vermivora celata*	OCWA	X	X			X		
peregrine falcon	*Falco peregrinus*	PEFA		X					
pine siskin	*Carduelis pinus*	PISI	X	X	X	X	X		
pinyon jay	***Gymnorhinus cyanocephalus***	**PIJA**		**X**		**X**	**X**		**X**
plumbeous vireo	***Vireo plumbeus***	**PLVI**	**X**	**X**	**X**	**X**	**X**		
prairie falcon	Falco mexicanus	PRFA						X	X
pygmy nuthatch	Sitta pygmaea	PYNU	X		X	X			
red crossbill	Loxia curvirostra	RECR	X						
red-breasted nuthatch	Sitta Canadensis	RBNU	X		X	X	X		
red-naped sapsucker	**Sphyrapicus nuchalis**	**RNSA**	**X**		**X**				
red-tailed hawk	Buteo jamaicensis	RTHA		X	X				X
red-winged blackbird	Agelaius phoeniceus	RWBL					X		
rock wren	Salpinctes obsoletus	ROWR		X			X	X	X
ruby-crowned kinglet	Regulus calendula	RCKI	X	X	X	X	X		X
rufous hummingbird	***Selasphorus rufus***	**RUHU**			**X**				
rufous-crowned sparrow	***Aimophila ruficeps***	**RCSP**							**X**
sage thrasher	***Oreoscoptes montanus***	**SATH**							**X**
Say's phoebe	*Sayornis saya*	SAPH	X	X				X	X
scaled quail	***Callipepla squamata***	**SCQU**					**X**	**X**	
Scott's oriole	*Icterus parisorum*	SCOR				X			X
sharp-shinned hawk	*Accipiter striatus*	SSHA							X
spotted towhee	*Pipilo maculatus*	SPTO		X		X	X		X
Steller's jay	*Cyanocitta stelleri*	STJA	X		X	X	X		
Townsend's solitaire	***Myadestes townsendi***	**TOSO**	**X**		**X**	**X**	**X**		**X**
tree swallow	*Tachycineta bicolor*	TRES					X		
turkey vulture	*Cathartes aura*	TUVU	X	X		X	X	X	
vesper sparrow	***Pooecetes gramineus***	**VESP**						**X**	**X**
violet-green swallow	*Tachycineta thalassina*	VGSW	X	X	X	X	X	X	X
Virginia's warbler	***Vermivora virginiae***	**VIWA**	**X**				**X**		
warbling vireo	*Vireo gilvus*	WAVI	X	X	X				X
western bluebird	***Sialia mexicana***	**WEBL**	**X**	**X**	**X**	**X**	**X**		
western kingbird	*Tyrannus verticalis*	WEKI		X				X	X
western meadowlark	***Sturnella neglecta***	**WEME**					**X**	**X**	**X**
western scrub-jay	*Aphelocoma californica*	WESJ				X	X		
western tanager	***Piranga ludoviciana***	**WETA**	**X**	**X**	**X**	**X**	**X**		**X**
western wood-pewee	***Contopus sordidulus***	**WEWP**	**X**	**X**	**X**	**X**	**X**		**X**
white-breasted nuthatch	*Sitta carolinensis*	WBNU	X	X	X	X	X		
white-crowned sparrow	*Zonotrichia leucophrys*	WCSP		X			X		X

Common name	Scienfic name	Code	BAND mc	CACH ri	GRCA mc	GRCA pj	MEVE pj	PEFO gr	WUPA gr
white-throated swift	*Aeronautes saxatalis*	WTSW	X	X	X	X	X	X	X
wild turkey	*Meleagris gallopavo*	WITU	X	X	X		X		
Williamson's sapsucker	***Sphyrapicus thyroideus***	**WISA**	**X**		**X**				
willow flycatcher	***Empidonax traillii***	WIFL		X					
Wilson's warbler	***Wilsonia pusilla***	WIWA	X	X					
yellow warbler	***Dendroica coronada***	YEWA		X					
yellow-breasted chat	***Icteria virens***	YBCH		X					
yellow-headed blackbird	***Xanthocephalus xanthocephalus***	**YHBL**					**X**	**X**	
yellow-rumped warbler	*Dendroica coronada*	YRWA	X	X	X	X	X		X

Appendix C

Yearly Project Task List

Table C-1. This table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution.

Stage	Task description	Responsibility	Timing
Preparation	Post announcements for seasonal technician positions, begin hiring	Project manager	Jan-Feb
	Determine field season objectives and general schedule	Project manager	Jan-Feb
	Notify data manager and GIS specialist of needs for the coming season (maps, GPS support, etc.)	Project manager	Jan-Feb
	Submit/renew research permit applications	Project manager	Feb
	Notify park contacts of schedule/itinerary; obtain back-country permits	Project manager	Feb-Mar
	Order equipment and supplies	Project manager	Feb-Mar
	Develop detailed field schedule; make logistic arrangements	Project manager	Feb-Mar
	Generate site folders including site coordinates, field maps, and access information	Project manager and GIS specialist	Mar
	Ensure that project workspace is ready for use and implement working database copy	Data manager	by April 1
	Update and load data dictionary, background maps and target coordinates into GPS units	GIS specialist	by April 15
	Provide database data entry and GPS training as needed	Data manager and GIS specialist	second half of April
	Train field crew in sampling methods	Project manager and crew leader	second half of April
Data collection	Collect field observations/samples	Crew	May-July
	Review data forms after each sampling day	Crew	daily
	Check in with park contacts and project manager	Crew	during and after each field trip
	De-brief project manager on operations, field methods, gear needs, etc.	Crew	after each field trip
Data entry verification and validation	Enter field data into working database	Crew	May-July
	Field data verification	Project manager, crew	Aug-Sept
	Merge and export GPS data. Upload processed and verified GPS data to database	GIS specialist and data manager	Aug-Sept
	Field data validation (tabular and spatial)	Project manager, data manager and GIS specialist	Aug-Sept
	Scan datasheets	Project manager, crew	Aug-Sept
Data management	Merge working database into master project database	Data manager	Oct-Nov
	Create/update project metadata records	Data manager and project manager	Oct-Nov
	Export summary data and reports from database	Data manager	Oct-Nov
	Certify database	Data manager	Mar
Data summary and reporting	Generate report-quality map output for reports	GIS specialist	Dec-Feb
	Prepare and submit IARs	Project manager	Jan-Mar
	Prepare draft annual reports; complete internal review	Project manager and program manager	Jan-Mar

Table C-1. (*continued*) This table identifies each task by project stage, indicates who is responsible, and establishes the timing for its execution.

Stage	Task description	Responsibility	Timing
Posting and distribution	Post annual reports to SCPN website and distribute to parks	Data manager and project manager	Apr
	Submit metadata to NPS IRMA	Data manager	Apr
	Create and update bibliographic and species records in NPS IRMA	Data manager	Upon receipt
Archiving data	Archive all digital and hardcopy products	Project manager and data manager	Apr - May
Season close-out	Inventory equipment and supplies	Project manager	Nov-Dec
	Meet to discuss recent field season and any needed changes to protocols, database, or analysis and reporting procedures	Project manager, data manager, GIS specialist, and program manager	by Dec 15

Appendix D

Habitat-Based Bird Community Monitoring Protocol Database Documentation

1 Purpose

This appendix documents the Habitat-Based Bird Community database for the SCPN. Microsoft Access is the primary software used to manage data, while SQL Server is increasingly used to host and visualize the data.

2 Habitat-based bird community database: Data model

The Habitat-Based Bird Community database employs a front-end/back-end configuration. The front-end file contains the forms, queries, modules, macros, and reports; the back-end file contains the data tables. This front-end/back-end configuration allows for continual improvements to the user interface (i.e., the various forms and queries for getting data into and out of the database) without requiring duplication or modification of the underlying data tables. Figure D-1 shows the relationships among the primary tables in the database. The database is based on the National Park Service Natural Resources Database Template (NRDT) Version 3.

3 Documentation of database tables

3.1 Table: tbl_Canopy_Closure

Description: Stores canopy closure data collected in the 5m radius plot. There are 4 measurements per plot in each of the four cardinal directions.

Field name	Field type	Field Description
Subplot_ID	ReplicationID	Foreign key – links to tbl_Subplots
N	Integer	Number of dots covered by vegetation. Measured facing north.
E	Integer	Number of dots covered by vegetation. Measured facing east.
S	Integer	Number of dots covered by vegetation. Measured facing south.
W	Integer	Number of dots covered by vegetation. Measured facing west.
Notes	Memo	Any notes about canopy closure

3.2 Table: tbl_Cover_Type

Description: Stores information about major land-use cover types (other than vegetation) present within macroplots.

Field name	Field type	Field Description
Macro_ID	ReplicationID	Foreign key – links to tbl_Macroplot
OtherCover	Text	Type of non-vegetation or land-use ground cover present within the macroplot
OtherCoverClass	Integer	Braun-Blanquet cover class value corresponding to the visual estimate of non-vegetation land-use cover – values defined in tlu_Cover_Class (also see Table 5-3 and SOP #5)
Notes	Memo	Notes about land-use cover types

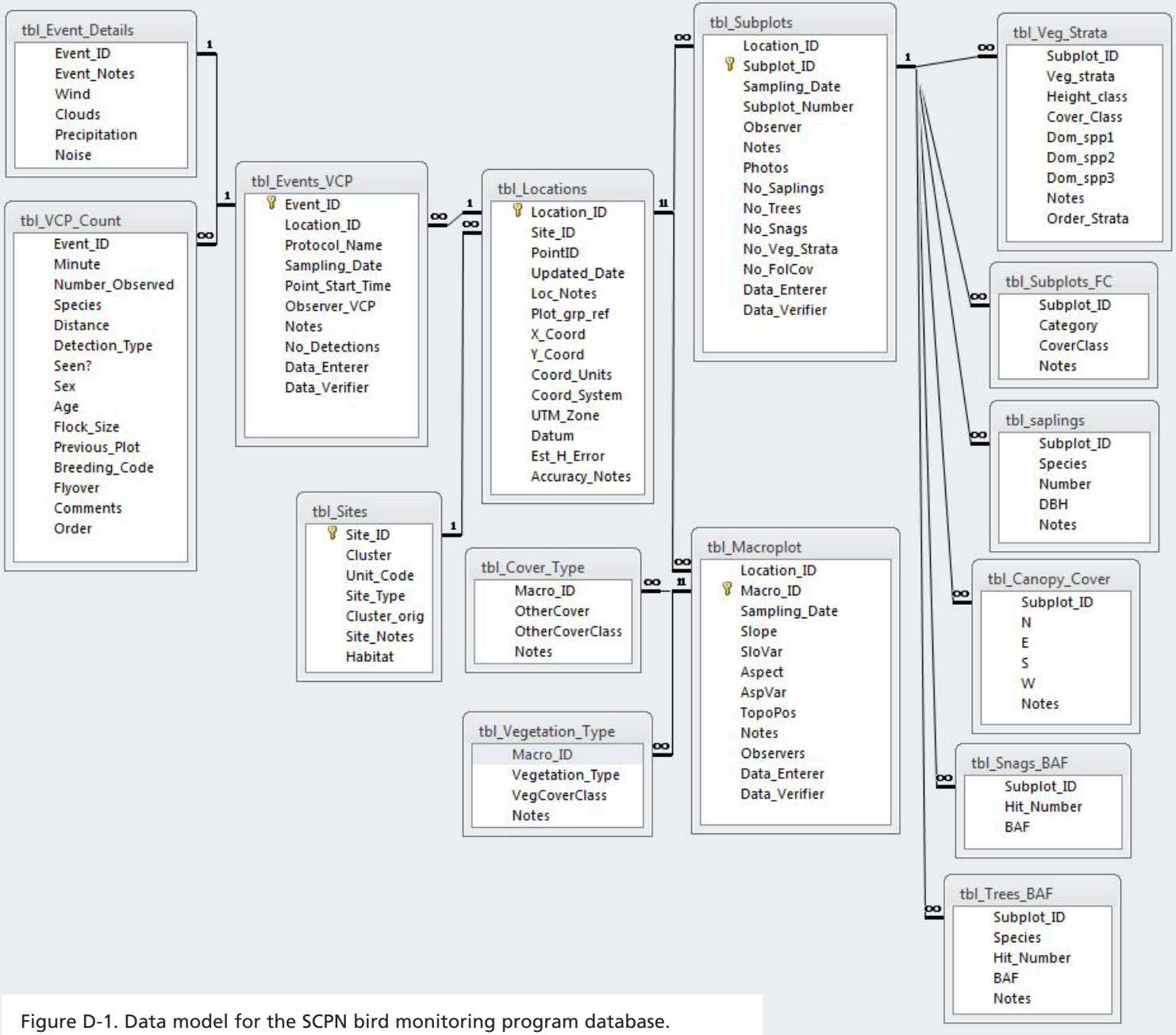

Figure D-1. Data model for the SCPN bird monitoring program database.

3.3 Table: tbl_Event_Details

Description: Holds details about each sampling event. There is one record in this table for every record in tbl_Events_VCP.

Field name	Field type	Field description
Event_ID	ReplicationID	Foreign key – links to tbl_Events_VCP
Event_Notes	Memo	General notes on the event
Wind	Integer	Beaufort wind scale code for the average wind conditions during for the 8-minute count - values defined in tlu_Wind (also see Table 4-4 in SOP #4)
Clouds	Integer	Visual estimate of the percent cloud cover during the 8-minute count, rounded to the nearest 10 percent
Precipitation	Integer	Precipitation during the 8-minute count - values defined in tlu_Precipitation (also see Table 4-5 in SOP #4)
Noise	Integer	Background noise conditions during the 8-minute count, as it relates to observer's ability to hear birds - values defined in tlu_Noise (also see Table 4-6 in SOP #4).

3.4 Table: tbl_Events_VCP

Description: Stores information about each VCP sampling event.

Field name	Field type	Field description
Event_ID	ReplicationID	Primary key – VCP event identifier
Location_ID	ReplicationID	Foreign key – links to tbl_Locations
Protocol_Name	Text	The name or code of the protocol governing the event
Sampling_Date	Date/Time	Date of VCP sampling event
Point_Start_Time	Date/Time	Start time of VCP sampling event
Observer_VCP	Text	Observer on the VCP plot
Notes	Memo	General VCP sampling event notes
No_Detections	Yes/No	Checked if no birds were detected during this sampling event
Data_Enterer	Text	Person who entered the data into the database for this event
Data_Verifier	Text	Person who verified the data in the database for this event

3.5 Table: tbl_Locations

Description: Table stores details about sampling points.

Field name	Field type	Field description
Location_ID	ReplicationID	Primary key. Location identifier
Site_ID	ReplicationID	Foreign key- links to tbl_Sites
Plot_grp_ref	Text	Plot grouping reference- plots in each group are within close proximity of each other but are not part of a cluster
PointID	Text	Name of point
Updated_Date	Text	Date of entry or last change
Loc_Notes	Memo	General notes on the location
X_Coord	Number	X coordinate (UTM Easting) of plot center
Y_Coord	Number	Y coordinate (UTM Northing) of plot center
Coord_Units	Text	Coordinate distance unites
Coord_System	Text	Coordinate system used
UTM_Zone	Text	UTM zone
Datum	Text	Datum of mapping ellipsoid
Est_H_Error	Number	Estimated horizontal accuracy
Accuracy_Notes	Text	Positional accuracy notes

3.6 Table: tbl_Macroplot

Description: Holds macroplot sampling data

Field name	Field type	Field description
Macro_ID	ReplicationID	Primary key. Macroplot identifier
Location_ID	ReplicationID	Foreign key- links to tbl_locations
Sampling_Date	Date/Time	Date macroplot was sampled
Slope	Single	Percent slope of ground across entire plot
SloVar	Text	Slope variability across entire plot
Aspect	Integer	Aspect of plot - slope direction of entire plot
AspVar	Text	Aspect variability of entire plot
TopoPos	Text	Topographical position
Observer	Text	Observers at macroplot sampling
Notes	Memo	Notes about macroplot
Data_Enterer	Text	Person who entered the data into the database for this event
Data_Verifier	Text	Person who verified the data in the database for this event

3.7 Table: tbl_Macroplot_Fire

Description: Holds fire data for macroplot

Field name	Field type	Field description
Macro_ID	Number	Foreign key links to tbl_Macroplot
Fire_Name	Text	Name of the fire (if it has one)
Fire_Date	Text	Date the fire occured (month and year
Fire_Type	text	Wildfire, prescribed
No_Burn	Yes/No	Checked if point was within area considered to be the fire perimeter, but didn't actually burn
Burn_Heterogeneity	Text	Low (uniformly affected by burn), Medium (2 or 3 discrete area of different severities, or High (patchy distribution of differing severeties
Burn_Het_Comments	Memo	Comments about the heterogeneity of the burn
No_Canopy_Affected	Yes/No	Selected if the canopy was not affected by the fire
Scorch_Or_Mortality	Text	Whether assessment is based on scorch (<1 year sice fire) or tree mortality (>1 year since fire)
Canopy_Low	Number	Plot level cover class value for low canopy scorch or low tree mortality (classified percent)
Canopy_Low_Med	Number	Plot level cover class value for low-med canopy scorch or low-med tree mortality (classified percent)
Canopy_Med_High	Number	Plot level cover class value for med-high canopy scorch or med-high tree mortality (classified percent)
Canopy_High	Number	Plot level cover class value for high canopy scorch or high tree mortality (classified percent)
Percent_Tree_Mortality	Number	Approximate percentage of overstory tree mortality based on basal area
Canopy_Comments	Memo	Comments on canopy burn severity
No_Understory_Affected	Yes/No	Selected if the understory was not affected by the fire
Unclear_Understory_Affected	Yes/No	Selected if it is unclear how the understory was affected by the fire
Understory_Low	Number	Plot level cover for low understory scorch (classified percent)
Understory_Low_Med	Number	Plot level cover for low-med understory scorch (classified percent)
Understory_Med_High	Number	Plot level cover for med-high understory scorch (classified percent)

3.7 Table: tbl_Macroplot_Fire (continued)

Field name	Field type	Field description
Understory_High	Number	Plot level cover for high understory scorch (classified percent)
Understory_Comments	Memo	Comments on understory burn severity

3.8 Table: tbl_saplings

Description: Stores sapling data collected in the 5 m radius subplot.

Field name	Field type	Field description
Subplot_ID	ReplicationID	Foreign key- links to tbl_Subplots
Species	Text	Sapling species - values defined in tlu_Veg_spp
Number	Integer	Number of individuals in each DBH size group
DBH	Text	DBH size group
Notes	Memo	Any notes about saplings

3.9 Table: tbl_Sites

Description: Stores details about sites.

Field name	Field type	Field description
Site_ID	ReplicationID	Primary key- site identifier
Cluster	Text	Unique name or code for a cluster- park name is used if simple grid sampling is used
Site_Type	Text	Sampling type - simple or cluster
Habitat	Text	Habitat type
Cluster_orig	Text	Original cluster name
Unit_Code	Text	4-letter Park, Monument or Network code
Site_Notes	Memo	General notes about the site

3.10 Table: tbl_Snags_BAF

Description: Stores subplot snag Basal Area Factor data.

Field name	Field type	Field description
Subplot_ID	ReplicationID	Foreign key- links to tbl_Subplots
Hit_Number	Integer	Number of snags in BAF group
BAF	Integer	Basal Area Factor- either 10 or 40

3.11 Table: tbl_Subplots

Description: Holds plot data for four 1.78 m radius plots.

Field name	Field type	Field description
Location_ID	ReplicationID	Foreign key. Links to tbl_Locations
Subplot_ID	ReplicationID	Primary key- subplot identifier
Sampling_Date	Date/Time	Date the subplot was sampled
Subplot_Number	Integer	Subplot identification number (1-4)

3.11 Table: tbl_Subplots (contintued)

Field name	Field type	Field description
Observer	Text	Full name of person who collected data for this subplot
Notes	Memo	General notes about subplots
Photos	Yes/No	Checked if photos were taken
No_Saplings	Yes/No	Checked if no saplings existed in the subplot - used for data verification
No_Trees	Yes/No	Checked if no trees existed in the subplot - used for data verification
No_Snags	Yes/No	Checked if no snags existed in the subplot - used for data verification
No_Veg_Strata	Yes/No	Checked if no veg strata existed in the subplot - used for data verification
No_FolCov	Yes/No	Checked if no foliar cover existed in the subplot - used for data verification
Data_Enterer	Text	Person who entered the data into the database for this event
Data_Verifier	Text	Person who verified the data in the database for this event

3.12 Table: tbl_Subplots_FC

Description: Holds subplot functional category and cover class data for 1.78 m radius plot.

Field name	Field type	Field description
Subplot_ID	ReplicationID	Foreign key- links to tbl_Subplots
Category	Text	Functional vegetation categories – values defined in tlu_foliar_cover (also see in Table 5-4 in SOP #5)
CoverClass	Integer	Braun-Blanquet cover class value corresponding to the visual estimate vegetation category over the 1.78 m radius plot – values defined in tlu_Cover_Class (also see Table 5-3 and SOP #5)
Notes	Memo	Notes about functional category records

3.13 Table: tbl_Trees_BAF

Description: Stores subplot tree Basal Area Factor data.

Field name	Field type	Field description
Subplot_ID	ReplicationID	Foreign key- links to tbl_Subplots
Species	Text	Tree species
Hit_Number	Integer	Number of each tree species in BAF group
BAF	Integer	Basal Area Factor- either 10 or 40
Notes	Memo	General notes about tree BAF records

3.14 Table: tbl_VCP_Count

Description: Stores bird data from variable circular plot sampling.

Field name	Field type	Field description
Event_ID	ReplicationID	Foreign key- links to tbl_Events_VCP
Minute	Text	Minute in 8-minute count bird(s) was first observed
Number_Observed	Integer	For each detection, the number of birds observed
Species	Text	For each detection, species code of bird(s) observed – values defined in tlu_Bird_Codes
Distance	Integer	For each detection, the horizontal distance in meters between the plot center and the location or presumed location of where the bird was first detected

3.14 Table: tbl_VCP_Count (continued)

Field name	Field type	Field description
Detection_Type	Text	How the bird was first detected (valid detection codes defined in Table 4-2 in SOP #4)
Seen	Yes/No	Checked if the bird was seen in addition to the original detection type
No_Saplings	Yes/No	Checked if no saplings existed in the subplot - used for data verification
No_Trees	Yes/No	Checked if no trees existed in the subplot - used for data verification
Sex	Text	Sex of bird(s) if known - M= male, F= female, U= unknown
Age	Text	Age of bird(s) if known - A = adult and J = juvenile
Flock_Size	Integer	Approximate number of individuals in flock
Previous_Plot	Yes/No	Checked if the bird or flock was already detected from a previous plot
Breeding_Code	Text	Breeding code – values defined in tlu_breeding_codes (also see Table 4-3 in SOP #4)
Flyover	Yes/No	Checked if the bird was observed flying above the top of the vegetation canopy, but never touched down in the observer's field of view and did not appear to be using the habitat below them
Order	Long Integer	Used to keep track of the order in which data were entered - used for data verification
Comments	Memo	Comments about variable circular plot data

3.15 Table: tbl_Veg_Strata

Description: Stores vegetation strata data measured in the 11.3 m radius subplot

Field name	Field type	Field description
Subplot_ID	ReplicationID	Foreign key- links to tbl_Subplots
Veg_strata	Text	Name of vegetation strata (See SOP 5 for a more detailed explanation)
Height_class	Single	The height to a point in the stratum that represents the average height of the stratum within the 11.3 m radius plot (measured with a clinometer) – values defined in tlu_Height_Class
Cover_Class	Integer	Braun-Blanquet cover class value corresponding to the visual estimate of the foliar cover for the stratum over the 11.3 m radius plot – values defined in tlu_Cover_Class (also see Table 5-3 and SOP #5)
Dom_spp1	Text	Dominant species 1 – values defined in tlu_Veg_spp
Dom_spp2	Text	Dominant species 2 – values defined in tlu_Veg_spp
Dom_spp3	Text	Dominant species 3 – values defined in tlu_Veg_spp
Notes	Memo	General notes about vegetation strata
Order_strata	Long Integer	Used to track order in which records are entered

3.16 Table: tbl_Vegetation_Type

Description: Stores data about vegetation types present in each macroplot.

Field name	Field type	Field description
Macro_ID	ReplicationID	Links to tbl_Macroplot
Vegetation_Type	Text	Type of vegetation cover present within the macroplot - values defined in tlu_Veg_Type (also see Appendix E)
VegCoverClass	Integer	Braun-Blanquet cover class value corresponding to the visual estimate of the percent of vegetation cover – values defined in tlu_Cover_Class (also see Table 5-3 and SOP #5)
Notes	Memo	General notes about macroplot vegetation type

3.17 Table: tbl_Verification

Description: Stores information on which records have been verified, and of those, which records have been corrected.

Field name	Field type	Field description
Location_ID	ReplicationID	Foreign key- links to tbl_Locations
Sampling_Date	Date/Time	Sampling event date
Unit_Code	Text	4-letter Park, Monument or Network code
Loc_Name	Text	Name of point
Proofed	Text	Indicates if the record was verified or not
Proof_Count	Integer	How many times the record was verified
Corrected	Yes/No	Indicates if the record was corrected for errors or not
Proof_Date	Date/Time	Date record was verified
Proof_Reader	Text	Who proofed the record

3.18 Table: tbl_Verification_Tracking

Description: Keeps a tally of which fields were corrected during data verification.

Field name	Field type	Field description
Event_Date	Date/Time	Sampling event date
Field	Text	Field in table that was corrected for errors
Proof_Date	Date/Time	Date the record was verified
Was	Memo	Stores value that was originally entered
Changed_To	Memo	Stores value that the record was corrected to
Park	Text	4 letter park unit code
Cluster	Text	Cluster identifier
Point	Text	Point identifier

3.19 Table: xref_Event_Contacts

Description: Links tlu_contacts to protocol data tables.

Field name	Field type	Field description
ID	ReplicationID	Foreign key. Links to Event_ID in tbl_Events_VCP, Subplot_ID in tbl_Habitat_Char, and Macro_ID in tbl_Macroplot.
Contact_ID	ReplicationID	Foreign key- links to tlu_contacts.

3.20 Table: tlu_Bird_Codes

Description: Lookup table for bird species codes and definitions.

Field name	Field type	Field description
SpCode	Text	Four letter species code
CoName	Text	Common name of bird
ScName	Text	Scientific name of bird

3.21 Table: tlu_breeding_codes

Description: Lookup table for bird breeding codes.

Field name	Field type	Field description
Code	Text	Two-letter breeding code
Explanation	Memo	Explanation of breeding code

3.22 Table: tlu_Contacts

Description: Lookup table that stores contact data for project-related personnel.

Field name	Field type	Field description
Contact_ID	ReplicationID	Primary key- unique contact identifier
Last_Name	Text	Last name
First_Name	Text	First name
Middle_Init	Text	Middle initial
Organization	Text	Organization or employer
Position_Title	Text	Title or position description
Address_Type	Text	Address (mailing, physical, both) type
Address	Text	Street address
Address2	Text	Address line 2, suite, apartment number
City	Text	City or town
State_Code	Text	State or province code
Zip_Code	Text	Zip code
Country	Text	Country
Email_Address	Text	E-mail address
Work_Phone	Text	Phone number
Work_Extension	Text	Phone extension
Contact_Notes	Memo	Contact notes
Active	Yes/No	Checked if the person is currently working

3.23 Table: tlu_Cover_Class

Description: Lookup table that stores modified Braun-Blanquet cover class scale codes and definitions.

Field name	Field type	Field description
Code	Integer	Cover class code
Height_Range	Text	Range of heights associated with height class codes
Midpoint	Single	Midpoint of range of height

3.24 Table: tlu_Height_Class

Description: Lookup table for tree canopy height classes

Field name	Field type	Field description
Code	Integer	Cover class code
Cover_Range	Text	Range of cover associated with cover class code
Midpoint	Single	Midpoint of range of cover

3.25 Table: tlu_Noise

Description: Lookup table for background noise as it affects observer's ability to hear birds.

Field name	Field type	Field description
Explanation	Text	Explanation of noise code

3.26 Table: tlu_Parks

Description: Lookup table for 4-letter park codes

Field name	Field type	Field description
Explanation	Text	Full park name

3.27 Table: tlu_Precipitation

Description: Lookup table for precipitation codes.

Field name	Field type	Field description
Explanation	Text	Explanation of precipitation code

3.28 Table: tlu_Veg_spp

Description: Lookup table that stores plant species codes and definitions.

Field name	Field type	Field description
Scientific_name	Text	Scientific name of plant
Common_name	Text	Common name of plant
Form	Text	Plant growth form
Code	Text	Plant code based on scientific name

3.29 Table: tlu_Wind

Description: Lookup table that stores wind codes and definitions.

Field name	Field type	Field description
Code	Integer	Wind code
Explanation	Text	Explanation of wind code

Appendix E

Vegetation Map Classes Occurring in Target Habitats for Bird Community Monitoring

Vegetation map classes occurring in or adjacent to target habitats, listed by park and target habitat. The vegetation map classes are described in the most recent vegetation mapping report for each park (see *Sources* at the end of this table).

Vegetation type	Description
Bandelier National Monument - Mixed conifer habitat	
Mixed Conifer Forest (wet)	The overstory is a mixture of conifers (Douglas-fir [*Pseudotsuga menziesii]*, white fir [*Abies concolor*], blue spruce [*Picea pungens*], southwestern white pine [*Pinus strobiformis*], limber pine [*Pinus flexilis*], and ponderosa pine [*Pinus ponderosa*]). White fir and blue spruce tend to dominate the overstory. May also contain quaking aspen, if so it comprises less than 75% of the total tree cover. Understory is variable, including montane bunchgrasses, luxuriant forbs, and mesic shrub species including Rocky Mountain maple (*Acer glabrum*) gooseberry (*Ribes* spp), rock spirea (*Holodiscus dumosus*) and snowberry (*Symphoricarpos oreophilus*). Generally occupies positions on north-facing slopes and ridgelines.
Mixed Conifer Forest (dry)	The overstory is a mixture of conifers (Douglas-fir, white fir, blue spruce, southwestern white pine, limber pine, and ponderosa pine), along with quaking aspen (*Populus tremuloides*), which can comprise between 25% and 75% of the total tree cover. Understory is variable, Gambel oak (*Quercus gambelii*) and common juniper *(Juniperus communis*) may be well represented. Herbaceous layer tends to be sparse, with much less cover than in the wet type. Tends to occur on south-facing slopes.
Aspen Forest	Overstory is dominated by aspen (exceeds 75% of total tree cover). Understory is variable, usually dominated by either bunchgrasses or a diverse suite of herbs. Few shrubs are present.
Ponderosa Pine Forest	Overstory tree canopy is relatively continuous (>60%) and dominated by ponderosa pine, which exceeds 75% of total canopy.
Ponderosa Pine Woodland/ Savanna	Overstory tree canopy is 10-60% total cover. The canopy is dominated by ponderosa pine (exceeds 75% of total tree cover). May also include pinyon-juniper component. Understory is usually represented by a variable mix of bunchgrasses and forbs, however, gambel oak and New Mexico locust (*Robinia neomexicana*) may be well represented.
Gambel Oak Shrubland	Shrub canopy dominated by Gambel oak, Apache plume (*Fallugia_paradoxa*) or New Mexico locust. May also contain Fendler ceanothus (*Ceanothus fendleri*). Shrub cover exceeds 25%. Tree canopy is absent or sparse (<10%).
Post-fire Herbaceous/shrub Disturbance Vegetation	Areas that have experienced evident stand replacement fire, and remaining live conifer cover is less than 10%. Understory is a diverse mix of native and exotic grasses and native and exotic forbs. When present, Gambel oak and New Mexico locust cover doesn't exceed 25%.
Montane Grassland	Overstory trees are absent, or comprise <10% cover. Sites are characterized by a herbaceous layer dominated by perennial bunchgrass species, including Parry's oatgrass (*Danthonia parryi*) and Thurber fescue (*Festuca thurberi*).
Canyon De Chelly National Monument	
Gambel Oak-Mixed Montane Shrubland	Occurs on canyon walls, slopes, or floor. Shrub layer dominated by Gambel oak (*Quercus gambelii*) and/ or other shrubs, including Cliff fendlerbush (*Fendleria rupicola*), Utah serviceberry (*Amelanchier utahensis*), and rabbitbrush (*Ericameria nauseosa*). Herbaceous layer variable.
Pinyon-Juniper Woodland	Areas with 10-60% total canopy cover of pinyon (*Pinus edulis*) and/or juniper (*Juniperus* spp). Shrub and herbaceous layer variable from shrub dominated to sparse.
Riparian Woodland and Shrubland (dense) (no cottonwood)	Riparian areas dominated by various combinations of Russian olive (*Elaeagnus angustifolia*), tamarisk (*Tamarix ramosissima*), Goodding willow (*Salix goodingii*), boxelder (*Acer negundo*) and cottonwoods (*Populus* spp.). Dense cottonwood overstory not present.
Riparian Woodland and Shrubland (dense)(cottonwood)	Dominated by various combinations of Russian olive, tamarisk, Goodding willow, boxelder and cottonwoods. Dense cottonwood overstory present.
Riparian Woodland and Shrubland (open)	Dominated by open cottonwood overstory and a sparse understory with few trees and/or shrubs.

Vegetation type	Description
Restoration treatment area: cleared	Riparian areas where Russian olive and/or tamarisk have been cut down and debris left or removed. No native trees and shrubs are present
Shrub-Steppe & Scrub	Areas dominated by shrub layer consisting of various combinations of big sagebrush (*Artemisia tridentata*), prickly pear (*Opuntia* spp.), rubber rabbitbrush and mormon-tea (*Ephedra* spp). May contain pinyon juniper, but cover is less than 10% .
Semi-desert Grassland	Few to no trees and shrubs. Herbaceous layer dominated by native or exotic grasses. Cover of both shrub and tree layers are <10%.
Barren	Includes wash bottoms and exposed bedrock.
Agriculture/Pasture	Areas that have been used by canyon residents for farming or pasturelands
Rock Outcrop or Cliff	Areas of exposed bedrock
Grand Canyon National Park - Pinyon-juniper habitat	
Pinyon-juniper Woodland / Grass - Forb Understory	Canopy is co-dominated by pinyon pine (*Pinus edulis*) and juniper (*Juniperus osteosperma*). Shrub layer is not dominate or absent. Understory is often dominated by grass species including muttongrass (Poa fendleriana) or blue grama (Bouteloua gracilis).
Pinyon-juniper Woodland / Mountain Mahogany/ Oak Understory	Canopy is co-dominated by pinyon pine and juniper. Shrub layer includes mountain mahogany (*Cercocarpus* spp.), Utah serviceberry (*Amelanchier utahensis*) and/or oak (*Quercus* spp).Herbaceous cover may exceed shrub cover, but shrub cover is present at greater than 5%.
Pinyon-juniper Woodland / Sagebrush Understory	Canopy is co-dominated by pinyon pine and juniper. Shrub layer may be varible, but must include sagebrush (*Artemisia bigelovii* or *Artemisia tridentata*).
Pinyon-juniper Woodland / Sparse Understory	Canopy is co-dominated by pinyon pine and juniper. Understory is sparse (<10% relative cover)
Big Sage Shrubland	Shrublands with less than 15% cover of pinyon-juniper. Shrub layer is dominated by A*rtemisia tridentata or bigelovii*, with greater than 40% cover. Other shrubs may be present, including Mormon tea (*Ephedra* spp), rubber rabbitbrush (*Ericameria nauseosa*) or cliffrose (*Purshia stansburiana*).
Ponderosa Pine Forest/Woodland	Overstory is dominated by ponderosa pine (*Pinus ponderosa*), although pinyon and juniper may still be present. Understory is variable mix of shrubs, forbs and grasses.
Post-Fire Herbaceous/Shrub Disturbance Vegetation	Location has experienced evident stand replacement fire and remaining live conifer cover is less than 10%.
Grand Canyon National Park - Mixed conifer habitat	
Mixed Conifer Forest (dry)	Forests and woodlands dominated or codominated by white fir (*Abies concolor*) and Douglas fir (*Pseudotsuga menziesii*) (but may include other species, not exceeding 50% relative cover). Understory is variable mix of shrub (most commonly New Mexico locust [*Robinia neomexicana*], Arizona wood's rose, [*Rosa woodsii*]), low shrub (including Oregon grape [*Berberis repens*] and common juniper ([*uniperus communis*], and graminoid and forbs.
Mixed Conifer Forest (wet)	Forests and woodlands dominated or codominated by white fir or blue spruce (*Picea pungens*) (with lesser amounts of Doublas fir, ponderosa pine [*Pinus ponderosa*] and/or aspen). Often, white fir also dominates the sub-canopy. Shrub layer may be dominated by mountain snowberry (*Symphoricarpos oreophilus)* or common juniper, with 1-5% cover. Dryspike sedge (*Carex siccata)* dominates the herbaceous layer when present, ranging from 5-20% cover. Commonly occurs at higher elevations and sites on north-facing slopes.
Aspen Forest	Aspen (*Populus tremuloides)* occupies greater than 50% of tree cover. Understory is a variable mix of shrubs and/or and grasses and sedges.
Ponderosa Pine Forest/Woodland	Areas in which ponderosa pine occupies greater than 50% of total tree cover. May contain lower amounts of other species including Douglas Fir and true fir (Abies), but at covers generally less than 15%. Understory is variable and can be dominated by shrubs, grasses and sedges and forbs or sparse.
Montane Grassland	Total tree cover does not exceed 10%. Understory vegetation includes a lush mix of grass and sedges and forb species.
Post-Fire Herbaceous/Shrub Disturbance Vegetation	Areas that have experienced evident stand replacement fire and remaining live conifer cover is less than 10%.

Vegetation type	Description
Mesa Verde National Park	
Gambel Oak-Mixed Montane Shrubland	Areas dominated by Utah serviceberry (*Amelanchier utahensis*), fendlerbush (*Fendlera rupicola*) and gambel oak *(Quercus gambellii)*. Shrub cover exceeds 40%. Little to no overstory pinyon or juniper. Generally found in more northern portions of the park.
Pinyon-Juniper Woodland	Pinyon pine (*Pinus edulis*) and juniper (*Juniperus* spp.) dominate the overstory (15-65% cover). The shrub layer can be well developed with antelope bitterbrush (*Purshia tridentata*) and Utah serviceberry. Mountain mahogany (*Cercocarpus montanus*), big sagebrush (*Artemisia tridentata*), fendlerbush, and gambel oak are also present, but less common components. The herbaceous layer is commonly sparse, most frequently characterized by muttongrass (*Poa fendleriana*), toadflax penstemon (*Penstemon linariodes*). Opuntia and Datil yucca (*Yucca baccata*) are also frequent.
Big Sagebrush Shrubland	Areas with little to no overstory (<15% cover) and high shrub cover, including big sagebrush. May also have relatively high forb cover. Shrub cover of Utah serviceberry, fendlerbush, and gambel oak is <40%.
Semi-Desert Grassland	Areas that have been cleared of pinyon-juniper woodland. Understory are dominated by grasses, with little to no overstory tree or shrub cover (<10%).
Sparse Vegetation - Pinyon-Juniper Barrens	Total vegetation cover is sparse, generally less than 10%. Pinyon-juniper may be present as overstory, but does not exceed 10% cover. Exposed sandstone bedrock is present at high cover values and is the dominant feature.
Post-Fire Herbaceous/Shrub Disturbance Vegetation	Occurs in areas affected by previous fire. Vegetation is a mix of native and non-native forbs and grasses. Tree and shrub cover together doesn't exceed 20%.
Petrified Forest National Park	
Alkali Sacaton Steppe and Mixed Grasslands	Little to no tree cover (<10%). Includes both grasslands and mixed shrublands often dominated by alkali sacaton (*Sporobolus airoides*), but also including snakeweed (*Gutierrezia sarothrae*), prickly pear (*Opuntia* spp.), galleta (*Hilaria jamesii*) and grama grasses (*Bouteloua* spp.)
Badland Sparse Vegetation	A mix of low shrub (<0.5m) and herbaceous species. Total vegetated cover does not exceed 10% with the exception of annual grasses which may briefly dominate following wet periods.
Barren Wash	Non-vegetated area associated with wash.
Cliff-rose - Crispleaf Buckwheat Shrubland	Exposed bedrock and boulders of basalt or sandstone dominated by cliff-rose (*Purshia tridentata*) and crispleaf buckwheat (*Eriogonum corymbosum*) on slopes, terraces and mesas in the northern portion of the park.
Sandsage - Fourwing Saltbush Colorado Plateau Shrubland	Sandsage (*Artemisia filifolia*) and/or four-wing saltbush (*Atriplex canescens*) dominates or co-dominates the shrub layer. Herbaceous layer varies. Occurs on sand dunes and sandsheets and rolling plains.
Vegetated Rim Complex	Occurs on edges of mesas along clifflines. Vegetation is variable, typically a mix of shrubs and herbaceous. Usually with exposed basalt and sandstone bedrock.
Vegetated Wash Complex	Mixed shrub and grassland closely associated with washes.
Wupatki National Monument	
Juniper Woodland	Cover of one-seed juniper (*Juniperus monosperma*) exceeds 10%. Herbaceous cover is sparse to moderate and generally dominated by grasses with some forbs.
Mixed Shrublands	Shrub is the dominant lifeform. Cover of shrubs is more than twice cover of herbaceous species and generally greater than 10%.
Apache Plume Cinder Shrubland	Apache plume dominates, although other shrub species such as rabbitbrush, fourwing saltbush and and Torrey's joint-fir (*Ephedra torreyi*) may be be frequent. Herbaceous cover is sparse and substrate is black and red fine gravel or cinders.
Sand Sagebrush Shrubland	Dominated by shrubs, with greater than 10% cover. Sand sagebrush occurs as a dominant or subdominant. Other shrubs include rabbitbrush, fourwing saltbush and and Torrey's joint-fir.
Grasslands	Dominated by grasses and forbs, cover generally higher than 10%. Dominant grass species include galleta grass and grama grass (*Bouteloua gracilis* and/or *B. eriopoda*). Cover of shrubs averages less than 10%.
Moenkopi Sparse Vegetation	Vegetation is typically sparse (excepting annual species, which may dominate depending on local rainfall). Shrubs and dwarf shrubs are dominant, including four wing saltbush, shadscale (*Atriplex confertifolia*) and (*Atriplex obovata*) with mormon tea (*Ephedra viridis*) and snakeweed (*Gutierrezia sarothrae* and *G. microcephala*).

Vegetation type	Description
Cinder Barren	Cover of vegetation is sparse (less than 10%). Soil surface is characterized by a layer of red or black fine gravel or cinders. Often occurs on the margins of mesas.
Wash	Area of sparse vegetation that functions as a waterway for short periods of time. May be lined with dense shrub and herbaceous vegetation.
Basalt Outcrop Shrubland	Shrub cover is greater than 10% and consists of bricklebush (*Brickellia californica*) and skunkbush (Rhus aromatica). Substrate of basalt rock outcrops and deep cinders.

Sources

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